The Chernaya river annual flow security calculation and the Chernorechensk reservoir catchment area in Sevastopol

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Abstract. On the Crimean Peninsula territory, there are 1657 permanent and temporary watercourses with a total length of 5996 km, their length, catchment areas and water volumes are small. Most (92.1\%) are watercourses less than 10 km long. Particular attention is paid to the Chernaya river basin, supplying the Chernorechensk reservoir - one of the largest in the region and providing water to the city of Sevastopol. Explored for the first time in the complex of the r. Chernaya and all tributaries - the r. Uzundzha, the r. Bosa, the r. Baga Nizhnyaya, the r. Baga Verchniyaya, the r. Urkusta, the r. Ay-Todorka, Sukhaya rivers, the r. Bajdarka, the r. Uppa, the r. Armanka, the r. Calenda. The article presents calculated data on the Chernaya river annual run-off availability and all its tributaries. It was revealed that the annual run-off statistical characteristics adopted for the water stations adequately reflect the current situation in the long-term section with the river run-off of the Chernaya River and the Chernorechensk reservoir catchment area.

1. Introduction

By the beginning of the 21st century, the freshwater shortage had acquired a global character; accordingly, the water resources rational use ecological and social aspects were attributed to the most acute problems. This is evidenced by the World Water Forums, held every three years since 1997. Research on changes in the natural environment is one of the most relevant, which results should contribute to solving the global ecological crisis problems \cite{1, 2}. The basin concept \cite{3} has become a recognized approach in such geological and landscape studies. The authors have carried out a studies number in this direction on the Karachaevo-Cherkess Republic territory \cite{4-6}. The river basins study contributes to improving the management of economic activities, environmental management \cite{7-9}, including the water resources optimal use in their shortage conditions \cite{10-13}.

The water resources problem is also urgent for Crimea. The territory own water resources' volume under consideration, available for use at present, taking into account the water infrastructure development existing level, is, depending on the year water content, from 336 million m\textsuperscript{3} to 250 million m\textsuperscript{3} freshwater for medium and dry years respectively. The municipal, industry and agriculture services water demand is 715 million m\textsuperscript{3}. Thus, to ensure the population vital activity and the economy sustainable functioning, the region needs from 379 million m\textsuperscript{3} to 465 million m\textsuperscript{3} of freshwater (depending on the year water content for an average and dry year, respectively). For the region future...
development (2030), taking into account the changes that take into account the increase in the volume of groundwater intake from the Nezhinsk and Prostornensk water intakes, as well as changes in the resident population number and the vacationers' number, the water amount required will be 384 million m³ for average and 470 million m³ for a dry year [14, 15]. 1657 permanent and temporary watercourses with a total length of 5996 km flow through the Crimean Peninsula territory. Their length, catchment areas and flowing water volumes are small. Most (92.1%) are watercourses less than 10 km long [16].

The Chernaya River belongs to the rivers group on the Crimean Mountains main ridge northwestern slope and is one of the most significant rivers in the Sevastopol region in length and water content terms (figure 1).

![Figure 1. The Chernaya river catchment area on the Crimean Peninsula satellite image (Google).](image)

The river basin upper part is located on the mountain range western slopes and has a rugged relief. The Chernaya river forms the longest canyon in Crimea. The catchment basins have an elongated shape along the river, expanded in the upper part, which is the main feeding area. The Chernaya river begins near the Rodnikovskoye village with a powerful Skelsky source, which provides the river flow main part, its flow rate is 40 - 220 l/s. The river is 35 km long, the catchment area is 669 km². In the upper reaches, the river slope is significant (70 m/km), and after entering the Baidar Valley it sharply decreases. The water main sources for rivers in the Baidar Valley are snow-rain, underground and mixed.

In the low-water period, drying is observed in the rivers' estuaries.

The Chernaya river belongs to the flood type rivers. During a flood, the water level in the river can rise by 2 - 3 m. Even during the low-water period, the river discharge during extreme floods can increase by an order of magnitude or more. The river is fed mixed - atmospheric and underground. The river atmospheric feeding occurs both due to rainfall and snow and is predominant. When analysing the long-term average run-off hydrograph, two periods are distinguished: a high-water period (from December to April inclusive), when 51.2% of the annual runoff passes, and a low-water period (from May to November) [17].

