With the obtained coefficient the datum was calculated, from the balance of the mean discharge of the Mrzlek in the period (10.12 m^3/sec), of the mean discharge of the Mrzlek in the time of an individual tracing experiment (Tab. 3.8). More details are given in Chapter 6.

Tab. 3.8: The data base of the Mrzlek spring used for the estimation of the quantity of recovered tracer. Due to technical reason only in 1995 sampling from both the Mrzlek-spring in the Soča (i) and from the pumping station (v) was possible. In 1993 and 1994 only samples from the pumping station are available.

	1993	1994	1995
tracer presence: from - to	10/23 - 12/23	04/24 - 06/01	09/03 - 12/31
average concentration [mg/m^3]	0.022	0.125	0.041(i) 0.038 (v)
coefficients (k) used for the discharge estimation	1.7	0.9	1.2
average discharge Q = 10.12 · k	17.20	9.11	12.14
average discharge Q = 7.29 · k	12.39	6.56	8.75

3.2. THE WATER BALANCE OF THE TRNOVSKO-BANJŠKA PLANOTA

(J. POLAJNAR, J. PRISTOV, M. BAT, M. KOLBEZEN)

3.2.1. Introduction

By making water balance, the ratio was established between the average quantity of precipitation, evapotranspiration and water runoff into the border rivers in the area of the Trnovsko-Banjška Planota (TBP); the aim was to determine the shares of the underground drainage from the entire TBP, and of the still unknown drainage from the karstic massif into the area of the underwater spring Mrzlek.

The water balance of the TBP plateau was determined for three periods.

The thirty-year water balance (1961-1990)

Following the WMO recommendations, the 30-year period, from 1961 to 1990, was to be taken into account for the study of hydrological and meteorological data over several years.

The two-year water balance (1993 - 1995)

For the period of two years the time when the tracing experiments were performed in the area of the TBP (Chapter 6) was used (November 1, 1993 to October 31, 1995).

The five-year water balance (1991 - 1995)

For the period of five years 1991 to 1995 was chosen as a comparison to the thirty-year and two-year hydrological balances.

Two methods were applied for the calculation of water balance. With the first one, the runoff was determined, from the area of the TBP to the border rivers, the Idrijca, Soča and Vipava. No separation between the surface and the underground runoffs is included. With the second method, the runoff from the karstic area of the TBP was determined. For the discussed periods both the runoff conditions in the areas with the surface runoff, and the runoff conditions in the areas with underground runoff to the surface streams were separately calculated.

3.2.2. The method of establishing water balance for the area of the TBP without separation

Following the described methods, the water balance was established for the 30-year period, from 1961 to 1990.

The starting point for establishing the water balance was the calculation of the common, surface and underground runoffs from the area of the TBP, on the basis of the data on precipitation, evapotranspiration, and the data on discharges at the gauging stations on the border rivers and their tributaries. The catchment area which was taken into account, stretches over the entire upper Soča river basin, to the confluence with the Idrijca, the contributing basin of the Soča on its right bank between Most na Soči and Solkan, the Tolminka contributing basin, the contributing basin on the right bank of the Idrijca between Podroteja and the confluence with the Soča, the contributing basins of the Bača and the Cerknica, the contributing basins of the Vipava springs in the area of the Nanos, and the contributing basin on the left bank of the Vipava, between Vipava and Miren, and the contributing basins of the Močilnik and the Branica; the entire area measures 1337.5 sq km. The foregoing area was divided into 12 contributing sub-basins of which only the sub-basin no. 2 includes the contributing area of the TBP (Fig. 3.7).

This is a part of the Soča contributing basin on the left bank, between Most na Soči and Solkan, the Idrijca contributing basin on the left bank, and the Vipava contributing basin on the right bank, between Ajdovščina and

