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WORKING DESIGN

Amendment under Art. 154 according to the Spatial Development Act
SITE: "INCREASING THE HYDRAULIC CONDUCTIVITY OF R. TSAPAREVSKA ON THE TERRITORY OF THE VILLAGE OF MIKREVO, TOTAL. FLOWED BY INNOVATIVE METHODS FOR WATER MANAGEMENT (GEOCELLS) "

ASSIGNOR: MUNICIPALITY OF STRUMYANI

CONTRACTOR: GEOCONSTRUKT LTD.

PART: HYDROLOGICAL REPORT

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2019

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1. Objectives of the study

The purpose of this engineering and hydrological development is to establish the hydrological characteristics of the Tsaparevska River in the section of the village of Mikrevo in connection with a project for cleaning and correction of the river within the village of Mikrevo, Strumyani Municipality.

2. Data and materials used

During the development of the report the requirements for the Water Act and under the normative acts to it have been observed, as they have been used.

• Available hydrological and climatic data;

• The existing methodological guidelines contained in the reference literature, incl. Manuals, methodological manuals and scientific publications;

• The data for hydrometric and hydrometeorological stations are used by the Hydrological Handbook of the Rivers of the Republic of Bulgaria, published by the Institute of Hydrology and Meteorology at the Bulgarian Academy of Sciences from 1982-1990 and 1936-1983;

• Climate Handbook for Precipitation in Bulgaria - Publishing House of BAS 1990.

Standard and author's software is used for information processing. The hydrographic, hypsographic and other characteristics of the water source in the section from the source of the river to the mouth are established on the basis of maps in M 1: 25000 and M 1: 50000.

3. Location of the site

The correction of the Tsaparevska River is envisaged on a section of about 1200 meters, within the village of Mikrevo. The area for correction is only within the village, and the aim is to protect residential buildings from flooding due to high water overflow. In the spring of 2013, only thanks to the emergency measures taken by the Municipality of Strumyani, the exit of high waters from the riverbed was prevented.

4. General data for the Tsaparevska River

Tsaparevska River collects its waters from the Malishevska Mountain and originates from the southeastern part of Golak Peak with a height of 1502 m. The catchment in the mountainous part is fan-shaped, as in the upper part two main tributaries are formed - Goremska River and

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Tsaparevska River, which gather in a common river 2.0 km below the village of Tsaparevo. The river is a right tributary of the Stuma River and flows into it after the village of Mikrevo. The total length of the river is 22.5 km, with an average slope of 52.5 ‰. Neighboring rivers with similar characteristics of the catchment basins are the river Lebnitsa to the south and the river Sushitsa to the north.

On the Tsaparevska River there are no observations of the water levels and the flowing water quantities. Close HMSs that are monitored are:

- HMS 51510 (old № 227) on the Sushitsa River at k. 440 m near the village of Polena, discovered in 1955.
- HMS 51550 (old № 219) on the river Lebnitsa on k. 125 m near the village of Dragush, opened in 1974

5. Water catchment area and orohydrographic characteristics of the Tsaparevska River

The main orohydrographic elements of the Tsaparevska River catchment required for the hydrological survey are shown in the following table 1

Table 1

№	Characteristic	Unit	Amount
1.	Length of the river in the section	km	22.5
2.	Average slope of the river in the section	‰	35
3.	Catchment area	km^2	76.0
4.	Average water level above sea of the watter area	m	947.0
5.	Slope of the catchment area in the section	‰	26.0

6. Climatic characteristics

The nearest HMS are located in the village of Krupnik, the town of Simitli and the town of Sandanski.

The average characteristics of the main climatic characteristics such as precipitation, temperature, wind and humidity are presented in Tables 2 to 6.

Average annual precipitation amounts per month in mm

Table 2

HMS	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Yearly
Blagoevgrad	42	37	36	50	58	67	42	31	35	50	63	49	560

Sandanski	48	39	39	44	52	49	34	26	30	52	67	53	533

Average monthly and average annual air temperatures in t°C

Table 3

HMS	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Yearly
Simitly	2,5	4,7	8,5	13,7	18,3	22,0	25,0	24,8	20,5	14,5	9,3	4,6	14,0
Blagoevgrad	0,5	3,0	6,7	12,3	16,8	20,3	23,0	22,8	19,0	13,3	7,7	2,9	12,4
Sandanski	2,1	4,5	8,2	13,6	18,3	22,1	24,9	24,7	20,6	14,6	9,4	4,2	13,9

