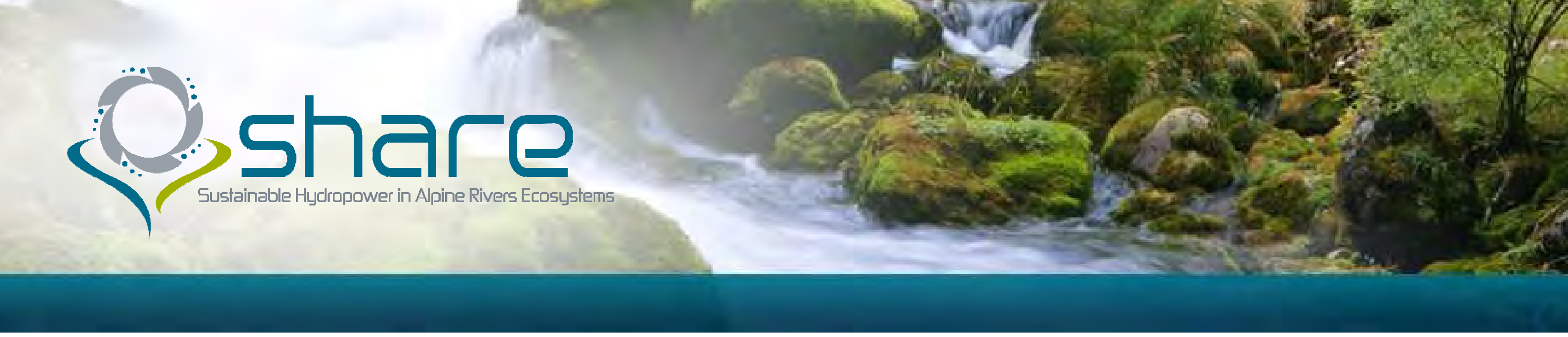

WP7
Cordevole River Basin Monograph

28/02/2011 Version 2.0

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Summary

Short Description
This document intends to give a comprehensive but synthetic description of the Cordevole River Basin

Document Control

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Introduction

The present work has the function to describe the Cordevole river basin from many points of view. Initially it is described from the morphometric and morphological point of view, then an hydrological characterization follows.
For what concerns the river quality, some results of a monitoring project promoted by the Province of Belluno are presented. They deal with the Biotic Index evaluation, the characterization of fish fauna and the estimation of river functionality.
To complete the knowledge frame, an overview of acting plan and programs and of main water uses is reported.

1. Pilot case study area

1.1 Basin characteristics

The creek Cordevole is the most important tributary of the river Piave. It is 79 km long and it is fully included into the Belluno Province (North-Veneto), of which it represents the main stream. The catchment area is about 830 km^2. The spring is located at Passo Pordoi, in the Municipality of Livinallongo del Col di Lana-Fodom, near Arabba, at the elevation of 1919 m a.s.l.. Cordevole stream flows into the Piave at the Municipality of Sedico, at the elevation of 275 m a.s.l. The catchment morphometric characteristics are:

- maximum altitude: 3330 m a.s.l.
- average altitude: 1500 m a.s.l.
- minimum altitude 196 m a.s.l..

The main tributaries of Cordevole, and their reltive catchment basins are listed below:

- Andraz (left tributary, 26 km^2)
- Pettorina (right tributary, 53 km^2)
- Fiorentina (left tributary, 58 km^2)
- Biois (right tributary, 135 km^2)
- Tegnas (right tributary, 50 km^2)
- Mis (right tributary, 117 km^2)

Other minor tributaries are:

- on the right: Sarzana, Rio Valle Imperina, Rumarna
- on the left: Setraza, Zumaia, Corpassa, Rova, Missiaga, Bordina, Muda, Rio Valle del Vescovai

Figure 1: Cordevole upper reach

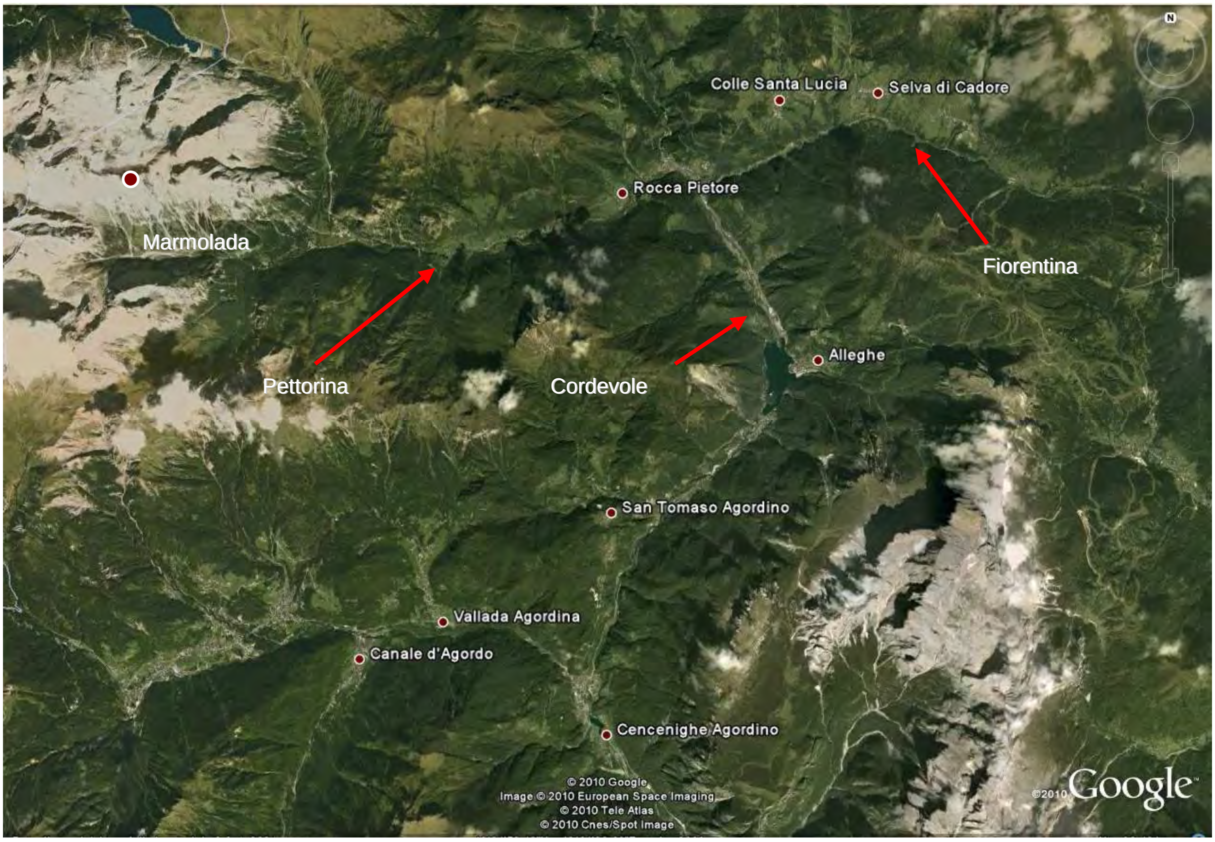

Figure 2: Cordevole middle-upper reach

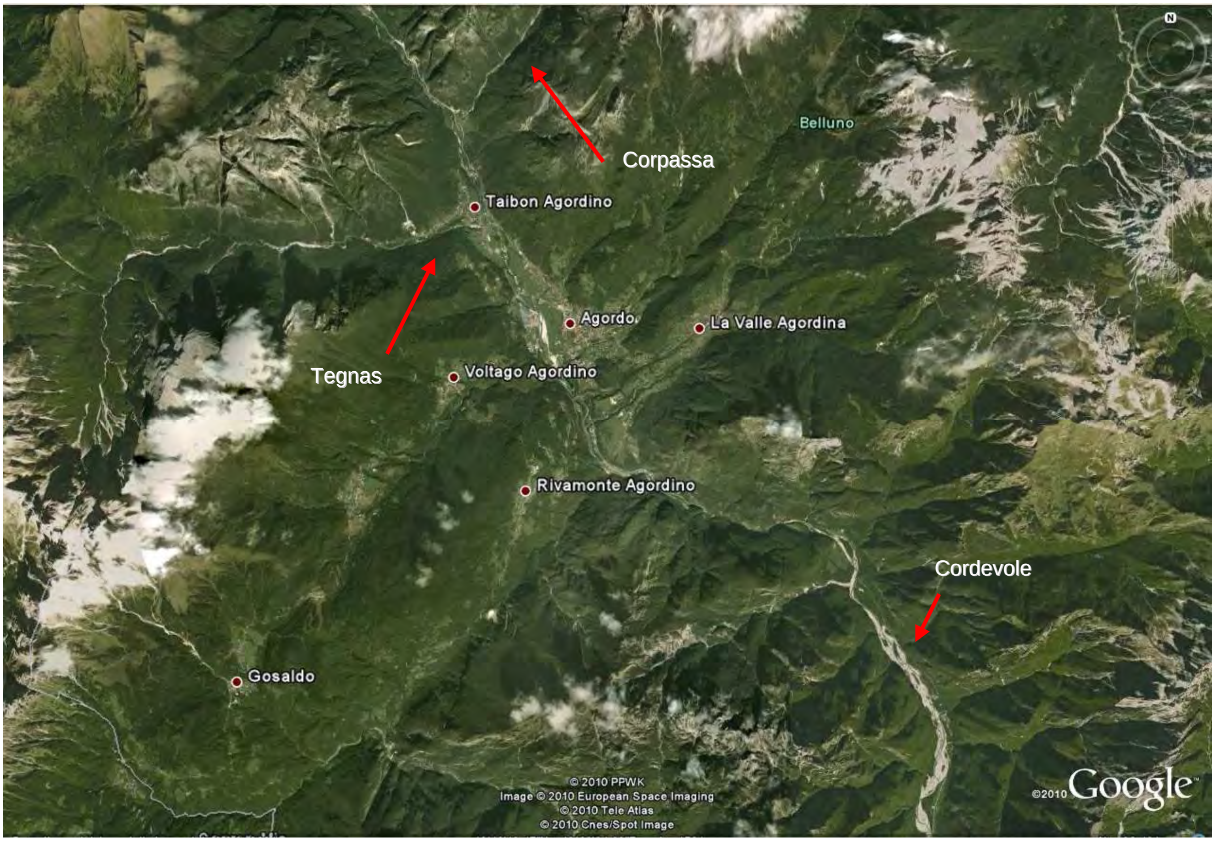

Figure 3: Cordevole middle-lower reach

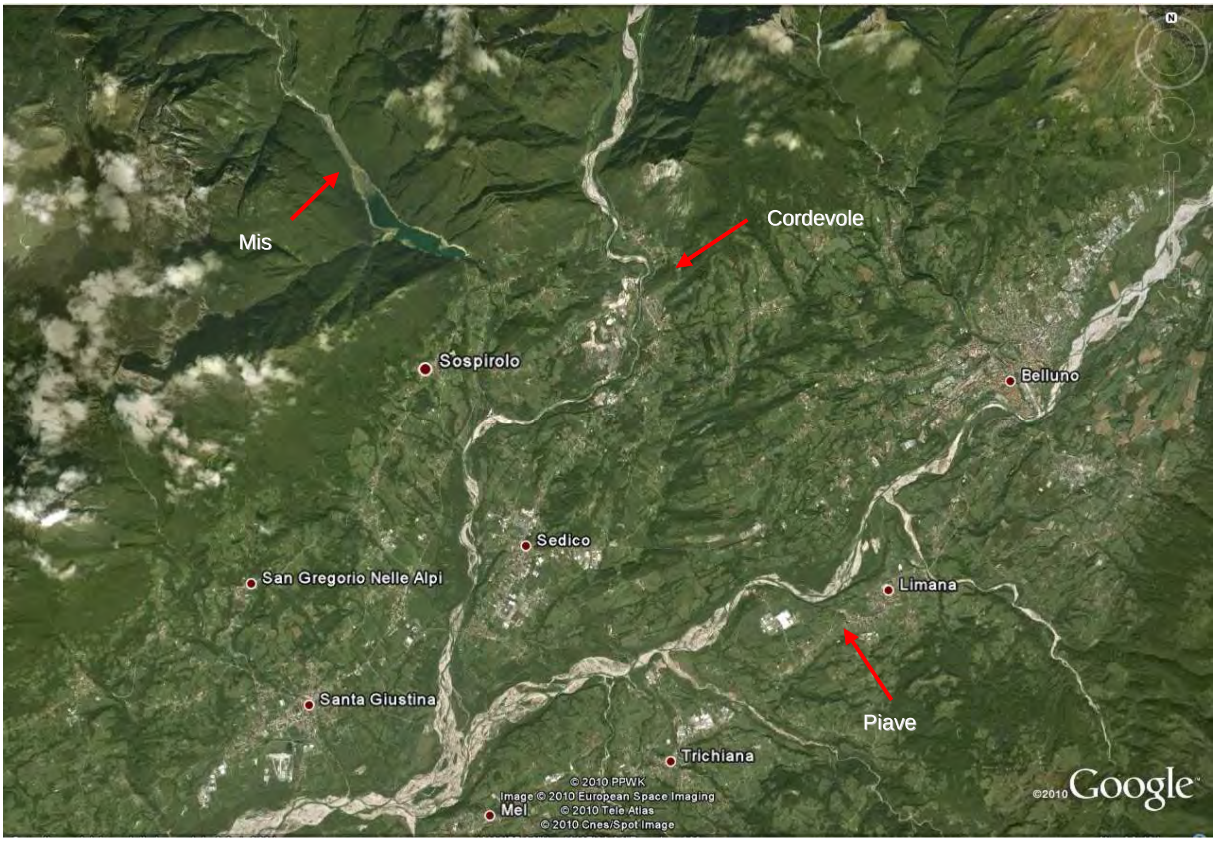

Figure 4: Cordevole lower reach

The Corevole river basin is almost totally comprised in the zone of the Belluno Province named Agordino. Following the river, from upstream to downstream, there are some particular sites which must be mentioned. At Caprile, in the Municipality of Alleghe, important tourist resort, the Cordevole receives the steams Fiorentina and Pettorina. Creek Pettorina originates from the south slope of the Marmolada massif, the highest Dolomites mountain, home of the largest Dolomites glacier.

Figure 5: Alleghe's Lake

Figure 6: Mis' Lake

Figure 7: Cordevole near Agordo

At Alleghe the Cordevole creates the Alleghe Lake, which has been originated in 1771 by the Monte Piz landslide, and it is now closed by an artificial dam. The stream course continues towards Cencenighe Agordino, where it meets the Biois and creates the Ghirlo Lake. The Tegnas flows into the Cordevole at Taibon Agordino. Afterwards we can find the Municipality of Agordo, which gives the name to the zone, and finally the Cordevole flows inside a narrow valley until it meets the Piave near Sedico, at Peron. Few kilometres before the confluence, the Cordevole receives the Mis stream, which discharge is often bigger then that of the Cordevole itself, since the Mis receives several water releases coming from upstream hydropower plants.
The river network is shown in the next Figure. The Cordevole catchment basin contour is traced in red, while the yellow lines are the Veneto Provinces boundaries.

Figure 8: Cordevole near Peron

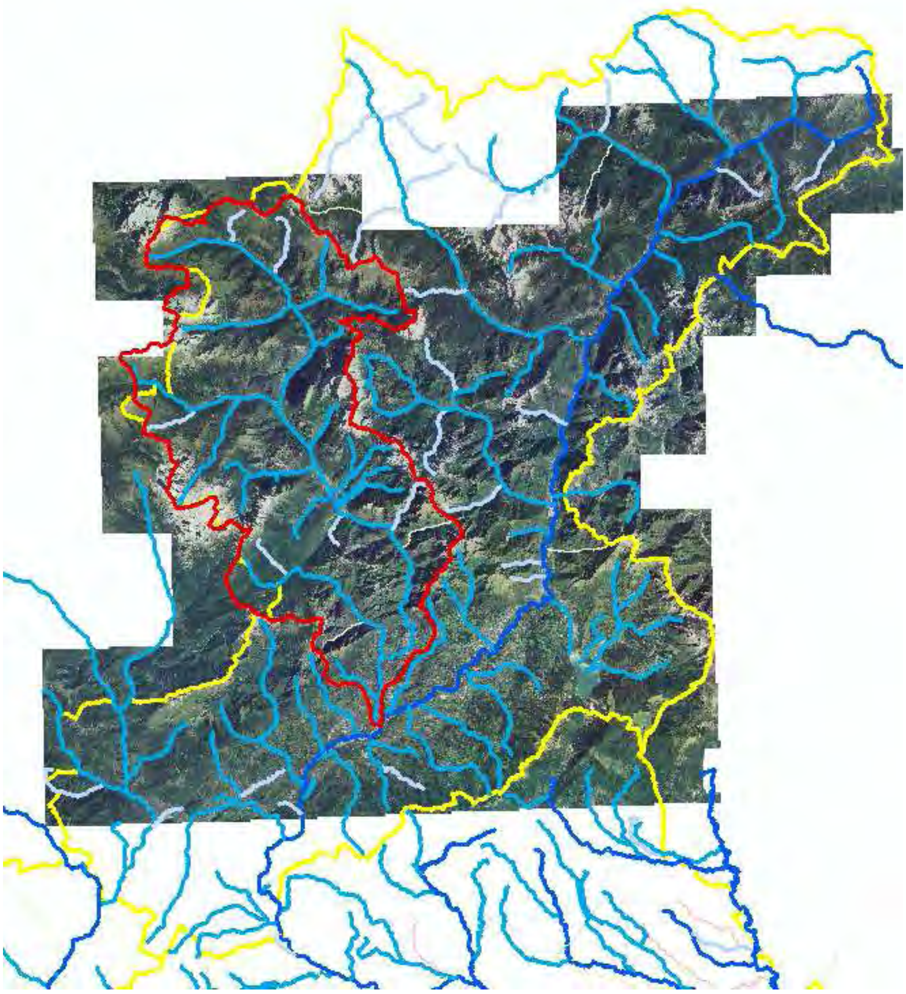

Figure 9: Cordevole river network and river basin position inside the Belluno Province

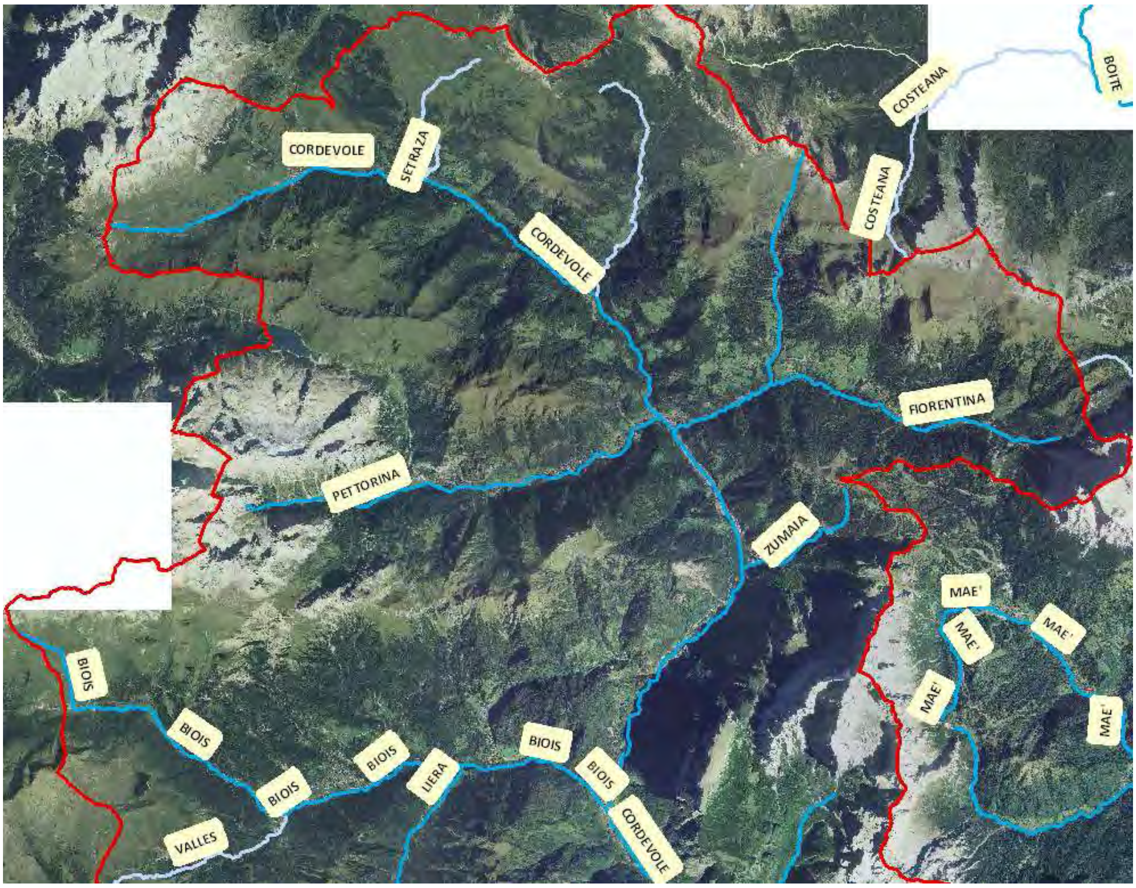

Figure 10: Upper Cordevole basin detail

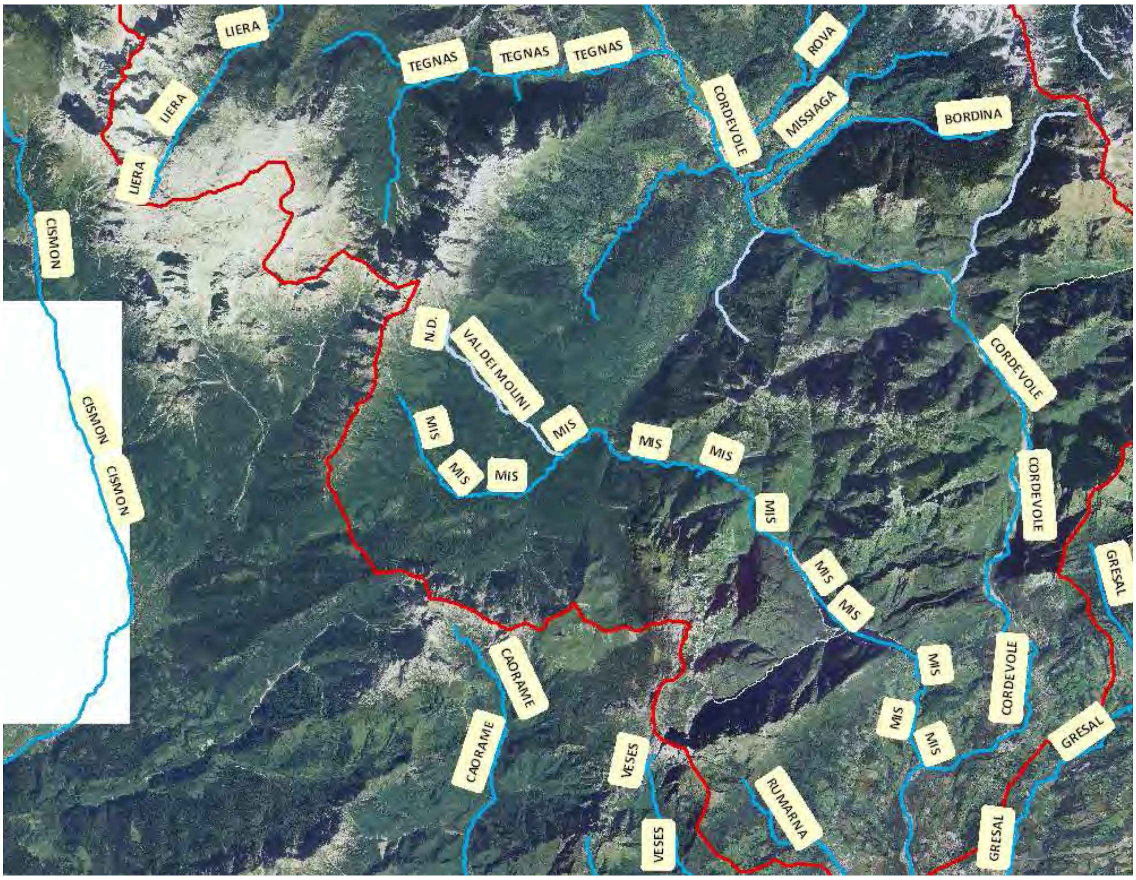

Figure 11: Lower Cordevole basin detail.

1.2 Geolithological and land cover characterization

1.2.1 Geolithological characterization

The Cordevole Valley can be seen as a link channel between the Dolomites and the Alpine Foothills. The Cordevole Valley, a narrow and deep connection channel between the lower Belluno Province and the Agordino zone, is an ancient transversal valley, which crosses the entire Dolomites mountain range. At is often occurs for ancient valleys, it is a complex environmental system, developed as a sum of the effects of valley's glaciers, water streams, hill slopes degradation processes (landslides and erosions) and Karst corrosion. The glacial modelling which originated the Cordevole valley during Ice Age, is simply recognizable by the slightly U-shaped cross section of the valley, that is with relatively wide bottom and steeps sides, often of naked rock. The reach between the localities La Stanga and I Castei is particularly suggestive, as it looks like a gully deeply graved inside the sub-horizontal planes of the stratified Principle Dolomite rocky structures.
Beside the main valley, the Cordevole river basin includes many lateral little valleys, some of them clearly located along important faults, like Val di Piero, Val Vescovà and Val Pegolera.
The lithology of emerging terrains is highly variable, due to the presence of structures coming from the Pre-Permian and Lower Miocene Ages. Carbonate lithotypes are dominant, and they are characterized by generally good mechanic characteristics. Besides, there is also abundance of lithotypes which, due to the high clay content of their alteration products or to the bad geotechnical characteristics, often concur in causing important landslide phenomena.
The Quaternary coverage is widely extended and highly variable both in thickness and composition. When the presence of the lime-clay fraction is considerable, it is involved by erosion and landslide phenomena.
From the tectonic point of view, the Cordevole river basin is characterized by several transversal structures. The most important are the Belluno Syncline and the Valsugana Line. The latest develops in the NE-SW direction and provoked the rising of the middle-upper basin zone.
On the northern basin there is a sequence of anticlines and synclines, locally complexly articulated, but mainly parallel one another. The further north structure is the Cordevole Anticline, which axis almost follows the homonym creek course.
In the next Figure, the Piave river basin geologic map is represented. The red box indicates the Cordevole river basin. Its upper part is characterized by limestone with variable marl component, claystone, gypsums. The middle part is instead characterized by Werfen sandstone and dolomite limestone. In this zone, also some metamorphic structure is present, like lower Silurian schist. The lower part of the basin is almost totally constituted by dolomite limestone of the Upper and Middle Triassic and by various Cretan limestone.

1.2.2 Land cover characterization

The Cordevole river basin is mainly represented by mountain areas, characterized by little or medium built-up areas. The most important municipalities are Alleghe, Agordo and Sedico. In the Cordevole valley only few industrial activities are present.
Referring to both Corine Landcover and Veneto Region Characterization, it is evident that the Cordevole basin is mainly covered by forests and shrubs or herbaceous vegetation. An important basin portion is also represented by naked rock and non-vegetated areas.
Urban centres are discontinuous and develop especially along river paths. The most of the arable land for agriculture is concentrated at the basin closure, where the Cordevole meets the river Piave. This zone is also the most populated and industrialized.

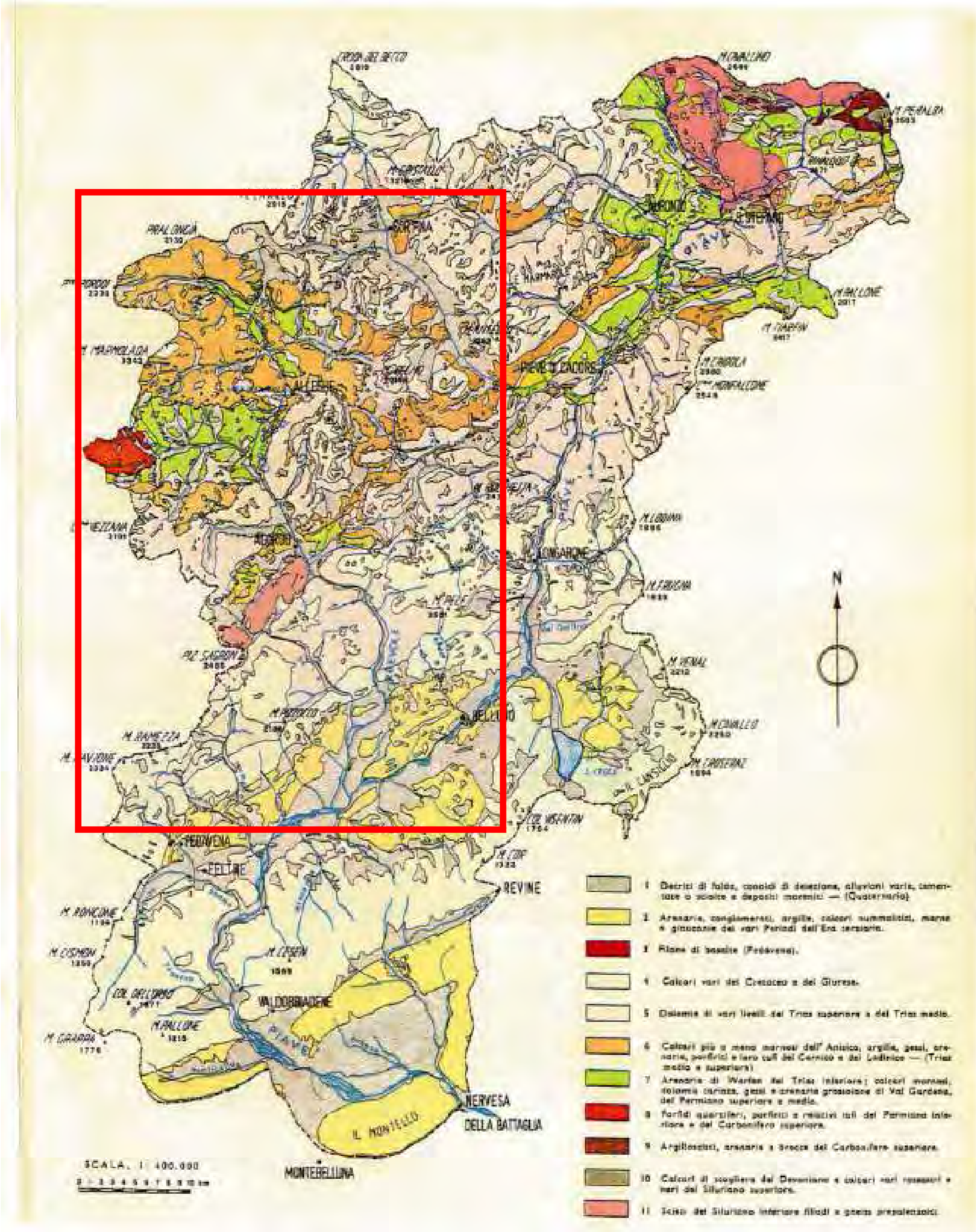

Figure 12: schematic geologic map of the Piave river basin.

