AIS LLC

Project on the Construction and Operation of 9.1 MW Akhalkalaki HPP (Akhalkalaki 1HPP and Akhalkalaki 2 HPP) and 35 kV Transmission Line in Akhalkalaki Municipality

Environmental Impact Assessment (EIA) Report

Executor

Gamma Consulting LTD

Director Z. Mgaloblishvili

2019

GAMMA Consulting Ltd. 17a. Guramishvili av, 0192, Tbilisi, Georgia
Tel: +(995 32) 261 44 34 +(995 32) 260 15 27 E-mail: zmgreen@gamma.ge; j.akhvlediani@gamma.ge
www.gamma.ge; www.facebook.com/gammaconsultingGeorgia

Content

1 Introduction

1.1 General Overview

This document represents the Environmental Impact Assessment (EIA) report prepared for the project on the construction and operation of small HPPs on Paravani River and its right tributary Korkhi River in Akhalkalaki municipality and power transmission line. The name of the project is "Akhalkalaki HPP". The name of the HPP planned on Paravani River is "Akhalkalaki HPP 1", and the name of the HPP planned on Korkhi River is "Akhalkalaki HPP 2".

The project will utilize the flows of Paravani and Korkhi rivers to generate electricity. For this purpose, low dams, diversion-pressure pipelines and two separate powerhouses will be constructed on the rivers. A common substation will be constructed in the vicinity of Akhalkalaki HPP 1, from which it will be connected to the Diliska 35 kV substation through a proposed 35 kV transmission line.

Construction works include arrangement of access roads to the project corridor, mobilization of temporary construction infrastructure, earthworks at headworks and power units and arrangement of diversion-pressure pipeline corridors, construction of permanent structures, waste management, etc.

After commissioning, the generated electricity will be connected to the state power system of Georgia.

The project is implemented by Aisi LLC. This EIA report is prepared by Gamma Consulting LTD (Information on the personnel involved in the EIA report preparation process is given in Table 1.2.). The contact information of the client and the consulting company is provided in Table 1.1.

Table 1.1. Contact information

Project developer	Aisi LLC
Legal address of the company	Georgia, Tbilisi, Gldani-Nadzaladevi district, Didubis Dasakhleba str. №13, Building N1 (lit. a)
Address of the project area	Akhalkalaki municipality
Type of the activity	Construction and operation of HPPs and ETL
Contact information of Aisi LLC	
Identification Number	400251543
E-mail	tmatitashvili@ais-georgia.ge ;– hsabouri@ais-georgia.ge
Contact person	Teimuraz Matitashvili
Contact phone number	(+995) 593320216
Consulting company:	Gamma Consulting LTD
Director of Gamma Consulting LTD	Z. Mgaloblishvili
Contact person	Jughuli Akhvlediani
Contact phone number	(+995) 595595255

Table 1.2. Information on the personnel involved in the EIA report preparation process

N	სახელი, გვარი	სამუშაო ადგილი	პოზიცია	ხელმოწერა
1	ზურაბ მგალობლიშვილი	შპს „გამა კონსალტინგი"	დირექტორი	
2	ჯუჯული ახვლედიანი	შპს „გამა კონსალტინგი"	ეკოლოგი	
3	ელენე მგალობლიშვილი	შპს „გამა კონსალტინგი"	სოციოლოგი	
4	სალომე მეფარიშვილი	შპს „გამა კონსალტინგი"	ეკოლოგი	
5	ლევან დოლიაშვილი	შპს „გამა კონსალტინგი"	გეოლოგი	
6	გიორგი ნემსიწვერიძე	შპს „გამა კონსალტინგი"	GIS-ის სპეციალისტი	
7	ნიკოლოზ დვალი	შპს „გამა კონსალტინგი"	ზოოლოგი	
8	ლიკა გოგალაძე	შპს „გამა კონსალტინგი"	ორნითოლოგი	
9	თამთა კაპანაძე	შპს „გამა კონსალტინგი"	ბიტანიკოსი	

1.2 Legal Basis for Preparation of EIA Report

This Environmental Impact Assessment Report has been prepared in accordance with the requirements of the Environmental Assessment Code of Georgia, in particular:

The Akhalkalaki HPP project, by its design characteristics (9.1 MW installed capacity, including: installed capacity of Akhalkalaki HPP 1 is 7.5 MW and installed capacity of Akhalkalaki HPP 2 is 1.6 MW), falls under the category of activities provided for in Annex I of the Code (Paragraph 22: "Construction and/or operation of power plants with a capacity of 5 MW or more"). Since the total installed capacity of the proposed Akhalkalaki HPP is more than 5 MW, the activity is subject to EIA process without a screening procedure and can only be carried out after environmental decision is made.

As mentioned, the project also envisages the construction of a substation and 35 kV ETL, which fall under the category of activities referred to in Annex II (Paragraph 3.4.: „Construction of overhead and/or underground electrical power lines with a voltage of 35 kV or more, and construction of electrical substations with a voltage of 110 kV or more"), which is subjected to screening procedure. However, pursuant to Article 7, paragraph 13 of the Code, the person carrying out activities may, under the procedure established by Article 8 of this Code, submit to the Ministry a scoping application without going through the screening stage.

Due to the above requirements of the Code, Aisi LLC prepared a scoping report, on the basis of which the company obtained the Scoping Conclusion N46 19.04.2019. Information on the implementation of the issues defined by the Scoping Conclusion and to be considered in the EIA Report is provided in Table 10.1. This EIA report is prepared in accordance with the said scoping conclusion, which includes the information required by Article 10 (3) of the Code.

The project implementation is planned with the support of the international financial organization - the European Investment Bank (EIB). Accordingly, EIB environmental and social standards have been used during the preparation of this EIA, in particular:

- Assessment and management of environmental and social impacts and risks;
- Prevention and reduction of pollution;
- Biodiversity and ecosystems;
- Climate-related standards;
- Cultural heritage;
- Involuntary resettlement;
- Rights and interests of vulnerable groups;
- Labor standards;
- Occupational and public health and safety;
- Stakeholder engagement.

1.3 Objectives of EIA

According to the Environmental Assessment Code, the purpose of the EIA is to identify, study and describe the following direct and indirect impacts caused by the planned activities:

a) Human health and safety;
b) Biodiversity (including plant and animal species, habitats, ecosystems);
c) Water, air, soil, ground, climate and landscape;
d) Cultural heritage and material values;
e) Interaction of factors referred to in (a) to (d).

Impact detection, study and description should also include activity-related hazards to large-scale accident and / or natural disaster risks.

To perform the tasks listed below, the consulting company has performed the following main works:

- Technical documentation of planned activities was studied;
- information on the natural and social environment of the project area and the project corridor was collected;
- Based on the analysis of the information obtained, the expected environmental and social impacts of the project and its alternatives at various stages of the project were determined;
- Environmental management and monitoring schemes were established on the basis of the identified types and scales of environmental impacts. Effective mitigation measures were developed to reduce environmental impacts;
- The public was informed about the planned activities and appropriate measures were taken to ensure public participation in the EIA process.

2 Legal Aspects

Georgian legislation comprises the Constitution, environmental laws, international agreements, subordinate legislation, normative acts, presidential orders and governmental decrees, ministerial orders, instructions and regulations. Georgia is signatory of a number of international conventions, including international environmental conventions.

2.1 Environmental Legislation of Georgia

This EIA report has been prepared in accordance with the requirements of the Low of Georgia on Environmental Assessment Code. In addition, other environmental laws of Georgia have been taken into account in the EIA process. A list of Georgian environmental laws is given in Table 2.1.1.

Table 2.1.1. List of Environmental Laws of Georgia

Year	Law	Registration code	Final version
1994	Law of Georgia on Soil Protection	370.010.000.05.001.000.080	16/07/2015
1994	Law of Georgia on Roads	310.090.000.05.001.000.089	24/12/2013
1995	Constitution of Georgia	010.010.000.01.001.000.116	04/10/2013
1996	Law of Georgia on Environmental Protection	360.000.000.05.001.000.184	11/11/2015
1997	Law of Georgia on Wildlife	410.000.000.05.001.000.186	26/12/2014
1997	Law of Georgia on Water	400.000.000.05.001.000.253	26/12/2014
1997	Maritime Code of Georgia	400.010.020.05.001.000.212	11/12/2015
1999	Law of Georgia on Protection of Air Quality	420.000.000.05.001.000.595	05/02/2014
1999	Forest Code of Georgia	390.000.000.05.001.000.599	06/09/2013
1999	Law of Georgia on Compensation for Harm Caused by Hazardous Substances	040.160.050.05.001.000.671	06/06/2003
2003	Law of Georgia on Red List and Red Book of Georgia	360.060.000.05.001.001.297	06/09/2013
2003	Law of Georgia on the Conservation of Soils and Restoration and Improvement of Their Fertility	370.010.000.05.001.001.274	19/04/2013
2005	Law of Georgia on Licenses and Permits	300.310.000.05.001.001.914	11/11/2015
2006	Law of Georgia on Regulation and Engineering Protection of the Sea shores, Reservoir and River Banks	400010010.05.001.016296	13/05/2011
2007	Law of Georgia on Ecological Examination	360.130.000.05.001.003.079	25/03/2013
2007	Law of Georgia on Public Health	470.000.000.05.001.002.920	11/12/2015
2007	Law of Georgia on Cultural Heritage	450.030.000.05.001.002.815	26/12/2014
2014	Law of Georgia on Public Safety	140070000.05.001.017468	16/12/2015
2014	Waste Management Code	360160000.05.001.017608	19/02/2015
2017	Low of Georgia on Environmental Assessment Code	360160000.05.001.018492	07/12/2017

2.2 Environmental Standards of Georgia

The following environmental standards have been used in the process of evaluating the quality of environmental objects (soil, water, air). (See Table 2.2.1.):

Table 2.2.1. List of Environmental Standards

Year	Nmae of Normative Document	Registration code
31/12/2013	Technical Regulation – "Protection of Surface Water Contamination", approved by the decree №425 of the Government of Georgia.	300160070.10.003.017650
03/01/2014	Technical Regulation – "Operation of Dust-Trapping Devices", approved by the decree №21 of the Government of Georgia.	300160070.10.003.017590
03/01/2014	Technical Regulation - "The unfavorable weather conditions for Protection of Environment", approved by the decree №8 of the Government of Georgia.	300160070.10.003.017603
31/12/2013	Technical Regulation – "Methods of calculation of maximum permissible emission of hazardous substances into ambient air", approved by the order №408 of the Government of Georgia	300160070.10.003.017622
06/01/2014	Technical Regulation - "Method for inventory of Stationary Sources of Air Pollution", approved by the decree №42 of the Government of Georgia.	300160070.10.003.017588
03/01/2014	Environmental Technical Regulation – approved by the decree №17 of the Government of Georgia.	300160070.10.003.017608
14/01/2014	Technical Regulation - "Environmental Damage Determination	300160070.10.003.017673

	(calculation) Method", approved by the decree №54 of the Government of Georgia.	
31/12/2013	Technical Regulation – "Methods of calculating the actual amount of emissions according to instrumental methods for determining the actual amount of emissions in ambient air from stationary sources of pollution, list of special measuring and controlling equipment for determining the actual amount of emissions in ambient air from stationary sources of pollution and technological processes from stationary pollution sources," approved by the order №435 of the Government of Georgia	300160070.10.003.017660
31/12/2013	Technical Regulation – "Fishing and protection of fish stock", approved by the order №423 of the Government of Georgia.	300160070.10.003.017645
31/12/2013	Technical Regulation – "Quarries Safety", approved by the order №450 of the Government of Georgia.	300160070.10.003.017633
31/12/2013	Technical Regulation - provisions on "Determining Levels of Soil Fertility " and "Soil Conservation and Fertility Monitoring", approved by the decree №415 of the Government of Georgia.	300160070.10.003.017618
31/12/2013	Technical Regulation - "Topsoil Removal, Storage, Use and Cultivation", approved by the decree №424 of the Government of Georgia.	300160070.10.003.017647
15/01/2014	Technical Regulation – "Maximum Allowed Concentrations of harmful substances at work places", approved by the order №70 of the Government of Georgia	300160070.10.003.017688
15/01/2014	Technical Regulation on "Drinking Water", approved by the decree №58 of the Government of Georgia.	300160070.10.003.017676
31/12/2013	Technical Regulation – "on water protection zones", approved by the order №440 of the Government of Georgia.	300160070.10.003.017640
31/12/2013	Technical Regulation - "water protection zones of small rivers in Georgia", approved by the decree №445 of the Government of Georgia.	300160070.10.003.017646
03/01/2014	Technical Regulation - "sanitary rules of water sampling", approved by the decree №26 of the Government of Georgia.	300160070.10.003.017615
13/08/2010	"Rule on Forest Protection and Restoration". Approved by the decree №241 of the Government of Georgia.	-
20/08/2010	„Forest Utilization Plan". Approved by the decree №242 of the Government of Georgia.	-
17/02/2015	„The Rule of Implementation of State Control by the Environmental Supervision Department of Subdivision Agency of the Ministry of Environment and Natural Resources Protection of Georgia". Approved by the decree №61 of the Government of Georgia.	040030000.10.003.018446
29/12/2014	„The list of the Green Zones and Resorts of the State Forest Fund under the Management of the National Forestry Agency – Legal Entity of Public Law of the Ministry of Environment and Natural Resources Protection of Georgia". Approved by the decree №161 of the Minister of Environment and Natural Resources Protection of Georgia.	360050000.22.023.016284
04/08/2015	"Rules of reviewing and coordinating the company's waste management plan". Approved by the decree №211 of the Minister of Environment and Natural Resources Protection of Georgia.	360160000.22.023.016334
17/08/2015	"Determination and classification of the list of waste according to their types and characteristics". Approved by the decree №426 of the Minister of Environment and Natural Resources Protection of	300230000.10.003.018812

	Georgia.	
11/08/2015	Regulation #422 of the Georgian government on Form and Content of. Conducting Waste Recording and Reporting dated by August 11, 2015.	360100000.10.003.018808
29/03/2016	Technical regulation on "Waste Transportation Rule" approved by. #143 of the of the Government of Georgia (March 29, 2016, Tbilisi).	300160070.10.003.019208
29/03/2016	Government Resolution # 144 (March 29, 2016, Tbilisi) "On the Rules and Conditions for the Registration, Transportation, Pre-Treatment and Temporary Storage of Waste".	360160000.10.003.019209
29/03/2016	Technical Regulation on # 145 (March 29, 2016) of the Government of Georgia on Approval of Technical Regulations on Special Requirements for Hazardous Waste Collection and Treatment	360160000.10.003.019209
1/04/2016	Resolution # 159 of the Government of Georgia (April 1, 2016, Tbilisi) on the Procedure for Municipal Waste Collection and Treatment;	300160070.10.003.019224
15/08/2017	Technical Regulation of the Government of Georgia "On Acoustic noise limits for rooms/premises in residential houses and public establishments and their accommodation. Resolution No. 398.	300160070.10.003.020107

2.3 International Agreements

Georgia is signatory to many international conventions and agreements, out of which the followings are significant for the EIA process of the given project:

Name of International Agreements	Year of adoption	Year of ratification by Georgia
Aarhus Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters (Convention, 1998).	1998	2001
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	1989	1999
United Nations Convention on Persistent Organic Pollutants (POPs), Stockholm.	2001	2006
Convention on Biological Diversity, Rio de Janeiro	1992	1994
Cartagena Protocol on Biosafety	2003	2008
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Washington.	1973	1996
Convention on the Protection of the Ozone Layer, Vienna.	1985	1996
Montreal Protocol on Substances that Deplete the Ozone Layer	1987	1996
Amendment to the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer	1997	2000
Amendment to the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer, Copenhagen.	1992	2000
United Nations Framework Convention on Climate Change, New York.	1994	1994
Kyoto Protocol, Kyoto.	1997	2005
Geneva Convention on Long-range Transboundary Air Pollution.	1979	1999
United Nations Convention to Combat Desertification, Paris.	1994	1999
Convention on Wetlands of International Importance especially as Waterfowl Habitat, Ramsar, 1971	1971	1996

3 Description of Planned Activity

3.1 Project Area

Implementation of the Akhalkalaki HPP construction and operation project is planned in Samtskhe-Javakheti region, on the territory of Akhalkalaki municipality. The project envisages the construction of two independent powe houses with a common 35 kV substation, including: Akhalkalaki 1 HPP will be constructed on Paravani River section between 1616 m and 1555 m altitudes, and Akhalkalaki 2 HPP will be constructed on Korkhi River section betweeen 1627.5 m and 1555.4 m altitudes.

The Akhalkalaki-1 HPP headworks is planned to be arranged downstream of confluence with Kirbulakhi River, northwest of Diliska village at 1616 m a.s.l. Approximate coordinates of headworks location are: X-372162; Y-4587550. Several alternative locations for headworks structure was discussed in detail at the design stage. Their description is given in the following Paragraphs.

Left bank of Paravani River was selected for the arrangement of penstock and power unit of the HPP. Power unit will be arranged near the confluence of Korkhi River. Approximate coordinates of the selected area are: X-371903; Y-4590673.

Akhalkalaki-2 HPP headworks structure is planned to be arranged on Korkhi River at an altitude of 1627.5 m, southeast of Orja Village. Approximate geographical coordinates of the location selected for the headworks are: X- 372353; Y- 4592330.

Right bank of Korkhi River was selected for the arrangement of penstock and power unit of Akhalkalaki 2 HPP. Powerhouse is planned to be arranged near the confluence of Korkhi River, in the vicinity of highway. Approximate coordinates of the location selected for the power unit are: X-371792; Y-4590818.

Areas that fall within the project influence zone are wholly state-owned. The territory of only one construction camp (Akhalkalaki 2 HPP headworks) is privately owned land that will be leased by Aisi LLC.

3.2 Project Alternatives

3.2.1 No-action Alternative/Justification of the need for the Project

No-action alternative means rejection of the project implementation, which excludes the potential negative environmental impacts, caused by the project construction and operation, on natural and social conditions.

Nowadays, utilization of hydraulic resources is one of the main directions of the energety policy of the Georgian Government. First of all, hydraulic resources, effective from technical-economic viewpoint, are subject to utilization. It should also be noted that Georgia is the country with small land resources and construction of HPPs with large reservoirs is restricted. Arrangement of run-of-the river HPPs becomes more and more attractive, as the degree of the environmental impact of them is far less and the construction is carried out in the short period of time.

The project HPPs are HPPs with small capacities, operating on the natural runoff the river. Although it does not have special strategic function for the country, it is very important to supply additional power to the state energy system and it is meaningful for economic development of Akhalkalaki Municipality. Following should be singled out from various socio-economic benefits, expected in the result of the project implementation

- Generation of additional power and meeting mostly local demands by generated electricity;

- Creation of certain number of temporary and permanent job-places. Although the number of people employed during the project implementation is not high, baseline demographic indicators of the project area and socio-economic conditions of local population should be taken into account. Population migration level is high; job shortage is one of the reasons for this. As it is shown from similar project implementation practice, local population represents the major part of employed people on the construction. Accordingly, the project implementation will make its contribution to the growth of population employment level in the region and improvement of their socio-economic conditions;
- Improvement of infrastructure (small sized manufacturers of the construction materials, transport service, food provision, etc.) required for the project implementation, which in its turn will create additional income sources and job-places;
- It is noteworthy that the project implementation will attract additional incomes to the local budget in the form of various taxes, including property tax and land tax;
- Improvement of the local infrastructure, etc.

In addition to the above-mentioned, the project, considering the conditions of the project implementation location; has its own characteristics, which makes the project different from other hydrological power projects and emphasizes its profitability both from economic environmental viewpoint. The project specifications are shown in the following issues:

- High-pressure capability with consideration of local morphological conditions, ensuring low cost of generated electricity;
- Construction of a large reservoir is not considered;
- No tunnel is planned to be constructed;
- Large scale works are not required for the construction of new roads;
- Basic construction materials for the project - sand, gravel and timber can be found locally.

As for the need for construction of the planned power transmission infrastructure (substation and power transmission line) - the construction of the HPPs is impossible without them. Generated electricity shall be connected to the state power system. Construction and operation of power transmission infrastructure will further increase the expected positive social and economic benefits of the project.

In addition to the above-mentioned it is important to note that the vegetation cover is actually is not represented within the project HPP corridors, corridors do not cross state fund lands, and according to the field survey results, no habitats of red-listed animal species of Georgia were observed on the project areas. Accordingly, the risk of negative impact on terrestrial animals will not be high.

Taking into consideration the above, it can be said that the implementation of the project will have quite high positive socio-economic results, both regionally and specifically for local residents.

Expected impacts can be reduced to a lower level than average. For this purpose, appropriate preventive, mitigation, compensation measures shall be implemented and acting environmental standards shall be met. In conclusion, it can be said that the construction and operation of HPPs and related power transmission lines will result in far more significant socio-economic benefits than the No-Action alternative of the project, therefore, it has been rejected.

3.2.2 Alternatives for the Project Communication Locations

Locations for the arrangement of the proposed infrastructure were selected based on the complex analysis of natural environmental conditions and social issues, which, on the one hand, determines the profitability of the project in financial-economic terms and on the other hand, reduces expected environmental and social impacts to a minimum.

During the designing process, several alternatives for the arrangement of the project HPPs and power transmission line were discussed. Detailed overview of alternatives for HPPs and ETLs is given below separately.

3.2.2.1 HPP Infrastructure Location Alternatives

During the preliminary feasibility study, the project prepared in 2011-2012 was considered as one of the alternatives, according to which one HPP (Alternative-1) was planned to be arranged.

According to the Alternative I, the main headworks was planned to be arranged to the north of Akhalkalaki city, on Paravani River between the altitudes of 1640 -1644 m., from where 5840 m long diversion tunnel was planned to be arranged to the west of Korkhi village, till the surge tank. Water from surge tank would be diverted to 160 m long penstock. Project headwork was planned on Korkhi river adjacent to Orja village between the altitudes of 1640-1645 m. The diversion system was represented by a 1772 m long diversion pipeline and subsequently by a 1250 m long diversion tunnel (total derivation length - 3022 m). Through the diversion system the water was supplied to the above-mentioned surge tank.

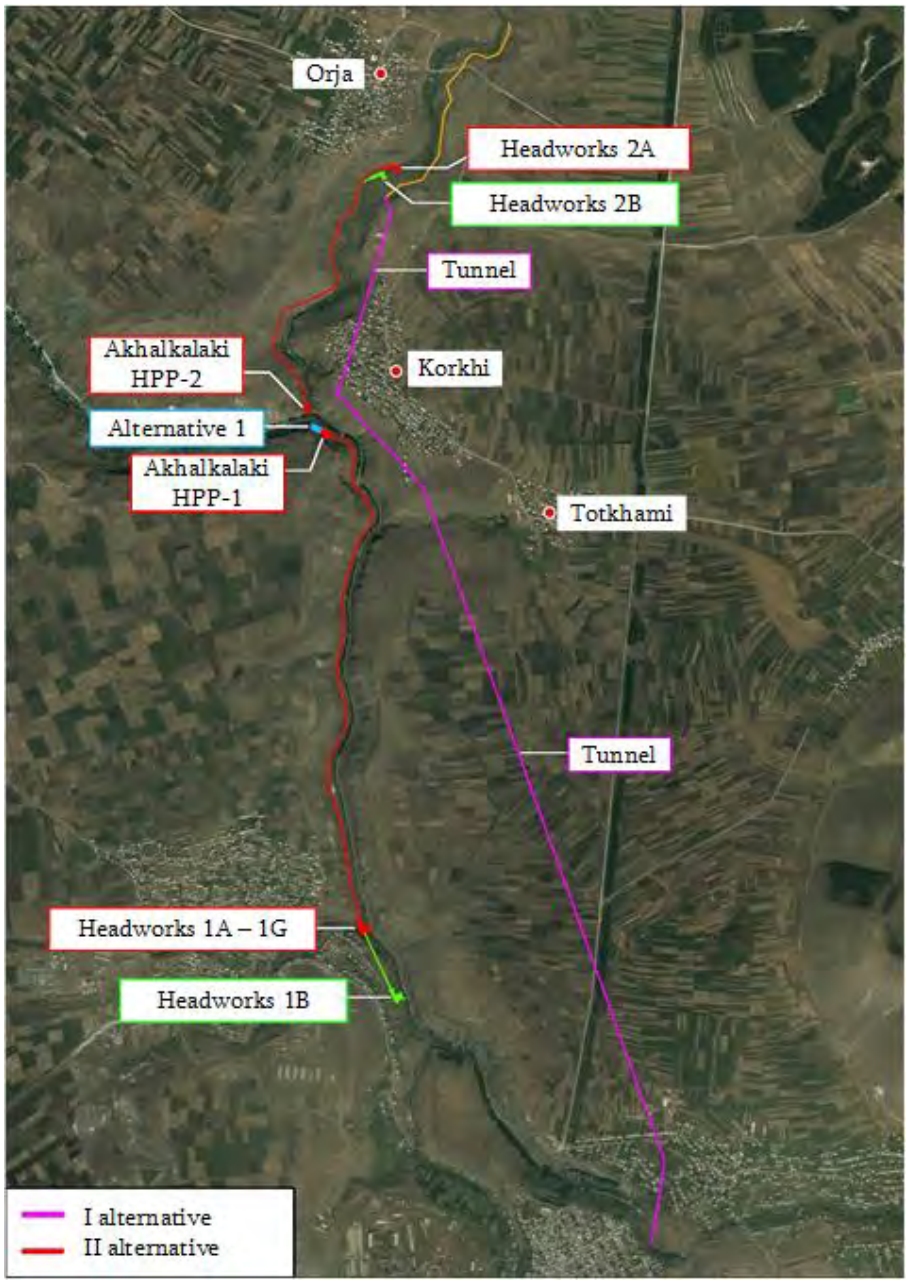
In addition to this, for the operation of Akhalkalaki HPP, the project envisaged to utilize the hydropower potential of Kirkhbulakhi River - the left tributary of Paravani River. For this purpose, additional headworks was considered to be arranged between Murjakheti village of Akhalkalaki municipality and Kaurma village of Ninotsminda Municipality.

Land for the construction of the common power house was selected in the west of Korkhi village, near the confluence of Paravani and Korkhi rivers at 1555 m a.s.l.

Thus, Akhalkalaki HPP was able to generate 95,889 GW/h electricity through utilizing the hydropower potential of the rivers Paravani, Korkhi and Kirkhbulakhi. The installed capacity was 17,28 MW. According to this project, the scale of construction works and costs of Akhalkalaki HPP were much higher. What is the most important, the given alternative is characterized by high risks of impact on natural and social environment, and therefore, the discussion of this alternative was rejected at the very first stage.

The Alternative II, developed by the design team of Akhalkalaki HPP, on both rivers considers arrangement of low-threshold dams and water diversion through the penstock. Headwork structures are moved to lower elevations, the length of diversion-pressure systems is reduced, arrangement of complex engineering structures, such as tunnels and a surge tank is no longer considered by the project. Therefore, the need for construction of new access roads is decreased. From environmental point of view, it is also important that the main construction sites are away from residential zones. As a result of changes made to the HPP's infrastructure, scale of construction works and environmental impacts related to construction are also reduced.

Figure 3.2.2.1.1. Alternatives for HPP Communication Locations



Main environmental advantages of Alternative II:

- Reduced duration and scale of construction works. Consequently, construction-related environmental risks are also reduced: risk of negative impact on the population caused by noise propagation and emission of harmful substances in ambient air; probability of water and soil pollution, etc;
- Reduced area of land required for construction of HPP infrastructure. Therefore, there is less risk of impact on land resources, biological and geological environment;
- Reduction of utilized sections of the Project Rivers. Hence less impact is expected on the hydrology of rivers and water biodiversity;
- The volume of expected waste rock is significantly reduced due to excluding tunnels from the project and reducing the length of access roads. Negative results related to the tunneling are also excluded, etc.

For arrangement of the project HPP communications according to Alternative 2, several sub-alternatives were discussed, including: for Akhalkalaki-1 HPP - Akhalkalaki 1a, Akhalkalaki 1b and Akhalkalaki 1c. For Akhalkalaki 2 HPP - Akhalkalaki 2a and Akhalkalaki 2b.

3.2.2.1.1 Akhalkalaki 1 HPP Alternatives

The **Akhalkalaki-1a** alternative harnesses flow in the Paravani river between elevation 1619,5 m a.s.l. and elevation 1560 m a.s.l. The headworks structures are located just downstream of the confluence of Kirkhbulaki river (a small tributary) and Paravani river, between Akhalkalaki and Diliska village.

It is planned to make an intake pond by constructing a 5,3 m high and 30 m long dam across the Paravani river. Integrated into the dam structure will be a gated spillway both for flushing of sediments and flood control. Facilities for releasing stipulated environmental flow as well as the seasonal water demand for the irrigation pumping station located downstream from the headworks will be incorporated into the structure. The dam will raise the normal water level to elevation 1622,5 m a.s.l. The intake pond will be approximately 45.500 m^3 in volume and extend some 570 m upstream from the dam. The existing highway along Paravani river will be elevated along a 360 m section in order to keep it from being flooded.

A fishway will connect the natural riverbed downstream of the dam to the intake pond. From the intake pond the water will be diverted through an intake and sand basin located on the left riverbank. From the intake, the harnessed water will flow through a 4,26 km long steel pipe estimated to be 2,8 m in diameter. The pipe will be located on the left bank and will in general be installed in a trench and covered with earth fill. The last 1200 m of the pipe route are located on a steep scree slope next to Paravani river. Crossing this section of the pipe route will involve large volumes of excavation and most likely also some slope stabilization measures.

The powerhouse is assumed to be a typical above ground structure, located on the left bank of the Paravani, adjacent to the confluence of Paravani and Korkhi. Due to difficult terrain, the powerhouse site is assumed to be partially excavated into the steep scree slope, most likely also involving some slope stabilization measures. The powerhouse is assumed to be a concrete structure, housing three Francis turbines and generators on a horizontal axis. The design discharge is 5,0 m^3/s for each turbine. The harnessed water will be released back to the riverbed via a short tailrace canal. Normal tailwater elevation is assumed to be 1560 m a.s.l. Conventional surge facilities are not foreseen. In return, pressure regulating valves are installed to regulate pressure variations.

In case of **Akhalkalaki-1b,** HPP harnesses flow between elevation 1616 m a.s.l. and elevation 1560 m a.s.l. This alternative is in many aspects similar to the Akhalkalaki-1a alternative. The headworks structures are located just upstream of the confluence of a small tributary and Paravani river close to Diliska village. This tributary is very small and sometimes even totally dry.

The layout assumes an intake pond being formed by constructing a 5,4 m high and 30 m long dam across the Paravani river. Integrated into the dam structure will be a gated spillway both for flushing of sediments and flood control. Facilities for releasing stipulated environmental flow as well as the seasonal water demand for the irrigation pumping station located downstream from the headworks, will be incorporated into the structure. The dam will raise the normal water level to elevation 1619 m a.s.l. The intake pond will be approximately 68.000 m^3 in volume and extend some 780 m upstream from the dam. The existing highway along the Paravani will be elevated to about 1 km (specified in detailed road design) in order to keep it from being flooded.

A fishway will connect the natural riverbed downstream of the dam to the intake pond. From the intake pond the water will be diverted through an intake and sand basin located on the left riverbank. From the intake, the harnessed water will flow through a 3375 m long steel pipe, 2,8 m in diameter. The pipe will be located on the left bank and will be installed in a trench and covered with earth fill. The last 1200 m of the pipe route are located on a steep scree slope next to the Paravani. Crossing this section of the pipe route will involve large volumes of excavation and most likely also slope stabilization measures.

The powerhouse is assumed to be a typical above ground structure, located on the left bank of the Paravani, adjacent to the confluence of Paravani and Korkhi. Due to difficult terrain, the powerhouse site is assumed to be partially excavated into the steep scree slope, most likely also involving some slope stabilization measures. The powerhouse is assumed to be a concrete structure, housing three Francis turbines and generators on a horizontal axis. The design discharge is 5,0 m^3/s for each turbine. The harnessed water will be released back to the riverbed via a tailrace canal. Normal tailwater elevation is assumed to be 1555 m a.s.l. Conventional surge facilities are not foreseen. In return, pressure regulating valves are installed to regulate pressure variations.

Alternative **Akhalkalaki-1c** is in many aspects quite similar to alternative AKH-1b. It harnesses flow between current river elevation 1616 m a.s.l. and elevation 1560 m a.s.l.

The headworks structures are located just upstream of the confluence of a small tributary and Paravani river close to the Diliska village.

The layout assumes an intake pond being formed by constructing a 5,5 m high and 30 m long dam across the Paravani river. Integrated into the dam structure will be a gated spillway both for flushing of sediments and flood control. Facilities for releasing stipulated environmental flow as well as the seasonal water demand for the irrigation pumping station located downstream from the headworks, will be incorporated into the structure. The dam will raise the normal water level to elevation 1619 m a.s.l. The intake pond will be approximately 61.000 m^3 in volume and extend some 780 m upstream from the dam. The existing highway along the Paravani will be elevated along a 650 m section in order to keep it from being flooded.

A fishway will connect the natural riverbed downstream of the dam to the intake pond. From the intake pond the water will be diverted through an intake and sand basin located on the left riverbank. From the intake, the harnessed water will flow through a 3130 m long steel pipe, 2,8 m in diameter. The pipe will be located on the left bank and will in general be installed in a trench and covered with earth fill. The last 940 m of the pipe, upstream from the powerhouse, will be laid in a tunnel connecting the pressure pipe to the powerhouse.

The powerhouse is assumed to be underground, located on the left bank of the Paravani, adjacent to the confluence of Paravani and Korkhi. The powerhouse will house three Francis turbines and generators on a horizontal axis. The design discharge is 5,0 m^3/s for each turbine. The harnessed water will be released back to the riverbed via a 100 m long tailrace tunnel. Normal tailwater elevation is assumed to be 1560 m a.s.l. Conventional surge facilities are not foreseen. In return, pressure regulating valves are installed to regulate pressure variations.

The tunnels and powerhouse cavern are assumed to be excavated with drill and blast technique and supported with conventional rock bolts and shotcrete as may apply. Width of tunnels is assumed 6,0 m, to allow for access and installation of pressure pipe.

3.2.2.1.2 Akhalkalaki 2 HPP Alternatives

According to the **Akhalkalaki-2a** alternative, AKH-2a, will harness the flow of the Korkhi river between the current river elevation 1627.5 m a.s.l. and elevation 1555.4 m a.s.l. Headworks structure is located some 200 m south-east of the Orja village. It is assumed that the headworks will consist of a 25 m long overflow spillway equipped with a Tyrolean type intake, flushing gates and a water intake. Maximum height of the spillway/dam is estimated to be 3 m. The intake pond will extend some 80 m upstream from the dam. A fishway will be provided to connect the natural riverbed downstream of the spillway to the intake pond.

From the intake, the diverted water will flow through a 1950 m long, 1,2 m diameter steel pipe located on the right bank of the Korkhi river. The pipe is assumed to be buried. The powerhouse, assumed to be

a conventional above ground powerhouse, is located on the right bank of the Korkhi river, immediately upstream of the confluence of Korkhi and Paravani rivers. The powerhouse is assumed to be a concrete structure, assumed to house one crossflow turbine and a generator. The design discharge is 2,8 m^3/s. The harnessed water will be released back to the riverbed via a short tailrace canal. Normal tailwater elevation is assumed to be 1555.4 m a.s.l. Pressure regulating valves are installed to regulate pressure variations.

According to the **Akhalkalaki-2b** alternative, AKH-2b, will harness the flow from the Korkhi river between the current river elevation 1621 m a.s.l. and elevation 1560 m a.s.l.

Headworks structures are located some 200 m south-east of the Orja village. It is assumed that the headworks will consist of a 25 m long overflow spillway with a Tyrolean type intake, flushing gates and a water intake. Maximum height of the spillway/dam is estimated to be 3 m. The intake pond will extend some 60 m from the dam. A fishway will be provided to connect the natural riverbed downstream of the spillway to the intake pond.

From the intake, the diverted water will flow through a 1685 m long, 1,3 m diameter steel pipe located on the right bank of the Korkhi river. The pipe is assumed to be buried the whole distance from the intake to the powerhouse.

The powerhouse, assumed to be a conventional above ground powerhouse, is located on the right bank of the Korkhi River, immediately upstream of the confluence of Korkhi and Paravani rivers. The powerhouse is assumed to be a concrete structure, assumed to house one cross flow turbine and a generator. The design discharge is 2,8 m^3/s. The harnessed water will be released back to the riverbed via a short tailrace canal. Normal tailwater elevation is assumed to be 1555.4 m a.s.l. Pressure regulating valves are installed to regulate pressure variations.

3.2.2.1.3 Brief Summery

From Akhalkalaki-1 HPP scheme alternatives, Akh-1b is relatively better option regarding negative environmental impact risks, as in this case, relatively shorter section (3375 m) of Paravani river will get within the project impact zone, than it is in case of alternatives 1a and 1c (relatively 4260 m and 4070 m). Thus, the impact risk on aquatic biological environment will be slightly lower.

Regarding the impact on flora and fauna, alternatives do not actually differ from each other, the project area is located on the territory under high anthropogenic load and there are no trees and vegetation within the project impact zone.

As for impact risks on social conditions, the three alternatives are identical, in particular: Risks of physical and economic resettlement are not expected according to any alternative. The irrigation system pumping station will be located downstream the project headwork structures. As for the impact on amateur fishing conditions, according to Alternative 1a relatively higher impact is expected, as relatively longer section of Paravani river is going to be within the impact zone.

Besides, according to Alternative 1c, the project considers arrangement of 940 m long and 6 m wide tunnel and underground power house. Considering the fact that tunneling and arrangement of the space for underground power houses are planned using drill and blast method, there are some risks of the impact on geological conditions, activation of hazardous geodynamic processes.

According to Alternative1b, underground penstock will be arranged, which is planned on the first terrace of the left bank slope of Paravani river. Although in this case, it is required to cut slope in some areas, considering corresponding reinforcement works, it will be possible to minimize the risks of hazardous geodynamic process activation. The same can be stated about the aboveground power house option, the construction site of which requires slope excavation.

Considering aforementioned the preference is given to the Alternative 1b for Akhalkalaki 1 HPP communication location.

Akhalkalaki 2 HPP alternatives are actually the same in terms of environmental impact risks. Considering better conditions for arrangement of headworks, the alternative 2a was preferred.

3.2.2.2 ETL and Substation Location Alternatives

3.2.2.2.1 ETL Alternatives

Several alternatives were discussed for connection of the power generated by Akhalkalaki HPP to the state electric system, including two alternatives of 110 kV ETL corridor and three alternatives of 35 kV ETL corridor. The scheme of alternatives is given on Figure 3.2.2.2.1.1.

In case of arrangement of 110 kV ETL, it was considered to connect it to the existing 110 kV ETL "Vardzia". The latter passes through Korkhi river valley in the vicinity of the headwork of Akhalkalaki 2 HPP. After connection, length of the existing 110 kV ETL till 110/35/10 kV substation "Akhalkalaki" is ≈8.

Two alternative routes were discussed for connection to ETL Vardzia: the right and left bank slopes of Korkhi river. The preference was given to the right bank alternative, as if the left bank corridor was used ETL would be arranged near the residential zone of Korkhi village, and this would be related to impact risks of electrical-magnetic radiation.

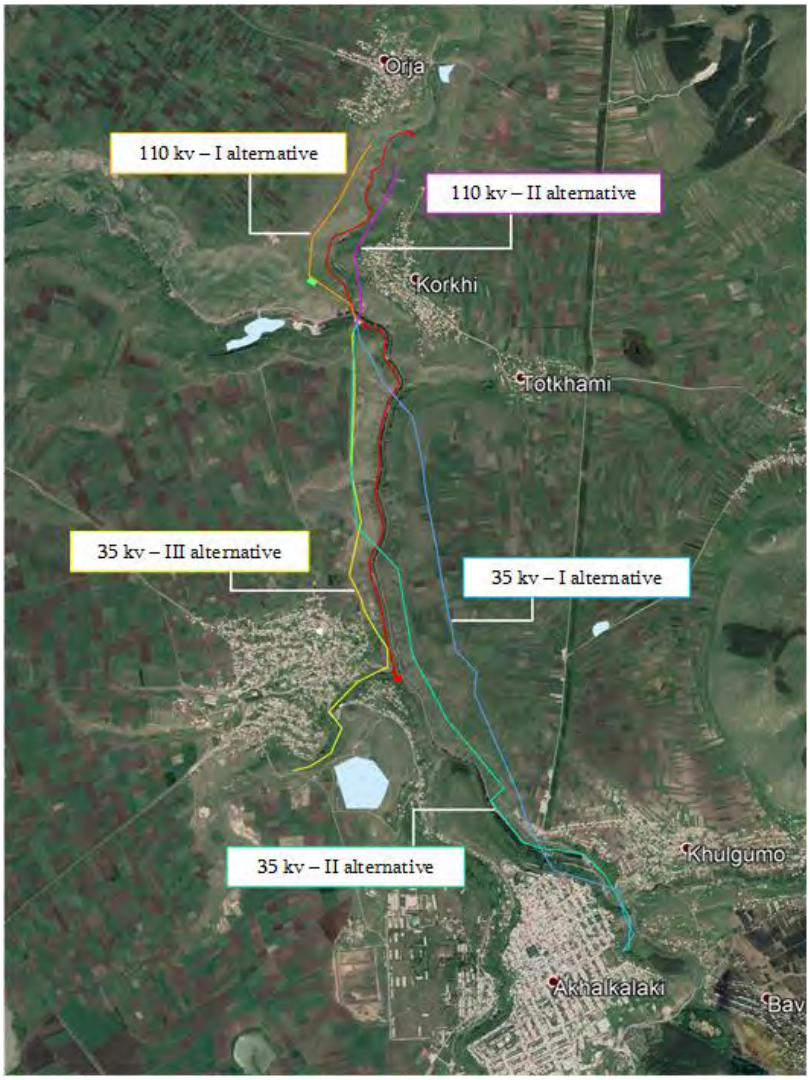
As for arrangement of 35 kV ETL, three alternatives were discussed (see Figure 3.2.2.2.1.1.). According to the alternative 1 and alternative 2, ETL connection is planned to substation "Akhalkalaki 110/35/10kV", and according to the alternative 3 – to substation "Diliska 35/10kV".

In case of the alternative 1 and alternative 2, the length of the ETL is about 7.0-7.5 km, and in case of the alternative 3, the corridor length is about 4.6 km. As it is shown on the scheme, in case of the alternatives 1 and 2, the length of ETL final section will pass the densely populated settlement on about 2 km, where the risks of economic resettlement are high. In case of the alternative 3, ETL corridor will pass near the residential zone on about 450 m section and there are no physical or economic resettlement risks. In case of the alternative 3 vegetation cover will not be damaged; no trees or vegetation are represented within the project corridor.

Alternative 3 of 35 kV ETL arrangement was considered to be the best option, which is stipulated by following advantages:

- The shortest length of the project corridor and relatively lower risks of environmental impacts considering the small scale of the planned works;
- No risks of resettlement;
- Low risk of impact on biological environment (ETL does not cross river valley; there is no vegetation cover within the project corridor):
- Relatively lower risks of impact on geological conditions (with the exception of the two initial tower locations, the project corridor passes through areas with calm terrain, where actually there are no risks of hazardous geodynamic process activation);
- Considering distances to the residential zones, there is no risk of impact related to the electrical-magnetic radiation.

Figure 3.2.2.2.1.1. Scheme of ETL Location Alternatives



3.2.2.2.2 Substation Location Alternatives

Two alternatives were discussed for substation location, including (the scheme of alternatives is given on Figure 3.2.2.2.2.1.):

- Alternative 1 - arrangement of the substation near proposed powerhouses, on the left bank of Paravani River (approximate Coordinates: X – 371831; Y - 4590701). The area is approximately ≈295 m away from populated zone (Korkhi village);
- Alternative 2 - arrangement of substation on the right slope of Paravani River (approximate Coordinates: X – 371452; Y - 4591036). The area is approximately ≈410 m away from populated zone (Korkhi village).

As it is mentioned in ETL corridor alternatives, arrangement of 35 kV ETL is the best option, which from the area, adjacent to Akhalkalaki 1 HPP, passes on the upper elevations of the left bank of Paravani river. In case of the alternative 2, ETL corridor will cross Paravani river, which increases the impact risk on birds. Implementation of the alternative 2 would be suitable in case of 110 kV ETL project, but in conditions of 35 kV ETL project implementation, this alternative should be deemed unacceptable.

According to the results of engineering-geological survey, Alternative 1 site is acceptable for substation arrangement. Considering the distance to the settlement, the risk of impact on population is actually absent.

In addition, in case of the Alternative 1, the substation will be arranged on the project area of Akhalkalaki 1 HPP power house and unlike to the Alternative 2, usage of the new area will not be needed. Accordingly, the alternative 1 is characterized with relatively lower risks of environmental impacts.

Considering aforementioned, alternative 1 was preferred.

Figure 3.2.2.2.2.1. The Scheme of Substation Location Alternatives

3.2.2.2.3 ETL and Substation Type Alternatives

Overhead and cable line alternatives are discussed for ETL types.

The main advantages of cable transmission line are its safety (cables under the ground are maximally protected from weather or human impact). It is even safer for humans, domestic animals and especially, for birds. In addition, its construction does not require a wide corridor, therefore, less impact is expected on different receptors of the environment (biodiversity, soil, etc.). It is invisible and poses less visual and landscape impact risks. Cable transmission lines do not need wide protection lines for consideration of the electrical fields. Thus it can be designed so as not to have impact on human health. In addition to less expected environmental impacts, cable transmission lines are much more efficient in terms of energy conservation.

However, alternative of arrangement of cable ETL is unacceptable from technical viewpoint. In case of overhead ETL arrangement, road construction is required only for access to towers, while in case of cable ETL, road construction is required within the whole corridor. Accordingly, there are threats of cable damage due to risks of erosive process development.

The second issue, which justifies rejection of this alternative, is the impact on local infrastructure. In particular, the cable will cross local roads. This can become the impact source on natural and social environment.

In the regard with the impact on natural environment, it is noteworthy that in case of the cable arrangement, the corridor will be utilized continuously. In case of overhead ETL arrangement, corridors between towers (wire route) can be used for various purposes (growth of plants in safe distance from wires, agricultural activities). The risk of animal habitat fragmentation can be high in case of cable ETL arrangement too, as for safety reasons, it is required to clean the whole corridor from vegetation cover.

Considering aforementioned and the length of ETL, the solution of the overhead ETL arrangement was selected.

The design organization considers arranging both outdoor and indoor substations. There is no significant difference in terms of environmental and local population safety, as the project area is away from the populated areas. In any case, the substation will be properly protected from unauthorized access.

Considering local meteorological conditions, closed substation alternative should be preferred.

3.3 Akhalkalaki HPP Project Overview

As it is given in par. 3.1., Akhalkalaki HPP will consist of two independent HPPs (Akhalkalaki 1 HPP and Akhalkalaki 2 HPP) with common substation and 35kV power transmission line (controlled from Akhalkalaki 1 HPP). Both HPPs are run-of-the river type with low-threshold dams. Upstream from Akhalkalaki 1 HPP, a reservoir with 68.000 m³ area is planned; at the headworks of Akhalkalaki 2 HPP, Tyrolean intake will be arranged and accordingly the reservoir volume will be insignificant.

According to the selected alternative, main project parameters of Akhalkalaki 1 and Akhalkalaki 2 HPPs are given in Table 3.3.1., and the layout scheme of HPPs – on Figure 3.3.1.

Some of the parameters and technical solutions mentioned in this document will be specified during detailed design.

Constituent facilities of each HPP are characterized in the following paragraphs.

Table 3.3.1. Main specifications of Akhalkalaki HPP

Parameter	Unit	Value	
		Akhalkalaki 1 HPP	Akhalkalaki 2 HPP
HPP type	-	Non-regulated, run-of-river	Non-regulated, run-of-river
Hydrological data of Paravani river in the project section			
Catchment area	km²	1,640	404
Average flow at the intake	m³/s	13.4	3,0
Environmental flow	m³/s	1.3	0,3
Irrigation flow (July 10 – September 15)	m³/s	0,85	-
Design flow at the headworks (with 1,0 % provision)	m³/s	170	65
Check flow at the headworks (with 0,5 % provision)	m³/s	205	75
Headworks:			
Normal Water level	m asl	1616,0	1627,5
Maximum flood elevation	m asl	1616,2	1629,8
Penstock:			
Length	m	3375	1950
Diameter	m	2,8	1,2
Water velocity (in normal water level conditions)	m/s	2,44	2,5

Power House:			
Turbine installed capacity	MW	3×2,5	1×1,6
Turbine type	-	Francis horizontal	Francis horizontal
Tailrace channel:			
Length	m	10	10
Bottom elevation	m	2.5	2.5
Average tailwater level	m asl	1555,0	1555,4
Maximum tailwater level	m asl	1557,0	1556,0
Substation:			
Type	-	Gas-insulated breaker (GIS)	
Length	m	17	
Width	m	10	
Transformer 6,3/35 kW	MW/A	12	
Efficiency and capacity:			
Total rated flow	m^3/s	15,0	2,8
Total head	m	61	71,6
Total head loss	m	5,7	6,5
Net head in normal water level conditions	m	55,3	65,1
Installed capacity	MW	7,5	1,6
Average annual generation	GW.h	42,51	10,34
Construction time	**month**	**24**	

Figure 3.3.1. Layout Scheme of Akhalkalaki HPP Communication Location

3.3.1 Brief Overview of Akhalkalaki 1 HPP Project

According to Akhalkalaki 1 HPP project, it is planned to arrange a concrete low-threshold dam at 1612 m elevation of Paravani river, which will be equipped with the regulated spillway. Upstream the intake, the normal operating level of the reservoir will be 1616 m asl. Reservoir flood area in normal water level conditions will be about 36.000 m^2. The headwork structure also includes flushing gate, fish way and intake structure.

The design flow of the headworks is 170 m^3/s, which corresponds to 100-year return period flow. The check flood (flow) is 205 m^3/s, which corresponds to 200-year return period flow. The headwork structures are to withstand the design flood without any damages and to withstand the check flood with possibly some minor and easily repairable damage.

The dam site is located in a narrow valley, with a paved main road a few meters from the dam on the right river bank, and a flat terrace on the left river bank. The terrace consists of boulders, cobbles, gravel, sand and silt. Layer of greenish-grey stiff clay was encountered in boreholes. Depth to bedrock is assumed 7-10 m according to borings and geophysical surveys.

The project considers arrangement of about 3,4 km long, Ø 2,8 m diameter buried steel pipeline. Three Francis turbines will be located in a conventional surface power house. From the power house, a very short tailrace canal will transfer harnessed water from each turbine back to the Paravani river.

A substation is planned outside the power house connected by a 35 kV overhead transmission line to the national grid.

The general plan of Akhalkalaki 1 HPP is given on Figure 3.3.1.1.

Figure 3.3.1.1. General Plan of Akhalkalaki 1 HPP

3.3.1.1 Intake Structure

The Akhalkalaki-1 HPP headwork structure is located some 800 m downstream of the confluence of Kirkhbulakhi river and Paravani river, close to Diliska village. Headworks drawings are given on Figures 3.3.1.1.1.---- 3.3.1.1.3.

The average river bottom elevation at the proposed spillway section is about 1612 m a.s.l. The crest elevation of the side retaining walls on the upstream side of the headwork is 1617,2 m. The elevation of the spillway gates orifices is 1612,7 m, 0,7 m higher than the average river channel bottom elevation. The normal operating water level of the headworks will be 1616,0 m. The spillway gates are designed to pass 170 m^3/s flow, corresponding to a 100-year occurrence with check flood of 205 m^3/s, corresponding to a 200-year occurrence.

It is envisaged to install three 6 m wide spillway gates. The orifices, where these gates will be installed, are separated by 1,5 m wide intermediate retaining walls. The spillway gates will be equipped with an overflow profile, at elevation 1616,2 m a.s.l. Therefore, in case of sudden increase of the river flow, the excess water will automatically flow over the spillway gates. To maintain the water level below 1616 m a.s.l. during the high floods, all three gates will be kept in an open position.

Figure 3.3.1.1.1. Headworks Site Views

At the downstream side of the headworks dam, a 19 m long and 1,6 m deep stilling basin will be constructed.

The water intake and fish way will be situated at the left bank of the river. The fish way will be located between the spillway and the water intake. It is envisaged to arrange two water intake orifices, each 5 m wide and 2 m high. Elevation of the water intake orifice threshold is 1614 m a.s.l. Coarse trash racks will be arranged at the entrance of the water intake orifices, followed by intake gates. From the intake orifices, the water flows to the penstock. The transition section is approximately 30 m long, whereof about 20 m have a gently sloping bottom. At the end of the mentioned section is a 1,2 m high threshold and a 1,5x1,5 m^2 flushing gate. After flowing over the threshold, the water flows through a coarse trash rack and the 2,8 m diameter steel pressure pipeline.

A settling basin structure is not envisaged for the Akhalkalaki-1 water intake. Based on years of operation of Paravani HPP intake, the limited amount of sediments is accumulated in the water. Paravani HPP intake is located downward from Korkhi and Paravani confluence. Upstream the project intake, considering relatively small inclination of Korkhi river riverbed, transportation of only small amount of sediments is expected. The pond upstream the intake will act as a settling pond. Periodic flushing and potentially manual removal of deposited sediment upstream of the weir might be required.

The fish way is dimensioned to provide 0.14 m³/s flow of river Paravani, while the rest part of ecological flow - 1.16 m³/s will be released through the pipe existing on the dam. So-called fish way ladder is proposed, that has been widely used on different headworks, constructed during recent years in Georgia.

The existing highway along the right-hand bank of the Paravani river will be elevated to elevation 1616,9, in order to keep it from flooding during the design flood event. In addition, an almost 200 m section downstream of the headworks will be elevated, which will be specified at detail desing stage.

Figure 3.3.1.1.1. General Plan of the Headworks

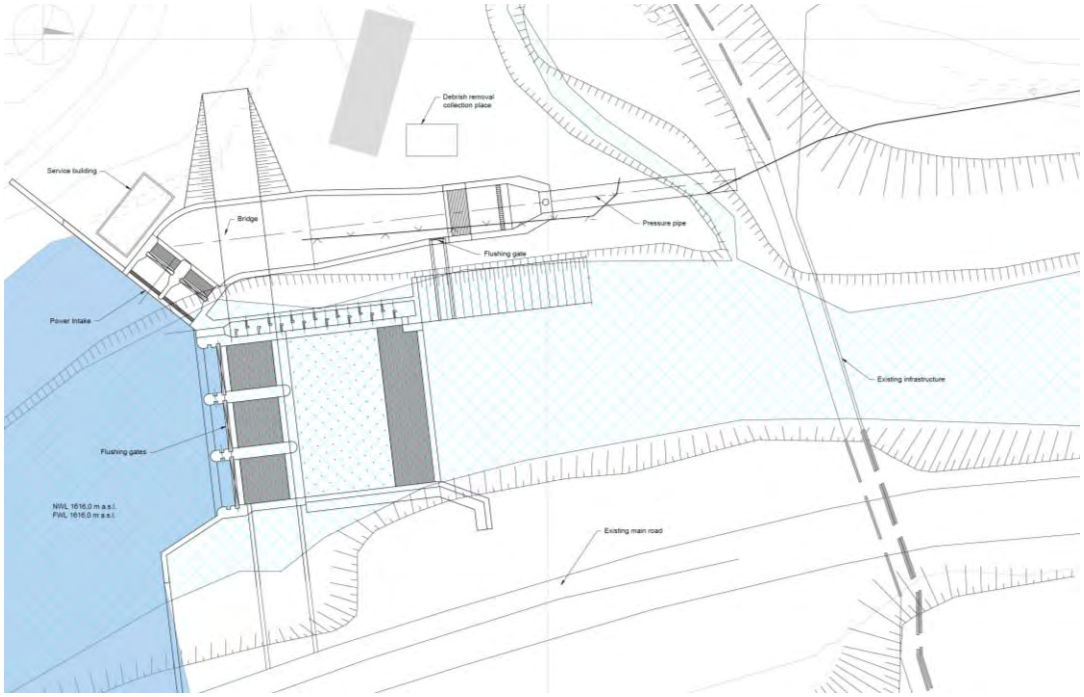


Figure 3.3.1.1.2. Headworks Plan

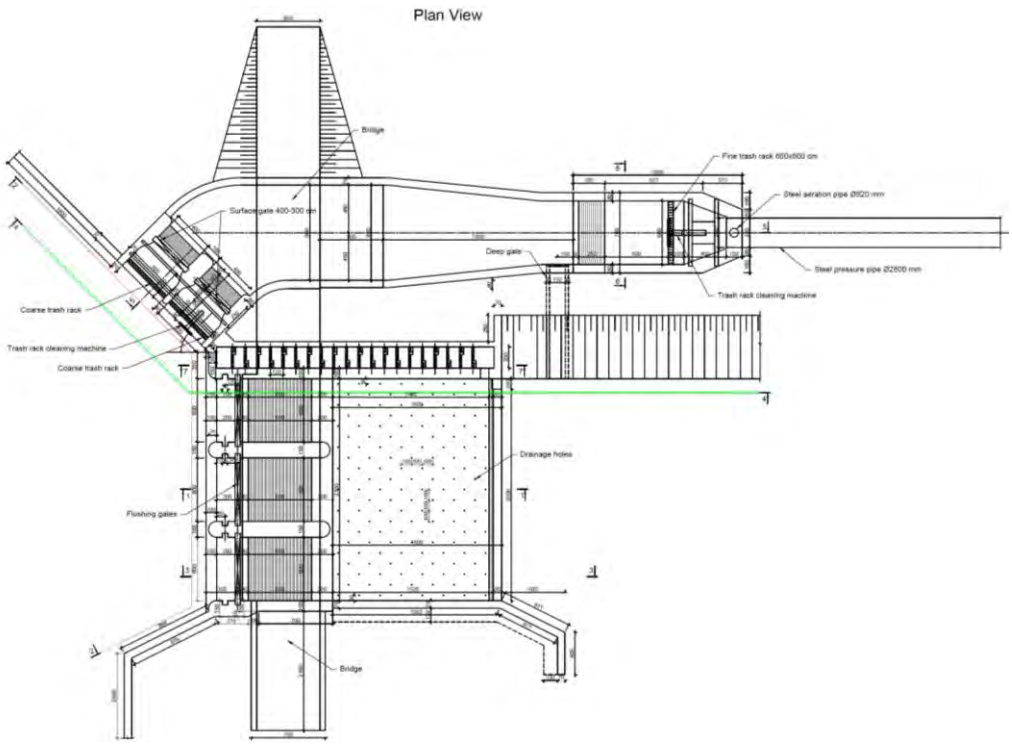
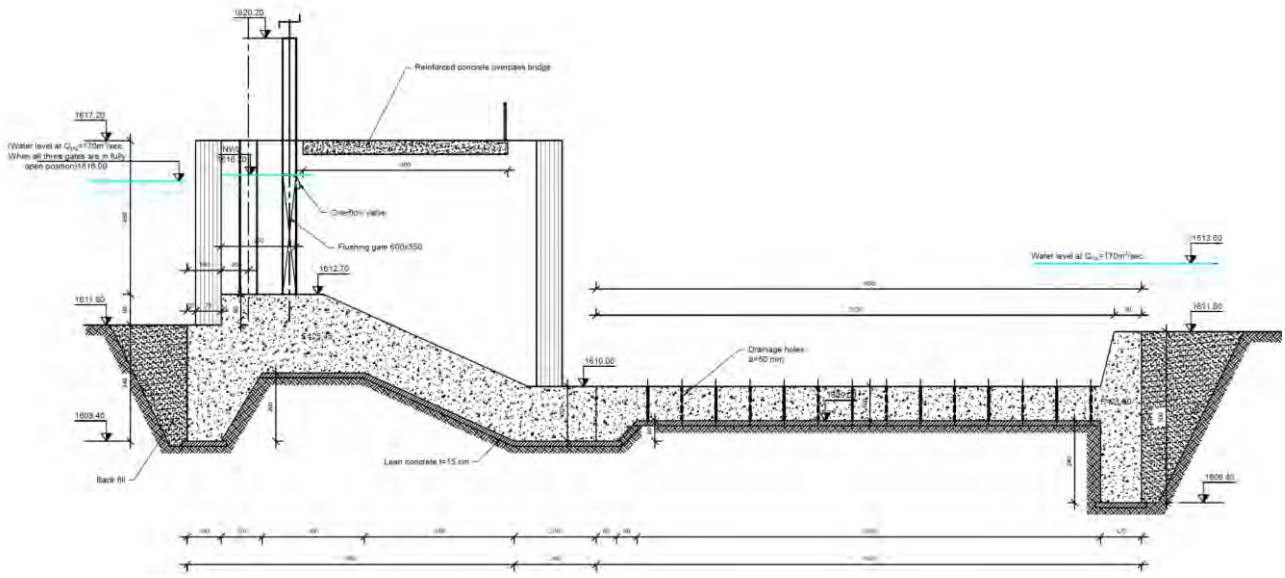


Figure 3.3.1.1.3. Headworks. Sluiceway. Section 1-1



3.3.1.2 Fishway

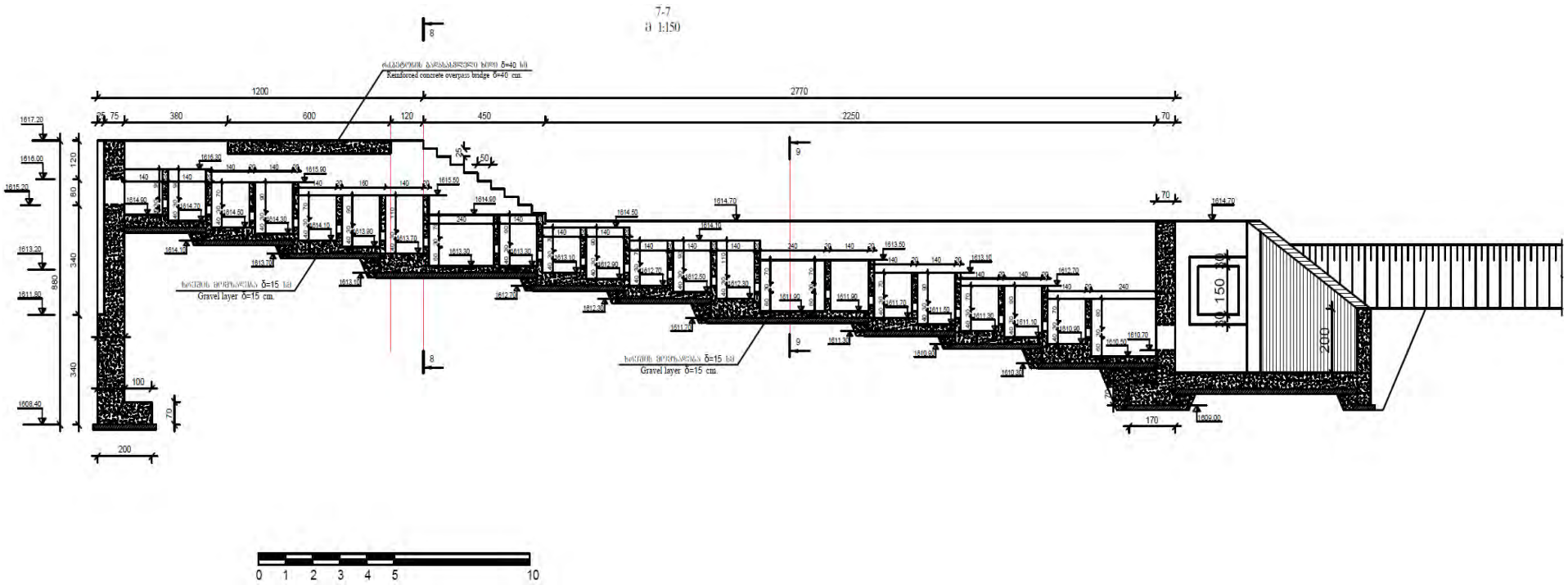
The fishway is planned on the left bank side of the river between the intake and the spillway. It is considered to arrange pool (so-called fish ladder) fishway, which aims at keeping continuous stream of natural water flow, ensuring continuity of the river stream and the possibility of upstream migration of fish.