1.1. The research subject

The Chernaya River annual flow water availability and the Chernorechensk reservoir catchment area in Sevastopol.
1.2. The study purpose
To calculate the Chernaya river annual flow water availability and the Chernorechensk reservoir catchment area in Sevastopol.

Based on the goal, the following tasks were set: to calculate the river annual run-off to calculate the annual flow of the Chernaya River and its tributaries and to determine the Chernorechensk reservoir catchment area dependence on the Chernaya River and its tributaries annual flow.

1.3. The study novelty
The study novelty lies in the fact that for the first time the river all tributaries catchments calculation made and their total volume is determined.

2. Materials and methods
The study main approach was the basin concept, general scientific and geographical methods were applied - statistical, cartographic, etc., which are a field and cameral techniques’ combination, and detailed Google satellite images were deciphered using GIS technologies. Hydraulic structures were inspected under the current instructions using measuring equipment. Used factual material collected by the Safety of Hydraulic Structures Engineering Consulting Center in 2014-2019.

3. Results
Three main rivers flow through the Sevastopol city territory - the Black River (35 km long) with tributaries (the Uzundzha river, the Bosa river, the Baga Nizhnyaya river, the Baga Verkhnyaya river, the Urkusta river, the AyTodorka river, the Sukhaya river, the Baydarka river, the Uppa river, the Armanka river, the Kalenda river), as well as the Kacha final parts (5.4 km long) and Bel'bek rivers (17 km long).

The summer low-water period can be interrupted by intense short-term floods. The maximum water discharge can range from 120 m$^3$/s (flow volume 24.7 million m$^3$) in a warm period up to 200 m$^3$/s (flow volume 37 million m$^3$) in a year cold period. The minimum discharge on the Chernaya river is observed in the summer and autumn months (in August - September) due to an atmospheric precipitation decrease or absence and groundwater flow depletion.

3.1. The Chernaya river catchment area
The Chernaya river catchment area is characterized by the following indicators:
- The catchment area - 427 km$^2$.
- The catchment is pear-shaped.
- The catchment length is 31 km.
- The catchment area average width is 13.8 km.
- The maximum catchment width is 18.1 km.
- The catchment shape factor $L/F^{0.56}=0.18$.
- The hydrographic network density - in the basin varies from 0.7 km/km$^2$ in the upper reaches to 0.2 km/km$^2$ in the area lower part, on average over the area - 0.35 km/km$^2$.

3.2. The Chernorechensk reservoir catchment
The reservoirs and ponds area - 7.18 km$^2$ (1.7% of the catchment area), including 2 reservoirs (Chernorechensk and in the Urkusta river lower reaches) - 6.31 km$^2$, and 17 ponds - 0.87 km$^2$.
- Catchment slopes average slope $I_{sc}$ = 100 %.
- The average catchment height above sea level is 430 m.

The Chernorechensk reservoir catchment area (figure 2) has a shape that is spread out in width, but its shape is similar to the catchments form along the Rodnikovskye water basin and near Mount Kizil-Kaya. The Chernorechensk reservoir catchment area hydrographic indicators are shown in table1.
Table 1. The Chernorechensk reservoir catchment area main hydrographic characteristics.

| Catchment area, km² | Average catchment height, m | Distance from the river mouth in km | Channel length (with the Uzundzha tributary), km | Channel slope, % | The slopes, slope % | Ponds and reservoirs area, km² |
|---------------------|-----------------------------|------------------------------------|-----------------------------------------------|----------------|-----------------|----------------------|
| 108                 | 600                         | 28.9                               | 16.1                                          | 4.8            | 201             | 6.06                 |

The catchment length is 8.4 km.
The catchment area average width is 12.8 km.
The maximum catchment width is 16.4 km.
The catchment shape factor = 0.61.
The hydrographic network density is 0.7 km/km².

Figure 2. The Chernaya river catchment area on the Crimean Peninsula satellite image (Google).