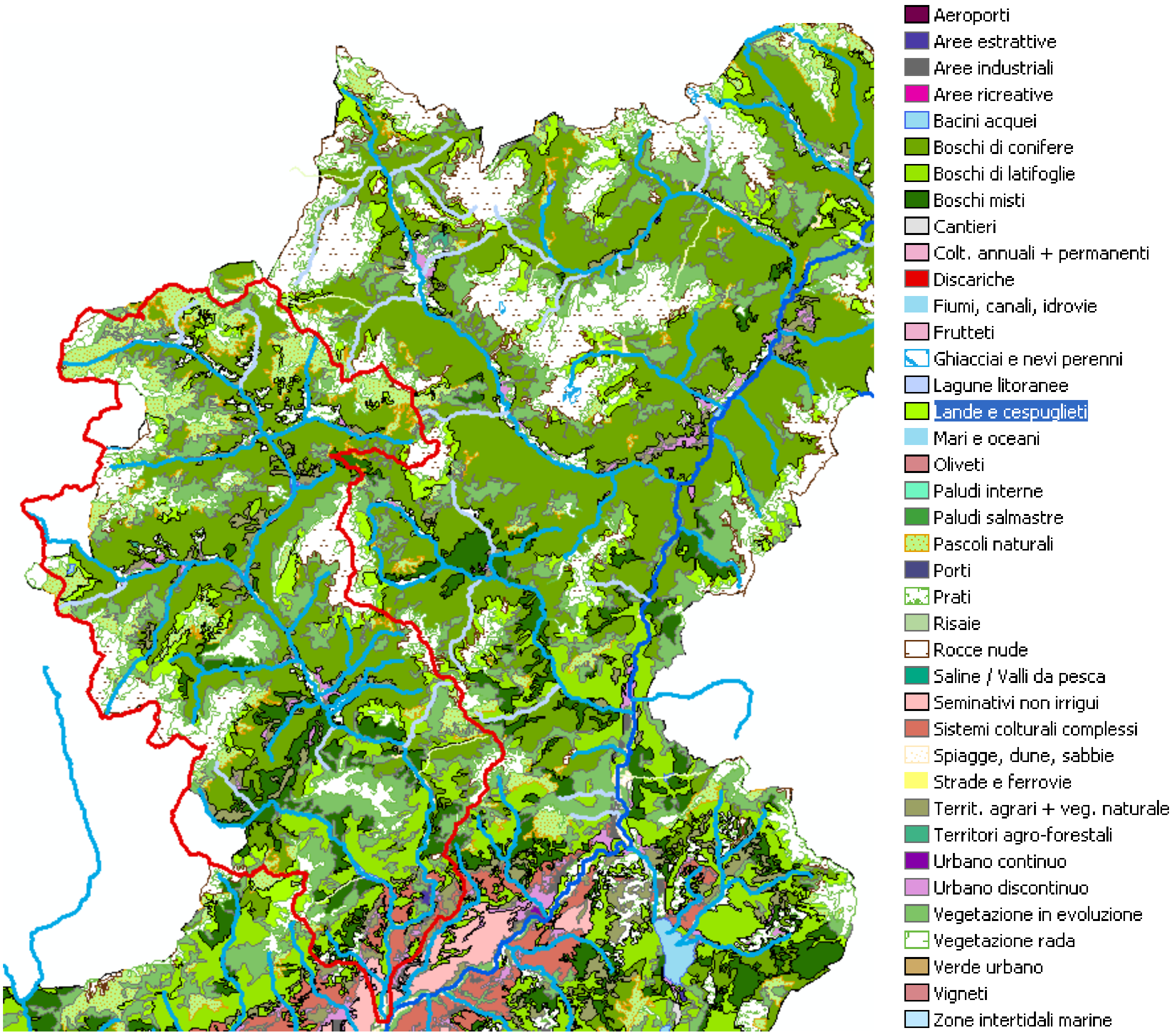

Figure 13: Corine LandCover charaterization

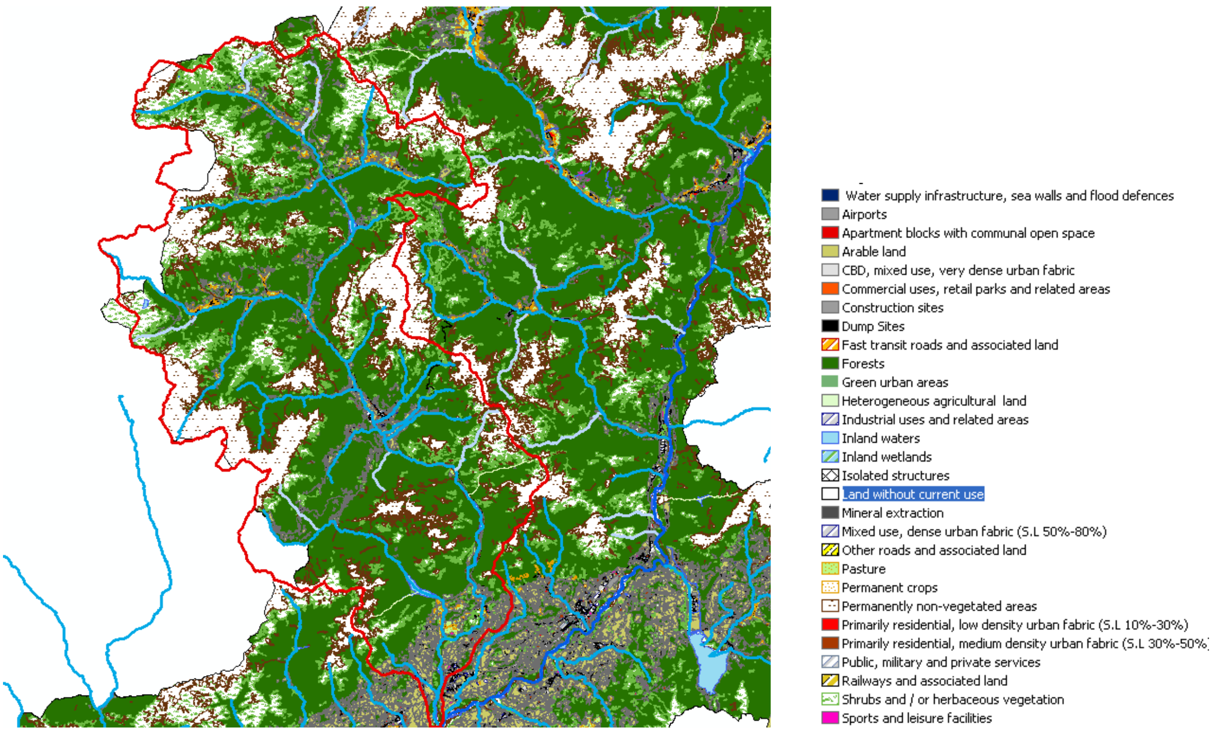

Figure 14: Regional land coverage characterization.

1.3 Hydrological characterization

1.3.1 Meteo-climatic typology

The whole Cordevole river basin belongs to the continental tempered and wet climatic zone, common to most of the southern Alpine regions. Seasons are well defined: winter is cold but generally not so severe. Mean temperatures are about 2-4 ℃ in January, minimum temperatures are few degrees below zero, and maximum often few degrees over zero. The temperature range is therefore relatively wide. The winter is the less rainy season, in which there is alternation of wet and grey days or sunny and dry periods. Spring is characterized by variable weather, with rainy days and good weather. Rainfall and temperature increase, and early thunderstorms occur. The summer begins in June, which is one of the two most rainy months. Afternoon storms in mountain zones are frequent. After the summer, the autumn period brings the other rainfall maximum, generally in November. Temperature decreases, but the fluctuation range is limited.

Obviously, the temperature generally decreases with the altitude and the climate gets more wintry going from the Alps Foothills to the Dolomites. As it is expected, an important role is also played by the mountainside exposure and slope.

Referring to the rainfall regime, the Cordevole river basin is halfway between the Alpine Foothills zone and the Inner Alpine zone. The Alpine Foothills zone includes the catchment basin closure, and the confluence between Cordevole and Piave. It is the most rainy zone, even if the rainfall contribute is appreciably lower than that of neighbouring eastern basins. The annual mean rainfall ranges between 1400 and 1600 mm. During the 30 year period 1960-1990, the most dry years presented values of 1000-1200 mm, while wettest years were characterized by measured values between 2000 and 2200 mm. The less rainy month is February, with 70-90 mm, while the wettest is November with about 140-160 mm, immediately followed by October.

The Inner Alpine zone includes most of the Cordevole river basin. The rainfall amount gradually decreases moving to North-West. Mean annual rainfall ranges between 1500 mm in the south of the concerned zone, and 1100 mm in the upper part, near to the Dolomites core. Less rainy years have values of 800-1100 mm, while wettest years reach 1400-2000 mm. Also in the Inner Alpine zone, the less rainy month is February, with 50-80 mm, and the wettest month is November, with 100-160 mm. Driest summer months during the period 1960-1990 were characterized by 40-50 mm rainfall.

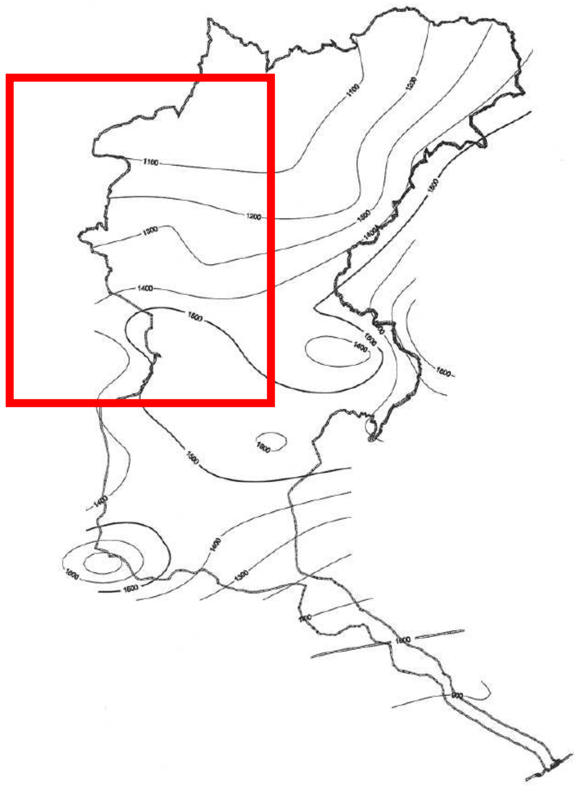

Figure 15: Piave river basin mean annual rainfall map. Cordevole river basin is identified by the red box.

1.3.2 Natural-Virtual Flow regime

The term "natural-virtual flow regime" indicates the natural flow regime that would take place in specified water course cross-sections, in the absence of anthropic activities. The actual river system is really far from its natural conditions, due to the strong presence of hydroelectric and irrigation abstractions, and to catch-and-release operations of upstream reservoirs.

Most of data usable to characterize water streams belonging to the Cordevole river basin can be found by the electricity societies which in the past, or also nowadays, had a monitoring network including significant river cross sections, in which levels were measured, and rating curves have been determined. A great database comes from the "Annali Idrologici" (Hydrological Annals), published by the Hydrographic Service. It also has an official value, since data are carefully validated. Many other data have been collected by ENEL-CRIS (Structural and Hydraulic Research Center), by Belluno's ENEL-RID (Hydropower Plants Group) and by Teolo's CSIM (Hydrological and Meteorological Experimental Centre of Veneto Region). In particular, ENEL-CRIS owns the magnetic data archive of daily mean flows collected by the ex-SADE (Adriatic Electric Society) in the period 1926-1950. These data refer to the majority of monitoring stations operating before the hydropower plant construction, and can therefore be considered as representative of the natural flow regimes. Previous studies ("L'Energia Elettrica", M. Tonini and U. Pulselli), used this database to evaluate the hydrological regime of the hydrographic network, also for the reaches in which no measured data were available. To this purpose, the river Piave hydrographic network has been divided into 89 sub-basins, and for each of them the mean specific contribution and the correspondent flow coefficients have been determined. These representation scheme has been kept also inside the Water Resources Management Plan of the River Piave Basin Authority. Among the 89 Piave sub-basin, the ones belonging to the Cordevole catchment are listed in the following Table. Sub-basins numbering has been kept unchanged, to ensure compliance with Water Resources Management Plan.

Table 1: Mean flow regime of Cordevole river basin

SUB-BASIN NUMBER	WATER BODY	SUB-BASIN DESCRIPTION	MAXIMUM ALTITUDE [m a.s.l.]	MAXIMUM ALTITUDE [m a.s.l.]	AREA [km^2]	MEAN ANNUAL RAINFALL [mm]	MEAN ANNUAL FLOW COEFFICIENT	A*	B*
54	Cordevole	Cordevole creek from the spring to the confluence with Rio Andraz	1752	1120	70.6	1124	86	2.19	31
55	Rio Andraz	Rio Andraz sub-basin	1954	1120	26.3	1115	86	0.81	31
56	Cordevole	Cordevole creek from the confluence with Rio Andraz to the confluence with Pettorina creek	1615	1010	12.1	1057	86	0.35	29
57	Pettorina	Pettorina creek sub-basin	1970	1010	52.8	1169	86	1.71	32
58	Cordevole	Cordevole creek from the confluence with Pettorina creek to the confluence with Fiorentina creek	1161	1000	0.5	1110	86	0.02	31
59	Fiorentina	Fiorentina creek from the spring to the confluence with Rio Codalunga	1869	1153	38.1	1104	86	1.16	31
60	Codalunga	Rio Codalunga sub-basin	1928	1153	13.7	1057	86	0.40	29
61	Fiorentina	Fiorentina creek from the confluence with Rio Codalunga to the confluence with Cordevole creek	1450	1000	6.7	1077	86	0.20	30
62	Cordevole	Cordevole creek from the confluence with Fiorentina creek to the confluence with Biois creek	1517	751	58.9	1262	86	2.06	35
63	Biois	Biois creek from the spring to the confluence with Liera creek	1859	950	74.8	1280	84	2.59	35
64	Liera	Liera creek sub-basin	2004	950	43.0	1482	84	1.72	40
65	Biois	Biois creek from the confluence with Liera creek to the confluence with Cordevole creek	1365	751	17.2	1297	84	0.60	35
66	Cordevole	Cordevole creek from the confluence with Biois creek to the confluence with Tegnas creek	1644	608	52.0	1382	86	1.99	38
67	Tegnas	Tegnas creek sub-basin	1662	608	50.0	1570	86	2.17	43
68	Cordevole	Cordevole creek to the confluence with Tegnas creek to “Ponte del Cristo”	1313	521	94.3	1406	86	3.67	39
69	Cordevole	Cordevole creek from “Ponte del Cristo” to the confluence with Mis creek	1123	325	100.5	1390	86	3.86	38

SUB-BASIN NUMBER	WATER BODY	SUB-BASIN DESCRIPTION	MAXIMUM ALTITUDE [m a.s.l.]	MAXIMUM ALTITUDE [m a.s.l.]	AREA [km^2]	MEAN ANNUAL RAINFALL [mm]	MEAN ANNUAL FLOW COEFFICIENT	A*	B*
70	Mis	Mis creek from the spring to Titele	1400	595	59.1	1565	88	2.62	44
71	Mis	Mis creek from Titele to the confluence with Cordevole creek	1058	325	58.4	1533	88	2.53	43
72	Cordevole	Cordevole creek from the confluence with Mis creek to the confluence with Piave river	641	279	37.8	1496	86	1.56	41

*Table fields description:
A = Contribution to the mean annual flow [m^3/s]
B = Specific contribution to the mean annual flow [l/(s·km^2)

Table 2: Hydrological and measured discharges on the river Cordevole

AREA	SUB-BASINS	WATER COURSE	CATCHMENT AREA [km^2]	A**	B**	C**	D**	E**	F**	G**	H**	I**	J**	K**	L**
15	54-55	Cordevole	96.90	2.98	2.98	0.99	0.99	1.03	0.95	0.61	0.61	0.71	0.71	0.75	0.75
16	56-61	Cordevole	123.90	4.00	6.98	1.35	2.40	1.43	2.28	0.85	1.56	0.95	1.65	1.05	1.93
17	62-65	Cordevole	193.90	6.82	13.80	2.34	4.81	2.54	4.55	1.52	3.17	1.61	3.23	1.88	3.94
18	66-68	Cordevole	196.30	7.71	21.51	2.66	7.53	2.89	7.12	1.73	4.99	1.82	5.03	2.15	6.22
19	69	Cordevole	100.50	3.82	25.33	1.29	8.88	1.36	8.39	0.81	5.89	0.91	5.92	1.00	7.35
20	70-71	Mis	117.50	5.11	5.11	1.74	1.74	1.87	1.66	1.11	1.11	1.21	1.21	1.38	1.38
21	72	Cordevole and Mis	37.80	1.55	31.99	0.48	11.23	0.47	10.61	0.27	7.46	0.38	7.47	0.33	9.31

**Table fields description:
A = Mean hydrological production [m^3/s]
B = Mean discharge at the catchment basin closure cross-section [m^3/s]
C = Low regime hydrological production (347 days) [m^3/s]
D = Low regime discharge (347 days) at the catchment basin closure cross-section [m^3/s]
E = Low regime hydrological production (355 days) [m^3/s]
F = Low regime discharge (355 days) at the catchment basin closure cross-section [m^3/s]
G = Absolute low regime hydrological production [m^3/s]
H = Absolute low regime discharge at the catchment basin closure cross-section [m^3/s]
I = Low regime hydrological production with a 10 year occurrence time [m^3/s]
J = Low regime discharge with a 10 year occurrence time at the catchment basin closure cross-section [m^3/s]
K = Low regime hydrological production with a 7 days duration and with a 10 year occurrence time [m^3/s]
L = Low regime discharge with a 7 days duration and with a 10 year occurrence time at the catchment basin closure cross-section [m^3/s]

Table 3: High and low discharges based on the ENEL-SADE measuring stations

WATER COURSE - MEASURING STATION	MEAN DISCHARGE [m^3/s]	Q_{347} [m^3/s]	Q_{355} [m^3/s]	MIN. OBSERVED DISCHARGE [m^3/s]	A***	B***
Cordevole at Digonera	2.76	0.68	0.62	0.40	0.51	0.53
Pettorina at Franzedas	0.45	0.06	0.06	0.05		
Rù di Arei at Tabià Palazze	0.14	0.01	0.01			
Pettorina at Malga Ciapela	0.96	0.23	0.20	0.13	0.15	0.16
Pettorina at Ponte Pezzè	1.63	0.52	0.48	0.39	0.39	0.40
Fiorentina a Pezzagù	1.60	0.39	0.34	0.24	0.29	0.29
Cordevole at Caprile	6.51	1.51	1.4	1.05	1.24	1.29
Liera at Gares	0.52	0.08	0.07	0.04		
Mis at the Stua	3.30	0.73	0.67	0.52		
Mis at Ponte Sant'Antonio	5.33	1.28	1.14	0.79	0.85	0.92
Mis at Mis	4.02	1.28	1.20	0.95		

**Table fields description:
A = Minimum annual discharge with a 10 year occurrence time [m^3/s]
B = Minimum annual discharge with a 7 days duration and with a 10 year occurrence time [m^3/s]

1.4 River quality

1.4.1 WFD quality elements

The data and conclusions reported in this section, come from the project Belaqua, promoted and funded by the Belluno's Province from 2001 to 2006. The Belaqua project is composed by several activities, based on previous data and new data collection. All the water bodies of the Belluno's Province were considered, included the Cordevole river basin. The aim of the project was to assess and monitoring the water quality of Belluno's rivers and creeks. To this aim, IBE index has been evaluated in several cross-sections, and MIF evaluations have been carried out in some representative cross sections in 2004 and 2006.

Evaluation of I.B.E. index

The IBE evaluation on the Cordevole river basin involved 20 cross sections, 12 of which on the Cordevole main reach and the remaining 8 on the tributaries.

Table 4: IBE monitoring stations and relative data series extension.

STATION	RIVER	SITE	MUNICIPALITY	DATA SERIES
55	CORDEVOLE	Arabba	Pieve di Livinallongo	1996-2000
56	BOE'	Arabba	Pieve di Livinallongo	1996-2004
57	CORDEVOLE	Saviner di Laste	Rocca Pietore	1996-2000
58	PETTORINA	Saviner di Laste	Rocca Pietore	1996-2004
59	FIORENTINA	Caprile	Alleghe	1996-2006
60	CORDEVOLE	Le Grazie	Rocca Pietore	1996-2004
61	CORDEVOLE	Avoscan	Alleghe	1996-2000
62	CORDEVOLE	Cencenighe	Cencenighe Agordino	1996-2004
63	BIOIS	La Mora	Falcade	1996-2000
64	LIERA	Ponte del Forno	Canale d'Agordo	1996-2000
65	BIOIS	Cencenighe	Cencenighe Agordino	1996-2004
66	CORDEVOLE	Listolade	Taibon Agordino	1996-2004
67	CORDEVOLE	Ponte Alto	Agordo	1996-2000
68	CORDEVOLE	Pinei	Rivamonte Agordino	1996-2004
69	CORDEVOLE	Peron	Sospirolo	1996-2006
70	CORDEVOLE	Bribano	Sedico	1996-2004
71	MIS	Upstream Mis Lake	Sospirolo	1996-2000
72	MIS	Gron	Sospirolo	1996-2006
88	CORDEVOLE	Ciampulo	Livinallongo del Col di Lana	1996-2004
89	CORDEVOLE	Pian dei Salesei	Livinallongo del Col di Lana	2001-2004

For every station a specific card has been provide, which specifies the station position with photographs and brief description. An example can be seen in Figure 16. The IBE index has been evaluated twice a year during the period reported in the last column of Table 4, in correspondence to low discharge and seasonal high discharge regimes. Then, for every monitoring station, two different graphs are provided, reporting the values of the systematic units number (U.S.), the IBE value (I.B.E.) and the correspondent Quality Class (C.Q.)

Figure 16: Example of IBE station card from the Belaqua project

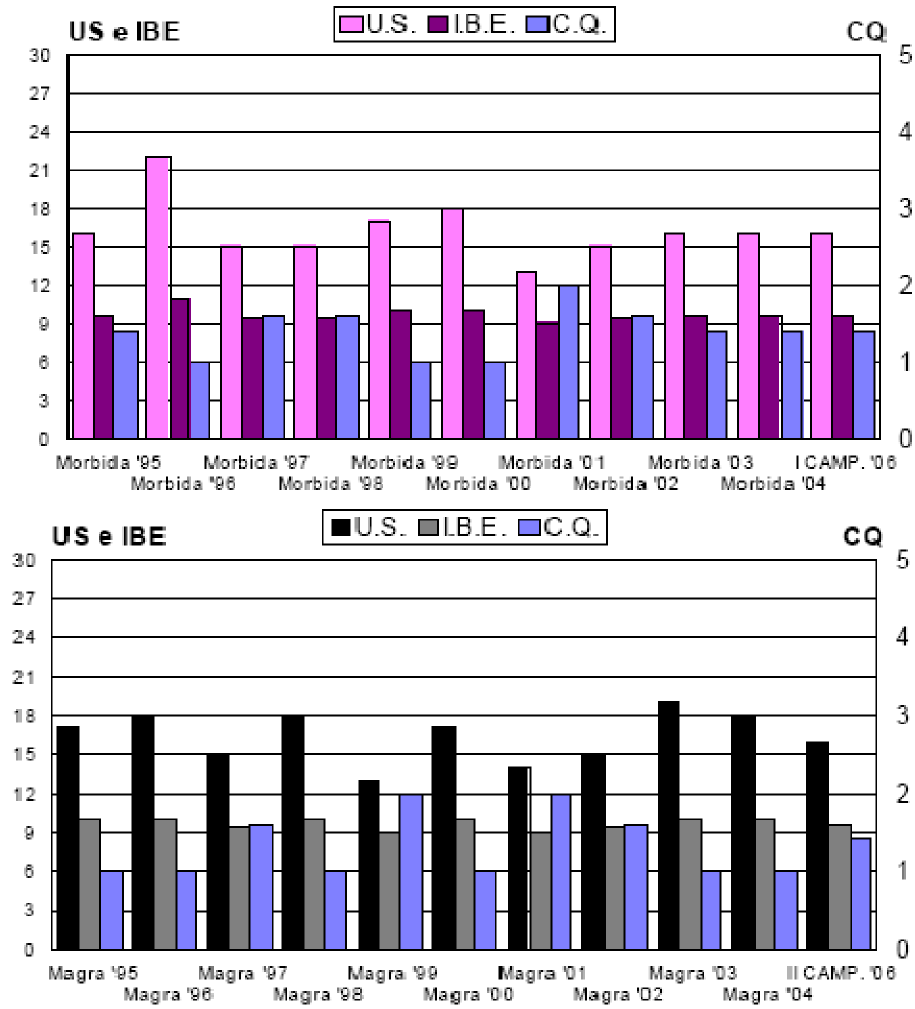

Figure 17: Example of graphs provided for every monitoring station. The first corresponds to the seasonal high discharge regime, the second to the low discharge regime

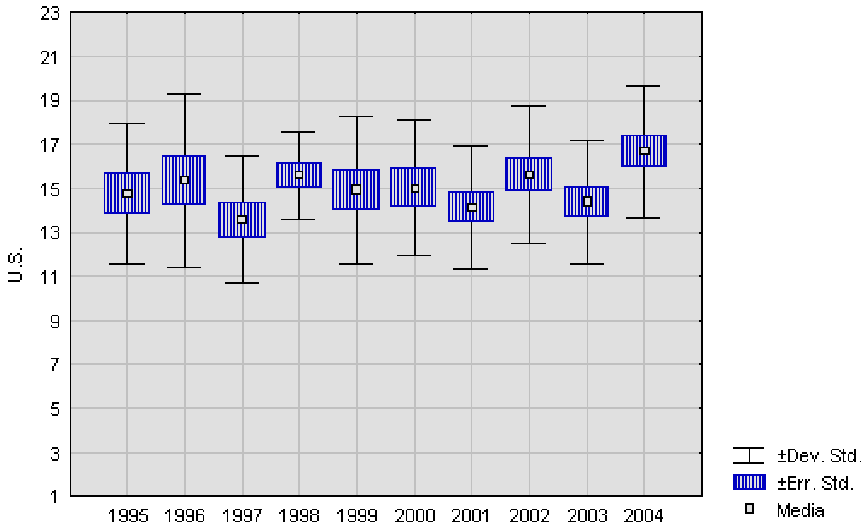

Figure 18: Statistical variation of Systematic Units presence

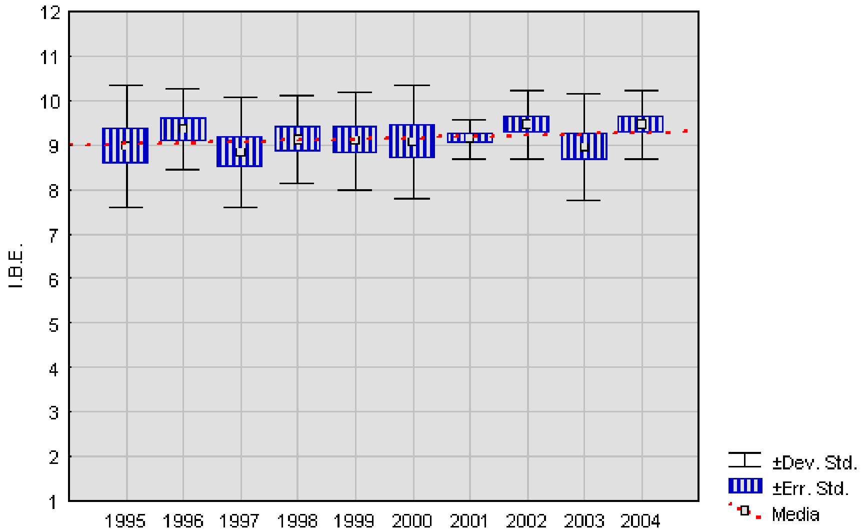

Figure 19: Statistical variation of IBE values

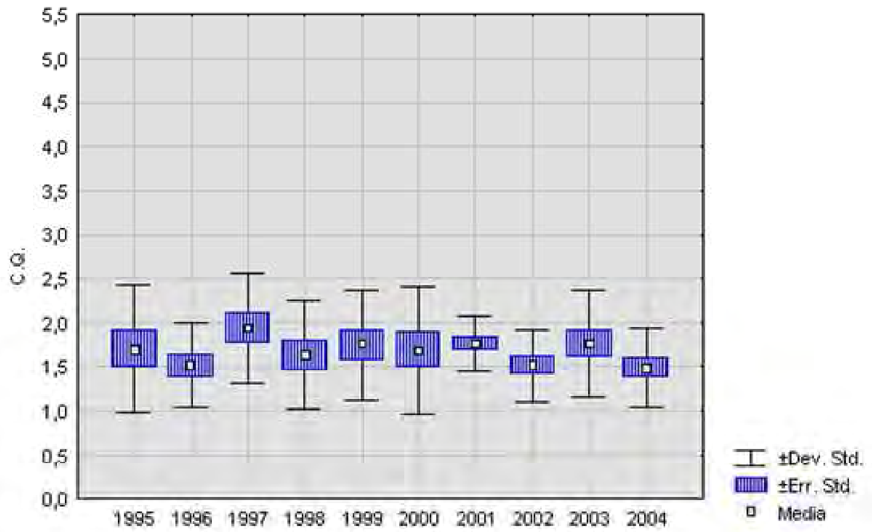

Figure 20: Statistical variation of Quality Class values

General conclusions have finally been drawn for the entire river basin, also by means of statistical analysis. Averagely, in the period 1995-2004, river Cordevole has been characterized by the biological class II, with an IBE value close to 9. Data of 2004 depart from the historical average and get close to those of 2002, when biological quality class was intermediate between I and II. The standard error results to be little and the standard deviation is comprised between quality class I and II and between a maximum IBE equal to 10 and minimum between 9 and 8, underlining however the absence of significant quality drought The medium number of systematic units is noticeably higher than the historical range, normally around 15, but close to 17 in 2004.
Analyzing the trend line on the biotic index values we can see that during the ten years of study there is a tendency to a slight improvement in average recorded values. Figure 21 shows that the stream Cordevole has a good biological quality with only moderate symptoms of disturbance in the area between Pieve di Livinallongo and Alleghe’s Lake, and in the reach immediately downstream Agordo. If compared with data of the previous year (2003), it is clear a good recovery of the biological quality, in particular downstream Agordo, where the Quality Class in 2003 was III.
For what concerns tributaries, the recovery of torrent Boè is confirmed, the Fiorentina creek is characterized by a slight quality improvement during seasonal high discharge period, the Pettorina creek is still classified as a slightly altered environment on both monitoring periods and the Bios still results altered.