The concept of the structure considers sequenced arrangement of steps and pools. Each of them is arranged slightly lower than the previous one and fenced with boulders, thus creating a small barrier. Boulders are fixed to the bottom or even between steps, leaving vertical open area at each step. These steps are not located at the same level; they are arranged alternately between the left and right sides.

Given the height of the dam and the above recommendations, the total length of the fishway will be 28 m. Number of steps - 20. Length of each step - 2.5 m, width - 1.5 m. The height difference between upper and lower steps of the fish way is 0.2 m.

The fishway section if given on Figure 3.3.1.2.1.

Figure 3.3.1.2.1. Fishway section 7-7



3.3.1.3 Penstock

A penstock will convey the water from the headworks to the powerhouse. The penstock will be made of steel pipes and have a total length of approximately 3,4 km. The diameter will be 2,8 m, thickness - 12 mm.

The penstock will be installed in a trench, buried with a minimum cover of 1 m. The penstock is placed on the left-hand bank of the river all the way from the intake to the power house.

On the upstream section, the penstock is located on a relatively flat but sometimes quite narrow terrace a short distance from the river bank. Based on geological investigation, the terrace is made of colluvial and alluvial sediments. Boulders, cobbles and gravel mixed with sand and sandy silt are on top of the fissured andesite and basalt bedrock. Depth to bedrock is about 7-8 meters from the earth surface. It is envisaged to arrange a construction road between the penstock trench and the river for transportation of construction materials.

The last approximately 1,0 km section of the pipeline is characterized by a steep slope of colluvial sediments, consisting of angular boulders and cobbles mixed with gravel, sand and sandy silt. The colluvial deposit sits on top of fissured andesite and basalt bedrock. Rock outcrops are numerous along the planned penstock route.

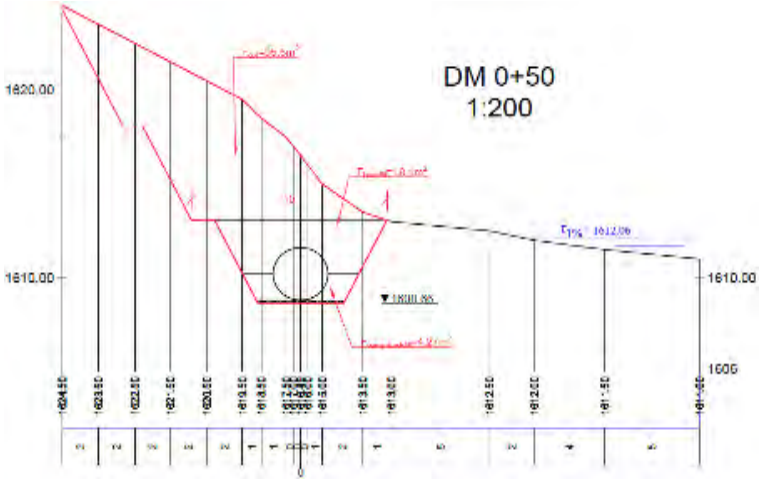
Downstream of the intake the penstock will lie below the existing water level of the Paravani river. On this section the pipe will be designed to prevent it from floating up due to uplifting forces during high water level in the river and a possibly empty pipe. Special anchoring supports of reinforced concrete will be arranged at all these points. The dimensions of the anchoring supports are defined according to water pressure and velocity in the pipe at each anchor point and the respective angle of bend, both horizontal and vertical.

Considering such length of the penstock, surge facilities must be considered. Due to the local topographic conditions it is not considered feasible to install conventional surge facilities. Therefore, the closing time of the butterfly inlet valves must be secured slow enough to prevent water hammer in the penstock during closing of the valves. Furthermore, it is deemed necessary to provide a by-pass valve at each turbine to prevent water hammer in the penstock in case of a sudden load rejection of the turbine.

The cross section of some penstock sites is given on Figure 3.3.1.3.1., and views of some sections of the pipeline corridor – on Figure 3.3.1.3.1.

Figure 3.3.1.3.1. Penstock Corridor Views

Figure 3.3.1.3.1. Cross section of some sections of the penstock



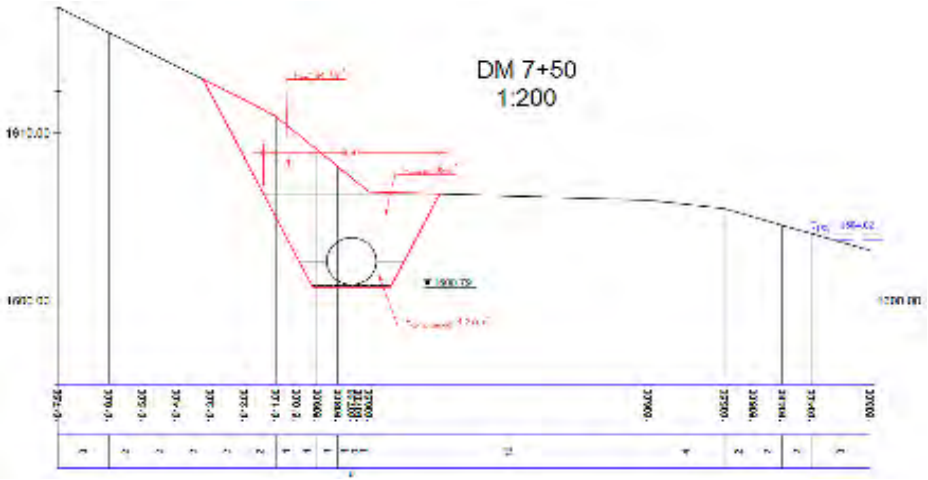
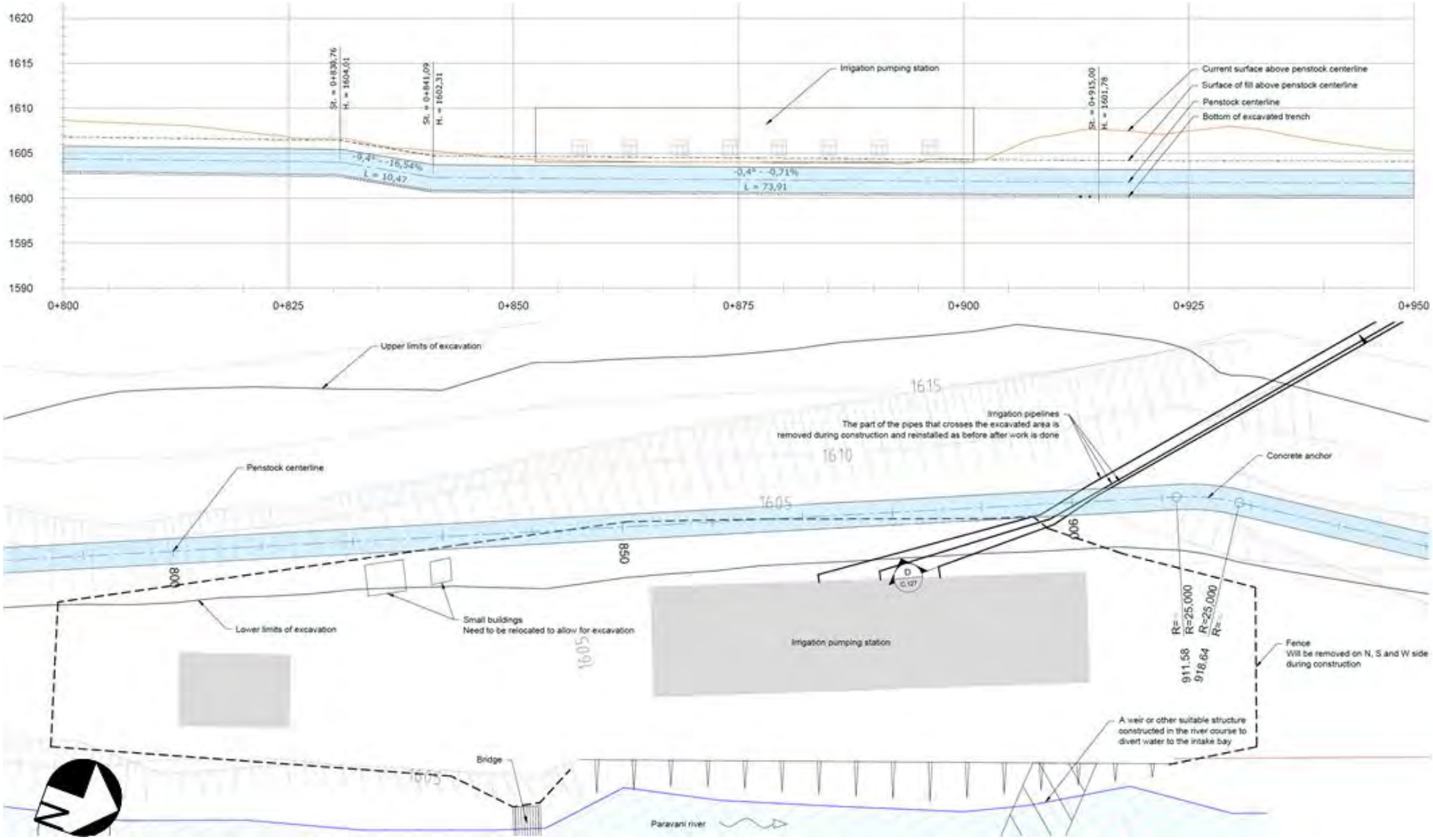


Figure 3.3.1.3.2. Penstock on Irrigation Pumping Station Site, Longitudinal Section and Plan.



3.3.2 Power Unit

An above ground power house will be located on the left bank of the Paravani river a short distance upstream from the confluence of Korkhi and Paravani rivers. It will house three Francis units.

The power house will be approximately 52 m long, 12 m wide and 14 m high. Distance between units is set at 10,0 m.

The powerhouse has exits at both ends where emergency staircases are also located. All interior walls are made of reinforced concrete structure and interior doors will be fire resistant. Firefighting angles will be arranged at selected locations in the power house.

Each turbine has an approximately 10 m long fully concrete lined tailrace canal connecting the power house to the Paravani river. The bottom of the tailrace canal will be 2,5 m wide with vertical concrete walls on both sides. According to the preliminary calculations, at the tailrace canal confluence with the river the maximum water level will be 1557 m a.s.l during the 100 year design flood.

Access to the power house will be from the main road on the right-hand bank of the Paravani, and a permanent bridge. The bridge is an 18 m long one span steel beam bridge with concrete deck and concrete abutment walls.

Figure 3.3.2.1. View of Power House Site from the Right River Bank

Figure 3.3.3.1. Akhalkalaki 1 Powerhouse Plan

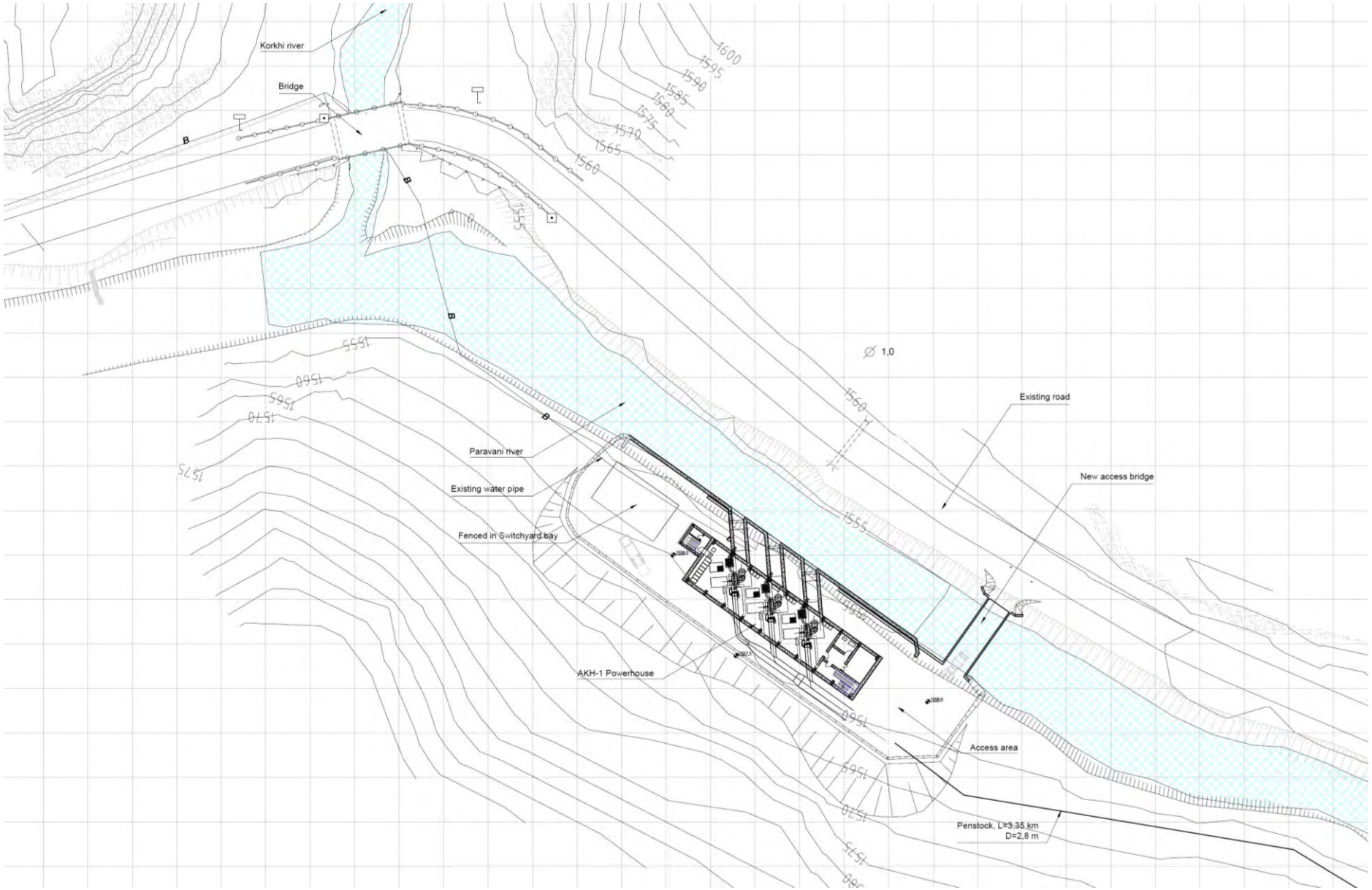
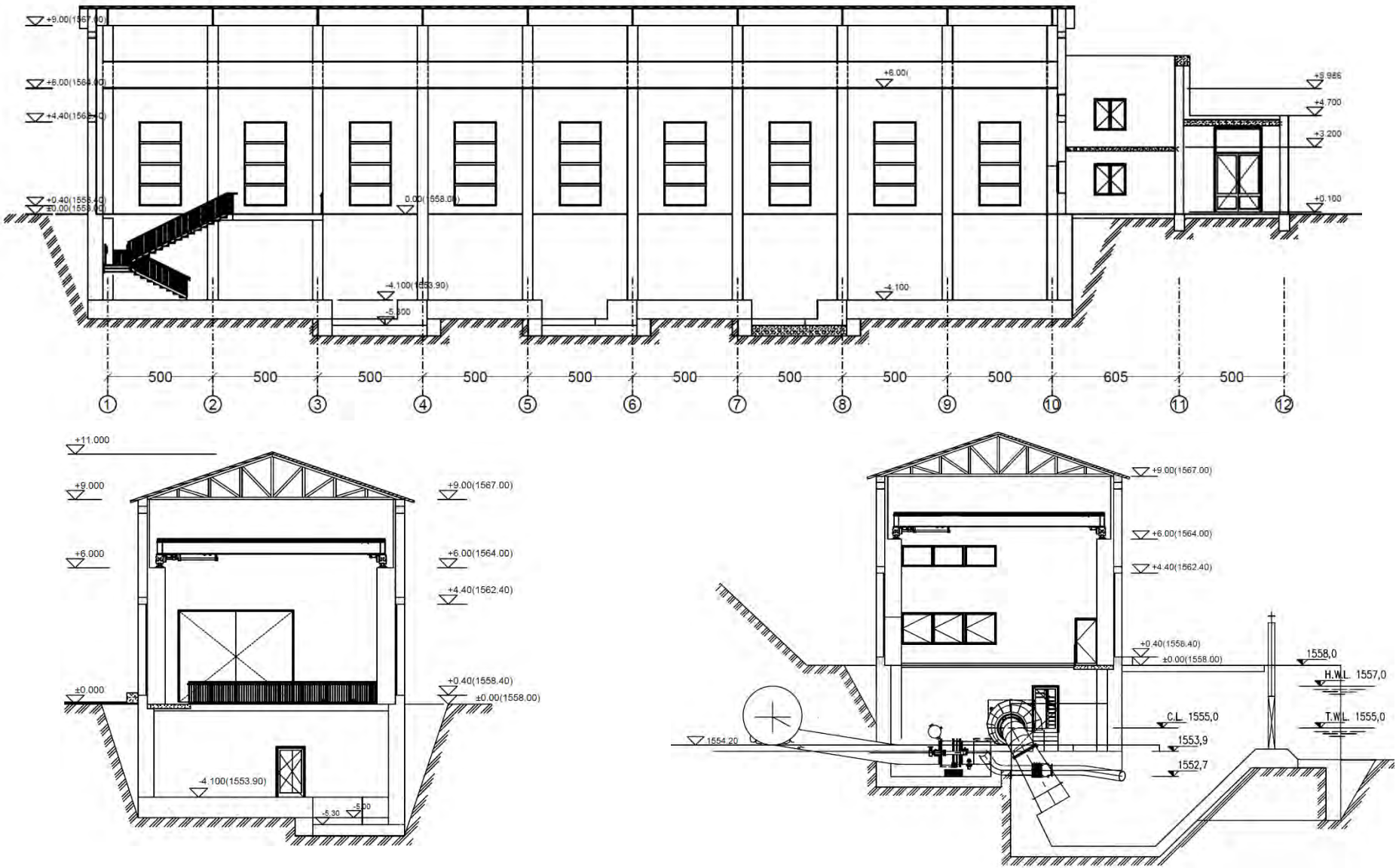


Figure 3.3.3.2. Power House Sections



3.3.3 Brief Overview of Akhalkalaki 2 HPP Project

3.3.3.1 General Overview

According to the project, Akhalkalaki 2 HPP headworks will be arranged at 1625 m elevation of Korkhi river. A concrete low-threshold dam, Tyrolean intake, transition section, flushing gate and fishway will be included in the headworks.

Upstream the intake, the normal operating level of the reservoir will be 1627,5 m asl. Reservoir flood area will be about 11.000 m^2. Estimated volume of water retained by the dam is 11.200 m^3.

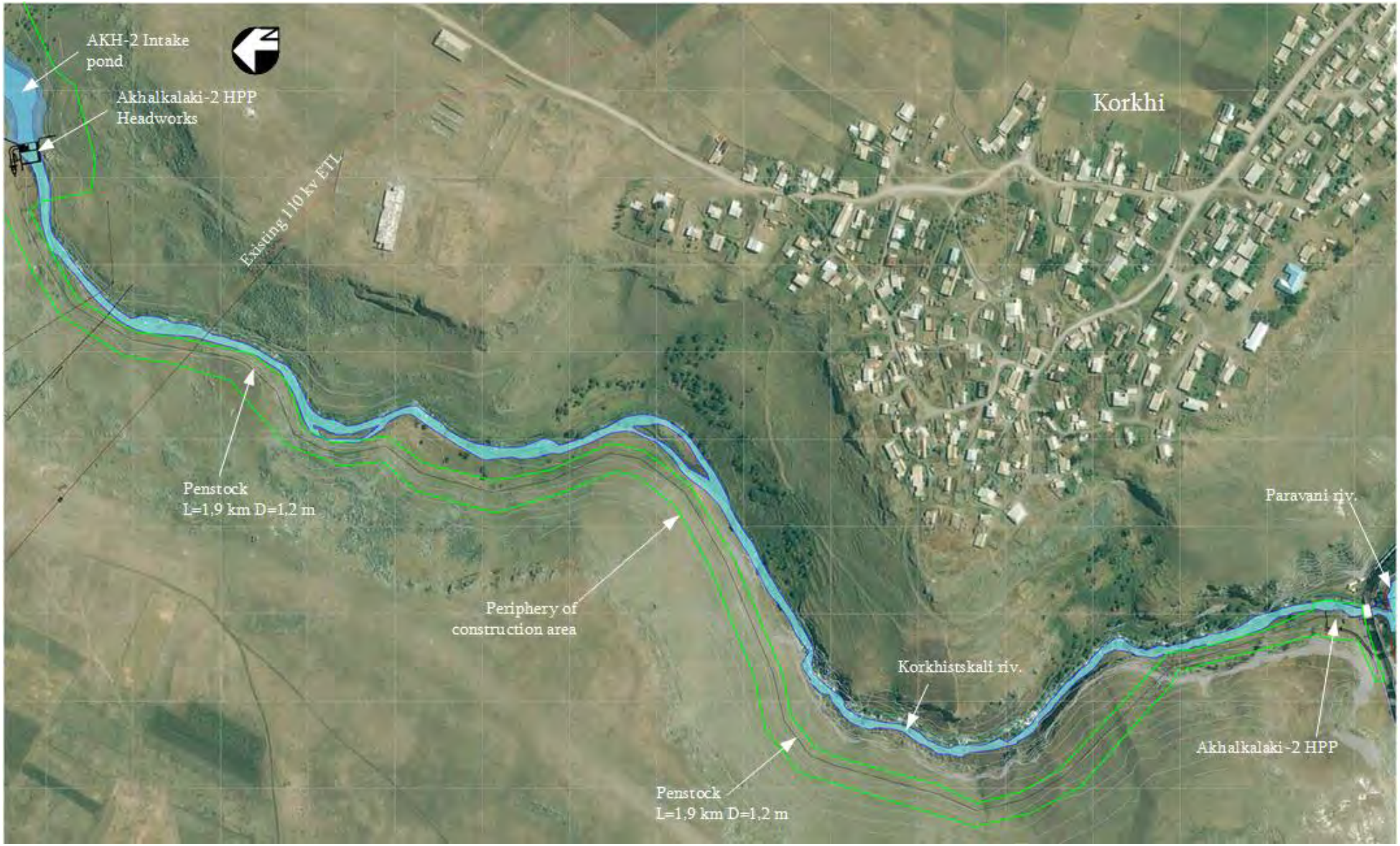
The design flow of the headworks is 65 m^3/s, which corresponds to 100-year return period flow. The check flood (flow) is 75 m^3/s, which corresponds to 200-year return period flow. The headwork structures are to withstand the design flood without any damages and to withstand the check flood with possibly some minor and easily repairable damage.

At the dam site the river flows on a shallow alluvium layer, consisting of boulders, cobbles, gravel, sand and silt. Below the uppermost alluvial layer are layers of reddish-brown and greenish-grey stiff clay with coarse grained alluvial layers in between. Depth to bedrock is more than 25 m at the dam site, according to a borehole and geophysical survey. The project considers arrangement of about 1,95 km long penstock. From the power house, a 5-6 m long concrete tailrace canal will convey the turbine water back to the Korkhi river.

Generated electricity will be transferred to 35 Kv substation located at Akhalkalaki-1 HPP site, from where it will be supplied to the national grid.

A general plan of Akhalkalaki 2 HPP is given on Figure 3.3.3.1.1.

Figure 3.3.3.1.1. General Plan of Akhalkalaki 2 HPP



3.3.3.2 Headworks

The headworks for Akhalkalaki-2 will be located where Korkhi river course is at approximately elevation 1625 m a.s.l. The normal intake pond elevation is set at 1627,5 m a.s.l. The main components of the headworks are a concrete spillway, flushing sluice, Tyrolean type intake, and a fishway, arranged on the left-hand bank of the river.

The concrete spillway will be located close to the left-hand bank of the river, with spillway crest arranged at elevation 1628,0 m a.s.l. Adjacent to the spillway, a flushing sluice with an invert elevation at 1626 m a.s.l will be arranged. The sluice will be separated from adjacent parts of the headworks by 1,2 m wide concrete pillars. A 2,5x2,5 m^2 gate will enable periodic flushing of sediments from upstream of the spillway, should there be need for such flushing.

Adjacent to the flushing sluice, close to the existing right-hand bank of the river, a 6 m wide Tyrolean type intake with one intake chamber will be arranged. The crest of the intake section will be at elevation 1627,5 m a.s.l., i.e. 0,5 m below the crest of the fixed concrete spillway at the left-hand bank. The intake chamber will be 2,0 m wide at the bottom and 6 m long, having the bottom sloping towards the right-hand bank of the river. During winter conditions it will be possible to divert water from the intake pond through a submerged gate, located immediately upstream of the flushing gate, into the chamber and further on towards the penstock. The intake chamber is designed to pass the design flow of 2,8 m^3/s.

From the Tyrolean intake chamber the water flows towards the penstock, which will be located on the right-hand bank of the Korkhi river. The penstock intake will be equipped with a fine trash rack preventing potentially harmful debris from entering the penstock. A low threshold flushing gate will be provided upstream from the trash rack, enabling periodic flushing of potential sediments.

The length of the spillway sections is chosen such that the design flood can safely be passed downstream without any harm to the structures. During the design flood, 65 m^3/s which corresponds to a 100-year event, the water level in the intake pond is estimated to rise to 1629,4 m a.s.l. and during the check flood, 75 m^3/s corresponding to a 200-year event, the water elevation is estimated at 1629,6 m a.s.l. In both cases the flushing gate is assumed to be in a fully closed position.

Downstream of the dam, a 19,5 m wide, 14 m long and 1,2 m deep stilling basin will be constructed in order to prevent scouring of the downstream riverbed.

The intake pond created by the headwork dam is only for water intake purposes. No daily water regulation is envisaged by this pond. The reservoir area at normal water level is 11,000 m^2.

The headworks are not designed with a settling basin structure. No measurements of sediment transport in the Korkhi river have, as far as the authors of this report know, been performed. Information on sediment discharge in the Paravani river, based on a few years of operation of the downstream Paravani HPP intake, indicate limited amount of sediments in Paravani river. Paravani HPP intake is located downstream of the confluence of rivers Korkhi and Paravani. Relatively shallow slope of the Korkhi river course upstream of the proposed intake location also indicate that limited sediment transport might be expected. The intake pond upstream of the Tyrolean intake will act as a settling pond. Periodic flushing and potentially manual removal of deposited sediment upstream of the weir might be required.

In order to ensure fish migration at headworks, the project envisages arrangement of a fishway closest to natural conditions, the so-called bypass channel. The fishway will bve located on the left bank of the river. The topographical conditions of the headworks are favorable for arranging this type of fishway. The fish way is designed for 0,3 m^3/s water discharge, approximately the same as the required environmental flow in river Korkhi at the headwork site.

The photo-material reflecting Akhalkalaki 2 HPP headwork site is given on Figure 3.3.3.2.1.; the plan

and sections of the headworks – on Figures 3.3.3.2.1. ---- 3.3.3.2.4.

As it is shown on the figure, the irrigation water pumping station of Korkhi village is located on the section, selected for headwork site, which is out of order and is not in operation for the last several years. According to the project, upstream of the headworks, arrangement of the new pumping station is planned, from where the irrigation water will be provided to Korkhi village.

Downstream from the headworks, there are no consumers (irrigation system, mill, etc.) of Korkhi river water represented. The design section of the river is used solely for amateur fishing. Consequently, during the operation phase, there is only the risk of impact on the conditions of amateur fishing.

Figure 3.3.3.2.1. Views of Headwork Locations

Headworks Site

Upstream of the Headworks

Downstream of the Headworks

Figure 3.3.3.2.1. General Plan of Akhalkalaki 2 HPP Headworks

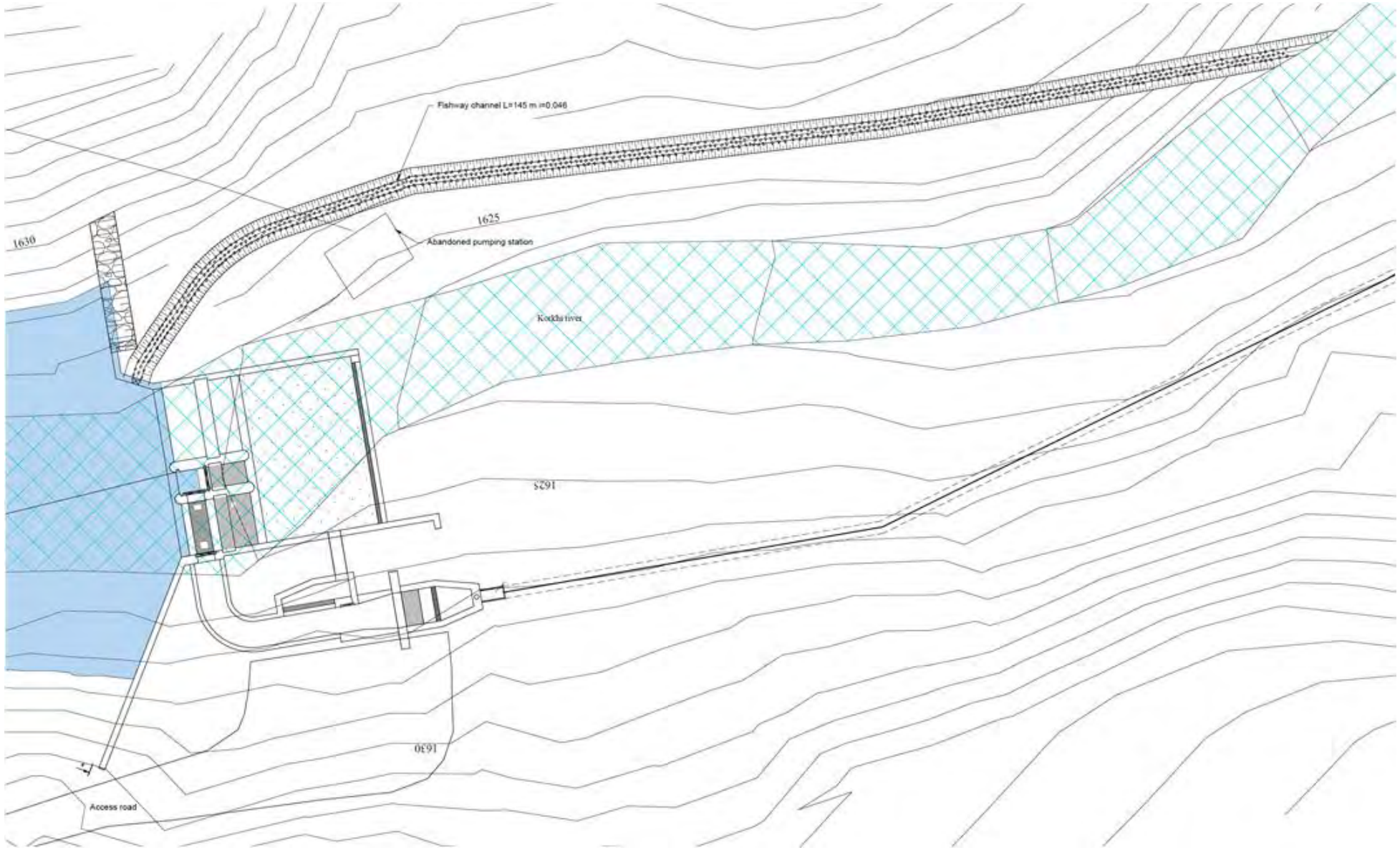


Figure 3.3.3.2.2. Headworks Plan

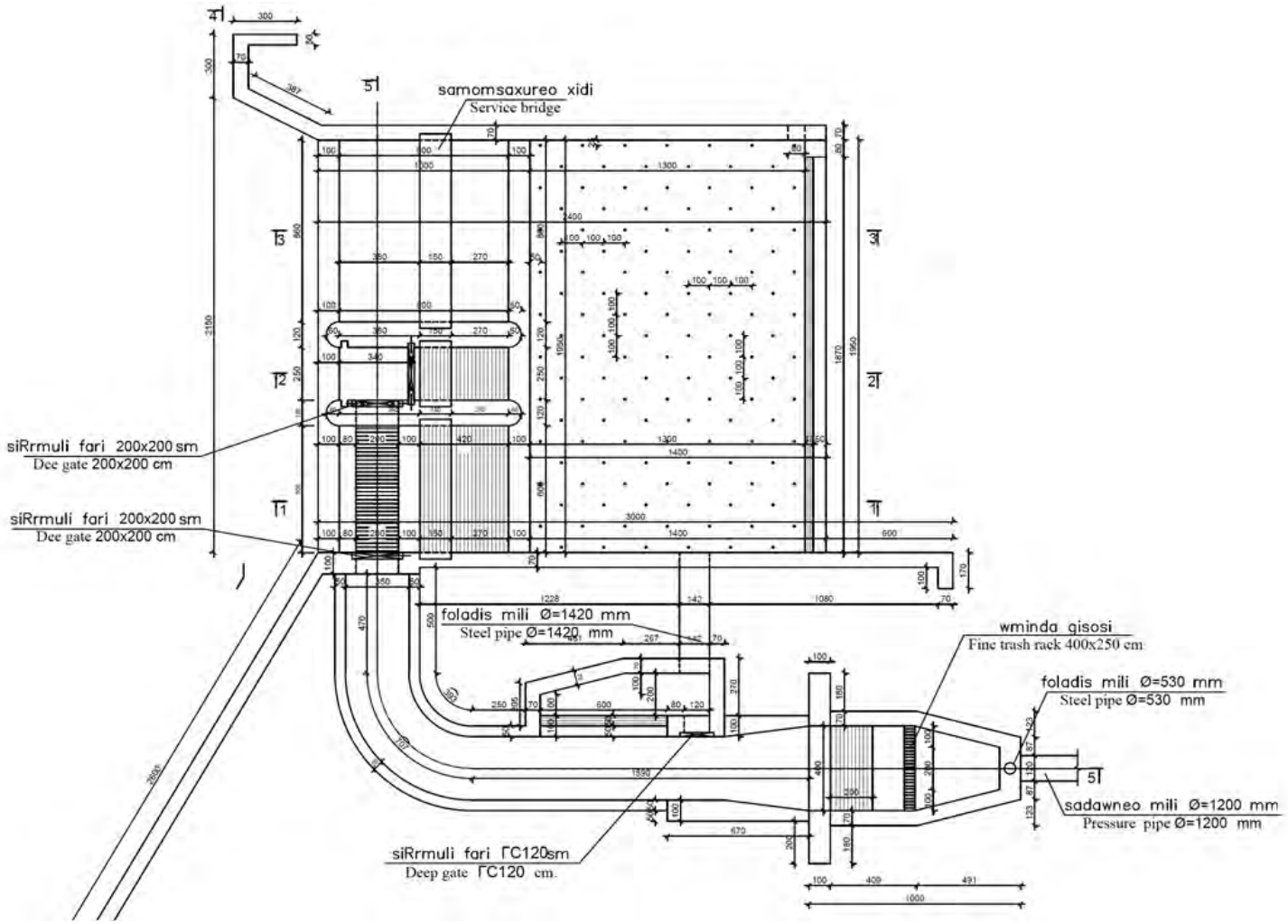


Figure 3.3.3.2.3. Longitudinal Section of the Headworks

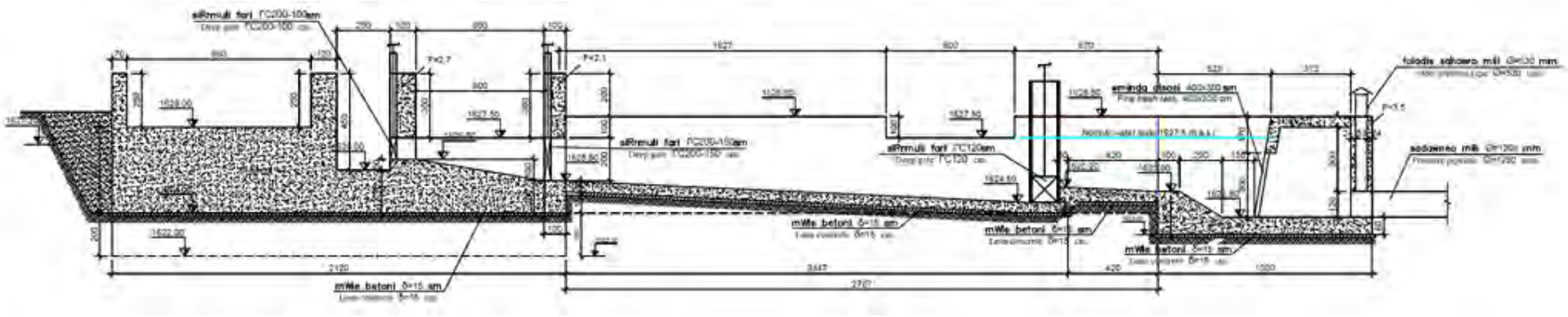
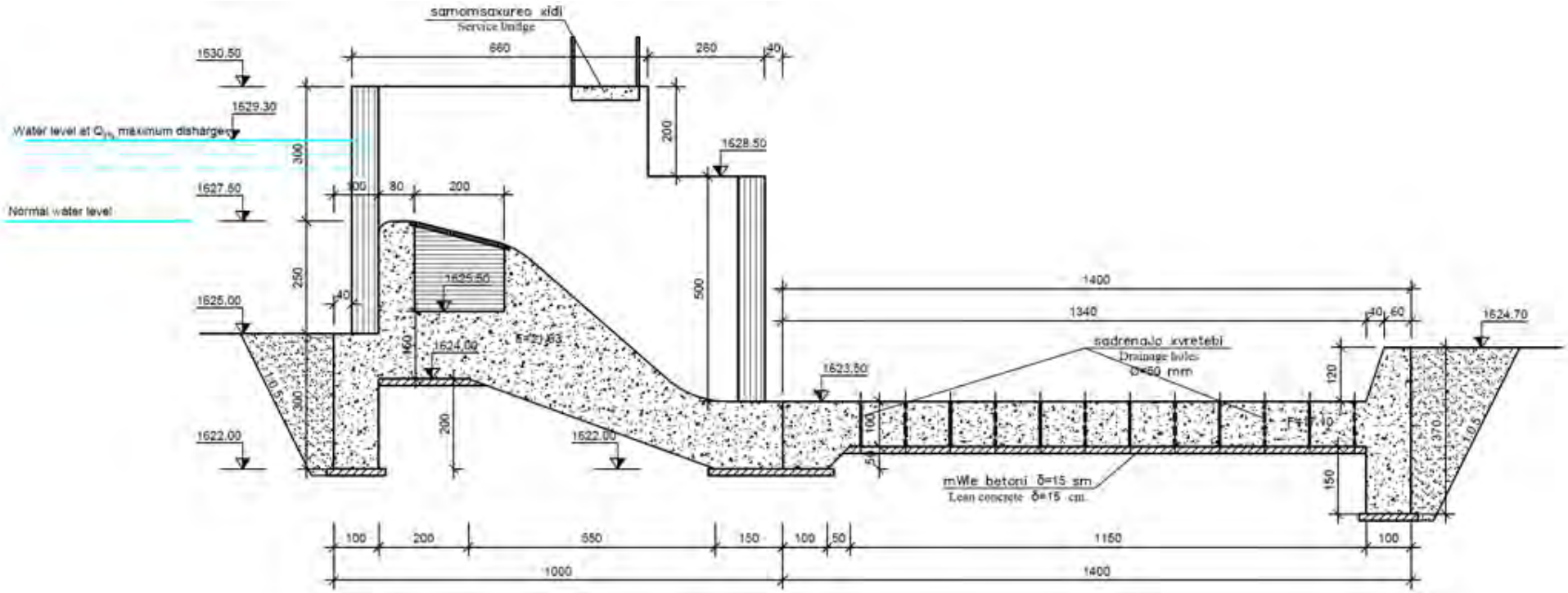


Figure 3.3.3.2.4. Spillway Section



3.3.3.3 Penstock

A buried GRP penstock will convey the water from the headworks to the power house. The total length of the penstock is approximately 1950 m. The optimum diameter of the penstock will be 1,2 m.

The penstock will be installed in a trench and buried with a minimum cover of 1,0 m. The penstock will be located on the right river bank the entire distance from the headworks to the powerhouse.

According to the project bends are foreseen at some 30 locations along the penstock route. Special anchoring supports of reinforced concrete will be arranged on all these points. Due to the somewhat challenging terrain conditions, the penstock is at this stage designed with an air-valve.

During the operation of a long penstock, such as Akhalkalaki 2 HPP penstock, there is the risk of hydraulic hammer; for this purposes, surge facilities must be considered in the project. However, due to the local topographic conditions it is not considered feasible to install conventional surge facilities. Therefore, the closing time of the butterfly inlet valve must be secured slow enough to prevent water hammer in the pipeline when the valve must be closed. Furthermore, the turbine must be equipped with a pressure regulating valve to prevent water hammer in the pipeline in case of sudden load rejection of the turbine.

Cross sections of the some penstock areas are given on Figure 3.3.3.3.1., and views of the project corridor – on Figure 3.3.3.3.1.

The river valley has mainly the box-like shape within the project section (except the last section) and adjacent slopes are not distinguished with high inclination. Accordingly, preparation of trenches for the penstock does not require arrangement of large cuts on the slopes, however, due to the presence of rockfall risk, on construction phase it will be necessary to take some precautions, in particular: prior to work start, boulders in active dynamics should be removed and special protective meshes should be arranged on high risk bearing sites.

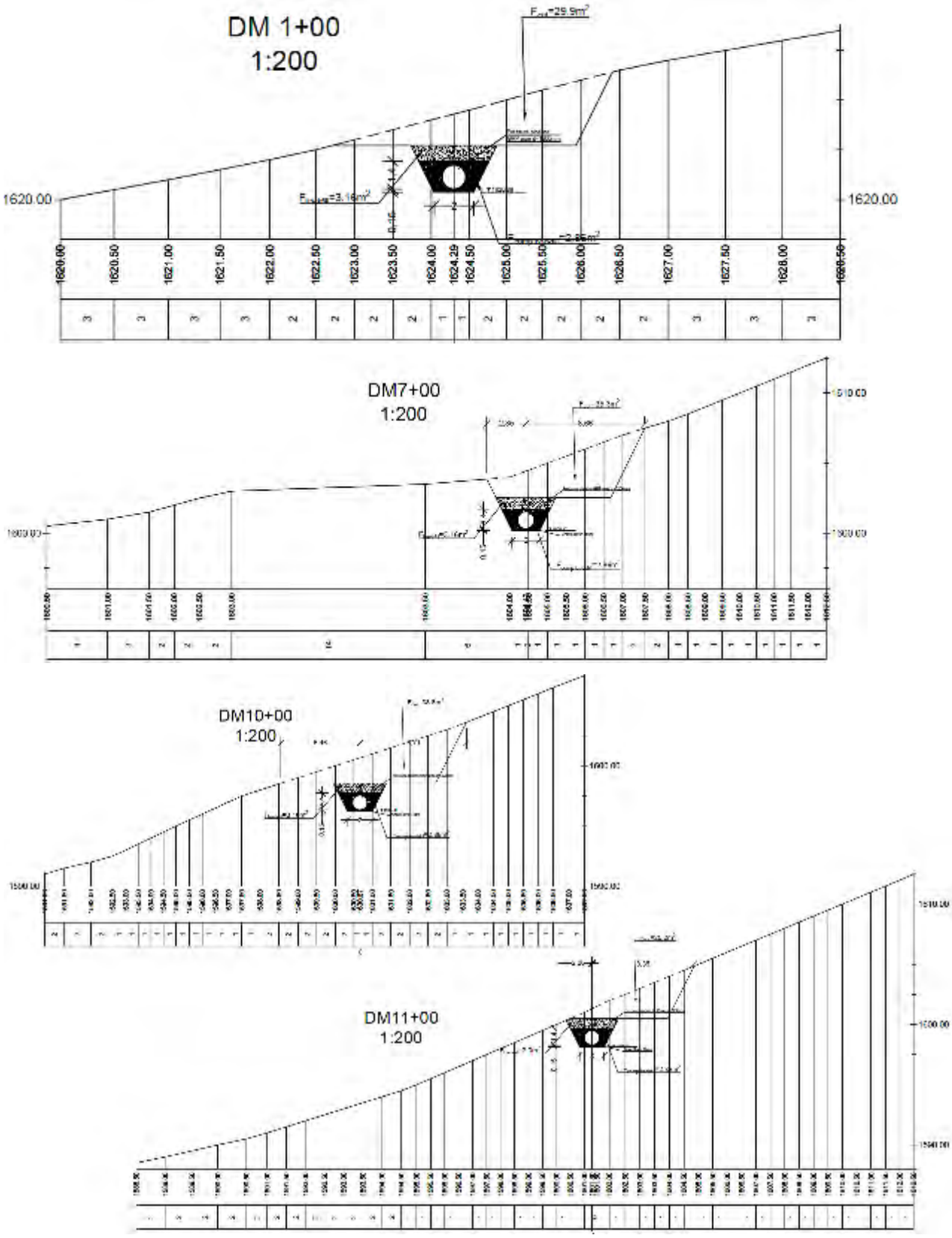
On operation phase, regarding the rockfall, the risk of the damage to the penstock is at minimum, as the penstock surface will be covered with 1 m thick ground layer.

Figure 3.3.3.3.1. Penstock corridor

Upper Section of the Corridor

Last Section of the Corridor

Figure 3.3.3.3.1. Cross Section of Some Penstock Sites



3.3.3.4 Power House and Tailrace Channel

The power house will be above ground, located a short distance upstream from the confluence of rivers Korkhi and Paravani, some 30-40 m from the existing bridge across Korkhi. Existing ground elevation at the power house site is about 1555 m a.s.l.

The power house will house one Francis turbine. Tailwater level of river Korkhi is at 1555,4 m a.s.l.

The power house will be about 14 m long, 10,5 m wide and 8,5 m high. A concrete tailrace canal will convey the harnessed water back to the Korkhi river course. Power generated by HPP will be supplied to 35 kV substation, planned on Paravani river left bank.

Veiws of Akhalkalaki 2 HPP powerhouse sites are given on Figure 3.3.3.4.1., and plan and sections - on Figure 3.3.3.4.1 and 3.3.3.4.2.

Figure 3.3.3.4.1. Views of Akhalkalaki 2 HPP Site

Figure 3.3.3.4.1. General Plan of Akhalkalaki 2 HPP Powerhouse

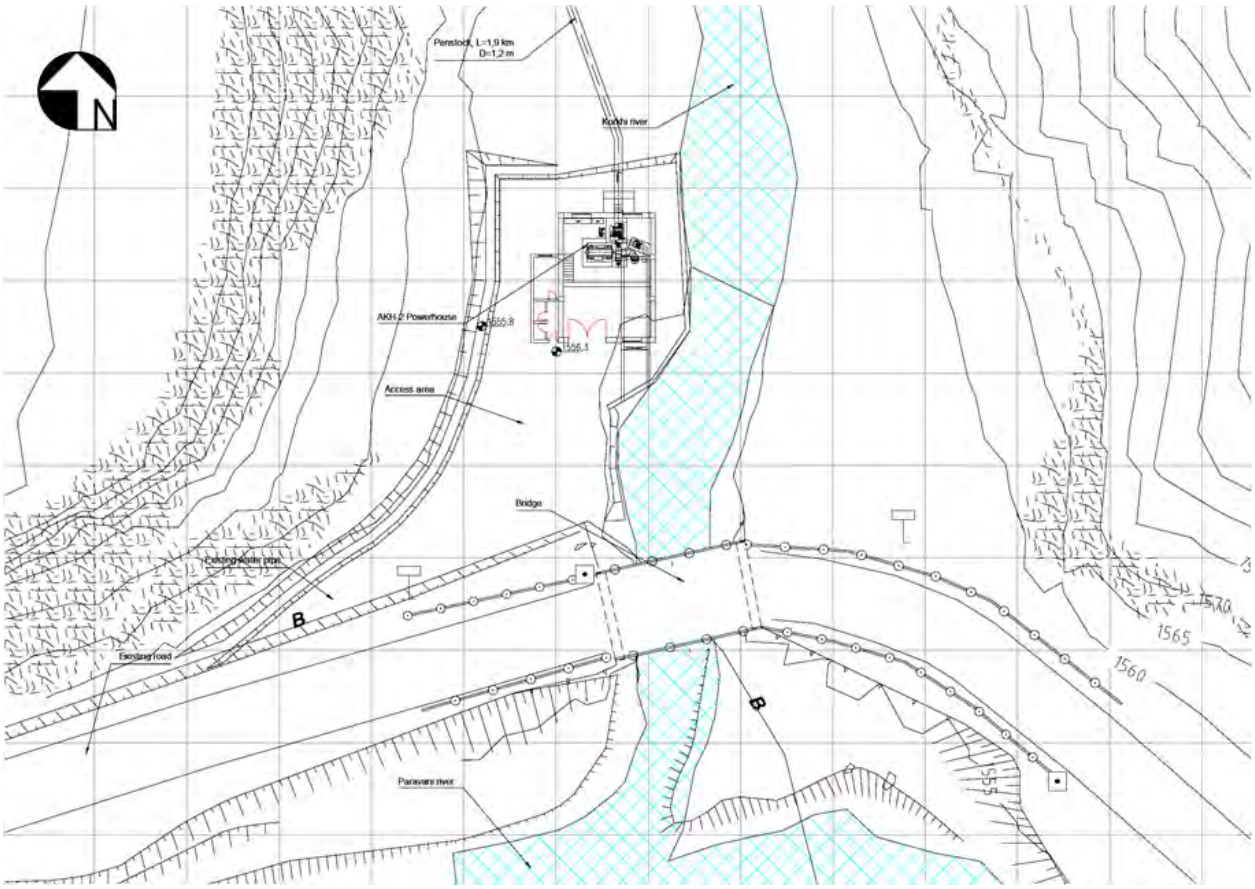
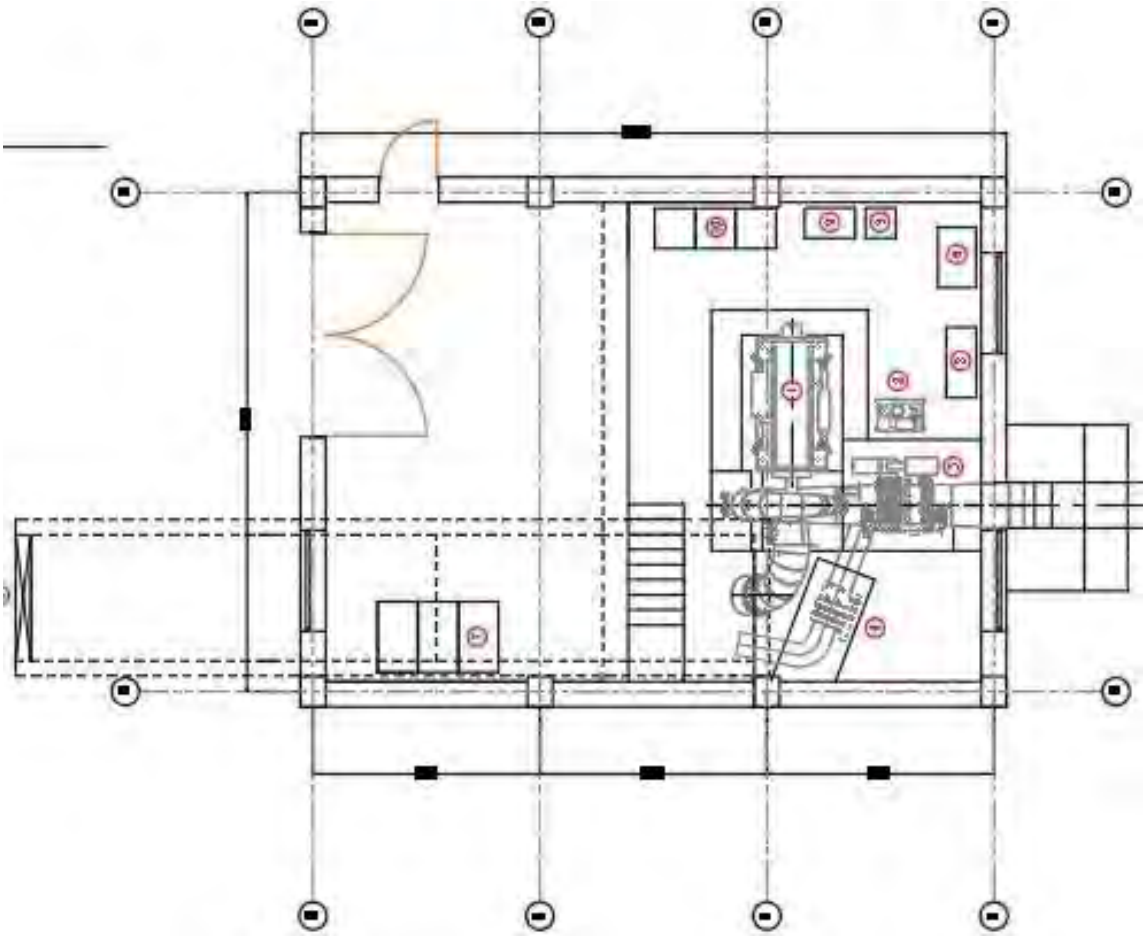
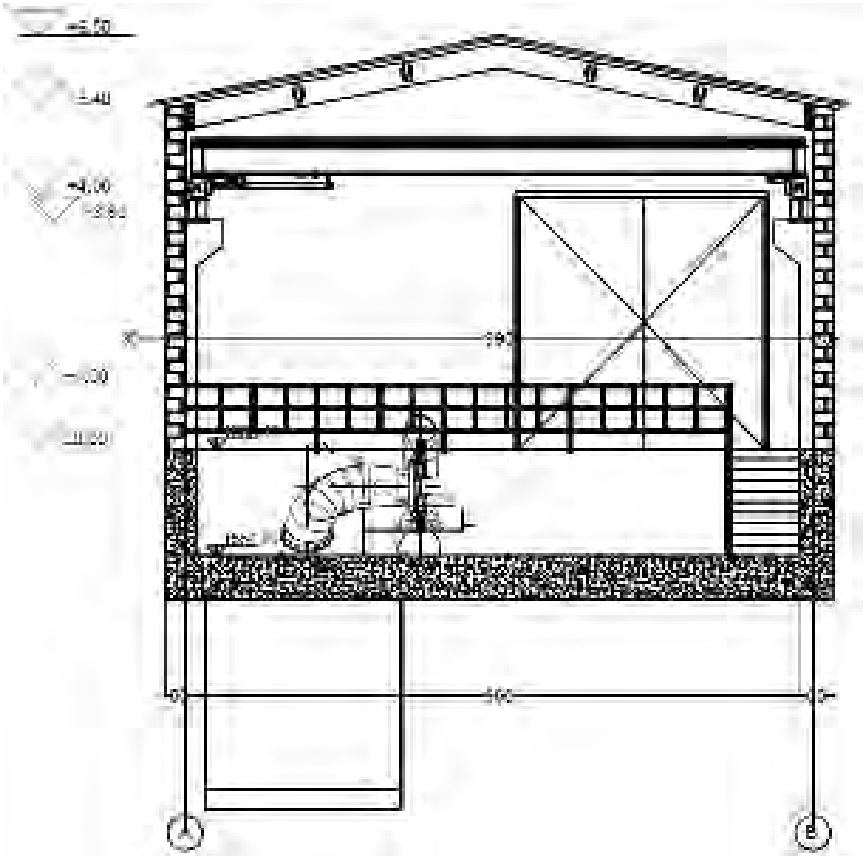


Figure 3.3.3.4.2. Plan and Sections of Akhalkalaki 2 HPP Power House





3.3.4 Electromechanical Equipment

3.3.4.1 Turbines

According to the project, Francis type turbines are planned to be arranged for both power stations.

Akhalkalaki-1 HPP: The design flow of each of the three Francis turbines will be 5,0 m^3/s, resulting in the design flow of the plant being 15,0 m^3/s. The rated net head is assumed to be approximately 55,3 m and the turbine output is estimated to be around 2,5 MW per unit at rated load.

Akhalkalaki -2 HPP: The design flow of the Francis turbine is 2,8 m^3/s. The rated net head is assumed to be approximately 65,1 m and the turbine output is estimated to be around 1,6 MW at rated load.

3.3.4.2 Governors and Shut-Off Valves

Project considers to use digital PID governors. The hydraulic system will be a high-pressure system with double pumps and piston accumulators. System capacity will secure a controlled stop of the units in case of electric power failure.

Each turbine will be furnished with a turbine inlet valve and a by-pass pressure relief system, if necessary. The opening and closing times of the turbine inlet valve and the by-pass pressure relief valve will be adjusted to maintain safe pressure during normal operation and emergencies. The inlet valves will be of a butterfly type, having the valve diameter DN1200 for AKH-1 and DN900 for AKH-2 with a pressure rating of PN10. The by-pass pressure relief system will by-pass the turbine in case of unit shutdown and convey water to the tailwater while maintaining safe pressure on the upstream side of the turbine.

3.3.4.3 Station Power Supply Systems

In each station and each intake, there will be one station service transformer.

A diesel generating set for reserve power will be installed at the AKH-1 power plant and connected to the 400 V distribution. The generating set will start automatically in case of malfunction of the power supply system.

There will be a 110 V double direct current system in each power house. Each system will consist of a dry type battery-bank, charger and distribution. A 110 V or 24 V DC system with dry type battery-bank, charger and distribution will be located in each intake building, serving the headrace control equipment and water measurements.

3.3.4.4 Firefighting and Ventilation Systems

No special fire extinguishing system is foreseen for the electromechanical equipment, however handheld fire extinguishers and fire hoses will be installed in both powerhouse buildings.

Ventilation systems will be provided for both HPP powerhouses. Each ventilation system will be based on a main ventilation unit which will blow fresh and filtered air to the powerhouse. The ventilation system will supply the required cooling air volume for the generators. Exhaust air fans will drive air from locations/rooms where pollution is expected, like battery room, in toilets etc. Smoke exhaust will also be provided, by using smoke ventilators (louvres) on the power stations roofs.

According to the project, cooling of generators is considered with air.

3.3.5 Substation

The substation will be arranged on the area adjacent to Akhalkalaki 1 HPP. The 35/6,3 kV, 12 MVA step-up power transformer is envisaged in the substation, which will be common for the four generators in both powerhouses.

Special tank will be arranged under the transformer, the volume of which will be sufficient to collect the transformer oil during emergency situation.

3.4 Project Description of Electrical Transmission Line (ETL)

The length of the project 35 kV ETL is 4.6 km and it will be arranged on 24 towers. Table 3.4.1. provides coordinates and project characteristics of tower sites, and Figure 3.4.1. provides ETL layout scheme.

Table 3.4.1 Tower Location Coordinates and Design Data

#	X	Y	Tower Type	Span Length	Conductor
1	371850,81	4590698,62	У35-1Т	0	AC- 120/19
2	371798,69	4590560,97	У35-1Т+5	147	AC- 120/19
3	371811,33	4590329,39	У35-1Т	232	AC- 120/19
4	371813,17	4590087,12	У35-1Т	242	AC- 120/19
5	371799,29	4589847,56	П35-1Т	240	AC- 120/19
6	371785,32	4589606,39	П35-1Т	242	AC- 120/19
7	371771,44	4589366,78	У35-1Т	240	AC- 120/19
8	371814,14	4589137,20	П35-1Т	234	AC- 120/19
9	371852,18	4588932,70	У35-1Т	208	AC- 120/19
10	371815,70	4588787,21	У110-1Т	150	AC- 120/19
11	371740,12	4588466,39	У110-1Т	330	**AC- 150/24**

12	371842,88	4588252,30	У35-1Т	237	АС- 120/19
13	371857,65	4588168,31	У35-1Т	85	АС- 120/19
14	371976,94	4587948,68	П35-1Т	250	АС- 120/19
15	372063,98	4587819,65	АУГ-30тр-8,5	156	АС- 120/19
16	372058,97	4587654,87	АУГ-60тр	165	АС- 120/19
17	371793,23	4587529,83	АУГ-30тр-8,5	288	АС- 120/19
18	371671,05	4587407,10	П35-1Т	179	АС- 120/19
19	371542,18	4587278,78	АУГ-60тр-8,5	182	АС- 120/19
20	371649,87	4587129,05	У35-1Т	184	АС- 120/19
21	371549,96	4586912,43	У35-1Т	239	АС- 120/19
22	371362,72	4586798,64	У35-1Т	219	АС- 120/19
23	371289,22	4586782,82	П35-1Т	75	АС- 120/19
24	371214,15	4586764,10	У35-1Т	76	АС- 120/19

Figure 3.4.1.1. Layout Scheme of ETL Corridor

3.4.1 Brief Overview of the Project ETL Corridor

The project ETL corridor starts on the left bank of Paravani river, from 35 kV Akhalkalaki HPP substation and goes till 35 kV substation located on the Diliska village area. It is noteworthy that there is no vegetation cover within the project corridor and on construction phase none of trees will be cut. Besides, local earth road passes near all project towers and accordingly, it will not be required to arrange the new road.