The Chernaya river longitudinal profile (based on the map M 1:25000) is shown in figure 3.
3.3. Annual runoff calculation

The river weighted average slope over 35 km is 7.4%. Four sections with characteristic slopes can be distinguished along the river length. The river upper reaches section, crossing the Bajdark Valley, has a channel slope of 4.83‰ and this section contains the Chernorechenskoye reservoir. Starting from the Kizil-Kaya rock on the Bajdark Valley border, the Chernaya river flows in a winding gorge, squeezed on both sides by almost sheer cliffs several tens of meters high. In some places, this canyon-like gorge is difficult to pass: the river bed is replete with extensive rifts and cascades, boulders heaps, the channel slope is 21.4%.

The current weakens after the Chernaya River enters the Inkerman Valley; the slope in this section is about 4.0%. For the last two kilometres, the river has practically no slope along a flat low-lying valley and flows into Sevastopol Bay.

The river bed belongs to the mountain river beds incised type (according to the Moscow State University classification [18]), rapids and waterfalls, with undeveloped alluvial forms. Such channels are characterized by a depths uniform distribution along the stream length, disturbed by large boulders. On this type’ rivers, the ratio $h/\Delta < 5$ is observed for the channel at almost any point, where $h$ is the flow depth above the roughness protrusion with height $\Delta$ (figures 4-6).

Figure 3. The Chernaya river longitudinal profile (Crimean Peninsula).

Figure 4. The Chernaya river annual run-off module.
At the entrance to the Inkerman Valley, the bottom sediments' size decreases, in the gravel-pebble channel, the fine sediment fractions amount (<10 mm) increases.

Figure 5. The Chernaya river annual flow rate along the reference shafts.

Figure 6. Change in the Chernaya river annual run-off variation coefficients.

In analyzing the annual run-off process of the Chernaya river the run-off balance calculation between the hydrological stations was carried out. The catchment area between the Rodnikovsk village and Kizil-Kaya mountain - 197 - 47.6=149.4 km²

An annual run-off between stations ΔW=63.4 - 49.2=20.2 million m³
This section contains the catchments of the Baidarka rivers (62.8 km², L=11 km), Urkusta (20 km², L=7.6 km) and the catchment area of the Chernorechensk reservoir with the Bosa's tributaries (8.72 km², L = 4.8 km), Kalenda (3.43 km², L=5.4 km), Armanka (12.0 km², L=7.6 km), Baga Verhnyaya (6.47 km², L=5.9 km), Baga Nizhnyaya (21.3 km², L=10 km). The rivers flowing into the reservoir have a total catchment area of 51.92 km². The total catchment area of all rivers in the section between the above stations is 134.72 km². The slope catchments share, excluding the reservoir itself area (6.04 km²), accounts for 149.4 – 62.8 – 20.0 – 51.92 – 6.02 = 8.66 km².

### 3.3.1. Annual runoff of the Urkusta river

\[ M = 3.0 \text{ l/s km}^2 \text{ (RPV, 1966)}, \quad Q_0 = 0.060 \text{ m}^3/\text{s}, \quad W_0 = 1.89 \text{ million m}^3. \]

According to the Z V Timchenko formula [19]:

\[ M = 3.963 \cdot 10^{-8} \cdot H^{-2.8} \cdot i_p^{3.36} \cdot F^{1.33}, \]

where \( N \) is the fall of the river section, km, \( i_p \) is the average slope of the river section, %.

\[ M = 3.963 \cdot 10^{-8} \cdot 0.17^{-2.8} \cdot 19^{3.36} \cdot 20^{1.33} = 6.02 \text{ l/s km}^2, \]
\[ Q_0 = 0.12 \text{ m}^3/\text{s}, \quad W_0 = 3.8 \text{ million m}^3. \]