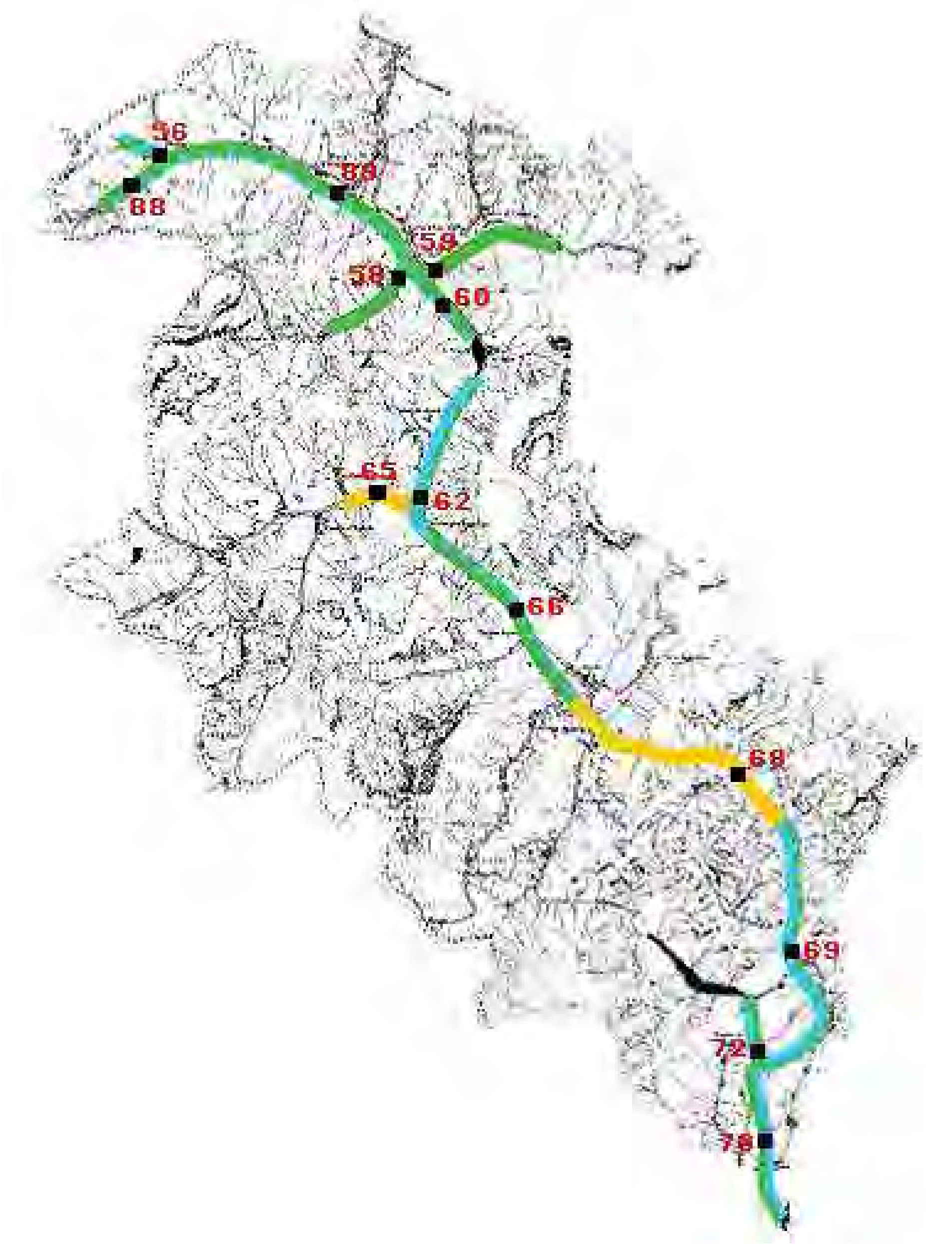

Figure 21: IBE map on the Cordevole river basin relative to year 2004

Table 5: IBE classification legend

COLOUR	QUALITY CLASS	DEFINITION
	I	Unaltered environment
	II	Slightly altered environment
	III	Altered environment
	IV	Highly altered environment
	V	Extremely altered environment
		Intermediate conditions

MIF experimental release on the Cordevole river basin

Another important part of the Belaqua work is the estimation of MIF in five significant river cross sections of Piave hydrographic basin. Two of these five stations are inside the Cordevole river basin, in particular one is on the Cordevole main stream at Peron (Sedico), and the other is on the Mis stream at Gron (Sospirolo).
This activity began in 1997 with the first experimental release of 1 m^3/s on creek Mis. On the following table, the release discharges recommended by the River Basin Authority are reported.
During the experimentation period, discharge measurements have been carried out by the Belluno's section of ARPAV, in order to check the value of the discharge effectively released. It resulted, in effect, that the mandatory values established by the River Basin Authority are not always respected. These measures are however not sufficient to establish a relationship between flowing discharge and monitored biological elements. In particular in 2004 they are fragmentized and cover a short period between September and November.

Table 6: Discharge releases prescribed by the protection measures of the River Basin Authority from 12/04/2001 to 28/02/2002.

RIVER	REACH	01/01/2001 – 11/04/2001 [m^3/s]	QHYDROLOGIC FOR SUMMERTIME (1ST JUNE – 31ST AUGUST) AND WINTERTIME (1ST DECEMBER - 28TH FEBRUARY) [m^3/s]	QMIF [m^3/s]
Cordevole	From the intake of La Stanga plant to the Mis confluence	2.876	1.675	3.350
Mis	From the Mis Lake to the Cordevole confluence	0.665	0.709	0.709

Table 7: Discharge releases prescribed by the protection measures of the River Basin Authority for year 2002

MONTH	CORDEVOLE [m^3/s]	MIS [m^3/s]
January	1.675	0.709
February	1.675	0.709
March	3.350	0.709
April	3.350	0.709
May	3.350	0.709
June	1.675	0.709
July	1.675	0.709
August	1.675	0.709
September	3.350	0.709
October	3.350	0.709
November	3.350	0.709
December	1.675	0.709

Table 8: Discharge releases prescribed by the protection measures of the River Basin Authority for year 2003

PERIOD	CORDEVOLE [M^3/S]	MIS [M^3/S]
1-31 January	1.675	0.709
1-28 February	1.675	0.709
1-31 March	3.350	0.709
1-9 April	3.350	0.709
10-30 April	2.345	0.709
1-15 May	2.848	0.709
16-31 May	3.350	0.709
1-30 June	1.675	0.709
1-31 July	1.675	0.709
1-31 August	1.675	0.709
1-30 September	3.350	0.709
1-31 October	3.350	0.709
1-30 November	1.675	0.709
1-31 December	1.675	0.709

Table 9: Discharge releases prescribed by the protection measures of the River Basin Authority for year 2004

MONTH	CORDEVOLE [M^3/S]	MIS [M^3/S]
January	1.687	0.868
February	1.687	0.868
March	3.375	0.868
April	3.375	0.868
May	3.375	0.868
June	1.687	0.868
July	1.687	0.868
August	1.687	0.868
September	3.375	0.868
October	3.375	0.868
November	3.375	0.868
December	1.687	0.868

MIF evaluation in 2004

The analysis performed to evaluate MIF in 2004 are the following:

- chemical – physical
- macrobenthos qualitative analysis (IBE)
- drift evaluation
- macrobenthos quantitative analysis
- fish analysis

Chemical – physical analysis

The temperature values recorded at the Gron station on the river Mis show a maximum of 16.1 ℃ recorded in June 2003 and a minimum of 4.7 ℃ in Fe bruary 1999. The temperature trends recorded in the river Cordevole at Peron show fairly small variations with a minimum in January of 5.9 ℃ and a maximum of 16.3 ℃ both in June 2003 and June 2004.

The pH value on all sampling stations showed an almost constant and always alkaline value, within the normal water range in the Dolomite Region.

The torrents Mis and Cordevole generally show minimum values in winter and maximum values during summer. Normally, due to the different vapor pressure of water molecules, the presence of oxygen in water is inversely proportional to the temperature, the higher the temperature turns out to be, the less is the concentration of oxygen and vice versa. In this case the we see the contrary phenomenon, and it is reasonable to assume that the maximum oxygen in summer is due to the action of the photosynthetic algal mat, and the minimum observed in winter is due to oxygen consumption by the aerobic bacterial colonies.

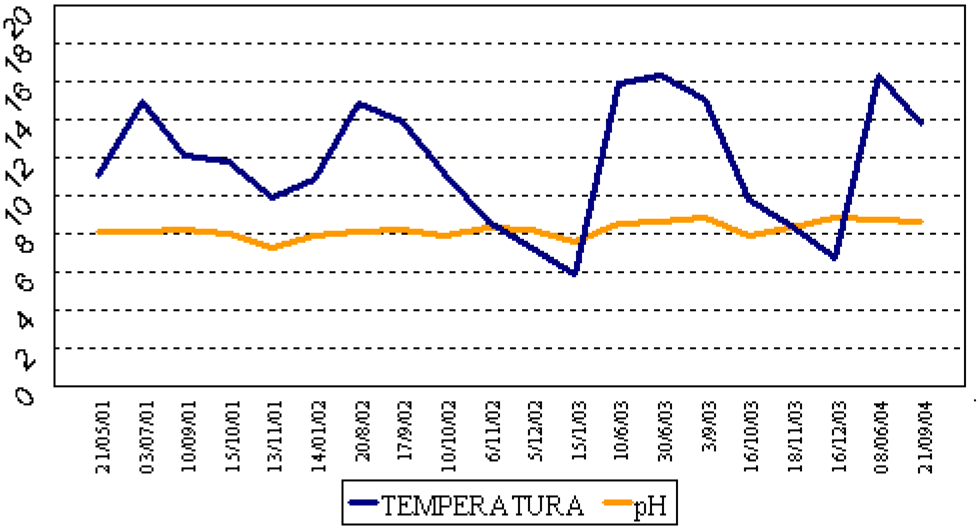

Figure 22: Temperature and pH on Cordevole river from 2001 to 2004

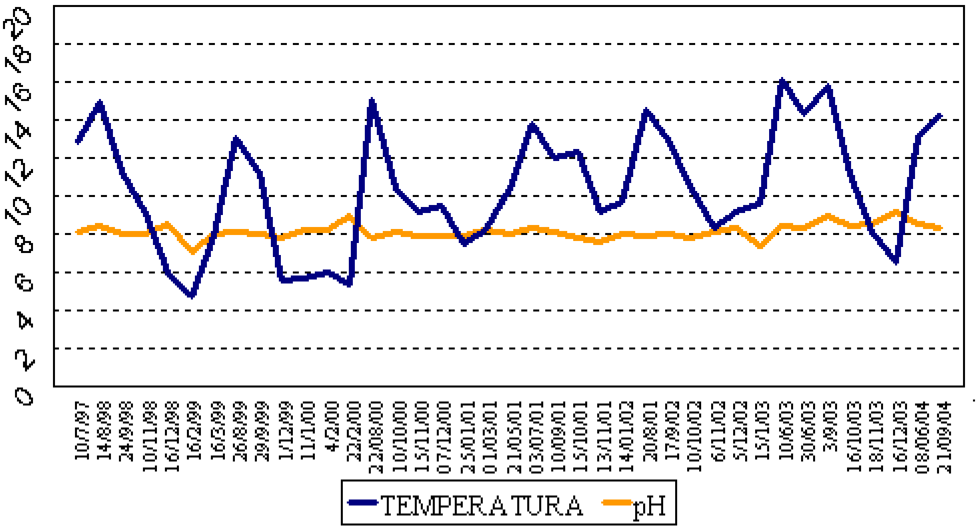

Figure 23: Temperature and pH on Mis creek from 1997 to 2004

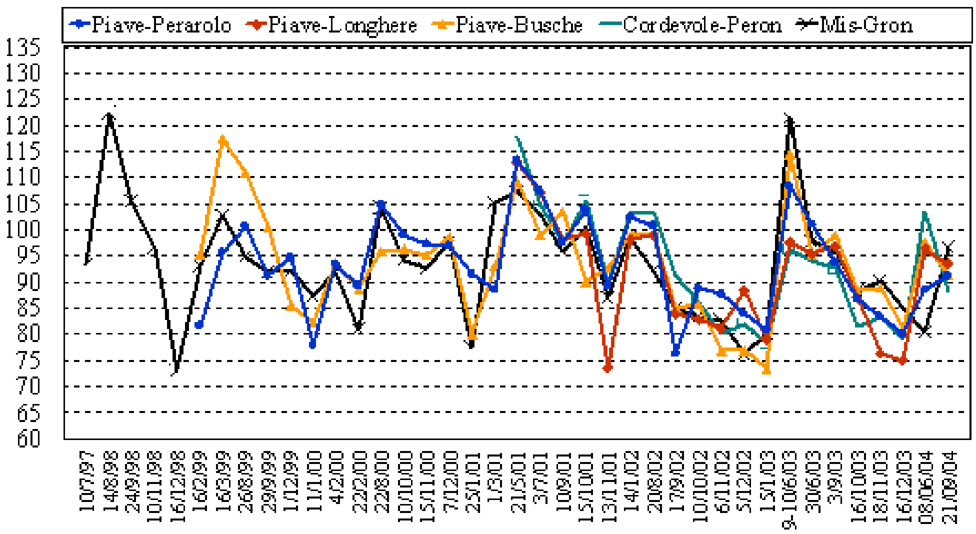

Figure 24: Diluted oxygen in the 5 experimental station for MIF evaluation

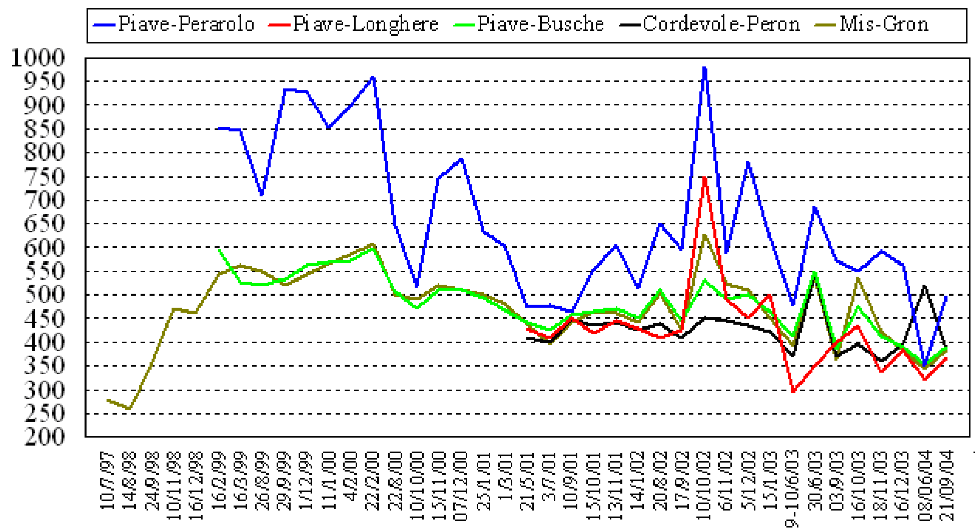

Figure 25: Conductivity values in the 5 experimental station for MIF evaluation

Analyzing the averages of the percentage of diluted oxygen of the river Cordevole, divided by year, a sharp decline can be seen between 2001 and 2003, passing from an average value of supersaturation in 2001 (103%) to 91% in 2002 and 86.4% in 2003. During the last year (2004), the average of the two periods of high and low discharge flow is higher than that of the previous two years and amounts to 95.8%. In 2004, the average data of the river Mis are historically among the lowest, 88.6%, and also the summer percentage value is lower to the autumn one: 80.5% in June and 96.6% in September.
Te conductivity values for Mis and Cordevole are comprised in the range of historical values.

Macrobenthos qualitative analysis (IBE)

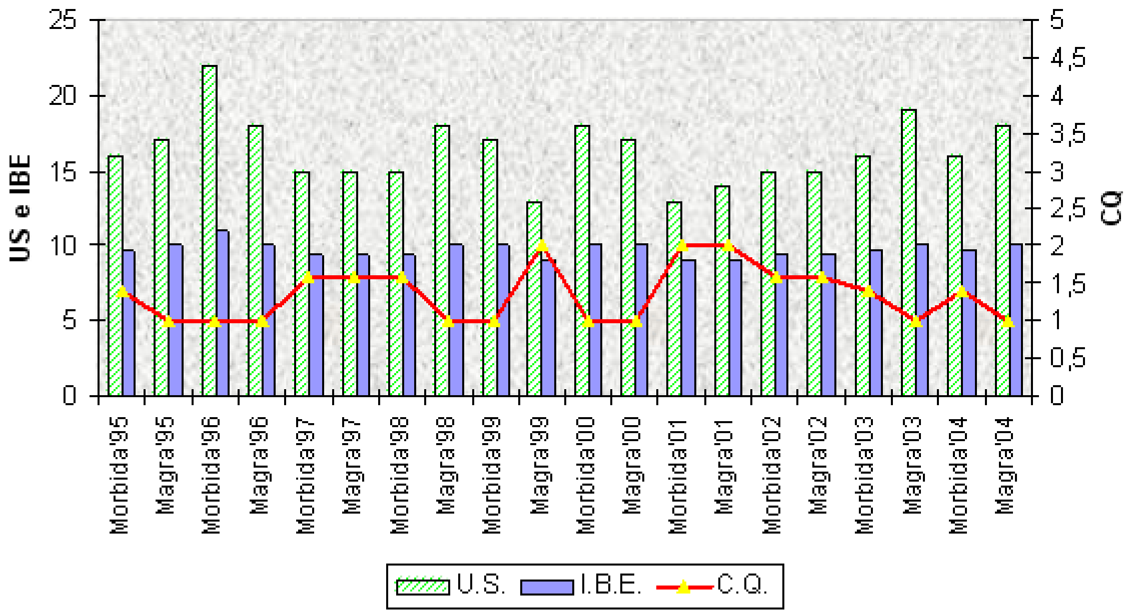

Figure 26: Cordevole at Peron. IBE index, Systematic Units number and Class Quality from 1995 to 2004, in seasonal high discharge and low discharge regime

The torrent Cordevole station at Peron has been included in 2001 among the experimental stations for MIF release evaluation, in order to check the effects of water abstraction at La Stanga. The release amounts to 2.9 m^3/s form January to April 2001, and to 3.4 m^3/s from April 2001 to the end of the experimental period (December 2004), exception made for summer and winter months during which the release is reduced to 1.7 m^3/s, for the application of the hydrologic discharge (see Table 6; Table 7; Table 8; Table 9). Moreover, in the periods 10-30 April and 1-15 May 2003 a further reduction has been applied, respectively to 2.3 m^3/s and 2.8 m^3/s. In 2004 the values slightly increase thanks to the River Basin Authority recalculation.

Analyzing the historical data, one can observe that the class quality II observed in 2001, in the previous seven years has occurred only one time in 1999 during the low discharge period. Also the number of systematic units is less than the previous one. Data obtained in 2002, corresponding to biological class quality II-I with biotic index equal to 9-10, seem to offer a qualitative recovery signal, after the 2001 break. Macrobenthos community seems to be well structured, especially for what concerns taxa more sensitive to environmental alterations, but without an adequate number of systematic units. The recovery began in 2002 is confirmed by 2003 data, which give a class quality I to this river reach, with a biotic index of 10 during the seasonal high discharge period, and ranging from 9 to 10 during the low discharge period, with a class quality between I and II. Macrobenthos community is similar to 2002 surveying, but richer in the taxa number, which allow therefore a better input in the IBE calculation table. Comparing the obtained results with discharge variations at Sass Muss, one can notice that, as in the period prior to the seasonal high discharge survey, no noticeable discharge variations occurred, even in the daily medium discharge. Macrobenthos community stability took profit by this phenomenon, bringing to the quality improvement of 2003.
In 2004 the biological quality assessment ranges from class I-II to class I, with IBE 9-10 to 10, respectively in June and September. The quality improvement in Autumn is due to the greater number of systematic units, passing from 16 to 18. The two cards structure looks very similar at the EPT-taxa level, there is in fact the presence of two stoneflies, sustained by a significant number of Heptageniidae genres (two in June and three in September), and by three caddis' families. The remaining part of the IBE card is composed mainly by Dipteras. It is interesting to note that during the seasonal high discharge, Dipteras Simuliidae, but especially oligochets Naididae, nearly represent the totality of macrobenthos, from the quantitative point of view, highlighting a certain trophic disequilibrium among filter feeders and gatherers. Data of 2004 confirm therefore the qualitative recovery began in 2002, even if falling in the historical variability of the quality class from I to II.

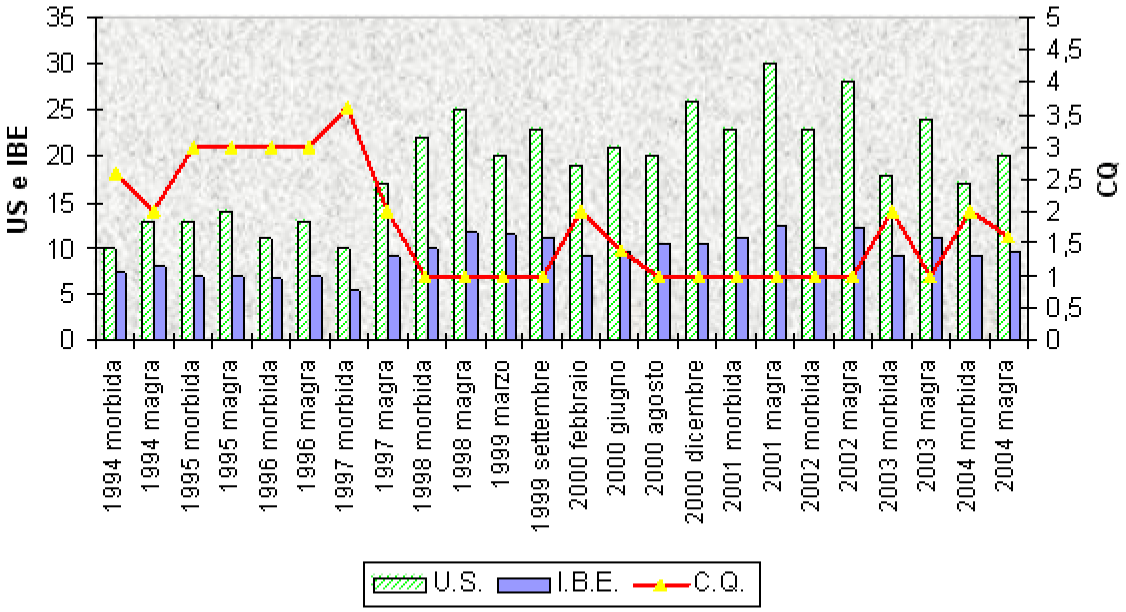

Figure 27: Mis at Gron. IBE index, Systematic Units number and Class Quality from 1995 to 2004, in seasonal high discharge and low discharge regime

In the reach downstream the Mis dam, experimental releases began in 1997 with 1 m^3/s. Starting from March 2001 they were lowered to 0.6 m^3/s, from April 2001 they were increased to 0.709 and finally from January 2004 they have been set to 0.868 m^3/s.
Since 1997 the quality improvement has been rapid, passing from class quality III, or even III-IV of the previous years, to II in the Autumn 1997, few months after the releases, and to class I from 1998 to the end of 1999. In February 2000 a class quality II has been recorded, but afterwards the situation positively evolved getting back to class quality I. However, analyzing the macrobenthos community, one can notice that, though the taxa number is high, they mainly belong to the second card part. The horizontal table input for the IBE calculation, even if it is at the maximum level, is only sustained by Leuctra and Protonemoura, stoneflies not so sensitive to pollutants.
Also in 2002 the environmental assessment results very good, with IBE index ranging from 10 during high discharge and 12 during low discharge periods. The too much high number of taxa found, 23 in

Spring and 28 in Autumn, seems to confirm what already said. The community seem in fact to be too rich especially for taxa less sensitive, belonging to the card second part, among which the high number of oligochets stands out, as they are particularly apt to live in an environment rich of organic material. The community is moreover supported only by Leuctra e Protonemoura, stoneflies which can stand high organic load. A deep analysis of the 2002 macrobenthos community, shows how the good IBE values recorded are the result of the superimposition of two communities, one of which is fairly good, while the other is composed by individuals not so sensitive to pollution and in particular to organic load. Therefore the results seems to be extremely abnormal, and surely not aligned with all the other investigated parameters.
2003 results range from class II to I with IBE respectively equal to 9 and 11. Seasonal high discharge period data seem to put in evidence a certain settlement of the macrobenthos community, which results to be represent by a number of taxa, 19, which are distributed in the middle-lower zone of the IBE card. During the low discharge period, the 24 systematic units which have been found, confirm the problems linked to the superposition of two communities. Moreover, in both sampling periods, the number of drift taxa is high, 13 on a total of 18 during high discharge and 11 on a total of 24 during low discharge. The strong drift effect, also confirmed by specific analysis, mainly during low discharge periods, probably enhances artificially the collected taxa, leading to an overestimated biological quality. Quantitative analysis results, on the other hand, are the lowest since February 2000, putting in evidence an impoverishment of benthonic biomass for the riverbed. This reflects also in the total number of taxa surveyed in 2003,the lowest since the high discharge regime of 1998. It must be kept in mind also that, in confirmation of the interpretation doubts on the obtained results, during 2003 the discharge values measured by ARPAV were 5 times out of 6 lower than the mandatory ones.
During 2004, the biological quality assessment ranges from the slightly altered environment, corresponding to IBE 9 and quality class II and a little altered environment corresponding to IBE 9-10 and quality class I-II. In both seasons, the qualitative input in the table for the calculation of the biotic index counts just one stonefly, Leuctra genre, while the quantitative input shifts from 17 to 20 systematic units, bringing to a little biological improvement in autumn. During the high discharge regime, the macrobenthos community misses in particular stoneflies, in fact the remaining EPT-taxa is composed by two Heptageniidae and by a good number of caddis families. During low water discharge, the stoneflies absence is confirmed, as it is the structure of the upper IBE card, which loses the second Heptageniidae but at the same time gains two caddis families. The quantitative difference depends therefore by the number of taxa belonging to the second part of the card, where less sensitive species take place. Among these, the presence of the gasteropod Ancylidae is very interesting, since, during Spring, only empty shells have been found.
The comparison with historical data confirms the moderate alteration recorded in 2003 after five years averagely characterized by a quality class I. The low discharge regime, on the other hand, shows a little qualitative regression with respect to previous seven years dat. It is worth noting that for the first time since 1998, the second stonefly is not present.