From the data in the tables, the following conclusions can be drawn regarding the climate in the region in question:

Distribution of the outflow by months for security years

Table 4

Months	P%	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	X	Yearly
Av. year	%	3,6	4,3	5,1	7,8	25,6	22,2	10,2	6,9	3,0	2,9	4,1	4,3	100
Very dry year	%	5,0	4,5	15,2	11,3	18,5	17,3	10,5	5,0	2,4	2,2	4,4	3,7	100

Average monthly and average annual precipitation amounts for representative stations

Table 5

Month	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	X	Yearly
Krupnik	70	67	73	56	46	50	58	65	44	30	31	54	664
Kresna	69	59	49	48	39	40	46	52	32	23	28	47	532
Blagoevgrad	62	50	40	39	36	50	56	58	39	29	35	50	544

Maximum 24 hour precipitation (mm)

Table 6

Rain gauge station	Ho m	Observed period Year.	$N_{cp.max}$ mm	$N_{абс.max}$ mm	Cv	Cs=	Security %			
					-	4Cv	N1%	N5%	N10%	N20%

Krupnik	600	50	42,5	72	0,31	4Cv	84	70	67	60
Kresna	350	55	36,4	66	0,35	4Cv	78	64	61	52
Blagoevgrad	410	34	36,3	68	0,32	4Cv	73	61	58	51

• The average annual precipitation height of HMS Blagoevgrad is 544 mm, of Kresna is 532 mm and of Krunik is 664 mm. Based on the relationship between precipitation and altitude, it can be estimated that for the catchment area of the Tsaparevska River, from the source to the mouth, the average altitude of which is 947 m, the average annual precipitation is 655 mm.

Figure 1

• The average annual precipitation height in the area can be determined by the formula

$P = 123,1.H^{0,2568}$, where: **(1)**

P – average annual rainfall in mm

H – altitude of the catchment in m
At a coefficient of determination 0,8663

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- Rainfall is mainly from rain
- The snow cover lasts from mid-December to mid-March
- There are two peaks in the annual rainfall - in May-June and November-December
- The minimum rainfall is in August
- The distribution of temperature by months corresponds to the nature of the distribution by months of precipitation and river runoff

7. Orohydrographic characteristics. Hydrological study

The study area falls hydrographically in the catchment area of the Struma River.

On the Struma River and its tributaries in the region, measurements are made of water levels and water quantities at many hydrometric points. Studies have shown that the runoff regime of the tributaries of the Struma in the southern part of the river is different from that of the other tributaries in the northern and western part of the catchment. For this reason, out of all 50 points, 2 were selected, through which the main runoff characteristics for the Tsaparevska River region were established. The data are presented in Table 7.

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Orohydrographic and runoff characteristics of the runoff in HMP in the Struma river valley

Table 7

№	Characteristic	Unit	Stuma, village of Razhdavitsa	Dragovishtitsa, village of Goranovtsi	Bistritsa (Svolyanska) village of Svolyano	Novoselska village of Slokoshtitsa	Eleshnitsa, village of Vaksevo	Struma, town of Boboshevo	Rilska village of Pastra	Bistritsa (Blagoevgradska) Blagoevgrad	Gradevska Gradevo village	Sushitska village of Polena	Struma village of Krupnik	Lebnica, village of Dragush	Strumeshnitsa, village of Mitino	Treklyanska village of Vranya stena	Gradevska (Elhovska) quarter Marevo
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.	HMP number old	-	201Аа	181Аб	182д	185Ав	186б	193	190	194Б	195д	227а	2020	219а	200в	442А	196в
2.	HMP number new		51700	51360	51380	51390	51410	51750	51450	51480	51500	51510	51800	51550	51580	51340	51490
3.	Length of the river to HMP	km	120,1	55,14	39,4	15,3	44	173	24,1	37,18	20,3	11,9	220,6	22,1	111,3	44	13,6
4.	Medium slope of the river	‰	13,9	19,2	33,6	50,6	130,4	-	50,3	30,8	62	-	8,8	27,4	6,4	-	98,5
5.	Catchment area	km^2	2171	819	257,1	63,5	315,2	4320	222	206,5	180	32	6777	270,5	1822	515,3	59,8
6.	Average altitude	m	884	1188	1120	1240	1058	974	1918	1467	1212	1680	973	1000	641	600	1402
7.	Average slope of the water. reg.	-	0,195	0,325	0,309	0,034	0,14	-	0,519	0,442	0,317	-	0,267	0,317	0,264	-	0,297
8.	Outflow module	$l/sec/km^2$	4,9	9,95	9,37	14,7	11,6	6,65	28,8	13,5	11	21,125	7,74	9,78	5,67	5,94	16,4
9.	River network density	km/km^2	-	-	-	-	-	-	1,48	-	-	-	-	-	-	-	-
10.	Afforestation	%	24	-	-	-	-	-	43,9	-	-	-	-	-	-	-	-
11.	Distance from the mouth or border	km	169,9	14,86	11,4	9,7	9	117	26,9	3,82	10,7	8,1	69,4	27,9	2,7	6	17,4
12.	Elevation of the point	m	502,1	570,1	553,75	611,6	528,2	371,6	858,5	421,8	492,3	472,2	260,8	96,75пх	84,13	611,24	691,97