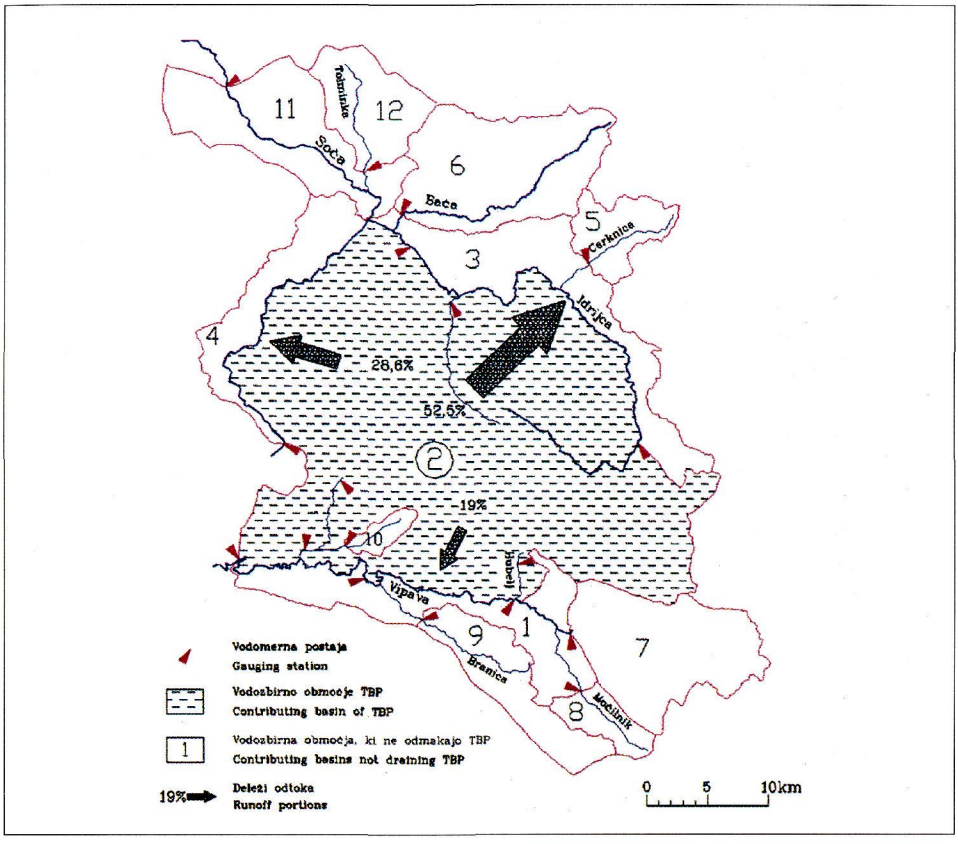

Fig. 3.7: Runoff from the TBP for the 30 years period (1961 to 1990) without distinguishing surface and underground discharge.

Miren, with 832.8 km^2. The remaining sub-basins with their contributing areas and rivers extend outside the area of the TBP; yet, their water quantities were taken into account in the establishing of water balance.

For each sub-basin the database used consisted of the mean precipitation and evapotranspiration quantities in the period, as well as the discharges at the following gauging stations (VP) on the border rivers:

Idrijca:
VP Podroteja and VP Hotešk
the Idrijca and the Soča confluence (calculated data)
tributaries: the Cerknica-VP Cerkno
the Bača-VP Bača Pri Modreju
the Trebuša-VP Dolenja Trebuša

Soča:
VP Solkan
VP Kobarid
the Idrijca and the Soča confluence (calculated data)
tributary: the Tolminka-VP Tolmin

Vipava:
VP Vipava
VP Dolenje
VP Dornberk
VP Miren
tributaries: the Močilnik-VP Podnanos
the Branica-VP Branik
the Hubelj-VP Ajdovščina
the Lijak-VP Šmihel
the Lijak-VP Volčja Draga
the Vogršček-VP Bezovljak

For the sub-basins without gauging stations, the mean discharges (sQs) of the period were calculated by discharge coefficients. With this method, the underground runoff is not separate from the surface runoff. Only the ratio was established between the precipitation and the run off water from the wider area of the TBP. By eliminating the discharges from the contributing sub-basins outside the TBP, also the runoff from this plateau was determined.

Following the foregoing method, the result was obtained for the wider area of the TBP; i.e., 34.92 m^3 of water was discharged per second, on average, from the wider area of the TBP during the period of thirty years:

$$sQs_{(TBP)} = sQs_{(\text{discharge to the Idrijca})} + sQs_{(\text{discharge to the Soča})} + sQs_{(\text{discharge to the Vipava})}$$

$$sQs_{(TBP)} = 17.72\ m^3/sec + 10.57\ m^3/sec + 6.63\ m^3/sec$$

$$sQs_{(TBP)} = 34.92\ m^3/sec$$

The major share, i.e. 52.5 % into the Idrijca, 28.5 % into the Soča, and 19 % into the Vipava. The runoff coefficient for the hydrologically diverse area amounts to K = 0.57. The specific runoff of the thirty-year period amounts to 41.8 l/sec/km^2.