Macrobenthos quantitative analysis

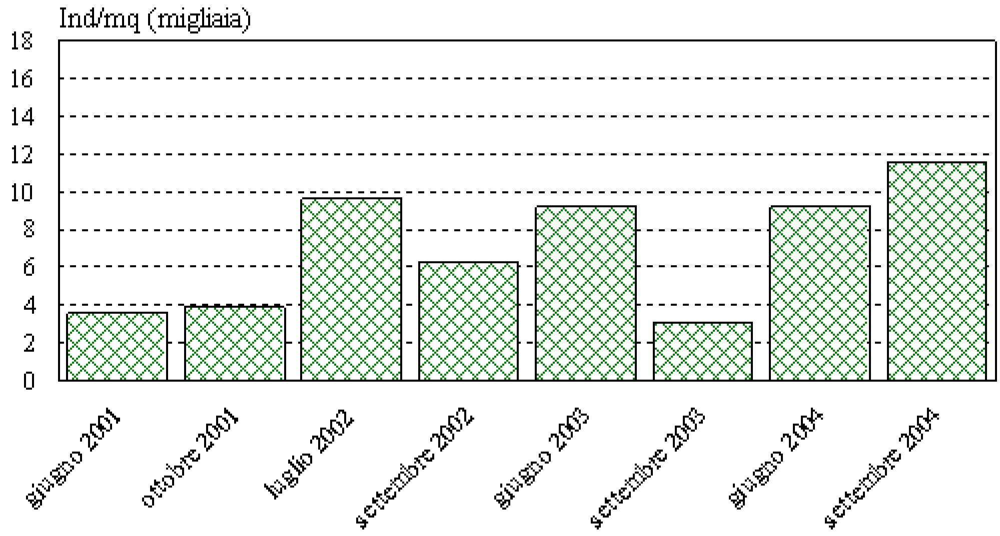

Figure 28: Total number of individuals on river Cordevole at Peron from 2001 to 2004

Table 10: Total number of individuals on river Cordevole at Peron from 2001 to 2004

PERIOD	JUNE 2001	OCTOBER 2001	JULY 2002	OCTBER 2002	JUNE 2003	SEPTEMBER 2003	JUNE 2004	SEPTEMBER 2004
Ind/m^2	3.539	3.918	9.642	6.239	9.203	3.112	9.209	11.579

Table 11: Macrobenthos taxa on river Cordevole at Peron during seasonal high discharge in 2004

TAXA	INDIVIDUALS NUMBER	IND/m^2
Leuctra	85	258
Cloroperla	19	58
Protonemura	1	3
Baëtis	678	2.055
Rhithrogena	7	21
Ecdyonurus	3	9
Ephemerella	90	273
HYDROPSYCHIDAE	12	36
RHYACOPHILIDAE	2	6
CHIRONOMIDAE	1.270	3.848
EMPIDIDAE	6	18
CERATOPOGONIDAE	4	12
BLEPHARICERIDAE	1	3
SIMULIIDAE	623	1.888
NAIDIDAE	238	721
TOTAL	**3.040**	**9.209**

Table 12: Macrobenthos taxa on river Cordevole at Peron during low discharge regime in 2004

TAXA	INDIVIDUALS NUMBER	IND/m^2
Leuctra	366	1.109
Cloroperla	182	552
Dinocras	1	3
Isoperla	185	561
Perlodes	1	3
Nemoura	5	15
Protonemura	1	3
Baëtis	576	1.745
Rhithrogena	448	1.358
Ecdyonurus	159	482
Epeorus	43	130
Ephemerella	76	230
ELMIDAE	3	9
HYDROPTILIDAE	8	24
HYDROPSYCHIDAE	1.342	4.067
RHYACOPHILIDAE	102	309
LIMNEPHILIDAE	1	3
CHIRONOMIDAE	154	467
LIMONIIDAE	11	33
EMPIDIDAE	21	64
BLEPHARICERIDAE	3	9
PSYCHODIDAE	1	3
SIMULIIDAE	129	391
LYMNAEIDAE	1	3
ENCHYTRAEIDAE	1	3
NAIDIDAE	1	3
TOTAL	**3.821**	**11.579**

Table 13: Trophic roles on river Cordevole at Peron in 2004

	HIGH DISHARGE			LOW DISCHARGE		
	POOL	RIFFLE	TOTAL	POOL	RIFFLE	TOTAL
Collectors (R)	283	641	924	311	349	660
Filterers (F)	69	687	756	117	698	815
Scrapers (S)	224	573	797	386	964	1350
Shredders (T)	21	7	28	30	125	155
Predators (P)	229	306	535	159	674	833
Others (A)	0	0	0	8	0	8
Total	826	2214	3040	1011	2810	3821
% Collectors(R)	34,3	28,9	30,4	30,7	12,4	17,3
% Filterers (F)	8,3	31,0	24,9	11,6	24,9	21,3
% Scrapers (S)	27,2	25,9	26,2	38,2	34,3	35,3
% Shredders (T)	2,5	0,3	0,9	2,9	4,4	4,0
% Predators (P)	27,7	13,8	17,6	15,8	24,0	21,8
% Others (A)	0,0	0,0	0,0	0,8	0,0	0,2
Total	100	100	100	100	100	100
T/R	0,07	0,01	0,03	0,10	0,36	0,23
T/(R+F)	0,06	0,01	0,02	0,07	0,12	0,10
T/S	0,09	0,01	0,04	0,08	0,13	0,11
P/(TOT-P)	0,38	0,16	0,21	0,19	0,32	0,28

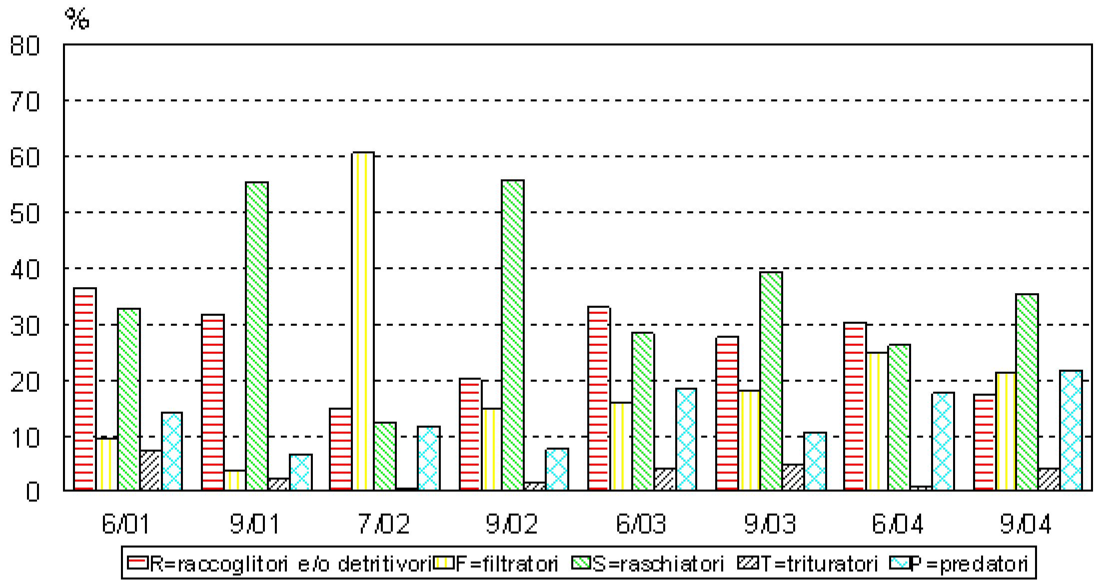

Figure 29: Trophic roles on river Cordevole at Peron in 2004

The two sampling periods present some differences in the trophic distribution. The high discharge period is characterized by the collectors predominance, that is the sum of filtrators and predators, which percentages are respectively of 30.4 % and 24.9 %, and by a certain presence of scrapers, 26.2 %. During low discharge the scrapers have the prevalent trophic role, with 35.3 %, collectors diminish, mainly because of the gatherers drop (17.3 %). Shredders still represent a marginal trophic role and predators are again too much than expected.
The analysis of the estimated ratios T/R, T(R+F) and T/S highlights that shredders are a secondary ring in the food chain, in fact all ratios are close to zero. This Cordevole reach is therefore characterized by poor coarse organic particulate supply, in fact shredders are scarce, but it is characterized by good thin organic material supply (FPOM and UPOM), which favours the presence of gatherers and scrapers. Historical data highlight one single event of severe trophic disequilibrium, occurred during 2002 seasonal high discharge, in which a huge anthropic organic load caused a demographic explosion of filtrators. The structure of the food chain of 2004 is far from historical data series, but, as it can be seen in Figure 29: Trophic roles on river Cordevole at Peron in 2004 Figure 29 and Figure 30, it does not have a linear behaviour in time, signal of an unstable system.

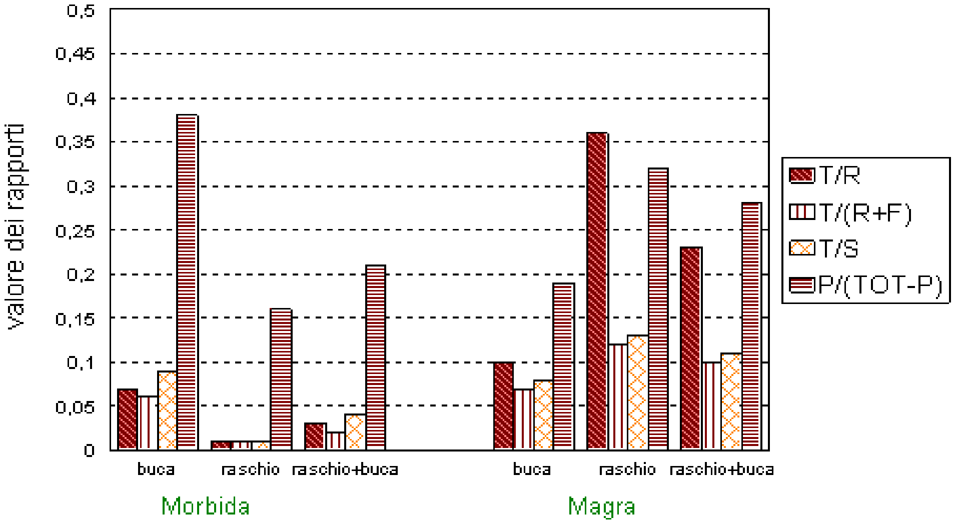

Figure 30: Trophic roles ratios on river Cordevole at Peron in 2004: high discharge on the left, low discharge on the right

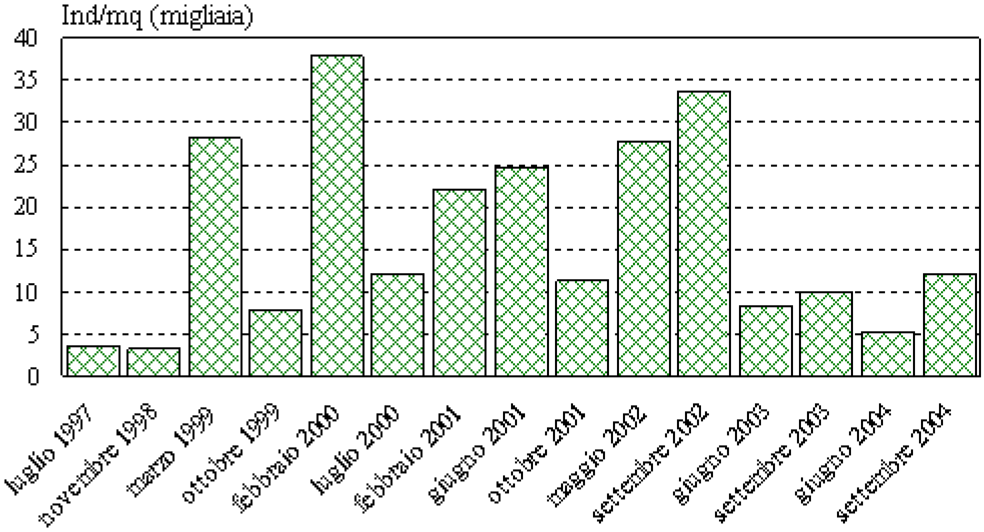

Figure 31: Total number of individuals on river Mis at Gron from 2001 to 2004

Table 14: Total number of individuals on river Mis at Gron from 2001 to 2004

PERIOD	JUL. 1997	NOV. 1998	MAR. 1999	OCT. 1999	FEB. 2000	JUL. 2000	JAN. 2001	JUN. 2001
Ind/m^2	3.577	3.193	28.108	7.911	37.826	12.165	22.108	24.736
PERIOD	OCT. 2001	MAY 2002	SEP. 2002	JUN. 2003	SEP. 2003	JUN. 2004	SEP. 2004	
Ind/m^2	11.276	27.813	33.643	8.391	9.997	5.23	12.103	

At Gron, during the high discharge regime, gatherers and scrapers represent more than 85 % of the entire macrobenthos community on river Mis. The low discharge regime is instead characterized by the filtrators increment, which percentage passes from 6 % to 24.8 %, and by gatherers and scrapers halving, which together represent little more than the macrobenthos 50 %. In September the trophic distribution results to be more equilibrated among different elements of food chain, and gets closer to what it is expected for this river reach.
Estimated ratios T/R, T/(R+F) and T/S for both periods highlight the nearly total absence of shredders in favour of gatherers, scrapers and, only for low discharge period, also for filtrators. The estimated ratio between predators and the others (P/(P-TOT)) results to be particularly high only in the second survey.

The comparison between the two sampling periods puts in evidence that in June this torrent reach had an appreciable thin organic material load on the riverbed (FPOM), which favoured the demographic explosion of gatherers and scrapers. in September the percentages of scrapers and gatherers diminish, and contextually the suspended thin organic material increases (UPOM), favouring filtrators.
It is evident that this torrent reach is strongly affected by the Mis dam presence and by waste discharges of Sospirolo village, on which a water discharge reduction has the effect of increasing the suspended organic material.

Table 15: Macrobenthos taxa on river Mis at Gron during low discharge regime in 2004

TAXA	INDIVIDUALS NUMBER	IND/M^2
Leuctra	58	176
Cloroperla	2	6
Isoperla	1	3
Perlodes	1	3
Nemoura	1	3
Protonemura	4	12
Baëtis	1.364	4.133
Rhithrogena	1	3
Ecdyonurus	3	9
Ephemerella	43	130
HYDROPTILIDAE	5	15
SERICOSTOMATIDAE	3	9
HYDROPSYCHIDAE	1.410	4.273
RHYACOPHILIDAE	85	258
LIMNEPHILIDAE	5	15
GOERIDAE	11	33
POLYCENTROPODIDAE	21	64
ELMIDAE	20	61
HYDRAENIDAE (adults)	2	6
CHIRONOMIDAE	349	1.058
LIMONIIDAE	2	6
EMPIDIDAE	21	64
PSYCHODIDAE	3	9
SIMULIIDAE	221	670
GAMMARIDAE	51	155
LYMNAEIDAE	2	6
PHYSIDAE	1	3
ANCYLIDAE	15	45
HYDROBIIDAE *Bythinella*	7	21
PISIDIIDAE	27	82
Dina	18	55
Erpobdella	2	6
ENCHYTRAEIDAE	1	3
LUMBRICIDAE	23	70
NAIDIDAE	2	6
TUBIFICIDAE	209	633
TOTAL	**3.994**	**12.103**

Table 16: Macrobenthos taxa on river Mis at Gron during seasonal high discharge in 2004.

TAXA	INDIVIDUAL NUMBERS	IND/M^2
Leuctra	24	73
Protonemura	1	3
Baëtis	672	2036
Rhithrogena	48	145
Ecdyonurus	10	30
Habrophlebia e Habroleptoides	3	9
Ephemerella	580	1758
HYDROPTILIDAE	10	30
HYDROPSYCHIDAE	12	36
RHYACOPHILIDAE	13	39
LIMNEPHILIDAE	4	12
GOERIDAE	1	3
POLYCENTROPODIDAE	1	3
ELMIDAE	3	9
HYDROPHILIDAE	2	6
CHIRONOMIDAE	176	533
EMPIDIDAE	1	3
SIMULIIDAE	80	242
GAMMARIDAE	1	3
ASELLIDAE	4	12
HYDROBIIDAE *Bythinella*	1	3
Polycelis	1	3
LUMBRICIDAE	1	3
NAIDIDAE	76	230
HAPLOTAXIDAE	1	3
TOTAL	**1.726**	**5.230**

Table 17: Trophic roles on river Mis at Gron in 2004.

	HIGH DISCHARGE			LOW DISCHARGE		
	POOL	RIFFLE	TOTAL	POOL	RIFFLE	TOTAL
Collectors (R)	195	544	739	291	780	1071
Filterers (F)	13	91	104	35	955	990
Scrapers (S)	188	581	769	126	1008	1134
Shredders (T)	4	9	13	46	35	81
Predators (P)	29	61	90	47	666	713
Others (A)	2	9	11	2	3	5
Total	431	1295	1726	547	3447	3994
% Collectors(R)	45,2	42,0	42,8	53,3	22,6	26,8
% Filterers (F)	3,0	7,0	6,0	6,4	27,7	24,8
% Scrapers (S)	43,7	44,9	44,6	23,0	29,3	28,4
% Shredders (T)	0,8	0,7	0,8	8,3	1,0	2,0
% Predators (P)	6,8	4,7	5,3	8,5	19,3	17,8
% Others (A)	0,5	0,6	0,6	0,4	0,1	0,1
Total	100	100	100	100	100	100
T/R	0,02	0,02	0,02	0,16	0,04	0,08
T/(R+F)	0,02	0,01	0,02	0,14	0,02	0,04
T/S	0,02	0,02	0,02	0,36	0,03	0,07
P/(TOT-P)	0,07	0,05	0,06	0,09	0,24	0,22

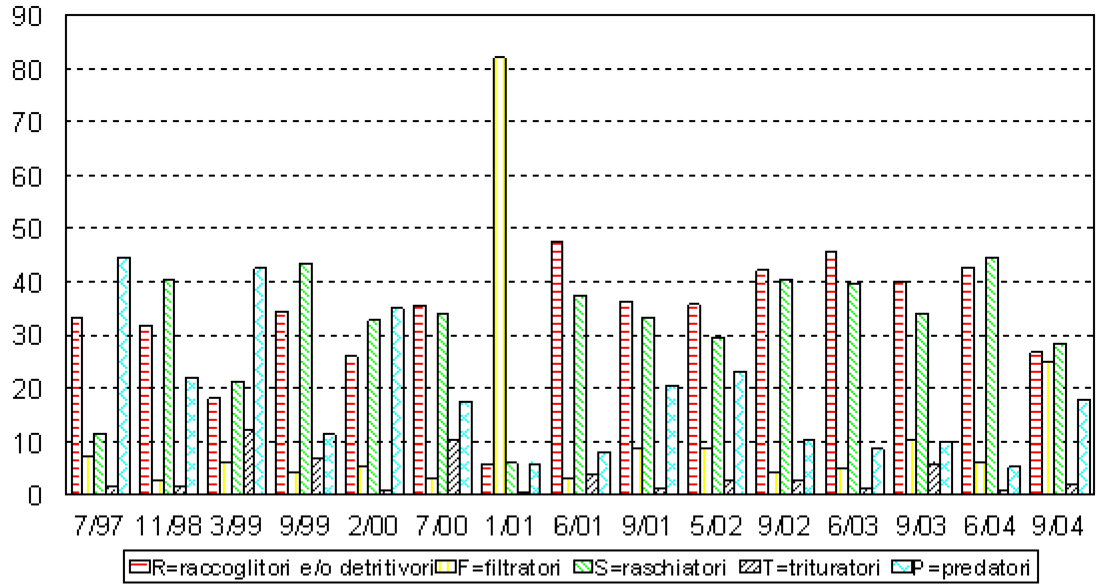

Figure 32: Trophic roles on river Mis at Gron in 2004

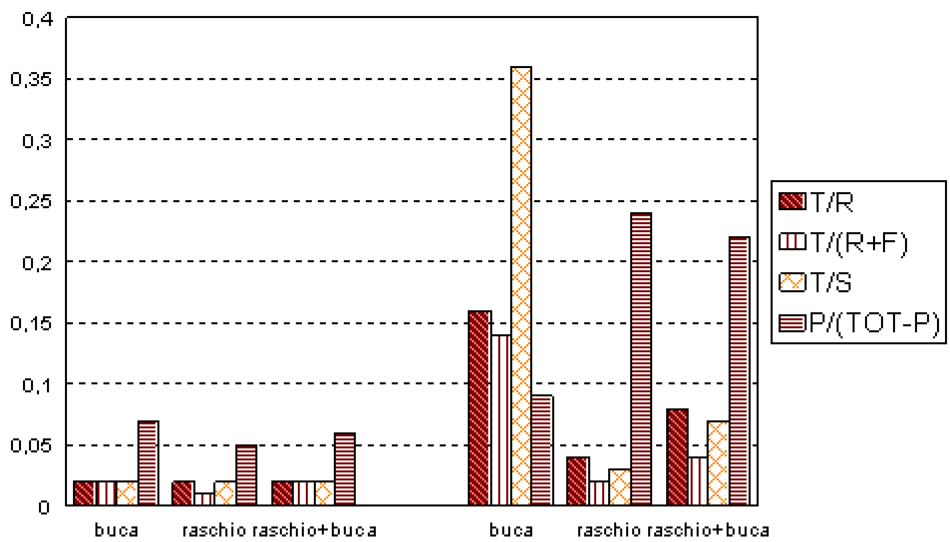

Figure 33: Trophic roles ratios on river Mis at Gron in 2004: high discharge on the left, low discharge on the right

Drift analysis on torrent Cordevole at Peron

Figure 34 and Figure 35 show the taxa percentages found with higher density during the two sampling periods of 2004. Table 18 shows the percentages of more represented systematic units from the beginning of the monitoring activity. Figure 36 reports the percentage presences trend of the mostly found systematic units, obtained using the mean drift value for every surveyed year.

In June 2001 the most represented species was Chironomidae (larvae), followed by Baëtis (on the right) and Simuliidae (on the left), all the other taxa, though numerous, had modest densities. In October 2001 Baëtis was the most drifted taxon, while Chironomidae, Simuliidae, Leuctra and external species had clear minor densities. In 2002 the community was again taxa's rich, but the most frequent are the Chironomidae (larvae) in summer and Baëtis in autumn. There is therefore vicariance between the two taxa. In 2003 the vicariance between Chironomidae's larvae in summer and Baëtis in autumn seems to be confirmed, even if, for what concerns the data on the left sample in spring, Ephemeropteras win with 7 percentage points. The Baëtis Ephemeropteras percentage always reaches high percentage values in autumn.

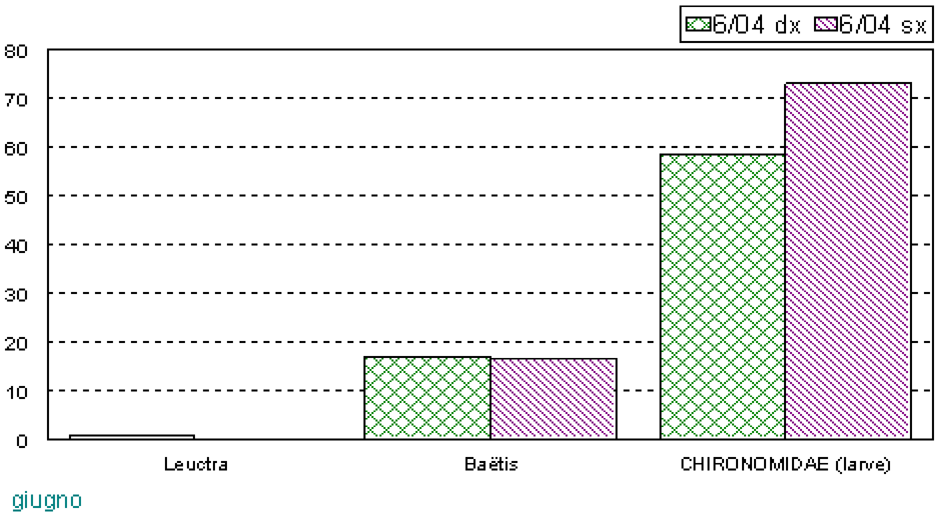

Figure 34: Taxa percentage found with higher density in June 2004

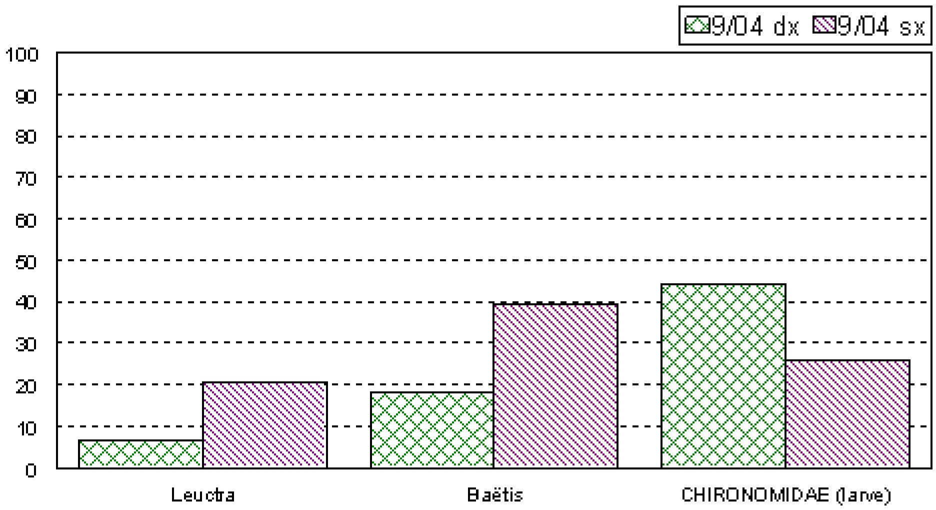

Figure 35: Taxa percentage found with higher density in September 2004

Table 18: Trophic percentages of more represented systematic units from the beginning of the monitoring activity

	6//01 RIGTH	6//01 LEFT	9/01 RIGHT	9/01 LEFT	7/02 RIGHT	7/02 LEFT	9/02 RIGHT	9/02 LEFT
Chironomidae	63	82	4	6	59	43	0	0
Simuliidae	2	9	1	1	9	9	0	0
Baetis	29	5	74	74	8	24	96	97
Leuctra	0	0	5	4	0	0	1	1
Naididae	1	0	0	0	0	0	0	0
	6/03 RIGHT	**6/03 LEFT**	**9/03 RIGHT**	**9/03 LEFT**	**6/04 RIGHT**	**6/04 LEFT**	**9/04 RIGTH**	**9/04 LEFT**
Chironomidae	40	36	8	9	59	73	44	26
Simuliidae	3	9	2	10	1	0	9	2
Baetis	38	43	85	73	17	17	18	39
Leuctra	0	0	0	1	1	0	7	21
Naididae	0	0	0	0	5	2	0	0

As highlighted by historical data, also in 2004 springtime is characterized by Diptera Chironomidae larvae on both riverbanks. In September the historical vicariance with Ephemeropteras Baëtis is confirmed only on the left riverbank, while on the right Chironomidae larvae are prevail.
However, considering the sum of the estimated densities, Baëtis results the most drifted taxon.

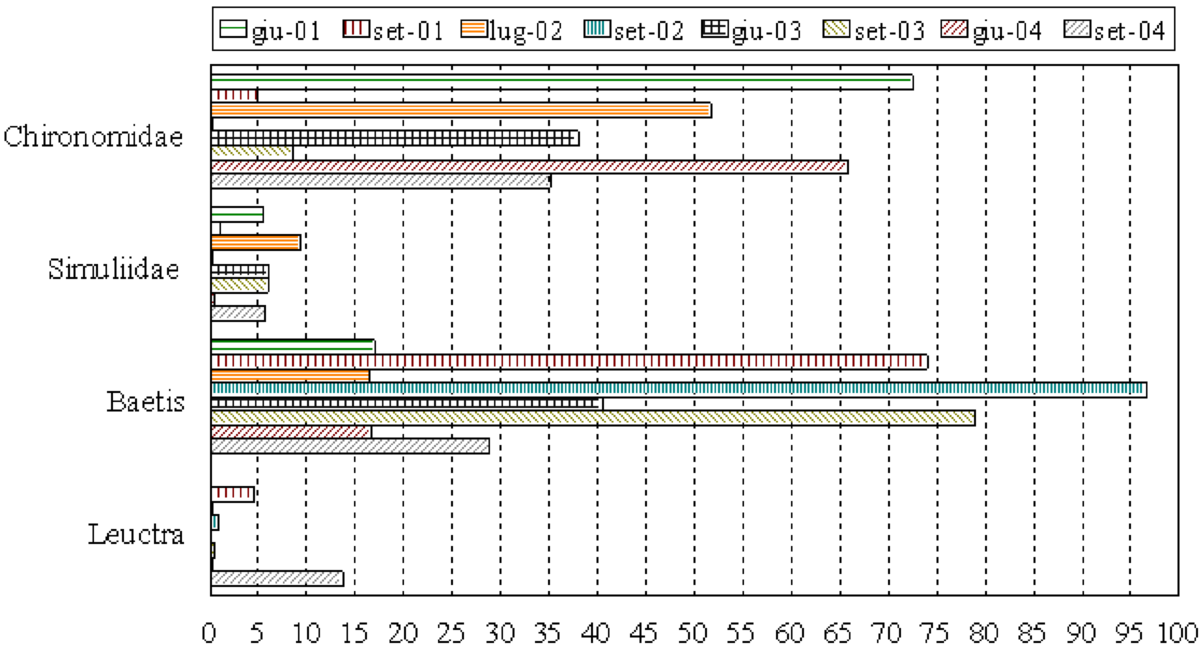

Figure 36: Percentage presences trend of systematic units

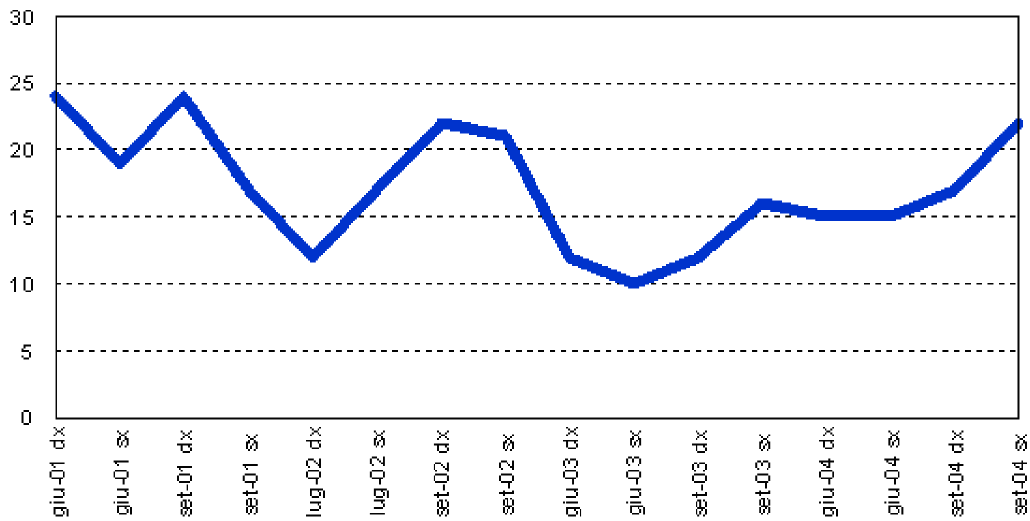

Figure 37: Taxa number surveyed

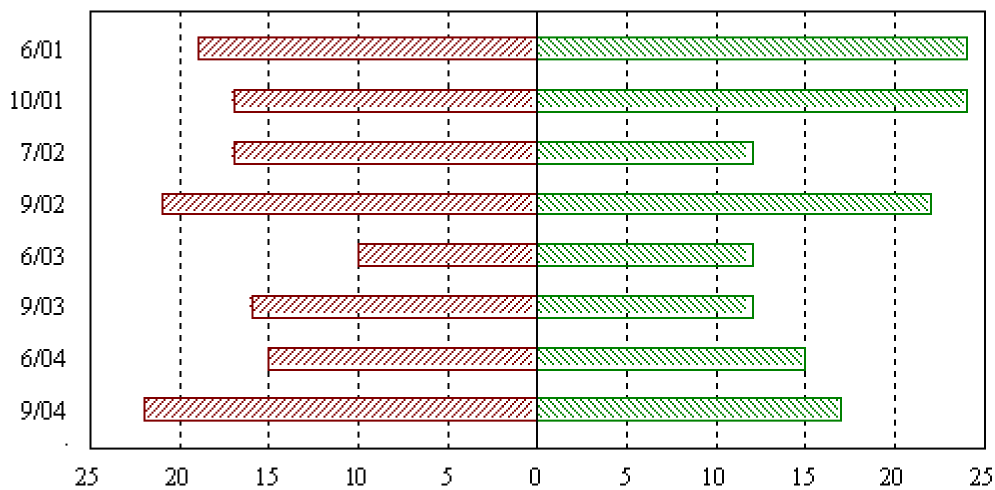

Figure 38: Taxa number surveyed on left riverbank (on the left) and on right riverbank (on the right)

Drift analysis on torrent Mis at Gron

Figure 39 and Figure 40 show the taxa percentages found with higher density during the two sampling periods of 2004. Table 19 shows the percentages of more represented systematic units from the beginning of the monitoring activity. Figure 41 reports the percentage presences trend of the mostly found systematic units, obtained using the mean drift value for every surveyed year.