To determine the parameters of the Tsaparevska River runoff to the water intake point, dependences are made between the runoff modulus and the average altitude of the catchment and between the coefficient of variation of the runoff and the average altitude of the catchment for the annual runoff. The runoff characteristics of the hydrometric substations that were used to compile these dependences are on the Lebnitsa River near the village of Dragush and on the Sushitsa River near the village of Polena.

Using the data in Table 7, the following dependences between the flow modulus and the coefficient are obtained. of variation and the average altitude and catchment area.

<u>**Module for the average annual outflow (figure 2)**</u>

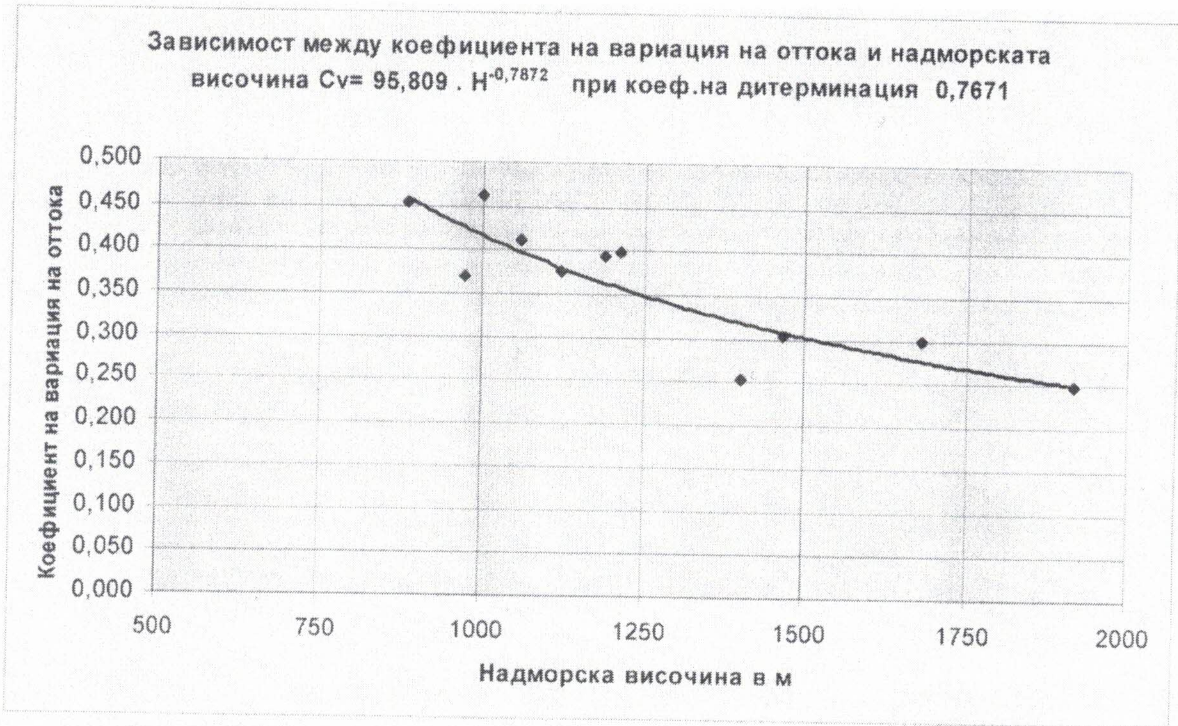
$M=2,8099.e^{0,0012.H}$, with a coefficient of determination $R^2=0,9187$ **(2)**

Figure 2

<u>**Coefficient of variation of the average annual outflow (figure 3)**</u>

$Cv=95,809.H^{-0,7872}$, with a coefficient of determination $R^2=07671$ **(2)**

Figure 3



In the formulas:

- **Mo** – outflow module in l/sec/km^2
- **H** – average altitude of the catchment in m
- **Cv** – coefficient of variation
- **Cs** – coefficient of asymmetry adopted Cs=2*Cv

Through these dependences the parameters of the runoff from the catchment area of the Tsaparevska River near the village of Mikrevo are calculated. The results are shown in the following table.