For the northwestern slope rivers from the monograph by Z V Timchenko [20]

\[ C_v = 0.935 \cdot 0.402 \cdot H^{-0.016} \cdot F^{-0.427} \]
\[ C_s = 4.37 \cdot C_v - 1.1 \cdot C_v^2 - 0.755 \quad C_v = 0.935 \cdot 7.6^{0.402} \cdot 0.17^{-0.016} \cdot 20^{-0.427} = 0.61 \]
\[ C_s = 4.37 \cdot 0.61 - 1.1 \cdot 0.61^2 - 0.755 = 1.65. \]

### 3.3.2. Annual runoff of the Baidarka river

\[ Q_0 = 0.26 \text{ m}^3/\text{s}, \quad W_0 = 8.20 \text{ million m}^3. \]

\[ C_v = 0.77, C_s = 1.05. \]

The volume of annual run-off in the area without the Urkusta and Baidarka rivers is 20.2 – 3.8 – 8.2 = 8.2 million m³.

Assuming the average run-off modulus for slope catchments M=3.0 l/s·km², we obtain the annual run-off from these catchments 3.0·8.66·31 =1.04 million m³.

Thus, the rivers share flowing into the reservoir accounts for 8.2-1.04=7.16 million m³ (from the tributary along the Chernaya near the Rodnikovsk town, this is (7.16/49.2) 100=14.6%).

Below the post at Mount Kızıl-Kaya, the Chernaya river main tributaries are At tributary (15.9 km², L=5.0 km), the Sukhaya river (51.7 km², L=12 km), Aytodorka (38.1 km², L=15 km). These rivers in the GVK (1985) are not illuminated in any way, they flow into the Chernaya river at its entrance to the Inkerman Valley, the run-off modulus does not exceed 1-3 l/s·km².

### 3.3.3. Annual runoff of the Suhaya river.

According to the Z V Timchenko formula:

\[ M = 3.963 \cdot 10^{-8} \cdot 0.15^{-2.8} \cdot 10^{3.36} \cdot 51.7^{1.33} = 3.5 \text{ l/s km}^2, \]
\[ Q_0 = 0.18 \text{ m}^3/\text{s}, \quad W_0 = 5.68 \text{ million m}^3. \]

\[ C_v = 0.935 \cdot 12^{0.402} \cdot 0.15^{-0.016} \cdot 51.7^{-0.427} = 0.49 \]
\[ C_s = 4.37 \cdot 0.49 - 1.1 \cdot 0.49^2 - 0.755 = 1.13. \]

### 3.3.4. Annual runoff of the Aytodorka river.

According to the Z V Timchenko formula:

\[ M = 3.963 \cdot 10^{-8} \cdot 0.46^{-2.8} \cdot 25^{3.36} \cdot 38.1^{1.33} = 2.2 \text{ l/s km}^2, \]
\[ Q_0 = 0.084 \text{ m}^3/\text{s}, \quad W_0 = 2.65 \text{ million m}^3. \]
\[ C_v = 0.935 \cdot 15^{0.402} \cdot 0.46^{-0.016} \cdot 38.1^{-0.427} = 0.59 \]
\[ C_s = 4.37 \cdot 0.59 - 1.1 \cdot 0.59^2 - 0.755 = 1.45. \]

3.3.5. Annual runoff of the Upa river. According to the Z V Timchenko formula:

\[ M = 3.963 \cdot 10^{-8} \cdot 0.35^{-2.8} \cdot 40^{3.36} \cdot 15.9^{1.33} = 7.16 \text{ l/s km}^2, \]
\[ Q_0 = 114 \text{ m}^3/s, \ W_0 = 3.59 \text{ million m}^3. \]
\[ C_v = 0.935 \cdot 5^{0.402} \cdot 0.35^{-0.016} \cdot 15.9^{-0.427} = 0.56 \]
\[ C_s = 4.37 \cdot 0.56 - 1.1 \cdot 0.56^2 - 0.755 = 1.35. \]

The catchment area between the village near Mount Kizil-Kaya and the Khmelnytskyi village - 342-197 = 145 km².

The three rivers above have an area of 15.9+38.1+51.7 = 105.9 km².

These rivers annual runoff volume is 3.59+5.68+2.65 = 11.92 million m³.

The run-off volume from the catchment area slope part (145-105.9 = 39.1 km²) at M=2.5 l/s km² will be 2.5\cdot39.1\cdot31.54 = 3.08 million m³.