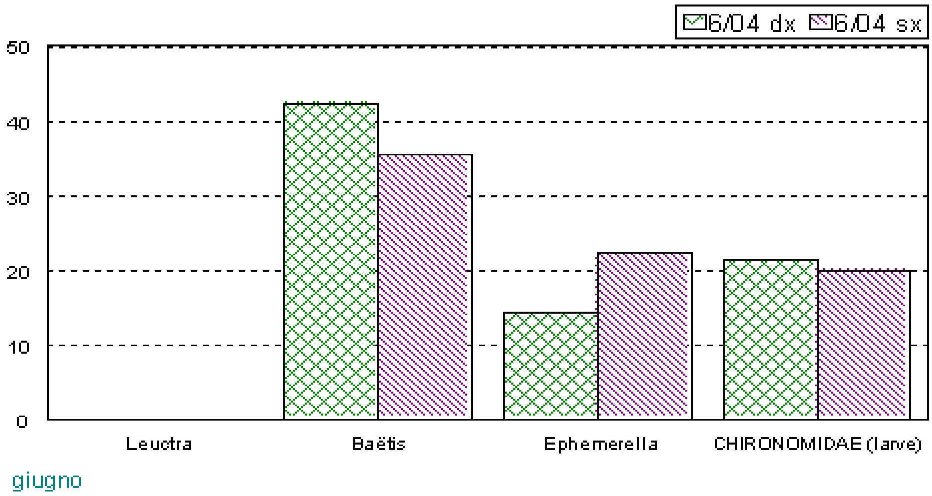

Figure 39: Taxa percentage found with higher density in June 2004

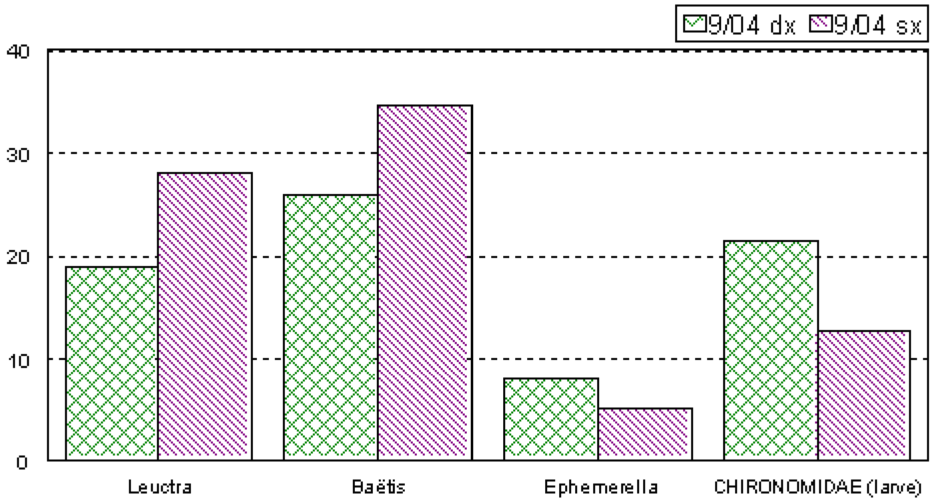

Figure 40: Taxa percentage found with higher density in September 2004

Table 19: Trophic percentages of more represented systematic units from the beginning of the monitoring activity

	7/97	3/99 RIGHT	3/99 LEFT	9/99 LEFT	9/99 RIGHT	2/00 RIGHT	2/00 LEFT	8/00 RIGHT	8/00 LEFT
Chironomidae	58	48	37	23	25	41	49	44	35
Simuliidae	20	26	10	2	1	13	11	0	0
Baëtis	4	12	20	46	44	19	16	32	27
Leuctra	0	0	0	9	8	0	1	3	4
Ephemerella	0	0	0	3	5	0	1	4	5
Naididae	0	0	0	0	0	13	4	0	1
Psychodidae	0	0	0	0	0	0	0	0	0

	2/01 RIGHT	2/01 LEFT	6/01 RIGHT	6/01 LEFT	10/01 RIGHT	10/01 LEFT	7/02 RIGHT	7/02 LEFT	9/02 RIGHT
Chironomidae	57	46	21	32	48	53	32	41	43
Simuliidae	2	10	2	10	0	1	1	1	4
Baëtis	23	19	24	30	31	29	42	29	40
Leuctra	1	2	1	1	1	2	0	2	4
Ephemerella	1	2	7	10	3	1	10	12	4
Naididae	10	4	15	0	1	2	3	1	0
Psychodidae	0	0	2	20	0	0	0	0	0
	9/02 LEFT	**6/03 RIGHT**	**6/03 LEFT**	**9/03 RIGHT**	**9/03 LEFT**	**6/04 RIGHT**	**6/04 LEFT**	**9/04 RIGHT**	**9/04 LEFT**
Chironomidae	40	11	12	35	33	21	20	21	13
Simuliidae	3	0	2	1	1	4	8	4	4
Baëtis	43	81	72	44	39	42	36	26	35
Leuctra	3	0	0	3	4	0	0	19	28
Ephemerella	5	0	3	8	5	14	22	8	5
Naididae	0	2	6	3	6	8	2	0	1
Psychodidae	0	0	0	0	0	0	0	1	0

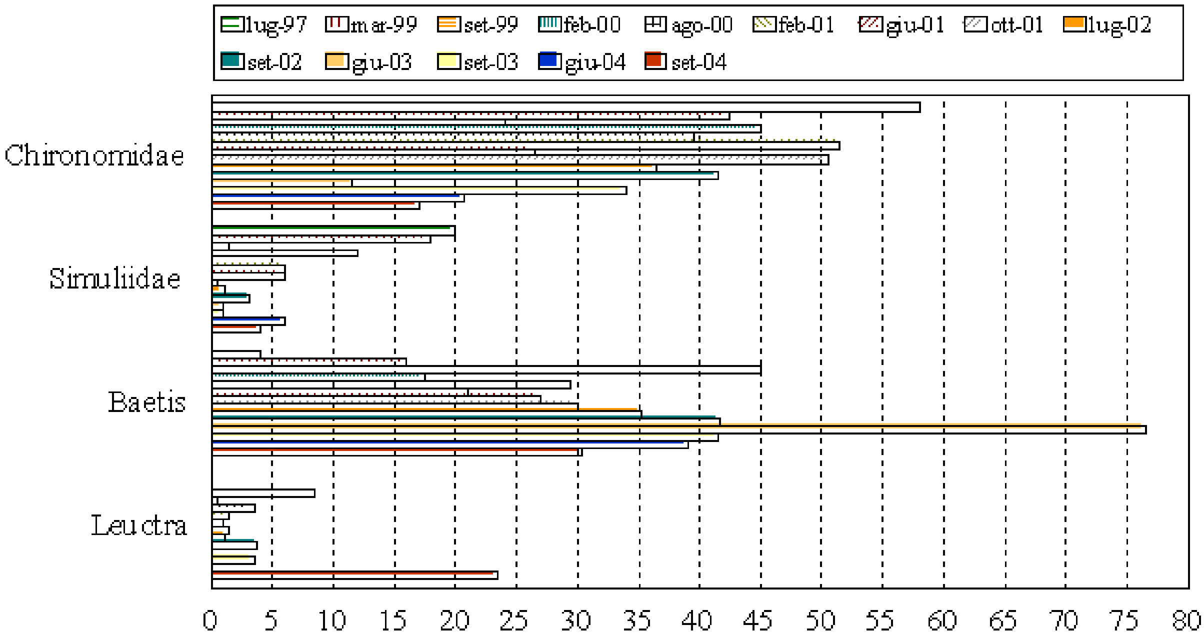

Figure 41: Percentage presences trend of systematic units

In this torrent reach, a vicariance phenomenon has always been observed between Chironomidae (larvae) and Baëtis, even if not always clearly divided by season, and surely not so evident like in the other MIF experimental monitoring stations. In 2003 Baëtis prevails in both sampling periods with extraordinary high values in spring, where the recorder average of two samples is 76.5 %. However, Baëtis and Chironomidae (larvae), according to 2002 surveys, represent, alone, values between 83 % and 92 % in summer and 79 % -72 % in autumn, numerically sustaining a poorly diversified community. Also in 2004 Ephemeropteras Baëtis continue to be the most drifted taxon, and in June Ephemeropteras Ephemerellae (18 % average for both riverbanks) and stoneflies Leuctra in September (23.5 % average for both riverbanks). So, if compared with historical data, surveyed drifted species seems to be more differentiated than in the past.

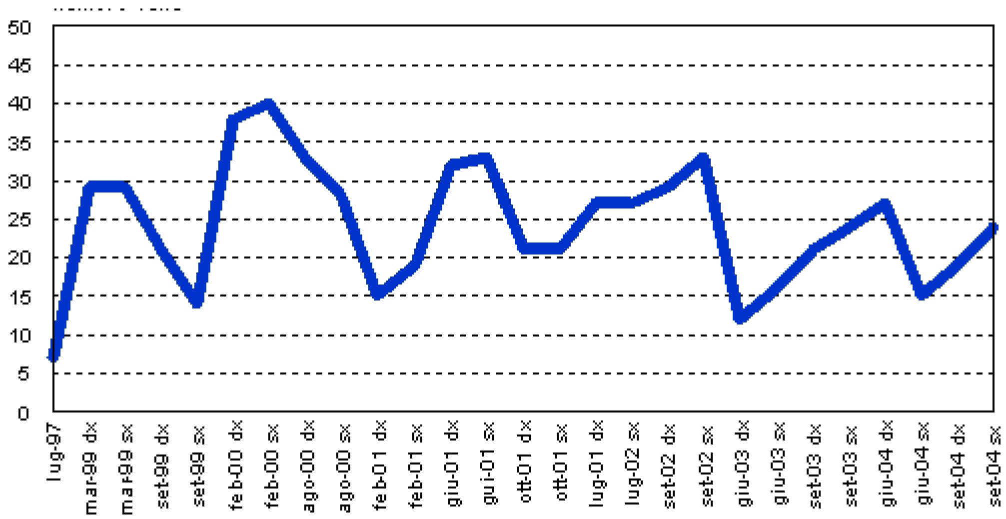

Figure 42: Taxa number surveyed

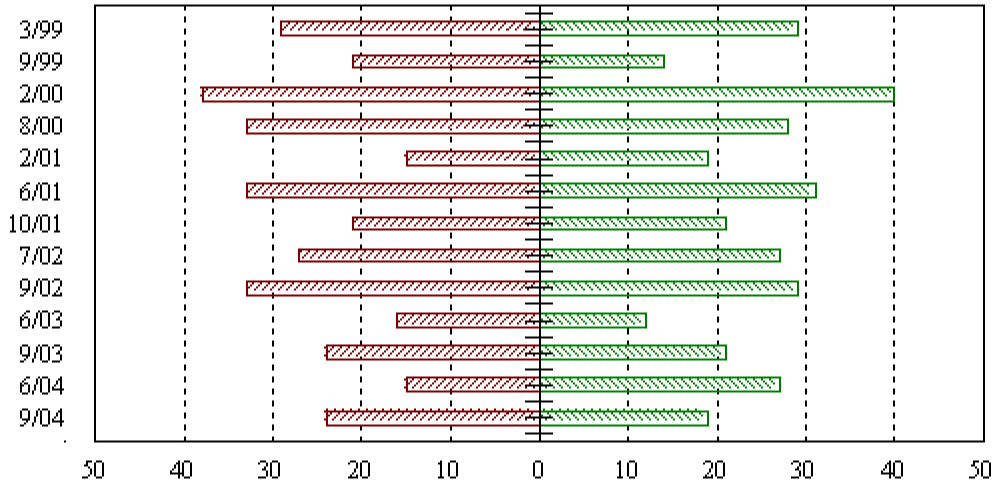

Figure 43: Taxa number surveyed on left riverbank (on the left) and on right riverbank (on the right).

Fish analysis on torrent Cordevole at Peron

Quantitative sampling results, analyzed for different species, are reported on the following. This sampling activity has been performed on the 30th August 2004.

Table 20: Density and biomass values for each surveyed species

SPECIES	TOTAL DENSITY [IND/M^2]	TOTAL BIOMASS [G/M^2]
Salmo (trutta) trutta	0.005	0.08
Salmo (t.) marmoratus and hybrid FxM	0.056	3.59
Total Salmonids	**0.061**	**3.67**
Cottus gobio	0.012	0.16
Phoxinus phoxinus	0.001	0.001
Total	**0.074**	**3.83**

Table 21: Abundance index following Moyle and Nichols (1970, mod.)

SPECIES	ABUNDANCE INDEX
Cottus gobio	3
Phoxinus phoxinus	1

Marble trout and FxM hybrid have density of 0.056 ind/m^2 and biomass of 3.59 g/m^2. The population of this species results to be the most abundant in the surveyed reach. It is divided into 6 age classes, with the highest concentration in classes 0+ and 1+. From 2002 no trout seeding occurred in this reach, one can therefore conclude that these are the results of natural reproduction. The linear species increase in shown in the following table.

Table 22: Marble trout linear species increase

AGE [YEARS]	AVERAGE TOTAL LENGTH [MM]	D. S. [± MM]	AVERAGE WEIGHT [G]	D.S. [± G]
0+	95.7	14.5	9.7	5.7
1+	177.7	19.4	60.9	21.4
2+	226.6	15.9	127.4	35.4
3+	267.0	4.2	146.5	51.9
4+	342.0		427.0	
6+	450.0		1180.0	

The marble trout and FxM hybrid population is represented by pure specimens for the 30.8 %. Among hybrids, the dominant morphotype is ++ (44.4 %), intermediate between marble trout and brown trout, with the other two hybrids (+ and +++) both under 30 %.

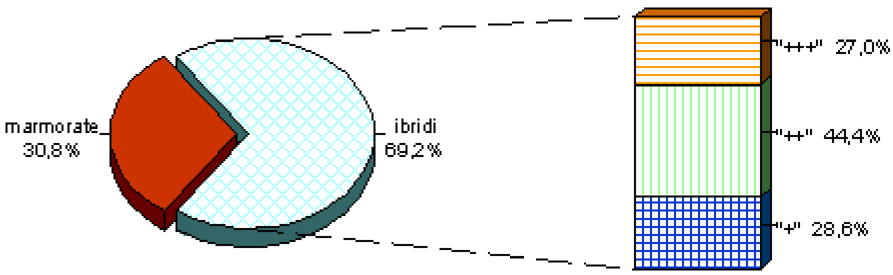

Figure 44: Hybridism degree of marble trout

For what concern brown trout density and biomass, the values are 0.005 ind/m^2 and 0.08 g/m^2. Just a few elements of class 1+ are present, probably originated by natural reproduction, since no youth seeding has been done since 2003. The linear species increase in shown in the following table.

Table 23: Brown trout linear species increase

AGE [YEARS]	AVERAGE TOTAL LENGTH [MM]	D. S. [± MM]	AVERAGE WEIGHT [G]	D.S. [± G]
1+	112.7	16.7	6.0	1.9

Few bullhead specimens have been found. The abundance index for this species is 3. Minnow has been surveyed with abundance index equal to 2, present.

Since August 2001, starting point of the analysis in this station, there has been an increase in the salmonid population in terms of density up to March 2003, a decrease in subsequent samples, and a slight recovery in 2004. Biomass instead shows a trend of continuous decline since August 2002 until August 2004, that reported values similar to those of the previous year. In particular, the population of brown trout continue decreasing in density and confirms, in practice, in 2004 sampling, the negative biomass data of last years. The population of trout reveals, however, a slight increase if compared with the last sampling in 2003, both in terms of biomass and density. The decline of fish presence on this stretch of river Cordevole is correlated with the deep changes that occurred in the sampling area after the floods of April 2002 and November 2003. However, this decline seems to have stopped in 2004 with a stabilization of collected data.

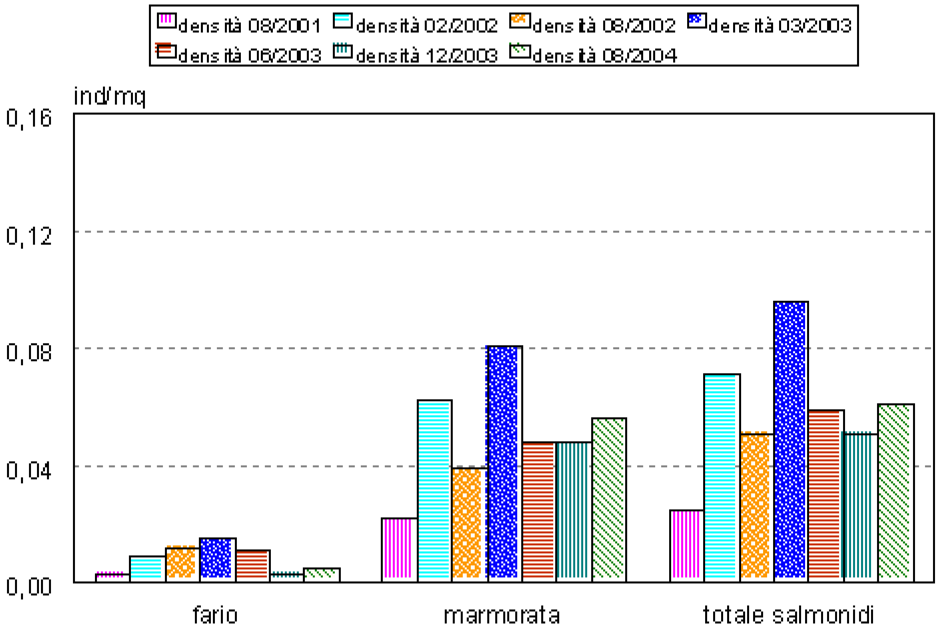

Figure 45: Historical density data

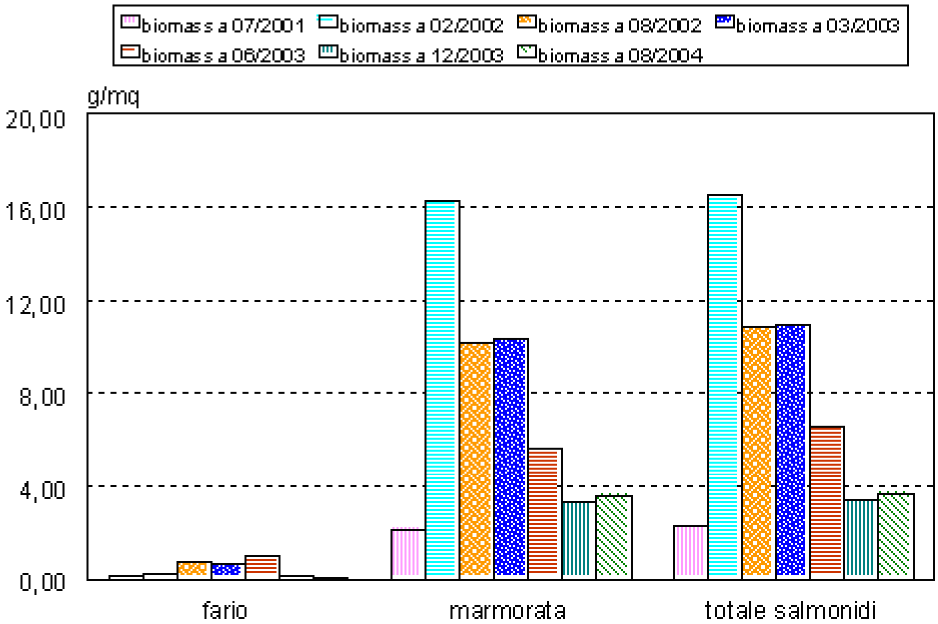

Figure 46: Historical biomass data

Fish analysis on torrent Mis at Gron

Quantitative sampling results, analyzed for different species, are reported on the following. This sampling activity has been performed on the 30th August 2004.

Table 24: Density and biomass values for each surveyed species

SPECIES	TOTAL DENSITY [IND/M^2]	TOTAL BIOMASS [G/M^2]
Salmo (trutta) trutta and lake var.	0.053	2.28
Salmo (t.) marmoratus and hybrid FxM	0.677	32.66
Thymallus thymallus	0.025	5.53
Total Salmonids	**0.755**	**40.47**
Cottus gobio	0.014	0.37
Phoxinus phoxinus	0.002	0.002
Total	**0.771**	**40.48**

Table 25: Abundance index following Moyle and Nichols (1970, mod.)

SPECIES	ABUNDANCE INDEX
Cottus gobio	1
Phoxinus phoxinus	1

Marble trout and FXM hybrid has been found with high biomass and density values, 0.677 ind/m^2 and 32.66 g/m^2. Population is structured in 5 age classes, with high density of specimens belonging to classes 0+, 1+, 2+. They are surely originated by natural reproduction. This site results therefore to be very productive and protection deserving.

Table 26: Marble trout linear species increase

AGE [YEARS]	AVERAGE TOTAL LENGTH [MM]	D. S. [± MM]	AVERAGE WEIGHT [G]	D.S. [± G]
0+	97.8	15.2	9.8	5.3
1+	171.8	20.9	56.9	21.9
2+	229.1	16.2	146.4	52.3
3+	282.5	12.7	246.3	58.6
4+	345.0	7.1	475.5	2.1

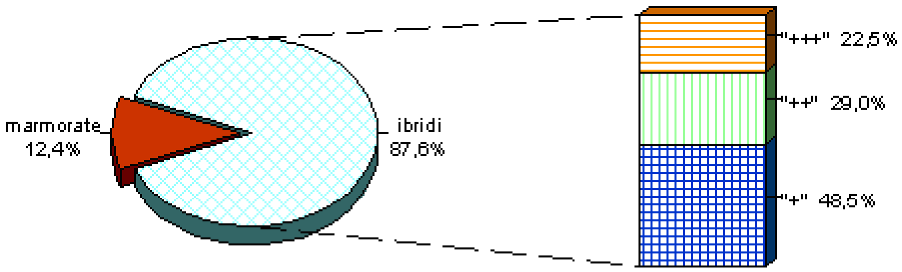

Figure 47: Hybridism degree of marble trout

Marble trout is present with 12.4 % of totality. Among hybrids, the dominant morphotype is +, with 48.5 %, which is the closest to the marble trout.
Brown trout population has biomass 0.053 g/m^2 and density 2.28 ind/m^2. It is present with specimens belonging to age classes up to 2+, and with a lake specimen aged 6+. The most abundant class, from the density point of view, is 0+. The number of caught individuals is however low, but they have probably a natural origin.

Table 27: Brown trout linear species increase

AGE [YEARS]	AVERAGE TOTAL LENGTH [MM]	D. S. [± MM]	AVERAGE WEIGHT [G]	D.S. [± G]
0+	96.6	10.1	9.8	3.3
1+	127.7	10.9	23.9	8.0
2+	191.0		87.0	
6+	390.0		734.0	

The grayling is present with good biomass and density, respectively 0.025 ind/m^2 and 5.53 g/m^2. Individuals up to age class 2+ were found, and this is also the most important class for what concerns density.

Table 28: Grayling linear species increase

AGE [YEARS]	AVERAGE TOTAL LENGTH [MM]	D. S. [± MM]	AVERAGE WEIGHT [G]	D.S. [± G]
0+	106.5	6.4	7.0	1.4
1+	205.0		152.0	
2+	273.4	16.3	224.6	46.8

The bullhead was found with a few individuals, and with an abundance index equal to 1.
The minnow was found with only two individuals and low index of abundance, equal to 1.

Since July 1997 there has been an initial increase in biomass and density parameters immediately after the beginning of releases, and a sharp decrease until the month of February 2000. Afterwards, a recovery has occurred during summer 2000, with the start of an ups and downs period. The ups and downs in terms of density has been observed also in 2003, with maximum values during summer. That trend has been confirmed also by samples of December 2003 and August 2004. In particular the August 2004 survey has shown a net increase of salmonids total density and biomass if compared to samples of 2003, also thanks to the values observed for the marble trout. For the brown trout the values remain unchanged. The grayling was surveyed in the last two surveys with a steady increase in biomass and density compared with a total absence in the first two surveys in 2003.

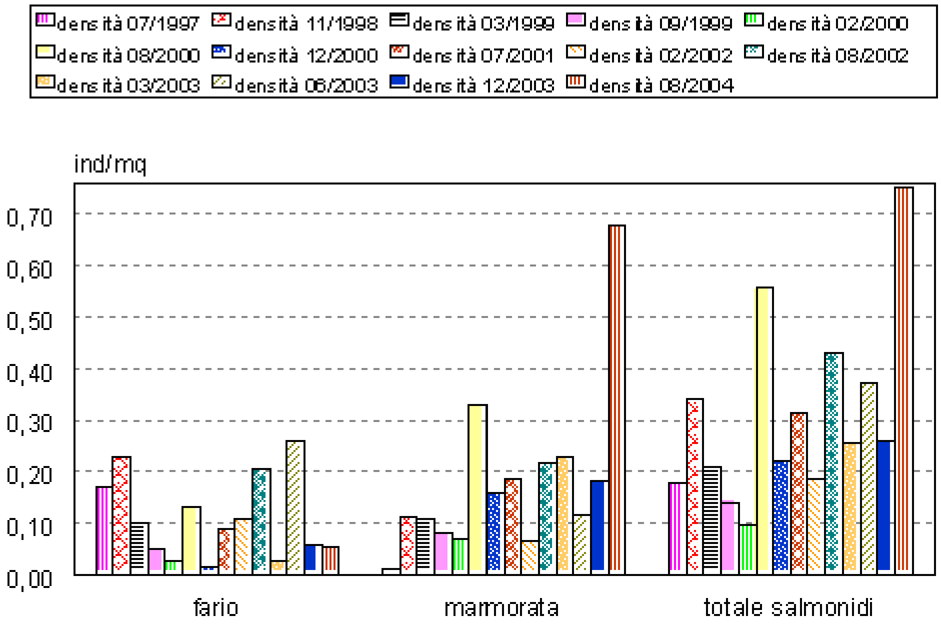

Figure 48: Historical density data

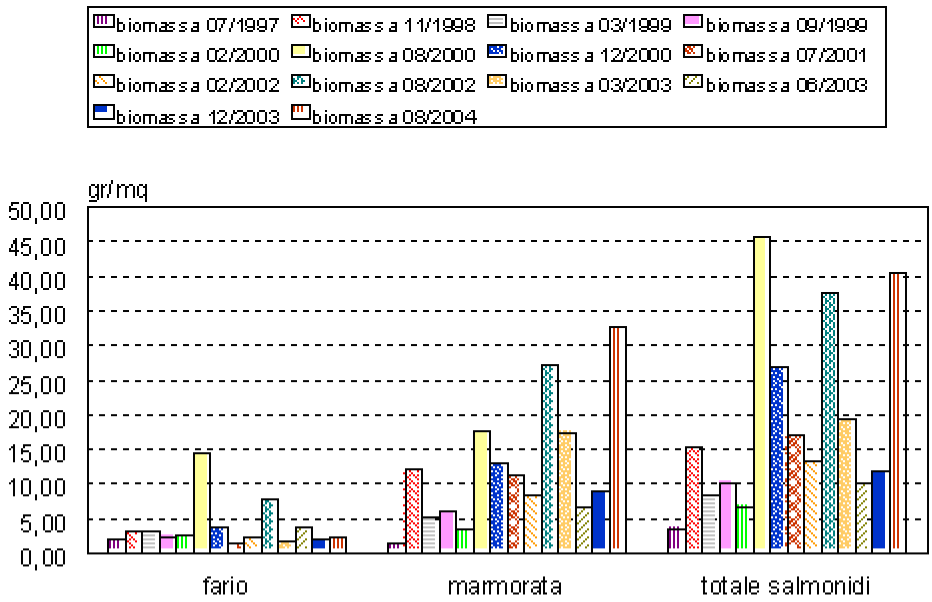

Figure 49: Historical biomass data

MIF evaluation in 2006

The analysis performed to evaluate MIF continued in 2006 with the following activities:

- macrobenthos qualitative analysis (IBE) and macrobenthos quantitative analysis
- drift evaluation
- fish analysis
- IFF and IFM evaluation

IFF and IFM evaluation

Surveys for IFF and IFM evaluation, have been performed on Mis and Cordevole during July and October 2006.
For what concerns river Cordevole at Peron, in the monitored station, an urbanized area is present on the left, while on the left lawns, pastures and woods characterize the zone. The perifluvial vegetation strip is of secondary kind on the left, because of the presence of a defense wall, while on the right it is of primary kind. Vegetation is riparian shrubby on the left and riparian arboreal on the right. The width is 1-5 m with repeated interruptions on the left, 5-30 m without interruptions on the right. Channel hydraulic conditions are just fair, the station is immediately downstream La Stanga dam. Riverbanks are covered by a thin grass layer on the left, and by boulders on the right. Channel retention capacity is fair, with boulders presence and sediment deposition. For what concerns erosion structures, on the left artificial protections are present, and on the right erosion is present only on narrow reaches or along bends. The riverbed, from the morphological point of view, has a natural cross section, with minor artificial interventions, mobile bed and regular riffle and pool sequence. For what concerns the biological structure, *periphyton* is noticeable only in the turbulent stream reach, organic debris is made of recognizable fragments and the macrobenthos community is well sorted and adequate to the fluvial type. The investigated reach results to have mediocre functionality on the left, and good on the right, on both survey periods. As shown in Figure 50, the left side is back to value 3 after the mediocre-poor level of 2003, while on the right level 2 is aligned with past data.
Figure 51, which compares the results obtained in 2006 from IFF and from the Morphologic Functionality Index IFM, puts in evidence that the result is always mediocre on the left, as the IFF is, because of the presence of protection works, and high on the right, where IFF is good.