Parameters of the outflow of the Tsaparevska River near the village of Mikrevo

Table 8

№	**Parameters**	**Unit**	**Amount**	**Secur. 50%**	**Secur. 75%**
1	2	3	4	5	6
1.	Catchment area	km^2	76,0		
2.	Average altitude	m	964,0		
3.	Outflow module	l/sec/km^2	9,0	9,0	9,0

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4.	Outflow rate	l/sec		684	486
5.	Coefficient of variation	-	0,5	0,5	0,5
6.	Average year. water mass - W	mil. m^3		21,5	15,3
7.	High waters with 1% security	m^3	48		
8.	High waters with 5% security	m^3	27		

8. Selection of an analogue for modeling the outflow of the Tsaparevska River near the village of Mikrevo

To determine the nature of the outflow in annual terms, the data for all years of observations available are analyzed. Based on all available runoff data for the two neighboring HMP-227a and 219a, the percentage distribution of runoff by months in each individual year was obtained, after which a general comparison of these percentage distributions was made for each individual hydrometric point. The results of the comparison show that in 96.2% of the years, the maximum outflow is in the period April - June. In the months of August - September is the absolute annual minimum.

As the most suitable analogue we choose the river Sushitsa, which has a similar in nature and area catchment area. On the Sushichka River there are observations of the outflow by days and by months in the period 1954-2011 in a hydrometric point HMP № 51510 (227) near the village of Polena. This point is accepted as an analogue for determining the parameters of the outflow of the Tsaparevska River due to the following considerations:

- The two catchments are close in character and altitude and are on neighboring rivers, located at a distance of about 30 km from each other;
- Before HMP 51510 there are no built-in and active outflow disturbances and the outflow range is long enough.

<u>Parameters of the outflow of the HMP 51510 line on the Sushichka River</u>

The data by years for the period 1955-1983, for the average water quantity in the year and for the minimum for the year water quantity in HMP 51510 on the river Sushichka near the village of Polena are given in the following table 9 for the average annual water quantities and in table 10 for the minimum in the year water quantities.

Average water quantities on the Sushichka River near the village of Polena HMP

Table 9

№	**Year**	**Qср. в m³/sec**		**Security P%**
		Chronological order	**Descending order**	
1	2	3	4	5
1.	1955	0,800	1,000	2,555
2.	1956	1,000	0,920	6,204
3.	1958	0,920	0,861	9,854
4.	1959	0,600	0,860	13,504
5.	1960	0,790	0,842	17,153
6.	1961	0,520	0,827	20,803
7.	1963	0,860	0,820	24,453
8.	1964	0,360	0,820	24,453
9.	1965	0,820	0,800	31,752
10.	1966	0,820	0,790	35,401
11.	1967	0,460	0,782	39,051
12.	1968	0,390	0,780	42,701
13.	1969	0,780	0,780	46,350
14.	1970	0,780	0,780	50,000
15.	1971	0,640	0,750	53,650
16.	1972	0,530	0,700	57,299
17.	1973	0,750	0,658	60,949
18.	1974	0,540	0,640	64,599
19.	1975	0,290	0,631	68,248
20.	1976	0,780	0,600	71,898
21.	1977	0,700	0,540	75,547
22.	1978	0,631	0,530	79,197
23.	1979	0,861	0,520	82,847
24.	1980	0,842	0,460	86,496
25.	1981	0,827	0,390	90,146

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26.	1982	0,782	0,360	93,796
27.	1983	0,658	0,290	97,445
Average		**0,6937**	**0,6937**	
Cv		**0,25985**	**0,25985**	
Cs		**-0,59558**	**-0,59558**	

Minimum water quantities by years on the Sushichka River near the village of Polena HMP51510/227