ETL towers №1, №2 and №3 will be located on the slope of the left Paravani river bank, where there is no topsoil represented and the surface is covered with boulders.

From tower №4 to tower N7 the corridor will pass on homogenous area, which is pasture. On this section the corridor goes along the earth road. The thickness of topsoil is 15-20 cm.

On the section between towers №7 and №8 ETL crosses the natural ravine; towers will be located at the edges of the ravine. A road passes on the both sides of the mentioned ravine, and the topsoil layer is very scarce due to large consistence of grit.

Tower N1

Tower N2

Tower N3

Tower N4

Tower N5 & N6

Tower N7& N8

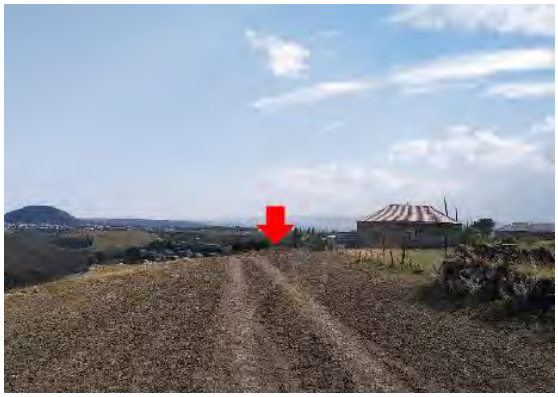
The corridor between towers №8, №9, №10 and N11 is homogenous; the thickness of the topsoil on the tower location points is averagely 15-20 cm. Between towers №10 and №11 ETL crosses aboveground pipelines of irrigation water.

On the section of towers №12 and №13, ETL approaches the residential zone of Diliska village, namely, tower №13 is in 40-45 m from the nearest residential house. ETL corridor from the tower N14 goes down to Paravani river canyon, where towers N15 and N16 will be located on the slope of the left river bank. Diliska village cemetery is located on the section between towers N15 and N16 to the west side of the corridor. The distance from the border of cemetery is 15-20 m. Topsoil cannot be removed on this section, as the surface is covered with grit and boulders.

From tower N16 ETL corridor will cross the natural ravine and leads to the south-west, to the substation site along the right bank of the ravine. The tower №17 is in about 40 m from the nearest residential house. Between towers №19 and №20, ETL crosses Akhalkalaki-Diliska road.

Towers N9 &N10

Towers N11 &N12



Tower N13

Towers N14 & N15

Tower N16

Towers N17 & N18

The last towers - №23 and №24 will be located near the substation. Tower location points are uniform. ETL distance from the nearest residential house exceeds 40 m. on the section between towers N16-N24 it will not be possible to remove the topsoil .

Tower N19

Towers N20, N21 & N22

3.4.2 ETL Installations

1. Preparation of precast reinforced concrete foundations;
2. For the new towers, arrangement of the earthing loop with Φ-12 round steel;
3. Installation of the single-circuit steel galvanized tower;.
4. Installation of the suspension and tension strings for AC-120/19 type conductor;
5. Installation of tension string for TK-35 grade lightning protection cable, single tension string of 1X1ПС70E type;
6. Installation of AC-120/19 grade conductor from tower №1 to tower №21, with the route length of 4,6 km;
7. Installation of connecting fasteners for 1PA100-100 type loops on anchor poles
8. Installation of the new ГВ-1,6/1,2-11-400/16-20 type vibration dampers for AC-120/19 grade conductors.

Standard materials and devices, towers, foundations and unified typical structures of other line elements were used during designing, which meet all requirements. The given project is developed based on "Engineering Design Norms for 35-750 kV voltage Overhead Electrical Transmission Lines", ПУЕ-6, 1987, acting in Georgia, as well as "Rules for Arrangement of Electrical Facilities" and other normative and methodic documents, which does not contradict the legislation of Georgia and in case of the decisions made, ensures long-lasting and safe operation of the facility.

3.4.3 Towers and Foundations

3.4.3.1 Towers

According to the given project, within the route of 35 kV overhead electrical transmission line it is considered to install unified, individual 35 kV and 110 kV voltage anchor-tension single-circuit poles; their total number is 24 units, including: unified anchor-tension У35-2Т type - 17 units, У35-2Т+5 type - 1 unit; unified anchor-tension Y110-1T - 2 units, and individual structure anchor-tension АУГ-30тр-8,5 – 2 units and АУГ-60тр-8,5 – 2 units.

Within the ETL route, as it is defined in the project, used tower structures are checked and calculated for loads considering the specific conditions. According to the design it is considered to use Вст3пс5 grade steel for metal structures. Hot galvanization is considered by the project in order to prevent corrosion of ETL steel towers.

3.4.3.2 Foundations

Precast reinforced concrete mushroom shaped foundations will be used for У35-1Т and У35-1Т+5 type unified steel towers according to typical 7271тм project. As for the individual structure steel towers, the individual structures steel foundations will be used. Foundation loads are taken from 3078TM typical project.

Individual structure steel foundation is selected under АУГ-30тр-8,5 type towers. In order to level the bottom of the steel foundation ditch, the project considers to arrange compacted 10-15 cm thick gravel or crushed stone layer. Steel foundations are made from welded structure. Welding is considered with Э42-А label electrode. The project considers to use Вст3пс5 label steel for steel foundations. It is required to paint the structure twice with БТ-577 label paints and lacquer in order to protect the steel foundations against corrosion. Backfilling of ditches will be provided with non-humus (20%) ground mass added to gravel or crushed stones. Backfilling will be provided by compacting 20-30 cm layers. In order to level the bottom of the reinforced concrete foundation ditch, the project considers to arrange compacted 10-15 cm thick gravel or crushed stone layer.

The project considers arrangement of reinforced concrete crossbars in order to receive horizontal forces, which exceed forces, admissible for foundation block. Project envisages arrangement of reinforced concrete crossbars. Special metal fasteners will be used for fixation of the crossbar to the pole of the foundation block. All works related to the foundation arrangement will be carried out in compliance with the requirements of Construction Norms and Rules, acting at the moment in Georgia (СНиП 3.02.01-87 and СниП III-4-80).

The land area, required for arrangement of foundations and installation of towers, is calculated according to tower types, namely: for У35-1Т and Y110-1T type towers 67,64 m^2 is required, for У35-1Т+5 type - 94 m^2, АУГ-30тр-8,5 and АУГ-60тр - 8,5 36,00 m^2 land area. Accordingly, the total land area required for tower arrangement will be 1590.8 m^2.

3.5 Description of Construction Works

3.5.1 Construction Time and Schedule

The construction phase considers implementation of the following works: mobilization of the equipment, transportation means and machinery, required for the construction; arrangement-improvement of access roads; construction of earth works and design facilities; installation of mechanical and electric devices; recultivation works and commissioning of HPP. Duration of construction works is 24 months.

Daily work schedule is from 09:00 to 18:00. Number of employees will be 80-100 people, from where 70% will be local population.

3.5.2 Construction Camps

The construction camp for service of Akhalkalaki 1 HPP construction works will be arranged on the area, adjacent to Diliska village, on the former poultry factory site, which is in the state ownership; Akhalkalaki 2 HPP construction camp will be arranged on the state land on the left bank slope of Korkhi river. It is agricultural land but it has been used for grazing for years.

Construction camp locations and infrastructure to be arranged there will be specified by the construction contractor, which will be selected after receiving environmental decision. General overview of the construction camp locations and planned infrastructure is provided below.

In case of change of the construction camp location or arrangement of different infrastructure, corresponding information will be submitted to the Ministry of Environment protection and Agriculture of Georgia.

It is noteworthy that 35 kV ETL construction works (storage of construction materials, equipment parking etc.) will be provided from Akhalkalaki 1 HPP construction camp.

3.5.2.1 Akhalkalaki 1 HPP Construction Camp

As it was mentioned, the construction camp will be arranged on the 3.6 ha area of the former poultry factor with the following geographic coordinates.

1. X= 371883, Y= 4586723;
2. X= 371585, Y= 4586739;
3. X= 371582, Y= 4586619;
4. X= 371880, Y= 4586605.

The area is flat, there is no vegetation cover and topsoil; there are structures of old buildings and construction waste observed on the site.

There is an earth road till the construction bank site, which is in satisfactory technical condition and prior to operation, it will be needed to carry out minor repair works. The photo-material of the construction camp and access road is given on Figure 3.5.2.1.1.

Figure 3.5.2.1.1.

Construction Camp Site

Access Road

Potable water supply to the construction camp will be provided from Diliska village water supply network, and there is agreement with local authorities and population on this issue. For technical purposes, Paravani river water will be used, which will be delivered to the site with tank trucks.

The sealed cesspool will be arranged for wastewater collection, which will be discharged by the municipal service of Akhalkalaki city on the basis of agreement. At the same time, there is an opinion on the arrangement of a biological treatment plant, from which the purified water will be discharged into a natural ravine northwest. The issue will be clarified after the construction company is identified and, in case of construction of biological treatment plantthe project for MPD will be prepared and agreed with the Ministry of Environment Protection and Agriculture of Georgia prior to the construction.

Power will be supplied from the village electric grid.

Paravani river is the nearest surface water body which is in 600 m. A dry gully flows in 200 m in the west of the area.

The distance between the residential zones of Dilika village and construction camp is 285 m from the east and 280 m from the west.

The layout scheme of the construction camp is given on Figure 3.5.2.1.2., and the plan of the camp - on Figure 3.5.2.1.3.

Following infrastructure will be arranged on the camp site: concrete plant, inert material storage areas, pipe storage areas, fitting warehouse, parking for equipment, warehouse for fuel-lubricants, office and workers' living containers. Fuel reservoir will be considered for diesel and will have 20 m^3 capacity. Spill prevention barrier will be arranged on the perimeter of the reservoir.

At this stage, arrangement of inert material crushing and sorting plant is not planned on the construction camp site. Inert materials will be purchased from licensed quarries.

Figure 3.5.2.1.2. Layout Scheme of the Construction Camp

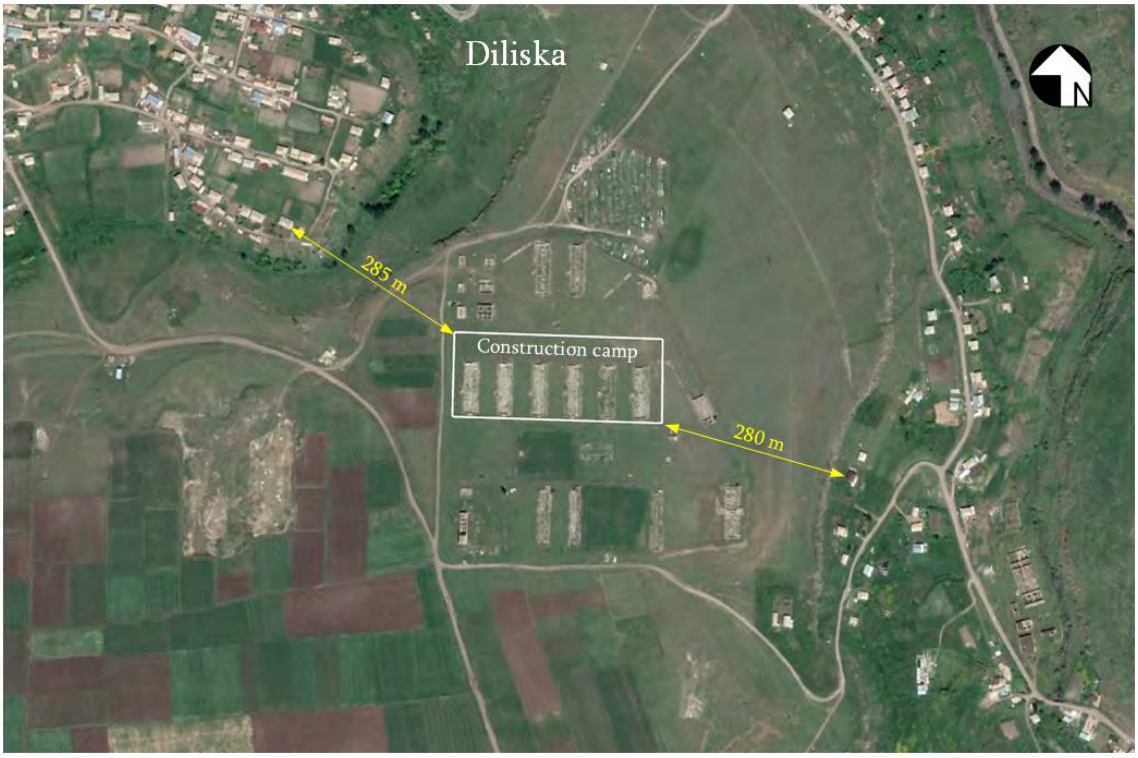


Figure 3.5.2.1.3. General Scheme of the Construction Camp

3.5.2.2 Akhalkalaki 2 HPP Construction Camp

As it was mentioned, arrangement of Akhalkalaki 2 HPP construction camp is planned on upper elevations of the left bank of Korkhi river, on 4800 m² area with the flat surface. The angle of the site has following geographic coordinates:

1. X= 372866, Y= 4592889;

2. X= 372810, Y= 4592915;
3. X= 372775, Y= 4592841;
4. X= 372832, Y= 4592817.

The site selected for the construction camp is in 200 m distance from Korkhi river left bank. There is no vegetation cover there, and the thickness of the topsoil ranges between 12-15 cm. It is noteworthy that the area directly merges with the asphalted road and accordingly, it is not required to arrange a new road. The nearest settlement to the site is Orja village, the distance to which is 255 m.

Water for sanitary purposes will be supplied to the camp with tank trucks, and for potable purposes – bottled water will be used. For technical purposes, a part of Korkhi river will be used. 10 m^3 capacity sealed cesspool will be arranged for sanitary-household wastewater collection. If the construction contractor decides to arrange a biological treatment plant, water will be discharged into Korkhi River. Project for MPD will be agreed with the Ministry of Environment Protection and Agriculture of Georgia prior to construction.

The power supply of the camp will be provided from Orja village electric grid.

Figure 3.5.2.2.1. Site Selected for the Construction Camp

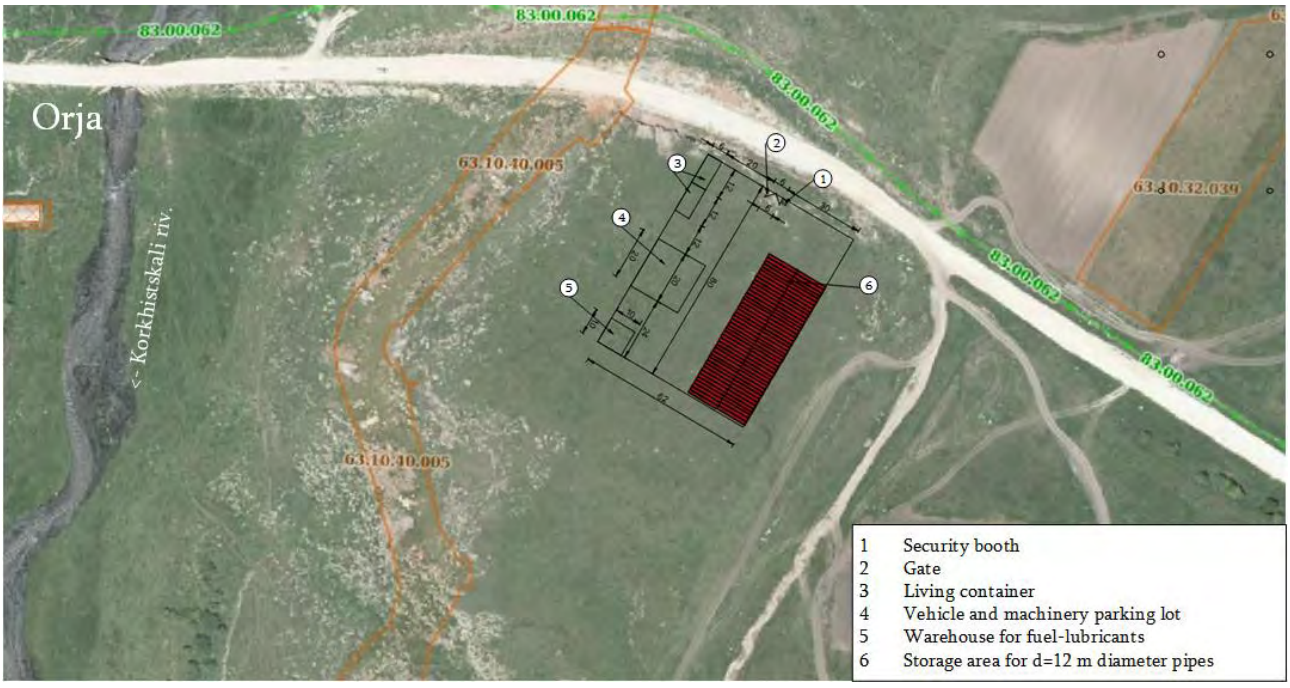
According to the feasibility study, the construction camp will not be large. Following infrastructure is planned on the camp site: office and living containers (considered for 30-35 persons), pipe storage areas, parking lot for equipment and a warehouse for the fuel-lubricants. Concrete mixture will be supplied to the construction sites of Akhalkalaki 2 HPP headwork and the power house from the Diliska construction camp.

On construction phase, roads, passing through Orja village area will not be used for the project purposes. Fuel reservoir will be considered for diesel fuel and will have the capacity 20 m^3. A barrier against fuel distribution on the site will be arranged around the reservoir perimeter.

A layout scheme of Akhalkalaki 2 HPP construction camp site is given on Figure 3.5.2.2.2., and a plan of the camp – on Figure 3.5.2.2.3.

Figure 3.5.2.2.2. A layout scheme of Akhalkalaki 2 HPP construction camp site

Figure 3.5.2.2.3. General Plan of Akhalkalaki 2 HPP Construction Camp



3.5.3 Equipment Used for the Project

The presumable list and approximate amount of the equipment and transportation means, used during the construction works is given in the Table 3.5.3.1. This list may be changed at the discretion of the construction contractor, as required.

Table 3.5.3.1. The presumable list of the construction equipment to be used during construction

№	Name	No
1.	Trucks (Dump trucks)	12

2.	Truck-concrete mixer	5
3.	Bulldozer	3
4.	Excavator	5
5.	Crane, lifting mechanisms	3
6.	Excavator mounted drill (woodpecker)	4
7.	Auto-loader	5
8.	Auto-grader	3
9.	Pneumatic drills	4
10.	Electric vibrators	4
11.	Roller (compactor)	3
12.	Watering-washing car	3
13.	Trailer	4
14.	Mobile compressor	3

3.5.4 Access Roads

For the project purposes, both state and local roads will be used. Main construction materials and equipment (pipes, turbine generators, transformers, etc.) of HPP will be transported from Poti Sea Port, for which international road will be used. The length of this road is 340 km. For access from Tbilisi to the project area, a road, passing through Borjomi and Akhalkalaki can be used, as well as road leading to Tsalka and Ninotsminda.

Considering the locations of the project HPP corridors, it will not be required to carry out large-scaled road works. In particular: Akhaltsikhe-Akhalkalaki highway passes on the right river bank, in parallel to Akhalkalaki 1 HPP. A bridge will be constructed for access to the construction site of Akhalkalaki 1 HPP powerhouse, and construction of the headworks will be provided from the existing road.

Akhalkalaki-Korkhi-Orja asphalted road will be used for the construction of Akhalkalaki 2 HPP. Arrangement of new roads will be required on short sections for access to the headworks and the power house.

As it is given in par. 3.5.2.2., it is not required to arrange new access roads to the construction camps as existing ones will be used.

A new service road construction will be required for arrangement of the penstock, which will be located within the project penstock corridors, thus no new land utilization will be needed.

Due to arrangement of Akhalkalaki 1 HPP headwork and upstream impoundment, it will be needed to raise the highway elevations on 1km long section. Works for raising the road elevation will not be connected to change of existing corridor. Rocks excavated during HPP construction will be used for road level elevation works.

3.5.5 Headworks Construction Works

Headworks construction works will be carried out in dry riverbeds, sequentially, in separate blocks. During construction water will be released through temporary cofferdams and diversion channels.

A temporary cofferdam, which is planned for water removal during construction and diversion channel is calculated for 10-year return period maximum flow.

Construction scheme of Akhalkalaki 1 HPP headwork is given on Figure 3.5.5.1. As it is given on the figure, on the first stage of the construction, 4 m height crib-type cofferdam will be arranged on the left river bank of Paravani river, and water will be diverted to the right bank. Accordingly, left bank

infrastructural works will be implemented. After that, the right bank infrastructure will be arranged in a similar way.

For construction of Akhalkalaki 2 HPP headwork, it is planned to arrange 10 m long and 2 m high temporary cofferdam upstream of the weir (see Figure 3.5.5.2.), and the temporary tailrace channel will be arranged along the left river bank. The depth of the channel will be 2 m, the width at the bottom elevation - 2 m, and at the crest elevation - 8 m. After finishing the headwork construction, the cofferdam and channel will be dismantled and water will be released through headworks.

Figure 3.5.5.1. Construction Scheme of Akhalkalaki 1 HPP Headworks

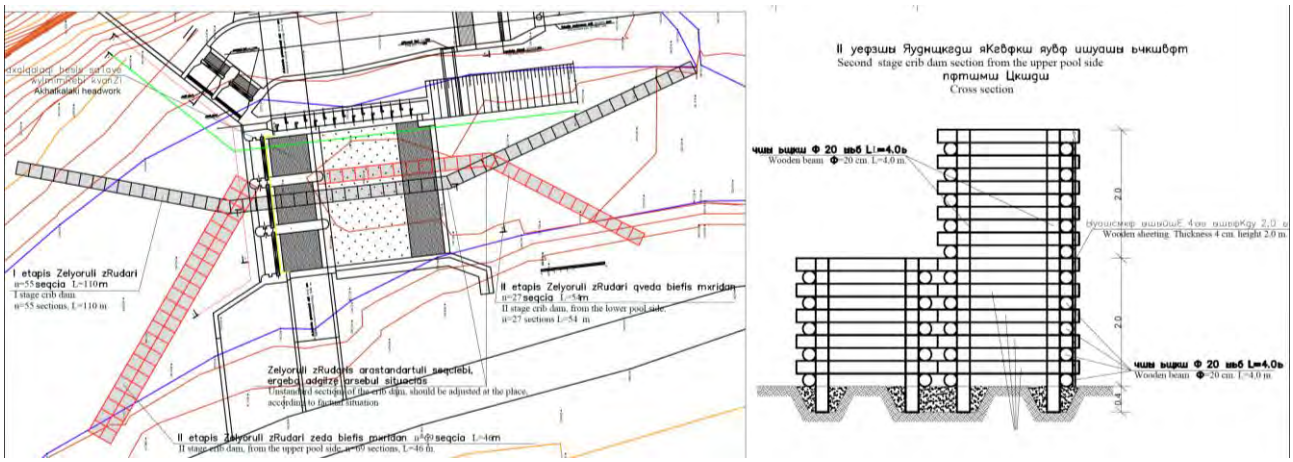
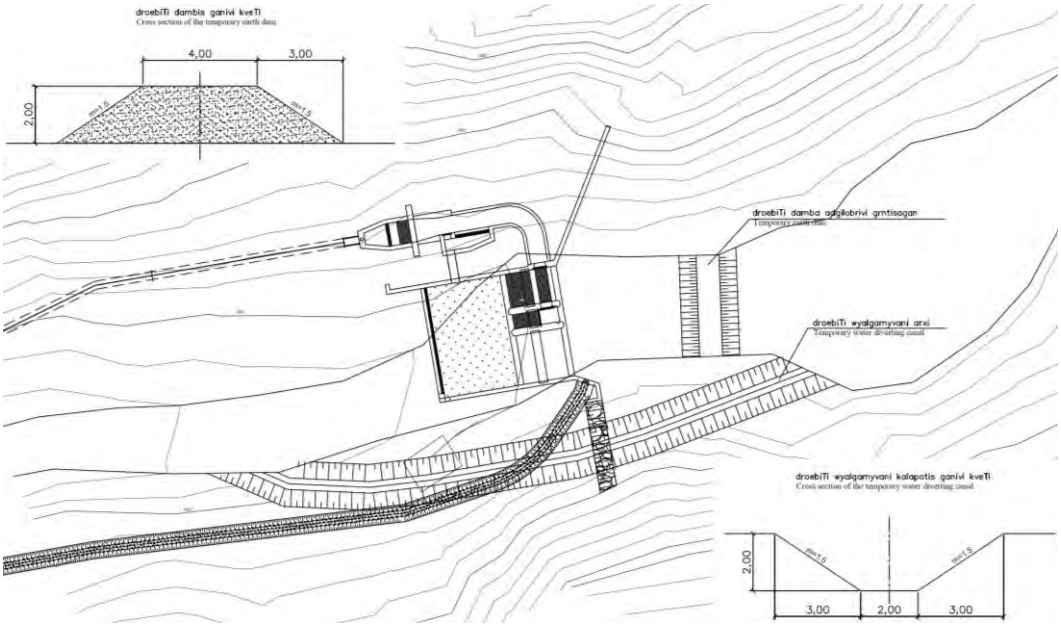


Figure 3.5.5.2. Construction Scheme of Akhalkalaki 2 HPP Headworks



3.6 Water Supply and Sewerage

3.6.1 Construction Phase

On HPP construction phase water will be used for preparation of the concrete mixture, for potable-sanitary purposes, firefighting and watering of the construction sites inn dry weather conditions. The concrete plant will be located only on the area of Akhalkalaki 1 HPP construction camp.

3.6.1.1 Akhalkalaki 1 HPP Construction Camp

The construction camp will be supplied with technical water from Paravani river, and for potable-sanitary purposes water will be used from Diliska water supply system.

Amount of water required for operation of the concrete plant, depends on the amount of water used for preparation of production and 1 m^3 mixture. Water amount needed for preparation of 1 m^3 mixture is 0,13 t. Maximum passport capacity of the concrete plant existing on the construction camp is 30 m^3/h. Maximum annual capacity considering single-shift work mode and 180 working days a year will be 30 m^3/h * 8 h/daily * 180 daily/a = 43,2 thousand m^3/a. Considering aforementioned, the water flow required for the concrete plant operation is:

$$30 * 0,13 = 3,9 \text{ m}^3/\text{h},$$

$$3,9 * 8 * 180 = 5\,616 \text{ m}^3/\text{a}.$$

Amount of potable-sanitary water depends on the water amount, used for the construction personnel and per worker. As it was mentioned, the maximum number of employees will be 100 people, including 60 workers, employed for Diliska construction camp. According to the Construction Norms and Rules – "Water Supply and Sewerage in Buildings" - СНиП 2.04.01-85, water flow per worker during 8 hours is 45 l., 2700 l/daily, **i.e. 2.7 m^3/daily;** 2.7 × 250 = **675 m^3/a.**

On the construction phase, water amount, required for creation of firefighting water storage and training personnel, as well as watering roads and construction sites in dry weathers, will be about 2500-3000 m^3.

In addition to the above-mentioned, technical water will be needed for wetting of the construction sites and earth road surfaces, which will be about 2000 m^3/a.

The total amount of required technical water will be **10 616 m^3** a year.

On the construction phase, only sanitary-fecal wastewater will be generated. Generation of industrial wastewater is not expected (a water required for concrete plant will be fully consumed in the technological process).

Sanitary-fecal water will be collected in the sealed cesspools and removed from the site. It is considered to discharge sanitary-fecal water into Akhalkalaki city sewer. Amount of sanitary-fecal water is calculated with 5% loss of used water and accordingly, will be: **2.57 m^3/daily** and **641.3 m^3/a.** As mentioned above, the installation of a biological treatment plant will also be considered. The issue will be specified by the construction contractor before construction begins. In case of biological treatment plant construction, the project for MPD will be agreed with the Ministry of Environment and Natural Resources Protection of Georgia.

3.6.1.2 Akhalkalaki 2 HPP Construction Camp

A concrete plant is not planned in Akhalkalaki 2 HPP (Orja) construction camp; accordingly water will be used for potable-sanitary purposes, for firefighting purposes and watering the surfaces of construction sites and access roads in dry weather conditions.

Number of people, employed for the construction camp will be 35-40 people. Accordingly, the amount of consumed potable-sanitary water will be 1800 l/daily, **i.e. 1.8 m^3/daily;** 1.8 × 250 = **450.0 m^3/a.**

Amount of firefighting water will be about 2500-3000 m^3/a, and amount of water, used for watering of roads and construction sites will be 2000 m^3/a. Total technical water amount will be **5000 m^3/a.**

Industrial wastewater will not be generated on the camp site, and as for collection of sanitary-fecal wastewater, a sealed cesspool will be arranged for this purpose, which will be discharged into

Akhalkalaki city sewer. Amount of sanitary-fecal water is calculated with 5% loss of used water and accordingly, it will be: **1.71 m³/daily** and **427.5 m³/a.** In case of biological treatment plant construction, the project for MPD will be agreed with the Ministry of Environment and Natural Resources Protection of Georgia.

In total, water amount used for construction phase of Akhalkalaki HPPs will be:

- Potable-sanitary water -4.5 m³/daily and 1125 m³/a;
- Technical water -15 616 m³/a.

In total, amount of sanitary-fecal wastewater, generated on both camps will be: 4.28 m³/daily and 1068.8 m³/a.

3.6.2 Operation Phase

On operation phase, water will be used for potable-sanitary and firefighting purposes.

For water supply of Akhalkalaki 1 HPP, spring water will be used, which is located on the left bank of Paravani river. At present, this spring is used for water supply of trout fish farm. Water supply will be provided using the pump, and potable water storage tank will be arranged on the site.

For water supply of Akhalkalaki 2 HPP power house, a spring water can be used which is located adjacent to the bridge on Korkhi river, from where water will be supplied using the pump. The distance from the spring outfall and the power house is about 70 m.

20 people will be employed for HPP operation, including 12 people for Akhalkalaki 1 HPP, and 8 – on Akhalkalaki 2 HPP. A shower with one point is considered on both power houses. Daily amount of water required for one point of the shower is 500 l.

Considering aforementioned, the maximum water amount of potable-sanitary water, required for Akhalkalaki 1 HPP will be 12 x 45 + 500 = **1040 l/daily i.e. 1,04 m³/daily and 379.6 m³/a.**

Similarly, for Akhalkalaki 2 HPP it will be: 8 x 45 + 500 = **860 l/daily i.e. 0,86 m³/daily and 313.9 m³/a.**

A water basin needed for firefighting system will be arranged on plants, which will be refilled regularly with Paravani and Korkhi river water. Water amount used on one occasion is 20 m³. Considering the fact that during a year the basin will be filled 7-8 times, approximate amount of water, used for firefighting purposes will be 320 m³/a for both HPPs.

Amount of sanitary-fecal wastewater is calculated with 5% loss of used water and for Akhalkalaki 1 HPP it is: 0,988 m³/daily and 360.6 m³/a, and for Akhalkalaki 2 HPP: 0,939 m³/daily and 342.6 m³/a.

The sealed cesspools will be arranged on the power house sites for sanitary-fecal water collection, which will be regularly cleaned and wastewater will be discharged into Akhalkalaki city sewer. At the detailed design phase, it is possible to make decision on the construction of a biological treatment plant for Akhalkalaki 1 HPP. If such a decision is made, the project for MPD shall be agreed with the Ministry in the prescribed manner.

3.7 Waste

During the project implementation, various types and amounts of waste will be generated, including hazardous waste. Waste types, approximate amount and waste management conditions are provided in the Waste Management Plan in Annex 4. Waste rocks should be highlighted in terms of quantity, and its management conditions are provided in the following paragraph.

3.7.1 Waste Rock Management

During the HPP construction, waste rocks will be generated during preparation of foundations for buildings (headworks and powerhouse) and trenches for the penstocks. According to the feasibility study, the total amount of waste rocks will be ≈120 000 m³; during the construction of Akhalkalaki 1 HPP - ≈55 000, and during construction of Akhalkalaki 2 HPP ≈65 000 m³.

1 spoil ground will be arranged for Akhalkalaki 1 HPP in the vicinity of Diliska village, and 1 spoil ground will be arranged for Akhalkalaki 2 HPP on the right slope of River Korkhi.

Arrangement of the spoil ground for Akhalkalaki 1 HPP is planned on the area, adjacent to Diliska village, namely: on the area of natural basin in the south-west. The north-west slope of the basin is erosive, which poses a threat to homestead lands and houses of population at upper elevations. Actually, there is no vegetation cover and topsoil on the area. 10 kV ETL passes through the site, which will be relocated prior to the spoil ground operation.

The area selected for the spoil ground is about 1.4 ha; angle coordinates of the area are as follows:

1	X=370789, Y=4587030	4	X=370539, Y=4586940
2	X=370716, Y=4587051	5	X=370601, Y=4586885
3	X=370655, Y=4586984	6	X=370663, Y=4586952
		7	X=370765, Y=4586985

The selected site is non-agricultural land and is in state ownership. Views of the spoil ground are given on Figure 3.7.1.1.

Figure 3.7.1.1. Akhalkalaki 1 HPP Spoil Ground Site

As it was mentioned, arrangement of Akhalkalaki 2 HPP spoil ground is planned on the areas, selected on the right bank slope of Korkhi river. The selected area is inclined in Korkhi river direction, the surface of the site is covered with stones and grit and accordingly, there is no vegetation cover and topsoil layer. The land plot belongs to non-agricultural land category and is in state ownership. The distance to Korkhi river is 35-40 m.

The area of the project site is 0.72 ha. Angle coordinates of the site:

1. X= 372098, Y= 4592169;
2. X= 372031, Y= 4592182;
3. X= 371998, Y= 4592064;
4. X= 372055, Y= 4592048.

Figure 3.7.1.2. Akhalkalaki 2 HPP Spoil Ground Site

Shape files of the areas, pre-selected for the spoil grounds, are attached to the report.

Waste rocks will be disposed within the allocated spoil grounds under the following conditions:

- Waste rocks will be transported by trucks;
- Safe movement of the transport will be provided to the spoil grounds where waste rocks will be disposed;
- Transportation of waste rocks to the spoil grounds will be carried out by strictly following the rules of traffic movement and with the minimum limits of traffic movement (5-20 km / h). If required, the movement of vehicles will be regulated by specially trained regulators (flag-bearers) personnel;
- Waste rocks will be stored in sections, in layers;
- Height of each pile (fill) will not be more than 2 m;
- Boundaries of the selected areas will be strictly controlled in order to prevent disposal of waste rock outside the perimeter and damage to vegetation cover and blockage of the riverbeds;
- Recultivation works will be carried out on the slopes and surface of the spoil grounds after they are filled; in particular, the topsoil layer will be arranged on the surface and tilled; the growth-development of the herbaceous cover will be facilitated;
- After the closure of spoil ground, monitoring of erosion processes will be continued and appropriate correction measures will be carried out if necessary.

Prior to the construction, the project on spoil ground arrangement and the detailed recultivation measures of spoil grounds will be submitted to and agreed with the Ministry of Environment protection and Agriculture of Georgia.

3.8 Cultivation

Recultivation works involve the demolition of temporary structures, restoration of sections, damaged during the construction, removal of contaminated soil/ground and disposal for remediation, construction waste removal, etc.

The recultivation works will be carried out in accordance with the requirements of the Technical Regulation approved by Decree No. 424 of the Government of Georgia on "Removal, Storage, Usage and Recultivation of Topsoil", dated by December 31, 2013, namely: All types of damaged and deteriorated soil, as well as the area adjacent to it, which partially or fully lost productivity under the negative impact of damaged and deteriorated soils are subject to recultivation.

The Client is obliged to ensure the integrity of the soil cover and its fertility to the original condition for which it is necessary: in case of land contamination, to liquidate the source of pollution and in the shortest possible time to recultivate the contaminated area in the direction of restoration of the integrity of the soil cover; Protect the surrounding area from damage and degradation.

Degraded soil is recultivated for its restoration for agricultural, forestry, water industry, construction, recreation, environmental, sanitary-recreation and other purposes.

The project executor is obliged to ensure the integrity of soil cover and its productivity to the state, close to its initial condition. For this it is necessary to carry out following measures: in case of contamination of the site, the pollution source should be liquidated and the polluted section should be recultivated in the shortest possible time in the direction of the soil cover restoration; the adjacent area should be protected from damage and degradation.

According to the same technical regulation, recultivation works must be carried out according to recultivation project. The Recultivation project for the construction sites will be developed after selection of the construction contractor (after specification of various technical issues). A detailed Recultivation project will be submitted to the Ministry for agreement.

4 Environmental Baseline Condition

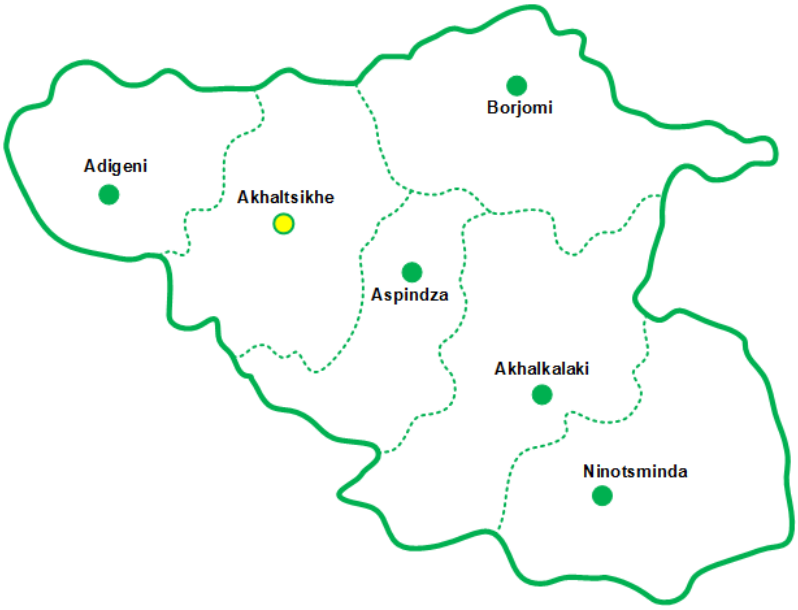
4.1 General Overview

Akhalkalaki HPP construction and operation project is planned to be implemented in Samtskhe-Javakheti region. Samtskhe-Javakheti is located in the southern part of Georgia and covers the territories of Samtskhe-Javakheti's historical-geographical provinces. The project area is located within the historical Javakheti region. Geographically, the area is located on the volcanic plateau of Javakheti, a mountainous plateau, mostly forestless, covered by many lakes and rivers.

The project area is administratively part of the Akhalkalaki municipality, which in turn is part of the Samtskhe-Javakheti region. The Akhalkalaki municipality is bordered by the Republic of Turkey from the south, Ninotsminda municipality from the east, and Borjomi and Aspindza municipalities from the north and west.

Figure 4.1.1. Physical Map of Georgia

Figure 4.1.2. Administrative-territorial division of Samtskhe-Javakheti region



4.2 Description of Physical-geographical Environment

4.2.1 Climate and Meteorological Conditions

Samtskhe-Javakheti region is characterized by a diverse climatic conditions. It is characterized by moderate precipitation, seasonal changes in climate parameters and high levels of solar radiation. The climate is mostly continental, characterized by cold winters and cool, short summers.

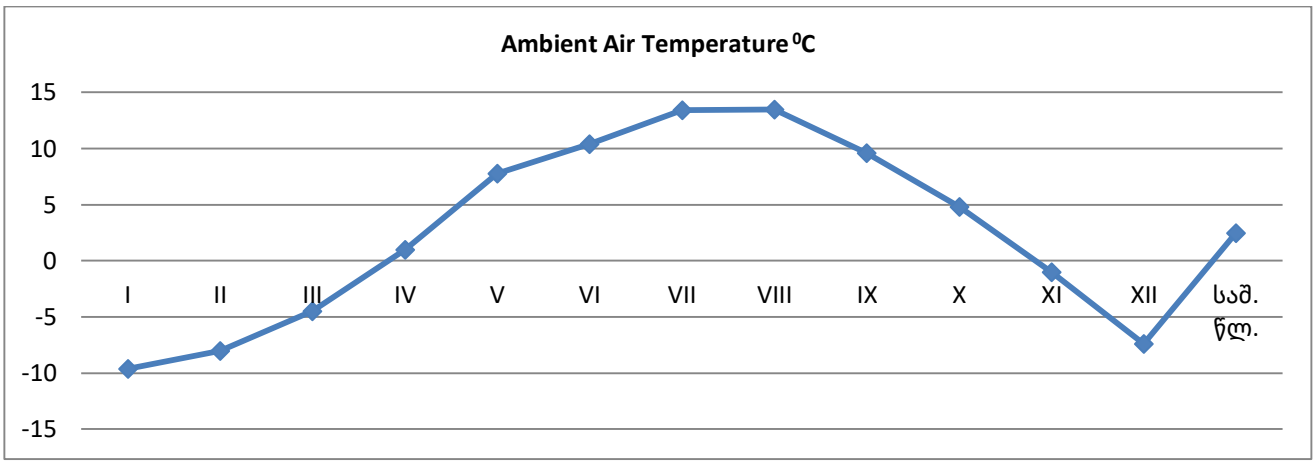
The climate of Samtskhe and Javakheti varies considerably. Samtskhe is characterized by moderately dry, subtropical mountainous climate, with less snowy winters and warm, long summers. The Javakheti zone is dominated by mild dry weather with cold winters and long, cool summers.

Akhalkalaki municipalityis characterized by mountain steppe climate, with cold, less snowy short winters and cool summers. The highest areas are characterized by moderately dry climate.

The meteorological features characteristic of the project area are presented in the tables and diagrams below (according to Akhalkalaki Meteorological Station). (Source: CNR "Construction Climatology" (01. 05-08).

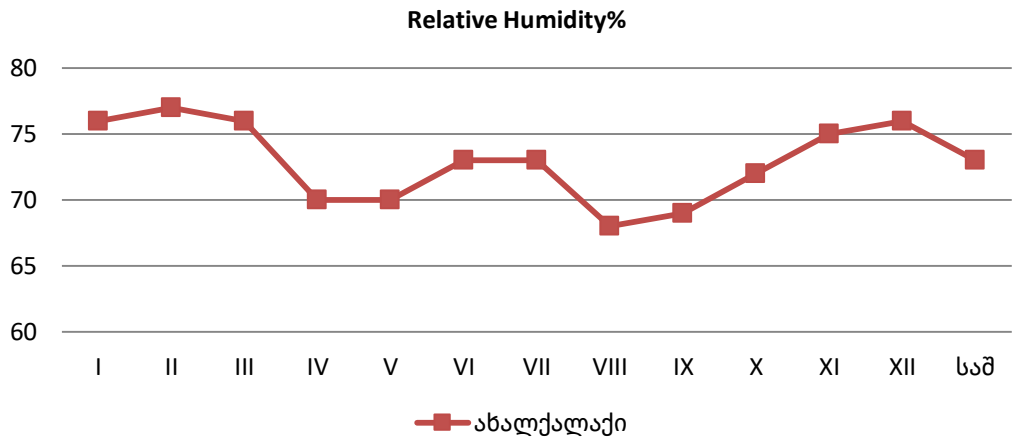
Ambient Air Temperature (^{0}C)

Meteorological Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Aver. ann.	Abs. max. ann.	Abs. min. ann
Akhalkalaki	-7,3	-6,1	2,2	4,4	9,6	12,6	15,4	16,0	12,0	6,9	1,4	-4,2	4,9	37	-38



Relative humidity (%)

Meteorological Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Ave.
Akhalkalaki	76	77	76	70	70	73	73	68	69	72	75	76	73



Meteorological Station	Average relative humidity at 13 o'clock		Average daily relative humidity amplitude	
	The coldest month	The hottest month	The coldest month	The hottest month
Akhalkalaki	70	45	20	39

Precipitation (mm)

Meteorological Station	Annual precipitation, mm	Max. daily precipitation, mm
Akhalkalaki	542	63

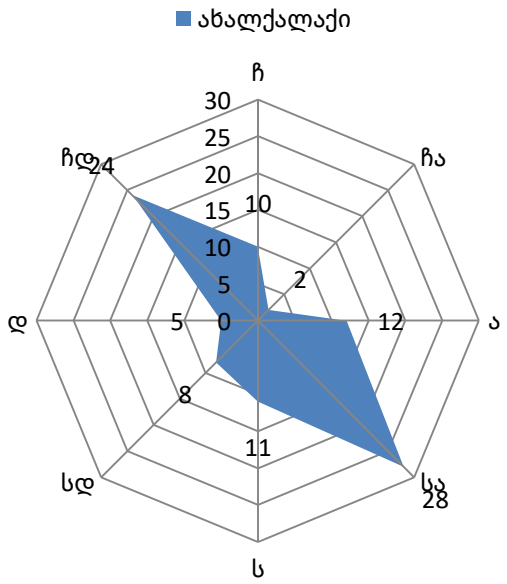
Wind

Meteorological Station	Highest wind speed possible once in 1,5,10,15,20 year. m/s				
	1	5	10	15	20

Meteorological Station	The highest and lowest average wind speeds in m / s	
	January	July
Akhalkalaki	6,1/1,7	4,3/1,4

Meteorological Station	Wind direction and calm (%) per year								
	N	NE	E	SE	S	SW	W	NW	Calm

Akhalkalaki	10	2	12	28	11	8	5	24	10



4.2.2 Geological Environment

4.2.2.1 Geomorphology and Hydrography

In terms of geomorphology, the HPP location area is within the Akhalkalaki Plateau of the Javakheti Uplands of Georgia's volcanic highland region. Akhalkalaki Plateau represents a highland plain, with 1500-1800 m elevation a.s.l. Its meridional length is 35-40 km, and latitudinal width is 25-30 km. It is mostly structured with Upper Pliocene - Lower Quaternary volcanic doleritic lavas. The plain is broken with erosion canyons, among which the most significant is the r. Paravani valley and its tributaries - the Chobaretistskali, the Baraletistskali, the Murjakhetistskali (the Kirbulakh). The r. Paravani erosion depression reaches its maximum (400-500m) in the lower reaches of the r. Akhalkalakistskali, within the region of its confluence with the r. Mtkvari, and gradually becomes smaller upstream. Near Akhalkalaki, at the place where the planned hydroelectric station will be placed, the width of the canyon is within 200 m. The side canyons of the tributaries of the main artery - the r. Paravani wedge at a short distance and a little upstream of it is slightly deepened in the plain. The valley floors are relatively extended, with small grade and the river channels create many meanders in the bottom line.

The river Paravani canyon direction within the HPP location area is northward. The valley is slightly winding. The valley floor width, most of which is occupied by the river channel and the motor road running along its right bank, is 45-60 meters; the river does not have a flood-plain, while the channel width is mostly 18-25 meters. The canyon slopes on the top are rocky, with 40 to 60 degrees slope, sometimes overlapping, occasionally almost right, through the full height. At the bases of the rocky slopes, mostly detritus of fragmentary rock material (colluvial) is accumulated, which lessens the slope grades in the lower part, though their grade here sometimes still reaches 40-45 degrees. In the canyon walls structured with fractured hard rocks, artificial and natural shallow caves and rocky offsets are observed.

Within the HPP facilities site, erosion ravines are formed in the r. Paravani valley slopes. In the right slope, 1 erosion gully has formed near the powerhouse site, with small water inflow, and in the left slope 2 gullies have formed, one of which is developed adjacent to vil. Diliska, with small water inflow, and the other - dry gully, is registered in the mid-part of the project segment. The gullies are short, are

deeply cut in the lower parts, or on the sites of joining with the r. Paravani, have steep rock slopes, while going more to the upstream, the depth of their cut-in decreases sharply and after 1000-1500 meters it merges with the plain surface of the volcanic plateau.

The river Korkhi valley, within the HPP location site is winding and has overall southward direction. It joins the river Paravani. On 1.2-1.3 km distance, the valley is canyon-like on the whole, with high rocky slopes. In the morphology of the rocky slopes, two steps are distinguished on both sides. The first step, on both sides, is developed along the river channel, which overlooks the accumulation of angular boulders having formed between its base and the river channel. After this step, the slope decreases to 30-350, where it is covered with large boulders and cobbles and after this again, a steep ledge rises with its edge reaching the surface of the volcanic plateau. In the lower part, the r. Korkhi does not have a flood-plain; it runs through the boulders having fallen from the steep and vertical valley slopes. Only on the site of confluence with the r. Paravani, the Korkhi channel on both sides borders with the above-flood-plain terraces with 1-1.5 meters height, about 80-100 meters length and 15-20 meters width. On the right terrace, which is partly covered with the accumulation of boulders fallen from the rocky slope, the powerhouse of Akhalkalaki 2 HPP will be located.

After the canyon-like segment, upstream, the r. Korkhi slopes are relatively low, extended, though sometimes not high large cliffs are still observed. In the upstream, at certain segments of the valley floor, fragments of low (0.5-1m) above-flood-plain terraces are observed, upstream of which, in the slope bases, there are colluvial coarse boulder accumulations are developed again. Based on the existing design layout, the upstream of the HPP's penstock (diversion), at about 400-450 distance from the source, runs along the fragments of the said terraces, along the river channel, on its right bank, and then gradually goes up, at the small-grade slope covered with boulder-cobbles between the two steps of the canyon. The last, small segment of the penstock sharply goes down toward the river bank, to the powerhouse construction site.

The r. Korkhi slopes, within the project segment are not cut down with lateral gullies. One shallow gully cut in the slope is observed, which joins the r. Korkhi upstream of the headworks.

4.2.2.2 Geological Structure

Based on the tectonic zoning scheme of the territory of Georgia (I. P. Gamkrelidze, 2000), the project area is attributed to the Lesser Caucasus fold system (System III), Artvin-Bolnisi Zone (Zone III_2), Javakheti Sub-zone (Sub-zone III_2^1). Stratigraphically, the project area is structured by Upper Pliocene - Lower Quaternary continental volcanogenic formations ($\beta N_2^3 Q_I$), which are lithologically represented by basalts, dolerites, andesite-basalts and andesites of Tsalka- Akhalkalaki Suite. Based on archive materials, in the said volcanogenic rocks, sometimes lacustrine conglomerates, sands, sandstones and clay lenses and bands are revealed. Existence of such inclusions in the rock mass is not excluded on the sites of the HPP's project area, where hard rocks are covered with Quaternary non-rock soils. Quaternary, various-genesis soils comprise almost the whole project zone of the HPPs location.

Below is given first, description of Quaternary (non-rock) soils, and then - brief description of basic rocks.

4.2.2.3 Engineering-Geological Conditions

The engineering-geological maps of the Akhalkalaki HPP project corridor are shown in Figure 4.2.2.5.1. While the geological maps and section of the project structures are in Annex N1.

The location areas of Akhalkalaki 1 HPP and Akhalkalaki 2 HPP are identical according to all factors of natural environment (geomorphology, geological structur, hydrogeological and geodynamic conditions,

soils), therefore, soils and rocks types revealed on these areas are discussed as part of the environment and they are described in one complex.

Based on field and laboratory investigation results, 6 soil types and 1 rock type or engineering-geological element **(EGE)** aredistinguished. The elements are graphically shown on the engineering geological map and geotechnical sections of the construction area. Their distribution in depth, based on boreholes and trial-pits, is given in Table 4.2.2.3.1.

According to geophysical data, the five EGEs with differant physical properties are mainly observed (identification was made based on geological engineering results):

EGE 1 – Boulders, gravel, coarse sand with loamy filler, which, according to geological data, combines EGE 1 and EGE 2;

EGE 2 – Gravel with pebbles inclusions, sand filler, dense, water-saturated, which, according to geological data, combines EGE 3 and EGE 4;

EGE 3 – Clay with inclusions of coarse sand and break stone, which, according to geological data, combines EGE 5and EGE 6;

EGE 4 - Andesites and basalts, slightly weathered, fissured, which, according to geological data, correspond to EGE 7;

EGE 5 - Andesites and basalts, which, according to geological data, correspond to EGE 7;

A detailed report on the geophysical survey is given in ANNEX 3.

Table 4.2.2.3.1. Distribution of EGEs in depth based on boreholes and trial-pits

EGE N	*Description of element*	EGE in-depth distribution, m.						
		BH-PAR-HW-11	BH-PAR-HW-12	BH-PAR-PS-22	BH-PAR-PS-27	BH-PAR-PH-32	BH-KOR-HW-41	BH-KOR-PH-61
	Topsoil layer	0.0-0.2 0.2	0.0-0.3 0.3				0.0-0.5 0.5	
1	Angular cobbles and angular gravel containing angular boulders, with clayey soil (colluvial-cQ_{IV})			0.0-0.9 0.9				
2	Coarse angular boulders and angular cobbles, with angular gravel and clayey soil (Colluvial-cQ_{IV})				0.0-5.0 5.0			
3	Angular boulders, angular cobbles, sub-rounded boulders and cobbles, with clayey soil. (Alluvial-aQ_{IV})	0.2-1.3 1.1 2.0-3.9 1.9 7.5-9.4 1.9	1.7-10.7 9.0		5.0-6.4 1.4	0.0-8.0 8.0	0.5-2.9 2.4	0.0-8.0 8.0
4	Hard, saturated rounded gravel with rounded cobbles inclusions, with sand/ clay sand. (Alluvial-aQ_{IV})	5.1-7.5 2.4	10.7-11.5 0.8			8.0-9.1 1.1	4.4-7.3 2.9 10.1-11.5 1.4	8.0-9.1 >1.1
5	Very stiff reddish-brown clay with angular gravel and angular cobbles inclusions (Lacustrine-lQ_{IV})		0.3-1.7 1.4				2.9-4.4 1.5 7.3-8.4 1.1 20.0-23.0 3.0	
6	Very stiff greenish-gray clay with angular gravel and angular cobbles inclusions (Lacustrine-lQ_{IV})	1.3-2.0 0.7 3.9-5.1 1.2					8.4-10.1 1.7 11.5-20.0 8.5 23.0-25.0	

							>2.0	
7	Slightly weathered, fractured andesites and basalts (Upper Pliocene/Lower Quaternary volcanic lava material- βN^{3}-Q)	9.4-20.0 >10.6	11.5-20.0 >8.5	0.9-7.0 >6.1	6.4-7.0 >0.6			
	Groundwater level	**2.30**	**2.20**	-	-	-	**2.20**	-

Table 4.2.2.3.1. (Continued)

EGE #	*Description of element*	EGE in-depth distribution, m.						
		TP-PAR-PS-21	TR-PAR-PS-22	TP-PAR-PS-23	TP-PAR-PS-24	TP-PAR-PS-25	TP-PAR-PS-26	TP-KOR-PS-53
1	Angular cobbles and angular gravel containing angular boulders, with clayey soil (colluvial-cQ_{IV})	0.0-2.3 2.3		0.0-2.5 2.5	0.0-0.7 0.7	0.0-0.9 0.9	0.0-0.4 0.4	
2	Coarse angular boulders and angular cobbles, with angular gravel and clayey soil (Colluvial-cQ_{IV})							0.0-0.5 0.5
3	Angular boulders, angular cobbles, sub-rounded boulders and cobbles, with clayey soil. (Alluvial-aQ_{IV})							
4	Hard, saturated rounded gravel with rounded cobbles inclusions, with sand/ clay sand. (Alluvial-aQ_{IV})							
5	Very stiff reddish-brown clay with angular gravel and angular cobbles inclusions (Lacustrine-lQ_{IV})							
6	Very stiff greenish-gray clay with angular gravel and angular cobbles inclusions (Lacustrine-lQ_{IV})							
7	Slightly weathered, fractured andesites and basalts (Upper Pliocene/Lower Quaternary volcanic lava material-βN^{3}-Q)							
	Groundwater level	-	-	-	-	-	-	-

Below is given description of soil and rock elements.

4.2.2.3.1 Soils

EGE1 – Angular cobbles and angular gravel containing angular boulders, with clayey soil. The element is a colluvial deposit (cQIV) and is distributed in the project zone of both HPPs. In the river Paravani valley it is mostly found in the zone between the slope bases and the river valley, and in the river Korkhi vally, its distribution area is mostly the mid-parts of the slopes where their grade is not high. The colluvial deposit has formed as a result of gravity forces and it is a product of fractured rock fall from the steep slopes. Particle-size distribution of the colluvium depends on the slope grade and rock fracturing extent. The greater the grade and the greater the size of inter- fracture boulders, the coarser the boulders and cobbles in the colluvial mass. In this type of colluvium, coarse fragments are filled with clayey soil which, despite its small amount in the overall mass, functions as a certain binder. Coarse particle-size of the soil creates favourable conditions in terms of water transmissivity as a result of which influent seepage (if there is such) of the atmospheric precipitation from the upper slope frontally discharge into the river fast and unobstructed.

Grouped quantities of fractions and physical properties of filler are given below in Table 4.2.2.3.1.1.

Based on the values given in the table, average content of angular boulders, angular cobbles and angular gravel in EGE-1 is 74.2% according to which it is classified as coarse soil. Plastic index of filler in the coarse fraction I_P=11.7 and liquidity index I_L=-0.16 according to which EGE-1 filler is clayey soil.

EGE-1 mechanical properties [internal friction angle (φ), cohesion (c) and modulus of deformation (E)] have been calculated with the existing method. Calculation results are given in Annex 4.1.8. Parameter values are as follows:

In consolidated state:

- Internal friction angle φ=33.6^0;
- Cohesion c=25.5 kPa

In non-consolidated state:

- Internal friction angle φ=26.80;
- Cohesion c=15.30 kPa;
- Modulus of deformation E_0=44.29 MPa;

According to composition and the characteristics values for their properties, as per Construction Norms and Regulations 2.02.01-83 (SNIP), EGE-1 design resistance value R_0=400kPa (4kgf/cm^2).

For density (specific weight - ρ) of the element 2.0 g/cm^3 can be accepted.

EGE-2 - Coarse angular boulders and angular cobbles, with angular gravel and clayey soil. The element is also a colluvial deposit (cQ_{IV}) and is mostly distributed on the r. Korkhi valley slopes, though it is also found on certain sites of the r. Paravani valley in the downstream part of the project area. Within the r. Korkhi valley, it entirely takes the zone of the lower parts of the slopes adjacent to the channel on both banks. The specific characteristic of the colluvium of this type, unlike the above-described, is high content of coarse angular boulders (the size of some reaches 2-2.5 m) as well as filler composition and its relatively small amount in the overall mass. The filler, due to its composition (angular gravel, clayey soil) cannot function as binder and, therefore, it is likely that this type of colluvium is loose in depth, as well as on the surface. Coarse particle-size of the soil creates favourable conditions for groundwater drainage here as well, as a result of which there will be no water show during execution of earth work on the slopes.

Grouped quantities of fractions and physical properties of filler are given below in Table 4.2.2.3.1.2.

Table 4.2.2.3.1.1. EGE-1 particle-size distribution and physical characteristics of filler

Sequential # in summary table	Borehole/trial-pit #	Sampling interval, m	Fraction size, mm								Moisture content W%		Plasticity			Liquidity index I_L	Bulk density, γ gcm^3	Description of soil
			Angular boulders % 200.0-63.0	Angular cobbles % 200.0-63.0	Angular gravel % 63.0-2.0	Sand			Silt % 0,063 - 0,002	Clay % < 0,002	Natural	Filler	Upper limit, W_L%	Lower limit, W_P%	Plastic index, Ip			
						Coarse% 2.0-0,600	Medium % 0,600-0,212	Fine% 0,212-0,063										
24	TP-PAR- PS-21	2.3	12.0	29.1	30.2	4.2	6.4	6.6	11.5		14.7	20.5	41.3	25.0	16.3	-0.28	1.62	Sandy, silty angular cobbles and angular gravel containing angular boulders
25	TP-PAR- PS-22	0.4	15.5	28.7	28.6	7.6	7.5	3.5	8.6		14.8	22.4	34.7	22.4	12.3	0.00	1.50	Sandy, silty angular cobbles and angular gravel containing angular boulders
26	TP-PAR- PS-23	2.5	10.0	20.5	43.6	4.5	6.7	6.8	7.9		15.4	23.0	36.0	23.8	12.2	-0.07	1.56	Sandy, silty angular cobbles and angular gravel containing angular boulders
27	TP-PAR- PS-24	0.7	18.0	24.9	33.4	3.8	5.5	5.0	9.4		11.8	19.6	34.8	21.6	13.2	-0.15	1.63	Sandy, silty angular cobbles and angular gravel containing angular boulders
28	TP-PAR- PS-25	0.9	20.0	22.8	34.1	5.4	5.4	6.0	6.3		13.7	20.7	32.3	24.3	8.0	-0.45	1.59	Sandy, silty angular cobbles and angular gravel containing angular boulders
29	TP-PAR- PS-26	0.4	14.0	24.0	35.7	5.4	6.3	4.7	9.9		10.9	23.1	31.7	23.3	8.4	-0.02	1.49	Sandy, silty angular cobbles and angular gravel containing angular boulders
Mean value			**14.9**	**25.0**	**34.3**	**5.2**	**6.3**	**5.4**	**5.4**		**13.6**	**21.6**	**35.1**	**23.4**	**11.7**	**-0.16**	**1.57**	

Note: Fractions with >200 mm size have been determined on site, visually.

Table 4.2.2.3.1.2. EGE-2 particle-size distribution and physical characteristics of filler

Sequential # in summary table	Borehole/trial-pit #	Sampling interval, m	Fraction size, mm								Moisture content W%		Plasticity			Liquidity index I_L	Bulk density, r g/cm³	Description of soil
			Angular boulders % >200.0	Angular cobbles % 200.0-63.0	Angular gravel % 63,0-2,0	Sand			Silt % 0,063 - 0,002	Clay % < 0,002	Natural	Filler	Upper limit, W_L%	Lower limit, W_P%	Plastic index, Ip			
						Coarse % 2.0-0,600	Medium % 0,600-0,212	Fine % 0,212-0,063										
30	TP-KOR-PS-53	0.52	53.6	12.4	8.1	5.0	7.0	7.5	6.4		12.3	22.2	34.5	22.4	12.1	-0.02	1.54	Sandy, silty angular boulders, angular cobbles, with angular gravel and clayey soil

Note: *Fractions with >200 mm size have been determined on site, visually.*

Based on the values given in the table, content of angular boulders with over 200 mm size in EGE-2 is 53.6%, according to which it is classified as very coarse soil. Plastic index of the filler in the coarse fraction I_P=12.1 and liquidity index I_L=-0.02 according to which EGE-2 filler is hard clayey soil.