3.2.3. The method of establishing water balance for the area of the TBP with the underground drainage

The purpose of the second part of the water balance of the TBP was to obtain the underground runoff. By applying the method of gradual elimination of contributing sub-basins with the surface runoff, the runoff from the karstic

contributing sub-basin, characterised by almost exclusively underground drainage, was calculated. Besides, the assessment was also made, of the discharge in the area of the underwater spring Mrzlek. This is the lowest lying karstic spring in the area of the springs at the western rims of the TBP where, hypothetically, the basic runoff from the karstic massif comes to the surface. The water balance and the assessment of discharge in the spring area of the Mrzlek were calculated by applying the described method, for the thirty-year, five-year and two-year periods.

The area of the TBP was divided in detail to the sub-basins with the surface runoff and with the underground runoff. The karstic sub-basin with the underground runoff comprises the central part of the TBP with the major karstic springs: the Hubelj, Lijak, Mrzlek, the Podroteja karstic springs, and the Divje Jezero, and measures 348.5 km^2 (sub-basin 108, Fig. 3.8).

The mean discharge of the period from this sub-basin was calculated by applying the data on the mean precipitation quantities for the discussed periods (30 years, 5 years, 2 years) and the mean quantity of evapotranspiration for the thirty-year period. (Tab. 3.9).

Tab. 3.9: The calculated mean discharges for the karstic area of the TBP plateau (Fig. 3.8: sub-basin 108) for the 30, the 5 and the 2 years periods.

Sub-basin 108 with the prevailing underground runoff	**30 years**	**5 years**	**2 years**
Mean discharge of the period (sQs in m^3/sec)	20.02	19.43	18.32
Specific runoff (q in l/sec/km^2)	57.45	55.75	52.56
Runoff coefficient (k)	0.74	0.73	0.72

The water from the karstic massif comes to the surface in the karstic springs of which only the following were longer under the observations: the Hubelj, the Lijak, the Podroteja springs, and the Divje Jezero. For the calculation of discharges of the Podroteja springs and the Divje Jezero, the discharge of the Idrijca from the part of its contributing basin with the surface runoff above the gauging station and the karstic springs (sub-basin 41), was deduced from the discharge of the Idrijca at the gauging station Podroteja where the underground and surface runoff are joined (see also Chapter 3.1).

From the assessment of discharges of the remaining karstic springs, the strongest of which is the underwater spring Mrzlek, the gauged mean discharges of the foregoing springs were deduced from the mean discharges from the karstic massif (sub-basin 108).