Table 10

№	**Year**	**Qср. в m³/sec**		**Security P%**
		Chronological order	**Descending order**	
1	2	3	4	5
1.	1955	0,180	0,270	2,381
2.	1956	0,200	0,250	5,782
3.	1957	0,270	0,250	9,184
4.	1958	0,250	0,250	12,585
5.	1959	0,160	0,240	15,986
6.	1960	0,180	0,220	19,388
7.	1961	0,200	0,210	22,789
8.	1962	0,200	0,200	26,190
9.	1963	0,070	0,200	29,592
10.	1964	0,058	0,200	32,993
11.	1965	0,170	0,180	36,395
12.	1966	0,170	0,180	39,796
13.	1967	0,170	0,180	43,197
14.	1968	0,150	0,180	46,599
15.	1969	0,130	0,170	50,000
16.	1970	0,150	0,170	53,401
17.	1971	0,150	0,170	56,803
18.	1972	0,170	0,170	60,204

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19.	1973	0,180	0,170	63,605
20.	1974	0,210	0,160	67,007
21.	1975	0,160	0,160	70,408
22.	1976	0,160	0,160	73,810
23.	1977	0,220	0,150	77,211
24.	1978	0,180	0,150	80,612
25.	1979	0,150	0,150	84,014
26.	1980	0,250	0,150	87,415
27.	1981	0,240	0,130	90,816
28.	1982	0,170	0,070	94,218
29.	1983	0,250	0,058	97,619
Average		**0,1792**	**0,1792**	
Cv		**0,26853**	**0,26853**	
Cs		**-0,3625**	**-0,3625**	

Based on these data, the following parameters of the runoff for the river Sushitsa in HMP 51510 near the village of Polena - runoff modulus **21.6794** l / sec / km2 and coefficient of variation **Cv = 0.25985** were calculated. The following characteristic water quantities and volumes of the river to the point were obtained through them.

Main parameters of the runoff at the point analogous to the river Sushichka in HMP № 510 near the village of Polena

Table 11

№	**Characteristic**	**Unit**	**Symbol**	**Amount**
1	Catchment area	km^2	F	32
2	Average altitude	m	Hcp	1680
3	Outflow module	$l/sec/km^2$	M_o	21,6794
4	Outflow rate	m^3/sec	Q_o	0,6937
5	Coefficient of flow variation	-	Cv	0,25985
6	Coefficient of asymmetry	-	Cs	-0,59558
7	Debit in the year with collateral 25%	m^3/sec	$Q_{25\%}$	0,805

8	Debit in the year with collateral 75%	m^3/sec	$Q_{75\%}$	0,564
9	Debit in the year with collateral 95%	m^3/sec	$Q_{95\%}$	0,427
10	Average annual water mass Wo	$mil.m^3$	W_o	21,878
11	Water mass in wet year W25%	$mil.m^3$	$W_{25\%}$	25,390
12	Water mass in wet year W75%	$mil.m^3$	$W_{75\%}$	17,785
13	Water mass in wet year W95%	$mil.m^3$	$W_{95\%}$	13,468
14	Minimum average annual flow	m^3/sec	Q_{mino}	0,1792
15	Coefficient of variation of minimum flow	-	Cv	0,26853
16	Coefficient of asymmetry	-	Cs	-0,36250
17	Minimum flow with collateral 75%	m^3/sec	$Q_{min75\%}$	0,145
18	Minimum flow with collateral 95%	m^3/sec	$Q_{min95\%}$	0,108

The security curves of the average annual outflow and the minimum outflow in the year are shown in figure 4 and figure 5.