EGE-2 mechanical properties [internal friction angle (φ), cohesion (c) and modulus of deformation (E)] have been calculated with the existing method. Calculation results are given in Annex 4.1.8. Parameter values are as follows:

In consolidated state:

- Internal friction angle φ=33.5⁰;
- Cohesion c=28.7 kPa

In non-consolidated state:

- Internal friction angle φ=26.7⁰;
- Cohesion c=17.33 kPa;
- Modulus of deformation E_0=50.11 MPa;

According to composition and the characteristics values for their properties, as per Construction Norms and Regulations 2.02.01-83 (SNIP), EGE-2 design resistance R_0=450kPa (4.5 kgf/cm²).

For density (specific weight - ρ) of the element 2.2 g/cm³ can be accepted.

EGE-3 - Angular boulders, angular cobbles, sub-rounded boulders and cobbles, with clayey soil. The element is alluvial deposit (aQ_{IV}) and is present only in the river channels, as well as in the fragnments of the low, narrow terraces at its banks. By structural properties it practically does not differ from the above-described colluvial material, since its particle-size distribution is similar - all of them are attributed to coarse sub-group of sedimented incoherent rock group. The specific characteristic of the alluvium distinguishing it from colluvium is its saturated state, since the groundwater in it is fed from the river, as well as the fact that part of its constituent coarse fractions is subrounded by the river.

Grouped quantities of fractions and physical properties of filler are given below in Tables 4.2.2.3.1.3. and

4.2.2.3.1.5.

Table 4.2.2.3.1.3. EGE-3 particle-size distribution

Sequential # in summary table	Borehole/trial-pit #	Sampling interval, m	Fraction size, mm								Description of soil
			Angular boulders/Rounded boulders % >200.0	Angular cobbles/rounded cobbles % 200.0-63.0	Angular gravel/rounded gravel % 63.0-2.0	Sand			Silt % 0.063 - 0.002	Clay % < 0.002	
						Coarse % 2.0-0.600	Medium % 0.600-0.212	Fine % 0.212-0.063			
5	BH-PAR-HW-11	7.5-9.4	27.5	15.8	28.1	5.4	8.3	8.0	6.9		Angular cobbles , angular cobbles and angular gravel with sand and clay
8	BH-PAR-HW-12	4.0-7.0	32.4	21.8	35.8	1.3	1.9	2.0	4.8		Angular cobbles , angular cobbles and angular gravel with sand and clay

Note: *Fractions with >200 mm size have been determined on site, visually.*

Table 4.2.2.3.1.4. EGE-3 filler physical characteristics

#	Borehole #	Sampling interval, m	Moisture content W%		Plasticity			Liquidity index I_l	Bulk density, γ g/cm^3
			Natural	Filler	Upper limit, W_L%	Lower limit, W_P%	Plastic index, Ip		
1	BH-PAR-HW-11	0.5-1.0	12.6	18.8					1.63
3	BH-PAR-HW-11	3.0-3.5	12.8	20.3	30.3	22.6	7.7	-0.30	1.66
7	BH-PAR-HW-12	4.0-5.0	7.9	15.2	22.8	15.3	7.5	-0.01	1.61
9	BH-PAR-PS-27	5.4-5.7	15.8	29.9	40.8	23.5	17.3	0.37	1.57
11	BH-PAR-PH-32	2.3-2.5	25.3		36.7	20.4	16.3	0.30	1.69
12	BH-PAR-PH-32	6.2-6.4	22.4		35.5	21.3	14.2	0.08	1.75
22	BH-KOR-PH-61	6.6-7.0	15.4	33.8	35.9	22.3	13.6	0.85	1.55
Mean value									

Based on the values given in Table 4.2.2.3.1.3., content of over 63 mm size fractions in EGE-3 is 52.1%, according to which it is classified as very coarse soil. Plastic index of the filler in the coarse fraction Ip=12.8 according to which it is clayey soil.

EGE-3 mechanical properties [internal friction angle (φ), cohesion (c) and modulus of deformation (E)] have been calculated with the existing method. Calculation results are given in Annex 4.1.8. Parameter values are as follows:

In consolidated state:

- Internal friction angle $\varphi=33.3^0$;
- Cohesion c=20.2 kPa

In non-consolidated state:

- Internal friction angle $\varphi=26.6^0$;
- Cohesion c=11.72 kPa;
- Modulus of deformation E_0=48.94 MPa;

According to composition and the characteristics values for their properties, as per Construction Norms and Regulations 2.02.01-83 (SNIP), EGE-3 design resistance R_0=400kPa (4 kgf/cm^2).

For density (specific weight - ρ) of the element 2.1 g/cm^3 can be accepted.

Along with boring in the element, standard penetration testing (SPT) was performed. The results are given in borehole lithologs (Annex-2).

EGE-4 - Hard, saturated rounded gravel with rounded cobbles inclusions, with sand/ clay sand. The element is an ancient alluvial deposit (aQ). It is not found on the ground surface and has revealed only in the boreholes, at different depth ranges, under the above-described soil strata. The specific characteristic this type of alluvial deposit is that its main mass represents well- rounded gravel and contains little rounded cobbles and rounded boulders while the filler is mainly sand. The element is in saturated state, since it is everywhere located below the river level.

Particle-size distribution and physical characteristics of the element have been investigated on borehole samples. Investigation results are fully given in Table 4.2.2.3.1.5.

Table 4.2.2.3.1.5. EGE-4 particle-size distribution and physical characteristics of filler

Sequential # in summary table	Borehole/trial-pit #	Sampling interval, m	Fraction size, mm							Moisture content W%		Plasticity			Liquidity index I_L	Mineral particles density,	Bulk density, r g/cm3	Description of soil
			Rounded cobbles % 200.0-63.0	Rounded gravel % 63.0-2.0	Sand			Silt % 0.063 - 0.002	Clay % < 0.002	Natural	Filler	Upper limit, W_L%	Lower limit, W_p%	Plastic index, Ip				
					Coarse % 2.0-0.600	Medium % 0.600-0.212	Fine % 0.212-0.063											
14	BH-PAR-PH-32	8.0-9.0		74.5	8.5	5.0	3.1	8.9		10.3	23.3	33.7	21.4	12.3	0.15	2.70	1.55	Sandy, silty rounded gravel
16	BH-KOR-HW-41	6.0-7.0	33.8	39.7	8.9	4.3	2.4	10.9		13.3	21.8	35.5	23.8	11.7	-0.17	2.71	1.57	Sandy, silty rounded gravel containing rounded cobbles
23	BH-KOR-PH-61	8.0-9.0		79.1	12.1	3.5	1.3	4.0		11.9	23.1	30.3	25.2	5.1	-0.41	2.69	1.59	Sandy, silty rounded gravel
Mean value			**11.3**	**64.4**	**9.8**	**4.3**	**2.3**	**4.8**		**11.8**	**22.7**	**33.2**	**23.5**	**9.7**	**-0.14**	**2.70**	**1.57**	

Based on the values given in the table, average content of over 2 mm size fractions in EGE- 4 is 75.7%, according to which it is classified as coarse (gravelly) soil. Plastic index of the filler in the coarse fraction I_P=9.7 and liquidity index I_L=-0.14, according to which EGE-4 is hard clayey soil.

EGE-4 mechanical properties [internal friction angle (φ), cohesion (c) and modulus of deformation (E)] have been calculated with the existing method. Calculation results are given in Annex 4.1.9. Parameter values are as follows:

In consolidated state:

- Internal friction angle φ=34.5^0;
- Cohesion c=20.2 kPa

In non-consolidated state:

- Internal friction angle φ=27.6^0;
- Cohesion c=11.21 kPa;
- Modulus of deformation E_0=47.37 MPa;

According to composition and the characteristics values for their properties, as per Construction Norms and Regulations 2.02.01-83 (SNIP), EGE-4 design resistance R_0=400kPa (4 kgf/cm^2).

For density (specific weight - ρ) of the element 2.0 g/cm^3 can be accepted.

Along with boring in the element, standard penetration testing (SPT) was performed. The results are given in borehole lithologs (Annex-2).

EGE-5 - Very stiff reddish-brown clay with angular gravel and angular cobbles inclusions. The element is a lacustrine deposit (lQIV) and is represented in only the river channels area where it alternates with other alluvial, coarse and clayey soil strata. In borehole #KOR-HW-41, EGE-5 repeats several times at different depth intervals.

Particle-size distribution and physical characteristics of the element are given in Tables 4.2.2.3.1.6. and 4.2.2.3.1.7.

Table 4.2.2.3.1.6. EGE-5 particle-size distribution

Sequential # in summary table	Borehole/trial-pit #	Sampling interval, m			Fraction size, mm					Description of soil
					Sand					
			Angular cobbles % 200.0-63.0	Angular gravel % 63.0-2.0	Coarse % 2.0-0.600	Medium % 0.600-0.212	Fine % 0.212-0.063	Silt % 0.063 - 0.002	Clay % < 0.002	
6	BH-PAR-HW-12	1.0-1.3		40.0	23.1	12.4	6.5	12.2	5.8	Coarse, silty, clayey. very gravelly sand
15	BH-KOR-HW-41	3.2-3.6				0.5	1.0	53.9	44.6	Very highly plastic silty, slightly sandy clay
20	BH-KOR-HW-41	20.6-21.0		7.9	8.3	6.6	11.3	47.9	18.0	Stiff , slightly clayey, slightly sandy, slightly gravelly silt

Mean value		**16.0**	**10.5**	**6.5**	**6.3**	**38**	**22.8**	

Table 4.2.2.3.1.7. EGE-5 filler physical characteristics

Sequential # in summary table	Borehole/trial-pit #	Sampling interval, m	Moisture content, W%	Plasticity			Liquidity index I	Density, g/cm³			Porosity, n%	Voids ratio, e	Moisture degree, S_z	Shear test of soil		Description of soil
				Upper limit, WL%	Lower limit, Wp%	Plastic index, Ip		Mineral particles, ρ_σ	Natural, ρ	Matrix, ρ_δ				Cohesion, c, MPa	Internal friction angle, φ^0	
6	BH-PAR-HW-12	1.0-1.3	25.1					2.66	1.99	1.59	40.22	0.673	0.994			Coarse, silty, sandy, clayey, very gravelly sand
15	BH-KOR-HW-41	3.2-3.6	47.8	78.4	35.7	42.7	0.28	2.74	1.74	1.18	57.04	1.328	0.987	0.018	15.4	Very stiff, silty, slightly sandy clay
20	BH-KOR-HW-41	20.6-21.0	38.4	45.3	35.4	9.9	0.30	2.70	1.68	1.21	55.04	1.224	0.847	0.043	25.4	Slightly clayey, slightly sandy, slightly gravelly stiff silt
Mean value			**37.1**	**61.9**	**35.6**	**26.3**	**0.29**	**2.70**	**1.80**	**1.33**	**50.77**	**1.075**	**0.943**	**0.031**	**20.4**	

Based on the values given in Table, average content of over 2 mm size fractions in EGE-5 varies from 8 to 40%. It is non-uniform soil and out of three tests represents sand in one case, clay in one case, and silty soil in one case. Based on averaged value of plastic index (I_P=26.3), most of its mass is clay. Soil is normally consolidated.

Based on the test performed in the element, the values for its shear characteristis are as follows:

- Internal friction angle φ=20.40;
- Cohesion c=31 kPa.

According to composition and the said values for its physical properties, as per reference and standardized documentation, the values for EGE-5 mechanical charactereristics are as follows:

- Modulus of deformation E_0=9 MPa;
- Modulus of elasticity E=80 MPa.

Along with boring in the element, standard penetration testing (SPT) was performed. The results are given in borehole lithologs (Annex-2).

EGE-6 - Very stiff, greenish-gray clay with angular gravel and angular cobbles inclusions. The element is a lacustrine deposit (lQ_{IV}) and is present only in the river channels zone, where it alternates with other alluvial, coarse and clayey soil strata. In boreholes # PAR-HW-11 and KOR-HW-41, EGE-6 has revealed at several depth ranges.

Particle-size distribution and physical characteristics of the element have been investigated on borehole samples. Investigation results are fully given in Tables 4.2.2.3.1.8. and 4.2.2.3.1.9.

Table 4.2.2.3.1.8. EGE-6 particle-size distribution

Sequential # in summary table	Borehole/trial-pit #	Sampling interval, m			Fraction size, mm					Description of soil
					Sand					
			Angular cobbles % 200.0-63.0	Angular gravel % 63.0-2.0	Coarse % 2.0-0.600	Medium % 0.600-0.212	Fine % 0.212-0.063	Silt % 0.063 - 0.002	Clay % < 0.002	
2	BH-PAR-HW-11	1.5-1.8		27.4	9.1	15.4	5.3	29.7	13.1	Low-plasticity, silty, slightly sandy, slightly gravelly clay
4	BH-PAR-HW-11	4.3-4.7								Stiff clay
17	BH-KOR-HW-41	9.2-9.6		11.7	14.7	8.8	13.3	24.2	27.3	Stiff, slightly silty, sandy, slightly gravelly clay
18	BH-KOR-HW-41	16.5-16.9		6.2	8.0	11.0	12.2	39.0	23.6	Stiff silt
19	BH-KOR-HW-41	19.0-19.4		8.8	12.4	8.9	11.0	40.3	18.6	Stiff, slightly clayey, slightly sandy, slightly gravelly silt
Mean value				13.5	11.1	11.0	10.5	33.3	20.7	

Table 4.2.2.3.1.8. EGE-6 physical characteristics

Sequential # in summary table	Borehole/trial-pit #	Sampling interval, m	Moisture content, W%	Plasticity			Liquidity index I	Density, g/cm³			Porosity, n%	Voids ratio, ε	Moisture degree, S_z	Shear test of soil		Description of soil
				Upper limit, WL%	Lower limit, Wp%	Plastic index, Ip		Mineral particles, ρ_σ	Natural ρ	Matrix, ρ				Cohesion, c, MPa	Internal friction angle, φ^0	
2	BH-PAR-HW-11	1.5-1.8	30.5	32.2	24.7	7.5	0.77	2.70	1.87	1.43	46.91	0.884	0.931			Low-plasticity, silty, slightly sandy, slightly gravelly clay
4	BH-PAR-HW-11	4.3-4.7	35.8	40.8	26.1	14.7	0.66	2.71	1.86	1.37	49.47	0.979	0.992	0.014	11.3	Stiff clay
Seq				Plasticity				Density, g/cm³						Shear test of soil		

				Upper limit, WL%	Lower limit, Wp%	Plastic index, Ip		Mineral particles, γ_s	Natural, γ	Matrix, γ_d				Cohesion, c, MPa	Internal friction angle, φ	Description of soil
17	BH-KOR-HW-41	9.2-9.6	35.0	45.5	29.8	15.7	0.33	2.71	1.73	1.28	52.71	1.115	0.851	0.045	22.4	Stiff, slightly silty, sandy, slightly gravelly clay
18	BH-KOR-HW-41	16.5-16.9	36.5	44.7	32.9	11.8	0.31	2.71	1.71	1.25	53.77	1.163	0.850	0.047	25.4	Stiff silt
19	BH-KOR-HW-41	19.0-19.4	36.2	42.7	31.3	11.4	0.43	2.71	1.78	1.31	51.77	1.074	0.914			Stiff, slightly clayey, slightly sandy, slightly gravelly silt
Mean value			**34.8**	**41.2**	**29.0**	**12.2**	**0.50**	**2.71**	**1.79**	**1.33**	**50.93**	**1.043**	**0.907**	**0.035**	**19.7**	

Based on the values given in Table, average content of over 2 mm size fractions in EGE-6 varies from 6.2 to 27.4%. It is clayey-silty soil and out of five tests represents low- plasticity and stiff clay in three cases and stiff silty soil in two cases. Based on averaged value of plastic index (I_P=12.2), most of its mass is stiff clay. Based on liquidity index (I_L=0.50), it is firm. Soil is normally consolidated

Based on the test performed on the sample from the element, the values for its shear characteristis are as follows:

- Internal friction angle φ=19.7^0;
- Cohesion c=35 kPa.

According to composition and the said values for its physical properties, as per reference and standardized documentation, the values for EGE-6 mechanical charactereristics are as follows:

- Modulus of deformation E_0=6 MPa;
- Modulus of elasticity E=60 Mpa;
- Calculated design resistance R_0=150kPa (1.5kgf/cm^2).

Along with boring in the element, standard penetration testing (SPT) was performed. The results are given in borehole lithologs (Annex-2).

4.2.2.3.2 Rocks

EGE-7 - Slightly weathered, fractured andesites and basalts. The rocks are Upper Pliocene/Lower Quaternary volcanic lava material (N23-QI) and are distributed within Akhalkalaki Plateau, including the cut in it erosion valleys of the r. Paravani and the r. Korkhi. The steep, sometimes vertical slopes are everywhere represented by the said rocks.

The rocks have been tested on 14 borehole samples. The testing results are given in Table 4.2.2.3.2.1.

Table 4.2.2.3.2.1.

Borehole #	Sampling depth interval, m.	Density, r g/cm^3	Uniaxial compression strength, s MPa
BH-PAR-HW-11	12.0-12.2	2.34	17.0
BH-PAR-HW-11	13.3-13.5	2.63	26.9

BH-PAR-HW-11	17.0-17.1	2.57	29.0
BH-PAR-HW-11	17.6-17.8	2.55	46.1
BH-PAR-HW-11	19.0-19.2	2.55	49.7
BH-PAR-HW-12	14.0-14.2	2.45	17.7
BH-PAR-HW-12	17.5-17.7	2.46	34.6
BH-PAR-PS-22	2.7-3.0	2.66	68.6
BH-PAR- PS -22	6.0-6.25	2.49	40.2
BH-PAR- PS -22	6.6-7.0	2.59	56.6
BH-PAR- PS -27	5.8-6.0	2.51	54.3
BH-PAR-PH-32	5.3-5.45	2.46	38.6
BH-KOR-PH-61	0.6-0.8	2.45	35.2
BH-KOR-PH-61	1.5-1.8	2.60	45.4
Mean value		**2.52**	**40.0**

Based on the 14 test results, EGE-7 is classified in three cases as strong (strength is within the range of 50 MPa to 100 MPa), while in 11 cases it is classified as moderately strong (strength is within the range of 12.5 MPa to 100 MPa). Based on average value of strength (s=40 MPa), EGE-7 is a moderately strong rock.

The rocks are fractured. Fractures have formed in the process of initial coooling of lava, due to decrease of its volume. A certain part of the chaotic fractures on the steep slopes was created as a result of gravitaion forces action as well. Both, cooling and gravitational fractures, due to their genesis, are characterized by large blocking and quite big width, which creates corresponding cavity in the mass. On the stripped rocky slopes, 3 main fracture systems are observed, as well as many chaotic fractures. Among the fracture systems, the longest fractures are characteristic of individual layering lava courses, in the direction of their movement after eruption. Dip azimuth of the layering courses is within 50-80 degrees, and dip angle is 10-20 degrees. On some sites of the r. Paravani and the r. Korkhi valley slopes rock fracturing was investigated. The investigated sites (outcrops) are marked on the engineering geological map, and fracture mapping results are given below in a tabular form.

Table 4.2.2.3.2.2. Rock fracturing investigation results

Outcrop #	System	Dip azimuth, degree	Dip angle, degr.	Fracture width mm.	Fracture length, m.	Spacing between fractures, m.	Surface shape	Filler
	R. Paravani valley						Fracture surfaces are everywhere stepped, rough	Clay sand
1	I banding	70	10	0.5-3	5-15	0.7-3		
	II	270	80	0.5-5	3-8	0.5-2.5		
	III	200	80	0.5-5	4-10	0.7-3.5		
2	I	75	12	0.3-6	6-17	0.6-3		
	II	265	82	0.2-8	1.5-7	0.7-2.4		
	III	200	85	0.3-8	4-9	0.5-2.1		
3	I	80	13	0.5-5	4-20	0.7-2.8		
	II	275	85	0.5-7	3-9	0.3-2.2		
	III	205	86	0.5-6	3-8	0.6-3.3		
4	I	80	15	0.5-8	>10	0.7-3.5		
	II	250	83	0.5-6	3-12	0.4-2.1		
	III	175	80	0.4-9	3-10	0.6-2		
5	I	78	15	0.3-6	>10	0.6-2.9		
	II	220	80	0.5-15	0.8-5	0.5-2.0		
	III	210	80	0.5-7	2.5-8	0.6-2.5		
6	I	75	13	0.5-15	>10	0.4-1.1		
	II	240	80	0.3-7	5-16	0.4-1.9		
	III	215	77	0.2-9	2-7	0.3-2.0		
	R. Korkhi valley							

7	I	50	20	0.3-6	>10	0.6-2.2		
	II	260	85	0.4-7	6-16	0.4-2.0		
	III	200	83	0.8-11	2-6	0.4-2.1		
8	I	65	12	0.2-12	>10	0.7-2.8		
	II	250	82	0.3-8	4-15	0.3-2.5		
	III	195	85	0.5-12	1.5-6	0.3-1.85		
9	I	75	15	0.3-13	>10	0.5-2.4		
	II	260	80	0.4-9	3-12	0.3-2.7		
	III	190	80	0.4-11	1.2-7	0.2-2.1		

Apart from the systems given in the tables, there are many chaotic fractures of various orientation.

4.2.2.3.3 Aggressiveness of Environment Against Concretes

In order to determine soils and groundwater aggressiveness against concretes, chemical analysis of soil and water samples has been performed. Based on the chemical analyses results, the environment does not show aggressiveness against any permeability type of concrete. The environment is characterized by slight aggressiveness against concrete reinforcement in the zone of its periodical wetting and is not aggressive under conditions of its permanent presense in water (below the water level).

4.2.2.4 Hydrogeological Conditions

Due to the above-described fracturing and quite large size of the open fractures (in which fractures formed as a result of cooling play the major role), there are good conditions for infiltration of the fallen precipitation within Akhalkalaki volcanic plateau and its adjacent zone. Lava sheets play the role of a collector here. At the same time, fracturing promotes migration of the water leaked in the depth and their discharge in the direction of the local erosion bases - the river channels. Discharge of groundwater (fracture water) takes place mainly frontally, along the river channels, though on the area adjacent to Akhalkalaki, there are also sources with quite high debit. For instance, the debit of Albari sources is 2-2.5 m^3/s. In general, groundwater resource of Akhalkalaki Plateau is quite high and makes up 35 m^3/s. Waters, by their chemical composition, are hydrocarbonate - calcium - containing, with overall mineralization 0.1-0.3 g/l.

Within the area of the HPP facilities zone itself, only 1 source was revealed during engineering geological plotting, on the r. Paravani right bank, adjacent to the headwork site. The flow rate of the source is 0.15 l/s. Colluvial very coarse deposits described above do not contain water, though it is not excluded that they might be sporadically wet with the water flowing in from the hard rocks, which may reveal during development of the penstock trench or construction pits. Alluvial deposits (aQ_{IV}-EGE-3 and aQ-EGE-4) are the major and water-abundant strata within the project zone. The strata are saturated up to the river level, and therefore, there will be considerable water inflow during development of construction pits for the facilities and trenches for the penstock pipes below the river level. Filtration characteristics of the stratum were tested with pumping method. Results of the tests are given in Table 4.2.2.4.1.

Table 4.2.2.4.1. Results of groundwater inflow field testing work

Borehole #	Method	Borehole depth, m	Discharge of borehole, m³/24 hrs	Calculation value for the aquiferous stratum opened by borehole, m	Level change value (drawdown), m	Grade C	Filtration coefficient,K m/24hrs	Specific discharge m³/24hrs / m
BH-11	Level draw down	20	30.2	17.4	0.83	0.8	27.6	36.4
BH-12	Level draw down	20	25.9	17.4	0.6	0.6	31.5	43.2
BH-41	Level draw down	25	21.6	17.4	0.62	1	15.8	34.8

According to the values for coefficient of filtration given in the table, the aqueous strata have "good permeability", since their filtration coefficients are within the range from 10 to 100 m/24hrs.

As mentioned above, packer injection tests (Lugeon tests) were performed in the rock mass (EGE-7).

4.2.2.5 Geodynamic Conditions

Within the Akhalkalaki HPPs facilities location zone, in the valleys of both the r. Paravani and the r. Korkhi, geodynamic conditions are complicated. The complexity of geodynamic conditions is caused here, first of all, by the colluvial and disruption processes ongoing on the steep slopes of the canyon-like valleys. Among them, colluvial phenomena, meaning falling down of individual blocks of fractured rocks, are more frequent, while disruption (rock avalanche) phenomena caused by tearing off of the blocks made up of the unity of individual rock fragments, are rarer. At the same time, it should be noted that there are very many shaky boulders and blocks on the steep slope, falling down of which will create big hazard to the construction process, as well as during operation of the facilities if the facilities are located under the hazardous ledges. According to the current layout plan of facilities, the sites of both HPPs located below the steep rocky slope contain hazard in this respect.

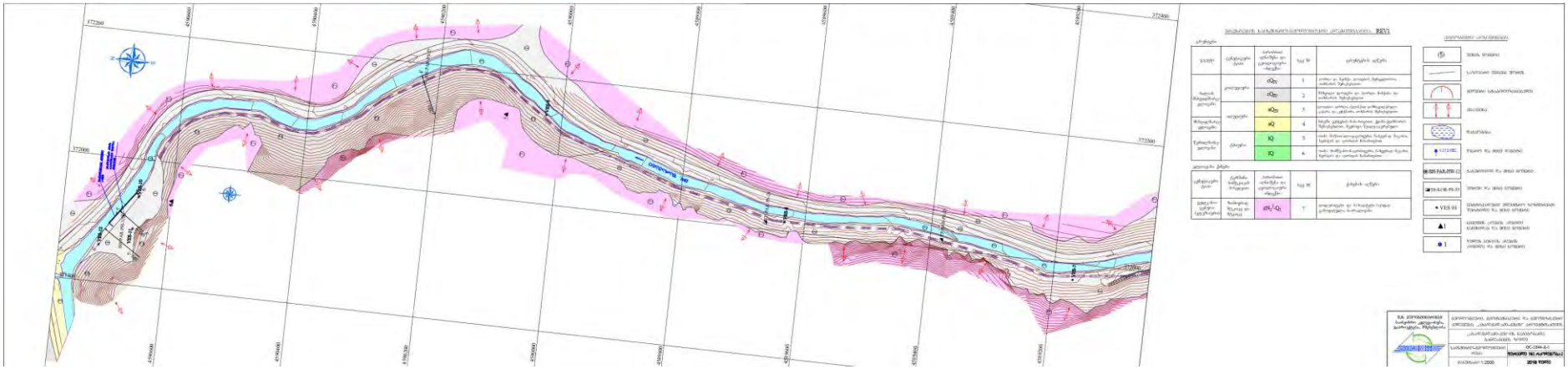
Certain hazard is also associated with the penstock laying process on the r. Korkhi right slope, though stone fall will not have any considerable negative impact on its future operation. Similar conditions will be in case of Paravani HPP's penstock if its surface will be located somewhat deeper than the ground surface. The sites of the headworks of both HPPs and Korkhi HPP's generator house are safe places in this respect.

Considering the fact, that the channels of the r. Paravani and the r. Korkhi, their banks, as well as the neighboring slopes are entirely structured with coarse angular boulders; erosion processes are not active on the river banks. The rivers run through the narrow channels; they do not have flood-plains, since the banks are mostly protected with coarse angular boulders and lateral erosion cannot develop. The r. Korkhi upstream in the segment adjacent to the headworks is an exception, where low flood-plain terraces are observed on both sides along the river channel, though due to the fact that the river flow is relatively sluggish and soils represent coarse rounded boulders and rounded gravel, the banks are protected against lateral erosion here as well. Within the penstock on the r. Paravani left bank and the

powerhouse site, anti-erosion actions should be taken, if necessary, for which coarse boulders of very strong rocks existing in great amount on the site can be used.

There are no other geodynamic phenomena (landslide, mudflow, or other) observed within the construction zone, which could be considered a barrier during construction or operation of HPP facilities.

Figure 4.2.2.5.1. Engineering-geological map of Akhalkalaki 1 HPP project corridor



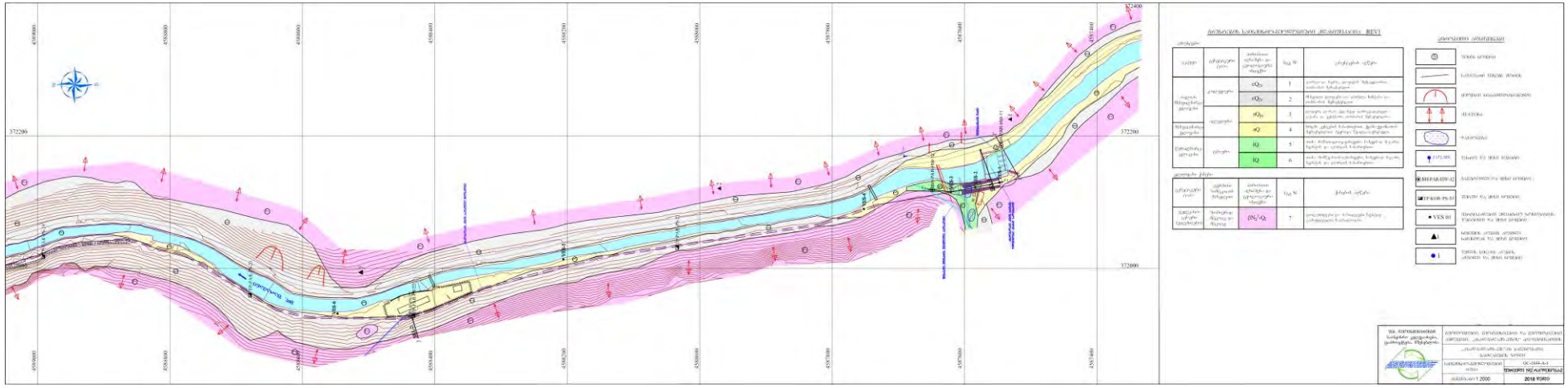
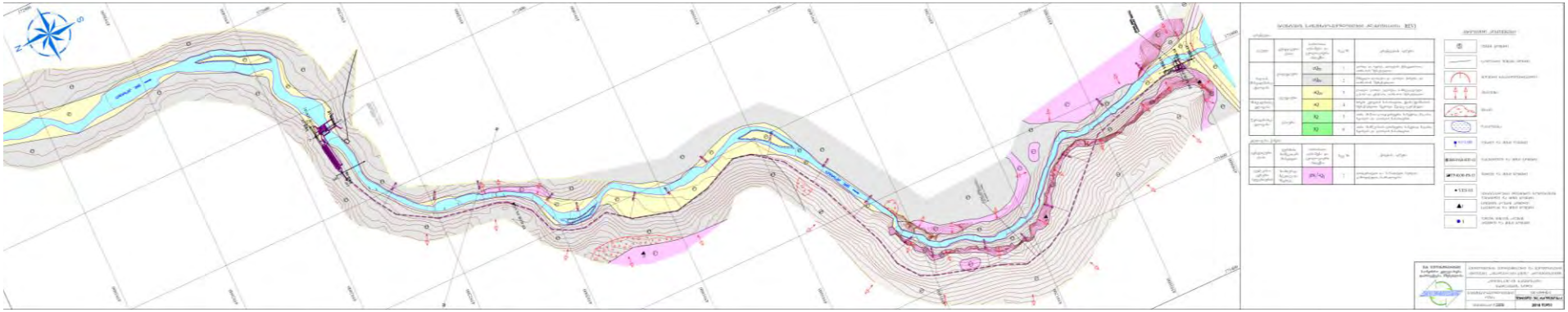


Figure 4.2.2.5.2. Engineering-geological map of Akhalkalaki 2 HPP project corridor



4.2.2.6 Conclusions

1. In terms of geomorphology, the construction area of "Akhalkalaki HPP" is complex and is represented by narrow and deep valleys with V-shaped lateral profiles of the valleys, with steep, sometimes canyon-like right slopes and winding floors, with small lateral erosion gullies cutting in valley slopes;
2. In terms of geology, the project area is structured with Upper Pliocene-Lower Quaternary continental volcanogenic buildups ($N_2^3Q_I$), lithologically represented by basalts, dolerites, andesitic basalts and andesites of Tsalka-Akhalkalaki Suite. In the said volcanogenic rocks, sometimes existence of lenses and bands of lacustrine conglomerates, sands, and sandstones is not excluded;
3. Based on the seismic zoning map of Georgia, the project area is attributed to intensity 8 seismic zone by MSK64 scale;
4. In terms of hydrogeology, both are aqueous - hard rocks (fracture water) and the overlying Quaternary soils. Especially highly aqueous are alluvial soils deposited at the valley floors, which are present within the river channels and narrow flood-plains. High water content in them and water abundance is due to their hydraulic connection with the rivers and high filtration properties. Therefore, when developing the construction pits or trenches in these deposits, below groundwater level, large water inflow is expected;
5. In geodynamic terms, stone falls occurring on rocky slopes are a hazard in the location zone of the HPPs facilities. In this respect, a hazard is likely on the HPPs' facilities sites and within the penstocks location zones, especially during construction of the latter. The powerhouses of the HPPs should be distanced from the slopes to the maximum. Deep and lateral erosion is not in active state; the banks are protected with coarse angular boulders naturally existing along the banks or artificially introduced, though for reliable protection of the facilities located near the banks, sometimes it may be necessary to protect the banks with laying the same boulders. The factor of river swelling and high water levels should be taken into consideration in the bank protection project. No other geodynamic phenomena are registered within the construction zone which could be considered a considerable hindering factor for construction or operation of the HPPs;
6. In terms of soil conditions, 6 soils and 1 rock engineering-geological elements (EGE-) are distinguished within the geological environment. Among them, EGE-1 and EGE-2, EGE-3 and EGE-4 are coarse and very coarse soil types, EGE-5 and EGE-6 - clayey soil types, and EGE-7 is moderately strong rock type.
7. Due to complexity of the above-said environmental factors, complexity of geotechnical conditions on the HPPs construction area is of III category (Complex) based on Annex-10 of State Standard 1.02.07-87.
8. The values to be used in design calculations are given above in the descriptions of each soil and rock element's physical/mechanical characteristics (items 4.2.2.3.1. and 4.2.2.3.2.).

The values of soil strata physical-mechanical properties parameters given in the below Table 4.2.2.6.1 shall be used in design calculations.

Table 4.2.2.6.1.

EGE #	Lithological Description of Soils	Density, □	Internal friction angle, □⁰	Cohesion,, c KPa	Modulus of deformation E MPa	design resistance, R_0 KPa	Uniaxial compression strength R_c MPa	Excavation group SNIP IV-5-82	Allowable slope gradients for trenches and foundation pits			
									Up to 1.5 m depth	Up to 3 m depth	Up to 5 m depth	Up to 12 m depth
1	Angular cobbles and angular gravel containing angular boulders, with clayey soil (colluvial-cQ_{IV})	2.0	26.8	15.3	44.29	400	-	6g, (collected book-1)	1:0.50*	1:1	1:1	1:1.5
2	Coarse angular boulders and angular cobbles, with angular gravel and clayey soil (Colluvial-cQ_{IV})	2.20	26.7	17.33	50.11	450	-	6d, (collected book-1)	1:0.50	1:1	1:1	
3	Angular boulders, angular cobbles , sub-rounded boulders and cobbles, with clayey soil. (Alluvial-aQ_{IV})	2.10	26.6	11.72	48.91	400	-	6d, (collected book-1)	1:0.50	1:1	1:1	
4	Hard, saturated rounded gravel with rounded cobbles inclusions, with sand/ clay sand. (Alluvial-aQ_{IV})	2.0	27.6	11.21	47.37	400	-	6v, (collected book 1)	1:0.50	1:1	1:1	
5	Very stiff reddish-brown clay with angular gravel and angular cobbles inclusions (Lacustrine-lQ_{IV})	1.80	20.4	31.0	9.0	200		8g, (collected book-1)	1:0.50	1:1	1:1	1:1.5
6	Very stiff greenish-gray clay with angular gravel and angular cobbles inclusions (Lacustrine-lQ_{IV})	2.54	19.7	35	6	150	-	8g, (collected book-1)	1:0	1:0.25	1:0.5	
7	Slightly weathered, fractured andesites and basalts (Upper Pliocene/Lower Quaternary volcanic lava material-□N_2^3 -Q_I)	2.52					40.0	20b (collected book-3)	1:0.3			1:0.3

Note *: *"1" means height of slope, whereas "0.50" means length.*

4.2.3 Hydrology

4.2.3.1 General Description of Paravani and Korkhi Rivers

Paravani River: The river Paravani originates at the southern end of the Paravani lake near the village Foka at an elevation of 2080 m a.s.l. and flows into the river Mtkvari from the right-hand side near the village Khertvisi. The total length of the river is 74 km with an elevation drop of 960 m and an average inclination of 1,3%. The total catchment area is 2350 km^2 with an average elevation of 2120 m a.s.l.

Near the headworks of Akhalkalaki 1 HPP, arrangement of which is planned downstream of the confluence of Murjakhetistskali River (Kirkhbulakhi) at 1600 m altitude. At this location the length of river Paravani is about 54 km with an elevation drop of 465 m and an average inclination of 0,86%. The catchment area is 1640 km^2 with an average elevation of 2220 m a.s.l. The river Paravani has many tributaries upstream of the project area, the most important ones being Agricha (11 km long), Ganzaskheva (19 km long), Buldasheni (16 km long) and Murjakhetistsyali (32 km long).

The catchment area has many lakes and swamp areas. The largest and most important lakes are Paravani (surface area 37,5 km^2), Saghamo (surface area: 4,81 km^2), Khanchali (surface area 13,3 km^2) and Madatapi (surface area: 8,78 km^2). Total area of lakes and swamps in the catchment area is 70-75 km^2, or about 3% of the area.

The geological structure of the basin mainly contains basalt and Andesite-basaltic layers of volcanic origin, which are generally covered by 15-30 cm of black sand. At the elevation of 1800 m, the catchment has a mountain step shape. There is alpine and subalpine vegetation above 1800 m a.s.l.

From Paravani Lake, the river course does not have a distinct form but after passing Jigrasheni town, the gorge has a box-like shape. From the village Ghaurmi to the confluence of the rivers in Akhalkalaki plateau, the river course has a deeply cut shape. Bottom width of the river varies from 250-400 m (in the upper reaches) to 25-50 m downstream of Akhalkalaki city. There are many springs on the slopes along the canyon.

The riverbed is curved till the City of Akhalkalaki. It branches till the village of Kaurma and creates ow-lying islands of various sizes. River flow width varies from 3 to 60 m, depth from 0.2 to 0.8 m, and velocity from 0.5 m / sec to 2-2.5 m / sec.

The river flow regime is characterized by spring floods, distinctive summer low flow and undistinctive low flows in the winter. Spring flow amounts to 38% of the annual flow, summer 30%, autumn 15% and winter 17%.

Flooding periods and duration vary between the upper section of the Paravani river and its lower section. In the upper section of the river, near the Akhalkalaki plateau, the river has a natural regulation in Paravani and Saghamo lakes. The flooding season starts from April or early May and lasts until end of July. In the lower section, the flooding season starts from February and lasts until end of July. Summer-Autumn low water season is the same in both upper and lower sections, as well as the occasional floods caused by heavy rains. During the winter period, mainly in January and February, snow and ice can be expected on the Akhalkalaki plateau.

Icy events on the river, mainly in the form of snow and pancake ice, occur annually. Their duration does not exceed 4 months. In some cold winters, the whole river is expected to freeze for 19 days on average and for maximum 77 days (1953-54) near the village of Almali.

The river water is used for irrigation and generation of electricity. In this regard, a few small HPPs are located on the Paravani river, upstream of the project area. Irrigation pumping stations are also located in the project area.

River Korkhi (Arakvistskali, Baraletistskali), on which Akhalkalaki 2 HPP headworks structure is planned to be arranged. The River originates on the south-west slope of mountain Motskirkokhi

(2249,5 m a.sl.) at an elevation of 1854 m a.s.l. and merges with the Paravani river from the right- hand side close to the Korkhi village at an elevation of 1574 m a.s.l. The total river length is 30 km with an elevation drop of 280 m, resulting in an average gradient of 9,33 %. The catchment area is 405 km^2 with an average elevation of about 2080 m a.s.l.

The river length from its source to the proposed project area near the village Korkhi at approximately 1600 m a.s.l. is 27,5 km with an elevation drop of 254 m and an average gradient of 9,24%. The catchment area is 404 km^2 with an average elevation of 2090 m a.s.l.

The river catchment basin is in the Akhalkalaki volcanic plateau. Northern side of the river watershed extends to Samsari's ridge. From the North, West, South and South-East, the catchment area borders with Tabatskuri lake and Jobareti rivers and the Akhalkalaki catchment area.

The river basin is characterized by a slightly dissected relief, which forms small lakes and wetlands. The river catchment basin from geological aspects consists of andesite and basalt layers of volcanic origins which is covered with black sands. The catchment area is mostly covered with grassland.

The river course has a box-like shape from its origin down to the village Orjami, from where it is V-shaped down to the confluence point. River flooding only occurs in the box-shaped section of the river. Its width varies from 5-10 m to 25-30 m. During floods, the depth of the river can increase some 0,5-0,7 m. The river bed is mostly made up of gravel and small boulders and its width varies from 5 to 20 m, depth varies from 0,5 to 1,5 m and velocity from 0,3-1,0 to 1,8-2,5 m/s.

The river is fed by snow, rain and ground water. Its flow regime is characterized by spring flooding and distinctive summer – autumn and undistinctive winter low waters. Spring flow amounts to 45% of the annual stream flow, summer 13%, autumn 14% and winter 28%.

The river is used for irrigation purposes and for rural mill. It has several small, local canals irrigating 1845 ha of agricultural land.

4.2.3.2 Average Annual Flows of Project Rivers and their Annual Distribution

4.2.3.2.1 Paravani River

The flow in river Paravani and some of its tributaries has been measured with analogy method and studied for a long period of time. Data of hydrological station Khertvisi are taken as analogue.

The most notable observation stations on the Paravani river and period of observation are as follows: village Foka (1928-1934, 1941-1943, 1945-1965, 1976-1986), village Ganzasti upper side (1949-1952, 1954-1970), village Ganzasti lower side (1948-1963, 1969, 1970), village Samao (1927-1934, 1939, 1941-1943, 1948-1963), village Aragiali (1945-1946, 1948, 1951-1986), village Orojolari (1936, 1938-1946, 1955-1958, 1960-1986), village Murjikiani (1930- 1934) and village Khertvisi (1936-1995, available data only for 1936-1986). Planned project intake on the Paravani river is located very close to the abandoned Diliska measuring station, but due to its very short period of operation of only 5 years, it is not possible to base projections on data from Diliska.

The closest hydrological station with a long record of data is the Khertvisi station which has 60 years of data. During these 60 years of observation, the average annual discharge in river Paravani at Khertvisi varied from 12,7 m^3/s (in 1948) to 27,3 m^3/s (in 1963).

The following parameters of the flow distribution curve are obtained after statistical processing of the available flow data:

- The average multiannual value of the average annual discharge, $Q_0 = 18,6\ m^3/s$
- Coefficient of variation, Cv = 0,17
- Skewness coefficient for average annual discharge: Cs = 2Cv = 0,34

The parameters for the evaluation of the representativeness of the variation row were calculated as:

- The relative average square error of the average multiannual discharge, which is equal to ε_{Q_0} = 2,2 %
- The relative average square error of the variation coefficient, ε_{C_v} = 9,2%.

The parameters are satisfactory as under Georgia's СНиП 2.01.14-83 requirements ε_{Q_0} < 5% and ε_{C_v} < 10%.

Based on the distribution parameters and a 3-parameter Gamma distribution, the average annual discharge of Paravani river at the Khertvisi station for different probabilities has been estimated. Information for flow at the Khertvisi station has been transferred to the proposed intake location using a transfer coefficient, K, defined as follows:

$$K = \frac{Fsapr.}{Fan.}$$

Where:

- $F_{sapr.}$ – is Paravani catchment area at the planned intake location, $F_{sapr.}$ =1640 km²;
- $F_{an.}$ – is Paravani catchment area at the Khertvisi measurement station, $F_{an.}$ =2350 km²;

Based on the above, the transfer coefficient is K = 0,698. Estimated annual discharge parameters for Paravani river at the planned intake location are presented in Table 4.2.3.2.1.1..

Table 4.2.3.2.1.1. Estimated average annual discharge of the Paravani river in m³/s

Section	F km²	Q_0 Q m³/s	C_V	C_S	K	Probability of higher value P%			
						10	50	75	90
Khertvisi	2350	18,6	0,17	0,34	-	23,1	19,2	17,0	15,7
Planned intake	1640	13,0	-	-	0,698	16,1	13,4	11,8	11,0

In the project area, calculated provisions (10%, 50%, 75% and 90%) of average annual discharge of multiyear observations according to the moths is calculated with two methods: with respect to particular years, as well as synchronizing of Khertvisi h/s multiyear data.

Since the average monthly discharge of 90% provision in real months of multiyear-years exceeds the average monthly discharge of 50%, as well as the 50% provision in real month's average monthly discharge exceeds 10% provision, average annual distribution of average annual discharge on calculation of provisions was not made according to actual years. In addition, the internal distribution of one particular year may not be reflected in the actual picture of the annual inflow of average annual report. The results are given in Table 4.2.3.2.1.2.

Ecological flow, which is assumed to be the minimum flow required in the river course downstream of the intake is set as 10% of the multiyear average daily discharge at that location, i.e. 1,30 m³/s.

Table 4.2.3.2.1.1. Annual distribution of average annual flows of Paravani River at project section

Flow	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
10 % probability of higher value (Good year)													
Avg. at intake	10,87	11,37	14,46	30,57	34,56	21,38	13,93	10,96	11,36	11,38	11,67	10,87	16,13
Ecological flow	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30
Irrigation flow	0,00	0,00	0,00	0,00	0,00	0,00	0,60	0,85	0,28	0,00	0,00	0,00	0,15

Available flow	**9,57**	**10,07**	**13,16**	**29,27**	**33,26**	**20,08**	**12,03**	**8,81**	**9,78**	**10,08**	**10,37**	**9,57**	**14,67**
50 % probability of higher value (Average year)													
Avg. at intake	9,13	9,60	11,98	24,20	27,76	21,74	11,62	9,19	8,72	8,93	9,12	8,94	13,42
Ecological flow	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30
Irrigation flow	0,00	0,00	0,00	0,00	0,00	0,00	0,60	0,85	0,28	0,00	0,00	0,00	0,15
Available flow	**7,83**	**8,30**	**10,68**	**22,90**	**26,46**	**20,44**	**9,72**	**7,04**	**7,14**	**7,63**	**7,82**	**7,64**	**11,97**
75 % probability of higher value (Below average year)													
Avg. at intake	7,24	7,60	10,09	23,38	23,99	16,79	10,71	8,35	8,38	8,88	9,28	7,28	11,84
Ecological flow	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30
Irrigation flow	0,00	0,00	0,00	0,00	0,00	0,00	0,60	0,85	0,28	0,00	0,00	0,00	0,15
Available flow	**5,94**	**6,30**	**8,79**	**22,08**	**22,69**	**15,49**	**8,81**	**6,20**	**6,80**	**7,58**	**7,98**	**5,98**	**10,39**
90 % probability of higher value (Poor year)													
Avg. at intake	7,66	8,14	9,01	20,11	24,58	13,25	10,88	8,47	7,25	7,33	7,43	7,48	10,98
Ecological flow	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30
Irrigation flow	0,00	0,00	0,00	0,00	0,00	0,00	0,60	0,85	0,28	0,00	0,00	0,00	0,15
Available flow	**6,36**	**6,84**	**7,71**	**18,81**	**23,28**	**11,95**	**8,98**	**6,32**	**5,66**	**6,03**	**6,13**	**6,18**	**9,53**

4.2.3.2.2 Korkhi River

Average annual flow in river Korkhi (Baraletistskali) at the proposed intake location is estimated by the analogy method. Records from the nearby hydrological station Arakvi were used as an analogy. Run off of the Korkhi river was recorded at the Arakvi station, near Arakvi village, for a period of 52 years (1938 – 1939, 1942 – 1943, 1945 – 1946, 1948 and 1950 – 1986).

The period of observation is characterized by missing years, due to which it was necessary to retrieve the data of the missing years (1940, 1941 and 1944) to get a continuous variable line. In order to recover the average annual discharge of the mentioned years, river Paravani data was used in hydrological station Khertvisi section. In hydrological station Arakvi section, the recovery of the average annual discharge of the skipped years was carried out using Vild formula, which has the following form:

$$Q_x = \frac{Q_{0x}}{Q_{0y}} \cdot Q_y$$

Where:

- Q_x - the average annual discharge of a short row hydrological post
- Q_y - the average annual discharge of a long row hydrological post
- Q_{0x} - the average multiannual discharge of a short row hydrological post
- Q_{0y} - the average multiannual discharge of a long row hydrological post

Estimated average annual discharge at the Arakvi section based on measured data and estimated flow (for missing years) during the period 1938 – 1986 fluctuates between 1,71 m³/s and 4,37 m³/s. Based on

statistical analysis of the data series, the following parameters were obtained for the flow distribution curve:

- The average multiannual value of the average annual discharge, Q_0 = 2,86 m³/s
- Coefficient of variation, Cv = 0,19
- Skewness coefficient for average annual discharge: Cs = 2 Cv = 0,38

The parameters for the evaluation of the representativeness of the variation row were calculated as:

- The relative average square error of the average multiannual discharge, equal to ε_{Q_0} = 2,7 %
- the relative average square error of the variation coefficient, ε_{C_v} = 10,0 %.

The parameters are satisfactory as under Georgia's СНиП 2.01.14-83 requirements ε_{Q_0} < 5% and ε_{C_v} < 15%.

Based on the distribution parameters and a 3-parameter Gamma distribution, the average annual discharge of Korkhi river at the Arakvi station for different probabilities has been estimated.

Information for annual flow at the Arakvi station has been transferred to the planned intake location using a transfer coefficient, Ka, defined as follows:

$$K = \left(\frac{Fsapr}{Fan} \right)^N$$

Where:

- $F_{sapr.}$ _ is Korkhi catchment area at the proposed intake location, Fsapr = 404 km²
- $F_{an.}$ _ is Korkhi catchment area the Arakvi station, Fan = 380 km²
- N _ is a reduction factor equal to 0,8 for average annual discharges.

By plugging in the given numbers into the equations given above, produced from analog, or got from hydrological station Arakva additional intake section, conversion coefficient is got to be 1,050.

By multiplying average annual discharge in the hydrological station Arakva section by conversion coefficient, average annual discharges are gotten in the additional intake structure.

Different provision average annual discharges of River Korkhi in analog and project sections are given in Table 4.2.3.2.2.1.

Table 4.2.3.2.2.1. Estimated average annual discharge of the Korkhi river in m³/s

Section	F km²	Q_0 Q m³/s	C_V	C_S	K	Provision P%			
						10	50	75	90
Hydrological Station Arakva	380	2,86	0,19	0,38	-	3,44	2,87	2,63	2,28
Project	404	3,00	-	-	1,050	3,61	3,01	2,76	2,39

Project section design provision (10%, 50%, 75% and 90%) average annual discharge distribution within the year according to months in this case was also carried out using two methods: according to actual years and synchronous to the average multi-year discharge distribution, in hydrological station Arakva section, within the year. High provision average monthly discharges of actual years' concrete months are more than low provision average monthly discharges, due to which average annual discharge distribution within the year, using this method, was not accepted as design values. It is also possible that the distribution within one concrete year does not show a clear picture of design provision average annual discharge distribution within that year. Therefore, distribution within one year was taken as a design value, which was gotten synchronous to hydrological station Arakva section average multi-year discharge distribution within one year.

Gotten results are given below, in table 4.2.3.2.2.2. River environmental flow value is also given there (which equals 10% of intake section river average multi-year discharge or 0.3 m^3/s) as well as the amount of water to be diverted by HPP considering environmental flow left in the river.

Table 4.2.3.2.2.2. River Korkhi design provision average annual discharge distribution within a year in project section

Discharge	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
10% provision (a lot of water)													
Average Monthly at the intake	3,43	3,06	4,27	7,47	5,43	3,42	2,19	1,93	2,90	3,07	3,17	3,05	3,61
Environmental Discharge	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30
To be diverted by the HPP	**3,13**	**2,76**	**3,97**	**7,17**	**5,13**	**3,12**	**1,89**	**1,63**	**2,60**	**2,77**	**2,87**	**2,75**	**3,31**
50 % provision (average water)													
Average Monthly at the intake	3,39	2,39	2,94	6,17	5,07	3,01	2,01	1,71	2,28	2,39	2,38	2,36	3,01
Environmental Discharge	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30
To be diverted by the HPP	**3,09**	**2,09**	**2,64**	**5,87**	**4,77**	**2,71**	**1,71**	**1,41**	**1,98**	**2,09**	**2,08**	**2,06**	**2,71**
75 % provision (little water on average)													
Average Monthly at the intake	2,03	2,03	2,51	5,98	4,65	2,88	2,01	1,94	2,24	2,45	2,44	1,91	2,76
Environmental Discharge	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30
To be diverted by the HPP	**1,73**	**1,73**	**2,21**	**5,68**	**4,35**	**2,58**	**1,71**	**1,64**	**1,94**	**2,15**	**2,14**	**1,61**	**2,46**
90 % provision (little water)													
Average Monthly at the intake	1,76	1,70	1,80	4,78	4,29	2,25	1,96	1,94	2,01	2,10	2,12	2,00	2,39
Environmental Discharge	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30
To be diverted by the HPP	**1,46**	**1,40**	**1,50**	**4,48**	**3,99**	**1,95**	**1,66**	**1,64**	**1,71**	**1,80**	**1,82**	**1,70**	**2,09**

4.2.3.3 Maximum Discharges

4.2.3.3.1 Paravani River

In order to determine River Paravani maximum discharge design values in HPP intake section, analog method was used. Multi-year observation data from hydrological station Khertvisi was taken as an analog. Mentioned data spans a period from 1937 to 1991, but was officially published only including 1986. During officially published observation period River Paravani maximum discharge values in hydrological station Khertvisi section fluctuated from 33 m^3/s (1986) to 437 m^3/s (1968).

After statistically processing officially published 50-year variation data using moment method, following distribution curve parameters were gotten:

- Water maximum discharge average multi-year value Q_0 = 83.2 m^3/s.
- Variation coefficient C_v = 0.70;

Because variation coefficient value exceeds 0.50, distribution curve parameters are also determined using graphical-analytical method, during which skewness coefficient value is determined as a slope coefficient S - function. Its value is calculated using

$$S = \frac{Q_{5\%} + Q_{95\%} - 2 \cdot Q_{50\%}}{Q_{5\%} - Q_{95\%}}$$

Maximum discharge average multi-year value is calculated using

$$Q_0^{\ I} = Q_{50\%} - \Phi_{50\%} \cdot \delta$$

Average quadratic deviation is calculated using following dependence

$$\delta = C_v \cdot Q_0^{\ I} = \frac{Q_{5\%} - Q_{95\%}}{\Phi_{5\%} - \Phi_{95\%}}$$

Where,

- $Q_{5\%}$, $Q_{50\%}$ and $Q_{95\%}$ _ are water maximum discharge 5, 50, and 95% provision values, determined from provision empirical curve;
- $\Phi_{5\%}$, $\Phi_{50\%}$ and $\Phi_{95\%}$ _ are provision binomial curve 5, 50 and 95% normalized ordinates.

Calculations carried out using graphical-analytical method revealed following distribution curve parameters:

- Maximum discharge average multi-year value $Q_0^{\ I}$ = 79.9 m³/s;
- Variation coefficient C_v = 0.53
- Skewness coefficient C_s = 2.40;
- Average quadratic deviation $\delta = 42.6$.

Using parameters got by means of graphical-analytical method and binomial curve normalized ordinates, river Paravani water maximum discharge different provision values in hydrological station Khertvisi section were generated. Water maximum discharge different provision values in the same section were determined also according to three-parameter Gamma-distribution and Gumbel distribution, but discharges got using graphical-analytical method were taken for the design, because they coincide best with empirical points drawn on probability cells.

Conversion from hydrological station Khertvisi section to HPP intake section was carried out using the same conversion coefficients, which were used for average annual discharges and which equal 0.698. By multiplying water maximum discharges in hydrological station Khertvisi section by conversion coefficients, water maximum discharge in Project section is calculated.

Below, in Table 4.2.3.3.1.1., river Paravani water maximum discharges for different provision values of hydrological station Khertvisi and Project sections are given.

Table 4.2.3.3.1.1. River Paravani water maximum discharge value m³/s

Method	Section	F km²	Q^I_0 m³/s	C v	C s	K	Provision P%						
							0,5 (200)	1 (100)	2 (50)	3 (33)	5 (20)	10 (10)	20 (5)
Analogue	Khertvisi	2350	79,9	0,5	2,4	-	295	240	215	190	165	135	90
Analogue	Intake	1640	55,8	-	-	0,698	205	170	150	135	115	95	63
Gambela type I	Intake	1640	51,6	-	-	-	158	142	127	117	106	90	73
Log – Prison type III	Intake	1640	51,6	-	-	-	202	166	136	120	103	83	65
Gambela and Log – Prison type	Intake	1640	51,6	-	-	-	180	154	131	119	105	86	69

4.2.3.3.2 Korkhi River

For determining River Korkhi (Arakvistskhali, Baraletistskhali) water maximum discharge design values in additional intake structure section, analog method was used. Hydrological station Arakva multi-year

observation data was taken as an analog. Mentioned data includes intermittent period from 1928 to 1990, but was officially published only including 1986. It is worth to mention that from 1928 including 1932 and 1936 maximum discharge values are rather approximate and doubtful. Therefore, water maximum discharge annual values were taken from 1937 to 1986. Consequently, a 46 year observation period was the result. (1937, 1939, 1942-1943, 1945-1986 years) It is known that mountain river maximum discharge recovery and continuing the data gathering is impermissible, therefore river Korkhi water maximum discharge values were determined using officially published 46 year observation intermittent data. In the mentioned period, river Korkhi water maximum discharge values in hydrological station Arakva section fluctuated from 6.30 m^3/s (1955) to 71.0 m^3/s (1968).

After performing statistical analysis on the officially published 46 year variation data using moment method, following distribution curve parameters were got:

- Water maximum discharge average multi-year value $Q_0 =$ 16,6 m^3/s;
- Variation coefficient $C_v =$ 0,68;

Because variation coefficient value exceeds 0.50, distribution curve parameters in this case are also generated using graphical-analytical method, during which skewness coefficient value is determined using slope coefficient S function. Its value is calculated using the following expression:

$$S = \frac{Q_{5\%} + Q_{95\%} - 2 \cdot Q_{50\%}}{Q_{5\%} - Q_{95\%}}$$

Maximum discharge average multi-year value is calculated using the following expression:

$$Q_0^{\ I} = Q_{50\%} - \Phi_{50\%} \cdot \delta$$

Average quadratic deviation is calculated using the following expression:

$$\delta = C_v \cdot Q_0^{\ I} = \frac{Q_{5\%} - Q_{95\%}}{\Phi_{5\%} - \Phi_{95\%}}$$

Where,

- $Q_{5\%}$, $Q_{50\%}$ და $Q_{95\%}$ – water maximum discharge 5, 50, and 95% provision values, determined from provision empirical curve;
- $\Phi_{5\%}$, $\Phi_{50\%}$ და $\Phi_{95\%}$ – provision binomial curve 5, 50 and 95% normalized ordinates.

Calculations carried out using graphical-analytical method revealed following distribution curve parameters:

- Maximum discharge average multi-year value $Q_0^{\ I} =$ 17.2 m^3/s;
- Variation coefficient $C_v = 0.65$
- Skewness coefficient $C_s = 1.90$;
- Average quadratic error $\delta = 11.24$.

Using parameters got by means of graphical-analytical method and binomial curve normalized ordinates, river Korkhi water maximum discharge different provision values in hydrological station Arakva section were generated. Water maximum discharge different provision values in the same section were determined also according to three-parameter Gamma-distribution and Gumbel distribution, but discharges gotten using graphical-analytical method were taken for the design, because they coincide best with empirical points drawn on probability cells.

Conversion from hydrological station Arakva section to Project intake section was done using conversion coefficient, which is calculated from the following expression:

$$K = \left(\frac{Fsapr}{Fan} \right)^N$$

Where,

- $F_{sapr.}$ _ river water reservoir basin area in project section is 404 km².
- $F_{an.}$ _ river water reservoir area is same as that of the analog, or in other words in hydrological station Arakva section, which equals 380 km²;
- N _ reduction level indicator, which is 0.5 for the average annual discharges.

By plugging in the given numbers into the equations given above, produced from analog, or got from hydrological station Arakva additional intake section, the conversion coefficient equals 1,031.

By multiplying average annual discharge, in the hydrological station Arakva section, by conversion coefficient, average annual discharges are got in the additional intake structure.

Different provision average annual discharges of River Korkhi in analog and project sections are given in table 4.2.3.3.2.1.

Table 4.2.3.3.2.1. River Korkhi water maximum discharge m³/s

Section	F km²	QQ_0^I m³/s	Cv	Cs	K	Provision P%						
						0.5	1	2	3	5	10	20
Hydrological Station Arakva	380	17,2	0,65	1,90	_	69.6	57.1	51.1	45.2	39.6	31.9	24.3
project	404	17.7	_	_	1,031	71.8	58.9	52.7	46.6	40.8	32.9	25.0

As we see from presented table 4.2.3.3.2.1, river Korkhi maximum discharge, determined based on observation data, is lower than the discharges published in hydrological literature, which can be explained with observation of water actual maximum discharge and also them being unrecorded.

Consequently, river Korkhi design values of maximum discharges in the Project section was determined using a method which is given in "Technical guide for river maximum flow calculation in Caucasus".

According to the above mentioned method, water maximum discharge values of the rivers water basin areas of which exceed 300 km², are calculated using empirical regional formula, which was derived specially for river Paravani basin and which looks the following way:

$$Q_{5\%} = \left[\frac{1,58}{(F+1)^{0,45}} \right] \cdot F \text{ m}^3/\text{s}$$

Where, F - is river water gathering basin area in Project section, which equals 404 km². From here we can get river Korkhi 5% provision (20 year repetitiveness) maximum discharge in the project section. Conversion from 5% provision to another provision is carried out using the same technical instruction with conversion coefficients. River Korkhi different provision maximum discharges in the Project section, calculated using regional empirical formula, are given in Table 4.2.3.3.2.2.

Table 4.2.3.3.2.2. River Korkhi maximum discharge in Project section, calculated using regional empirical formula

Section	Provision P%						
	0.5	1	2	3	5	10	20
Project	75.0	65.0	54.8	51.4	42.8	34.2	27.8

River Korkhi maximum discharge, given in table 4.2.3.3.2.1, was got from design values in the Project section.