The annual run-off volume between the gates is \( \Delta W = 56.46-63.40 = 6.94 \text{ million m}^3 \), i.e. the run-off selection in this section is:

- 11.92+6.94+3.08 = 21.94 million m³.
- (according to RPV [14], the total annual run-off of the Chernaya River is ~22 million m³).

From this analysis, it follows that the annual run-off statistical characteristics adopted for water posts adequately reflect the current situation in the long-term section with the Chernaya river run-off. By calculating the annual run-off supply curve coordinates (according to Rybkin), the supply curve was constructed (figure 7).

Table 2-6 presents the Chernaya river and the Chernorechensk reservoir hydrotechnical complex statistical calculations.

![Figure 7](#).

**Figure 7.** Change in the Chernaya river annual run-off variation coefficients.
Table 2. The Chernaya river annual run-off statistical parameters in a multi-year section.

| Hydropost                  | Drain module $M_0$, l/s km² | Consumption $Q_0$, m³/s | Volume $W_0$, million m³ | $C_v$ | $C_s$ |
|----------------------------|-----------------------------|------------------------|-------------------------|-------|-------|
| The Rodnikovsk village     | 32.8                        | 1.65                   | 49.2                    | 0.42  | 0.80  |
| near Kizil-Kaya Mount      | 10.2                        | 2.01                   | 63.4                    | 0.38  | 1.04  |
| The Khmelnitsk village     | 5.7                         | 1.79                   | 56.46                   | 0.36  | 1.55  |
| hydropower section         | 17.0                        | 1.84                   | 58.03                   | 0.36  | 1.04  |

Table 3. The maximum run-off statistical parameters in the Chernorechensk reservoir hydropower complex section.

| Estimated section | $F$, km² | $h_s.p.$, mm | $M_s.p.$, l/s km² | $Q_p$, m³/s | $W_0$, million m³ | $C_v$ | $C_s$ |
|-------------------|----------|-------------|------------------|-------------|------------------|-------|-------|
| Hydraulic unit    | 108      | 106         | 428              | 46.2        | 11.5             | 0.84  | 2.38  |

Table 4. The Chernaya river maximum run-off rate curve calculated ordinates in the hydraulic unit alignment.

| Indicator | Provision $P$, % |
|-----------|------------------|
| $Q$, m³/s | 0.01 0.1 1 3 5 10 25 50 75 90 95 97 99 |
| 550 (660*) | 370 232 162 130 93.0 53.4 |

* - taking into account the warranty amendment.

Table 5. The Chernaya river annual run-off rate ordinates calculation in the Chernorechensk reservoir hydraulic unit alignment (according to the binomial curve ordinates table – Pearson's type III curves) $C_v=0.36; C_s=1.04$.

| $P$, % | 0.01 0.05 0.1 1 3 5 10 25 50 75 90 95 97 99 |
|--------|------------------|
| $F$    | 6.07 5.05 4.60 3.06 2.26 1.88 1.34 0.54 –0.17 –0.74 –0.85 –1.12 –1.30 –1.40 –1.56 |
| $M_s=F_s$ | 2.19 1.82 1.66 1.10 0.81 0.68 0.48 0.19 –0.06 –0.27 –0.31 –0.40 –0.47 –0.50 –0.56 |
| $K_s=M_s+1$ | 3.19 2.82 2.66 2.10 1.81 1.68 1.48 1.19 0.94 0.73 0.69 0.60 0.53 0.50 0.44 |
| $Q_{avg.}$ m³/s | 1.84 |
| $Q=K_s \cdot Q_{ep.}$ m³/s | 5.87 5.19 4.89 3.86 3.33 3.09 2.72 2.19 1.73 1.34 1.27 1.10 0.98 0.92 0.81 |
| $W$, million m³ | 185.13 163.65 154.37 121.87 105.04 97.50 85.89 69.06 54.55 42.36 40.04 34.82 30.76 29.02 25.53 |
| An average year, million m³ | 58.03 |