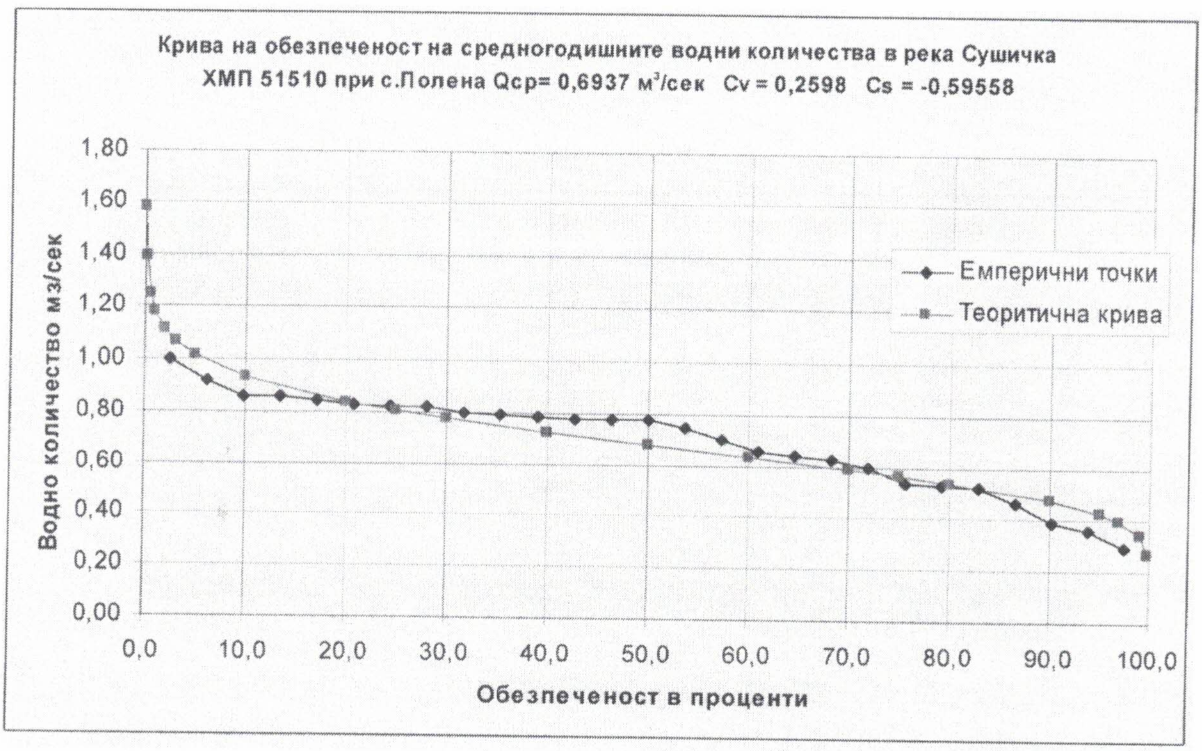

Figure 4

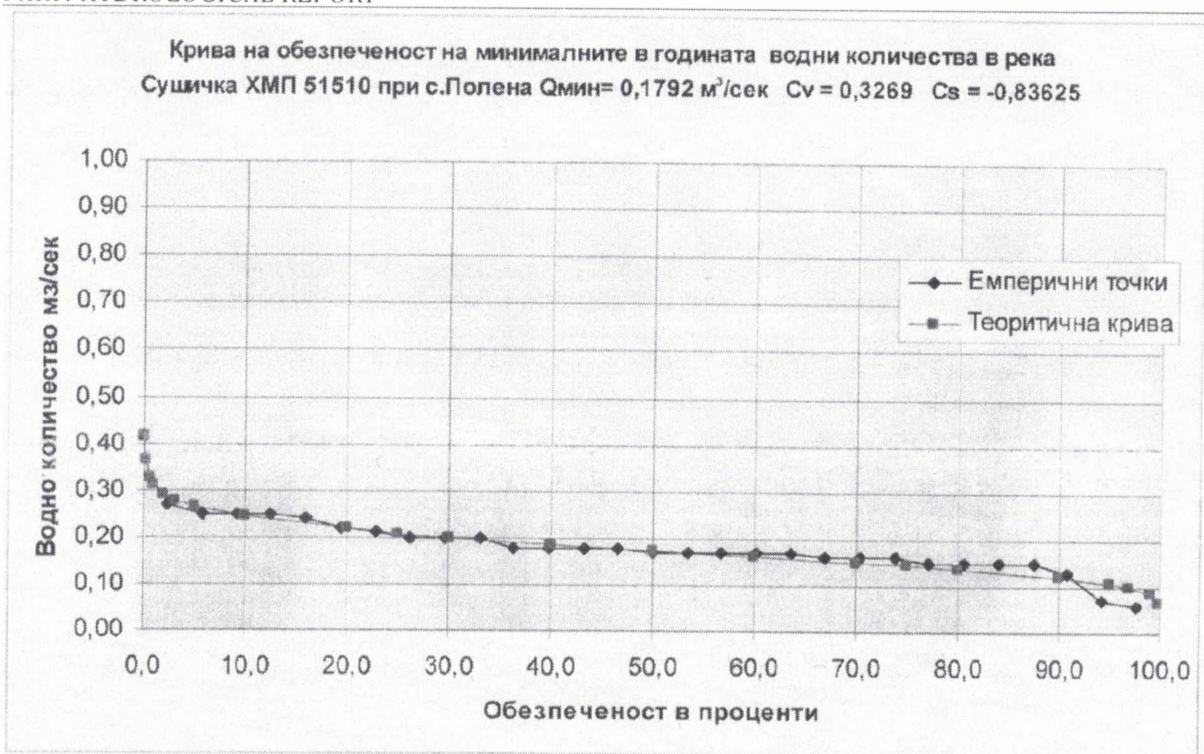

Figure 5

Using the data by months and years of HMP 51520 in Table 13 is given the distribution by months of the average flow for three typical years.