It is worth mentioning that maximum discharges mainly occur during spring-summer period, which is definitely taken into account during construction process.

4.2.3.4 Minimum Discharges

4.2.3.4.1 Paravani River

In order to determine river Paravani day-night minimal discharges in the Project section, analog method was used. Hydrological station Khertvisi data was taken as an analog, which includes 50 year observation period. (1936-1943, 1945-1986). 50 year observation period river Paravani day-night minimal discharges in hydrological station Khertvisi section fluctuated between 5.30 m³/s (1949) and 14.7 m³/s (1960). After performing statistical analysis on variation data of the mentioned period using moment method, following distribution curve parameters were got:

- minimal discharges average multi-year values Q_0 = 9,42 m³/s;
- variation coefficient C_v = 0.19;
- asymmetry coefficient was assumed for minimal discharges to be Cs=2, Cv=0,38.

Variational data representativeness evaluation parameters were determined: day-night minimal discharge relative average quadratic deviation, which equals ε_{Q_0} = 2.69% and variation coefficient relative average quadratic deviation, which equals ε_{C_v} =10,2 %. These parameters are satisfactory, because based on SNiP 2.01.14-83 requirements (active in Georgia), ε_{Q_0} < 5% and ε_{C_v} < 15%.

River Paravani day-night minimal discharges were determined using calculated distribution parameters and three-parameter Gamma-distribution ordinates in hydrological station Khertvisi section.

Conversion from analog, or hydrological station Khertvisi section to Project section intake structure section, was done using the same conversion coefficients, which were used in average annual and maximum discharge cases. By multiplying water minimal discharge by conversion coefficient, water minimal discharge is calculated in the Project section.

In table 4.2.3.4.1.1 below, River Paravani water day-night minimal discharge different provision values for hydrological station Khertvisi are given (in Project sections).

Table 4.2.3.4.1.1. River Paravani water day-night minimal discharges m³/s

Section	F km²	QQ_0 m³/s	Cv	Cs	K	Provision P%						
						75	80	85	90	95	97	99
Hydrological station Khertvisi	2350	9.42	0.19	0.38	_	8.15	7.89	7.55	7.22	6.70	6.37	5.77
Project	1640	6.58	_	_	0.698	5.71	5.51	5.27	5.04	4.68	4.45	4.03

4.2.3.4.2 Korkhi River

In order to determine river Korkhi day-night minimal discharge in Project section, analog method was used. Hydrological station Arakva data was taken as an analog, which includes 48 year observation period. (1936-39, 1942-43, 1945-86). 48 year observation period river Korkhi day-night minimal discharges in hydrological station Arakva section fluctuated between 0.21 m³/s (1976) and 2.35 m³/s (1936). After performing statistical analysis on variation data of the mentioned period using moment method, following distribution curve parameters were calculated:

- minimal discharges average multi-year values Q_0 = 1.14 m³/s;
- variation coefficient C_v = 0.50;
- asymmetry coefficient was assumed for minimal discharges to be Cs=2, Cv=1.00.

Variational data representativeness assessment parameters were determined: day-night minimal discharge relative average quadratic deviation, which equals ε_{Q_0} =7.2% and variation coefficient relative

average quadratic deviation, which equals ε_{C_v} =11,4 %. Calculated parameters are satisfactory, because ε_{Q_0} < 10% and ε_{C_v} < 15%.

River Korkhi different average annual discharges were produced using generated distribution parameters and three-parameter Gamma-distribution ordinates in hydrological station Arakva section.

Conversion from analog, or hydrological station Arakva section to Project additional intake section, was carried out using same conversion coefficients, which were used for average annual discharge case. By multiplying the water minimal discharge in hydrological station Arakva by conversion coefficient, water minimal discharge is calculated in the Project section.

In table 4.2.3.4.2.1 below, river Korkhi water day-night minimal discharges are given for different provision values of hydrological station Arakva and Project section.

Table 4.2.3.4.2.1. River Korkhi water day-night minimal discharges m³/s

Section	F km²	QQ_0 m³/s	Cv	Cs	K	Provision P%						
						75	80	85	90	95	97	99
Hydrological station Arakva	380	1.14	0.50	1.00	_	0.72	0.65	0.58	0.50	0.39	0.33	0.23
Project	404	1.20	_	_	1.050	0.76	0.68	0.61	0.52	0.41	0.35	0.24

4.2.3.5 Solid Material Discharge

Direct measurements of solid material discharge were not performed for the given two project site locations. Measurements of solid sediment movement were carried out on hydrological station Khertvisi during the period from 1949 to 1986. The Khertvisi hydrological station is located 17 km below the confluence of the Korkhi and Paravani rivers. Project area of the intake on Paravani River is approximately 3.5 km above the confluence, while the project area of intake on Korkhi river is approximately 2.0 km above the confluence. As already mentioned, the average river slope at the design intake is 0.86% on the Paravani River, while on Korkhi River -0.81%. For comparison, it should be noted that the average slope of the river within the 17 km long section downstream of the confluence of the Paravani and Korkhi rivers is 2,56%.

After performing statistical analysis on the mentioned solid material discharge 37 year variation data using moment method, following distribution curve parameters were got:

Solid discharge average multi-year value, or solid flow norm.

$$R = \frac{\Sigma R_i}{n} = 1.44 \text{ kg/s}$$

Variation coefficient $C_v = \sqrt{\frac{\Sigma(K-1)^2}{n-1}} = 1.12$;

Skewness coefficient value $C_s = 4 \cdot C_v =$ 4.48, which was set by coincidence of solid discharge empirical points and theoretical curve on probability cell.

Solid discharge and its corresponding flow values for different provisions of river Paravani in hydrological station Khertvisi section were got using distribution curve parameters and three-parameter distribution ordinates.

Methods of determining bottom sediment flow were very bad. The main reason for this, is the imperfection of existing equipment and the difficulty of sediment movement. Due to this, for

determining the amount of bottom sediment, empirical formula proposed by G.Khmaladze was used, which was derived based on those rivers of Georgia whose solid discharge is more or less well studied.

The above mentioned empirical formula has the following form:

$$\frac{G}{R} = 5{,}2 \cdot i^{0{,}9}$$

Where,

- G - is bottom sediment discharge in kg/s;
- R - is floating solid material discharge in kg/s;
- i - river's hydraulic slope until design section, which in our case equals to - 0.013.

From here, ratio between river Paravani bottom sediment and floating sediment is 0.11 or 11%.

River Paravani different provision solid material discharge, bottom and floating sediment, and their respective volume values in hydrological station Khertvisi section are given in Table 4.2.3.5.1.

Table 4.2.3.5.1. River Paravani – hydrological station Khertvisi, Solid discharge for different provision values

Provision P%	**1**	**3**	**5**	**10**	**20**	**50**	**75**	**90**
Solid Discharge R kg/s	7.8	5.3	4.3	3.1	2.1	0.95	0.51	0.29
Solid Discharge flow W thousand tons	246	167	136	98	66	30	16	9
Bottom sediment discharge R_1 kg/s	0.85	0.58	0.47	0.34	0.23	0.10	0.06	0.03
Bottom sediment flow W_1 thousand tons	27	18	15	11	7	3	2	1
$\Sigma R + R_1$ kg/s	8.6	5.9	4.8	3.4	2.3	1.0	0.56	0.32
$\Sigma W + W_1$ thousand tons	273	185	151	109	73	33	18	10

Table 4.2.3.5.2. Paravani River - Granulometric composition of solid flow at Khertvisi hydrological station (observation period 1949-1980)

High water content phase	**Sediment Description**	**Particle content (% according to mass) with diameter in mms**							
		1-0.5	**0.5-0.2**	**0.2-0.1**	**0.1-0.05**	**0.05-0.01**	**0.01-0.005**	**0.005-0.001**	**<0.001**
Flood Rise	Thick	7.4	48.6	15.5	12.7	15.8			
	Average	2.7	8.0	14.5	23.8	51.0			
	Thin	1.0	5.5	4.3	3.1	8.2	77.9		
Flood Decline	Thick	2.1	30.5	22.5	21.6	23.3			
	Average		19.4	25.4	33.0	22.2			
	Thin		0.6	0.8	2.1	96.5			
Fall water rise	Thick		20.0	8.0	52.0	20.0			
	Average		0.3	1.7	28.0	70.0			
	Thin			0.3	14.0	85.7			
Summer low Water level	Thick		1.7	12.3	21.2	33.6	31.2		
	Average			1.3	7.7	18.9	72.1		

	Thin					13.5	86.5		
Winter low water level	Thick		15.0	26.3	13.0	12.7	33.0		
	Average			2.7	8.0	28.8	60.5		
	Thin			1.1	4.5	15.1	79.3		

In the case of the river Korkhi, information on sediment transportation is not available.

The Paravani HPP, intake of which is located directly at the confluence of the Korkhi and Paravani rivers, has been in operation for several years. The water intake is equipped with a settling tank. During the operation of the Paravani HPP, sedimentation in the settling tank is negligible. The sediment in the settling tank is mainly of organic origin and does not pose a threat to the HPP turbines. In addition, on Paravani River, in the upper reaches of the design intake, several small hydroelectric stations have been operating for years. According to our information, there was no problem in transporting solid sediment to these stations, even though these stations are not equipped with settling basins. Some of these stations have low dams along the Paravani riverbed and large catchment basins. Sediment accumulation did not cause problems in these catchments. Based on the above, we can conclude that sediment transport will not be problematic in the case of Akhalkalaki-1 HPP. The same can be said for the design intake of Akhalkalaki-2 HPP.

4.2.4 Biological Environment

4.2.4.1 Aspects of Georgian and International Legislation of Impact on Flora and Fauna Environment

Document of impact on flora and fauna environment is connected to the following Georgian legislation due to its subject of review, location of study area and its biological diversity.

This document is also based on the standards of the European Investment Bank (EIB) and the International Finance Corporation (IFC).

4.2.4.1.1 IUCN Categories and Criteria

Categories and criteria of the International Union for Conservation of Nature (IUCN) were used for assessment the vulnerability of plants found within the study area, which are granted to them in compliance with the version of 2006 of the Red List of Georgia. In its turn, categorization is based on the international guidelines, established in 2004 and issued as the publication: „2004 IUCN Red List of Threatened Species: A Global Species Assessment", as well as sources - IUCN, 2003, 2010.

IUCN - Categories. This categorization is based on the exactly defined nine categories, according to which, all taxon in the world can be classified (except microorganisms).

IUCN – categories are formulated as follows:

1. “Extinct” EX is granted if there is no justified suspicion that the last individual of an assessing taxon still inhabits in the environment;
2. Extinct in the Wild (EW) - individual of taxon exist in captivity or in naturalized population beyond its typical habitat;
3. Critically Endangered (CR) - based on the reliable evidences, A or E criteria is relevant for taxon and is considered to be facing an extremely high risk of extinction in the wild;
4. Endangered (EN) - based on the existing evidences, one of A or E criteria is relevant for taxon and is considered to be facing a very high risk of extinction in the wild;

5. Vulnerable (VU) - taxon is vulnerable if based on the existing evidences one of A or E criteria is relevant for it and is considered to be facing a high risk of extinction in the wild;
6. Near Threatened (NT) - is close to qualifying for, or is likely to qualify for, a threatened category in the near future;
7. Least Concern (LC) - Widespread and abundant taxa are included in this category and are not qualified as endangered groups.
8. Data Deficient (DD) - there is inadequate information to make an assessment of a taxon's risk of extinction.
9. Not Evaluated (NE) - taxon has not yet been evaluated against the criteria of the Red List.

IUCN - Criteria. There are five criteria to assess whether taxon is endangered or if so, to which category does it belong (CR, EN, VU). Criteria from A to E correspond to all categories of danger; they are based on biological indicators of the endangered populations. These indicators are rapid decrease of population and extremely small size of the population. Majority of criteria also include sub-criteria; their usage is necessary to match any defined criteria to the certain taxon. For example, if taxon is granted the criteria "Vulnerable (C2a(i))", it means that the population includes less than 10 000 units of individuals achieved the reproduction age (C criteria) and population is rapidly decreasing, as all adult individual are in a single separate population (i sub-criteria of C_2 criteria).

The main five criteria are as follows:

- Sharp decrease of population (past, present or/and assessment made by the direct observation)
- Decrease or considerable variability of geographical borders of their distribution and the size of their fragments.
- Population fragmentation and decrease of their number or considerable variability.
- Extremely small population or very limited distribution.
- Result of quantitative analysis of the risk of extinction (or data confirming the variability of the population).

4.2.4.2 Flora and Vegetation

Information on flora and vegetation is presented in the given paragraph comprising the literary reviews and field survey results. The survey was conducted for twice within the HPPs corridors of Akhalkalaki hydro power plant - November 21-23, 2018 and May 15-17, 2019. Aim of the mentioned surveys was to detect plant species, sensitive habitats and vegetation cover of significant conservation value (species included in the Red List of Georgia or the IUCN Red List) through the project corridor of HPPs Cascade planned on Paravani River, in Akhalkalaki municipality.

4.2.4.2.1 General Characterization of the Region

The project territory is situated in Samtskhe-Javakheti region, this landscape-botanical zone includes wetlands, unique lakes and bogs, numerous modifications of the mountain steppes, mountain xerophytic shrubbery, dry and mesophilic meadows and forest relict remains used to exist on Javakheti plateau in the past (Ketskhoveli 1959).

Following vegetation zones are presented in the southern mountainous region of Georgia (Долуханов 1989. Хинтибидзе 1990.):

- Middle mountainous zone (800-1500 m) is mainly used as arable lands. Natural vegetation is preserved in the form of floodplain forests, oak-hornbeam woodlands, mountain xerophytic shrubbery and mountain steppes;
- Upper mountainous zone includes beech-coniferous mixed forests (1200-2050 m);

- Subalpine zone (1900(2050)-2400(2500) m) is presented with the forest upper border ecotone, tall herbaceous vegetation, shrubs and subalpine polydominant grain-forb meadows. This zone is typologically diverse;
- Alpine zone (2500 – 2900 mm) – communities of alpine meadows and alpine carpets are mainly used for grazing. Compared to the subalpine zone, vegetation is quite poor in terms of biomass, as well as the typological diversity;
- Subnival zone (2900-3300 m) is presented only on Abul-Samsar ridge;
- Azonal vegetation is presented by the species of boreal flora species –rich wetlands, fragments of communities of the desert halophilic and rocky areas. It should be noted that xerophyts of the rocky areas include numerous endemic species.

A. Dolulhanuv distinguishes two regions in Samtskhe-Javakheti region – Adigen-Borjomi region and Javakheti plateau.

Akhalkalaki is located on Javakheti volcanic plateau, where following biomes are presented: pine woodlands, xerophytic shrubbery, high mountainous steppes of the southern Georgia, subalpine and alpine meadows, vegetation of weathered rocks and bogs. There are fragments of subnival vegetation on Abul-Samsar ridges at the altitude of 2900 m above the sea level (Нахуцришвилй, 1966).

4.2.4.2.2 Flora Survey Methodology

Floristic assessment comprises two components: making detail lists of vegetation of the habitats through the corridor of Paravani HPP and vegetation inventory within the occasionally sampled plot of 10x10 m size along the HPP corridor. Together with plants species identification and making lists, statuses of danger and endemism were also determined for relevant species. Information about distribution of such species was included in the lists of all sample points. Along with inventory of plant species diversity, coverage share of each species was also determined in total projective coverage of vegetation. Braun-Blanquet assessment system Braun-Blanquet, 1965; Conklin & Meinzholt, 2004; Bonham, 2013; Peet & Roberts, 2013) and related percentage coverage scale have been used for determination of species coverage. In the plots sampled by Shannon-Wiener index, Evenness a widely used feature in plant ecology, such as spatial distribution of species in the community was determined based on the analysis of percentage coverage of plant species and their total number (see Table 4.2.4.2.2.1.).

Plants species identification was conducted according to the "Flora of Georgia" (Ketskhoveli, Gagnidze, 1971-2001) and other floristic lists (Czerepanov, 1995; Gagnidze, 2005). Taxonomic data and validity of species nomenclature was rechecked in the International Database of Plant Taxonomies (The Plant List Vers. 1, 2010). Floristic and geo-botanical characteristics of species distribution in the habitats of the study area were specified by the sources about Georgian forests and vegetation cover (Ketskhoveli, 1960, Gigauri 200, Akhalkatsi, Tarkhnishvili, 2012). Hazard categories for plant species were determined according to the Georgian Red List (2006).

Table 4.2.4.2.2.1. Interconnection of projection coverings determination scales of plant species and percentage ratio of the projection coverings: traditional "Braun-Blanquet" scale, conservative Domin scale, Domin's modified the so called "Krajina" scale and widely used Carolina and New Zealand scales (Peet & Roberts, 2013).

Covering area	Braun-Blanquet	Domin	Krajina	Carolina	New Zealand
One specimen	r	+	+	1	1
Minor, sparsely distributed	+	1	1	1	1
0–1%	1	2	1	2	1
1–2%	1	3	1	3	2

2–3%	1	3	1	4	2
3–5%	1	4	1	4	2
5–10%	2	4	4	5	3
10–25%	2	5	5	6	3
25–33%	3	6	6	7	4
33–50%	3	7	7	7	4
50–75%	4	8	8	8	5
75–90%	5	9	9	9	6
90–95%	5	10	9	9	6
95–100%	5	10	10	10	6

4.2.4.2.3 Characterization of Habitats and Vegetation Cover of the Project Corridor

Project corridor proposed for the construction of Paravani HPPs is localized in Akhalkalaki municipality, within the valley of the rivers Paravani and Kokhristskali. The corridor area crosses 4 types of habitats, which are classified as follows based on the European Nature Information System (EUNIS) (see Figure 4.2.4.2.3.1.):

- **D4.2 Basic mountain flushes and streamsides, with a rich arctic-montane flora**
- **E1.3 Mediterranean xeric grassland**
- **F9.1 Riverine scrub**
- **I Regularly or recently cultivated agricultural, horticultural and domestic habitats**

Each of them is characterized as follows:

D4.2 Rare Alpine, peri-Alpine, northern British and periarctic pioneer communities colonizing gravelly, sandy, stony, sometimes somewhat argilous or peaty, calcareous sedimentary substrates soaked by cold water, in moraines and on the edge of springs, rivulets, glacial torrents of the alpine or subalpine levels, or on alluvial sands of pure, cold, slow-flowing rivers and calm backwaters. The highly characteristic constituents, with a boreoarctic or glacial relict distribution. Following vegetation is distributed in these habitats: *Carex microglochin, C. vaginata, Kobresia simpliciuscula = K. persica = K. capilliformis = K. schoenoides, Typha minima, Carex capillaris, C. panicea, Blysmus compressus, Eleocharis quinqueflora = Heleocharis* spp*., Scirpus cespitosus = S. silvaticus, Primula farinose = P. auriculata, Equisetum variegatum.*

E1.3 Meso- and thermo-Mediterranean xerophile, mostly open, short-grass perennial grasslands rich in therophytes; therophyte communities of oligotrophic soils on base-rich, often calcareous substrates, e.g. vegetation of class Thero-Brachypodietea. Following species are distributed in this habitat: *Brachypodium distachyum, Aegilops neglecta = Ae. squarrosa, Ae. cylindrica, Ae.s biuncialis, Ae. triuncialis, Avena sterilis, A. barbata, A. pilosa, Cynosurus echinatus, C. dactylon, Dactylis hispanica = D. glomerata, Asphodelus microcarpus = A. lutea, A. dendroides, Anacamptis pyramidalis.*

F9.1 Riverine scrub - Scrub of broad-leaved willows, e.g. *Salix aurita*, *Salix cinerea*, *Salix pentandra*, beside rivers. Scrub of *Alnus* spp. and narrow-leaved willows, e.g. *Salix elaeagnos*, where these are less than 5 m tall. Riverside scrub of *Hippophae rhamnoides* and *Myricaria germanica*. Excludes riversides dominated by taller narrow-leaved willows *Salix alba*, *Salix purpurea*, *Salix viminalis* (G1.1). Following species are distributed in this habitat: *Salix pentandra, Frangula alnus, Hippophae rhamnoides, Myricaria germanica =Myricaria bracteata*.

I Regularly or recently cultivated agricultural, horticultural and domestic habitats – cultivated, forage or ornamental vegetation is distributed there.

Figure 4.2.4.2.3.1. Map of habitats ide notified through the HPP project corridor

It should be noted that **sensitive areas or any protected species** included in the Red List of Georgia or any other international convention **were not detected during the survey.** This is basically stipulated by location of the project territory that experiences considerable anthropogenic loading, in particular, the project corridors of Paravani and Korkhistskali rivers. Pipeline territory is running along Paravani River; as you know, Paravani River follows the roadside (section from the powerhouse to Akhalkalaki), where the windbreak consisting of poplars and willows is observed (see Figure .2.4.2.3.2.). As for the Korkhistskali River corridor, canyon type sections are observed there (see Figure 4.2.4.2.3.3.), the latter is also located near the village and anthropogenic factors such as using of meadows for grazing are frequently observed. None of the project corridors locating adjacent to the river are not sensitive sections in terms of floristic viewpoint.

Fig.4.2.4.2.3.2. One of the sections of Paravani River project corridor

Fig.4.2.4.2.3.3. One of the sections of Korkhistskali River project corridor

Lists of species distributed through the habitats of the project corridors are given in the tables below.

Vegetation typical for the basic mountain flushes and streamsides, with a rich arctic-montane flora observed trough the project corridor is given in the Table 4.2.4.2.3.1. Such habitat can be also found through the corridor of Korkhistskali River, where several specimens of the following species are developed, namely: Goat willow (*Salix caprea*), white willow (*Salix alba*), and white poplar (*Populus alba*); as for the other vegetation, shrubs and grass cover is presented there detailed information on which is provided in the table.

Table 4.2.4.2.3.1.

Vegetation projective coverage: 20% Habitat: **D4.2 Basic mountain flushes and streamsides, with a rich arctic-montane flora**	
List of species / percentage coverage (%)	

Latin name	English name	Species percentage coverage %	Latin name	English name	Species percentage coverage %
Carex dichroandra	Sedges	2	*Muscari armeniacum*	Grape hyacinth	2
Phragmites communis	Common reed	2	*Verbascum thapsus*	Common mullein	3
Sparganietum simplexae	Bur-reed	2	*Artemisia absinthium*	Wormwood	2
Arctium lappa	Greater burdock o	2	*Salvia verticillata*	Lilac sage	1
Polygonum amphibium	Water knotweed	2	*Echium vulgare*	Viper's bugloss	2
Sphagnum amblyphyllum	-	2	*Stipa stenophylla*	Needle grass	3
Carex canescens	White sedge	3	*Festuca sulcata*	Fescue	2
Comarum palustre	Purple marshlocks	2	*Phleum phleoides*	Purple-stem cat's-tail	1
Aulacomnium palustre	-	2	*Alchemilla erythropoda*	Dwarf lady's mantle	2
Eriophorum vaginatum	Hare's-tail cottongrass	3	*Koeleria caucasica*	Junegrasses	3
Typha minima	Dwarf bulrush	3	*Heracleum transcaucasicum*	Cow parsnip	2
Potamogeton gramineus	Grass-leaved pondweed	2	*Medicago hemicycla*	Medick	2
Hippurietum vulgaris purum	Common mare's-tail	2	*Potentilla recta*	Rough-fruited cinquefoil	2
Alopecurus aequalis	Shortawn foxtail	3	*Echinops transcaucasicus*	Thistle	3
Rumex sp.	Curly dock	3	*Cichorium intibus*	Common chicory	3
Pulsatilla pratensis	Pasque flower	1	*Salix caprea*	Great sallow	1
Salix alba	White willow	1	*Populus alba*	White poplar	1
Ajuga orientalis	Oriental bugle	2	*Salvia nemorosa*	Woodland sage	2
Astragalus fragrans	-		*Astragalus arguricus*	-	
Primula veris	Cowslip	1	*Myosotis alpestris*	Alpine forget-me-not	2
Prangos ferulacea	-	2	*Descurainia sophia*	Flixweed	2

Vegetation typical for mediterranean xeric grassland is given in the Table 4.2.4.2.3.2. They are observed through the project corridor on Paravani River

Table 4.2.4.2.3.2.

Vegetation projective coverage: 20% Habitat: **E1.3 Mediterranean xeric grasslands**					
List of species / percentage coverage (%)					
Latin name	**English name**	**Species percentage coverage %**	**Latin name**	**English name**	**Species percentage coverage %**
Brachypodium distachyon	Purple false brome	3	*Campanula crispa*	Bellflower	2
Dactylis glomerata	Cat grass	3	*Centaurea bella*	Common knapweed	2
Aconitum nasutum	Nasute Monkshood	2	*Minuartia micrantha*	Sandworts	2
Erysimum szowitzianum	-	2	*Jurinea carthaliniana*	Jurinea	1
Matricaria rupestris	Rauschert	2	*Astragalus fragrans*	-	2
Astragalus argurius	-	2	*Sedum spurium*	-	1
Carduus nutans	Musk thistle	2	*Siltbum marianum*	Milk thistle	2
Salvia nemorosa	Woodland sage	1	*Hyoscyamus niger*	Black henbane	1
Tephroseris caucasigena	-	2	*Primula veris*	Cowslip	1

Vegetation typical for the riverine scrubs is provided in the Table 4.2.4.2.3.3. They are observed through the project corridors of Korkhistskali River and Paravani River as well.

Table 4.2.4.2.3.3.

Vegetation projective coverage: 20% Habitat: **F9.1 Riverine scrub**					
List of species / percentage coverage (%)					
Latin name	**English name**	**Species percentage coverage %**	**Latin name**	**English name**	**Species percentage coverage %**
Salix pentandra	Bay willow	1	*Rosa canina*	Dog rose	2
Salix alba	White willow	2	*Typha minima*	Dwarf bulrush	2
Populus alba	White poplar	2	*Prunus divaricata*	Cherry plum	1
Alnus glutinosa	Common alder	1	*Heracleum transcaucasica*	Hogweed	2
Hippophae rhamnoides	Sea-buckthorn	2	*Phragmites communis*	Common reed	3
Rumex sp.	Curly dock	2	*Hyoscyamus niger*	Black henbane	
Salvia nemorosa	Woodland sage	1	*Silybum marianum*	Milk thistle	

Vegetation typical for regularly or recently cultivated agricultural, horticultural and domestic habitats is given in the Table 4.2.4.2.3.4. Artificial tree plantings such as apple, pear, etc can be also observed there.

Table 4.2.4.2.3.4.

Vegetation projective coverage: 20% Habitat: **I Regularly or recently cultivated agricultural, horticultural and domestic habitats**	
List of species / percentage coverage (%)	

Latin name	English name	Species percentage coverage %	Latin name	English name	Species percentage coverage %
Poa alpina	Alpine meadow-grass	2	*Rosa canina*	Dog rose	2
Arctium lappa	Greater burdock	2	*Malus sp.*	Apple	2
Pyrus sp.	Pear	2	*Morus alba*	White mulberry	1
Prunus divaricata	Cherry plum	1	*Heracleum stranscaucasica*	Hogweed	2
Salvia nemorosa	Woodland sage	2	*Carduus nutans*	Musk thistle	1
Urtica dioica	Common nettle	2	*Astragalus fragrans*	-	1

4.2.4.2.4 Photo Material of Some Plants Distributed through the Project Corridor

Rosa canina

Alchemilla erythropoda

Descrurainia sophia

Verbascum thapsus

Prangos ferulacea

Myosotis alpestris

Primula veris

Muscari armeniacum

Echinops transcaucasicus

Rumex sp.

Hyosyamus niger

Pulsatilla pratensis

Carduus nutans *Salvia nemorosa* *Urtica dioica*

Astragalus fragrans *Astragalus arguricus*

Salix caprea

4.2.4.2.5 Summary of Executed Botanical Survey

Based on the survey results of the project impact zone, four types of habitats are observed within the impact zone of Akhalkalaki HPP (see Paragraph 4.2.4.2.3.1.).

Sensitive areas or any protected species included in the Red List of Georgia or any other international convention were not detected during the survey. This is basically stipulated by location of the project territory that experiences considerable anthropogenic loading, in particular, the project corridors of Paravani and Korkhistskali rivers

In frames of the project section of Akhalkalaki HPP, pipeline corridor will pass along the left bank of the river, while the highway runs along the right bank. A windbreak consisting of poplars and willows is observed along the highway. The river bank opposite of the windbreak is poor in terms of wood species; about 20 specimens of the following species: white poplar (*Populus alba*), white willow (*Salix alba*) and several scrubs of dog rose (*Rosa canina*) are presented there.

As for the Korkhistskali River corridor, canyon type sections are observed there, the latter is also located near the village and anthropogenic factors such as using of meadows for grazing are frequently observed. The project corridors locating adjacent to the river are not sensitive sections in terms of floristic viewpoint. About 40 specimens of species can be found on the river bank, along the entire pipeline territory, in particular:

goat willow (*Salix caprea*), bay willow (*Salix pendantra*), white willow (*Salix alba*), white poplar (*Populus alba*), common alder (*Alnus glutinosa*), cherry plum (*Prunus divaricata*), and scrubs of sea-buckthorn (*Hippophae rhamnoides*) and dog rose (*Rosa canina*). Trees and vegetation are mainly observed at the river banks.

4.2.4.3 Wildlife

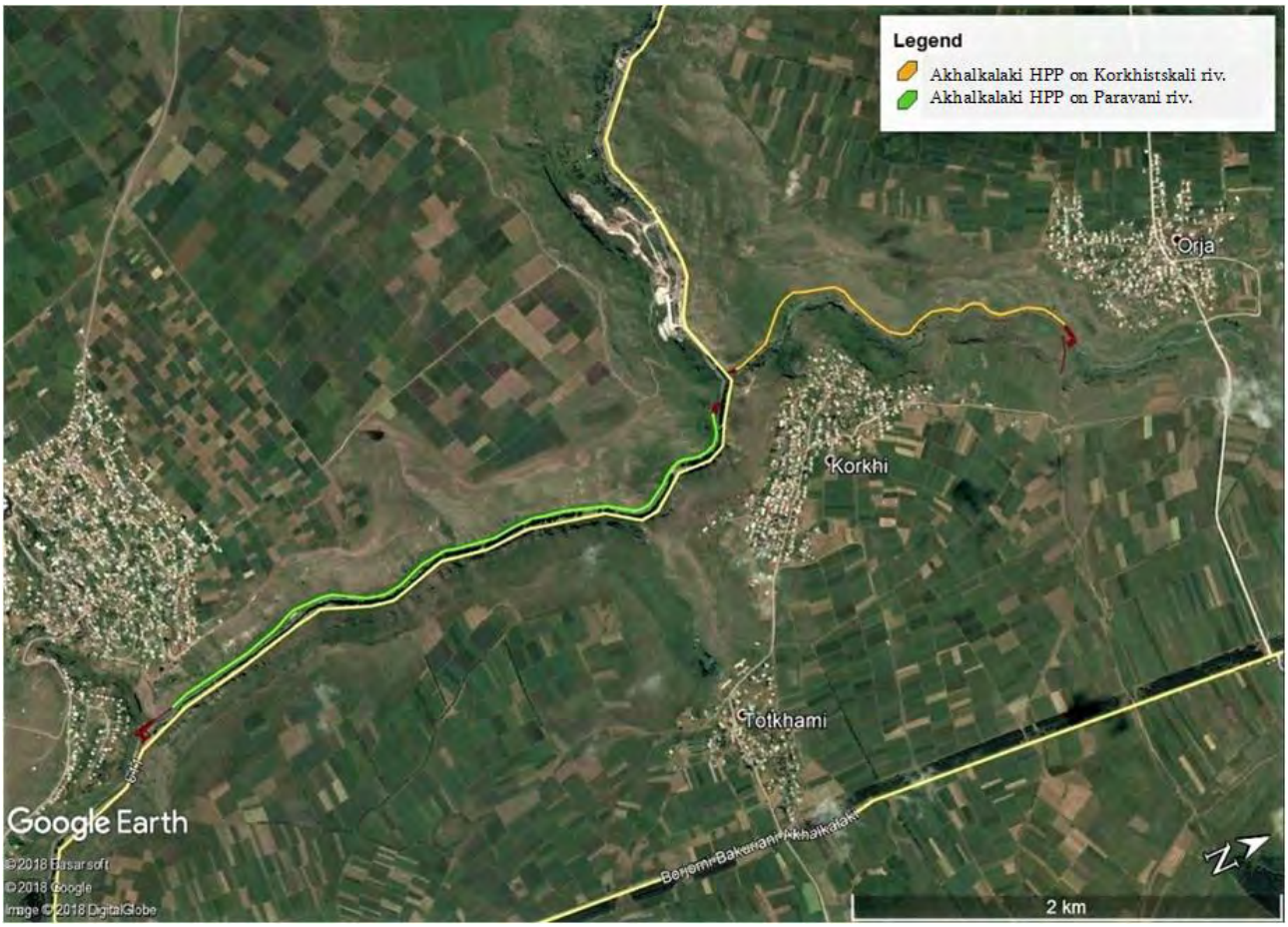
4.2.4.3.1 General Overview

In administrative viewpoint, the project territories are located in Samtskhe-Javakheti region, Akhalkalaki municipality. Geographically, Akhalkalaki is situated on Javakheti volcanic plateau, which

is the mountainous plateau, mostly forestless, covered with lots of lakes and rivers. Climatic conditions of Samtskhe-Javakheti region are diverse, as for Akhalkalaki weather conditions, the municipality is characterized by the mountain steppe climate, it is mainly continental, with moderate precipitations, cold winter and cool short summer.

Akhalkalaki HPPs construction impact zone comprises certain sections of Paravani and Korkhistskali rivers (Map 4.2.4.3.1.1.).

Map 4.2.4.3.1.1. Project territory



4.2.4.3.2 Objective of the Study

Objective of zoological survey is to identify of animal species composition inhabiting on the project territory and in its surroundings, as well as to determine impact during and after the construction process. Special attention was drawn to the species protected by the Georgian legislation and international treaties (red-listed species, species protected by Bern Convention and other normative acts). The report is based on the review of scientific literature and the field survey results carried out in November 2018 and May 2019.

4.2.4.3.3 Material and Methods Used for Survey

Walking, transect method was used during the survey. All occurring species were registered and visually observed. In addition, signs of vitality were recorded: footprints, feces, holes, feather, fur, etc. Data given

in the scientific literature were also used. All of these enable us to describe fauna of the project territory and to make relevant conclusions.

Used tools

- Photo camera - Canon PowerShot SX50 HS
- Photo camera - Canon PowerShot SX60 HS
- Garmin eTrex 30x
- 8x42 binocular „Opticron Trailfinder 3 WP"
- Bats detector Anabat Walkabout

Directions of field survey:

Survey of mammals – visual observation, photographing, finding of footprints, feces, fur, hollow, hole, den. In case of finding a prey, identification of a predator according to injuries.

Survey of bats – mammals survey methodology(bats detector Anabat Walkabout)

Survey of birds – watching with binocular, visual observation, identification by voice, finding of vitality signs.

Survey of reptiles and amphibians – visual observation, photographing, inspection of specific areas.

Survey of invertebrates – visual observation, inspection of stones soil, plants residues.

4.2.4.3.4 Field Survey Results

Habitat of the project corridor is not distinguished by fauna species diversity. Quantitative scarcity of animals is observed in the study area. As a result of the implemented surveys, fauna species spread through the project area were revealed. In addition, species were identified and their taxonomically valid names were determined.

Based on the field surveys and processing of existing scientific literary sources, 32 mammals, 8 bats,112 birds, 13 reptiles and amohibians, more than 500 species of molusks and various invertebrates were identified within the project area and its surroundings.

In frames of the survey 4 main habitats were singled out on the project territory, they were classified based on the EUNIS habitats classification system, namely:

1. **D4.2** Basic mountain flushes and streamsides, with a rich arctic-montane flora;
2. **E1.3** Mediterranean xeric grasslands;
3. **F9.1** riverine scrubs;
4. **I** Regularly or recently cultivated agricultural, horticultural and domestic habitats

Fig. 4.2.4.3.4.1. Separate sections of Akhalkalaki HPP project corridor

Fig. 4.2.4.3.4.1. Some sections of Korkhi HPP project corridor

Based on the implemented surveys, information was obtained on presence of following species within the construction area:

4.2.4.3.5 Mammals

Due to the project requirements, main attention was drawn to the species composition of mammals and their state in frames of assessment of the fauna environment. According to literary sources, the following species are recorded in the Project Area (Javakheti upland):

- From the red-listed species following ones are frequently observed: grey dwarf hamster *(Cricetulus migratorius),* Turkish hamster *(Mesocricetus brandti)*, rarely, Nehring's blind mole-rat *(Nannospalax nehringi)* , otter *(Lutra lutra)* and especially, marbled polecat *(Vormela peregusna).*
- In addition European snow vole *(Chionomys nivalis)* and European water vole *(Arvicola terrestris),* common vole *(Microtus arvalis),* social vole *(Microtus socialis).* Besides the above mentioned species, following ones also inhabit there: Gueldenstaedt's shrew (*Crocidura gueldenstaedtii*), bicolored shrew *(Crocidura leucodon),* Caucasian shrew (*Sorex satunini*), Transcaucasian water shrew *(Neomys teres),* Caucasian mole *(Talpa caucasica),* European badger *(Meles meles),* European hare *(Lepus europaeus)* and others. Following predators are mostly observed: red fox *(Vulpes vulpes),* beech marten *(Martes foina),* least weasel *(Mustela nivalis),* small number of grey wolves *(Canis lupus).*

Least weasel *(Mustela nivalis)* was observed in Paravani River valley during the field surveys of November 2018, while the molehills were found in Korkhistskali River valley (Fig. 4.2.5.3.5.1., and 4.2.5.3.5.3.). Red fox *(Vulpes vulpes)* (see Figure 4.2.5.3.5.2.) was observed in Paravani River valley during the field surveys of May 2019.

Mammals observed in Paravani River valley (signs of vitality)

Fig. 4.2.5.3.5.1. Least weasel *(Mustela nivalis)* E- 372097 N- 4590419 (November;2018)

Fig. 4.2.5.3.5.2. Red fox *(Vulpes vulpes)* E - 372267 N – 4590183 (May;2019)

Mammals observed in Korkhistskali River valley (signs of vitality)

Fig. 4.2.5.3.5.3. Molehill of a mole *(Talpa sp.)* E- 371780 N- 4590854 (November;2018)

Special attention was drawn to the red listed species – otter (Lutra lutra), but no signs of its vitality were found during the field survey. It should be noted that the favorable habitat for otter is less presented within the project territory. Bank of Korkhistskali River is basically structured by rocky massifs and the

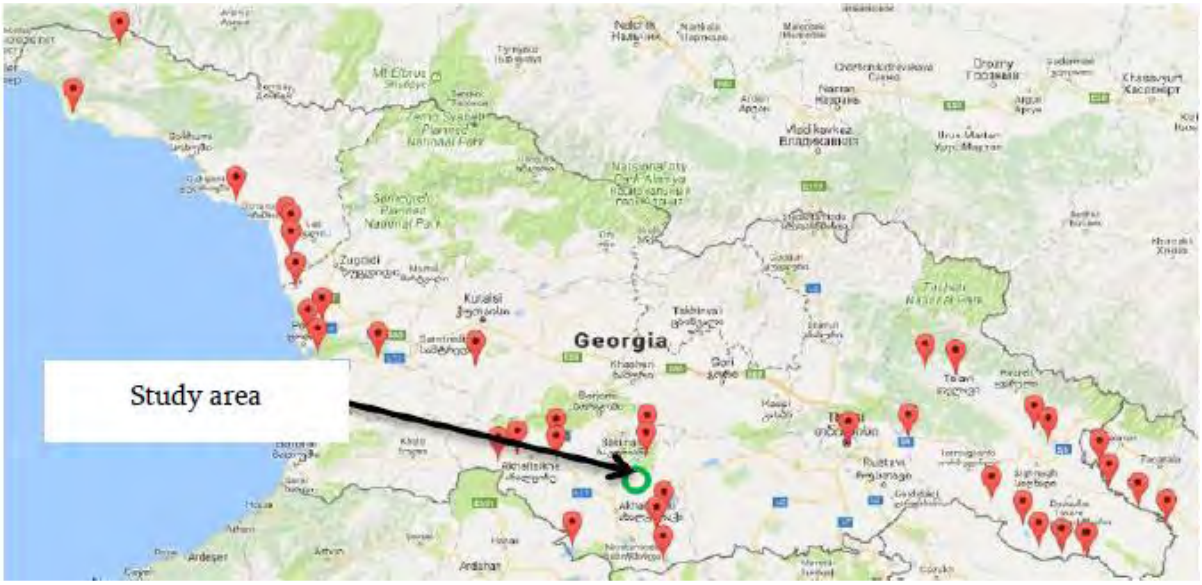
otter does not use such riverbanks for inhabiting. The habitat is relatively open in the upper reaches of the river, trees and vegetation are developed and the bank is less stony, but not optimal. Given the above, otter most likely does inhabit within the project influence area.

As for the section of the Paravani gorge that fall within the project influence area, the coastline is essentially built of large boulders, with rocky cliffs on each side, creating unfavorable inhabiting conditions. The projected section of Paravani has a very high anthropogenic load factor, which is related to the intensity of traffic on the motorway. The otter avoids such places and never uses it as a habitat.

In frames of the project territories, we thoroughly inspected those areas, where direct impact is expected on the otter, as well as the bank of Paravani River valley, but no traces and/or holes were found neither in daytime nor at night (it should be noted that the otter is active at night). We also used to observe food residues at the bank line area, because the otter eats food (obtained in water) on terrain. In addition, we observed feces as well; in case of otter, it contains large amount of bone residues. We could not find any signs of vitality during neither of the studies.

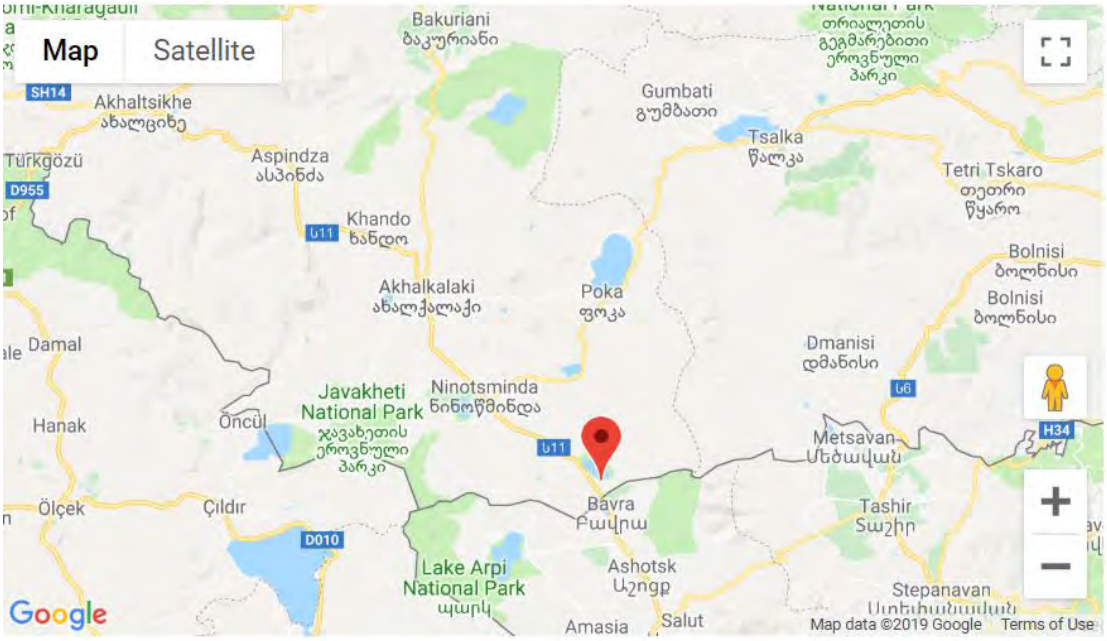
In view of all the above, it can be said that according to the results of the research, the presence of Otter in the project impact zone has not been confirmed. However, mitigation measures and monitoring is planned for the construction and operation phases.

Map 4.2.5.3.5.1. Otter distribution in Georgia



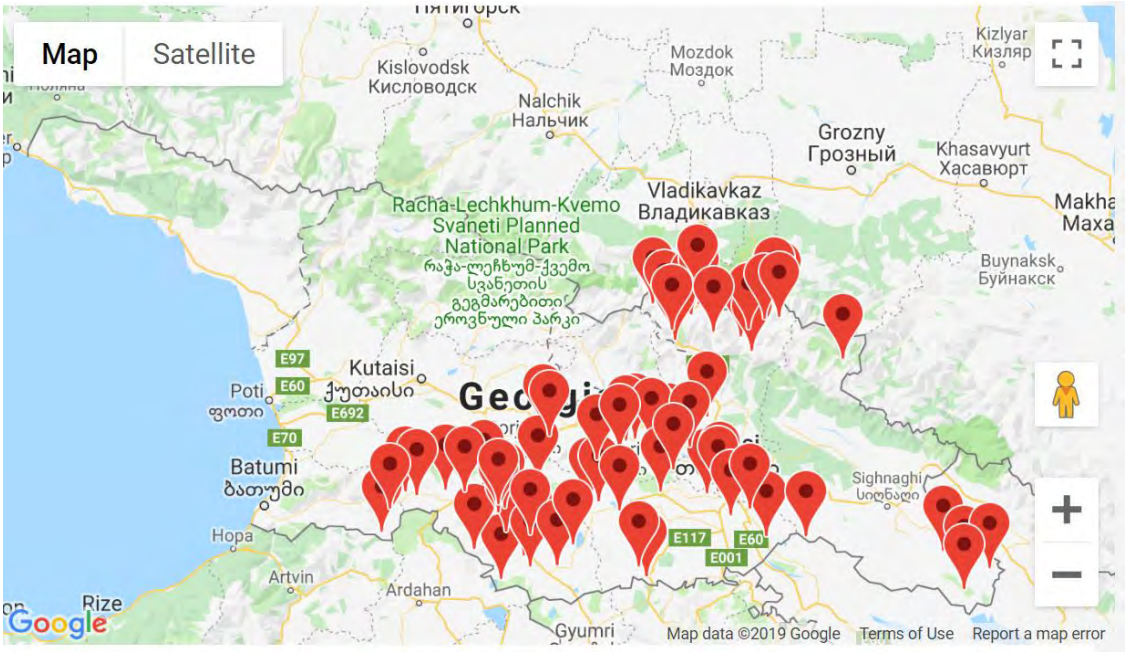
As for the marbled polecat *(Vormela peregusna*), it is very rare species; based on the literary sources it inhabits in southern Georgia, but is can be seen only in one point – near Madatapi Lake Bukhnikashvili, A. & Kandaurov, A., 2002. The annotated list of mammals of Georgia. Proceedings of the Institute of Zoology, Tbilisi, XXI: 319-336). During field surveys, no sign of marbled polecat was identified in the Project Impact Area and surrounding area, which, together with the absence of suitable habitat, is associated with the high anthropogenic load of the project corridor (The highway runs in the immediate vicinity of the Paravani River, and the Korki River Gorge is actively used for grazing). Given all this, the presence of marbled polecat (Vormela peregusna) within the project corridor is excluded.

Map 4.2.5.3.5.2. Distribution of marbled polecat (Vormela peregusna) in Georgia



Grey dwarf hamster *Cricetulus migratorius* and Turkish hamster *Mesocricetus brandti* are widespread in the southern Georgia and in this region; they are mainly observed on meadows.

Map 4.2.5.3.5.3. Distribution of the Grey dwarf hamster *Cricetulus migratorius* in Georgia



Map 4.2.5.3.5.4. Distribution of the Turkish hamster *Mesocricetus brandti* in Georgia

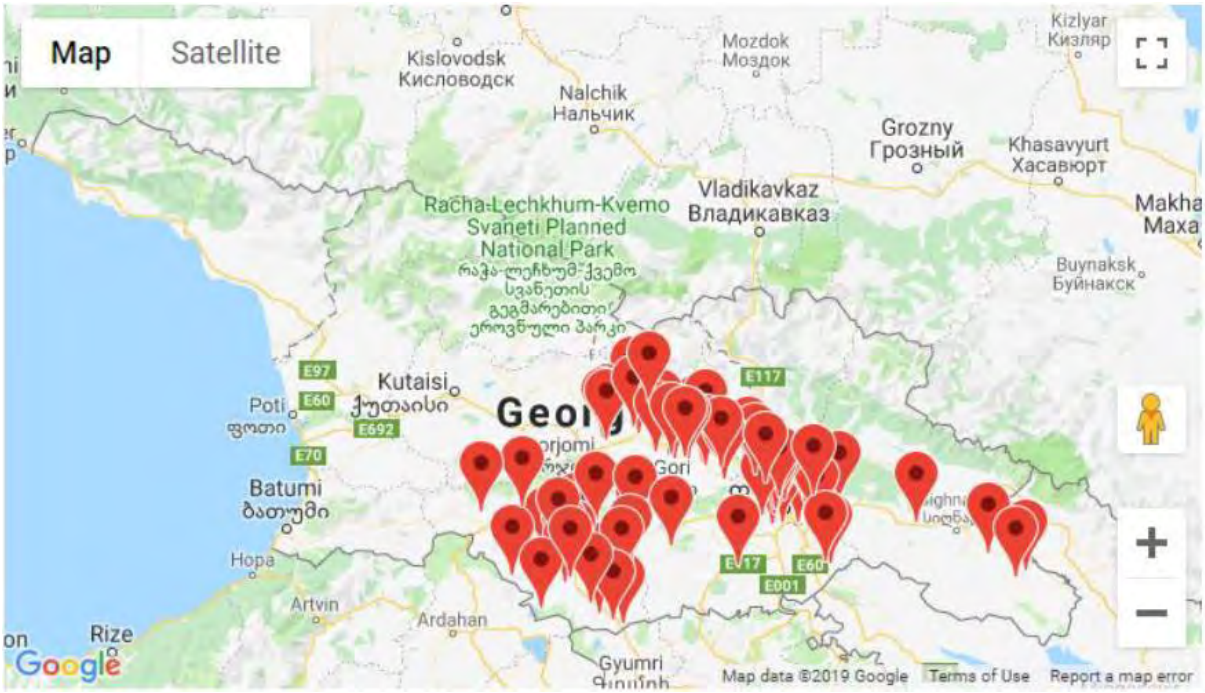


Table 4.2.5.3.5.1. Species of mammals of the study region provided in the study region

N	English name	Latin name	IUCN	RLG	Bern Conv.	Observed (habitat type - 1-4) not observed X
1	European hare	*Lepus europeus*	LC	-	√	x
2	Least weasel	*Mustela nivalis*	LC	-	√	1
3	Marbled polecat	*Vormela peregusna*	VU	EN		x
4	Grey dwarf hamster	*Cricetulus migratorius*	LC	VU	√	x
5	Turkish hamster	*Mesocricetus brandti*	NT	VU	√	x
6	Southern white-breasted hedgehog	*Erinaceus concolor*	LC	-	√	x
7	Otter	*Lutra lutra*	NT	VU		x
8	European badger	*Meles meles*	LC		√	x
9	Red squirrel	*Sciurus vulgaris*	LC		√	x
10	Levant mole	*Talpa levantis*	LC	-	√	x
11	Caucasian mole	*Talpa caucasica*	LC		√	x
12	Grey wolf	*Canis lupus*	LC	-		x
13	Red fox	*Vulpes vulpes*	LC	-	√	1
14	European pine marten	*Martes martes*	LC		√	x
15	Beech marten	*Martes foina*	LC	-	√	x
16	Nehring's blind mole-rat	*Nannospalax nehringi*				x
17	Common vole	*Microtus arvalis*	LC		√	x
18	Social vole	*Microtus socialis*	LC		√	x
19	European snow vole	*Chionomys nivalis*	LC			x
20	European water vole	*Arvicola terrestris*	LC			x
21	Macedonian mouse	*Mus macedonicus*	LC		√	x
22	Gueldenstaedt's shrew	*Crocidura gueldenstaedti*	LC		√	x
23	Bicolored shrew	*Crocidura leucodon*	LC			x
24	Radde's shrew	*Sorex raddei*	LC		√	x
25	Caucasian shrew	*Sorex satunini*	LC		√	x

26	Caucasian pygmy shrew	*Sorex volnuchini*	LC		√	x
27	Transcaucasian water shrew	*Neomys teres*	LC			x
28	Robert's snow vole	*Chionomys roberti*	LC		√	x
29	Eastern broad-toothed field mouse	*Apodemus mystacinus*	LC			x
30	House mouse	*Mus musculus*	LC		√	x
31	Black rat	*Rattus rattus*	LC		√	x
32	Brown rat	*Rattus norvegicus*	LC		√	x
IUCN – categories are formulated as follows: EX – Extinct; EW – Extinct in the Wild; CR – Critically endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern; DD – Data deficient; NE – Not Evaluated						

Bats (*Microchiroptera)*

Bats are the only flying mammals. They have been existed for about 50 million years and they are the most significant living organisms in evolutionary viewpoint. They live in groups and even can live with other bat species. They need quite different roosts

- Transitive roost;
- Hibernation roosto;
- Mating roost;
- Maternity roost;
- Summer roost;

They are characterized with winter dormany. Caves, rocky fractures, old buildings, where temperature is up to 6-12^{0}C are their hibernation roosts. Majority of bats die in conditions of lower than 5 ^{0}C. In active period they use caves, rocky fractures, buildings and hollow trees. They mainly feeds on insects. One bat destroyes several thousands of insects in a night.

Bats are poorly studied in Javakheti region. Based on the literary sources and the field surveys, 8 bats species are distributed through the study area and in its vicinities. Representatives of *Pipistrellus* family were observed during the surveys of may. The study was conducted using a bat detector (Anabat Walkabout) (see table).

The planned project activities will have no direct impact on bats, as their habitats are not related to the impact zone. The only disturbing factor is noise generated during the construction process, but it should be noted that the central highway runs through the study corridor and bats (as well as other fauna representatives) are adapted to noise and anthropogenic impact.

Fig. 4.2.5.3.5.4. Favorable habitats for bats

Table 4.2.5.3.5.2. Bat species of the study and nearby territories provided in the literary sources and observed during the surveys

№	Latin name	English name	IUCN	RLG	Bern Conv	CMS	Observed (type of habitat - 1-4) Not observed X
1.	*Rhinolophus ferrumequinum*	Greater horseshoe bat	LC		√	√	x
2.	*Rhinolophus hipposideros*	Lesser horseshoe bat	LC		√	√	x
3.	*Myotis mystacinus group*	Whiskered bat	LC		√	√	x
4.	*Pipistrellus pipistrellus*	Common pipistrelle	LC		√	√	1
5.	*Pipistrellus pygmaeus*	Soprano pipistrelle	LC		√	√	x
6.	*Plecotus auritus*	Brown long-eared bat	LC		√	√	x
7.	*Plecotus austriacus*	Grey long-eared bat	LC		√	√	x
8.	*Pipistrellus nathusii*	Nathusius' pipistrelle	LC		√	√	1
IUCN – categories are formulated as follows: EX – Extinct; EW – Extinct in the Wild; CR – Critically endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern; DD – Data deficient; NE – Not Evaluated							

4.2.4.3.6 Birds

Ornithological field surveys were conducted on the 21st -22nd of November, 2018 and the 15th -17th of May, 2019. The latter period is quite favorable for the birds' survey on the study area, because migration of birds starts in spring and autumn. We observed all earlier registered species and other species as well; their photo material is provided below. Special attention was drawn on the species protected by the Red List of Georgia and international conventions. One red-listed species was observed in Korkhistskali River valley, namely: White stork *Ciconia ciconia* with the status of Vulnerable (VU) (see Figure 4.2.5.3.6.23).

From birds of prey observed during the field survey common buzzard *Buteo buteo* is noteworthy, which flied over the project corridor of Korkhistskali Ricer from around 1 km height (see Figure 4.2.5.3.6.24.).

Locally inhabiting birds were basically observed through the study area, out of them prevailing species were small passerines. In Korkhi valley we also found white-throated dipper *Cinclus cinclus,* mountain chiffchaff *Phylloscopus sindianus*, Eurasian wren *Troglodytes troglodytes*, blue rock thrush *Monticola*

solitarius, Common raven *Corvus corax*, white wagtail *Motacilla alba* and rock bunting *Emberiza cia*. Large amount of Eurasian jay *Garrulus glandarius* were observed through the project corridor, we also found a nest of this species (see Figure 4.2.5.3.6.28.), which seemed to be abandoned.

Based on the surveys, 112 bird species were revealed, out of them 40 species are inhabiting and nesting, while the others are passage migrants or visit the territories only for breeding or wintering. From the registered 112 species, 6 of them are included in the Red List of Georgia, 4 Vulnerable (golden eagle *Aquila chrysaetos*, greater spotted eagle *Clanga clanga*, long-legged buzzard *Buteo rufinus*, white stork *Ciconia ciconia*) and 2 Endangered species (red-footed falcon *Falco vespertinus*, common crane *Grus grus*). Species protected by the IUCN Red List are as follows: meadow pipit *Anthus pratensis*, Armenian gull *Larus armenicus* and European turtle dove *Streptopelia turtur*. The Georgian and the international (IUCN) Red Lists protect greater spotted eagle *Clanga clanga* and red-footed falcon *Falco* vespertinus. The mentioned protecting species will visit the project territory, but they won't occur within the adverse impact zone, as the project territory is neither their inhabiting nor nesting area.

Birds watching used to carry out in cloudy weather in November, while in sunny and windless weather in May. Each ornithological survey had been lasted for 2-3 days, from 11 am to 6-7 pm. We walked through the route and visited all study areas and sites. We used to stop and observe birds on each site; proto material was also collected, while some species were identified by voice. Binoculars 8x42 " Discovery WP PC Mg" and "Opticron Trailfinder 3 WP" 8x42 were used for identification of birds species. We also identify some birds by using of special handbooks (Birds of Europe: Second Edition by Lars Svensson and Dan Zetterström and Collins Bird Guide. 2Nd Edition).

Photo material of observed species taken on the study area is given below. Along with the photos, location of photographing and its GPS coordinates and species scientific and English names are provided as well.

Birds species observed in Paravani River valley.

November 2018:

Fig. 4.2.5.3.6.1. Common buzzard *Buteo buteo* E 371982 N 4590579

Fig. 4.2.5.3.6.2. White-throated dipper *Cinclus cinclus*

Fig. 4.2.5.3.6.3. Common magpie *Pica pica*

Fig. 4.2.5.3.6.4. Great tit *Parus major*

May 2019:

Fig. 4.2.5.3.6.5. White wagtail *Motacilla alba*

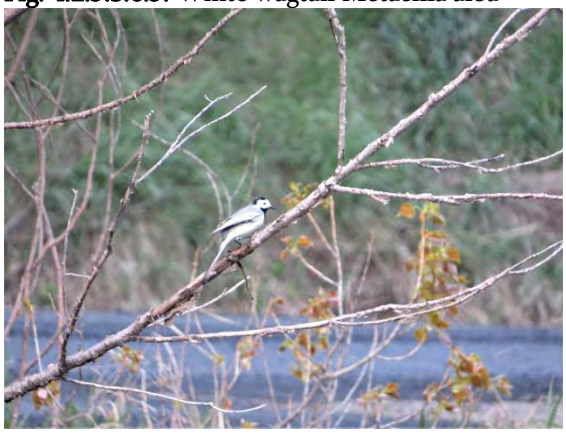


Fig. 4.2.5.3.6.6. Rock bunting *Emberiza cia*

Fig. 4.2.5.3.6.7. Great spotted woodpecker *Dendrocopos major*

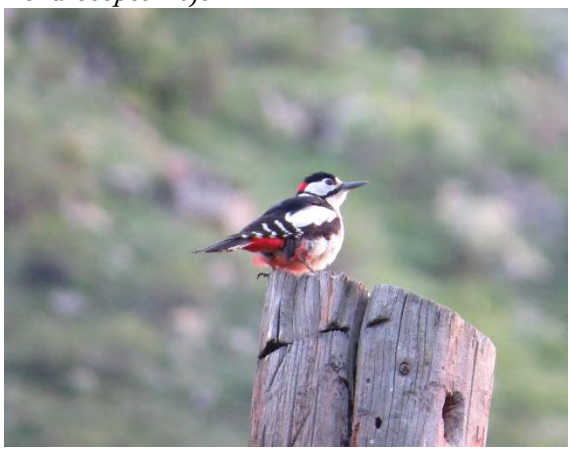


Fig. 4.2.5.3.6.8. European goldfinch *Carduelis carduelis*

Fig. 4.2.5.3.6.9. Eurasian sparrowhawk *Accipiter nisus*

Fig. 4.2.5.3.6.10. Black-eared wheatear *Oenanthe hispanica*

Fig. 4.2.5.3.6.11. Common magpie *Pica pica*

Fig. 4.2.5.3.6.12. Blackbird *Turdus merula*

Fig. 4.2.5.3.6.13. Great tit *Parus major*

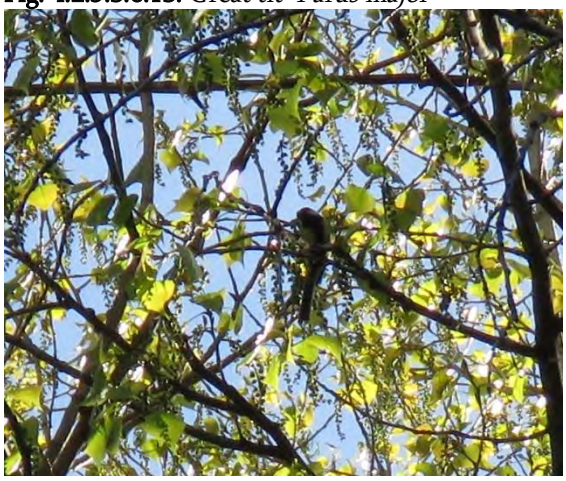


Fig. 4.2.5.3.6.14. Barn swallow *Hirundo rustica*

Fig. 4.2.5.3.6.15. Blue rock thrush *Monticola solitarius*

Fig. 4.2.5.3.6.16. Feather of a common buzzard *Buteo buteo E 371979 N 4589137*

Bird species observed in Korkhistskali River valley

November 2018:

Fig. 4.2.5.3.6.17. Eurasian jay *Garrulus glandarius*

Fig. 4.2.5.3.6.18. White-throated dipper *Cinclus cinclus*

May 2019:

Fig. 4.2.5.3.6.19. Mountain Chiffchaff *Phylloscopus sindianus*

Fig. 4.2.5.3.6.20. Eurasian wren *Troglodytes troglodytes*

Fig. 4.2.5.3.6.21. White-throated dipper *Cinclus cinclus*

Fig. 4.2.5.3.6.22. Blue rock thrush*Monticola solitarius*

Fig. 4.2.5.3.6.23. White stork *Ciconia ciconia* E 371983 N 4591907

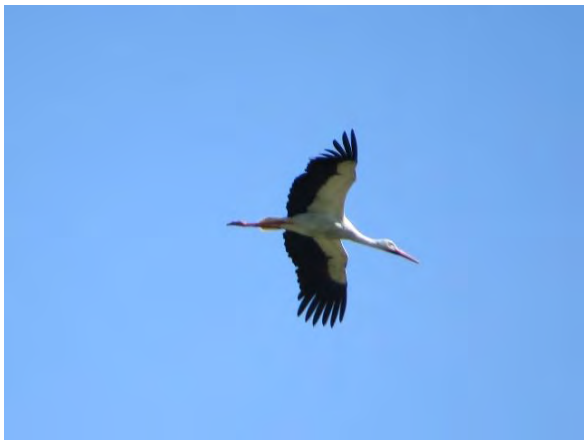


Fig. 4.2.5.3.6.24. Common buzzard *Buteo buteo*

E 371620 N 4591412

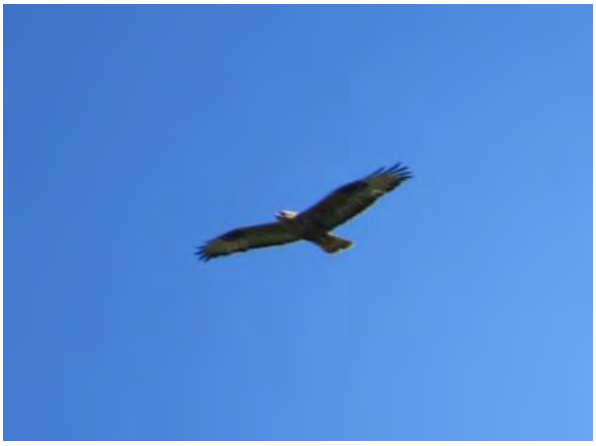


Fig. 4.2.5.3.6.25. Common raven *Corvus corax*

Fig. 4.2.5.3.6.26. White wagtail *Motacilla alba*

Fig. 4.2.5.3.6.27. Rock bunting *Emberiza cia*

Fig. 4.2.5.3.6.28. Nest of the Eurasian jay *Garrulus glandarius E 371961 N 4591697*

One of the most significant migration corridors of birds passes through the Javakheti Plateau, which is smaller than Batumi migration corridor in terms of number of birds, but is absolutely same with species diversity. This migration corridor does not pass through the project territory, however, it is in the same region and is quite close to the project area. Hence, all birds species flying through this migration route can occur within the study zone during spring-autumn migrations.