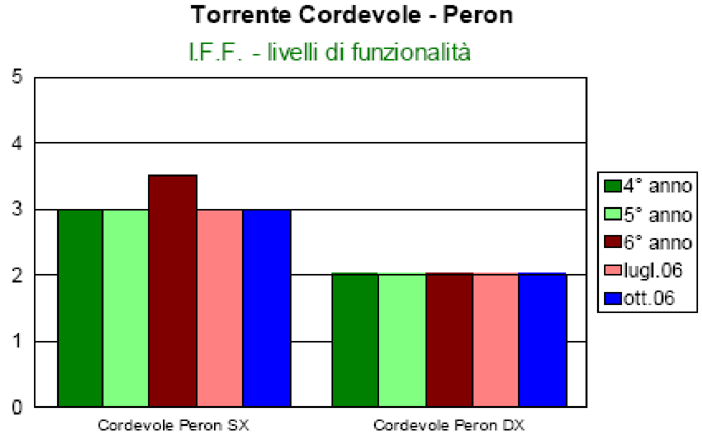

Figure 50: Functionality levels on Cordevole at Peron. ■ 2001; ■ 2002; ■ 2003; ■ July 2006; ■ October 2006

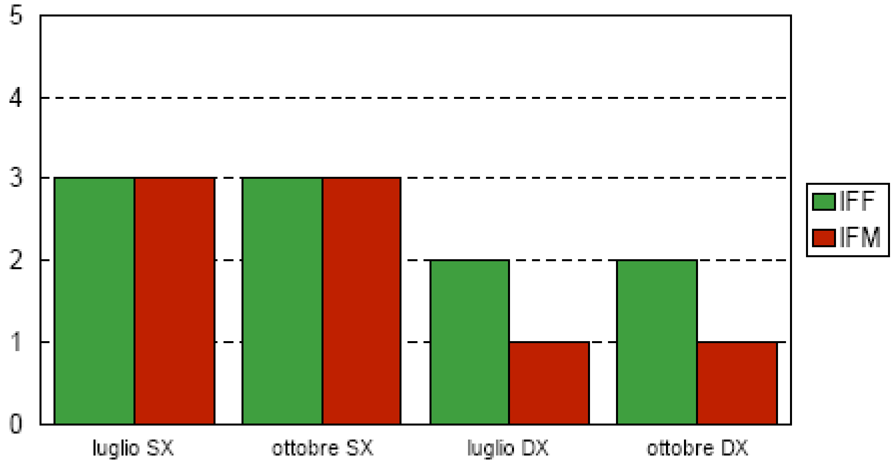

Figure 51: Fluvial Functionality Index and Morphologic Functionality Index on Cordevole at Peron

For what concerns torrent Mis at Gron, sparse urbanization is present on both torrent sides. The perifluvial vegetation strip is of secondary kind on the left, because of the presence of a defense wall, while on the right it is of primary kind. Vegetation is riparian shrubby on the left and riparian arboreal on the right. The width is 1-5 m on the left, 5-30 m on the right without interruptions on both sides. Channel condition is fair, the station is downstream Santa Giuliana's dam. Riverbanks are covered by grass and bushes on both sides. Channel retention capacity is fair, with boulders presence and sediment deposition. For that concerns erosion structures, they are present just on bends and narrow reaches on the left, while on the right they are not noticeable in July, but become evident on October along bends and narrow reaches. The riverbed, from the morphological point of view, has a natural cross section, with minor artificial interventions, mobile bed and regular riffle and pool sequence. For what concerns the biological structure, *periphyton* is noticeable only in the turbulent stream reach, organic debris is made of recognizable fragments and the macrobenthos community is well sorted and adequate to the fluvial type. The investigated reach has mediocre functionality on the left and good on the right in July, mediocre on the left and mediocre-good on the right in October.
Figure 53, which compares the results obtained in 2006 from IFF and from the Morphologic Functionality Index IFM, puts in evidence that the IFM result is always good, thanks to slight banks erosion, to grass and bushes presence, and to riffle and pool sequences.

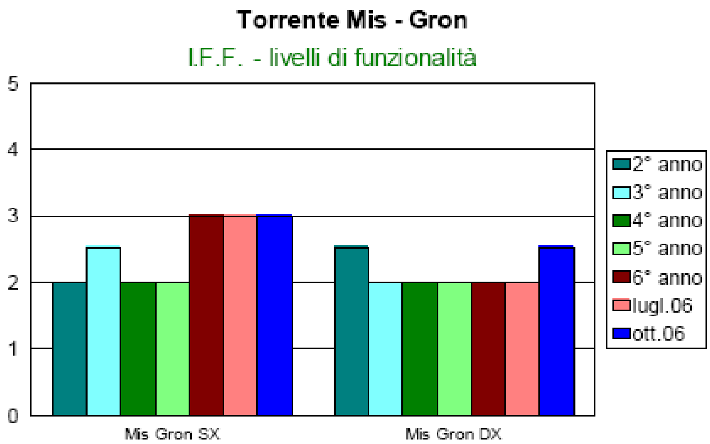

Figure 52: Functionality levels on Mis at Gron. 2001; 2002; 2003; July 2006; October 2006

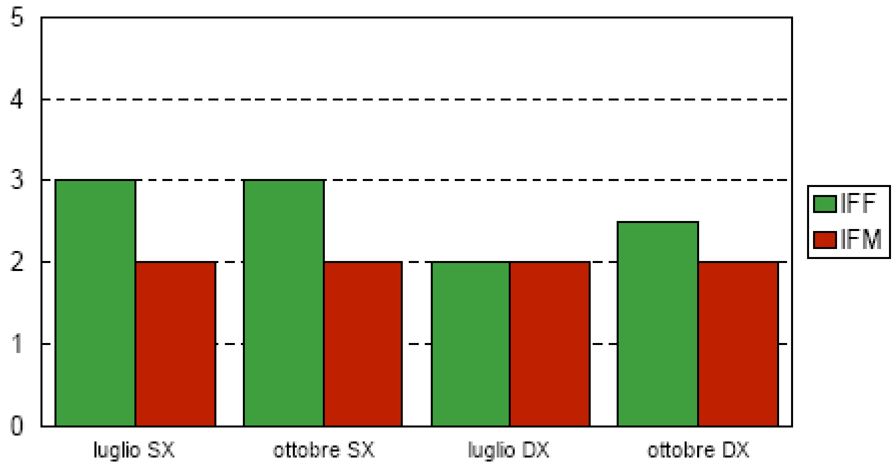

Figure 53: Fluvial Functionality Index and Morphologic Functionality Index on Mis at Gron

1.4.2 River functionality

Before the IFF analysis finalized to MIF evaluation in 2006, the Fluvial Functionality Index has been evaluated along Cordevole stream in 2003. The investigated reach of the torrent Cordevole shows, in general, a good functional condition. The River Functionality Index was applied to about 70.1 km and has provided a review of functionality rather different for the two sides.

Tables and graphs below summarize the functional levels obtained for the river left bank and right bank and the correspondent length:

FUNCTIONALITY LEVEL	LEFT BANK		RIGHT BANK	
	LENGTH [m]	%	LENGTH [m]	%
I	854	1,2	1.713	2,4
I-II	1.138	1,6	500	0,7
II	34.832	49,0	42.793	60,4
II-III	10.118	14,3	8.100	11,4
III	13.739	19,4	11.845	16,7
III-IV	5.574	7,9	2.637	3,7
IV	3.947	5,6	2.954	4,2
IV-V	340	0,5	0	0,0
V	327	0,5	327	0,5
TOTALE	70.869	100	70.869	100

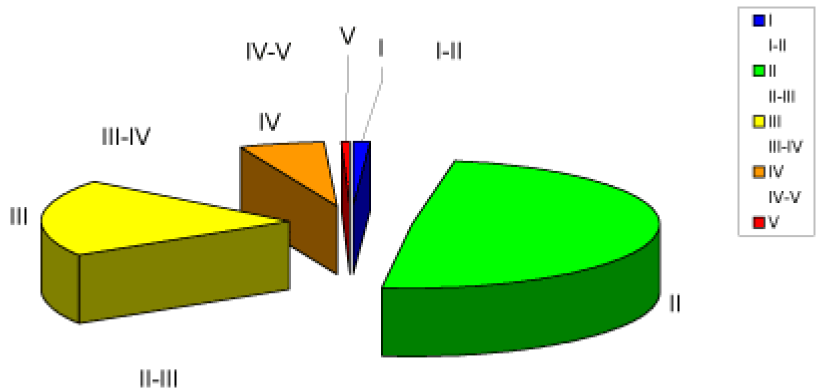

Figure 54: Left bank functionality

The left side presents a situation that is part of an overall assessment of good features. Indeed, this classification was given to 49.0% of the investigated reach, also for 1, 6% the level of functionality was high-good and good-poor 14.3%. In 1, 2%, the Cordevole stream on the left bank has a high level of functionality. A moderate level of functionality was achieved in 19.4% and a mediocre-poor in 7.9%. The poor and very poor levels have occurred in 5.6% and 0.5%, even the middle class bad-bad has occurred for 0.5%.

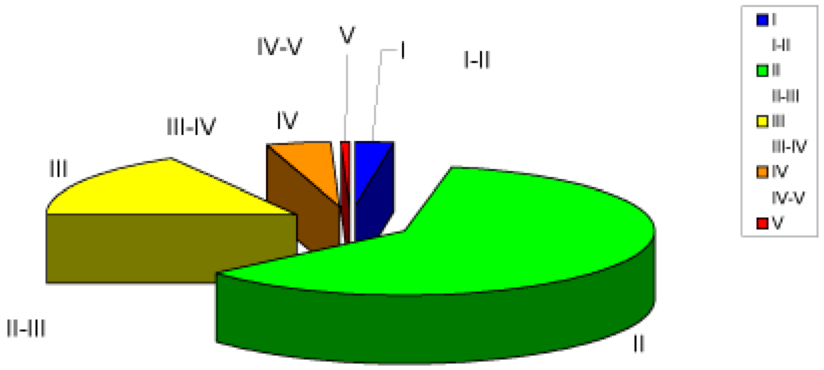

Figure 55: Right bank functionality

On the right bank the overall level of functionality appears to be good. In fact, it was achieved for 60.4% of Cordevole stream. Good-high and good-poor levels of functionality have been achieved respectively for 0.7% and 11, 4%. A high level was obtained for 2.4%. A mediocre situation was obtained from 16.7% of main reach and a mediocre-poor by 3.7%. The poor and very poor level were achieved in 4.2% and 0.5% of the right bank investigated.

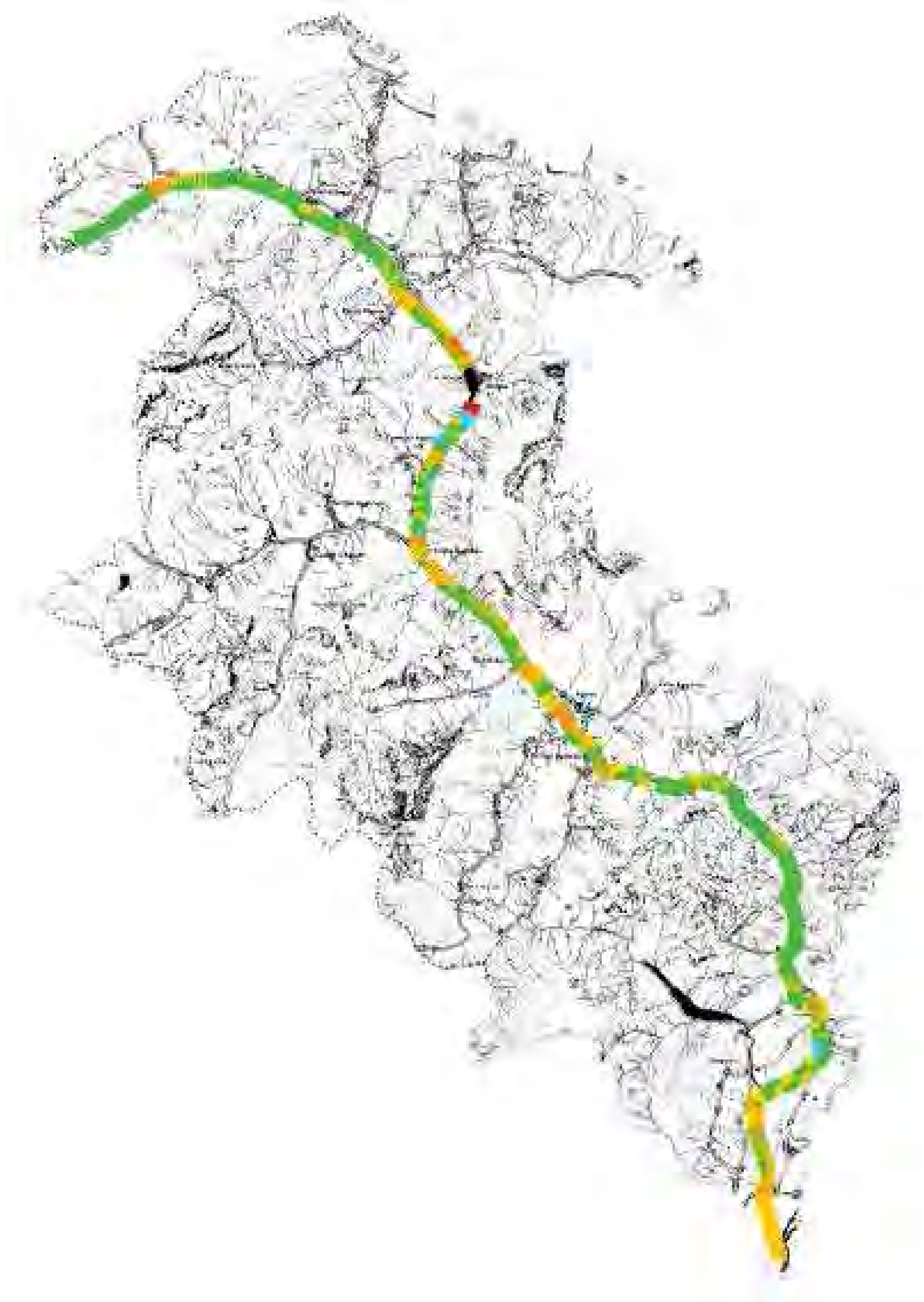

Figure 56: Fluvial Functionality Index along Cordevole River (2006)

Table 29: IFF classification legend

COLOUR	QUALITY CLASS	DEFINITION
	I	High
	I -II	High - Good
	II	Good
	II - III	Good - Mediocre
	III	Mediocre
	III - IV	Mediocre – Poor
	IV	Poor
	IV - V	Poor - Bad
	V	Bad

A further analysis of IFF along the main channel of Cordevole River was conducted during 2011 (Fig. 57).

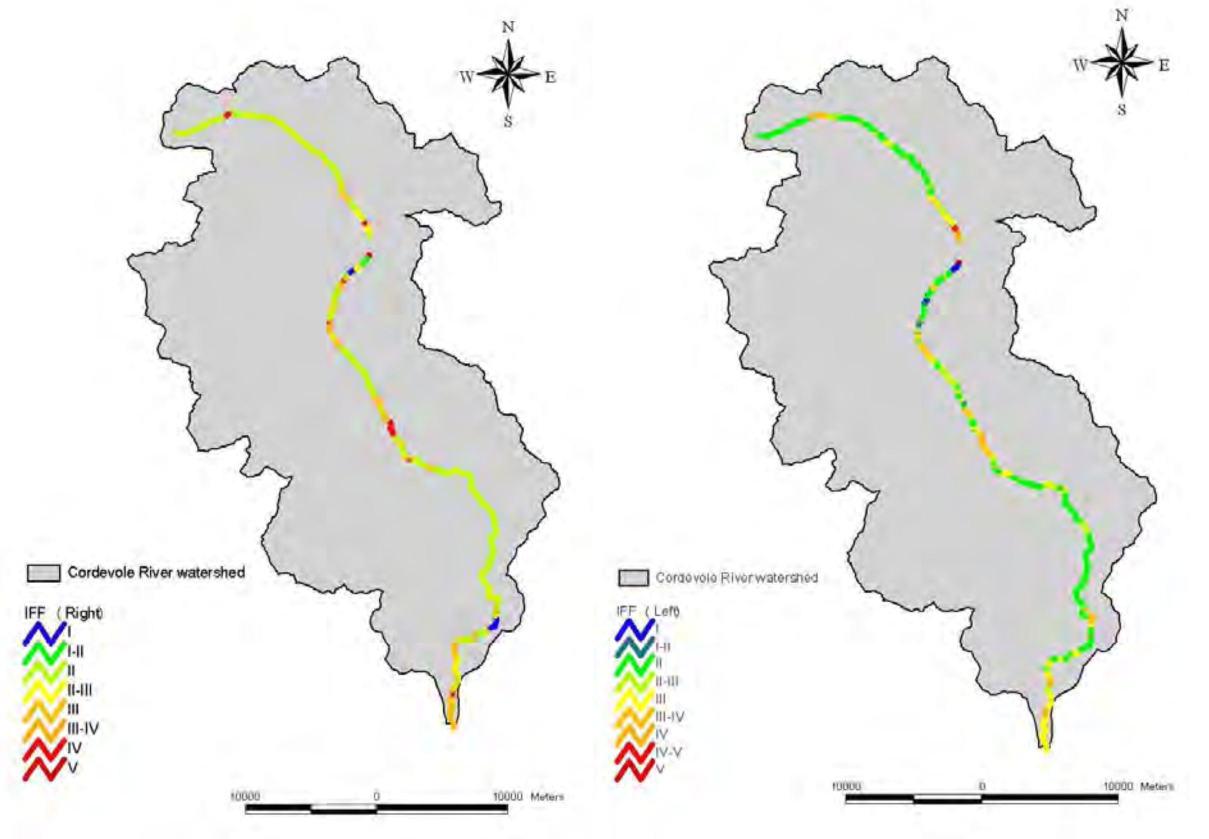

Figure 577: Fluvial Functionality Index along Cordevole River (2011)

The Cordevole stream flows in an area primarily characterized by the presence of forests and woodlands, especially on the right bank. On the left bank, forests and woodlands still strongly characterize the area surrounding the river but with minor importance if compared to other local structures.
The vegetation is predominantly of riparian type on both sides. Riparian shrubs and trees are located on approximately 70% of both sides. The width of trees and shrubs strip is often greater than 30 m on the right bank. The left side appears to be characterized by different distributed amplitudes, but none of them is clearly predominant. The longitudinal continuity of trees and shrubs strip is consolidated by a predominance of traits with no disruptions, or occasional, on both sides. The banks are mainly characterized by the presence of herbaceous vegetation or shrubs.
The stream Cordevole has a secondary level strip for about 15.5 km on the left bank and about 12.2 km on the right bank. It is remarkable that within these reaches, there are about 10.1 km on the left and 8.8 km on the right of mainly herbaceous vegetation or absent vegetation.
The wet bed is smaller than three times the seasonal high discharge wet bed for most of the length of the investigated reach. Important reaches with channel widths greater than three times the wet bed are still present on the upper part of the course of Cordevole.
Retention structures ensure in most of the reach a retentive capacity which ranges from poor to fair. Erosion is often localized only in the corners and narrow cross-sections. It should be pointed out that important stream reaches are characterized by the presence of landslide erosion very clear over the banks, but also with the presence of artificial interventions.
The cross section is mostly natural or natural with slight artificial interventions, and the channel morphologically appears to be characterized mainly by movable bed, or easily movable by floods.
From the standpoint of morphological diversification, the bed is characterized for most of the river by the presence of riffle and pools which alternate in sequence but with uneven distribution.

The *periphyton* is largely under-developed, sometimes it is discrete, or detectable by touch.
The organic debris is composed by fibrous and fleshy plant fragments and recognizable fibrosis.
The macrobenthos community appears to be well-structured and diversified or sufficiently diversified, but with altered structure if compared to what is expected.
Generally, from the map, one can see that reaches where the level of functionality achieves the worst results are those adjacent to residential areas. It should be noted also that starting from the springs area, the level of functionality is not good. This is not surprising, in fact, it is intrinsic in the method. Over areas above the altitudinal limit of tree, the application of the methodology leads an assignment of functional levels not high, because this kind of environment often have a physiological ecological-functional "fragility". Going downhill, it is already known that the area of Arabba presents bad situations, with nearly bad levels in the area upstream Alleghe's lake. Immediately downstream the lake, the worst feature are encountered, especially conditioned by interventions on banks and bottom consolidation. Other poor situations are found in the area of Cencenighe and Agordo. It is also interesting to note that the area downstream of the confluence with the river Mis, that theoretically has a higher water discharge, has many reaches in general mediocre functionality. Even if many reaches present good features, on the whole very few reach a high value. This is a symptom of a generalized state of slight suffering of the system.

Biological and chemical data from ARPAV monitoring

Other interesting biological and chemical data come from the annual analysis performed by ARPAV on Veneto's rivers, in order to assess their fish suitability. The following tables resumes the results for year 2009.

Table 30: Fish life suitability in 2009 over the Cordevole river basin.

WATER BODY	REACH	FISH CLASS	SURVEYS NUMBER IN 2009	SUITABILITY 2009	DISPENSATIONS OR NON SUITABILITY CAUSES
TEGNAS	From spring to the confluence with Cordevole	salmonids	0	Yes	It resulted to be suitable in 1999 and 2000 and no pollution or deterioration sources exist
SARZANA	From spring to the confluence with Cordevole	salmonids	0	Yes	It resulted to be suitable in 1999 and 2000 and no pollution or deterioration sources exist
ROVA	From spring to the confluence with Cordevole	salmonids	0	Yes	It resulted to be suitable in 1999 and 2000 and no pollution or deterioration sources exist
CORDEVOLE	From Ponte dei Castei to the confluence with Piave	salmonids	9	Yes	
MIS	From spring to Mis' Lake	salmonids	0	Yes	Downstream the Lake IBE class I in 2002 and I-II in 2003. No pollution or deterioration sources exist

Table 31: LIM evaluation in 2009 over the Cordevole river basin.

WATER BODY	75° PERCENTILE AMMONIA NITROGEN (N) MG/L	75° PERCENTILE NITRIC NITROGEN (N) MG/L	75° PERCENTILE TOTAL PHOSPHORUS (P) MG/L	75° PERCENTILE BOD_5 A 20 °C MG/L	75° PERCENTILE C.O.D. MG/L	75° PERCENTILE DILUTED OXYGEN. % SAT. O_2 (100-OD%)	75° PERCENTILE ESCHERICHIA COLI UFC/100 ML	POINTS $N\text{-}NH_4$	POINTS $N\text{-}NO_3$	POINTS P	POINTS BOD_5	POINTS COD	POINTS % SAT. O2	POINTS E.COLI	SUM (LIM)	MACRO-DESCR. CLASS
BIOIS	0.09	1.1	0.03	1.3	3	5	60000	40	40	80	80	80	80	5	405	2
CORDEVOLE	0.04	0.7	0.03	2.0	5	5	1100	40	40	80	80	40	80	20	380	2
CORDEVOLE	0.04	0.6	0.01	1.5	3	9	1800	40	40	80	80	80	80	20	420	2
CORDEVOLE	0.05	0.7	0.03	2.8	4	8	9000	40	40	80	40	80	80	10	370	2
MIS	0.03	0.6	0.02	1.5	6	12	468	40	40	80	80	40	40	40	360	2
FIORENTINA	0.06	0.5	0.01	2.0	3	10	130	40	40	80	80	80	40	40	400	2

1.4.3 WFD river classification.

According to WFD guide lines, Italian rivers typology is structured in three levels.

Table 32: List of the considered factors for the three levels proposed for Italian rivers typology definition

LEVEL	MANDAORY FACTORS	OPTIONAL FACTORS	OTHER FACTORS
1. REGIONALIZATION	Altitude, geologic composition (lithology), latitude, longitude	Medium slope, rainfall, air temperature	
2. GENERAL TYPOLOGY DEFINITION	Distance from spring	Main channel shape and configuration	Origin, upstream basin influence, perpetuity and persistence
3. DETAILED TYPOLOGY DEFINITION		Substrate medium composition	Temperature, discharge/ regime/ duration curves, interactions with underground water, lenthic-lotic features, other

Figure 58: HER defined by CEMAGREF for Italy

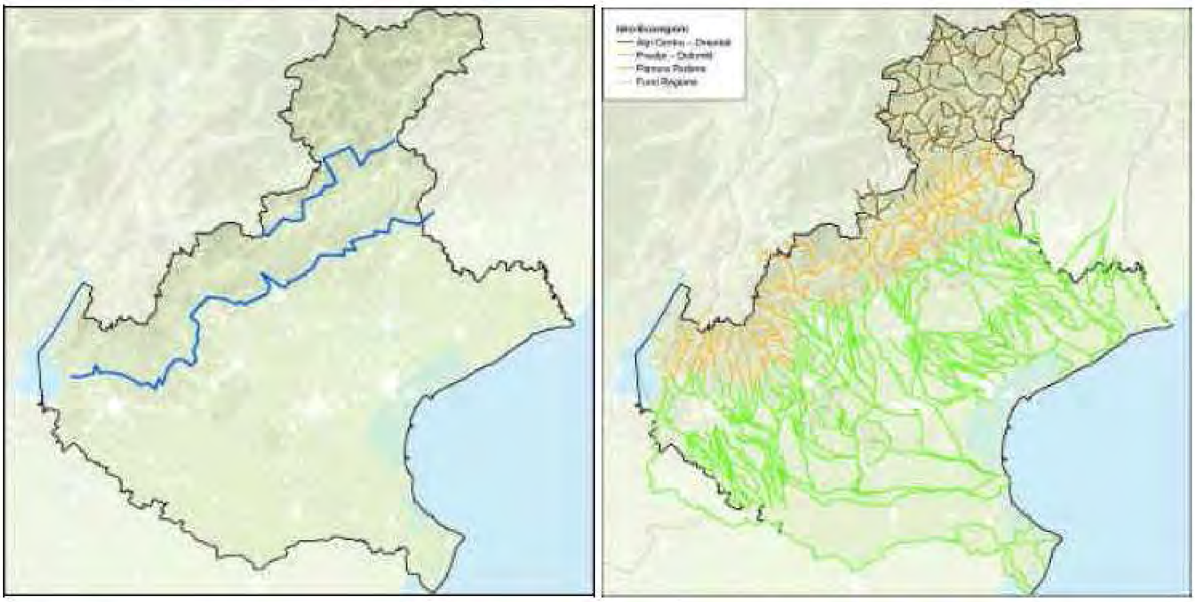

Figure 58: On the left, the separation lines between different HER zones. On the right, natural rivers reaches belonging to different HER zones.

Veneto Region is concerned by three Hydro-Eco-Regions, represented in the following Figure. They are:

- 03 Inner Alps
- 02 Calcareous Southern Alps and Dolomites
- 06 Po Plain

Cordevole river basin is concerned only by HER 03 and 02.
Every river type is then defined by a code which structure has this meaning

HER/ ORIGIN – PERSISTENCE/ DISTANCE FROM ORIGIN – MORPHOLOGY/ UPSTREAM BASIN INFLUENCE/ DISPERSIVE CHANNEL/ BRAIDED

Results of the classification for the Cordevole river basin are reported in the following table.

Table 33: River types inside the Cordevole river basin

RIVER BASIN	CHANNEL TYPE	NAME	CODE	TYPE	FROM	TO	TYPE CODE	HER/ ORIGIN – PERSISTENCE/ DISTANCE – MORPHOLOGY/ BASIN INFLUENCE/ DISPERSIVE/ BRAIDED
Piave	rivulet	Andraz, di Castello, Valparola	457	natural	spring	River Cordevole	03.SR.6.N.NO.NO	Inner Alps/ Springs/ <10 km/ Not applicable/ NO/ NO
Piave	torrent	Biois	447	natural	Channel beginning	Zingari's Lake Dam	03.SS.1.N.NO.NO	Inner Alps/ Surface run flow/ <5 km/ Not applicable/ NO/ NO
Piave	torrent	Biois	447	natural	Zingari's Lake Dam	Type change (Rio Valles inflow)	03.SS.1.N.NO.NO	Inner Alps/ Surface run flow/ <5 km/ Not applicable/ NO/ NO
Piave	torrent	Biois	447	natural	Type change (Rio Valles inflow)	Hydropower withdrawal	03.SS.2.N.NO.NO	Inner Alps/ Surface run flow/ <25 km/ Not applicable/ NO/ NO
Piave	torrent	Biois	447	natural	Hydropower withdrawal	River Cordevole	03.SS.2.N.NO.NO	Inner Alps/ Surface run flow/ <25 km/ Not applicable/ NO/ NO
Piave	torrent	Bordina	438	natural	spring	River Cordevole	03.SR.6.N.NO.NO	Inner Alps/ Springs/ <10 km/ Not applicable/ NO/ NO
Piave	torrent	Cordevol e	430	natural	spring	Type change (Rio Andraz inflow)	03.SR.6.N.NO.NO	Inner Alps/ Springs/ <10 km/ Not applicable/ NO/ NO
Piave	torrent	Cordevol e	430	natural	Type change (Rio Andraz inflow)	Alleghe's lake	03.SR.2.N.NO.NO	Inner Alps/ Springs/ 5-25 km/ Not applicable/ NO/ NO
Piave	torrent	Cordevol e	430	natural	Alleghe's lake	Cencenighe's lake	03.SR.2.N.NO.NO	Inner Alps/ Springs/ 5-25 km/ Not applicable/ NO/ NO
Piave	torrent	Cordevol e	430	natural	Cencenighe's lake	Type change (Rio Muda inflow)	03.SR.3.N.NO.NO	Inner Alps/ Springs/ 25-75 km/ Not applicable/ NO/ NO
Piave	torrent	Cordevol e	430	natural	Type change (Rio Muda inflow)	La Stanga's dam	02.SR.3.F.NO.NO	Southern Alps and Dolomites/ Springs/ 25-75 km/ High/ NO/ NO

RIVER BASIN	CHANNEL TYPE	NAME	CODE	TYPE	FROM	TO	TYPE CODE	HER/ ORIGIN – PERSISTENCE/ DISTANCE – MORPHOLOGY/ BASIN INFLUENCE/ DISPERSIVE/ BRAIDED
Piave	torrent	Cordevole	430	natural	La Stanga's dam	Pra della Varda' s barrage	02.SR.3.F.NO.NO	Southern Alps and Dolomites/ Springs/ 25-75 km/ High/ NO/ NO
Piave	torrent	Cordevole	430	natural	Pra della Varda' s barrage	River Piave	02.SR.3.F.NO.NO	Southern Alps and Dolomites/ Springs/ 25-75 km/ High/ NO/ NO
Piave	torrent	Corpassa	445	natural	spring	River Cordevole	03.SR.6.N.NO.NO	Inner Alps/ Springs/ <10 km/ Not applicable/ NO/ NO
Piave	torrent	Dumarana	431	natural	spring	River Cordevole	02.SR.6.T.NO.NO	Southern Alps and Dolomites/ Springs/ <10 km/ absent or negligible/ NO/ NO
Piave	torrent	Fiorentina	453	natural	glacier	River Cordevole	03.GH.6.N.NO.NO	Inner Alps/ Glacier/ <10 km/ Not applicable/ NO/ NO
Piave	torrent	Mis	432	natural	spring	Type change (Rio val dei Molini inflow)	03.SR.6.N.NO.NO	Inner Alps/ Springs/ <10 km/ Not applicable/ NO/ NO
Piave	torrent	Mis	432	natural	Type change (Rio val dei Molini inflow)	Mis' lake	02.SR.6.D.NO.NO	Southern Alps and Dolomites/ Springs/ <10 km/ Weak/ NO/ NO
Piave	torrent	Mis	432	natural	Mis' lake	River Cordevole	02.SR.2.D.NO.NO	Southern Alps and Dolomites/ Springs/ 5-25 km/ Weak/ NO/ NO
Piave	torrent	Missiaga	439	natural	spring	River Cordevole	03.SR.6.N.NO.NO	Inner Alps/ Springs/ <10 km/ Not applicable/ NO/ NO
Piave	torrent	Ombretta - Pettorina	456	natural	spring	Ombretta's dam	03.SR.6.N.NO.NO	Inner Alps/ Springs/ <10 km/ Not applicable/ NO/ NO
Piave	torrent	Ombretta - Pettorina	456	natural	Ombretta's dam	River Cordevole	03.SR.6.N.NO.NO	Inner Alps/ Springs/ <10 km/ Not applicable/ NO/ NO
Piave	torrent	Rova	441	natural	spring	dam	03.SR.6.N.NO.NO	Inner Alps/ Springs/ <10 km/ Not applicable/ NO/ NO

RIVER BASIN	CHANNEL TYPE	NAME	CODE	TYPE	FROM	TO	TYPE CODE	HER/ ORIGIN – PERSISTENCE/ DISTANCE – MORPHOLOGY/ BASIN INFLUENCE/ DISPERSIVE/ BRAIDED
Piave	torrent	Rova	441	natural	dam	River Cordevole	03.SR.6.N.NO.NO	Inner Alps/ Springs/ <10 km/ Not applicable/ NO/ NO
Piave	torrent	Sarzana	440	natural	channel beginning	River Cordevole	03.SS.1.N.NO.NO	Inner Alps/ Surface run flow/ <5 km/ Not applicable/ NO/ NO
Piave	rivulet	Setraza	458	natural	channel beginning	River Cordevole	03.SS.1.N.NO.NO	Inner Alps/ Surface run flow/ <5 km/ Not applicable/ NO/ NO
Piave	torrent	Tegnas	443	natural	spring	River Cordevole	03.SR.6.N.NO.NO	Inner Alps/ Springs/ <10 km/ Not applicable/ NO/ NO
Piave	rivulet	Val Fresca – Valle Imperina	437	natural	spring	River Cordevole	03.SR.6.N.NO.NO	Inner Alps/ Springs/ <10 km/ Not applicable/ NO/ NO
Piave		Valle del Vescovà	435	natural	spring	River Cordevole	03.SR.6.N.NO.NO	Inner Alps/ Springs/ <10 km/ Not applicable/ NO/ NO

2. Plans and management programs

2.1 Existing management plans and application rules

2.1.1 The Regional Territorial Plan of Coordination (PTRC) of Veneto Region

The PTRC of Veneto Region defines the regional policies oriented to achieve a balanced general environmental leading, together with the productive, and the "social" destination of land resources. The predicted balance must therefore be achieved by:

- soil conservation and safety of settlements through active prevention of hydrogeological disorder and reconstruction of degraded areas
- pollution control of primary resources (air, water, soil)
- the protection and conservation of natural or near-natural environments (flora and fauna resources, geology, wetlands, etc.)
- protection and enhancement of historical-cultural heritage (historical centres, isolated monuments, documents, culture, Veneto history and tradition, rural landscapes, infrastructure and historic 'signs')
- enhancement of agricultural areas, including their fundamental role in balance and environmental protection.