Table 6. The Chernaya river annual run-off rate ordinates calculation in the hydro post at Kizil-Kaya Mount alignment (according to the binomial curve ordinates table – Pearson's type III curves) $C_v=0.38; C_s=1.04$.

| $P$, % | 0.01 0.05 0.1 1 3 5 10 25 50 75 90 95 97 99 |
|--------|------------------|
| $F$    | 6.07 5.05 4.60 3.06 2.26 1.88 1.34 0.54 –0.17 –0.74 –0.85 –1.12 –1.30 –1.40 –1.56 |
### Ms=F*S

| Ms=F*S | 2.31 | 1.92 | 1.75 | 1.16 | 0.86 | 0.71 | 0.51 | 0.21 | -0.06 | -0.28 | -0.32 | -0.43 | -0.49 | -0.53 | -0.59 |
|--------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|-------|-------|

### Ks=Ms+1

| Ks=Ms+1 | 3.31 | 2.92 | 2.75 | 2.16 | 1.86 | 1.71 | 1.51 | 1.21 | 0.94 | 0.72 | 0.68 | 0.57 | 0.51 | 0.47 | 0.41 |
|---------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|

### Q avg., m³/s

| Q avg., m³/s | 6.65 | 5.87 | 5.53 | 4.34 | 3.74 | 3.44 | 2.43 | 1.89 | 1.45 | 1.37 | 1.15 | 1.03 | 0.94 | 0.82 |
|--------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|

### W², million m³

| W², million m³ | 209.84 | 185.11 | 174.34 | 136.93 | 117.92 | 108.41 | 95.73 | 76.71 | 59.59 | 45.64 | 43.11 | 36.14 | 32.33 | 29.80 | 25.99 |
|----------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|

### Q=Ks·Q avg., m³/s

| Q=Ks·Q avg., m³/s | 209.84 | 185.11 | 174.34 | 136.93 | 117.92 | 108.41 | 95.73 | 76.71 | 59.59 | 45.64 | 43.11 | 36.14 | 32.33 | 29.80 | 25.99 |
|-------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|

### An average year, million m³

| An average year, million m³ | 63.40 |
|-----------------------------|-------|

### 4. Conclusion

The Chernaya river catchment area Black is characterized by the following indicators: catchment area (catchment area) - 427 km², catchment shape - pear-shaped, catchment length-31 km, average catchment width-13.8 km, maximum catchment width - 18.1 km, catchment shape coefficient \( L/F \) = 0.56.

The hydrographic network density - in the basin varies from 0.7 km/km² in the upper reaches to 0.2 km/km² in the area lower part, on average over the area - 0.35 km/km². The catchment area between the Rodnikovsk village and Kizil-Kaya mountain – 197 - 47.6=149.4 km².

This section contains the catchments of the Baidarka rivers (62.8 km², \( L = 11 \) km), Urkusta (20 km², \( L = 7.6 \) km) and the catchment area of the Chernorechensk reservoir with the Bosa's tributaries (8.72 km², \( L = 4.8 \) km), Kalenda (3.43 km², \( L = 5.4 \) km), Armanka (12.0 km², \( L = 7.6 \) km), Baga Verhnyaya (6.47 km², \( L = 5.9 \) km), Baga Nizhnyaya (21.3 km², \( L = 10 \) km). The rivers flowing into the reservoir have a total catchment area of 51.92 km². The all rivers total catchment area in the section between the above stations is 134.72 km². The slope catchments share, excluding the reservoir itself area (6.04 km²), accounts for 149.4 – 62.8 – 20.0 – 51.92 – 6.02 = 8.66 km².

The Chernaya river annual run-off balance and its tributaries between the hydrological posts is calculated.

The minimum discharge on the Chernaya river is observed in the summer and autumn months (in August - September) due to an atmospheric precipitation decrease or absence and groundwater flow depletion.

The Chernaya river maximum run-off is formed most often in the year winter period as a snowmelt result with simultaneous heavy precipitation. It was revealed that the annual run-off statistical characteristics adopted for the water stations adequately reflect the current situation in the long-term section with the Chernaya river run-off.