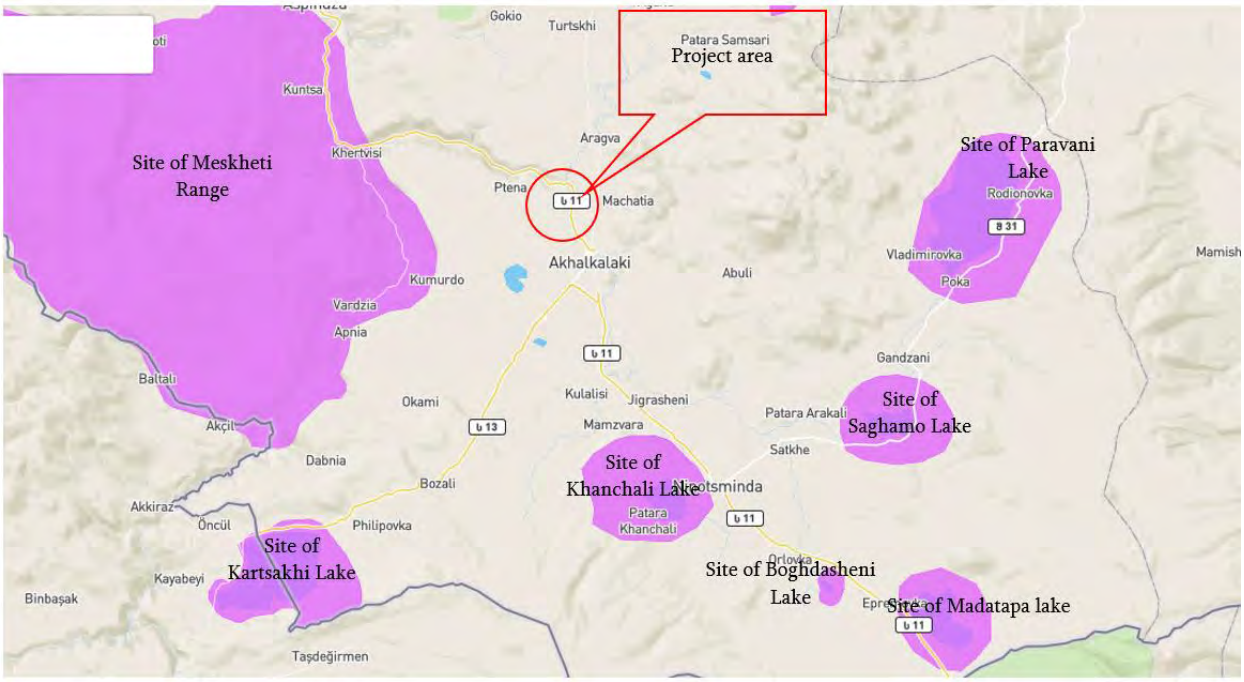
"Birds directives" are based on the Natura 2000 classification system.

Map 4.2.5.3.6.1. Migration corridors

Source: *National Geographic Georgia, 2018*

The study territory is not the Important Birds Area (IBA). IBA territories are quite far from the project zone. Despite this, any of birds flying through the migration route during spring-autumn migration periods can occur within the target territory. However, no landscapes (e.g. lakes) favorable for concentration of migrating birds are observed within the project impact zone.

Map 4.2.5.3.6.2. Location of the project area and Important Birds Areas (marked in pink)



Source: *https://conservation.ibat-alliance.org*

Table 4.2.5.3.6.1. Birds species observed on the study area and given in the literary sources

N	Georgian name	Scientific name	English name	Migration seasonality	IUCN	RLG	Bern Conv.	CMS	Observed (habitat types - 1-4) not observed X
1.	მიმინო	*Accipiter nisus*	Eurasian Sparrowhawk	YR-R	LC		√		1
2.	ძერა	*Milvus migrans*	Black Kite	M	LC		√	√	x
3.	ქორი	*Accipiter gentilis*	Northern Goshawk	M	LC		√	√	x
4.	ჩვეულებრივი კაკაჩა	*Buteo buteo*	Common Buzzard	M	LC		√	√	1
5.	ველის (ან გრძელფეხა) კაკაჩა	*Buteo rufinus*	Long-legged Buzzard	YR-R, M	LC	VU	√		x
6.	ფეხბანჯგვლიანი კაკაჩა	*Buteo lagopus*	Rough-legged Buzzard	WV,M	LC				x
7.	კრაზანაჭამია (ან ირაო)	*Pernis apivorus*	European Honey-Buzzard	BB,M	LC				x
8.	ჩვეულებრივი შავარდენი	*Falco peregrinus*	Peregrine Falcon	YR-R, M	LC		√		x
9.	წითელფეხა შავარდენი	*Falco vespertinus*	Red-footed Falcon	BB,M	NT	EN	√		x
10.	ჩია არწივი	*Hieraaetus pennatus*	Booted Eagle	M	LC			√	x
11.	მთის არწივი	*Aquila chrysaetos*	Golden Eagle	YR-R	LC	VU			
12.	დიდი მყივანი არწივი	*Clanga clanga*	Greater Spotted Eagle	WV, M	VU	VU	√		x
13.	მცირე მყივანი არწივი	*Clanga pomarina*	Lesser Spotted Eagle	BB, M	LC				
14.	ალალი	*Falco columbarius*	Merlin	M	LC		√	√	x
15.	ჩვეულებრივი კირკიტა	*Falco tinnunculus*	Common Kestrel	M	LC		√	√	x
16.	ჭაობის ძელქორი (ან ჭაობის ბოლობეჭედა)	*Circus aeroginosus*	Western Marsh Harrier	YR-R, M	LC		√	√	x
17.	გარეული მტრედი	*Columba livia*	Rock Dove	YR-V	LC				x
18.	გულიო (ან გვიმინი)	*Columba oenas*	Stock Dove	M	LC			√	x
19.	ქედანი	*Columba palumbus*	Common Wood-Pigeon	M	LC				x
20.	ჩვეულებრივი გვრიტი	*Streptopelia turtur*	Eurasian Turtle-Dove	BB, M	VU				x
21.	საყელოიანი გვრიტი	*Streptopelia decaocto*	Eurasian Collared-Dove	YR-R, M	LC				x
22.	გუგული	*Cuculus canorus*	Common Cuckoo	BB	LC		√		x
23.	ტყის ბუ	*Strix aluco*	Tawny Owl	M	LC			√	x
24.	ზარნაშო	Bubo bubo	Eurasian Eagle Owl	M	LC				x

25.	უფეხურა	*Caprimulgus europaeus*	European Nightjar	M	LC		√	√	x
26.	ოფოფი	*Upupa epops*	Common Hoopoe	M	LC		√		x
27.	ყაპყაპი	*coracias garrulus*	European Roller	BB, M	LC				x
28.	ალკუნი	*Alcedo atthis*	Common Kingsfisher	YR-R, M	LC				x
29.	ოქროსფერი კვირიონი	*Merops apiaster*	European bee-eater	BB, M	LC				x
30.	ჩვეულებრივი მექვიშია	*Actitis hypoleucos*	Common Sandpiper	BB	LC				x
31.	რუხი წერო	*Grus grus*	Common Crane	BB, M	LC	EN	√	√	x
32.	თეთრი ყარყატი	*Ciconia ciconia*	White Stork	YR-R, M	LC	VU			1
33.	რუხი ყანჩა	*Ardea cinerea*	Grey Heron	YR-R	LC				x
34.	ქარცი ყანჩა	*Ardea purpurea*	Purple Heron	BB, M	LC				x
35.	დიდი თეთრი ყანჩა	*Ardea alba*	Great White Egret	YR-V	LC				x
36.	მცირე თეთრი ყანჩა	*Egretta garzetta*	Little Egret	YR-R	LC				x
37.	ღამის ყანჩა	*Nycticorax nycticorax*	Black-crowned Night-Heron	BB, M	LC		√		x
38.	ტბის თოლია	*Chroicocephalus ridibundus*	Common Black-headed Gull	YR-R, M	LC				x
39.	სომხური თოლია	*Larus armenicus*	Armenian Gull	YR-R	NT				x
40.	დიდი ჩვამა	*Phalacrocorax carbo*	Great Cormorant	YR-R, M	LC				x
41.	დიდი კოკონა	*Podiceps cristatus*	Great Crested Grebe	YR-R, M	LC				x
42.	მცირე კოკონა	*Tachybaptus ruficollis*	Little Grebe	YR-R, M	LC				x
43.	ქათამურა	*Porzana porzana*	Spotted Crake	YR-R, M	LC		√		x
44.	მცირე ქათამურა	*Porzana parva*	Little Crake	M	LC		√		x
45.	პაწაწა ქათამურა	*Porzana pusilla*	Baillons Crake	BB, M	LC		√		x
46.	წყლის ქათამურა	*Gallinula chloropus*	Common Moorhen	YR-R, M	LC				x
47.	ლაინა	*Rallus aquaticus*	Water Rail	YR-R, M	LC				x
48.	ღალღა	*Crex crex*	Corn crake	BB,M	LC				x
49.	ნამგალა	*Apus apus*	Common Swift	BB	LC				x

50.	მწვანე კოდალა	*Picus viridis*	Eurasian Green Woodpecker	YR-R	LC		√		x
51.	დიდი ჭრელი კოდალა	*Dendrocopos major*	Greater Spotted Woodpecker	YR-R	LC		√		1
52.	საშუალო ჭრელი კოდალა	*Leiopicus medius*	Middle Spotted Woodpecker	YR-R	LC				x
53.	მცირე ჭრელი კოდალა	*Dryobates minor*	Lesser Spotted Woodpecker	YR-R	LC		√		x
54.	მინდვრის ტოროლა	*Alauda arvensis*	Eurasian Skylark	M	LC				x
55.	ქოჩორა ტოროლა	*Galerida cristata*	Crested Lark	M	LC				x
56.	რქოსანი ტოროლა	*Eremophila alpestris*	Horned (or Shore) Lark	YR-R	LC		√		x
57.	ტყის ტოროლა	*Lullula arborea*	Wood Lark	M	LC				x
58.	დიდი მოკლეთითა ტოროლა	*Calandrella brachydactyla*	Greater Short-Toed Lark	BB,M	LC		√		x
59.	მცირე მოკლეთითა ტოროლა	*Calandrella rufescens*	Lesser Short-Toed Lark	BB,M	LC				x
60.	სოფლის მერცხალი	*Hirundo rustica*	Barn Swallow	BB,M	LC		√		1
61.	ქალაქის მერცხალი	*Delichon urbicum*	Northern Hause-Martin	YR-V	LC		√		x
62.	კლდის მერცხალი	*Hirundo rupestris*	Eurasian Crag-martin	BB	LC		√		x
63.	მენაპირე მერცხალი	*Riparia riparia*	Sand Martin	BB,M	LC				1,2,3,4
64.	თეთრი ბოლოქანქარა	*Motacilla alba*	White Wagtail	YR-R	LC		√		x
65.	რუხი ბოლოქანქარა	*Motacilla cinerea*	Grey Wagtail	M	LC		√		x
66.	ყვითელი ბოლოქანქარა	*Motacilla flava*	Yellow Wagtail	M	LC		√	√	x
67.	ყვითელთავა ბოლოქანქარა	*Motacilla citreola*	Citrine Wagtail	BB,M	LC		√		x
68.	შავშუბლა ღაჟო	*Lanius minor*	Lesser Grey Shrike	M	LC		√	√	x
69.	ჩვეულებრივი ღაჟო	*Lanius collurio*	Red-backed Shrike	BB,M	LC		√		x
70.	მიმინოსებრი ასპუჭაკა	*Sylvia nisoria*	Barred Warbler	BB	LC		√		x
71.	შავთავა ასპუჭაკა	*Sylvia atricapilla*	Blackcap	BB	LC		√		x
72.	ჩვეულებრივი ბოლოცეცხლა	*Phoenicurus phoenicurus*	Common Redstart	BB,M	LC		√		x
73.	ჩვეულებრივი ბულბული	*Luscinia megarhynchos*	Common Nightingale	BB	LC		√		x
74.	შაშვი	*Turdus merula*	Eurasian Blackbird	YR-R	LC		√		1
75.	წრიპა შაშვი (მგალობელი	*Turdus philomelos*	Song Thrush	M	LC		√		x

	შაშვი)								
76.	ჩხართვი	*Turdus viscivorus*	Mistle Thrush	M	LC		√		x
77.	თოხიტარა	*Aegithalos caudatus*	Long-tailed Tit	YR-R	LC		√		x
78.	გულწითელა	*Erithacus rubecula*	European Robin	BB	LC		√		x
79.	დიდი წივწივა	*Parus major*	Great Tit	YR-R	LC		√		1
80.	მოლურჯო წივწივა	*Parus caeruleus*	Blue Tit	YR-R	LC				x
81.	მცირე წივწივა	*Parus ater*	Coal Tit	YR-R	LC				x
82.	ჩვეულებრივი მგლინავა	*Certhia familiaris*	Eurasian Tree-creeper	M	LC		√		x
83.	ჭინჭრაქა	*Troglodytes troglodytes*	Winter Wren	YR-R	LC		√		3
84.	წყლის შაშვი	*Cinclus cinclus*	White-throated Dipper	YR-R	LC				1
85.	მეფეტვია	*Miliaria calandra*	Corn Bunting	BB	LC				x
86.	კლდის გრატა	*Emberiza cia*	Rock Bunting	YR-R	LC		√		1,2
87.	სკვინჩა	*Fringilla coelebs*	Eurasian Chaffinch	YR-R	LC				x
88.	ჩიტბატონა	*Carduelis carduelis*	European Goldfinch	YR-R	LC		√		1
89.	მწვანულა	*Carduelis chloris*	European Greenfinch	YR-R	LC		√		x
90.	მინდვრის ბეღურა	*Passer montanus*	Tree Sparrow	M	LC				x
91.	სახლის ბეღურა	*Passer domesticus*	Hause Sparrow	YR-R	LC				x
92.	მოლაღური	*Oriolus oriolus*	Eurasian Golden Oriole	M	LC		√	√	x
93.	ჩხიკვი	*Garrulus glandarius*	Eurasian Jay	YR-R	LC				1,3,4
94.	ყორანი	*Corvus corax*	Common Raven	YR-V	LC		√		1,4
95.	რუხი ყვავი	*Corvus corone*	Hooded Crow	YR-R	LC				x
96.	ჭკა	*Coloeus monedula*	Eurasian Jackdaw	YR-R	LC				x
97.	კაჭკაჭი	*Pica pica*	Black-billed Magpie	YR-R	LC				1
98.	გაზაფხულა ჭივჭავი	Phylloscopus trochilus	Willow Warbler	BB	LC		√		x
99.	ჩვეულებრივი ჭივჭავი	Phylloscopus collybita	Common Chiffchaff	BB	LC				x
100.	ჭვინტა (მეკანაფია)	*Carduelis cannabina*	Eurasian Linnet	BB	LC		√		x
101.	თეთრწარბა (ანუ მდელოს) ოვსადი	*Saxicola rubetra*	Whinchat	BB	LC		√	√	x
102.	შავთავა ოვსადი	*Saxicola torquatus*	African stonechat	BB	LC		√		x
103.	კლდის ჭრელი შაშვი	*Monticola saxatilis*	Rock-Thrush	BB	LC		√		x

104.	კლდის ლურჯი შაშვი	*Monticola solitarius*	Blue Rock-Thrush	BB	LC				1
105.	სტვენია	*Pyrrhula pyrrhula*	Eurasian Bullfinch	M	LC				x
106.	რუხი მემატლია	*Muscicapa striata*	Spotted Flycatcher	BB, M	LC		√		x
107.	ჩვეულებრივი მეღორღია	*Oenanthe oenanthe*	Northern wheatear	BB, M	LC		√		x
108.	შავყურა მეღორღია	*Oenanthe hispanica*	Black-eared Wheatear	YR-R, M	LC				2
109.	ტყის მწყერჩიტა	*Anthus trivialis*	Tree Pipit	BB	LC				x
110.	მდელოს მწყერჩიტა	*Anthus pratensis*	Meadow Pipit	BB	NT		√		x
111.	წითელგულა მწყერჩიტა	*Anthus cervinus*	Red-Throated Pipit	M	LC		√		x
112.	მინდვრის მწყერჩიტა	*Anthus campestris*	Tawny Pipit	BB, M	LC		√		x

Period of seasonal presense of species on the given territory:
YR-R = Year-round resident; breeder, present throughout the year**; YR-V =** Year-round visitor; non-breeder, present throughout the year**; BB =** Breeding bird; breeder, absent during non-breeding period**; M =** Migrant; bird of passage; present primarily in fall and spring
IUCN – categories are formulated as follows**:**
EX – Extinct**; EW –** Extinct in the Wild**; CR –** Critically Endangered**; EN –** Endangered**; VU – V**ulnerable**; NT –** Near Threatened**; LC –**Least Concern**; DD –** Data deficient**; NE –** Not Evaluated

4.2.4.3.7 Reptiles and Amphibians

Reptiles: the study region is not distinguished by diversity of reptiles and endemism. Following reptiles inhabit on the study area: sand lizard *(Lacerta agilis)*, Spiny-tailed lizard *(Darevskia rudis)*, Armenian lizard *(Darevskia armeniaca)*, Caucasian rock lizard *(Darevskia valentini)*, Caucasian agama *(Paralaudakia caucasia).* Only four snake species are observed there: grass snake *(Natrix natrix)* , dice snake *(Natrix tessellata),* smooth snake *(Coronella austriaca)* and Transcaucasian ratsnake *(Zamenis hohenackeri).*

Spiny-tailed lizard *(Darevskia rudis)*, Caucasian agama *(Paralaudakia caucasia),* smooth snake *(Coronella austriaca),* and Transcaucasian ratsnake *(Zamenis hohenackeri)* were observed in Korkhistskali River valley during the foeld surveys of May 2019.

It should be noted that dice snake *(Natrix tessellata)* E 371839 N 4590757 was observed in Paravani River valley and grass snake *(Natrix natrix)* E 372070 N 4592034 – in Korkhistskali River valley, but unfortunatelly, we could not their photographing.

Fig. 4.2.5.3.7.1. Spiny-tailed lizard *(Darevskia rudis) (Darevskia rudis)*
E-371763 N-4591446

Fig. 4.2.5.3.7.2. Caucasian agama *(Paralaudakia caucasia)*
E-371728 N-4591440

Fig. 4.2.5.3.7.3. Smooth snake *(Coronella austriaca)*
E-371825 N-4591479

Fig. 4.2.5.3.7.4. Transcaucasian ratsnake *(Zamenis hohenackeri)* E-371610 N-4591276

Amphibians: following amphibians are observed: marsh frog *(Pelophylax ridibundus),* Shelkovnikov's Tree Frog *(Hyla orientalis)*, green toad *(Bufotes viridis)* and long-legged wood frog *(Rana macrocnemis).*

Marsh frog *(Pelophylax ridibundus)* was observed during the ield survey of May 2019 in Paravani River valley.

Fig. 4.2.5.3.7.5. Marsh frog *(Pelophylax ridibundus)* E-372097 N-4587608 (Paravani River -May; 2019)

Table 4.2.5.3.7.1. Species of the survey territory provided in the literary sources and observed during the field surveys

N	English name	Latin name	IUCN	RLG	Bern Conv.	Observed (Habitat types - 1-4) not observed X
1.	Grass snake	*Natrix natrix*	LC	LC	√	x
2.	Dice snake	*Natrix tessellata*	LC	LC	√	x
3.	Smooth snake	*Coronela austriaca*	LC	LC	√	1
4.	Transcaucasian ratsnake	*Zamenis hohenackeri*	LC	LC		1
5.	Spiny-tailed lizard	*Darevskia rudis*	LC	LC		1
6.	Sand lizard	*Lacerta agilis*	LC	LC	√	x
7.	Armenian lizard	*Darevskia armeniaca*	LC	LC		x
8.	Caucasian rock lizard	*Darevskia valentini*	LC	LC		x
9.	Caucasian agama	*Paralaudakia caucasia*	LC	LC		2
10.	Marsh frog	*Pelophylax ridibundus*	LC	LC	√	1
11.	European tree frog	*Hyla arborea*	LC	LC	√	x
12.	Green toad	*Bufotes viridis*	LC	LC	√	x
13.	Long-legged wood frog	*Rana macrocnemis*	LC	LC	√	x
IUCN – categories are formulated as follows: **EX –** Extinct; **EW –** Extinct in the Wild; **CR –** Critically Endangered; **EN –** Endangered; **VU – V**ulnerable; **NT –** Near Threatened; **LC –**Least Concern; **DD –** Data deficient; **NE –** Not Evaluated						

4.2.4.3.8 Invertebrates (Invertebrata)

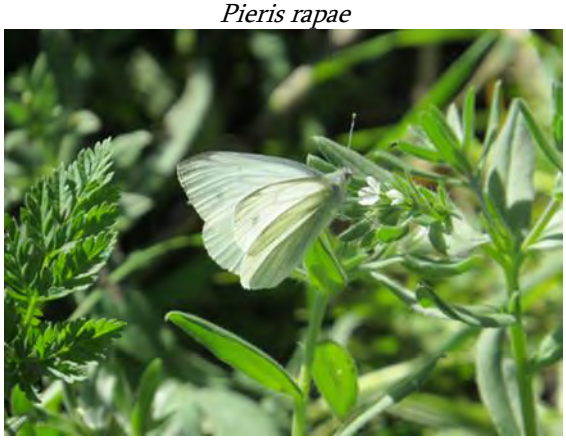
Fauna of invertebrates is based on the literary review and the field survey results (November 2018; May 2019). Aim of the implemented field survey was to identify invertebrates inhabiting within the project impact zone and to determine their habitats.

Insects in the literary sources: *Nordmannia ilicis* butterfly, *Mylabris quadripunctata* beetle, *Mylabris variabilis* beetle, *Dorcus parallelipipedus* lesser stag beetle, *Libellula depressa* broad-bodied chaser,

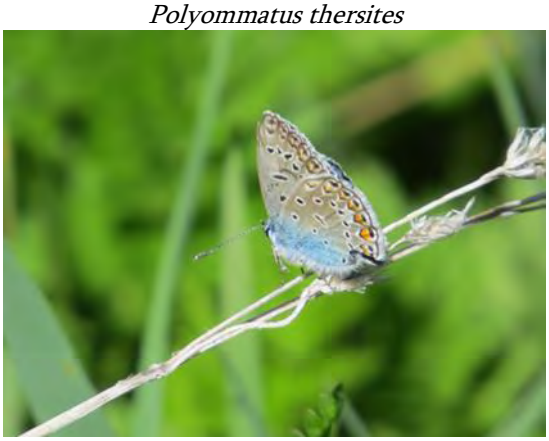
Morimus verecundus beelte, *Pieris napi* green-veined white, *Pieris rapae* cabbage white, *Papillio machaon* Old World swallowtail, *Plebeius argus* silver-studded blue, Cupido alcetas short-tailed blue, *Erynnis tages* dingy skipper, *Nimphalis antiopa* mourning cloak, *Lampyris noctiluca* common glow-worm, *Geotrupes spiniger* earth-boring dung beetle, *Diplolepis mayri galls* gall-inducing wasp, *Purpuricenus budensis* longhorn beetle, *Polyommatus amandus* Amanda's blue, *Polyommatus corydonius* false chalkhill blue, *Polyommatus thersites* Chapman's Blue, *Cercopis intermedia* froghoppers *Armadillidium vulgare* pill-bug, *Lithobius forficatus* brown centipede, *Vanessa atalanta* red admiral, *Vanessa cardui* painted lady, *Mantis religiosa* European mantis, *Ischnura elegans* blue-tailed damselfly, *Eulasia chrysopiga* beetle , *Xylocopa valga* carpenter bee, *Inachis io - European peacock, Issoria lathonia Queen of Spain fritillary, Panorpa connexa* - scorpion-flies, *Pieris ergane* mountain small *white, Apis melifera* western honey bee, *Bombus lapidarius* - red-tailed bumblebee, *Microlophium carnosum* - common nettle *Aphid, Aphis urticata* - dark green nettle aphid, *Rhynocoris iracundus* - true bugs, *Pieris napi* - green-veined white,, *Pieris brassicae* - cabbage butterfly, *Pyrrhocoris apterus* - firebug, *Lymantria dispar* - gypsy moth, *Gryllus campestris* - field crickets, *Decticus verrucivorus* - wart-biter, *Tettigonia viridissima* -great green bush-cricket, *Mantis religiosa* - European mantis, *Ischnura elegans* - blue-tailed damselfly, *Eulasia chrysopiga, Xylocopa valga* - carpenter bee, *Cercopis intermedia* froghoppers, *Nocarodes serricollis, Meloe proscarabaeus* - European oil beetle, *Ocypus picipennis,* Capnodis cariosa, *Armadilium sp.* - pill bugs, *Eulasia chrysopiga, Dorcus parallelipipedus* lesser stag beetle, *Cataglyphis sp.* - desert ants, *Chrysolina gypsophila* leaf beetle, *Saga ephippigera* bush crickets, *Palpares libelluloides* -ant, *Myrmecaelurus trigrammus, Creoleon lugdunensis, Polistes dominula European paper wasp, Stenopterus rufus - round-necked longhorns, sceliphron caementarium* black and yellow mud dauber, *Agalmatium bilobum, Apodiphus amygdali* - bug, *Bolivaria brachyptera, Oecanthus pellucens* - Italian tree cricket, *Paederus sp. Small beetles, Reduvius sp., nymph* masked hunter, *Rhynocoris iracundus* - thread-legged bugs, *Leptidea sinapis* - wood white butterfly, *Anthocharis cardamines* -orange tip, *Euchloe ausonia* - eastern dappled white, *Zegris eupheme* - sooty orange tip, *Aporia crataegi* - black-veined white

Insects detected during the survey of May 2019:

Pieris rapae



Polyommatus thersites



Vanessa cardui

Malacosoma castrensis

Spiders: *Misumena vatia, Pisaura mirabilis, Lycosoides coarctata, Oecobius navus, Alopecosa schmidti, Trochosa ruricola, Araneus diadematus, Micrommata virescens, Diaea dorsata, Agelena labyrynthica, Pellenes nigrociliatus, Asianellus festivus, Araniella dispcliata, dysdera crocata, Phialeus chrysops, Thomisus onustus, Xysticus bufo, Alopecosa accentuara, Argiope lobata, Menemerus semilimbatus, Pardosa hortensis, Larinioides cornutus, Uloborus walckenaerius Mangora acalypha, Evarcha arcuata, Agelena labyrinthica, Gnaphosa sp, Heliophanus cupreus, Linyphiidae sp., Parasteatoda lunata, Synema globosum, Tetragnatha sp, Philodromus sp., Pisaura mirabilis, Runcinia grammica.*

4.2.4.4 Fish Fauna

In June 11, 2019 hydro-biological-ichtyological group of Gamma Consulting LTD carried out the field survey works for the EIA report of the designing HPPs – the River Paravani – Akhalkalaki – 1 and the River Korkhistskali – Akhalkalaki – 2. Survey works included study of the river hydro flora and fauna state, as well as hydrochemical and hydrobiological-ichtyological surveys.

4.2.4.4.1 Survey Objectives and Tasks

Objective of the field survey was to study baseline condition of hydrobiological-ichtyological environment of Paravani and Korkhistskali Rivers and to assess the impact expected during the construction/operation process of the HPPs. Appropriate plan was set for this purpose:

- Survey of the river water quality – content of dissolved oxygen (mg/l), pH, temperature (water and air), content of suspended particles (mg/l);
- Study of fish fauna food base that implies research works of phyto and zoo benthos;
- Obtainment of ichtyological material upstream and downstream of the project territories – works imply fishing with a cast net and rods;
- Survey-analysis of the obtained ichtyological material;
- Visual audit – marking/detecting sensitive (critical) locations for fish species;
- Survey of population or/and local fishers to obtain additional information on fish species and number of their populations in the project rivers;
- Development of mitigation measures for critical sections according to the implemented works results.

4.2.4.4.2 Survey Methodology

Survey of fish fauna includes: desktop and field works, visual audit and obtainment of biological material, its processing and study, as well as survey results analysis and assessment.

4.2.4.4.2.1 Desktop Study

Plan of the field surveys was developed; assumed list of fish species distributed through the project section was made as to the literary sources; presumable locations of fishing and sites of hydrochemical-hydrobiological samples were determined; geographical coordinates of presumable control points were identified and appropriate cartographic materials were prepared.

We also obtained statuses of protection based on the International Union for Conservation of Nature: https://www.iucnredlist.org and the Red List of Georgia.

Fish statuses granted by the Red list of Georgia are taken by the following document – Decree №190 of the GoG on approval of the Red list of Georgia, dated as February 20, 2014; Tbilisi.

4.2.4.4.2.2 Field Survey Methodology

Complex survey method of fish fauna includes the following:

- Obtainment of ichtyological material;
- Species identification of the material;
- Study of the fish food base, hydroflora and hydrofauna;
- Identification of aquatic macroinvertebrates and feeding insects;
- Study of the habitat – ecological environment.

Following is applied for description of obtained fish:

- Digestive organs were studied for the survey of fish food base;
- Dissolved oxygen (O_2 mg/l), water and air temperatures, pH are determined by a special tool (AZ-86021 combo pH/EC/DO meter) to identify the fish fauna living environment during the field surveys. Water samples (1l) are taken to determine suspended particles in water (mg/l); samples are tested in a stationary laboratory.

4.2.4.4.2.3 Fishing Methodology

Getting of ichtyological material used to carry out within the river project sections, as well as upstream and downstream of the weirs. Following principle was used for fishing: fish fauna species that are presumably distributed in the project rivers, their habitats, diet and all biological behavior features were described based on the desktop works. Based on this information, fishing tools, types of fishing baits, time and locations of fishing were determined.

Cast net (weight 7,0 kg, knot size-14 mm) and rods were used for fishing.

Earthworms and other worms using by local fishers were used for bait.

As it was mentioned, a fisherman was guided by the presumable fish habitat, which were determined on site.

Data were registered in a special field register book, each specimen was numbered.

4.2.4.4.2.4 Survey Methodology of Fish Food Base

Papers of the Scientific Research Institute of Russia - ТРУДЫ ВНИРО, 2015 г. Том 156, Водные биологические ресурсы were used for the fish food base survey methodology.

In addition, fish food base is studied as follows: invertebrates are recorded on 1 m2 area on the river bottom; later they are weighed and their approximate amount through the project territory is

determined based on the obtained results; species composition of periphyton – the lowest plants are observed on the stones and boulders and their live biomass (kg/ha) is assessed.

4.2.4.4.2.5 Visual Audit

Visual audit implies description of habitat for certain species of fish fauna (general hydrological characteristics of the study rivers, habitat's hypsometry, relief, riverbed hypsometry, visual-landscape background), based on which general characterization of fish species inhabiting within the project rivers and in their tributaries is available.

4.2.4.4.2.6 Interview Methodology

Fishermen with at least 5-10 year fishing experience are selected for interviewing in order to get comprehensive results. Questionnaire is made in a way that facts of falsification to be reduced at maximum (see Table 4.2.4.4.2.6.1.). Information confirmed by three or more persons is deemed as reliable.

Table 4.2.4.4.2.6.1. Questions for anamnesis

1. What fish species are mainly obtained in the rivers Paravani and Korkhistskali?
2. Which fishing tools are used?
3. What amount and size of fish can be obtained in these rivers?
4. What baits are used by local fishermen?
5. Does fishing have the commercial purpose?
6. Is water level permanently same or does it change due to various reasons?

4.2.4.4.2.7 Laboratory Survey Methodology

Lab works include survey of fish scale and determination of suspended particles (mg/l).

Fish age research methodology as to the scale is performed by the literary source - Правдин И.Ф. 1966. Руководство по изучению рыб. М.: Пищ. Пром-сть. 105 с., where age determination method is described in detail. Identification of a fish age, growth and growth rate is available by its scale.

Suspended particles (mg/l) are determined in the accredited laboratory of the scientific-research firm "Gamma", according to the ISO 11923-97 standard.

4.2.4.4.3 Desktop Study

Modern literary data on fish fauna of the rivers Paravani and Korkhistskali are quite poor and the existing literature is outdated: „Барач Г.П. (сост.) Фауна Грузии. Том 1. Рыбы пресных вод. Из-во АН грузии. Тбилиси. 1941 г." A few monitoring results were used to determine the current baseline condition of fish fauna species composition:

- Materials of fish fauna monitoring of the Paravani HPP, I stage, March 23-26, 2015;
- Paravani HPP – monitoring of impact on icthyofauna (Stage III – intermediate report);
- Data of the monitoring works of Paravani HPP performed by ICEIA - „Aquatic Monitoring Report 2016" (http://paravanihpp.ge/reports.html).

According to the mentioned sources and materials obtained during the field survey, information on fish fauna species inhabiting in Paravani and Korkhistskali Rivers, their spawning periods and the protection status is given in the Table 4.2.4.4.3.1.

Table 4.2.4.4.3.1. Species inhabiting within the project impact zone and their protection status

##	Scientific name	Georgian name	English name	Status in Georgia*	IUCN status	Spawning period	Species obtained during the field survey	
							Paravani Riv.	Korkhistskali Riv.
1	*Salmo trutta morfa fario* (Linnaes,1758)	ნაკადულის კალმახი	Trout	VU (Ald)	NE	Breeds from September to February. Mostly in October-November;	+	+
2	*Barbus lacerta* (Heckel, 1843)	მტკვრის წვერა	Kura barbell	-	NE	Breeds in April-August	+	+
3	*Luciobarbus mursa* (Guldenstadt, 1773) (=*Barbus mursa* (Guldenstadt, 1773))	მურწა	Murtsa	-	NE	May-June	-	-
4	*Capoeta capoeta* (Guldenstadt, 1773)	ხრამული	Khramulya, Transcaucasian barb	-	NE	Spawns for several times, from the end of April to October.	-	-
5	*Capoeta capoeta sevangi* (De Filippi, 1865)	სევანის ხრამული	Sevan Khramulya	-	NE	May-July;	-	-
6	*Squalius cephalus* (Linnaeus, 1758) = (*Leuciscus cephalus orientalis* (Nordmann, 1840))	კავკასიური ქაშაპი	Chub, Skelly	-	LC	May-August	-	+
7	*Alburnoides bipunctatus* (Bloch,1782)	ჩვეულებრივი მარდულა, სწრაფულა	Schneider	-	-	May-September	+	+
8	*Neogobius (Ponticola) constructor* (Nordmann, 1840)	მდინარის კავკასიური ღორჯო	Caucasian river goby	-	LC	May-June	-	-
9	*(Carassius gibelio* (Bloch, 1782)) = *(Carassius auratus gibelio* (Bloch, 1782))	კარჩხანა	Crucian carp	-	LC	May-September	-	-
10	*Leuciscus leuciscus* (Linneus, 1758)	ჩვეულებრივი ქაშაპი	Common dace	-	LC	May-September	+	+
11	- *Barbatula brandtii* Kessler,1877	მტკვრის გოჭალა	Kura loach	-	LC	May-August	+	+
12	*Alburnus hohenackeri* Kessler, 1877	ამიერკავკასიური თაღლითა	North Caucasian bleak	-	LC	May-August	-	+
13	*Rutilus rutilus kurensis* Berg, 1932	მტკვრის ნაფოტა	Kura roach	-	-	Breeds in various seasons depending on location from March to June	-	+

- VU– Vulnerable taxon;
- LC - Least Concern);
- NE - Not Evaluated.

4.2.4.4.4 Field Surveys

4.2.4.4.4.1 Description of Riverbeds

4.2.4.4.4.1.1 Paravani River

Paravani River originates from the lake of the same name. After about 12 km it joins Saghamo Lake and finally joins Mtkvari River at Khertvisi village on the territory of Aspindza municipality.

Paravani River flows in U-shape valley through the project section. The riverbed is variable and is about 30 m at the headwork, 10-12 m – at the middle reaches and 15 m – at the design powerhouse. Depth of the river varies from 0,25-0,35 m to0,6-0,8 m, which does not restrict migration of fish fauna (0,2 m is the lower limit). Average velocity of the river varies from 0,8 m/s to 1,0 m/s.

Whirlpools and rapids are observed in the river that is stipulated by the fast flow and presence of average and large boulders in the riverbed.

In frames of the survey, several sites of rockfall from the cliffs was observed at the left bank.

In the project section, a small river – Akhalkalakis Tskali joins Paravani river from the left side (X= 372133.45; Y= 4587622.60; H= 1626 m, asl); the river water will add to the environmental flow (see Figure 4.2.4.4.4.1.1.1.).

Figure 4.2.4.4.4.1.1.1 Meeting section of the rivers Paravani and Akhalkalakis Tskali

It is noteworthy that:

- As it was mentioned, a small stream (Akhalkalakis Tskali) joins the river Paravani downstream of the design power house;
- A pumping station is functioning on the left bank of the river in the project corridor; this station supplies the nearby settlements with Paravani River water.

4.2.4.4.4.1.2 Korkhi River

Korkhistskali River flows in a single 20-25 m and then 6-10 m width meandering channel from the head to the powerhouse (generator room) site. River depth is averagely 0.2-0.5 m. Due to the riverbed morphology, its mean velocity varies from around 1 m/s to 3 m/s.

There are lots of stones and boulders of average size on the bottom in the narrow sections of the valley, they presumably occurred there due to the rockfall process from the riverbank cliffs; rapids are observed in the low water area.

The left tributary – a brook collecting ground waters was observed on the site that will add to the environmental flow (X= 371807.28; Y= 4591057.01; H= 1595 m, asl.); See Figure 4.2.4.4.4.1.2.1.

Figure 4.2.4.4.4.1.2.1. Groundwater collector brook

4.2.4.4.4.2 Sensitive Sections

The riverbed geomorphological and hydrological conditions are definitely significant for migration of fish species, feeding cycle and spawning sites.

"Sensitive points" are the geo-morphologically complicated sections of the river, where extremely narrow channels blocked with large boulders, rapids and waterfalls or wide and low water channels are observed. Such sections are barriers for spawning or feeding migration and they will become more problematic on the HPPs operation phase, when considerable part of the natural flow is diverted into the diversion system.

According to the visual audit results conducted at the project section of Korkhistskali River, 5 critical points were identified; while none of similar points were detected on Paravani River, due to its riverbed, landscape and relatively slow flow. On the HPPs operation phase, in case of the river water level reduction on these sections, fish migration will be hampered with high probability and feeding areas will be reduced as well. Based on this, implementation of effective mitigation measures will be essential, including calculation of minimum environmental flow with consideration of existing conditions. Brief description of critical points is provided in the Table 4.2.4.4.4.2.1., Map 4.2.4.4.4.2.1.

Figure 4.2.4.4.4.2.1. Map of critical points of Korkhistskali River project section

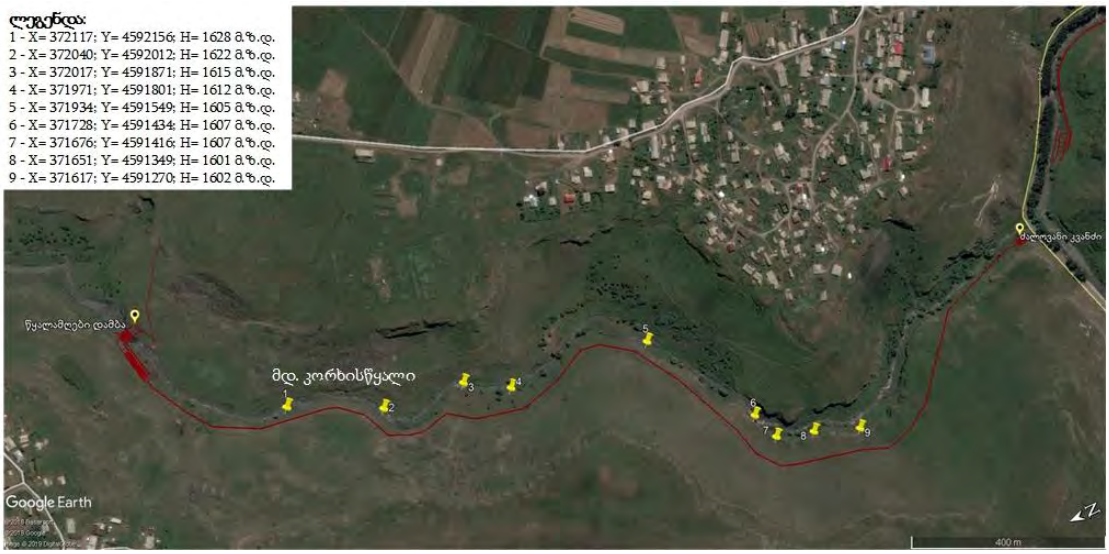


Table 4.2.4.4.4.2.1. Critical points on Korkhistskali River

№ 1	X= 372117.27; Y= 4592156.63; H= 1628 m.a.s.l.
Small islands and stones-boulders are observed in the riverbed. Releasing of the environmental flow may cause diffusion of water flow in the river branches. In case of the rockfall, the riverbed can be blocked.	
№ 2	X= 372040.94; Y= 4592012.99; H= 1622 m.a.s.l.
A large island in the river splits the water flow in two branches; due to this, the water depth won't be sufficient for fish migration on the operation phase. Apart from the island, large and medium boulders are also observed there that is presumable caused by rockfall.	
№ 3	X= 371934.34; Y= 4591549.36; H= 1605 m.a.s.l.
A large island is formed that splits the river flow in two parts; water level is quite low and even the stones on the bottom can be seen. In case of releasing environmental flow, water yield may be unable to provide fish migration.	
№ 4	X= 371728.57; Y= 4591434.86; H= 1608 m.a.s.l.
The riverbed is blocked by large and medium size boulders and is quite narrow. This section is still a significant obstacle for fish migration. In case of water flow reduction, fish migration will be totally restricted.	

№ 5	X= 371651.64; Y= 4591349.84; H= 1601 m.a.s.l.
Small islands and stone-boulders are observed in the riverbed; this will create a barrier for fish migration in case of releasing environmental flow.	
To facilitate the migration of fish to critical points, one of the important mitigation measures, by each HPP staff, is to monitor the donor bed and adjust the flow if necessary to create the required thickness (at least 30 cm) of water. Manually clean the bed if necessary. The introduction of equipment into the riverbed is not advisable to prevent the destruction of algae and zoobenthic organisms.	

4.2.4.4.4.3 Fishing Results

Fishing had been carried out along the project sections of Paravani and Korkhistskali rivers. Rods and a cast net were used. List of obtained ichtyological material and coordinates are provided in the Tables 4.2.4.4.4.3.1 and 4.2.4.4.4.3.2; while the fish catching locations are presented on the Figures 4.2.4.4.4.3.1. and 4.2.4.4.4.3.2.

Figure 4.2.4.4.4.3.1. Map of fishing on Paravani River

Figure 4.2.4.4.4.3.2. Map of fishing on Korkhistskali River

Table 4.2.4.4.4.3.1. Fish species obtained on Paravani River

- Bleak (Alburnoides bipunctatus (Bloch,1782)) - 2 specimens;
- Common chub (Squalius cephalus Linnaeus,1758) - 1 specimen;
- Common dace (Leuciscus leuciscus Linnaeus,1758) - 1 specimen;
- Kura loach (Barbatula brandtii Kessler 1877) - 5 specimens
- Kura barbell (Barbus lacerta (Heckel, 1843)) - 7 specimens
- Brook trout (Salmo trutta morfa fario (Linnaes,1758)) - 1 specimen

Table 4.2.4.4.4.3.2. Species obtained on Korkhistskali River

№ 1 X= 372360.06; Y= 4592332.50; H= 1636 m, asl

№ 2 X= 372363.84; Y= 4592336.13; H= 1637 m, asl

№ 3 X= 372047.28; Y= 4592016.89; H= 1628 m, asl

№ 4 X= 372016.55; Y= 4591867.50; H= 1628 m, asl

№ 5 X= 371874.49; Y= 4591497.98; H= 1607 m, asl

№ 6 X= 371798.61; Y= 4591458.60; H= 1607 m, asl

№ 7 X= 371666.82; Y= 4591329.21; H= 1596 m, asl.

№ 8 X= 371661.41; Y= 4591311.73; H= 1596 m, asl

№ 9 X= 371658.28; Y= 4591305.61; H= 1596 m, asl


№ 10 X= 371640.71; Y= 4591256.87; H= 1596 m, asl


№ 11 X= 371646.47; Y= 4591202.17; H= 1595 m, asl


Fish species detected upstream of Korkhistskali River project section are noteworthy, in particular: 5 specimens of Kura loach and 1 specimen of North Caucasian bleak, they were caught by local juveniles (see Figure 4.2.4.4.4.3.3.).

Figure 4.2.4.4.4.3.3. Fish species obtained by juveniles

Totally 41 specimens of 8 species were obtained during the expedition of June 2019:

- Common bleak (Alburnoides bipunctatus (Bloch,1782)) – 3 specimens;
- Common chub (Squalius cephalus Linnaeus,1758) - 2 specimens;
- Common dace (Leuciscus leuciscus Linnaeus,1758) – 2 specimens;
- Kura loach (Barbatula brandtii Kessler 1877) - 16 specimens;
- Kura barbel (Barbus lacerta (Heckel, 1843)) - 11 specimens
- Brook trout (Salmo trutta morfa fario (Linnaes,1758)) - 3 specimens;
- North Caucasian bleak (*Alburnnus hohenackeri* Kessler, 1877) - 3 specimens;
- Kura roach (Rutilus rutilus kurensis Berg, 1932) - 1 specimen;

It should be noted that quite a large brook trout (about 30 cm long) was caught in Paravani River.

Table 4.2.4.4.4.3.3. Survey results of specimens obtained in Paravani River

Date	Location coordinates and surrounding territories	number (pcs)	Fish species
11.06.2019	X= 372118; Y= 4587698; H= 1621 m, asl.	1	Common dace *Leuciscus leuciscus* Linnaeus,1758
		1	Common chub *Squalius cephalus* Linnaeus,1758
	X= 372072; Y= 4587964; H= 1634 m, asl.	4	Kura barbel *Barbus lacerta* (Heckel, 1843)
	X= 372034; Y= 4588180; H= 1632 m, asl..	1	Kura barbel *Barbus lacerta* (Heckel, 1843)
	X= 372024; Y= 4588221; H= 1628 m, asl.	2	Kura barbel *Barbus lacerta* (Heckel, 1843)
	X= 372002; Y= 4589188; H= 1615 m, asl..	3	Kura loach *Barbatula brandtii* Kessler 1877
	X= 372033; Y= 4589603; H= 1616 m, asl..	2	Kura loach *Barbatula brandtii* Kessler 1877
	X= 372099; Y= 4590365; H= 1591 m, asl.	2	Bleak *Alburnoides bipunctatus* (Bloch,1782)
	X= 371860; Y= 4590725; H= 1572 m, asl.	1	Brook trout *Salmo trutta morfa fario* Linnaes, 1758

Table 4.2.4.4.4.3.4. Survey results of specimens obtained in Korkhistskali River

Date	Location coordinates and surrounding territories	number (pcs)	Fish species
11.06.2019	X= 372360.06; Y= 4592332.50; H= 1636 m, asl.	1	Kura roach Rutilus rutilus kurensis Berg, 1932
	X= 372363.84; Y= 4592336.13; H= 1637 m, asl..	1	Brook trout *Salmo trutta morfa fario* Linnaes, 1758
		1	Common dace *Leuciscus leuciscus* Linnaeus,1758
	X= 372047.28; Y= 4592016.89; H= 1628 m, asl.	1	Kura loach *Barbatula brandtii* Kessler 1877
	X= 372016.55; Y= 4591867.50; H= 1628 m, asl..	1	North Caucasian bleak *Alburnnus hohenackeri* Kessler, 1877
	X= 371874.49; Y= 4591497.98; H= 1607 m, asl..	1	Kura loach *Barbatula brandtii* Kessler 1877
	X= 371798.61; Y= 4591458.60; H= 1607 m, asl..	1	Brook trout *Salmo trutta morfa fario* Linnaes, 1758
	X= 371666.82; Y= 4591329.21; H= 1596 m, asl..	1	Bleak *Alburnoides bipunctatus* (Bloch,1782)
		3	Kura loach *Barbatula brandtii* Kessler 1877
		2	Kura barbel *Barbus lacerta* (Heckel, 1843)
	X= 371661.41; Y= 4591311.73; H= 1596 m, asl.	1	Kura barbel *Barbus lacerta* (Heckel, 1843)
	X= 371658.28; Y= 4591305.61; H= 1596 m, asl..	1	North Caucasian bleak *Alburnnus hohenackeri* Kessler, 1877
	X= 371640.71; Y= 4591256.87; H= 1596 m, asl..	1	Kura barbel *Barbus lacerta* (Heckel, 1843)
		1	Common chub *Squalius cephalus* Linnaeus,1758
	X= 371646.47; Y= 4591202.17; H= 1595 m, asl..	1	Kura loach *Barbatula brandtii* Kessler 1877

4.2.4.4.4.3.1 Brief Biological Description of Fish Species Inhabiting in the Project Rivers

Brook trout (Salmo trutta morfa fario Linnaes, 1758)

Species: Brook trout

Family: Salmonidae

Genus: Salvelinus

Latin name: Salmo trutta morfa fario

Type: Freshwater form

Way of life: pelagic

Diet: Semi predator

Length 20-40 cm, weight - 100-200 g, it lives up to 12 years. Brook trout inhabits upstream of rapid, cold rivers; it achieves maturity from 2-4 years; breeds from September to February; mainly in October-November; it spawns in fast flowing low water, stony, sandy areas; fertility achieves 200-2000 spawns.

Brook trout feeds on benthos, insects fallen into the water, small fishes and spawn.

It is spread throughout Georgia, in mountain rivers, rarely in lowland rivers as well.

Kura barbel - *Barbus lacerta* (Heckel, 1843) - Kura barbell

Length 50 cm., weight 1 kg. Commonly smaller ones are observed. It is a benthobelagic, freshwater fish. Kura barbell is characterized with sexual dimorphism – female is bigger by 3-4 times than male. Female

achieves maturity in the age of 3, while male – in the age of 2. Breeding period lasts from April to August. Fertility achieves 24000 spawns.

It feeds on benthos and partly with algae.

It is observed in freshwaters, in Georgia, namely: in Mtkvari river and in its tributaries. Small amount of Kura barbell can be found in lakes and reservoirs.

Mursa - *Luciobarbus mursa* (Guldenstadt, 1773) (=*Barbus mursa* (Guldenstadt, 1773)) – Murtsa

Length 40 cm., weight 0,5 kg., smaller ones are mostly observed. Mursa achieves maturity in the age of 2-3; It spawns in May-June; Fertility achieves from 3000 to 23000 spawns.

Mursa mainly feeds on water insects and their larvae, Crustaceans and organic debris.

In Georgia Mursa inhabits in Mtkvari River basin, it can be observed all along the river, in fast flows and stony-sandy areas.

This species is endemic of Transcaucasia.

Caucasian scraper - *Capoeta capoeta* (Guldenstadt, 1773)

Length 50 cm., weight 2,5 kg., Caucasian scraper grows faster in lakes and reservoirs than in rivers. It well adapts to the fast flows and cold water. It achieves maturity in different ages in various water bodies. Amount of spawn depends on the age; male achieves maturity in the third year, female – 4-5 years old; fertility achieves from 6000 to 30000 in rivers; 90000 – in lakes and reservoirs; it spawns for several times in a year, from the end of April to October.

Caucasian scraper feeds on algae, organic debris and zoobenthos.

It can be observed almost everywhere in the rivers of Eastern Georgia. it has the commercial purpose. It is known with the names of "Pichkhuli" and "Tsotskhali".

Sevan Khramulya - *Capoeta capoeta sevangi* (De Filippi, 1865) – Sevan Khramulya

Maximum length of body - 68 cm., weight 2,5 kg., Maximum age 16. Sevan Khramulya is a freshwater fish, it prefers cold and fast river flow. It inhabits in the rivers, as well as in the lakes. Males achieve sexual maturity in the age of 4-6, females – 9; it breeds in about 0,5 m depth in lakes, it spawns on stony-sandy bottom in rivers, in May-July; fertility achieves 10000 – 70000 spawns.

Sevan Khramulya feeds on algae and organic debris.

In Georgia it is distributed in the lakes of Paravani and Saghamo, in waters of Akhalkalaki. This species is released in Tabatskuri Lake, Khrami, Tbilisi, Tkibuli reservoirs. it is also observed in Aras basin, Lake Sevan and in its tributaries.

It is one of the commercial fish species in Georgia.

Common chub - *Squalius cephalus* (Linnaeus, 1758) (= *Leuciscus cephalus orientalis* (Nordmann, 1840) – Chub, Skelly

Length 50 cm., weight 1,5 kg., As usual, small specimens are observed. It achieves maturity in the age of 2-3; it breeds from May to August; fertility achieves 15000-150000 spawns. Common chub is a fresh water fish, it inhabits in stony-sandy areas. It feeds on animal, as well as plant food.

It is distributed in almost all rivers, lakes and reservoirs in Georgia.

Common dace - Leuciscus leociscus (Linnaeus, 1758)

Length - 45 cm., weight - 1,5 kg., rarely larger and heavier specimens can be observed as well. Common dace achieves sexual maturity in the age of 2-3; it spawns from May to September, in stony-sandy areas;

its fertility achieves 4000 – 125000 spawns. It is a freshwater fish. It can easily adapt to the river, as well as the lake environment.

It feeds on animal, as well as plant food, fishes, their spawn, frogs, water insects, their larvae and algae.

It is distributed in almost all rivers, lakes and reservoirs in Georgia.

Kura loach Barbatula brandtii (Kessler,1877)

Length – up to 8,5 cm, weight- 4,5 g., Kura loach spawns from May to August; fertility achieves 3000-5000 spawns. In inhabits in the middle and upper reaches of the rivers, prefers stony-sandy areas rich in algae. It rarely inhabits in reservoirs and lakes.

Kura loach feeds on plankton, benthos and fish spawn.

In Georgia it is observed in Mtkvari and its tributaries, as well as in Lake Jandari, in Paldo, Tbilisi and Sioni reservoirs.

North Caucasian bleak - Alburnus hohenackeri Kessler, 1877

Maximum length 13,5, average length 10 cm, weight 28 g., it is a freshwater fish. It inhabits in slow, as well as in fast flows. North Caucasian bleak mostly stay in bottom layers, it can be observed in lakes and reservoirs. it spawns from May to August; its fertility achieves 500-7050 spawns.

North Caucasian bleak mostly feeds on plankton.

It inhabits in the rivers: Alazani, Iori, Mtkvari.

Endemic of Transcaucasia.

Kura roach - Rutilus rutilus kurensis Berg, 1932

Length 37 cm, weight 550 g., rarely achieves even 700 g. Kura roach achieves maturity in the age of 2-6; it spawns various periods depending on location, from March to June; Fertility achieves 1000-55000 spawns. It is a migratory, school fish. Kura roach spends majority of time in a sea, spawns in rivers.

Fries mainly feed on plankton, crustaceans, cladocera, Copepods; Juveniles specimens feed on mollusks, crustaceans and chrysalis of mayflies.

Kura roach is distributed in the rivers Mtkvari, Khrami, Iori, Alazani; in Tbilisi reservoir and lake Jandari.

It is endemic of Caucasus.

It is the significant trade fish.

Bleak - *Alburnoides bipunctatus* (Bloch,1782) – Schneider

Length 17 cm., commonly 8-10 cm., weight 100-150 g., mostly smaller ones are observed. Bleak achieves maturity in 2 years; it spawns on stony-sandy ground from May to September; fertility achieves 500-600 spawns. It prefers sluggish river sections.

Bleak feeds on zoobenthos, plankton and algae.

Bleak is distributed almost everywhere in rivers of the Eastern Georgia. it is a low value fish. It is a rival of trade fish species in feeding and spawning areas. Due to overcrowding, it has commercial purpose in some water bodies, for example, in Lake Paravani and Alazani River.

Bleak is included in the third annex of the Bern Convention (protected fauna).

Crucian carp - *Carassius gibelio* (Bloch, 1782)

Maximum length 45 cm., weight 1-3 kg., average length 15-20 cm., weight 500-600 g. Crucian carp inhabits in freshwater and saline waters, in 5 m depth. It achieves maturity in the age of 4; fertility is about 300000 spawns; it spawns for several times.

Young fish specimens feed on plankton, while adults – plant and animal food.

Crucian carp is distributed throughout Europe. It is introduced in many countries, including in Georgia. it negatively impacts on aquatic ecosystems (it is a rival of fish in feeding and spawning areas).

Caucasian river goby - *Neogobius (Ponticola) constructor* (Nordmann, 1840)

Main features of body are similar to its basic species. Color is dark brown; males become black color during breeding. Length is 15 cm, weight 35 g.

Diet: Caucasian river goby feeds on benthos and plankton.

Reproduction: it achieves maturity in the age of 3-4, it breeds in May-June, spawns under stones as the grouped rows, about 250-1500 spawns.

Habitat and way of life: Caucasian river goby is a fresh water form. It mainly inhabits in the middle and upper reaches of rivers, it prefers stony-sandy bottom in rapid rivers.

It is observed in all rivers of Georgia.

4.2.4.4.4.4 Survey of Fish Habitat

Water quality has been tested by a field combined tool (AZ-86021 combo pH/EC/DO meter) to characterize the aquatic environment; in particular, dissolved oxygen (O_2 mg/l), pH, water and air temperature was determined.

Based on the analysis of water samples of Paravani River conducted on 11th of June, 2019, following was identified:

- Amount of dissolved Oxygen (O_2) - 9,1 mg/l;
- pH – 8,73;
- Water temperature + 17,9^0 C;
- Ambient air temperature + 25° C;

Based on the analysis of water samples of Korkhistskali River conducted on 11th of June, 2019, following was identified:

- Amount of dissolved Oxygen (O_2) - 9,8 mg/l;
- pH – 7,5;
- Water temperature +17,4^0 C;
- Ambient air temperature + 23° C;

Based on the received results, ecological environment of the rivers is quite satisfactory for requirements of hydrobionts.

Water sampling process is provided on the Figure 4.2.4.4.4.4.1.

Figure 4.2.4.4.4.4.1 Water hydrochemical survey procedure

4.2.4.4.4.5 Survey of Fish Food Base

In frames of the field surveys, obtained specimens – algae and zoobenthos organisms were identified. Amount of food base was quite sufficient for predator fish species, as well as for phytobenthos feeding species; as it was mentioned, ecological environment of both rivers is favorable for inhabiting of fish species.

Photo material of hydrobionts obtained as a result of visual observetionis provided in the Tables 4.2.4.4.4.5.1. and 4.2.4.4.4.5.2.

Table 4.2.4.4.4.5.1. Observed zoobenthos organisms

№1 Caddisfly - Trichoptera

№2 Epeorus

№3 Caddisfly - Trichoptera

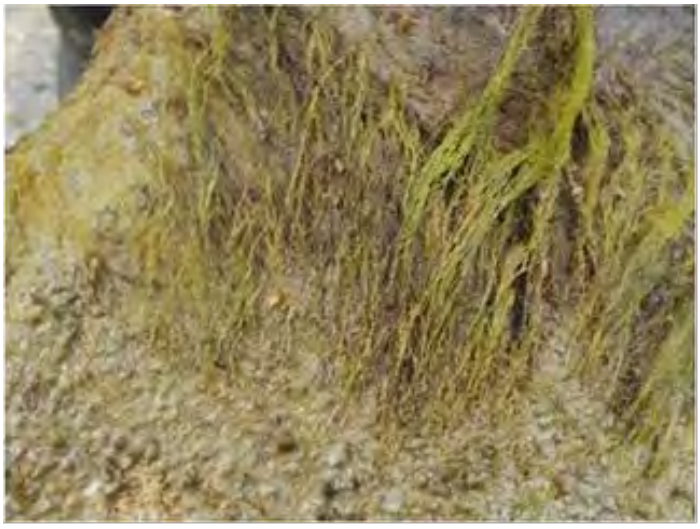
№4 Caddisfly - Trichoptera

Table 4.2.4.4.4.5.2. Periphyton organisms observed during the survey

№1 Algae of the river bank line

№2 Algae of the river bank line

№3 Colony of filamentous algae



Observed periphyton and zoobenthos organisms are given on the Diagram 4.2.4.4.4.5.1

Diagram 4.2.4.4.4.5.1 List of algae and benthos invertebrates observed within the study area

Algae

- *Rhizoclonium;*
- *Ulotrix zonata;*
- *Cladophora sp.*

Invertebrates

- Earthworms- Oligochaeta;
- Roundworms - Nematoda;
- Ostracods - Ostracoda;
- Mayflies - Ephemeroptera;
- Caddisflies- Trichoptera

4.2.4.4.4.6 Laboratory Study

Suspended solid particles (mg/l) was determined by the accredited laboratory of the scientific-research firm "Gamma".