In particular, in the field of environmental remediation and water pollution protection, the PTRC has the following objectives:

- protecting the sources of drinking water supply
- minimizing the production and the movement of environmental pollutants.

2.1.2 The General Plan of Waterworks (PRGA) of Veneto Region

In synthesis this plan prescribes:

- general use of groundwater, with the abandonment of surface water, kept only in small quantities to meet peak seasonal needs, especially in areas of predominantly tourist function
- rationalization of the sources already used in mountainous areas, with reserve solely for water distribution of precious water resources currently used for irrigation or industrial use and with the usage of sources not used
- rationalization of the structural and management aspects by identifying Bodies of water distribution in optimal size, based on technical and managerial considerations of the most relevant and significant parameters.

2.1.3 The Regional Plan of Drainage Water (PRRA) of Veneto Region

The strategies used by the PRRA to achieve the optimal protection degree of the aquatic environment consist in the following fundamental choices:

1. Identification, over the region territory, of homogeneous spatial sections, so defined:

- the zone of hills and mountains. It consists of the Dolomite mountains of Belluno and mountain and hill areas of various shape and origin bordering the north side of the Veneto
- the range of aquifer recharge in the foothills. It consists of alluvial fans deposited by streams outgoing from river mountain. This area, which has high permeability soils, it has the maximum contribution to feeding the underground aquifers.
- the lowlands. Downstream of the line of springs was originally a myriad of ditches that are only partially fed streams from upstream, mostly enclosed by embankments, while giving home to many small waterways are characterized by a significant permanence of flow rates and, at least at the source, a good water quality.
- the coastal zone, represented by the mouths of the rivers and link channels.

2. Splitting the region into homogeneous areas characterized by different levels of protection, on the basis of vulnerability of water bodies, of them use and of the hydrographic and of the geomorphological characteristics and of land settlement. Homogeneous regions are so identified:

- the mountain foothills and mountains zones, including the mountains of the whole province of Belluno and the northern areas the provinces of Treviso, Padua, Vicenza and Verona, this homogeneous zone is characterized by low population density, by limited industrial settlements, a rich and distributed hydrographic network, with morphological characteristics of river beds profiles which generally favour a good oxygenation of the water
- the range of groundwater recharge, located between the south mountain area and the range of springs, that area, formed by powerful alluvial fans consist mainly of coarse materials deposited by rivers edge of the mountain basin. For this peculiar morphological structure, this zone is a large reservoir of water which feeds the underground water in the plain below, and through the springs, several streams. On the one hand, the high permeability of land without great risk of contamination - particularly from conservative pollutants – of groundwater bodies with grave harm due to many uses, including drinking water, existing and projected. On the other, especially the high concentration of industrial settlements makes this risk very real and present. However, there are some areas marked by the presence of less permeable soils and defined low risk
- the lowlands extending from the end of the springs zone to the coast, including one part the major urban centres, and the other with purely agricultural vocation, like the territories of Eastern Veneto. The lowlands are characterized by a very dense river network of natural and articulate waterways, drainage and irrigation channels, where the man work has significantly altered the natural regime of outflows in the purpose, not always achieved, to optimize the use of the resource. These interventions, and the intensive uses which are subject, make the courses particularly exposed to concentrated plain water discharges and could not have massive or high dilution or elimination capacity or hydrodynamic conditions suitable for natural pollution residual elimination. Precisely because of these features, it seemed appropriate to divide the strip into two areas characterized by different densities of settlements and establishing the threshold value to 600 equivalent inhabitants per square kilometre
- the coastal area between the coastline and a conventional fixed border. The identification of this range is justified for the vulnerability of the delicate trophic balance of High Adriatic coastal waters. These characteristics are exacerbated by the high settlements concentration in the tourist strip.

3. Differentiation of treatment degree, as a function of plant potential and of the location of the discharge. In application of the criterion of territory division into homogeneous groups, the PRRA adopt the principle of diversification of treatment degree, as a function of plant potential and of the location of the discharge. In essence, the limits of acceptability of the discharge of public sewers and civil settlements not discharging into public sewers shall be based on tables for different groups according to the size and homogeneous population served in terms of population equivalents, requiring different values, even taking into account the prevailing use of the resource. Finally, the plan takes into account special requirements related to the ability of self-purification and dilution of the receiving water. The entire region is divided into 52 aggregates, which are grouped into best geographical areas. For each aggregate, the plan shows the position of existing structures and the proposal solution, which in some cases provides variants with different levels of aggregation. Assuming that a proper evaluation impact of a discharge in a water body must take into account on one hand the total amount of receptor-dependent part of pollutant and the degree of treatment of the used water. The Plan articulates the different levels of sewage treatment.

4. General guidelines for the discharge of purified sewage waters. The sewage effluent treatment is not limited to the treatment process. The self-purification or possible residual accumulation depend strongly on the hydrological regime of the recipient. The legislation aims to adapt to these concepts, in particular prohibiting direct discharges into the subsoil and lakes. and taking particularly caution in the case of watercourses designed to drinking use. It also sets a dilution limit of sewage water discharge which takes into account the natural resilience of the watercourse. However the legislation allows exceeding the limit for particular substances (sulphates and chlorides) if the water receptor of conditions still retain their existing uses.

2.1.4 The Provincial Spatial Plan in the Province of Belluno

On the issue of quality of flowing water, it is highlighted that the main cause of pollution is to be found in the production waste type, while for cases of diffuse but low pollution, the predominantly cause has to be found in the presence of an anthrop overload, mainly represented by the tourism component. Considering that, it is recognized that there is the need to:

- enable an integrated water system, under Law 36/94 on planning and management of various aspects of water resources;
- to formulate the Provincial Plan for areas, concerning organically the use of water resources and the quality protection, also in agreement with the Basin Authority.
- to pursue indications of PRRA , as a necessary but not sufficient condition for improving the situation;
- to pursue the proper conduct of human activities in accordance with the rules and regulations.

The programming report highlights how the supply situation and use of water resources are problematic with shortcomings in health and drinking water facilities, and with very weak primary distribution that do not meet the user needs. The draft plan calls the formulation of a Provincial sector plan including:

- the allocation of a cognitive framework sufficient to ensure the correct use the resource, including the study of a provincial geological system, the minimum environmental flow, the private supplies census;
- the minimum size of the releases to ensure downstream consistent water abstractions, consistent with the equilibrium of ecosystems and able to ensure an adequate self-purification of streams;
- definition of upgraded and / or strengthening of supply water networks and priorities for action on the waterworks net;
- proposed adjustment and standardization of regulations and charges;
- the census and the testing of the intake works;
- the land-use and non-potable water resources;
- revision of PRRA with adherence to specific issues and specific county.

The PTP provides the specific plan area on the Provincial integrated water system under Law 36/94, which are defined as follows:

- to maintain levels in the basins;
- the security measures in reservoirs;
- measures to reduce bank erosion due to abstraction plants;
- criteria for the use of materials accumulated in the dams as an alternative to excavations along the riverbeds.

2.1.5 National and Regional Energy Plan

An important objective of PEN is the improvement of environmental conditions of use of energy, obtained in agreement with the energy policy of the EEC, through, inter alia, the use of renewable sources. In this sense, the Regional Energy Plan, actuator instrument of PEN, according to law 10/1991, proposes, as regards hydropower, the realization of a series of average hydroelectric power, already part of the ENEL programming, and other low-power, already at that time included in the programs of Reclamation Consortia.

2.1.6 Belluno Dolomites National Park Plan

The Plan for the National Park of Belluno Dolomites aims to ensure the preservation, protection and enhancement of natural heritage values, environmental cultural and cultivation in the territory of Belluno Dolomites. The Plan aims eventually to create suitable conditions for promoting economic activities compatible with the primary goals of protecting natural resources and environment in the park and in neighbouring areas The Plan period is ten years. "The Plan has a landscape value, as defined in conformity with the effects of Law 431/85. The Plan will automatically replace the requirements and the constraints of the Regional Territorial Coordination Plan of the Region Veneto and Territorial Plan of the Province of Belluno and its requirements are also prevalent than any other provision of existing industry plan, regional and provincial, less restrictive for environmental protection and nature than the standard plan for park.

2.1.7 Regional Water Protection Plan

The water protection plan includes the following three main sections:

- State of the art: it summarizes the knowledge base and includes an analysis of critical situations for surface water and underground water, for the hydrologic and hydrographic river basins.

- Plan Proposal: it contains the identification of quality objects, general measures and specific actions planned to achieve them. It includes also the appointment of sensitive areas, areas vulnerable to nitrate and plant protection products, the areas subject to soil degradation and desertification.
- Technical Regulations for Implementation: contains the regulation of discharges, the discipline for areas requiring specific measures to prevent pollution and sanitation, such as guidelines for environmental protection and water saving.

2.2 Monitoring Programs

2.2.1 Year 1996-1998: Experiments on Cordevole aimed at definition of minimum environmental flow

The definition of criteria for evaluating the minimum environmental flow, vital for water courses, as repeatedly stressed by the legislation, is task of the River Basin Authority (Law 183/89). The river basin authority of Isonzo, Tagliamento, Livenza, Piave has always considered that, in addressing this problem, it should still be kept in appropriate consideration some traits of river environments, in particular those characterized by a particular environmental value and those more sensitive, as well as those sections where the medium to long-term preservation of biotic aquatic species of environmental value is not reasonably sustainable, either for natural reasons and for the presence of particular works or human activities already present For these traits it is clearly needed to quantify ad hoc the value of the minimum instream flow, or simply the appropriate assessment of an appropriate reductive factor for the minimum value of environmental flow calculated at the river catchment scale. The Basin Authority has therefore identified in agreement with the Veneto Region, the possibility of a trial on the Cordevole river basin in order "to conduct a hydrobiological study. The results will provide useful information for the quantification of outflow in the monitored reaches, but also allow comparisons and choices for other reaches inside the river basin. This experiment consisted in the release, downstream of abstractions, of a constant quantity of water and making a series of measures and studies to test the behaviour of hydrological, hydrogeological and environmental aspects of the watercourse concerned, before, during and after the releases themselves.

3. Water uses

The resident population within the basin amounts to about 35,000 people, but there is a strong tourist pressure on land, both during winter and in summer months.
Part of the territory of the basin is comprised within the National Park of Belluno Dolomites and there are many areas of nature and landscape regional interest.
Across the valley there is also an intense fishing activity, made by the residents (more than 1000 members in that the association which manages the fishing area) and tourists.
In addition to sanitation, tourism and recreational and environmental usage of Cordevole water resources, there is also a wide use for hydropower purpose, which superimposes an artificial water network to the natural one. This network is characterized by four main dams of the river and many abstractions structures on smaller tributaries. The disciplinary award, in most cases 50-60 years old, do not provide any obligation for the respect and the maintenance of minimum instream flows. Therefore, during low water training, the flow downstream of the dam and of the intake is almost nothing.

3.1 Hydropower exploitation

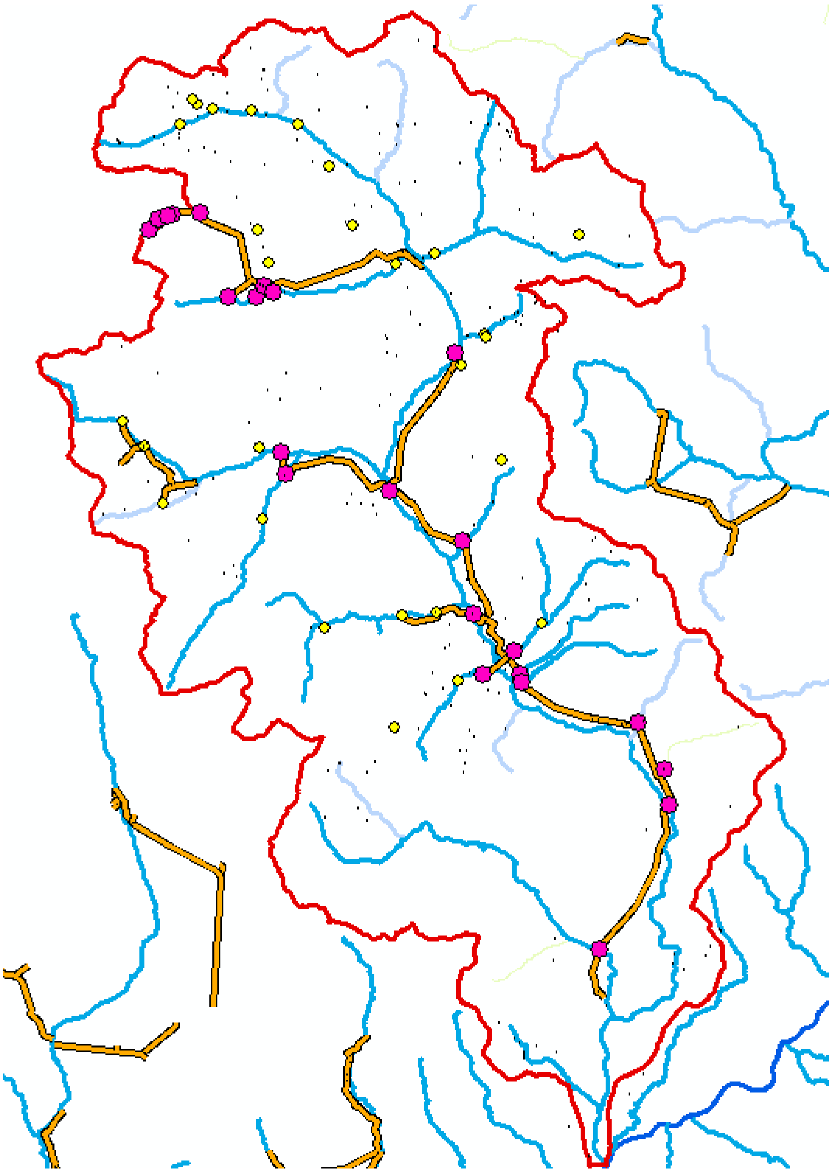

Figure 60: Hydropower plant abstractions and ENEL network.

In the Figure is presented an overview of the water abstractions for hydropower purposes within the Cordevole river basin. The big pink spots • indicate big abstractions, while the small yellow spots • indicate small abstractions. The orange line stands for the ENEL power production network.

Inside the Cordevole river basin there are the following hydro reservoirs (Table 34).

Table 34: ENEL hydro reservoirs

IMPOUNDING RESERVOIRS	MAX WATER LEVEL	DIRECT CATCHMENT AREA KM^2	EXPLOITABLE CAPACITY CU. M (MILIONS)
Fedaia	2053	5.6	16.2
Mis	427	108	35.8
MODULATING RESERVOIRS	MAX WATER LEVEL	DIRECT CATCHMENT AREA KM^2	EXPLOITABLE CAPACITY CU. M (MILIONS)
Malga Ciapela	1466	8.1	0.0
Alleghe	986.3	245	2.7
Ghirlo	751	419	0.1

The main hydroelectric power plant are reported in Table 35.

Table 35: ENEL hydroelectric power plants

STATIONS	HEAD [M]	MAXIMUM EXPLOITABLE DISCHARGE [M^3/S]	GROSS OUTPUT [MW]	MEAN ANNUAL ENERGY [GWH]
Malga Ciapela 1	587	4.1	19.5	14
Malga Ciapela 2	338	0.2	0.5	1
Saviner	457	3.5	13.0	31
Cavia 1	564	0.7	3.0	5
Cavia 2	213	0.6	1.0	3
Molino	358	0.9	2.7	12
Cencenighe	217	17.0	27.0	103
Agordo	156	24.0	24.0	96
Taibon	60	3.2	1.4	7
La Stanga	166	25.0	29.5	133
Sospirolo	94	52.5	40.0	101

For what concerns the Rio Cordon stream, which will be the object of MCA application, we have only a mini-hydro power plant, installed and managed by Consorzio BIM GSP S.p.A., which is a subsidiary company created by 67 Municipalities of the Belluno Province. This HP plant is placed at the altitude of 1638.70 m a.s.l., while the power plant is placed at the altitude of 1468.00 m a.s.l.. The difference in height at disposal for energy production is therefore 170.70 m. The maximum discharge that can be withdrawn is 0.195 m^3/s, the medium is 0.115 m^3/s. Consequently, the maximum plant power is 238 kW, and the medium is 191 kW. The annual production potential is 1’150’000 kWh.

Figure 61: Hydropower plant on which the MCA method will be applied.

3.2 Farming

As it happens in the rest of the Alpine Region, farming activities have a poor structure, typical of mountain zones. In the upper Agordino zone, the role of agriculture is significant in terms of active farms, and it is fundamental for environment and landscape protection, characterized by wide meadows and pastures.

Main activities are related to cattle and sheep farms, with milk and cheese production.

A particular role is covered by wood production, shared by public and private business.

Beside apples cultivation, the production of little fruit, like strawberries, cranberries, blackberries and raspberries is developing fast. Also wine production is growing. Other little activities concern beans, potatoes, cabbages and nuts.

However, no relevant water withdrawals for farming activities are present inside the Cordevole river basin.

3.3 Factory

An important eyeglasses factory is located at Agordo. The rest of the Cordevole river basin is characterized by little and local industrial activities, most of which are linked to the wood industry or to the textile sector. No relevant water withdrawals for industrial activities are present inside the Cordevole river basin.

3.4 Waste discharge

In the following Table, the list of the waste water treatment plants is reported, specifying the conurbation dimensions and the design plant capacity.

Table 36: Waste water plants inside the Cordevole river basin

CONURBATION	DIMENSION	WASTE WATER PLANT	DESIGN CAPACITY	RECEPTOR RIVER
Arabba - Renaz	1987	Livinallongo del Col di lana	2000	Cordevole
Cencenighe Agordino	2413	Cencenighe Agordino - Morbiach	2100	Cordevole
La Valle Agordina	7834	La Valle Agordina – Le Campe	6500	Cordevole
Mas	2774	Sedico – Mastella - Mas	2000	Cordevole
Meano	1894	Santa Giustina - Meano	1500	Cordevole
Sedico	7938	Sedico - Oselete	4000	Cordevole
Sedico	7938	Sedico - Meli	1200	Cordevole
Valcozzena	1106	Agordo - Valcozzena	2000	Cordevole

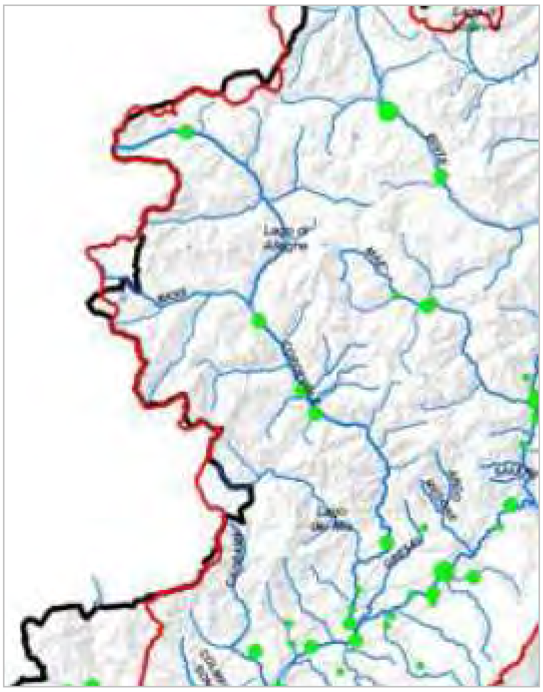

Figure 62: Map of waste water plants inside the Cordevole river basin

3.5 Drinking water

Drinking water is directly taken from springs. There are no water withdrawals from water bodies for drinking purposes.

3.6 Touristic fruition

Water withdrawals linked to touristic activities mainly concern artificial snowing. However, no direct water withdrawal from surface water bodies is present inside the Cordevole river basin.

4. Pressure and impacts related to water uses

Pressure and impacts related to water uses are described in the previous chapter, where the productive activities and their weight on water bodies are summarized.
Other impacts are due to dumps presence, as it can be seen in the next Figure.

Figure 593: Map of dumps inside the Cordevole river basin

An important pressure factor is represented by morphological changes du to anthropic activities, first of all the building of big water reservoirs for electricity production. The reservoirs presence has caused a generalized sediments lack all over the basin, with the consequence erosion process and riverbed lowering.
In the following Table, the risk assessment for the Cordevole river basin is shown. The columns 2 to 7 have the following meaning:

- Hydro: indicates how much the water body is affected by water withdrawal (1 low – 5 high)
- Dams: indicates dam's presence in the considered reach (1 absent – 5 present)
- Works: indicates the presence of flow regulation works, with respect to reach length (1 few – 5 numerous)
- Barrages: indicates the presence of transversal structures like check dams or sills, with respect to reach length (1 few – 5 numerous)
- IMA class: IMA is a synthetic indicator of the water body artificiality level, which values range from 1 (no anthropic alterations) to 5 (diffuse anthropic alterations). An IMA class is linked to every value 1 → -3, 2 → -2, 3 → 0, 4 → 4, 5 → 5
- Riparian strip class: The riparian strip is an indicator of the development and the continuity of the riparian strip vegetation, which values range from 1 (no anthropic alterations) to 5 (diffuse anthropic alterations). The corresponding class is linked to every value 1 → -3, 2 → -2, 3 → 0, 4 → 4, 5 → 5

Table 37: Risk assessment for river Cordevole and its main tributaries.

RIVER	HYDRO	DAMS	WORKS	BARRAGES	IMA CLASS	RIPARIAN STRIP CLASS	FROM	TO	HYDRO MORPHO LOGIC RISK	HYDRIC RISK	LATERAL H. R.	LONGITUDINAL H. R.	RIPARIAN STRIP RISK
Biois	1	1	1	1	-3	-3	Beginning	Zingheni's lake	NR				
Biois	5	1	1	1	-3	-3	Zingheni's lake	Type change (Rio Valles confluence)	PR	x			
Biois	1	1	1	1	-3	-2	Type change (Rio Valles confluence)	Hydropower abstraction	NR				
Biois	5	1	1	2	-2	-2	Hydropower abstraction	River Cordevole	PR	x			
Bordina	1	1	1	1	-3	-3	Spring	River Cordevole	NR				
Cordevole	5	1	1	3	-2	-2	Spring	Type change (Rio Setraza confluence)	NR				
Cordevole	3	1	1	1	-2	-2	Type change (Rio Setraza confluence)	Alleghe's lake	NR				
Cordevole	5	1	1	2	-2	-2	Alleghe's lake	Cencenighe's lake	PR	x		x	
Cordevole	5	5	1	1	-3	-2	Cencenighe's lake	Type change (Rio Muda confluence)	R				
Cordevole	1	1	1	1	-3	-3	Type change (Rio Muda confluence)	La Stanga's dam	NR	x		x	
Cordevole	5	1	1	1	-3	-3	La Stanga's dam	Barrage at Pra della Varda	PR	x		x	
Cordevole	1	1	1	1	-3	-2	Barrage at Pra della Varda	River Piave	NR				
Corpassa	5	1	1	1	-3	-3	Spring	River Cordevole	NR				
Dumarana	1	1	1	1	-3	-3	Spring	River Cordevole	NR				
Fiorentina	5	1	1	3	-2	-3	Pelmo's Glacier	River Cordevole	NR				
Mis	1	1	1	1	-3	-3	Spring	Type change (Rio val dei Molini confluence)	NR				
Mis	1	1	1	1	-3	-3	Type change (Rio val dei Molini confluence)	Mis' lake	NR				
Mis	5	5	1	1	-3	-3	Mis' lake	River Cordevole	R	x		x	
Missiaga	1	1	1	1	-3	-3	Spring	River Cordevole	NR				
Ombretta - Pettorina	1	1	1	1	-3	-3	Spring	Ombretta's dam	NR				
Ombretta -	5	1	1	1	-3	-3	Ombretta's dam	River Cordevole	PR	x			

RIVER	HYDRO	DAMS	WORKS	BARRAGES	IMA CLASS	RIPARIAN STRIP CLASS	FROM	TO	HYDRO MORPHO LOGIC RISK	HYDRIC RISK	LATERAL H. R.	LONGITUDIN AL H. R.	RIPARIAN STRIP RISK
Pettorina													
Rova	1	1	1	1	-3	-3	Spring	Barrage	NR				
Rova	4	1	1	5	0	-1	Barrage	River Cordevole	PR			x	
Sarzana	5	1	1	1	-3	-3	Beginning	River Cordevole	NR				
Setraza	1	1	1	1	-3	-3	Beginning	River Cordevole	NR				
Tegnas	5	1	1	1	-3	-3	Spring	River Cordevole	NR				

5. Restoration and mitigation actions

River restoration and mitigation actions are generally recommended in the Management Plan of River Piave Basin, in which the Cordevole and all its tributaries are included. These kind of actions are indicated both for hydraulic risk reduction and for biological quality improvement. However, at the moment, no specific works are planned for the Cordevole river basin.

6. Case study sub-basin – Cordon creek

The Multicriteria Analysis was chosen to be applied to a small tributary of the Cordevole River, the Cordon creek.

6.1 Geographic & morphometric informations

The Rio Cordon watershed drains a surface of 7.75 km^2, with a mean altitude of 2075 m a.s.l. (max 2673 m a.s.l., min 1420 m a.s.l.) and a mean slope equal to 54% (Fig. 64 and Tab. 38).
Precipitations occur mainly as snowfall from November to April. Runoff is usually dominated by snowmelt in May and June but summer and early autumn floods represent a significative contribution to the flow regime. Usually late autumn, winter and early spring lack noticeable runoff events.
The Rio Cordon is a boulder bed channel featuring a step-pool morphology, giving a high stability to the bed channel for flood events with recurrence intervals (R.I.) lower than 30-40 years. The average bed surface grain size distribution is characterized by D_{50} = 0.12 m and D_{84} = 0.36 m. The mean grain size (D_m) is 0.11 m. The mean channel slope is of about 15%, but the longitudinal channel profile displays an alternation of high-gradient and low-gradient stretches.

Table 38. Main physiographic and climatic characteristics of the Rio Cordon

Catchment area	7.75 km^2
Average elevation	2075 m a.s.l.
Minimum elevation	1419 m a.s.l.
Maximum elevation	2712 m a.s.l.
Mean slope gradient	24.2°(53.7%)
Length of the main stream	4430 m
Mean gradient of the main stream	15%
Annual precipitation	1100 mm
Maximum water discharge measured	10.40 m^3 s^{-1}
Minimum water discharge measured	0.05 m^3 s^{-1}

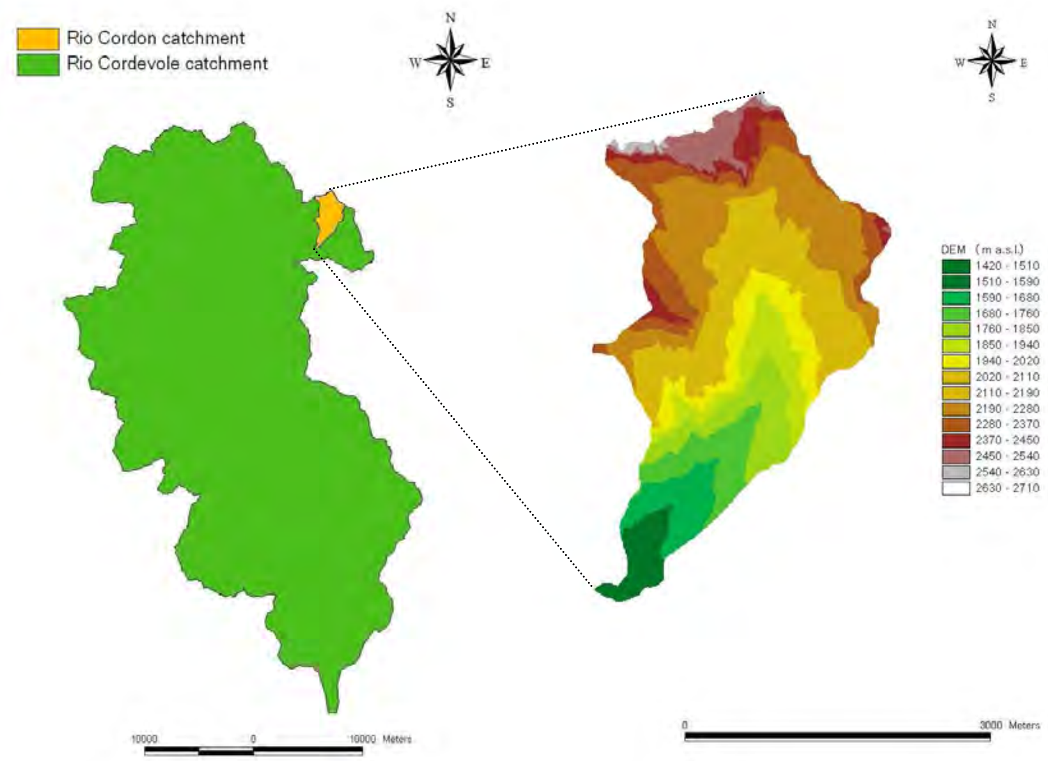

Figure 64. Rio Cordon, sub-basin of Cordevole basin; digital elevation model (*DEM*)

6.3 Channel reach; morphology and hydraulic works

The main stream can be divided into 4 sub-reaches, as function of artificial manufacts (ARPAV gauge station and BIM hydropower withdrawal and restitution points) (Fig. 65).