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### References

[1] Ivankova T V, Kipkeeva P A and Potapenko Yu Ya 2017 The natural environment Geoeconomic assessment is a necessary link in natural and economic planning for mountainous territories sustainable development (on the Karachay-Cherkessia example) The Voronezh State University Bulletin. Series: Geography. Geocology 4 76-82

[2] Volosukhin Ya V, Ivankova T V, Kipkeeva P A and Potapenko Yu Ya 2017 On the provision of target information for nature management of mountain territories (on the example of the Karachay-Cherkess Republic) The North Caucasus region. Series: Natural science 1(193) 89-95

[3] Korytny L M 2001 Basin Concept in Nature Management (Irkutsk: The Institute of Geography SORAN Publishing house) 163

[4] Kipkeeva P A and Potapenko Yu Ya 2015 Ensuring sustainable tourism main factors in Karachay-
Cherkessia: The Moscow University Bulletin, Geography, 5:76-81.

[5] Kipkeeva P A, Volosukhin Ya V, Ivankova T V, Potapenko Yu Ya and Shubaeva N V 2018 Small river basins landscape and geological analysis in mountain areas protected areas Engineering and Earth Sciences International Symposium: “Applied and Basic Research” (ISEES 2018) DOI https://doi.org/10.2991/ises-18.2018.6

[6] Ivankova T V and Kipkeeva P A 2016 The Northern Elbrus region mountain basin systems landscape structures as the basis for optimizing nature management The Black Sea Economic Cooperation scientific centres Ecological bulletin 13(3) 23-8

[7] Dega N S, Onishchenko V V, Uzdenova Kh I and Shidakov A K 2015 The Kuban River hydrochemical structure Dynamics in the Karachay-Cherkess Republic glacial feeding anthropogenic zone Regional ecology problems 3 92-9

[8] Ivankova T V 2020 Determination of the Anthropogenic Load Degree in the Basin of the Small Alma River IOP conferences Series: Earth and Environmental Science 459 042031

[9] Ivankova T V 2019 The soft tissue structures use to improve the selective irrigation water intake of the Partizansk reservoir The IOP Conf. Series: Earth and Environmental Science 272(2019) 032051 DOI: 10.1088/1755-1315/272/3/032051

[10] Garmaev E Zh 2017 The unexplored rivers annual run-off calculation in the Lake Baikal basin Geography and natural resources 4 69-73

[11] Korobkina E A, Filippova I A and Kharlamov M A 2020 Estimation of runoff in the river basin Don: the need to change the hydrological calculations' paradigm Water resources 47(6) 663-73

[12] Kharanzhevkaya Yu A and Sinyutkina A A 2017 Bogs role investigation in the river run-off formation in the Middle Ob' basin Geography and natural resources 3 97–109

[13] The Water Bodies Integrated Use and Protection Scheme in the Republic of Crimea River Basins. 2017 p 175 (date of treatment 20 October 2019) Retrieved from: https://gkvod.rk.gov.ru/uploads/gkvod/attachments/d4/1d/8c/d98f00b204e98009_98ecf8427e/ phXMIGfT_1.pdf

[14] The Federal State Statistics Service for the Republic of Crimea Official Site (date of treatment 12 September 2019) Retrieved from: http://crimea.gks.ru

[15] The State Committee for Water Management and Land Reclamation of the Republic of Crimea “On approval of the hydrographic units and water management sites and their boundaries number on the Republic of Crimea territory” (Order No. 201 from December 21, 2015)

[16] Chalov R S 2008 The River Channelling Theory, Geography, and Practice V 1 Channel Processes: Manifestation and Conditions Forms Factors, Mechanisms, Forms for the River Channels Formation (Moscow, Russia: LKI) p 608

[17] Timchenko Z V 2009 The Crimea rivers annual run-off variability characteristics calculation with karst sources known discharges in the hydrometric observations' absence The Taurida National University named after V I Vernadsky Scientific notes. Series: Geography 22(61)(2) 148-53

[18] Timchenko Z V 2012 The Crimean Rivers Hydrography and Hydrology: Monograph (Simferopol: IT ARIAL) p 290