Based on the survey results, suspended solid particles in Paravani River was 26.7 mg/l; in Korkhistskali River - 38.7 mg/l.

River water quality – hydrochemical and physical features was in full compliance with the habitat of fish species during the field surveys.

4.2.4.4.4.7 Anamnesis

4 local residents were interviewed during the expedition of June 11, 2019. They are: Dato Domelishvili and Misha Khutsishvili, the third person did not disclose his identity.

Figure 4.2.4.4.4.7.1. Process of interview on Paravani River

On Korkhistskali River one more interviewee was Ilia Nikogosyan.

Figure4.2.4.4.4.7.2. Ilia Nikogosyan – interviewed on Korkhistskali River

Table 4.2.4.4.4.7.1. Interview results

1. Mainly, the same fish species can be caught in Paravani and Korkhistskali rivers; they are as follows: trout (brook and lake), chub, Khramulya, Mursa. We have not caught any other fish species in these rivers.
2. we basically use a rod for fishing, because using a net is impossible in these rivers due to the landscape.
3. We used to catch more and larger fish until the HPP had been constructed. There was a case of catching even 12 kg trout.
4. We mainly use earthworms for fishing, because fish prefer this bait.
5. No, fish is obtained for private consumption and not for commercial purposes. In addition, fish amount is not sufficient for selling.

6. Water level reduced after construction of Paravani HPP. Seasonally, water level decreases even more, especially, in autumn and winter.

According to the locals, same fish species are distributed in Paravani and Korkhistskali Rivers. They also noted that water level and amount of fish was even more until Paravani HPP had been constructed. At present, the HPP uses the whole water that entailed reduction of fish species. Besides the water level reduction due to anthropogenic impact, seasonal fluctuation of water level also negatively influences over the fish fauna.

As to the local population, fishing is available only with a rod and using of other tools (e.g. net) is impossible due to the bed morphology. They also talked about the fish quality and noted that they have caught 5-6 kg and even 12 trout* in the past.

***Note:** Interviewees might imply a lake trout; unlike a brook trout it grows larger and it might occur in the project rivers from Paravani or Saghamo lakes.

4.2.4.4.4.8 Fish Pass Recommended for Headworks of the Design HPPs

For all specific projects, the type of fishway should be determined taking into account the hydrological regime of the project rivers and geomorphological conditions of the headworks locations, as well as fish fauna species inhabiting in the rivers.

The so-called pool pass (stepped pools) type fishways are mainly used on dams of HPPs operating in Georgia. The bypass channel type fishway is a structure that is close to the natural conditions, and is therefore more efficient than other types of structures. The appropriate topographic and geomorphological conditions are necessary for arranging this type of structure, in particular: Sufficient area and relatively quiet terrain slopes are necessary to allow for a suitable width and incline channel for fish movement. As for the pool pass type fishway, it does not require a large area and is arranged in the lower reaches of the dam in the riverbed.

Below is a comparative description of these two types of fishways.

Table 4.2.4.4.4.8.1. Comparative characterization of pool pass and bypass channel type fishways

Type	Advantages	Disadvantages
Bypass channel type fishway	• Passing species have the opportunity to avoid the dam; • Bypass channel is conducive to all kinds of barriers (dam / weir) and pressure (dam height); • In the case of the bypass channel, small fish and benthic invertebrates can migrate and exist; • New habitats are being created, especially for reef populations of the secondary biotype; • Are characterized by a reduced tendency for contamination and clogging, are reliable and require less maintenance; • Blends well with the natural landscape;	• Requires a large amount of free space - the channel can be extended to cover a large area; • It is sensitive to upstream level variability and may require the construction of additional intakes (fishway outlet); • Connecting to downstream often requires technical intervention; • May require deep digging of the terrain or a combination of other technical structures – bridge or underground passages that may make the project more expensive.
Pool pass (stepped pools) type fishway	• Under certain conditions, it can be arranged for all fish species; • Provides migration for both well-floating and small-scale fish species; • Uneven seabed can be arranged, leaving space for seabed representatives to allow them to move; • Operates even at relatively low water flow; Preference is given to a water flow interval of 0.05 m^3 / sec - 0.5 m^3 / sec under normal difference between the normal dimensions of the holes and the water levels.	• The fishway should be specially arranged taking into account the fish species and sizes; In this case, the size and stability of the water flow are of great importance. Fishes, given the species and size, will only be able to cross the fishway only in case of species-specific water flow; • High risk of clogging orifices with sediments; • High maintenance requirements.

According to the results of the project site location audit, the Akhalkalaki 1 HPP headworks is planned to be located within the narrow valley of Paravani River. The left bank is steep and rocky, and the highway runs in the immediate vicinity of right bank. In view of the above, there is no possibility of arrangement of bypass channel type fishway and therefore the decision was made to arrange pool type fishway.

On the section selected for the headworks of Akhalkalaki 2 HPP, coastal slopes of Korkhi River have flat terrain (especially on the left bank of the river) and are suitable for arranging the bypass channel type fishway. Accordingly, a decision was taken to build a bypass channel at the Akhalkalaki 2 HPP headworks.

4.2.4.4.5 Fish Excluders

According to the Article 14 (fish protection requirements in a water intake structure) of the Technical regulation on "Fishing and Fish Stock Protection" approved by the Decree №190, of February 20, 2014 of the GoG, "water intake structures with no less than 5000m^3 daily water withdrawal must be equipped with fish excluders-equipment.

Various methods are used to prevent fish occurrence into the water intake structure. Following ones are relatively well-known:

- Filtration method of fish protection;
- Separation method of fish pass;
- Method based on airlift effect;
- Impact method with light;
- Impact method with electric current;
- Acoustic impact method;
- Hydraulic impact method.

Filtration method is basically used for intakes of hydrotechnical structures in Georgia, which implies installation of a small grating in front of a water intake. As a rule, the so called "trash rack" – large grating is installed on the intake, behind of which a grating with small openings is installed that significantly reduces fish occurrence in the pressure system. Disadvantage of this method is that it is less effective in terms of protection of small fries. Consequently, the smaller size of openings is the more effectiveness of the protective grating is. However, in such case, permanent cleaning of the grating front surface from suspended sediments is required to prevent hindering of water supply to the water intake.

Considering the mentioned issue, arrangement of the protective gratings at the design headwork intake is planned.

According to the monitoring results within the first 3 years after commissioning of the HPPs, other method of fish excluding can be used if necessary, for example, airlift or acoustic method.

4.2.5 Protected Areas

Pursuant to the Law of Georgia "On Establishment and Management of Javakheti Protected Areas", Javakheti Protected Areas are the constituent part of the Georgian protected areas and are divided into the following categories:

- Javakheti National Part;
- Kartsakhi Managed Reserve;
- Sulda Managed Reserve;
- Khanchali Managed Reserve;
- Bughdasheni Managed Reserve;

- Madatapa Managed Reserve;
- Javakheti Multi Purpose Use Area (additional zone).

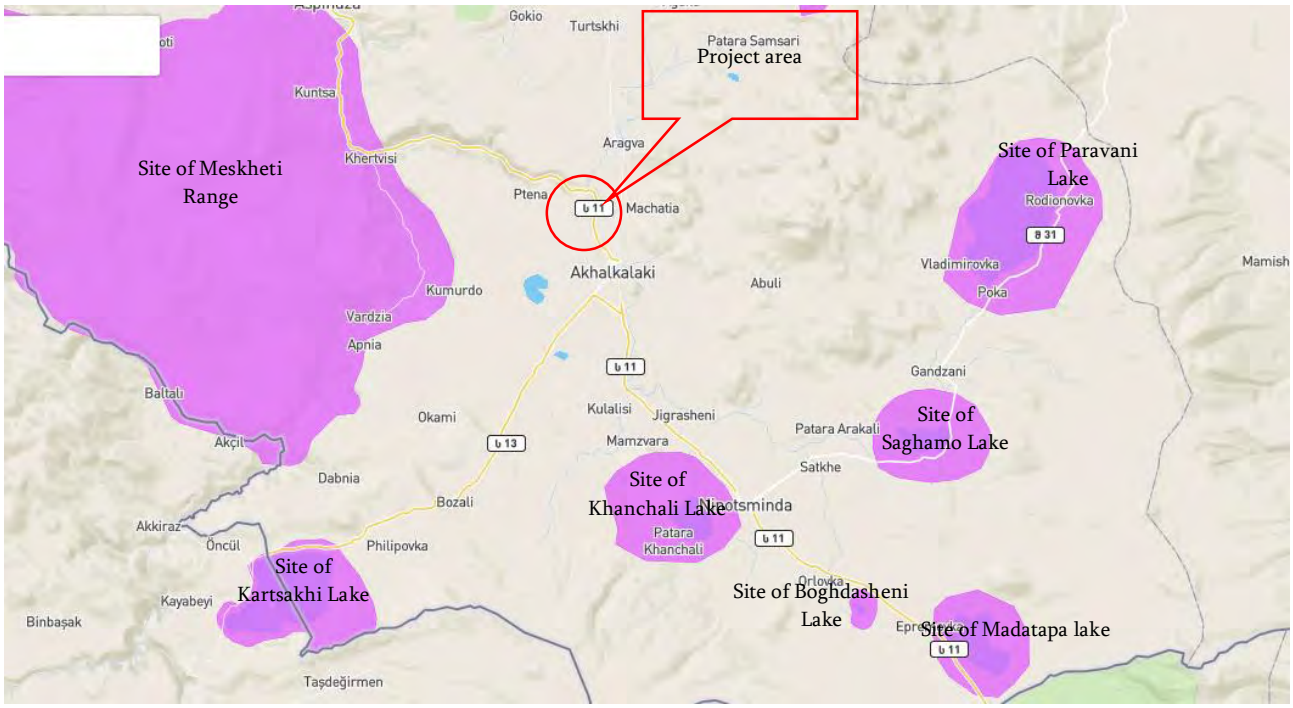
None of them are located no more than 16 km close to the project area. Emerald Network Candidate Sites (the nearest one – "Ktsia-Tabatskuri - GE0000038"and Khanchali - GE0000017") are in 16 km or more distance from the targeted area.

One of the most significant birds' migration routes runs through Javakheti Plateau, which is flied over by much less number of birds compared to Batumi migration route. However, these two routes don't differ from each other by species diversity. Considering the significance of the migration corridor, Important Bird and Biodiversity Areas (IBA) are singled out on Javakheti Plateau, among them the closest sites to the project area are as follows:

- Site of Meskheti Range (total area - 82828 ha). It is located to the west of the project area in 13 km and more distance. This site is identified as Important Bird and Biodiversity Area (IBA) based on the following issues:
  - Significant inhabiting area for endangered species in the worldwide;
  - Significant populations of endemic species, known only in limited areas;
  - Gathering area of one or more bird species at a certain period of their life cycle or during seasonal migration. Significant bird species are as follows: *Clanga clanga*, *Aquila heliacal, Falco naumanni.*
- Site of Paravani Lake (total area - 5830 ha). (To the east of the project area in 23 km or more distance. This site is identified as Important Bird and Biodiversity Area (IBA), as it represents gathering area of one or more bird species at a certain period of their life cycle or during seasonal migration. Significant bird species are as follows: *Crex crex,* waterfowls.
- Site of Saghamo Lake (total area - 857 ha). (To the east of the project area in 21 km or more). This site is identified as Important Bird and Biodiversity Area (IBA), as it represents gathering area of one or more bird species at a certain period of their life cycle or during seasonal migration. Significant bird species are as follows: *Crex crex,* waterfowls.
- Site of Khanchali Lake (total area - 2580 ha). (To the south of the project area, in 16 km or more). This site is identified as Important Bird and Biodiversity Area (IBA), as it represents gathering area of one or more bird species at a certain period of their life cycle or during seasonal migration and significant habitat of globally endangered species; significant bird species are: *Crex crex, Pelecanus crispus.*
- Site of Kartsakhi Lake (total area - 3618 ha). (To the south of the project area, in 26 km or more). This site is identified as Important Bird and Biodiversity Area (IBA), as it represents gathering area of one or more bird species at a certain period of their life cycle or during seasonal migration and significant habitat of globally endangered species; significant bird species are: *Crex crex, Pelecanus crispus.* Water birds

Colocation of the project area and Important Bird Areas is provided on the Figure 5.7.1.

Figure 4.2.5.1. Colocation of the project area and Important Bird Areas (IBA) (marked in pink).



Birds' migration route doesn't pass through the project area. Based on the figure, IBA territories are quite far from the project implementation area. Despite this, all those bird species that fly through the migration route can occur in the study area during spring-autumn migration period. But, it should be noted, that in frames of the preliminary survey, landscapes (e.g. lakes), where migrating species can concentrate, were not found through the impact area. Most part of the project corridor borders the territories of high anthropogenic loading, which additionally stipulates the lack of habitats of vulnerable migrating birds.

Considering the above mentioned issues, the project corridor of the design HPPs and the ETL infrastructure doesn't cross the areas protected by local legislation and international conventions and consequently, direct impact is not expected in this regard. The project doesn't need impact assessment on the Candidate Sites.

4.3 Socio-Economic Environment

4.3.1 General Overview

Project implementation is planned in Samtskhe-Javakheti region, on the territory of Akhalkalaki municipality. Surrounding territories of Diliska, Orja and Korkhi villages of Akhalkalaki municipalities will be under the project impact zone.

Samtskhe-Javakheti region includes 6 municipalities: Adigeni, Aspindza, Akhaltsikhe, Akhalkalaki, Borjomi and Ninotsminda. Akhalkalaki municipality is situated on Javakheti plateau, in the central part of the Southern Georgia volcanic plateau, altitude of which varies between 1500-3300 m above the sea level. Area of Akhalkalaki municipality is 123567 ha that is 19,3% of the entire territory of the region. Most territory of the municipality is stretched on the mountainous plateau.

Municipality includes 65 settlements: 1 town, 64 villages. The local self-governing highest body is the City Assembly. Territorial management units are: 1 city – Akhalkalaki and 15 communities – Azavreti, Alastani, Aragva, Baraleti, Gogasheni, Vachiani, Zakvi, Kartikami, Kartsakhi, Kochio, Kumurdo, Okami, Sulda, Khaveti, Khospio. 6 villages – Diliska, Kotelia, Ptena, Turtskhi, Chunchkha, Khando.

Diliska village is situated to the north-west of Akhalkalaki, on the left bank plateau of Paravani River at 1700 m asl. Diliska village is situated in 2 km distance from Akhalkalaki and the village is connected to this town with the asphalted road. Significant part of inner roads of the village is also asphalted. Akhalkalaki Municipal Cleaning Service carries out removal of household wastes in an organized way.

Korkhi village is situated upstream of the confluence of Paravani and Korkhistskali rivers, on Akhalkalaki plateau, at the altitude of 1660 m asl. The village is included in Aragva community. Korkhi village is situated 5.5 km distance from Akhalkalaki. Orja village locating on the right bank of Korkhistskali River, at the altitude of 1680 m asl, is also included in Aragva community. It is situated 9 km distance from Akhalkalaki. Korkhi and Orja villages are connected to Akhalkalaki with the asphalted roads.

4.3.2 Population and Demography

Number of population of Samtskhe-Javakheti region is 155,9 thousand persons, according to the official data of 2019. Akhalkalaki municipality is the most densely populated from the administrative units of the region. Table 4.3.2.1. provides population distribution of Georgia and Samtskhe-Javakheti administrative units according to years.

Table 4.3.2.1. Distribution of population according to administrative units (thousands persons)

Region, self-governing unit	2010	2011	2012	2013	2014	2015	2016	2017	2018
Georgia	3,799.8	3,773.6	3,739.3	3,718.4	3,716.9	3,721.9	3,728.6	3,726.4	3,729.6
Samtskhe-Javakheti	169.7	167.3	165.0	163.1	161.7	160.3	158.7	157.2	155.9
Adigeni municipality	17.1	16.9	16.7	16.6	16.5	16.5	16.4	16.4	16.3
Aspindza municipality	10.8	10.7	10.6	10.5	10.4	10.4	10.5	10.5	10.5
Akhalkalaki municipality	47.8	47.1	46.4	45.8	45.4	44.8	44.2	43.5	42.9
Akhaltsikhe municipality	40.4	40.0	39.6	39.2	39.1	22.9	22.8	22.7	22.6
Borjomi municipality	27.4	26.8	26.3	25.9	25.5	25.4	25.3	25.3	25.2

(Source www.geostat.ge)

Population of Samtskhe-Javakheti region is diverse in terms of ethnic viewpoint, Georgians, Armenians and Azerbaijanians live in the region. Information on gender distribution of population is provided in the Table 4.3.2.2.

Table 4.3.2.2. Gender indicator

	Total	Male	Female
Diliska village	160	85	74
Korkhi village	446	210	236
Orja village	519	260	259

(Source www.geostat.ge)

As to the state of 2018, population of Akhalkalaki municipality is 42,9 thousands persons based on the data of National Statistics Office of Georgia. As it was mentioned above, there are 65 settlements in the municipality, including 1 town and 64 villages. Number of population of Akhalkalaki town is 8295, out of them 3912 are males and 4383 – females. Population distribution in the region and Akhalkalaki municipality, according to the social status is provided in the Table 5.3.2.3.

Table 4.3.2.3. Distribution of population according to their social status (thousands person)

	Number of population	Recipient of pension package	Recipient of social package	Recipient of livelihood
Samtskhe-Javakheti region	155,9	29,753	6,254	11,456
Akhalkalaki municipality	42,9	7,423	1,278	1,598

(Source www.ssa.gov.ge)

4.3.3 Agriculture

Agriculture is the leading field of economics in Akhalkalaki municipality, almost full majority of population is involved in this occupation. Fruit-growing is less developed in the municipality and population is mainly involved in vegetable-farming. They basically grow potato, its average productivity is 18 ton on 1 ha. They also grow: cabbage, carrot, beet, radish, pepper, green tomato, cucumber, marrow, pumpkin.

Information on involvement of local population in the agricultural activity is given in the Table 4.3.3.1.

Table 4.3.3.1. involvement of local population in the agricultural activity (thousand person)

	Less than 25 years old	25-34	35-44	45-54	55-64	65 years old and more
Georgia - total	6.195	32.160	74.555	139.744	164.993	224.562
Samtskhe-Javakheti	337	2260	4610	8615	9199	10965
Akhalkalaki municipality	80	678	1180	2330	2419	2802

Animal husbandry – is one of the leading fields in Akhalkalaki municipality. Grassland-pasture area is 3119 thousands ha. Locals are involved in farming of cattle and small ruminants. Information on natural pastures and grasslands is given in the Table 4.3.3.2.

Table 4.3.3.2. Natural grasslands-pastures

	Natural grasslands-pastures (ha)
Georgia	300004
Samtskhe-Javakheti	46742
Akhalkalaki municipality	3119

(Source www.geostat.ge)

Information on private and leased land plots of the region and municipality locating under the project impact zone is provided in the Table 4.3.3.3.

Table 4.3.3.3. Lease and ownership of arable land plots

	Leased land plots (thousands ha)	Private land plots (ha)
Georgia	107 464	73482
Samtskhe-Javakheti	20 427	57706
Akhalkalaki municipality	4 432	12 905

(Source www.geostat.ge)

Both males and females participate in agricultural activity. Detailed information on gender indicators is provided in the Table 4.3.3.4.

Table 4.3.3.4. Gender indicators in agriculture

	Male	Female
Georgia	443.763	198.446
Samtskhe-Javakheti	25 648	10 338
Akhalkalaki municipality	6 872	2 617

(Source www.geostat.ge)

4.3.4 Economics

Main economic field of the municipality is agriculture, as well as retail and wholesale trade, food manufacturing. Industry is poorly developed; main economic field is food industry. Railway line

(Marabda-Akhalkalaki) passes through the territory of the municipality, it was linked to the border point Kartsakhi in 2018 and connected the railways of Georgia and Turkey.

4.3.5 Healthcare and Education

Following health care facilities are presented in the municipality: central medical hospital – Evex, Diagnostic / Outpatient Clinic – HEMA; primary care centers are functioning in the villages; there are 25 dental clinics and 2 emergency crews in the municipality.

As for the education, getting full general education is available in all villages of the region. There are 67 public and private schools in Akhalkalaki municipality, among them 1 – in Korkhi village, 2 – in Diliska village and one – in Orja village. 67 school libraries and preschool facilities are available in the municipality.

4.3.6 Infrastructure

Length of the road network is about 410 km in Akhalkalaki municipality, including 42 km Akhalkalaki-Armenia border road of international importance and 34 km Akhalkalaki-Kartsakhi road to the border of Turkey. Natural gas, potable water, electricity and satellite internet connection are available for local population.

4.3.7 Socio-Economic Survey Results Conducted within the Project Impact Zone

Survey of local population according to the questionnaire prepared in advance was conducted in June 2019. Purpose of the survey was to study socio-economic state of population of the settlements locating in the vicinities Akhalkalaki HPP project territories. Survey was carried out in the following settlements of Akhalkalaki municipality: Akhalkalaki, Diliska village, Korkhi village and Orja village.

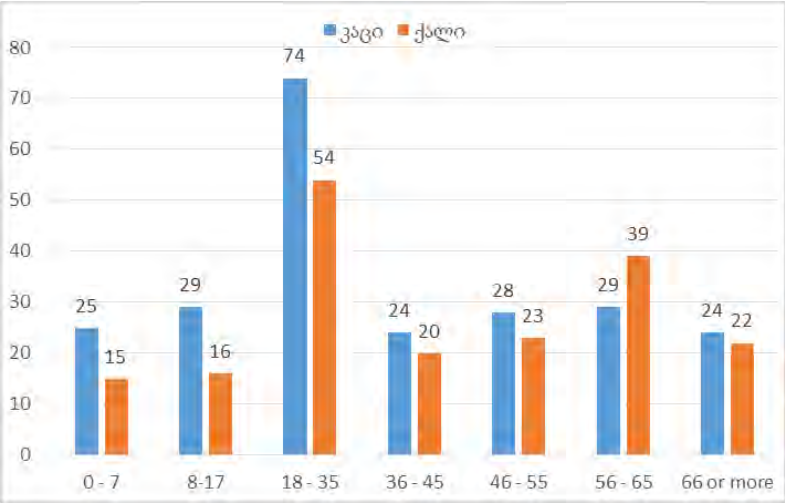
422 respondents were interviewed during the survey. Information on population is provided in the Table 4.3.7.1.

Table 4.3.7.1. Information on population

Number of surveyed households	Average number of family members of surveyed households	Number of surveyed persons	Number of surveyed males %	Number of surveyed females %
101	4	427	237	191

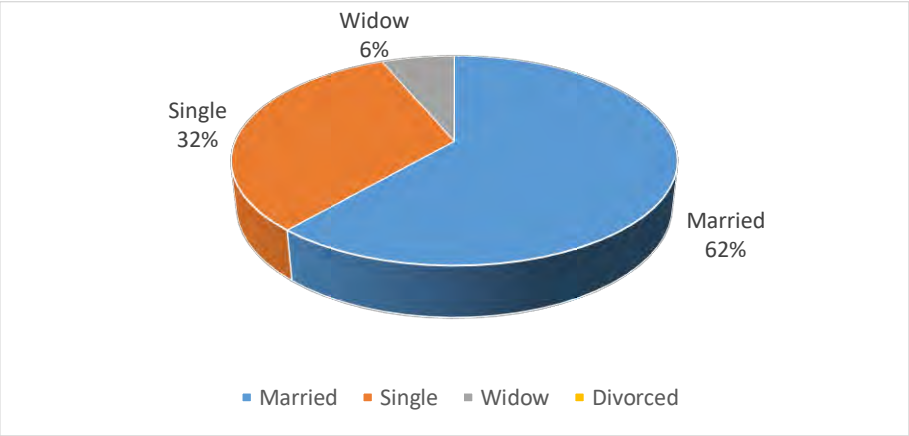
20% of surveyed population is up to 18 years old, 53% - up to 19-55, 27% - 56-65, while 11% - more than 66 years old. Percentage distribution of surveyed population according to their age and gender is given on the Diagram 4.3.7.1.

Diagram 4.3.7.1. Percentage distribution of population according to their age and gender



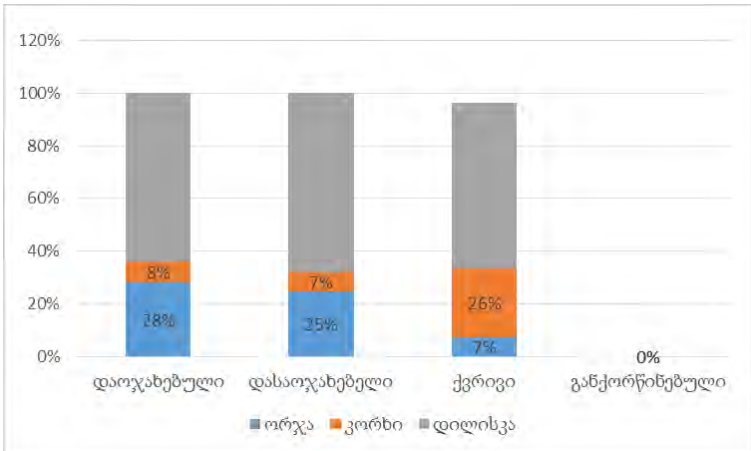
As for the marital status, none of the respondents was divorced, 6% - widow, 32% - single and 61% - married. Detailed information according to percentage indicators is given on the Diagram 4.3.7.2.

Diagram 4.3.7.2. Marital status of surveyed population



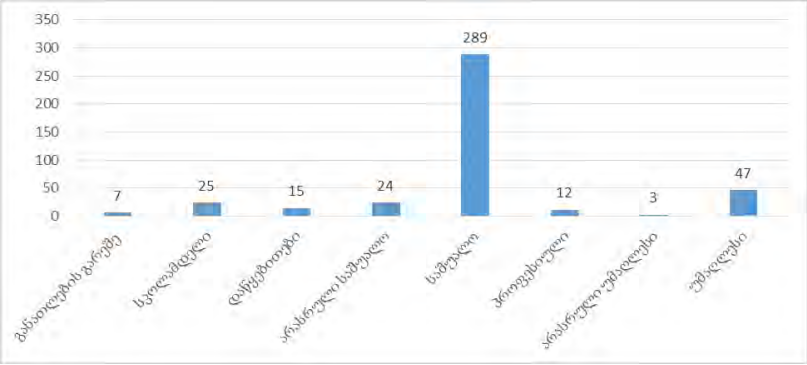
If we divide these figures according to the separate villages, we will get the following picture: number of married population in Orja village is 74, single – 34, widows – 2. In Korkhi village 20 respondents are married, single - 10, widows – 6, divorced – 0. As for Diliska village, number of married population is 168, single – 94, widow – 17, divorced – 0. Detailed information according to percentage indicators is provided on the Diagram 4.3.7.3.

Diagram 4.3.7.3. Information on marital status according to villages



Majority of surveyed population 68% received secondary education, 2% - has no secondary education, 4% - study in primary grade, 6% - is of preschool age, 3% - has vocational education, 11% - has higher education and 1% - has incomplete high education.

Diagram 4.3.7.1.1. Education indicator of surveyed population



As for the separate villages, based on the survey results, 5 respondents have no education in Orja village, 8 persons have preschool education, 2 of them have primary education, 8 persons have incomplete secondary education and 69 persons have the secondary education (the highest number in the village) 5 persons have the vocational education, 2 – incomplete higher education and 10 persons have the university degree.

There are no respondents without education in Korkhi village. As it turned out, there is only 1 preschool age kid among the surveyed families; in addition, nobody studies in the primary school in this village. 2 persons have the incomplete secondary education, 25 persons have the secondary education (the highest number in the village), 1 person has the vocational education, nobody has incomplete higher education and 8 persons have higher education. As for Diliska village, 2 persons have no education, 16 persons are of preschool age, 13 persons have the primary education, 14 persons have the incomplete secondary education, 195 persons have the secondary education (the highest number), 6 persons have the vocational education, 1 person has the incomplete higher education and 29 persons have the higher education.

Table 4.3.7.1.1. Education degree of surveyed population according to the villages

Education level	Orja	Korkhi	Diliska
Without education	5	0	2
Preschool	8	1	16
Primary	2	0	13
Incomplete secondary	8	2	14
Secondary	69	25	195
Vocational	5	1	6
Incomplete higher education	2	0	1
Higher education	10	8	29
Other	0	0	0

4.3.7.1 Employment

Based on the survey results, only 26% of respondents consider themselves as employed and 37% - as unemployed, this is stipulated by the fact that majority of population are involved in cultivation of their land plots and therefore, in the agricultural activity. Majority of employees have higher and vocational education, they are mainly employed in public and private sectors. Detailed information on the status of employment according to the specific villages is provided in the Table 4.3.7.2.1.

Table 4.3.7.2.1. Employment status according to the specific villages

Type of employment	Orja	Korkhi	Diliska
Public sector	10	4	19
Private sector	10	3	34
Self-employed	12	3	7
Farmer	0	0	0
Unemployed	29	8	101
Student/pupil	12	5	48
Pensioners	11	9	40
Housewife	5	2	7
Other	0	0	0
Total	89	34	256

4.3.7.2 Income

Main income source of a family and information about the income is given in the Table 4.3.7.3.1.

Table 4.3.7.3.1. Amount of monthly income (Gel)

Family income	<300	301-600	601-1500	>1500
Monthly income	15	31	20	1

According to the results, majority of surveyed population have low income and monthly revenue of their families is less than 300 Gel. From the surveyed families, 48 of them note that their main income source is the salary, while 47 families get income from the agricultural activity and 2 – from self-employment. On the question – what is the main income source for your family? – 1 family answered that they get income from money transfers and 3 of them mentioned other categories of income source. Difference in number of surveyed families and categories is entailed by the fact that one family has several sources of income

4.3.7.3 Communal Activity

Majority of surveyed population use the natural gas for heating. Based on the survey, only 23 families out of 101, use the wood for fuel, as for the electricity, it is available for all families. On the question – have you got a telephone/cell phone? – only 4 families gave a negative answer.

4.3.7.4 Agriculture

Based on the socio-economic survey in Akhalkalaki municipality showed that 58 families out of surveyed 101 have the cattle, 2 families – ruminants, 57 – poultry and 48 families noted that they have a pig and hare (difference between the sums of surveyed families and categories is stipulated by the fact that one family has various types of cattle/poultry).

On the question – do you cultivate any of the agricultural crops? - response of the population is as follows: hay - 26%, Potato - 88%, vegetable - 61%, grapes 1% nut/hazel nut - 2% ,fruit - 9%.

Detailed information about the agriculture is given on the Diagrams 4.3.7.5.1. and 4.3.7.5.2.

Diagram 4.3.7.5.1. Cattle /poultry

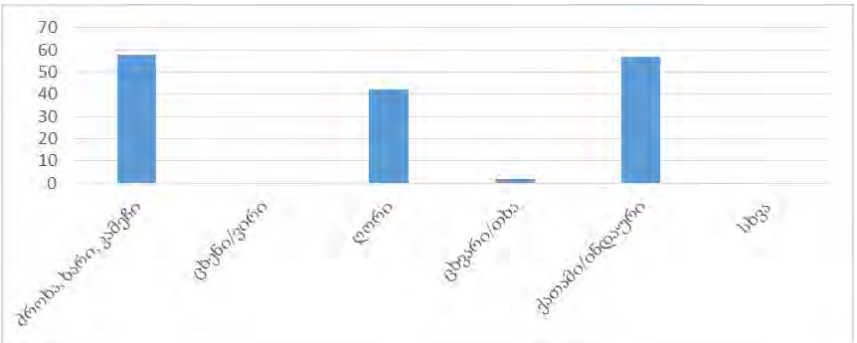
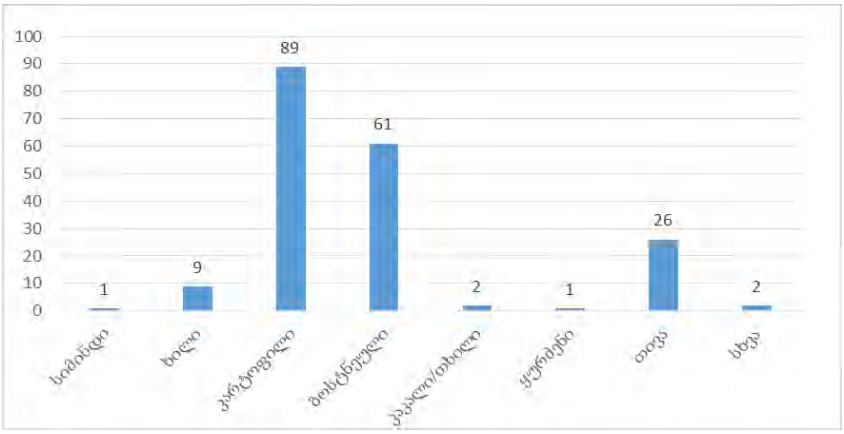
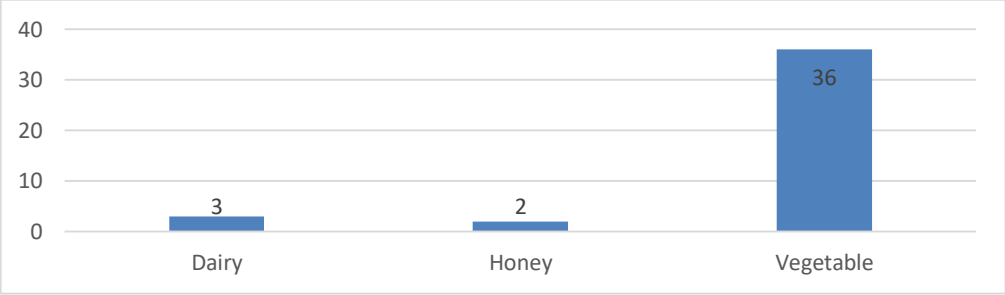


Diagram 4.3.7.5.2. Agricultural crops



On the question if they sell their cultivated crops, they positively answered. Information about selling agricultural products is given on the Diagram 4.3.7.5.3.

Diagram 4.3.7.5.3. Selling agricultural products



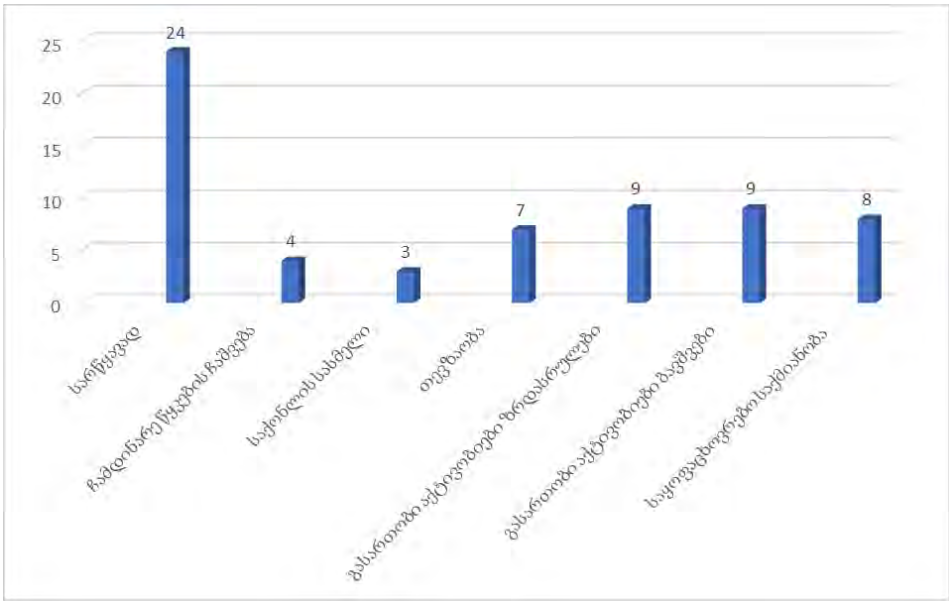
4.3.7.5 Migration

On the question if any of their family members are abroad, 23 families out of 101 gave a positive answer, while 78 families - negative answer.

4.3.7.6 River Consumption

In frames of the interview of Akhalkalaki HPP, on the question – "Does your family use the river water for any purpose?" – 24 families noted that they use the river water for irrigation, 4 families – for discharge of wastewaters, 3 – for cattle drinking, 7 – for fishing, 9 – for recreational purposes/adults, 9 – for recreational purposes/children and 8 – for household purposes. Data are provided on the quantitative Diagram 4.3.7.7.1.

Diagram 4.3.7.7.1. Use of the river



Use of the river according to the specific villages is given in the Table 4.3.7.7.2.

Table 4.3.7.7.2. Use of the river

Use of the river	Orja	Diliska	Korkhi
Irrigation	11	12	1
Discharge of wastewaters	4	0	0
Drinking for the cattle	1	2	0
fishing	4	3	0
Recreational activities for adults	5	4	0
Recreational activities for children	6	2	1
Household activity	5	2	1

Based on the Table, the river is basically used for irrigation in the villages, but unlike other villages, the river is less used in Korkhi River.

4.3.7.7 Awareness and Expectations

In frames of the survey associated with the construction and operation of Akhalkalaki HPP, 65 families out of 101 gave a positive response, while 36 of them expressed negative attitude. Detailed information about the information source is provided in the Table 4.3.7.8.1.

Table 4.3.7.8.1. Source of received information

Source of information	Persons	%
Local population	17	26%
Press/ radio television	1	2%
Friends/ relatives	32	49%
Other	15	23%

In frames of the survey, local population was given the following questions: 'What would you like to see in frames of the project?" Or "What is your expectation with regard to the project?" In Orja village they said that they would like to arrange a pumping station and to employ the local population on the construction phase.

The majority of the population in the village of Korki did not express any expectations about the project. Only two families have expressed expectations, with one of them saying they want to have the sewage system installed and the other one to restore the irrigation system.

As for Diliska village, they would like to provide jobs in frames of the project, to improve the road (to the cemetery), to construct a school; while their opinion divided regarding the shrine, one part of the population requires not to damage the shrine and they need to have access road, while the another part would like the shrine to be removed on other location.

5 Environmental Impact Assessment

5.1 General Principles of EIA Methodology

The present chapter provides assessment of the possible environmental impact during the project implementation. In order to assess expected changes in natural and social environment, it is necessary to collect and analyze the information about the current situation in the project impact area. The scale of the expected changes is determined on the basis of obtained information, impact recipient objects – receptors should be identified and their sensitivity will be assessed, which is necessary for determining the importance of the impact. After determination of the impact significance, following is defined: acceptance of the impact; project alternatives with less negative effect; the need for development of mitigation measures and mitigation measures themselves.

The following scheme have been used during the assessment of the environmental and social impact caused by the planned activities:

Stage I: Determination of the major types of the impact and analysis format - Determination of those impacts that may be significant for these types of projects based on the general analysis of the activities.

Stage II: Baseline study - Identification of the receptors, which are expected to be impacted by the planned activities; determination of sensitivity of the receptors.

Stage III: Characterization and assessment of the impact - Determination of the nature, probability, significance and other characteristics of the impact, taking into account the sensitivity of the receptor; Description of the expected changes in the environment and evaluation of their significance.

Stage IV: Identification of mitigation measures - Determination of mitigation, prevention or compensating measures for significant impact.

Stage V: Assessment of the residual impact - Identification of the magnitude of the expected changes in the environment after the implementation of mitigation measures.

Stage VI: Processing of monitoring and management strategies - Monitoring of the effectiveness of mitigation measures is needed to ensure that the impact does not exceed predetermined values, to verify the effectiveness of mitigation measures, or to identify the necessity of corrective measures.

5.1.1 Impact Receptors and their Sensitivity

There are following additional impact types expected during the project implementation:

- Deterioration of ambient air quality;
- Noise propagation;

- Impact on geological conditions, topsoil quality and stability;
- Impact on aquatic environment;
- Impact on biological environment;
- Impact expected during the waste management;
- Visual-landscape alteration;
- Impact on local socio-economic environment;
- Impact on human health and safety risks;
- Impact on the historical-cultural heritage monuments.

Sensitivity of a receptor is related to the magnitude of the impact and to the ability of a receptor to resist change or recover after changes, as well as to its relative ecological, social or economic value.

5.1.2 Impact Assessment

The major influence factors have been identified for the environmental impact assessment during the construction and operation phases. Assessment of the expected impact has been implemented in accordance with the following classification:

- Nature - positive or negative, direct or indirect;
- Magnitude - very low, low, medium, high or very high;
- Probability of influence - low, medium or high risk;
- Impact area – work site, area or region of activities;
- Duration - Short and long term;
- Reversibility - reversible or irreversible.

Expected changes in the environment and their nature, area of the influence and duration, reversibility and probability of risk realization have been determined for both phases of the project, based on which the significance of the impact has been assessed.

Below are the criteria established for the assessment of the impact on each environmental and social receptor; Characterization of the impact; determination of the impact scale and significance using established criteria; also mitigation measures and the scale and significance of potential residual impact considering these mitigation measures.

5.2 Impact on Ambient Air Quality

5.2.1 Impact Assessment Methodology

For the assessment of impact on ambient air quality normative documents of Georgia have been used, which determine the air quality standards. Standards are defined for the protection of health. As the impact on health depends on the concentration of harmful substances, as well as on the duration of the impact, evaluation criteria considers these two parameters

Table 5.2.1.1. Assessment criteria for the impact on ambient air quality

Ranking	Category	Short-term concentration (< 24 h)	Dust propagation (long-term or frequent)
1	Very low	C <0.5 MPC	Unnoticeable increase
2	Low	0.5 MPC < C < 0.75 MPC	Noticeable increase
3	Medium	0.75 MPC < C <1 MPC	Slightly disturbs the population, though has no negative impact on health
4	High	1 MPC < C <1.5 MPC	Quite disturbs the population, especially the sensitive individuals
5	Very high	C > 1.5 MPC	Population is very disturbed, has negative impact on health

Note: C - Estimated concentrations in the environment, considering the background.

5.2.2 Impact Description

5.2.2.1 Construction Phase

On construction phase of Akhalkalaki 1 HPP, the most notable sources for harmful substance emissions into ambient air will be located in the construction camp of Akhalkalaki 1 HPP, and as for Akhalkalaki 2 HPP, only one stationary source (diesel fuel tank) will be represented in the construction camp.

As it is given in the present report, arrangement of Akhalkalaki 1 HPP construction camp is planned near Diliska village (the distance to the nearest residential zone is 280 m), and Akhalkalaki 2 HPP construction camp will be arranged near Orja village (in 255 m).

The presented paragraph provides modeling of harmful substance emissions from stationary and mobile sources on both construction camps. The nearest residential houses, as well as the border of 500 standardized zone are deemed as main reference points. The calculation results are provided in the following paragraph. The quantitative report and software printout of harmful substance emissions are given in Annex 7.

5.2.2.1.1 Results of the Report on Harmful Substance Emissions into Ambient Air

Results of the report on emissions of harmful substances during operation of the construction camps - maximum concentrations of harmful substances in MPC shares at the reference points are given in Table 5.2.2.1.1.1. and 5.2.2.1.1.2.

Table 5.2.2.1.1.1. MPCs of Harmful Substances at Reference Points for the Construction Camp of Akhalkalaki 1 HPP.

Name of the Harmful Substance	MPC of the harmful substance from the facility	
	At the border of the nearest settlement	At the border of 500 m radius
1	2	3
Nitrogen dioxide	0,002	0,001
Nitrogen oxide	0,0	0,0
Soot	0,0002104	0,0001732
Sulfur dioxide	0,0	0,0
Hydrogen Sulfide	0,002	0,002
Carbon monoxide	0,0	0,0
kerosene fraction	0,0	0,0
Saturated hydrocarbons	0,006	0,005
Inorganic Dust 70-20%	0,262	0,084
Total impact group 6043(330+333)	0,002	0,002
Total impact group 6046(337+2908)	0,262	0,084
Total impact group 6204(301+330)	0,001	0,0009243

Table 5.2.2.1.1.2. MPCs of Harmful Substances at Reference Points for the Construction Camp of Akhalkalaki 2 HPP.

Name of the Harmful Substance	MPC of the harmful substance from the facility	
	At the border of the nearest settlement	At the border of 500 m radius
1	2	3
Nitrogen dioxide	0,003	0,001
Nitrogen oxide	0,0	0,0
Soot	0,0003907	0,000153
Sulfur dioxide	0,0	0,0

Hydrogen Sulfide	0,004	0,002
Carbon monoxide	0,0	0,0
kerosene fraction	0,0	0,0
Saturated hydrocarbons	0,01	0,005
Total impact group 6043(330+333)	0,004	0,002
Total impact group 6204(301+330)	0,002	0,0008168

According to the results of the conducted calculations, harmful substance concentrations at reference points (at the borders of 500 meter standardized zone and settlement) do not exceed the standard limits. So, operation of the construction camps in normal mode will not cause deterioration of ambient air quality and generated emissions can be qualified as maximum permissible concentrations.

5.2.2.2 Opertion Phase

During HPP operation, there will be no stationary sources of harmful substance emissions into ambient air on the headwork, as well as on the powerhouse sites. Single transportation means should be noted from moving sources, which will move with low intensity between the power house and the headworks.

The project does not consider arrangement of large reservoirs. Thus the impact on local climate due to evaporation and accordingly the growth of air humidity is not expected.

On operation phase emissions are expected only during repair and maintenance works, but they will be limited in time, reversible and smaller in scale than it is expected on construction phase. Accordingly, calculation of harmful substance emissions in this direction and development of the mitigation measures was not deemed necessary.

5.2.3 Mitigation Measures

Following mitigation measures for reduction of exhaust and dust emissions are considered for the construction phase:

- Ensure proper maintenance of machinery, as well as stationary facilities; transportation means and equipment, the exhaust of which is expected to be significant (due to technical malfunctioning) will not be allowed to the work site;
- Turning off engines or working on minimum rpm, when they are not used (in particular this is related to the equipment, operating on the construction camp);
- Providing optimal speed of vehicles (especially, on earth roads);
- Vehicles and machinery will be located far away from the sensitive receptors (residential zone, forest zone) as much as possible;
- Restriction using motorways through the populated zones (mainly Diliska village is meant), (population will be informed in advance on intensive movement of transportation means);
- Corresponding measures (e.g.: watering of work sites, following bulk material storage rules, etc.) will be carried out in order to reduce dust emissions in dry weather conditions;
- During the earth works and loading/unloading materials, precautions will be considered in order to avoid excessive dust emissions (e.g.: throwing material from height during loading/unloading will be restricted);
- Personnel will be instructed prior to wok start;
- Register/recording complaints and providing proper response considering above-listed measures.

Abve-mentioned measures will be considered during implementation of significant repair-maintenance works on HPP operation phase.

5.2.4 Impact Assessment

Table 5.2.4.1. Impact summary on ambient air quality caused by emissions

Description of impact and impact sources	Impact receptors	Assessment of residual impact					
		Nature	Likelihood	Impact area	Duration	Reversibility	Residual impact
Construction phase:							
Combustion products, welding aerosols and other harmful substances emitted into ambient air • Source of combustion products – construction and special vehicles, transportation. • Source of other harmful substances - Gaseous emissions of chemical substances (fuel - lubricants, etc.).	Nearby settlements (Diliska and Orja villages), biological environment	Direct, negative	Low	Adjoining territories of the construction camp, construction sites and residential zone.	During construction	Reversible	**Very low**
Dust propagation • Source - transportation, storage and usage of bulk construction materials, movement of equipment and vehicles, earth works, etc.		Direct, negative	High	Adjoining territories of the construction camp, construction sites and residential zone.	During construction, periodically	Reversible	**Medium.** Considering mitigation measures - **low**
Combustion products, welding aerosols and other harmful substances emitted into ambient air	Working personnel	Direct, negative	Medium risk	The construction camp and construction sites.	During construction	Reversible	**Low,** Considering mitigation measures – **very low**
Dust propagation		Direct, negative	Medium risk	The construction camp and construction sites	During construction, periodically	Reversible	**Very low**

5.3 Noise Propagation

5.3.1 Impact Assessment Methodology

Noise propagation levels in Georgia are regulated by technical regulation on "the norms of acoustic noise in the premises of buildings and areas of the residential houses and social/public establishments", approved by the Resolution #398 of the Government of Georgia, dated as August 15, 2017. The noise level should not exceed the values set by these standards. Considering requirements of the mentioned document, following criteria are adopted for assessment of the noise-related impact for the project under discussion:

Table 5.3.1.1. Impact assessment criteria related to noise propagation

Ranking	Category	Residential area	Working, industrial or commercial zone
1	Very low	Acoustic background will increase by less than 3 dBA [1]- at residential zone, during the daytime up to <50 dBA, while during night hours up to <45 dBA	Acoustic background will increase by less than 3 dBA and up to <70 dBA
2	Low	Acoustic background will increase by 3 – 5 dBA, at residential zone, during the daytime up to <55 dBA, while during night hours up to <45 dBA	Acoustic background will increase by 3 – 5 dBA and up to <70 dBA
3	Medium	Acoustic background with sensitive receptors will increase by 6-10 dBA, at residential zone, during the daytime up to <55 dBA, while during night hours up to <45 dBA	up to <70 dBA, Acoustic background with sensitive receptors will increase by 6-10 dBA
4	High	Acoustic background with sensitive receptors will increase by more than 10 dBA, at residential zone, during the daytime up to >70 dBA, while during night hours up to <45 dBA	up to >70 dBA, Acoustic background with sensitive receptors will increase by more than 10 dBA
5	Very high	Acoustic background with sensitive receptors will increase by more than 10 dBA, at residential zone, during the daytime up to <70 dBA and accompanied by a tonal or impulsive noise, while during night hours up to <45 dBA	up to >70 dBA, accompanied by a tonal or impulsive noise

5.3.2 Impact Description

5.3.2.1 Construction Phase

Construction of HPP infrastructural facilities considers intensive construction activities, which supposedly will have impact on acoustic background. In order to determine the potential impact, calculation of noise emissions is implemented in the following sequence:

- Determination of noise sources and their characteristics;
- Selection of reference points at the border of protecting areas;

[1] Such changes are unnoticeable for most of people

- Determination of noise direction from noise source to the reference point and calculation of acoustic of the environmental elements, affecting the distribution of noise (natural screens, green plantation, etc.);
- Determination of potential noise levels at reference points and its comparison to allowable levels of noise;
- Determination of noise level reduction measures, if necessary.

As it is given in the present report, Akhalkalaki 1 HPP construction camp will be in 280 m from the nearest residential zone, and Akhalkalaki 2 HPP construction camp – in 255 m.

Following facilities are defined as main noise sources on the construction camp of Akhalkalaki 1 HPP:

- Bulldozer - 90 dBA;
- Dump truck - 85 dBA;
- Lifting mechanism -92 dBA;
- Concrete plant - 83dBA

Following facilities are defined as main noise sources on the construction camp of Akhalkalaki 2 HPP:

- Bulldozer - 90 dBA;
- Dump truck - 85 dBA;
- Lifting mechanism -92 dBA;

During calculation it was admitted that all above-mentioned noise-generating sources would work simultaneously. Octave levels of the sound pressure in the reference point are calculated by the following formula:

$$L = L_p - 15\lg r + 10\lg \Phi - \frac{\beta_a r}{1000} - 10\lg \Omega, \quad (1)$$

where,

L_p – Octave level of the noise source capacity;

Φ – noise source direction factor, non-dimensional, is determined through trial and changes from 1 to 8 (depends on spatial angle of sound radiation);

r – Distance from the source of the noise to the reference point;

Ω – Spatial angle of sound radiation, which will be: $\Omega = 4\pi$- when located in the space; $\Omega = 2\pi$- when located on the surface of the area; $\Omega = \pi$ - double ribbed angle; $\Omega = \pi/2$ – triple ribbed angle;

β_a – Sound damping in the air (dBA/km) tabular description..

Average geometric frequencies of the octave lines, H Hz.	63	125	250	500	1000	2000	4000	8000
β_a dBA/km	0	0.3	1.1	2.8	5.2	9.6	25	83

Noise source levels on the noise-generating section are summarized according to the formula:

$$10\lg \sum_{i=1}^{n} 10^{0,1 L_{pi}} \quad (2)$$

Where: L_{pi} –power of i-type noise source.

Following assumptions are performed for calculations:

1) If distance between some noise sources, located on the same site is less than distance to the reference point, sources are combined into one group. Their total noise level is calculated by the following formula: $10\lg \sum_{i=1}^{n} 10^{0,1 L_{pi}}$;
2) To assess the total level of noise sources combined into one group, as a distance to accounting point was used their distance from geometric center;

3) For simplicity, the calculations are performed for the sound equivalent levels (dBA) and average value of its octave indicator is taken as sound damping coefficient in the air βave=10.5 dBA/km;

By putting the data in the second formula, we will obtain the total noise level resulted in simultaneous working of machinery/vehicles within the borders of the construction camp or noise level from the generation point:

For the construction camp of Akhalkalaki 1 HPP:

$$10\lg\sum_{i=1}^{n}10^{0,1Lpi} = 10\lg\,(10^{0,1x90}+10^{0,1x85}+100^{,1x92}+10^{0,1x83}) = 94{,}9\text{ dBA.}$$

For the construction camp of Akhalkalaki 2 HPP:

$$10\lg\sum_{i=1}^{n}10^{0,1Lpi} = 10\lg\,(10^{0,1x90}+10^{0,1x85}+100^{,1x92}) = 94{,}6\text{ dBA.}$$

By putting the data in the first formula we will obtain maximum noise levels at reference points:

For the construction camp of Akhalkalaki 1 HPP

$$L_{500} = L_p - 15\lg r + 10\lg\Phi - \frac{\beta_a r}{1000} - 10\lg\Omega, = 94{,}9 - 15*\lg 280 + 10*\lg 2 - 10.5*280/1000 - 10x\lg 2\ \pi = 50.3\text{ dBA}$$

For the construction camp of Akhalkalaki 2 HPP:

$$L_{1000} = L_p - 15\lg r + 10\lg\Phi - \frac{\beta_a r}{1000} - 10\lg\Omega, = 95{,}07 - 15*\lg 255 + 10*\lg 2 - 10.5*255/1000 - 10x\lg 2\ \pi = 50.9\text{ dBA}$$

Calculation results are given in the Table 5.3.2.1.1.

Table 5.3.2.1.1. Calculation results of noise propagation

Main operating machinery/vehicles	Equivalent Noise Level at Generation Point dBA	Distance to the nearest receptor, m	Equivalent Noise Level at the nearest receptor, dBA	Standard[2]
For the construction camp of Akhalkalaki 1 HPP:				
o Bulldozer o Dump truck o Lifting mechanism o Concrete plant	94,9	280	50.3	At daytime - 55 dBA At night- 45 dBA
For the construction camp of Akhalkalaki 2 HPP:				
o Bulldozer o Dump truck o Lifting mechanism	94,6	255	50.9	At daytime - 55 dBA At night- 45 dBA

According to the calculations, it is not expected that the noise standards, established for the day time will be exceeded at the border of residential zones during operation of the construction camps. Considering the fact that works are planned to be implemented only during the day, accordingly, the risk of impact on population during the night is actually excluded.

Disturbance and dissatisfaction of local population can be caused by construction material transportation operations, for which local roads will be used. Considering aforementioned, it can be stated that transportation of main construction materials and required machinery will be carried out on mobilization stage. And directly during the construction process, transportation operations will be

2 Sanitary standards – "the norms of acoustic noise in the premises of buildings and areas of the residential houses and social/public establishments"

mainly implemented from the camps to the construction sites. The impact is expected also during transportation of waste rocks to the spoil grounds.

Noise-related negative impact is expected on the personnel, working on all construction sites. The noise level on the construction site can exceed 100 dBA. The personnel (esp. during working with excess noise generating devices) will be equipped with protective means (earmuffs), if required.

Change of acoustic background will have some negative impact on the local wildlife, however, considering the fact, that there are no highly sensitive habitats of animals, distributed within the project impact zone, no significant impact is expected on wildlife.

During assessment of noise-related impacts, it is necessary to consider some circumstances, which significantly reduce the risk of negative impacts, in particular:

- Construction works (especially intensive noise generating activities) will be carried out only during the daytime;
- The main sources of noise is less likely to work simultaneously. Even so, it will not be a long process;
- Local relief conditions should be considered (works will be implemented in canyon-like ravines, and settlements are located on upper elevations of existing plateau), which is also one of the noise propagation reducing factors;
- Impact related to the noise, generated during construction, will be short-termed (some noise-generating activities will not last for a long period of time).

5.3.2.2 Operation Phase

On operation phase, hydraulic units installed in the power houses are main sources of noise propagation. It should be noted that turbines will be placed in closed cases, which have high noise absorption rate. Noise insulation materials, arranged in the interior will also reduce the noise propagation (considering the mentioned factors, noise will be reduced with about 25-30 dBA). At the power houses the noise level will be about 70-80 dBA. Powerhouses will be located in the deep valleys of Paravani and Korkhi rivers, in 90-100 m downstream from the nearest settlement - Korkhi village elevations, and the shortest distance between them will be 300 m.

Considering aforementioned, at the border of the nearest residential zone, the noise propagation levels will not exceed the standard values. Accordingly, it is not needed to carry out any significant mitigation measures in this direction.

The noise level in the power houses will be quite high; accordingly, the negative impact is expected on the working personnel. In this regard, it is necessary to carry out certain mitigation measures, namely: personnel should be provided with special earmuffs; control room should be arranged using special noise insulating material.

5.3.3 Mitigation Measures

Following mitigation measures will be implemented during the construction phase in order to minimize noise propagation levels:

- Ensure proper maintenance of machinery; prior to the start of each working day, the technical functionality of the machinery will be checked; transportation means and equipment, the noise level of which is expected to be significant (due to technical malfunctioning) will not be allowed to the work site;
- Noise-generating activities will be carried out only during the day. If work implementation at night is decided, the population will be informed in advance about it;

- Prior to the start of noisy activities near the residential zone (transport operations are meant here), the population will be informed and corresponding explanations will be provided;
- Noisy devices and machinery will be located far away from the sensitive receptors (residential houses) as much as possible;
- If required, the personnel will be provided with the protective means (earmuffs);
- In case of the entry of complaints, they will be registered/recorded complaints and properly responded considering above-listed measures.

On operation phase:

- During the large-scaled maintenance/repair works, mitigation measures, considered for the construction phase will be planned and implemented;
- Personnel will be provided with special earmuffs;
- Control rooms of the HPPs will be arranged using special noise insulation material;
- Plants and trees will be planted and grown around the power house gradually.

5.3.4 Impact Assessment

Table 5.3.4.1. Summary of noise impact

Description of impact and impact sources	Impact receptors	Assessment of residual impact					
		Nature	Likelihood	Impact area	Duration	Reversibility	Residual impact
Construction phase:							
Noise propagation in air: • Noise generated from machinery; construction operations; earth works; , • Noise generated by transport operations;	Population of nearby settlements, project staff, animals living nearby.	Direct, negative	Medium risk	In about 0.5 km radius from the construction sites.	Medium term- during construction	Reversible	**Medium –** considering mitigation measures **– low.**
Noise propagation in air: • construction operations; • Noise generated by transport operations;	Population of nearby settlements, project staff, animals living nearby.	Direct, negative	Medium risk	In about 0.5 km radius from the construction sites.	Medium term- during construction	Reversible	**Medium –** considering mitigation measures **– low.**
Operation Phase:							
Noise propagation in air: • Noise generated by operation of hydraulic units; • Noise generated by transport operations; • Noise generated by maintenance/repair works.	Population, working staff, animals living nearby.	Direct, negative	Low risk	In about 0.5 km radius from the power house.	Long-term	Medium	**low** considering mitigation measures **– very low.**

5.4 Impact on Geological conditions; Hazardous Geodynamic Processes

5.4.1 Impact Assessment Methodology

Geodynamic processes deal with ongoing gravitational processes on the earth surface, such as landslides, gullying and others, which can be caused or activated in the result of the project implementation. Risks are assessed considering receptors and project activities.

Table 5.4.1.1. Assessment criteria forgeodynamic processes activation risks

Ranging	Category	Geo hazardous (ravine formation, landslide, debris flow, rockslide, mudflow) risks
1	Very Low	The project does not include any type of activities at geo-hazardous areas/zones; the project activities practically are not related to the geo hazard causing risks.
2	Low	Preventative measures are considered during works in the geo-hazardous areas/zones that would effectively eliminate geological risks. Activities on the geologically safe areas do not cause erosion, or other changes, which may cause the geo-hazards. Geo-hazard management/effective plan of mitigation measures is developed and is being implemented.
3	Medium	Preventative measures are considered during works in the geo-hazardous areas/zones that would effectively eliminate geological risks. During implementation of the activities on geologically safe areas may cause development of such processes (e.g., erosion) which may cause geo-hazards without effective management. Geo-hazard management/effective plan of mitigation measures is developed and is being implemented.
4	High	Despite the preventative measures on the geo-hazardous areas/zones there is a risk of geo-hazardous processes development, or implementation of the activities caused geo-hazardous processes on the geologically safe areas. Geo-hazard management/mitigation measures plan do not exist or is less effective.
5	Very High	Despite the preventative measures on the geo-hazardous areas/zones there is a risk of geo-hazardous processes development, or implementation of the activities caused geo-hazardous processes on the geologically safe areas. Geo-hazard management/mitigation measures plan do not exist or are less effective.

5.4.2 Impact Description

Projects on construction and operation of the hydraulic facilities have some negative impacts on the geological conditions of the areas within the project impact zone. In the regard with the impact on geological conditions, implementation of earth works should be singled out on the construction phase and reservoir operation – on operation phase.

According to Akhalkalaki HPP project, arrangement of low-threshold weirs is planned at headworks and naturally, it will not cause large upstream impoundments of the river water (small impoundments will cover active riverbeds and lines along the riverbeds). Accordingly, presence of the reservoirs will not cause high impact risks on geological conditions.