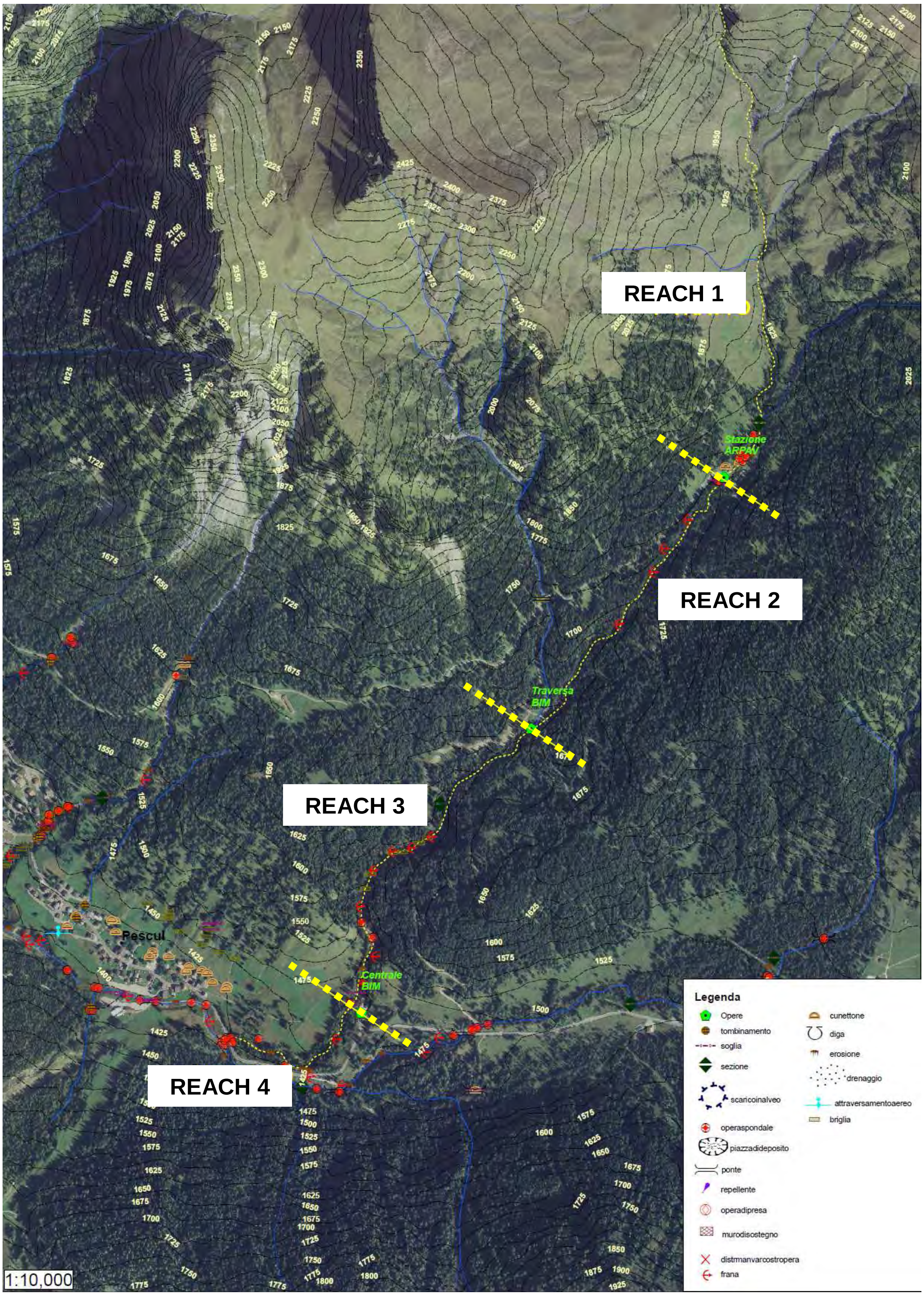

Figure 65. Rio Cordon stream: identification of 4 sub-reaches as function of artificialities breaking the natural longitudinal continuity and/of flow regime trend

The Rio Cordon is a typical steep mountain stream with specific geomorphologic features. Therefore, in order to relate the hydraulic parameters to the streambed adjustments, morphological and sedimentological surveys were carried out and led to the subdivision of the streambed into step-pool, riffle-pool and mixed reaches (Fig. 66 and 67).

Figure 66. Rio Cordon stream, upper reaches: morphological channel bed characteristics under minimum and *bakflull* water regime

Figure 67. Rio Cordon stream, lower reaches: morphological channel bed characteristics

Along the main stream, at 1760 m a.s.l., at the ending of Reach 1, on 1986 ARPAV installed a gauge station for discharge and sediment transport measuring (Fig. 68). The record of hourly liquid discharges make possible the analysis of water flow regime, sediment budgets, and the realization of discharge rating curves. The facility for measuring sediment transport operates by separating coarse bedload transport from fine sediment and water.
The station represents a remarkable discontinuity in the torrent longitudinal development. This structure could therefore be exploited for energy production.

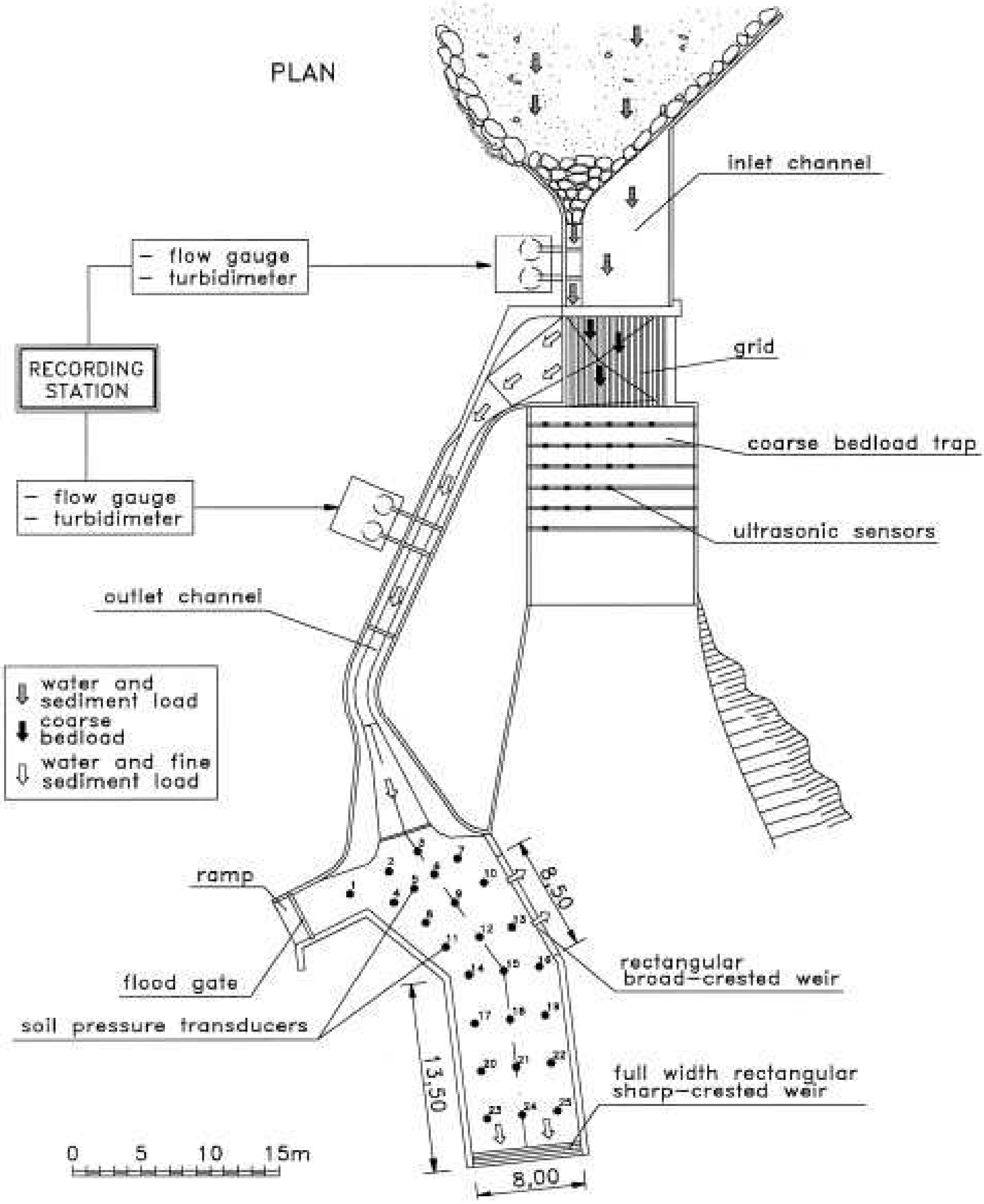
PLAN
inlet channel
- flow gauge
- turbidimeter
RECORDING STATION
grid
coarse bedload trap
- flow gauge
- turbidimeter
ultrasonic sensors
outlet channel
water and sediment load
coarse bedload
water and fine sediment load
ramp
8,50
flood gate
rectangular broad-crested weir
soil pressure transducers
13,50
full width rectangular sharp-crested weir
0 5 10 15m
8,00

Figure 68. Rio Cordon measuring station: a) Downstream view of the bedload storage, the outlet flume and the two buildings hosting instrumentations and the emergency power system; b) Upstream view of the fine sediment settling basin; c) Downstream view of the separating grid, the bedload storage area and the cable frame which host the 24 ultrasonic sensors; d) Upstream view of the bedload storage area; e) Downstream view of the inlet channel; f) Downstream view of the outlet channel. (From Mao et al., 2010)

Downstream the ARPAV station, at 1638 m a.s.l., on 2004 a small hydropower plant was built, and is managed by BIM consortium (consortium of the municipalities afferent to the upper Piave Rive basin, Belluno Province). The withdrawal points located at the altitude of 1639 m. The underlying hydrographic basin is 6.9 km^2. The water release point is at the altitude of 1468 m, for a reach length of 1190 m and an exploitable height is therefore 170.7 m (Fig. 69).

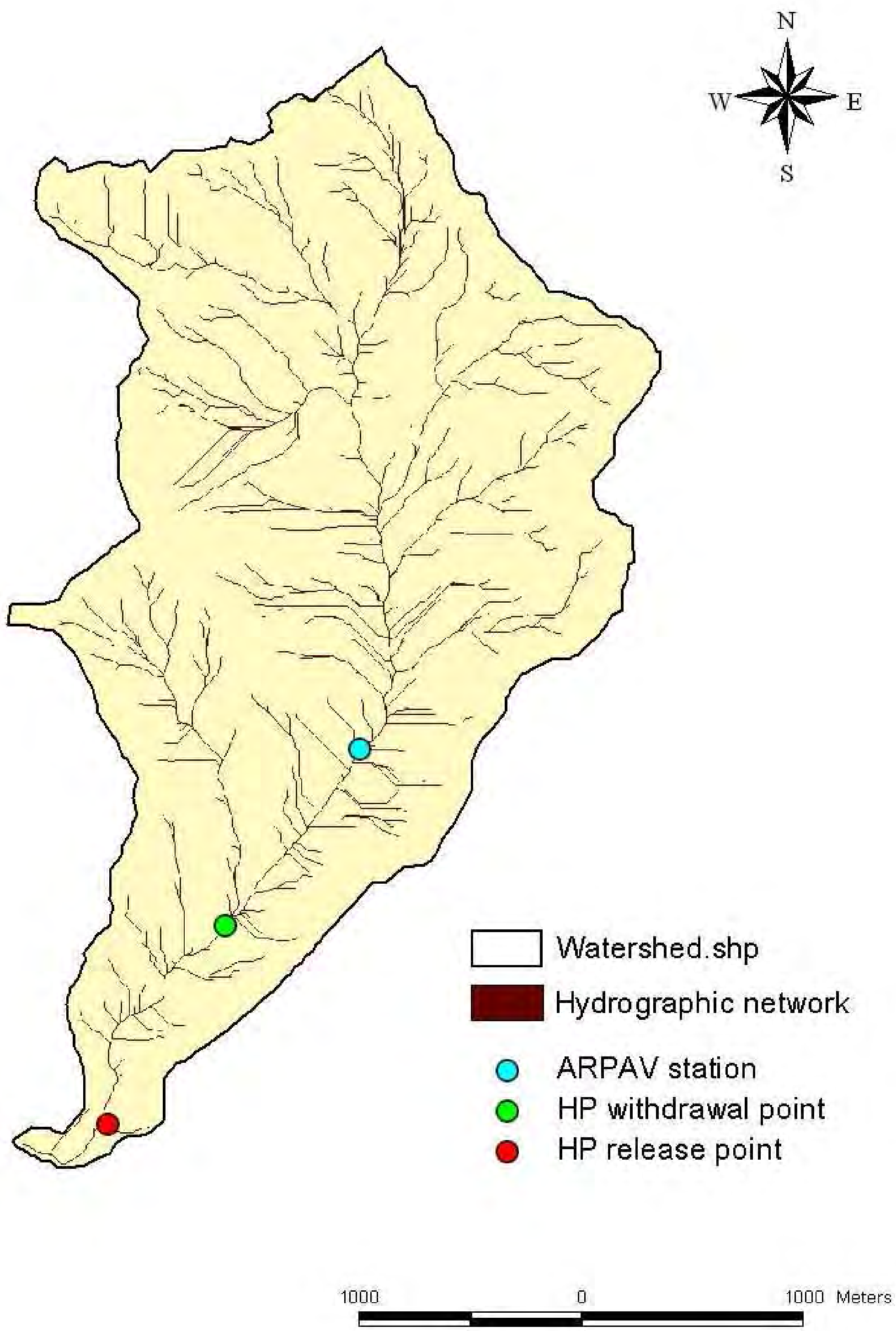

Figure 69: Cordon basin; localization of ARPAV station and of HP withdrawal and release points

The main characteristics of the HP plant installed are presented in table 39. The mean discharge conceded is of 0.115 m^3/s, while the MIF released just downstream the withdrawal point is 0.035 m^3/s.

Table 39: main characteristics of the HP plant installed along the Cordon creek

Upstream basin area	6.9 km^2
Withdrawal point	1639 m a.s.l.
Restitution point	1468 m a.s.l.
Exploitable height	170.7 m
Q max conceded	195 l/s
Q min conceded	0 l/s
Q mean conceded	115 l/s
Max Power instaled	238 kW
Min Power installed	0 kW
Mean Annual Production	1345763 kWh
MIF	35 l/s

Starting from the discharges data recorded by the ARPAV monitoring station, the specific flow contribution of Cordon basin was calculated and the value is equal to 30 l/s km^2. Such value, multiplied for the drainage basin area afferent to the withdrawal point ($A = 6.9\ km^2$) gives the value of mean annual discharge:
$Q = 220.8\ l/s = 0.2208\ m^3/s$
The Cordon stream rating curve is presented in figure 70.

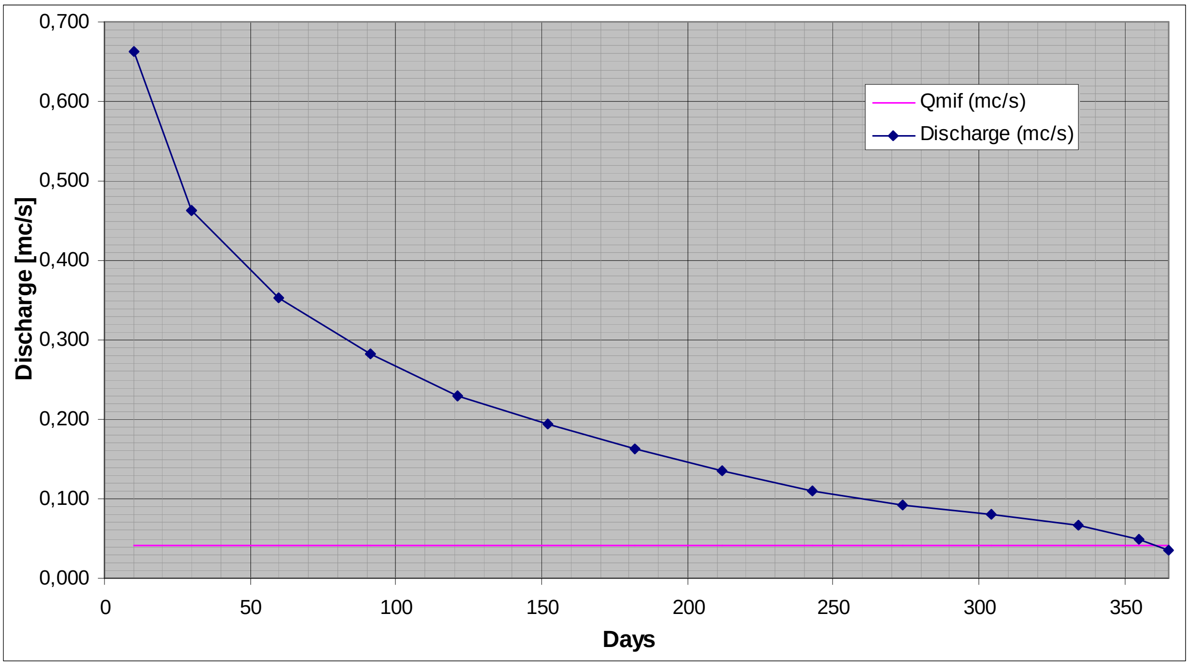

Figure 70: Cordon stream rating curve (data from: Impianto idroelettrico sul "rio Cordon" – Comune di Selva di Cadore – Relazione generale-idrologica-idraulica – 2004)

The diverted discharge rating curve is shown in figure 71. Figure 72 shows the mean discharge trend at the withdrawal point, and the diverted and released discharges during different periods of the year, compared to the minimum instream flow (MIF).

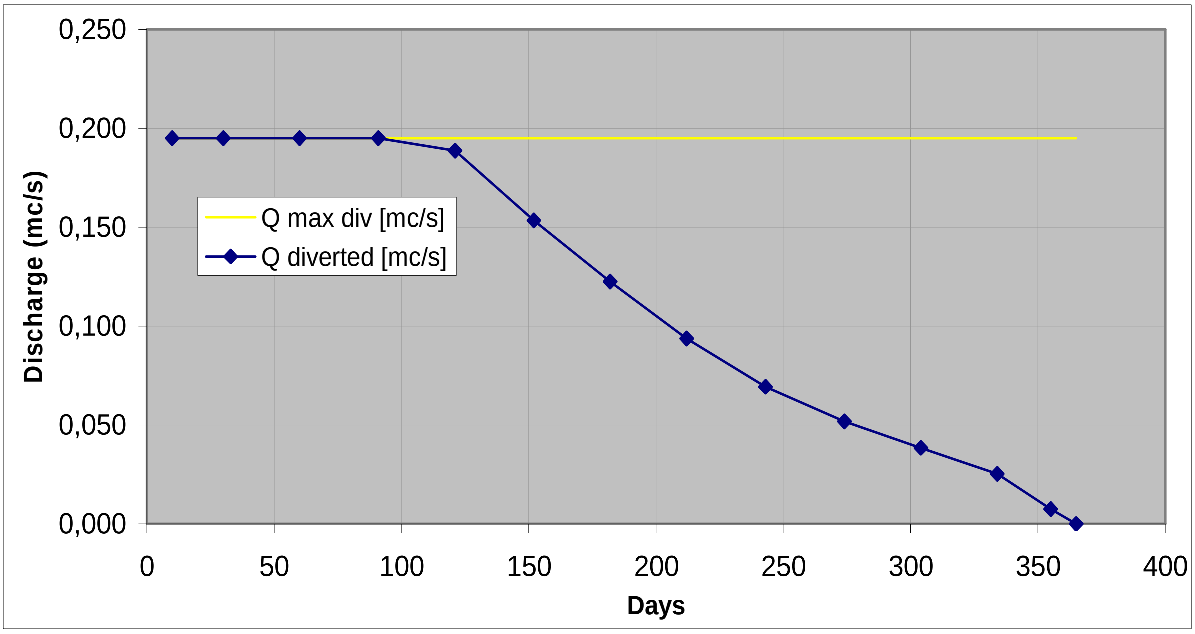

Figure 71: Cordon stream diverted discharge rating curve and maximum discharge derivable (data from: Impianto idroelettrico sul "rio Cordon" – Comune di Selva di Cadore – Relazione generale-idrologica-idraulica – 2004)

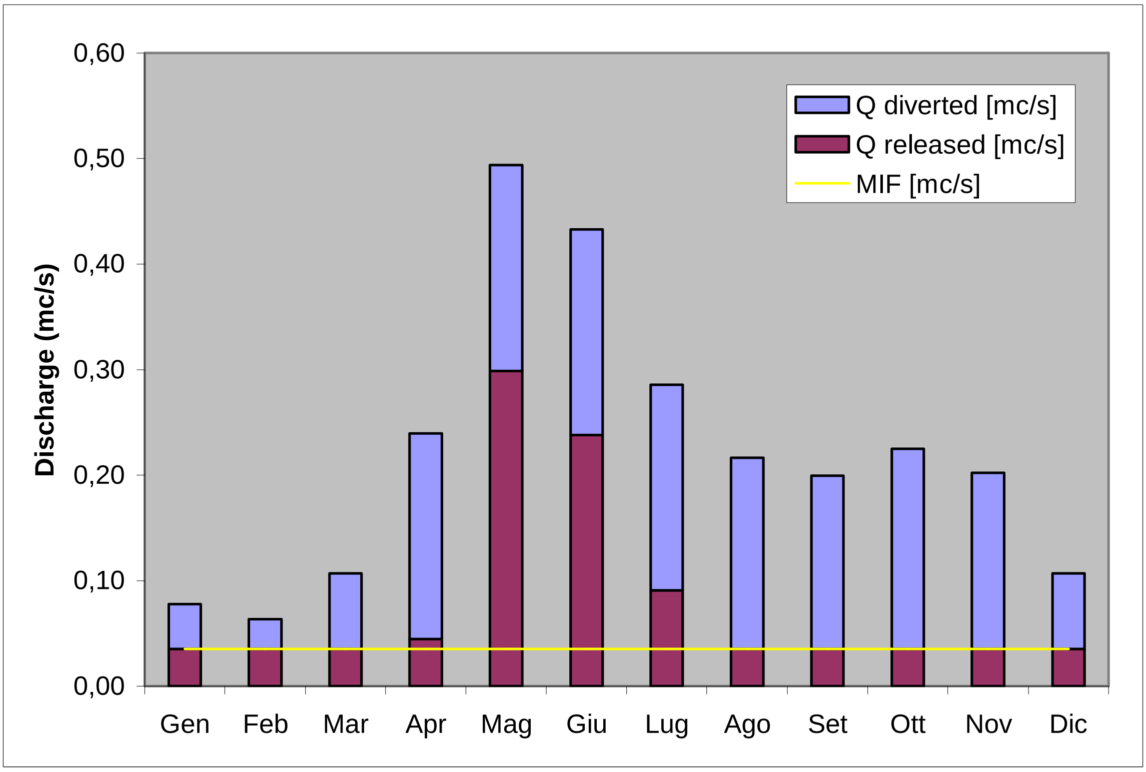

Figure 72: Cordon stream. Mean discharge trend at the withdrawal point; minimum instream flow (MIF), diverted and released discharge (data from: Impianto idroelettrico sul "rio Cordon" – Comune di Selva di Cadore – Relazione generale-idrologica-idraulica – 2004)

Figures 73-78 show the channel reach downstream the ARPAV monitoring station. Such station, even if constitutes an interruption of channel natural morphology, has not effects on the stream flow along the channel (Fig. 73). However, the channel reach downstream the withdrawal point (Fig. 75 and 76) shows an evident stream flow reduction till the restitution point (1190 m of length).

Figure 73: channel reach just downstream the ARPAV monitoring station

Figure 74: withdrawal point at 1639 m s.l.m.; small check dam and lateral channel for DMV ensurance

The reach downstream the withdrawal point is characterized by a series of check dams built in the past years (Fig. 76); such hydraulic works affect the longitudinal continuity of the channel (Fig. 77). Furthermore, some longitudinal bank protection works are located along the lower portion of the reach (Fig. 78).

Figure 75: channel reach downstream the withdrawal point

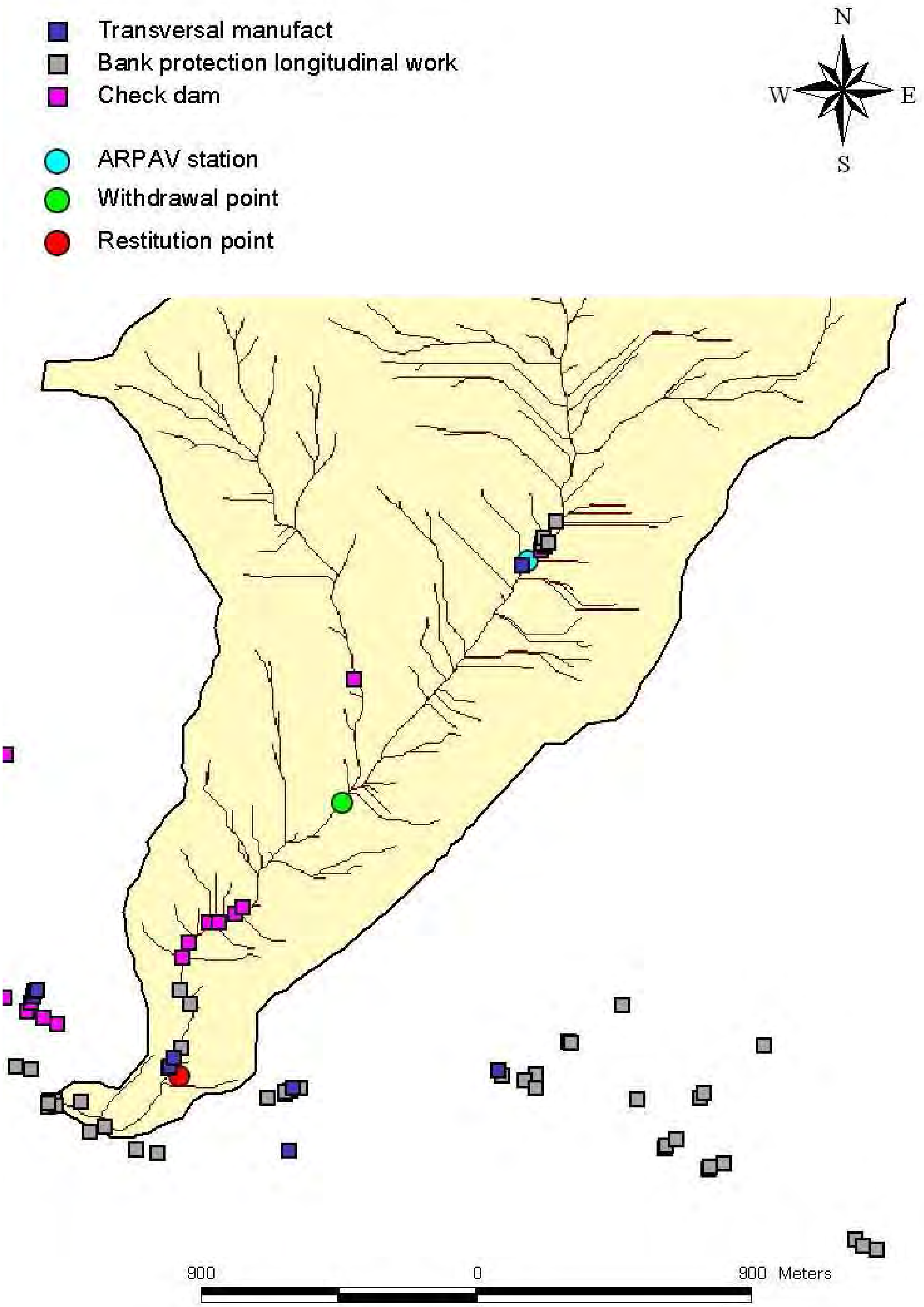

Figure 76: hydraulic works located along the Cordon stream

Figure 77: check dams along the channel reach downstream the withdrawal point

Figure 78: check dams and lateral bank protection works along the channel reach downstream the withdrawal point

The cannel reach upstream the withdrawal point (reaches 1 and 2 of figure 65) is characterized by a good naturality, with the exception of the small zone limited to the ARPAV monitoring station. Along Reach 1, in fact, there are no transversal and longitudinal hydraulic works (see Fig. 66), so the sediment transport and natural channel adjustments driven by formative discharges are assured. The morphological channel bed quality of Reach 1 and 2 can be assumed elevate. Downstream the withdrawal point (reaches 3 and 4 of figure 66), the presence of check dams (Reach 3: N = 9, along 1190 m, that is > 1 / 200 m) and of longitudinal hydraulic works (< 33% of total banks length), reduce the natural stream longitudinal and lateral continuity (connectivity between channel and hillslopes included between 33 and 90% of the reach length), thus affecting the natural sediment transport trend and the channel section adjustment processes. So, these reaches are basically characterized by a moderate/sufficient natural status, according to IDRAIM (2011) method for river morphological quality evaluation.

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