Average outflow: "average year" with a security of 50% - 1976, "dry year" with a security of 75% - 1974 and "very dry year" with a security of 95%

Distribution of the measured average outflow by months for three typical security years of the river Sushichka HMP 51510 Polena

Table 12

Year	Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Av. yearly
Average 50%	Q m^3/sesc	0,400	0,270	0,300	0,580	0,790	1,980	0,920	0,590	0,450	0,540	1,120	1,400	0,780
	W $m^3.10^6$	1,071	0,677	0,804	1,503	2,116	5,132	2,464	1,580	1,166	1,446	2,903	3,750	24,613
	%	4,35	2,75	3,26	6,11	8,60	20,85	10,01	6,42	4,74	5,88	11,79	15,24	100,00
Dry 75%	Q m^3/sesc	0,470	0,830	0,820	0,890	0,930	0,810	0,370	0,250	0,230	0,280	0,310	0,280	0,540
	W $m^3.10^6$	1,259	2,008	2,196	2,307	2,491	2,100	0,991	0,670	0,596	0,750	0,804	0,750	16,921
	%	7,44	11,87	12,98	13,63	14,72	12,41	5,86	3,96	3,52	4,43	4,75	4,43	100,00

Very	Q m^3/sesc	0,200	0,290	0,430	0,330	0,340	0,290	0,150	0,250	0,240	0,260	0,590	0,930	0,360
dry	W $m^3.10^6$	0,536	0,727	1,152	0,855	0,911	0,752	0,402	0,670	0,622	0,696	1,529	2,491	11,342
95%	%	4,72	6,41	10,15	7,54	8,03	6,63	3,54	5,90	5,48	6,14	13,48	21,96	100,00

We accept the same distribution of the outflow in the year for the Tsaparevska River, but for the purposes of the project the distribution of the outflow during the year is not of special importance.

9. Outflow violators

In the catchment area of the Tsaparevska River from k.310 m a water intake has been built for the SHPP "Mikrevo", which takes flows up to 800 l / sec outside the irrigation season.

The water from the leak of the Mikrevo HPP does not return to the Tsaparevska River, but is discharged into a drainage channel in the terrace of the Struma River. Also at k.760m there is a water intake for water supply of the village of Mikrevo with water abstraction with a flow rate up to 30l / sec.

10. Minimum water quantities

Given the objectives of the correction project, the issue of minimum runoff is not particularly important, as no water abstraction or runoff is foreseen.

To determine the minimum water quantities, the "Instruction for determining the minimum allowable runoff in rivers" of the Ministry of Environment and Water was used. According to it, it is recommended for the preservation of river ecosystems to ensure in the rivers an outflow equal to 10 percent of the average perennial water quantity, but not less than the minimum average monthly water quantity with a security of 95% per point.

The absolute minimum water quantity in the river analogous to the river Sushichka near the village of Polena is Qmin = 58 l / sec at Q10% = 68 l / sec. The same was measured on July 21, 1964 and has a security of 97.0%.

The minimum outflow of the Tsaparevska River in the section of the village of Mikrevo is determined as 10% of the average outflow and is equal to Qeq. = 70 l / sec, as the minimum outflow in the river at 95% security drops to 20 l / sec due to use. of the irrigation runoff.

11. Maximum water quantities

Maximum water quantities are an essential part of this development. They are a characteristic element in the outflow mode. Of great importance is the knowledge of the origin and nature of high waters. In view of the design task for the construction of the river correction, the determination of the high waters is essential. The large number of factors presented in a greater or lesser degree of quantitative assessment, which determine a complex relationship between them, do not allow the process to be expressed only by functional dependencies.

The physical expression of the maximum outflow is the high waves, whose main computational characteristics are the maximum water quantities, volumes and hydrographs. The characteristics that express the course of high waters as a function of time are: beginning, rise, peak, decline and end.

It is characteristic of the considered area that the high waters in most cases follow the distribution of precipitation. No less important for the formation of high waters are the orohydrographic features of the catchment area of the Tsaparevska River. It is typical for the considered catchment with mountain character that the high waters here have larger peaks, with significant volumes and short duration due to the small altitude.