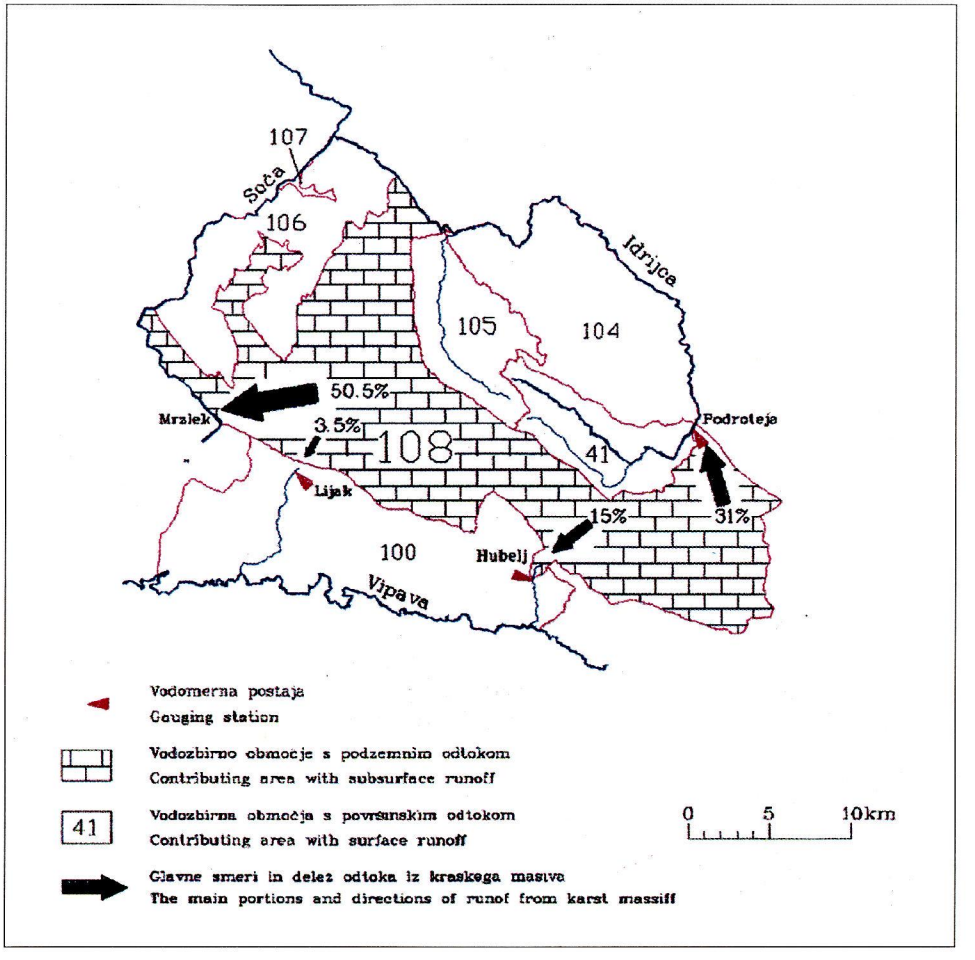

Fig. 3.8: Runoff from the karst region of the TBP for the 30 years period (1961 to 1990).

The difference is supposed to flow mainly into the Soča in the area of the underwater spring Mrzlek, and partly also with the other springs on the left bank of the Soča, between Most na Soči and Solkan:

$$sQs_{Mrzlek} = sQs_{\text{contributing sub-basin 108}} - sQs_{Hubelj} - sQs_{Podroteja} - sQs_{Lijak}$$

The calculated discharges in the area of the Mrzlek spring are only an assessment of the actual discharges in the underwater spring (Tab. 3.10).

Tab. 3.10: The calculated mean discharges for the catchment area of the Mrzlek spring for the 30, the 5 and the 2 years periods.

	30 years	5 years	2 years
Contributing sub-basin 108 with the prevailing underground runoff (sQs in m^3/sec)	20.02	19.43	18.32
Mrzlek spring area (sQs in m^3/sec)	10.12	9.80	7.29

In the 30-year and 5-year periods, the water from the karstic underground of the TBP was discharged as follows: a half of it to the Soča, one third to the Idrijca, and one fifth to the Vipava. While in the last two years, i.e. in the time of performing tracing experiments, 40 % was discharged to the Soča, 36 % to the Idrijca, and 24 % to the Vipava.

The water balance for the 30-year period was established by applying both the described methods. Following the first one (without separation), the data on the gauged discharges were made use of for the contributing sub-basins with the gauging stations, and following the second method, the data were applied, on the discharges that had been calculated by making use of the precipitation and evapotranspiration data.

Established was the average difference of 15 % between the gauged and calculated mean discharges of the period in individual contributing sub-basins. The theoretical discharge is by 15 % higher, on the average, than the gauged discharge.

In case that the values of the calculated mean discharges of the period in the sub-basin with the underground runoff (sub-basin 108) are reduced by the foregoing 15 %, the mean discharges of the period in the Mrzlek spring area amount: 7.10 m^3/sec for the thirty-year period, 6.9 m^3/sec for the five-year period, and 4.54 m^3/sec for the two-year period.

3.2.4. Conclusions

The results of water balance on the TBP show the main directions and the shares of the underground runoff. In the periods longer than two years, the greatest share of water from the karstic underground is discharged to the Soča, less to the Idrijca, and the least to the Vipava. The majority of the underground runoff gravitates westwards to the spring Mrzlek, which indicates the location and inclination of the impermeable basis (see Chapter 2.6) where the greatest part of basic runoff flows along the flysch depression into the Soča.