To determine the parameters of the maximum water quantities and their values at different levels, two methods were approached:

• By using the data from direct observations and measurements at the existing hydrometric station №227 on the river Sushitsa, accepted as an analogue river, applying the method of mathematical statistics and graphical methods;

• Limit intensity method with reduction curves of maximum precipitation

The high waters in HMS 227 were analyzed in detail for the entire observed period from officially published high water data. Due to the fact that a large number of the peaks of the high waters at the station were dropped for various reasons, lower maximums for high waters were obtained in HMS. This necessitated their recovery. The formed series of annual maxima from a hydrological point of view is sufficiently representative, as the series has a 28-year period.

The development trend is to determine the most probable high water parameters for the selected HMS station (Q max. Average, Cv and Cs). The way of determining the statistical parameters depends on the accepted theoretical law of distribution. For this purpose, on the basis of the series of actually observed extreme annual values, the most correct selection of their parameters has been made. The determination of these parameters was possible after the construction of the empirical security curve and various theoretical security curves in HMS. The best coverage of these theoretical curves with the empirical HMS station was studied.

After a thorough review of each coverage of the theoretical with the empirical security curve at the considered HMS station, the best coverage of these distribution curves often appears in the theoretical Pearson - type III curve and the normal distribution.

Based on Pearson - type III distribution, different values of the asymmetry coefficient Cs = k.Cv are investigated. It was found that the most common are the cases of the best coverage of the empirical with the theoretical curve at Cs = 4.Cv.

Static parameters are calculated using the "moment method". The following parameters are defined:

- arithmetic mean value – $Q_{ср.мах}$=8,0m^3/sec
- coefficient of variation - Cv=0,51
- coefficient of asymmetry - Cs=1,76

The parameters calculated in this way are transferred to the water abstraction point and in table №13 the water quantities with annual probabilities of 0.1%, 1%, 5% and 10% are calculated. Apart from the empirical-statistical way, the statistical parameters are also calculated by the graphoanalytical method of the reference quantiles. The results of both methods are within acceptable limits.

The lack of sufficiently direct observations on the water levels and measurements of the maximum water quantities passed to the studied area, necessitated the use of empirical formulas to verify the determination of the maximum water quantities:

According to SOKOLOVSKI's formula:

$Q = B\sqrt{F}$ m^3/sec, where:

F – catchment area in m2

B – coefficient depending on the catchment area and altitude

Indirect methods had to be used to determine the computational security of the high water peaks.

For comparison, empirical methods as well as the limit intensity method were used to determine high waters.

The basic formula in the method of the limit intensity of the Russian hydrologist GA Alekseev with an annual probability of exceeding p% has the form:

$$Qpi_{max} = 0.0116 \times Npi_{max} \times \eta_m \times kpi \times m \times F \text{ , m}^3\text{/sec}$$

The time of flow down the river is determined by successive approximations with the formula:

$$\tau_i = \frac{16,67.Lp}{d.J\ p^{1/3}.Qp^{1/4}}$$

in the denominator, which is Shezi's formula for the velocity of water in open water currents.

The runoff coefficients of the maximum water quantities are calculated taking into account the filtration and the simultaneity of the maximum precipitations.

Gerasimov's formula:

$Qp\% = Si.Fp$, m^3/sec

also based on the maximum precipitation, orohydrographic, soil-geological and climatic factors characterizing the specific catchment area. According to the requirements of the problem, the data are given at p = 0.1%, 1%, 3%, 5% and 10%, using the theoretical curve of the distribution of collateral Kritzky - Menkel, processed by the method of "moments". The results are given in Table №13

High waters, m^3/sec

Table 13

№	River - point	P=0,1%	P=1%	P=5%	P=10%
1	Tsaparevska river	75,0	48,0	27,0	18,0

12. Conclusions

From the performed engineering-hydrological calculations the following conclusions can be made:

- The average annual outflow of the Tsaparevska River in the section in the village of Mikrevo is equal to Qsr. = 0.684 m3 / sec, with an annual volume V = 21.5 mil. m3;
- The outflow of the Tsaparevska River near the village of Mikrevo with 75% security is equal to

0.486 m3 / sec, with volume V = 15.3 mil. m3;

• For ecological minimum in the river after the water intake the water quantity equal to 10% of the average outflow of 0.068 m3 / sec - 68 l / sec is accepted;

• The high waters with 1% security, for which the correction in the features of the village of Mikrevo must be dimensioned, are Q1% = 48 m3 / sec.

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Annex 1: Map 1:50000 of the catchment