On construction phase, notable scale of earth works will be implemented, namely: withdrawal and removal of alluvial ground from dam axis, arrangement of service roads for equipment within the penstock corridors and arrangement of trenches for penstock placement. For this purposes it will be necessary to cut slopes. Considering all aforementioned, change of the geological situation, which is more or less stable at the moment, will be required.

According to the engineering-geological surveys, geodynamic conditions are complex within the corridors of Akhalkalaki HPP locations. The complexity of geodynamic conditions is caused by the colluvial and rock fall processes (rock avalanche) ongoing on the steep slopes of the canyon-like valleys. Among them, colluvial phenomena, when individual blocks of fractured rocks fall down, are more

frequent, while rock fall phenomena, which are caused by disintegration of the blocks made up of the unity of individual rock fragments, are rarer.

It should also be note that there are boulders and blocks in active dynamic on the steep slopes, which will create some risks on the construction phase. On operation phase the penstocks will be located underground, at 1 m depth from the surface and accordingly, the risk of the damage to them is at minimum. Akhalkalaki HPP project powerhouses will be arranged on sites, highly sensitive in the relation with the rockfall processes. Headworks of both HPPs will be located on sites, safe regarding the rockfall processes.

Paravani and Korkhi rivers on the project sections flow within the narrow courses and do not have floodplains. Riverbeds are built with coarse boulders and accordingly, lateral erosion cannot be developed. In this regard, the exclusion is the section of the Korkhi river, where headwork is planned. Here there are low terraces of the floodplain represented, but due to low inclination of the riverbed, the river flow is slow; the riverbed is built with coarse boulders and pebbles and banks are protected against erosion.

Considering aforementioned, rockfall risks should be singled out from hazardous geodynamic processes within the project corridor. Other types of geodynamic processes (landslide, mudflow, etc) are not expected.

On construction phase, during the earth works it will be needed to cut the slopes in most cases, which highly likely will cause activation of rockfall processes and implementation of corresponding mitigation measures will be required. In addition to the impact risks on geological conditions during construction, in case of the project implementation, the impact of the rock fall processes on HPP communications will take place; for this purpose the project envisages implementation of the protective measures against rock fall.

In total it can be stated that the project implementation is planned on areas with the complex engineering-geological conditions, however, hazardous geodynamic processes that cannot be stabilized or that are related to high financial expanses will not be developed. The impact can be assessed as high or medium. Mitigation measures planned in parallel to the construction and on operation phase, strategy for geodynamic process stabilization and the project solutions for protection of facilities will ensure reduction of the impact to the low level.

5.4.3 Mitigation Measures

Considering above-discussed potential risks, following measures are worked out for prevention of geodynamic process development and protection of the structures:

Main measures:

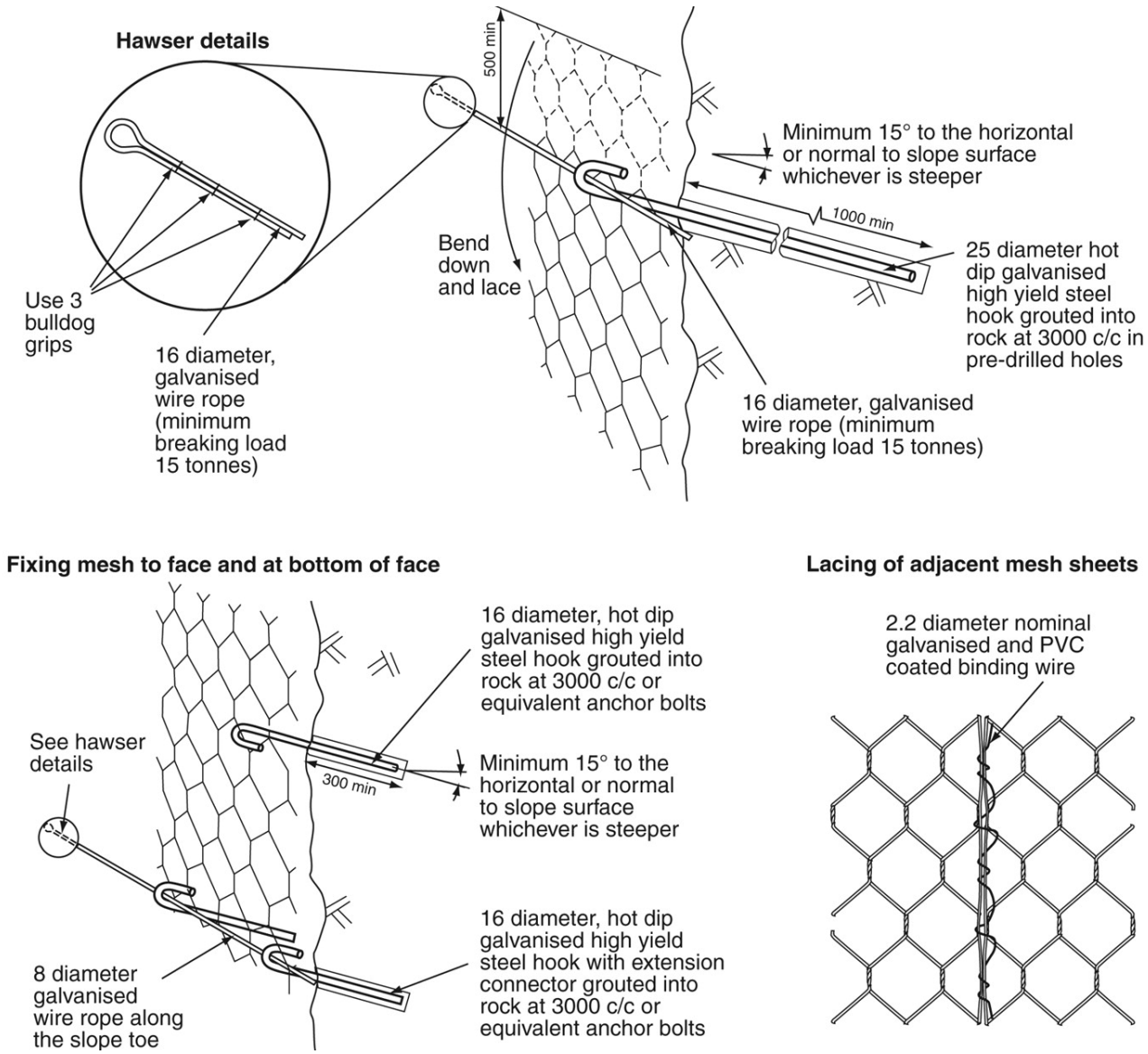
- Engineering-geological conclusions and recommendations, outlined in par. 4.2.2.6., will be considered during the project implementation;
- Construction works will be implemented under the strict supervision of engineer- geologist. If required, additional preventive measures will be carried out on the basis of his recommendations;
- Borders of the work corridor will be protected;
- Materials and waste will be disposed so that to avoid erosion and their removal from the construction site by surface water runoff. The height of the ground pile will not be more that 2 m; pile sides will have proper inclination angle (45^0); drainage channels will be arranged on the perimeter;
- After completion of the construction works, recultivation and landscaping of the construction sites will be carried out.

Strategy for prevention gravitational processes and protection of structures against them:

- In order to prevent rockfall process activation, prior to the construction, slopes of the construction sides will be cleaned from boulders and blocks in active dynamic. Implementation of the slope cleaning works will be required regularly, on the basis of monitoring results;
- Strengthening of the sites, bearing high rockfall risks (slopes adjacent to power houses, slopes adjacent to Akhalkalaki 1 HPP penstock corridor and slopes, adjacent to the last section of Akhalkalaki 2 HPP penstock) will be provided using wire mesh (see Figure 5.4.3.1).;
- Slopes adjacent to the construction sites and the perimeter of the spoil grounds will be provided with proper drainage systems;
- Foundation of main HPP facilities will be carried out on the basis of engineering-geological surveys.

On operation phase, monitoring of hazardous geological processes/state of protective structures will be carried out on all sensitive sites especially during the first 2 years. Personnel with relevant competence (engineer-geologist) will be involved in monitoring process. If required, corresponding preventive measures (geological survey, project development, reinforcement works, restoration of protective structures, etc.) will be carried out in the shortest possible time.

Figure 5.4.3.1. Typical Scheme for Arrangement of Steel Double Wire Mesh against Rockfall.



5.4.4 Impact Assesment

Table 5.4.4.1. Summary of the Risks of Geodynamic Process Development

Description of impact and its sources	Impact receptors	Residual Impact Assessment					
		Nature	Probability of occurrence	Influence area	Duration	Reversibility	Residual impact
Construction Phase:							
Geohazards, including development/activation of collapse, rockfall, ravine formation, etc. • Removal and storage of soil/slopes; • Construction works of HPP facilities; • Construction works and transport operations, especially use of heavy vehicles.	Land and land resources (plants, animals, water); population; Construction safety	Direct Negative	High-risk areas have been identified within the project corridor in terms of the rockfall process activation	Some of the construction sites and corridors of transportation roads	Medium term. In some cases – long term	Mainly reversible	Considering the local conditions and effectiveness of preventive/mitigation measures, impact can vary between **medium to high**. Considering the mitigation measures, impact may be reduced to **low** impact
Operation Phase:							
Geohazards, including development/activation of collapse, erosion, rockfall, ravine formation, etc: • Existence of the HPP infrastructure and reduced vegetation cover; • Maintenance and repair works and transportation, especially use of heavy vehicles,	Land and land resources (plants, animals, water); population; HPP facility safety	Direct Negative	Medium risk	Objects placed in difficult terrain conditions (headwork, penstock, power houses, road, etc.)	Long term	Mainly reversible	Considering the mitigation measures (including those, considered on designing and construction phases) **low** impact is expected

5.5 Impact on Surface Waters

5.5.1 Impact Assessment Methodology

Impact on aquatic environment includes following:

- Change of river water debit;
- Impact on sediment movement of the river, riverbed dynamic and on stability of the banks;
- Deterioration of river water quality.

Impact is assessed by considering the intensity, impact area and the sensitivity of riverbed/banks of the river.

Table 5.5.1.1. Assessment criteria for the impact on surface water

Range	Category	Change of rivers water debit	Impact on sediment movement	Deterioration of water quality of the River
1	Very Low	Change of the debit is invisible, does not impact on the water habitat/Ichthyofauna. Water use has not changed	The change of the solid run-off is practically unnoticeable, there is no impact on the river-bed or on the banks of the river	Background concentration of the substances and water turbidity has unnoticeably changed
2	Low	The river debit on certain sections has changed with 10%, impact is temporary (e.g., will be restored after completion of construction works) or is seasonal (e.g., there will be only shallowness), does not impact on water habitats/Ichthyofauna. Water use has changed temporarily or slightly.	Solid run-off has changed with 1-5% in the tailrace/lower water intake flow along the whole length of the river or on it's certain sections, which may cause some impact on sensitive areas, but the erosion processes has not been activated significantly.	Concentration or turbidity of the water has changed by less than 50%, but does not exceed maximum permissible concentration
3	Medium	The river debit on certain sections has changed with 10-30%, impact is temporary (e.g., will be restored after completion of construction works) or is seasonal (e.g., there will be only shallowness); certain impact on water habitats/Ichthyofauna is expected. Water use has changed temporarily and slightly.	Solid run-off has changed with 5-10% in the tailrace/lower water intake flow along the whole length of the river or on it's certain sections, which cause some impact on sensitive areas, significant activation of the erosion processes is expected, or development of the erosion processes on the erosion hazardous areas.	Concentration or turbidity of the water has changed by 50-100%, but does not exceed maximum permissible concentration
4	High	The river debit on certain sections has changed with 30-50%, which is irreversible by character, significantly impacts on water habitats, impact on Ichthyofauna is expected, visibly impacts on water use.	Solid run-off has changed with 10-15% in the tailrace/lower water intake flow along the whole length of the river or on its certain sections, which cause significant impact on sensitive areas, existing erosion processes has significantly activated or erosion is being developed on erosion hazardous areas.	Concentration or turbidity of the water has changed by more than 100%, or exceeded maximum permissible concentration

5	Very High	The river debit on certain sections has changed with more than 50%, impact is irreversible, lack of flow significantly impacts on water habitats, there is an impact on Ichthyofauna, water use has significantly changed.	Solid run-off has changed with >15% in the tailrace/lower water intake flow along the whole length of the river or on its certain sections, which significantly impacts the lower flow of the river, including sensitive areas, existing erosion processes has significantly activated, erosion developed on erosion hazardous or on previously stable areas.	Concentration or turbidity of the water has changed by more than 200% and exceeded maximum permissible concentration

5.5.2 Impact Description

Prior to construction works, cofferdams and temporary diversion infrastructure (construction site bypass channel) are considered to be arranged on construction sites to be arranged in the riverbeds. Water inflow will be fully released downstream through them. If required sites, adjacent to the construction sites will be cleaned from time to time from accumulated sediments. Above-mentioned temporary infrastructure will be arranged so that the potential negative environmental impact will be minimal. The selected project solutions will be targeted at prevention of the following hazards:

- Blockage/hindrance of the migration route for organisms living in the water (fish, invertebrates);
- Loss of the physical space and habitat;
- Hindrance of the sediment movement and flow mode;
- Creating a barrier and ponding;
- Impact on water quality.

According to the project on construction work organization, it is considered to arrange a concrete plant with maximum capacity of 30 m^3/h. Water for preparation of the concrete mixture will be taken from Paravani river, which is distinguished by quite high flow. Hourly flow of water required for preparation of the concrete mixture is much less than the natural runoff flow of the river in the given section.

Accordingly, on the construction stage the impact related to changing of river water debit and restriction of sediment movement in the riverbed is not expected and it is not needed to carry out additional mitigation measures in this direction.

On construction phase, risks of surface water quality deterioration should be highlighted. Facilities, bearing pollution risks, will be mainly concentrated on construction camps; Akhalkalaki 1 HPP construction camp will be located in large distance from Paravani river and Akhalkalaki 2 HPP construction camp will be in 200 m from the shoreline of Korkhi river.

Wastewater occurrence in the surface water bodies from any construction camps is not expected, since biological treatment facilities or hermetic pits will be provided for the management of agricultural and fecal waters.

Considering the infrastructure, planned on the camp sites, industrial wastewater will not be generated. In order to prevent the pollution with storm water, the fuel tanks will be fenced with corresponding barriers, drainage channels will be arranged on the construction camp perimeter. It should also be noted that large stocks of potentially polluted materials will not be stored on the camp sites.

Quite high flows of Paravani and Korkhi rivers should be noted and accordingly, relatively high probability of pollutant dilution during emergencies and contingencies.

There are some risks of river water contamination with suspended particles on the construction sites of headworks and powerhouses, as well as during preparation of trenches for penstocks.

Besides, there is the risk of various pollutant substance distribution due to improper management of solid and liquid waste (including sanitary-fecal water) and the fuel/oil accidental discharge.

Deterioration of the surface water quality will cause various type indirect impacts, especially, worsening of living conditions of fish and invertebrates living in the rivers, change of the state of groundwater quality, etc.

Surface water pollution risk during the construction phase depends on the performance of the measures envisaged by environmental management plan, as well as on the quality of monitoring of waste management and the functionality of the equipment. This is also important in terms of soil/ground and ground water protection against pollution. In case of proper implementation of the corresponding environmental measures, risks of impact on surface water within the project impact zone will be minimized.

5.5.2.1 Operation Phase

During HPP operation negative impact on surface water is expected in all three directions. At the given stage, risks related to the changes in river debit (reduction of natural runoff) and limitation of sediment movement should be singled out. Probability of water contamination is rather small.

Water diversion first to the intake and then to the penstock may cause the impact on water flow on section between headwork and the powerhouse tailrace channels. For minimization of the impact mitigation measure is considered ensuring the downstream passage of sanitary/environmental flow.

5.5.2.1.1 Change of Natural flows and Necessary Environmental Flow

One water consumer – irrigation water pumping station is located on the project section of Paravani river (from headwork to the powerhouse), which flow is 0.85 m^3/s. There are no water consumers on the project section of Korkhi river and accordingly, impact is not expected downstream from the weir. Two irrigation pumping stations are located upstream from the weir, which are out of operation. In case of putting them into operation during irrigation season, water flow in the river will be reduced with about 0.15-1.2 m^3/s. Reduction of water flow in rivers downstream of the weir will change the existing ecological balance to some extent. Negative impact on biological environment, especially on fish and water related animals will take place.

According to the feasibility study, minimum environmental flow to be released from the headworks of Akhalkalaki 1 HPP is determined as 1,3 m^3/s, and for Akhalkalaki 2 HPP headwork - 0,3 m^3/s. Part of the environmental flow from the Akhalkalaki 1 HPP headworks 0.14 m^3/s will be released through the fishway, while the rest part will be released downstream of the dam. At the headworks of Akhalkalaki 2 HPP a bypass channel type fishway is planned to be arranged and environmental flow (0,3 m^3/s) will be fully released through the fishway.

On the basis of hydrological data of Paravani and Korkhi rivers, Tables 5.5.2.2.1.1. and 5.5.2.2.1.2. are developed, with following information for the project sections

- Interannual distribution of average annual river flow with 10%, 50%, 75% and 90% provisions - m^3/s;
- Necessary minimum environmental flow, which should be passed downstream in average flow conditions with 10%, 50%, 75% and 90% provisions - m^3/s;
- Necessary minimum environmental flow, which should be passed downstream – in %, in relation with the natural river flow;
- Interannual distribution of flow, supplied to the hydro-turbines considering the environmental flow and maximum water withdrawal probability - m^3/s.

It should also be noted that on operation phase the operator company is obliged firstly to release necessary environmental flow downstream and only after that provide water withdrawal for energetic

purposes. Strict control over constant release of the environmental flow will be established in order to preserve the sanitary-ecological function of the project section. In total, the impact on the hydrological mode will not be high and irreversible considering the project solutions and natural baseline conditions.

Table 5.5.2.2.1.1. Akhalkalaki 1 HPP Headwork

Flow	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
10 % provision (high-water year)													
Ave. at the headwork	10,87	11,37	14,46	30,57	34,56	21,38	13,93	10,96	11,36	11,38	11,67	10,87	16,13
Environmental flow	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30
Environmental flow %													
Irrigation flow	0,00	0,00	0,00	0,00	0,00	0,00	0,60	0,85	0,28	0,00	0,00	0,00	0,15
Flow to be used by HPP	9,57	10,07	13,16	29,27	33,26	20,08	12,03	8,81	9,78	10,08	10,37	9,57	14,67
50 % provision (year with medium water year)													
Ave. at the headwork	9,13	9,60	11,98	24,20	27,76	21,74	11,62	9,19	8,72	8,93	9,12	8,94	13,42
Environmental flow	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30
Environmental flow %													
Irrigation flow	0,00	0,00	0,00	0,00	0,00	0,00	0,60	0,85	0,28	0,00	0,00	0,00	0,15
Flow to be used by HPP	7,83	8,30	10,68	22,90	26,46	20,44	9,72	7,04	7,14	7,63	7,82	7,64	11,97
75 % provision (averagely low water)													
Ave. at the headwork	7,24	7,60	10,09	23,38	23,99	16,79	10,71	8,35	8,38	8,88	9,28	7,28	11,84
Environmental flow	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30
Environmental flow %													
Irrigation flow	0,00	0,00	0,00	0,00	0,00	0,00	0,60	0,85	0,28	0,00	0,00	0,00	0,15
Flow to be used by HPP	5,94	6,30	8,79	22,08	22,69	15,49	8,81	6,20	6,80	7,58	7,98	5,98	10,39
90 % provision (low water year)													
Ave. at the headwork	7,66	8,14	9,01	20,11	24,58	13,25	10,88	8,47	7,25	7,33	7,43	7,48	10,98
Environmental flow	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30	1,30
Environmental flow %													
Irrigation flow	0,00	0,00	0,00	0,00	0,00	0,00	0,60	0,85	0,28	0,00	0,00	0,00	0,15
Flow to be used by HPP	6,36	6,84	7,71	18,81	23,28	11,95	8,98	6,32	5,66	6,03	6,13	6,18	9,53

Table 5.5.2.2.1.2. Akhalkalaki 2 HPP Headwork

Flow	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
10 % provision (high-water year)													
Ave. at the headwork	3,43	3,06	4,27	7,47	5,43	3,42	2,19	1,93	2,90	3,07	3,17	3,05	3,61
Environmental flow	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30
Environmental flow %													
Flow to be used by HPP	3,13	2,76	3,97	7,17	5,13	3,12	1,89	1,63	2,60	2,77	2,87	2,75	3,31
50 % provision (year with medium water year)													
Ave. at the headwork	3,39	2,39	2,94	6,17	5,07	3,01	2,01	1,71	2,28	2,39	2,38	2,36	3,01
Environmental flow	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30
Environmental flow %													
Flow to be used by HPP	3,09	2,09	2,64	5,87	4,77	2,71	1,71	1,41	1,98	2,09	2,08	2,06	2,71
75 % provision (averagely low water)													
Ave. at the headwork	2,03	2,03	2,51	5,98	4,65	2,88	2,01	1,94	2,24	2,45	2,44	1,91	2,76
Environmental flow	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30
Environmental flow %													
Flow to be used by HPP	1,73	1,73	2,21	5,68	4,35	2,58	1,71	1,64	1,94	2,15	2,14	1,61	2,46
90 % provision (low water year)													
Ave. at the headwork	1,76	1,70	1,80	4,78	4,29	2,25	1,96	1,94	2,01	2,10	2,12	2,00	2,39
Environmental flow	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30
Environmental flow %													
Flow to be used by HPP	1,46	1,40	1,50	4,48	3,99	1,95	1,66	1,64	1,71	1,80	1,82	1,70	2,09

5.5.2.1.2 Impact on Sediment Movement

In general, significant impact on sediment movement is expected by the operation of the weir. As a rule, the weir is a natural barrier and the sediment is accumulated upstream. In the result, upstream riverbed is elevated and flooding risks of floodplains along the riverbeds are increased. As for the downstream, there is the deficiency of sediments there, which has impact on the dynamics of the riverbed and bank stability.

In the regard with the mentioned impact, the project HPPs can be considered as low-risk projects. Low-threshold weirs will be arranged at headworks, which will be equipped with corresponding flushing gates. Settlings and relatively finer materials, accumulated in them, will be cleaned during floods, as well as the part of solid sediments accumulated in the riverbed.

Periodic maintenance of the headworks and fulfilling operation conditions are in the interest of the HPP operator company, as accumulation of sediments in large amount will worsen operation parameters, which in its turn will be reflected on the amount of generated power. Considering aforementioned, the infrastructure to be arranged at headworks and their characteristics in proper operation conditions will maximally help natural downstream movement of sediments.

In addition to the presence of headwork, the ability of the river move sediments from upstream to downstream will be limited due to reduction of natural water flow. However, during high-waters water, level will restore natural balance of the sediments.

Hence, existence of headwork structure and change of river water regime will not have significant impact on deformation of riverbeds, since reduction of the solid sediments of the river is not expected.

5.5.2.1.3 Surface Water Contamination Risks

In the HPP operation phase, river water contamination may occur in following cases:

- Oil spill on the territory of powerhouse and leachate of pollutants into tailrace channel;
- Oil pollution of water discharging from turbines;
- Discharge of waste and sanitary-fecal water into tailrace channel or into the river due to poor management.

No significant sources of water contamination will be arranged within the headworks. During initial years of operation, monitoring over the geological conditions (rockfall and erosion) of areas, used during construction and over slope protection structures will be significant for prevention of the growth of suspended particle concentrations in water.

Impact on water quality during the maintenance works will depend on the volume and type of works. Mitigation measures will be similar to those considered for the construction phase.

5.5.3 Mitigation Measures

Preventive measures for surface water contamination on the construction phase are as follows:

- During arrangement of the construction camp and storage areas, conditions outlined in the Technical Regulation – on "Water Protection Zone", approved by the governmental resolution #440, dated as December 31, 2013, should be considered;
- Ensure technical functionality of machinery/equipment;
- Arrangement of machinery and potentially polluting material in not less than 50 m from water bodies (where possible). If it is impossible, strict control will be established and safety measures will be carried out to avoid water contamination;
- Prohibit washing of vehicles in riverbeds;

- Cesspools will be arranged for collection of generated sanitary-fecal water (The construction of biological treatment plants will also be discussed. The final decision will be made by the construction company);
- Potentially polluting sites of storm water will be roofed with the shed-like structure;
- Fuel tank will be confined with water-proof barrier;
- Prior to the decision of wastewater discharge into the river, the project on MPC standards will be developed and agreed with the Ministry;
- After completion of works, all potential pollutant material will be removed. In case of fuel/lubricant spill, polluted site will be localized/cleaned;
- Personnel will be provided with corresponding instructions.

There are following mitigation measures for natural runoff changes during the operation phase:

- On construction and operation phases, constant observation will be established on river runoff. Besides, downstream release of the environmental flow will be controlled (monitoring over environmental flow will be carried out on a daily basis). Results of monitoring over natural runoff and environmental flow will be quarterly submitted to the Ministry of Environmental Protection and Agriculture of Georgia;
- In case of flow equal to or less than the environmental flow in the river, power plant(s) will stop operation and full volume of water flow will be released in tailrace of the headwork(s);
- During the first 2 years of operation, fish fauna of project rivers will be monitored and the report will be submitted twice a year to the Ministry of Environment Protection. Additional mitigation measures will be taken, if necessary;
- Within the framework of fish fauna monitoring, special attention will be drawn to checking of sensitive points, existing within the project impact zone. The control mainly considers checking how much is the continuity and the thickness of the water flow is preserved in conditions of environmental flow. If required, riverbed management measures will be implemented on critical points, which involves cleaning of mentioned sections from sediments and boulders, hindering free flow movement;

There are following mitigation measures for limited movement of sediments during the operation phase:

- During floods flush gates will be fully opened in order to ensure downstream passage of sediments;
- Twice a year, after the floods of spring and autumn, passage of sediments in the headwork sections will be monitored;
- According to the results of this monitoring, if it is revealed that the sediment downstream release is limited, appropriate measures will be taken (e.g. cleaning the upstream by excavator, etc.);

There are following mitigation measures to prevent surface water pollution during the operation phase:

- Systematic control over implementation of measures considered by the waste management plan;
- Systematic supervision on oil storage and usage rules;
- In case of accidental fuel/oil spill, localization of the pollution and implementation of measures to prevent deterioration of the surface water;
- Instruction of personnel on environmental and safety issues.

5.5.4 Impact Assessment

Table 5.5.4.1. Summary of the impact on surface water quality

Description of impact and its sources	Impact receptors	Residual Impact Assessment					
		Nature	Probability of occurrence	Influence area	Influence area	Duration	Reversibility
Construction Phase:							
Contamination of surface water with suspended particles, hydrocarbons and other substances: • Source of contamination with suspended particles - contaminated surface runoff, works close to the riverbed; • Source of contamination with hydrocarbon/chemical substances - inflow of contaminated surface water runoff due to their spillage, or their spillage directly in the water bodies; • Other pollution sources – industrial or household solid/liquid waste generated on construction camps.	Residents of nearby settlements, river inhabitants	Direct. In some cases - indirect (e.g. inflow of contaminated surface water runoff in rivers, as a result of spilled pollutants). Negative	medium risk, taking into account mitigating measures – low risk	Paravani river section until confluence and the last section of Korkhi river	Medium term (The impact is limited by the construction phase)	Reversible	**Medium.** considering mitigation measures **Low**
Operation Phase:							
Change of river water flow	Residents of nearby settlements, river inhabitants and terrestrial animals	Direct	High risk	Paravani and Korkhi river sections within the project impact zone.	Long term	Irreversible	**High,** considering mitigation measures – **Medium or low.**
Impact on sediment movement • Change in the dynamics of the riverbed and banks stability	Residents of nearby settlements, river inhabitants	Negative	Medium risk	Paravani and Korkhi river sections within the project impact zone.	Long term	Reversible	**Low**

Contamination of surface waters with suspended particles, hydrocarbon and other substances:
• Source of contamination with suspended particles:
  ○ Surface runoff contaminated with suspended particles from non-cultivated areas;
• Source of contamination with hydrocarbon/chemical substances:
  ○ Discharge water pollution with turbine oils;
  ○ Discharge of surface runoff, contaminated as a result of spillage of chemical substances, into the water bodies;
• Solid / liquid household waste, solid / liquid construction waste generated during maintenance works.
	Residents of nearby settlements, river inhabitants	Direct. In some cases - indirect (e.g. inflow of contaminated surface water runoff in river, as a result of spilled pollutants). Negative	Low risk	Downstream of powerhouses	Short term	Reversible	**Low**

5.6 Impact on Underground/Ground Water

5.6.1 Impact Assessment Methodology

Table 5.6.1.1. Assessment criteria of the impact on groundwater

Ranking	Category	Changes in groundwater debit	Deterioration of water[3] quality
1	Very low	Debit has changed unnoticeably	The background concentration of substances have changed unnoticeably
2	Low	Ground-water levels has declined markedly, though, it has not affected water levels in wells or flow of water	Concentration of substances of the II group[4] is below the permissible limits for drinking water
3	Medium	Ground-water levels and water extraction from wells has declined markedly affecting flow of springs	Concentration of substances of the II group exceeds the permissible limits for drinking water
4	High	Wells are not working temporarily, discharge of water has reduced in surface water bodies, which will cause a seasonal drought and ecological impact	Hazardous substances of I group are observed
5	Very high	Wells are drying, water is not discharging in surface water bodies, there is a great risk of drought and ecological impact	Concentration of substances of the I group exceeds the permissible limits for drinking water

5.6.2 Impact Description

5.6.2.1 Construction Phase

Akhalkalaki HPP project does not consider arrangement of tunnels and accordingly, crossing of deep water-bearing horizons is not expected. Thus, no impact is anticipated on the underground water debit.

There are no water consuming facilities within the project corridor of Akhalkalaki 2 HPP and in the vicinity, so the impact will be insignificant.

As for the project corridor of Akhalkalaki 1 HPP; here, on the last section of the penstock, the tapping structure is arranged on the groundwater outcrop in about 150 m from the power house; from this tapping structure, water is supplied to the trout farm, located downstream from Paravani HPP headwork. Besides, these groundwater are used by local population for curing purposes (according to the information, provided by local population, this water is used for curing infertility). Based on the survey results, groundwater flow out from deep hard rocks and as the penstock passes on upper elevations of the water outcrop, the risk of impact on its debit is at minimum. According to the results of the single time measurements, carried out within EIA process, the spring debit is about 15 l/s.

In the result of consultations with the local population, local authorities and the trout farm, it was agreed that the pipeline will be passed on this section and “AIS” LTD will carry out following mitigation and compensation measures, including:

[3] Groundwater quality is not regulated by the law of Georgia. Therefore, drinking water standard is used for the assessment
[4] EU Directive 80/68/EEC, December 17, 1979, "Protection of groundwater from contamination by certain hazardous substances"

- Preparation of the trench for the pipeline will be carried out with utmost cautiousness on the section of the spring outcrop (on this section, works will be mainly implemented manually without using equipment);
- The tapping structure existing on the spring outcrop will be reconstructed and improved, in order to make it easier to use by population;
- A well-developed pedestrian path will be arranged from Diliska village side;
- The prayer niche will be relocated to the adjacent area, which is agreed with population;
- The intake will be reconstructed in order to supply the trout farm with uninterrupted water supply.

Figure 5.6.2.1.1. Existing Tapping Structure and Prayer Niche arranged on the Spring Outcrop

It is noteworthy that there are numerous outcrops of springs on the slopes of the project corridor, which originate on plateaus, located on upper elevations of the valley. Considering the selected project solutions and baseline conditions of the corridor, it can be stated that no impact is anticipated or it will be insignificant.

During preparation of foundations for HPP facilities, as well as penstock trenches, there are some risks of groundwater contamination in the result of earth works. Accordingly, during preparation of HPP foundations, it is necessary to arrange contour drainage, and during construction – carry out dewatering works on construction sites.

In case of groundwater inflow, pollution risks are related to oil product and other substance spill and movement of pollutants to the deeper layers. In order to prevent groundwater contamination risks soil/ground quality protecting mitigation measures must be implemented, since these two environmental objects are closely related. Timely removal and remediation of the contaminated soil will be especially noteworthy during minimization of risks of pollutant movement in the deeper layers by atmospheric precipitation.

5.6.2.2 Operation Phase

During HPP operation river water flow will be reduced on the project sections of the river (from the headwork to the powerhouse). In the result, feeding areas of the underground water horizons may be restricted, which are hydraulically connected to the river. However, it should be noted that on the project sections, Paravani and Korkhi rivers flow in the narrow canyons, slopes are mostly inclined. Accordingly, the share of the river runoff in the groundwater feeding is not significant. Besides, minimum environmental flow, to be released downstream from weirs, will partly reduce the impact on the groundwater.

A small impoundment is envisaged upstream from weir. Considering the morphometric parameters of the valley on this section, the impoundment area will not exceed the narrow line along the riverbed. Flooding of the area is not expected due to ponding.

Risks of the groundwater contamination are relatively lower than on construction phase. Impact area will mostly be limited with the areas adjacent to the powerhouse storage areas. The accidental spillage of used oil products (oils) on the site can be the source of contamination.

5.6.3 Mitigation Measures

In order to reduce the probability of groundwater pollution it is necessary to implement the measures related to the protection of soil/ground and surface water quality, namely:

- Ensure technical functionality of machinery/equipment;
- In case of identification of fuel leakage, malfunctioning will be promptly solved;
- Proper management of sanitary-fecal water;
- In case of spillage, localization of spilled material and immediate cleaning of the polluted area. Personnel will be equipped with corresponding means (adsorbents, shovels, etc)
- After completion of works all potentially pollutant material will be removed. In case of fuel/lubricant spillage contaminated site will be localized/cleaned;
- Following measures will be carried out in order to prevent deterioration of the conditions for the usage of the spring, located on the left bank of Paravani river:
    - On the spring outcrop section, preparation of the trench for the penstock will be carried out with utmost cautious (works on this section will be mostly implemented manually, without usage of the equipment);
    - A tapping structure, located on the spring outcrop will be reconstructed and rehabilitated, in order to ease the access and usage of this spring by population;
    - A well-developed pedestrian path will be arranged from Diliska village side;
    - The prayer niche will be relocated to the nearby area, on the site preliminary agreed with population;
    - On the section within the HPP project impact zone, the new pipeline will be arranged for uninterrupted water supply to the trout farm, etc.

On operation phase, the significant environmental measure for reduction of the impact on the groundwater debit is the release of the environmental flow downstream of headworks; for this purpose, the permanent control will be established over above-mentioned measure performance. Implementation of measures, outlined in the Waste Management Plan is important for prevention of underground water contamination.

5.6.4 Impact Assessment

Table 5.6.4.1. Summary of impact on groundwater/underground water

Description of impact and its sources	Impact receptors	Residual Impact Assessment					
		Nature	Probability of occurrence	Influence area	Duration	Reversibility	Residual impact
Construction phase:							
• Change of groundwater flow during arrangement of the construction pits for structures and other earthworks; • Impact on groundwater standing level.	Animals, surface water with a hydraulic connection with the river.	Direct Negative	Medium risk	Area selected for the arrangement of the project structures. Spring outcrop on the left bank of Paravani river.	Medium term	Irreversible	**Medium,** considering mitigation measures – **low**
Deterioration of groundwater quality • Earth works; • As a result of pollutants movement into the deep layers of soil, or contamination of surface waters;	Surface water with a hydraulic connection with the river.	Mostly indirect, in some cases direct, negative	Low risk	Construction camp and sites	Short- or medium term	Reversible	**Medium,** considering mitigation measures – **low**
Operation Phase:							
• Change of groundwater flow during arrangement of the construction pits for structures and other earthworks; • Impact on groundwater standing level.	Surface water with a hydraulic connection with the river.	Indirect Negative	Low risk	Project sections of Paravani and Korkhi rivers	Long term	Irreversible	**Low**
Deterioration of groundwater quality • As a result of pollutants movement into the deep layers of soil, or contamination of surface waters;	Surface water with a hydraulic connection with the river.	Mostly indirect, in some cases direct, negative	Low risk	Mainly powerhouse sites	Medium term	Reversible	**Very Low**

5.7 Impact on Biological Environment

5.7.1 Impact Assessment Methodology

For the assessment of the impact on biological environment qualitative criteria is introduced for the following categories:

- Integrity of the habitat, where expected loss of habitat or fragmentation, impact on natural corridor are estimated;
- Loss of species. Impact on species behavior, where the assessment is implemented on changes in their behavior that are caused due to the physical changes, including visual impact, noise and atmospheric emissions.
- Impact on protected territories.

Criteria established for assessment of impacts on ecological systems is provided in Table 5.7.1.1.

Table 5.7.1.1. Criteria for impact assessment on biological environment

Category	Impact on habitat integrity	Loss of species. Impact on species behavior	Impact on protected habitats
Very low	Negligible impact on the integrity of the habitat. After the completion of recultivation works, recovery of the habitat in a short period of time (<1 year).	Changes in behavior are unnoticeable; death of not valuable species of small mammals/fish is expected; there is no risk of spreading invasive species.	No impact is observed throughout the areas protected by national legislation or international conventions.
Low	Noticeable impact on the integrity of low-value habitat, including loss of less valuable habitat of 10-20 ha of land. After the completion of recultivation works, recovery of the habitat in two years.	Changes in behavior may be revealed by standard methods; death of not valuable species of small mammals / fish is expected; there is no risk of spreading invasive species.	A temporary, short-term, minor impact is expected throughout the areas protected by national legislation or international conventions, which will not cause a long-term violation of ecological integrity.
Medium	Significant impact on the integrity of locally valuable habitat, its reduction, reduction of valuable habitats, or less valuable 20 - 50 ha of terrestrial habitat loss. After the completion of recultivation works, recovery of the habitat in 2-5 years.	Changes in behavior of endemic and other valuable species may be revealed by standard methods; death of less valuable animal species is to be expected; appearance of invasive species is expected.	A minor impact is expected throughout the areas protected by national legislation or international conventions, though ecosystem will be restored within 3 years.
High	Reduction of locally valuable habitats, or less valuable 50-100 ha of terrestrial habitat loss. After the completion of recultivation works, recovery of the habitat in 5-10 years.	Changes in behavior of protected species may be revealed by standard methods. The death and reduction of protected and valuable animal species is expected; Spread of invasive species.	Impact is expected throughout the areas protected by national legislation or international conventions. Mitigation measures are to be implemented in order to restore the ecosystem. It will need 5 years to be restored.
Very high	Reduction of locally valuable habitats, or less valuable more than 100 ha of habitats loss. After the completion of recultivation works, recovery of the habitat in more than 10 years.	Changes in behavior of an internationally protected species may be revealed by standard methods. Protected or valuable species of animals die and there is a probability of extinction. Spread of invasive species.	There is an impact on the areas protected by national legislation or international conventions.

5.7.2 Impact on Flora and Habitats

5.7.2.1 Construction Phase

Territory of Akhalakalki municipality, as well as the project corridor is poor in terms of vegetation cover. Individual specimens of trees and vegetation are presented within the project impact zone. There are no state forestry fund lands through the project area.

According to the survey results, high conservation value habitats are not presented through the corridor. Impact on habitats will be caused by the construction works and actions conducted on the preparatory phase. Considering the specificity of implementing works, expected impacts on habitats can be divided into the following types:

- Habitats destruction (permanent loss);
- Change of habitats structure and fragmentation;
- Spread of weeds in habitats;

Each type of impact is evaluated below.

Destruction of habitats – as a result of the construction works, on the preparatory phase habitats will be permanently lost on those territories, where arrangement of foundations of permanent structures (headwork, power house, penstock) is planned. As it was mentioned in characterization of the baseline environment, HPP infrastructural facilities will be constructed in 4 types of habitats, none of them belongs to the high conservation value habitat category.

Project corridor of Akhalkalaki 1 HPP runs through one habitat - E1.3 (Mediterranean xeric grassland), where about 9.8 ha area will be lost (penstock and power house corridor. The headwork and the reservoir will be mainly located within the riverbed of Paravani), on the most part of this area, namely: penstock corridor, the habitat will be restored in 4-5 years as a result of recultivation works. Corridor of the penstock service road and the powerhouse territory will be permanently lost ≈3.1 ha.

Akhalkalaki 2 HPP corridor crosses 4 types of habitats. Headwork arrangement will be associated with loss of small part of the 1st type of habitat; ≈0.12 ha of D4.2 habitat will be lost through the power house corridor. As for the penstock corridor, two types of habitats are presented there - E1.3 and F9.1; temporary impact is expected on ≈3.8 ha area of this corridor, while ≈0.96 ha area of the service road corridor will be permanently lost.

Fragmentation of habitats is expected on the HPP construction phase, namely: access to the rivers will be restricted for the species inhabiting on the surrounding plateaus. Risk of habitats fragmentation will be reduced at minimum after completion of the construction and implementation of recultivation works, because traffic movement on the service roads is expected only during the maintenance works.

Spread of weeds – implementation of various works and removal of local plant species in different habitats pose the risk of intrusion of invasive and adventive species in the habitats. Intrusion of invasive species will transform a habitat's structure and certainly impact on its ecological processes. In its turn, change of a habitat's floristic component will negatively affect its faunal components as well.

According to the survey results, plant species included in the Red List of Georgia or protected by the international treaties are not observed through the project corridor. Moreover, the project corridors are very poor in terms of presence of trees and vegetation.

About 20 specimens of plants, including white poplar (*Populus alba*), white willow (*Salix alba*) and a few scrubs of dog rose (*Rosa canina*) were recorded within the Akhalkalaki 1 HPP project corridor.

As for the corridor of Korkhistskali River, about 40 specimens of various species were observed through the entire territory, namely: Goat willow (*Salix caprea*), bay willow (*Salix pendantra*), white willow

(*Salix alba*), white poplar (*Populus alba*), common alder (*Alnus glutinosa*), cherry plum (*Prunus divaricata*), and scrubs sea-buckthorn (*Hippophae rhamnoides*) and dog rose (*Rosa canina*).

Vegetation of the project corridors are mainly presented in the vicinity of the river bank line and in most cases, plant specimens are beyond the project area; however, in case of steep slopes there is a high risk of their damage.

Despite the fact that amount of vegetation cover of the project impact zone is not considerable and no species included in the Red List of Georgia or protected by the international agreements are presented there, impact on flora and vegetation should be assessed as medium degree and implementation of appropriate mitigation measures will be essential.

5.7.2.2 Operation Phase

The HPP operation less requires rooting out-cutting of vegetation. Such small-scale works will be conducted only for repair-maintenance works, when the RoWs of the HPP facilities will be recurrently cleaned for the purpose of their safe functioning.

As it was mentioned above, arrangement of the underground penstock is considered by the project that will significantly reduce the impact caused by habitats fragmentation and less hamper movement of terrestrial animals.

On this stage of the activity, in appropriate environmental management conditions (adhering of boundaries of the corridors of the HPP infrastructural facilities, providing of geological stability of the adjacent slopes) risks of additional, indirect impact on the vegetation cover will be significantly reduced and at the same time, partial restoration of such significant components, as well as compensation of damage occurred on the construction phase is expected.

5.7.2.3 MitigationMeasures

Mitigation measures against impact on vegetation cover and habitats integrity on the construction phase are as follows:

- Personnel will be instructed on the issues of protection of vegetation cover prior to the works are launched;
- Vegetation resource removal works will be carried out so that to reduce number of cutting trees and scrubs at minimum;
- Boundaries of the working zone should be adhered, in order to avoid additional (excessive) damage of vegetation cover (herbaceous plants). Working boundaries should be marked in advance;
- To compensate damage of vegetation cover, trees and vegetation will be planted at the adjoining territories of the power facilities. Given the harsh local climate, local species will be used for the landscaping works;
- Period of earth works (arrangement of foundations) will be limited at maximum and excavated pits will be filled in short terms as far as possible;
- Artificial crossing
- In order to reduce the risk of habitats fragmentation, especially, in frames of the penstock corridor, artificial overpasses will be arranged as far as possible (wooden boards will be put on the penstock trenches especially, at night);
- After completion of the construction works recultivation of the temporary used areas will be carried out that will significantly reduce the impact related to the habitats fragmentation;
- Safety measures will be adhered to prevent fires;

Mitigation measures for impact on vegetation cover and habitat integrity on operation phase are as follows:

- Implementation of mitigation measures developed for construction phase during large scale repair and prophylactic works;
- Promotion of growing-development of artificially planted trees and vegetation;
- Strict control for elimination of illegal cuts by the personnel and for adhering of the boundaries of the HPP's corridor.

5.7.3 Impact on Wildlife

5.7.3.1 Construction Phase

Based on the results of two field surveys of Akhalkalaki HPP project corridor (surveys were carried out in autumn of 2018 and spring of 2019), no favorable habitats for the species included in the Red List of Georgia or protected by the international treaties are presented within the project area. The mentioned situation is basically stipulated by the high anthropogenic loading that is especially typical for Akhalkalaki 1 HPP project corridor. On the other hand, practically, there is no vegetation cover on the project territory and these areas are less attractive for large mammals. The upper section of Akhalkalaki 2 HPP project corridor is used for pasture. Despite this, vulnerable species of the region can be visitors of the project territory. Consequently, implementation of the construction works may impact on them.

In frames of the field surveys, vitality signs of the otter *(Lutra lutra)* were not detected, at the same time favorable habitats for this species are less presented within the project corridor, namely: bank of Korkhistskali River is basically structured by rocky massifs and the otter does not use such riverbanks for inhabiting. The habitat is relatively open in the upper reaches of the river and the bank is less stony, but not optimal. Despite this, presence of otter cannot be excluded in Korkhistskali River valley.

As for the section of Paravani River within the project territory, anthropogenic data is quite high there due to the intense traffic flow and considering the cautious nature of the otter, it avoids such habitats and its existence is less expected there. It is also important that the bank line is structured with large boulders and such habitat is less attractive for the otter.

Based on the literary sources, Marbled polecat *(Vormela peregusna*) is recorded in the project region from the protected species, but it is very rare species and is registered only in one point on the territory of Javakheti region, namely in the vicinity of Madatapi Lake. Signs of vitality of this species were not found within the project corridor during the field surveys, however, its presence within the project region can't be excluded.

Two more species - Grey dwarf hamster *(Cricetulus migratorius)* and Turkish hamster (*Mesocricetus brandti)* are also typical for the project region. These species are widespread in the southern Georgia and considering the fact that the vast meadows are presented on the adjoining plateaus of the project corridors, Grey dwarf hamster and Turkish hamster should probably inhabit within these territories. Specifically, the project corridor is not the best habitat for these species, but their occurrence within these areas cannot be excluded

In the project region, from 32 mammals registered in the literary sources, 23 of them are protected by the Bern Convention, majority of which, including 3 species red fox *(Vulpes vulpes),* Levant mole *(Talpa levantis)* and least weasel *(Mustela nivalis)* were observed on the neighboring territory of the project corridor. Relatively higher impact risk on these species is expected on the minor section of the ETL passing through the agricultural land plots near the village Diliska. Prior to construction of the ETL, specific locations of towers should be inspected and in case of finding any holes, their location should be changed.

According to the literary sources, 8 species of bats inhabit on Javakheti Plateau, all of them are protected by Bern Convention. In frames of the field surveys, two species of bats common pipistrelle *(Pipistrellus pipistrellus)* and grey long-eared bat *(Plecotus austriacus)* were recorded within the project corridor. It should be noted that the vegetation cover, including the hollow trees are very scarce through the project area. Bats favorable habitats are the rocky slopes, where many cracks are observed. Direct impact on bats habitats is not expected during the construction works, however, damage of inhabiting areas is expected within the clearing process of slopes from the shaky boulders. According to the project, explosion works are not planned and consequently, the related impact is not expected.

Javakheti plateau is one of the significant migration corridors for the migratory birds that is distinguished by species diversity. The project corridor does not coincide the migration flyway, but due to their proximity to each other, all the birds flying through the migration corridor can occur within the project area. At the same time, according to the Paragraph 4.2.4.3.4.2., the project corridor is not the Important Bird Area (IBA) due to the far distance from such territories. Typical landscapes of the region (e.g. lakes and bogs) that may be the birds concentration areas are not observed within the project impact zone.

From 112 species provided in the literary sources, 13 of them were observed during the field surveys, among them 1 species is included in the Red List of Georgia, while 8 species are protected by the Bern Convention.

Relatively higher risk of adverse impact on birds is expected on the ETLs operation phase. In frames of construction of the HPPs and the ETLs, negative impact risks won't be high, because destruction of the birds inhabiting sites is less expected due to absence of the appropriate habitats (vegetation cover, lakes, swamped areas) within the project corridors.

Considering all the above mentioned issues and the project specificity, adverse impact on animal species distributed within the construction zone is expressed in the following ways:

- Nesting areas of certain species may be disturbed due to the earth works. Main receptors can be small birds and bats that may inhabit on the neighboring rocky slopes
- Cleanup of grass cover on the territory may also limit habitat of various reptiles and amphibians
- Due to increased traffic, existence of humans and change in lighting background disturbance factors will increase for terrestrial mammals, amphibians, birds and bats inhabiting road-side territories and territories in vicinity of the construction sites. This may have a direct impact on existence of animal population, for instance impact on reproduction (nesting) areas during reproduction season, hunting and wintering areas, migration routes and resting points. Less valuable various animal species can be relatively sensitive toward such impacts;
- Construction will be related with increase of noise and vibration, as well as emissions of dust and other harmful substances into ambient air. Almost all species, inhabiting within the corridor will be impacted;
- Trenches arranged as part of earth works will pose some risks to small mammals: they may fall into the ditches which may lead to their injury or death;
- Animal mortality or migration can be also caused by waste, if any in environment, and visual-landscape changes;
- In case of pollutants spill into water or on the soil, populations of fish species, amphibians and otter will be affected, as well as animals inhabiting within the areas, where spill takes place or immediate vicinity;
- Facts of illegal hunting by personnel may be detected.

In order to minimize impact on animals during the construction phase, implementation of developed mitigation measures will be especially monitored within the sensitive sites.

Overall, impact on wildlife during the construction phase may be assessed as medium or high impact. In case of appropriate mitigation measures and constant monitoring impact on terrestrial fauna may be reduced to "low" level.

5.7.3.2 Operation Phase

Reduction of water level in the river can be deemed as the main source of the negative impact on wildlife on operation phase. Above-listed, esp. protected species can be the key impact receptors, part of which will have to migrate to other, analogous ecosystems in the region.

On operation phase, the main reason of the impact on water-related species is decrease of water runoff. In this regard, it is important to carry out mitigation measures for impact on river hydrology and fish fauna.

As for other Red List Species of Georgia, significant impact on them is not expected. As the there are many similar habitats and shelters for them within the project implementation region, majority of these species will return to old habitat and significant living areas. Headwork sites should be singled out among such areas, where small impoundments can have even positive impact on otter and water-related animal populations. On operation phase, the degree of the anthropogenic load and disturbance factor (noise, intensive human activities) will be insignificant, as it is planned to provide headwork management in an automated mode.

The project ETL corridor will not cross river valleys or natural ravines and accordingly, the risks of impact on birds will not be high (risks of negative impact on birds are discussed in paragraphs 5.7.3.2.1. and 5.7.3.2.2.).

Shelters of reptiles and bats will be destructed to some extent. Considering above-mentioned the main direction of mitigation measures will be minimization of such risks. For this purpose, proper recultivation of temporarily used areas will be emphasized.

Other than that, possible negative impacts on wildlife expected during operation phase of the project include:

- Impact related to noise distribution;
- Impact related to night lighting systems;
- In case of water quality deterioration, impact on water-related animals and birds.

Relatively significant impacts on fish fauna during operation phase are discussed in the following chapter.

5.7.3.2.1 Mitigation Measures of Impacts Caused by Electric Shock

In order to reduce death of birds by electric shock, conductors should be enough far from each other. Wet wings less provide the insulation, so, it is likely that distance between the wires should be more than wingspan and total length of a bird.

Following mitigation measures can be implemented to protect the bird fauna:

- Line design and configuration : proper separation of electric conductors;
- Insulation: electric transmission lines should be covered by such materials , which will protect birds during accidental touch to the cables;
- It is desirable to use suspension insulators and vertical break switches, length of insulator chain should exceed 0,7 m;.
- The so called "roosting" method should be established. In Europe minimum distance between cables of opposite poles is 1,4 m, and distance between roosts and charged particles – 0,6 m. in

those areas, where predators, such as eagle, are observed, distance should be more (between cables - 2.7<; between roost and charged particles - 1.8<).

5.7.3.2.2 Mitigation Measures of Impacts Caused by Collision

Cable marking: installation of visual barriers (e.g. Silhouettes of predators) is ineffective, because they are adaptable for birds over time. Acoustic barriers are not reliable as well, because they need considerable costs and their affect doesn't extend on long distance.

Proper selection of the electric transmission line design is more effective (e.g. horizontal location of wires of different poles). For marking hardly visible wires (thin wires) increase of their thickness, sharp color and attaching colorful objects, such as round items, ribbons, flags, etc., are accepted. In case of installation these items in 5-10 m interval, birds' mortality is reduced by 50-80%. Marking of electric transmission lines should be done within the sensitive sections (there where ETL crosses the rivers).

It is established that marking of wires reduces mortality of birds by 55-94%. Contrast of the items selected for marking has greater significance than color. Installation of movable items (during the wind) is also important.

Monitoring is essential to identify efficiency of the mentioned mitigation measures. Monitoring implies visual observation the surrounding area of the ETL and obtainment of a victim of collision. Most of them are recorded 40 m away from electrical transmission lines. Sites of searching of dead birds should be marked on the map, in order to reveal problematic areas. In addition, special notes about the precise site of collision should be made. Approximate age and gender of found bird should be identified. Reason of death should be recorded; it may be electric shock, collision or any other reason. Implementation of additional mitigation measures should be conducted in accordance with the monitoring results.

5.7.3.3 Mitigation Measures

On construction phase, there are following mitigation measures considered for the impact on terrestrial animals:

- Prior to the construction works, access roads, river crossings (esp. headwork sites) will be checked in order to find bird nests and traces and holes of predator mammals;
- Transport movement will be restricted near the sensitive sites and movement speed will be reduced;
- In the case of species listed on the Red List of Georgia or protected under international agreements are detected during the monitoring process, the project executor will address the Ministry of Environment Protection and Agriculture of Georgia in written form and will continue the further activities in accordance with instructions from the Ministry;
- Personnel hired for the construction will be instructed and corresponding warning will be provided to them on sanctions in case of damage to animals;
- Construction corridor will be protected in order not to exceed the marked zone and not to damage additionally the holes, bird nests and bat shelters. Earth works will be controlled by the personnel, having appropriate knowledge;
- Transport movement route will be protected;
- Optimum speeds of movement will be selected in order to reduce the likelihood of the direct impact (collision) on animals;
- Holes, trenches will be fenced in order to avoid animal falling into it;
- Activities (e.g. causing high level noise), causing excessive disturbance of animals will be carried out in the shortest possible time;

- After completion of the construction works, recultivation of areas, adjacent to communications and access roads will be carried out, which will significantly reduce the impact related to habitat fragmentation;
- For prevention of poaching, the personnel employed for the construction will be instructed and warned, in compliance with the Ministerial Order №95 (27.12.2013) on "Hunting Rules" and Technical Regulation on Fishing and Protection of Fish Stock" approved by the Governmental Resolution №423; (31.12.2013);

Besides, following will be highlighted:

- Proper waste management;
- Implementation of mitigation measures for water, soil and ambient air pollution, noise propagation, etc. (see relevant subparagraph);

On operation phase:

- Necessary environmental flow will be released downstream from headwork;
- Raise of the personnel awareness is considered on issues of illegal hunting/fishing and monitoring will be established for this purpose;
- Optimization of night illumination system.

5.7.4 Impact on Fish Fauna

5.7.4.1 Construction Phase

On construction phase possible impact on fish fauna can be of various types, namely:

- **Drying of separate sites of the river:**
  During construction of headwork and other riverbed works it will be necessary to change river flow direction – diversion to artificial riverbed. Accordingly, water will be dried out on some small areas of the natural riverbed or small ponds will be created, which can lead to the death of fish species;
- **Blockage of migration routes:**
  River diversion to temporary riverbed may create artificial barrier, causing blockage of the migration route. Surveys carried out by the World Comission on Dams showed that the most significant impact on ecosystems is creating barriers for migratory fish species.
- **Disturbing the river, changing turbulence:**
  Earth works that will be carried out on slopes, may cause getting large amount of earth into the water, leading to its turbulence; the scale of the turbulence will be depended on flow speed and granulometric composition of soil. Soil settled in the water will cover stones, which are significant substrata for reproduction of lithophylic fish species. High turbulence can damage fish gills. Getting large amount of soil into the water and siltation of riverbed will negatively impact on invertebrates;
- **Noise:**
  Usage heavy machinery (loaders, excavators, rock drilling equipment) will cause significant noise, which negatively impact natural life of fish;
- **Water Contamination:**
  In case of fuel leakage from equipment, working in the vicinity of river, deterioration of water quality and accordingly fish habitat is expected;

Drying of separate sites of the river and blockage of migration routes can be considered as direct impacts from above-listed impact types. Others can be deemed as indirect impacts, which are discussed in following paragraphs and corresponding mitigation measures are developed for them.

5.7.4.2 Operation Phase

On operation phase the negative impact on fish fauna can be expressed in the following directions:

- Sharp reduction of river water level within the project section will significantly change the environment for fish fauna;
- Existence of headwork will impede free movement of fish from downstream to upstream;
- In the operation phase there is the risk of getting the fish into intake and injury (death);
- Also it is unlikely but still expected the risk of impact on fish fauna due to the deterioration of river water quality (impact is described in relevant paragraph);
- Above-mentioned impacts will negatively impact on invertebrates, inhabiting in the river, which in its turn will negatively affect the food base of fish. Following negative factors can be observed in the regard of benthic fauna:
    - Change of river flow direction;
    - Change of sediment transportation regime;
    - Change of granulometric composition of soil, siltation;
    - Flow reduction on the section between weir and power house;
    - Mechanical and hydraulic barriers during upstream migration.

Impact Caused by River Blockage and Changes of Natural River Flow Regime:

HPP operation will lead to artificial distribution of the river runoff in time, which will disorganize natural environment for fish species, i.e. established natural breeding and inhabiting conditions of fish species will be changed. Hydrological, thermal, hydro chemical and hydro biological regimes, as well as fish movement, breeding and feeding conditions are changed. Reproduction and fish-growing periods are also changed for migratory and semi migratory fish.

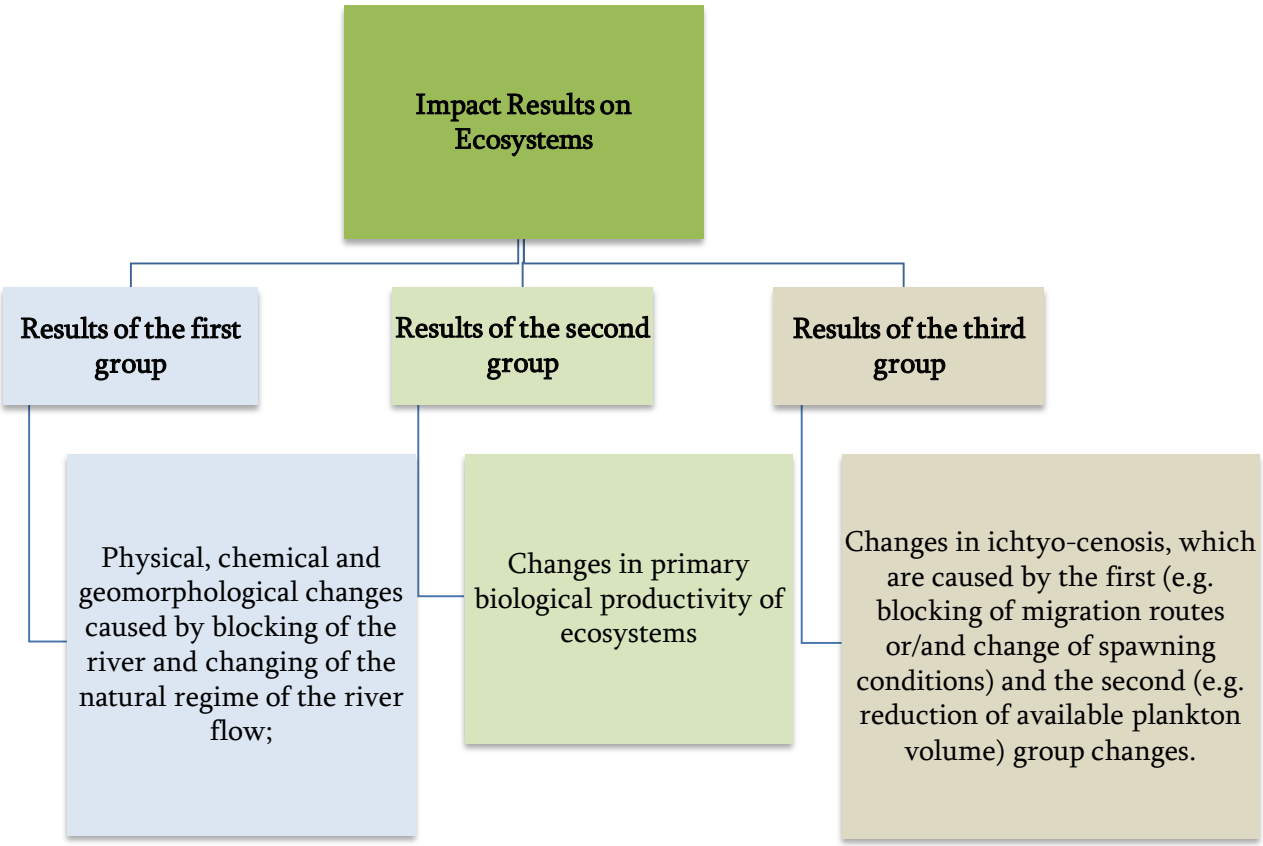
Reduction of river debit will impede instinctive striving of fish to spawning migration, which can lead to the death of weak fish; or due to early development of spawning areas and mixing of spawning periods, retention time of fries in the spawning areas can be reduced. In such conditions, fries leave the spawning sites earlier, when they are still weak. Accordingly, they cannot survive in existing conditions. Hydro-fauna of low-water rivers is especially sensitive to river flow fluctuation.

Results of impact on the ecosystem, which are mostly caused by anthropogenic regulation of the river runoff, may be listed as follows: see diagram 5.7.4.2.1.

It is noteworthy that some project solutions can significantly reduce the impact on fish fauna, caused by river blockage and changes in the natural regime of the river; namely: on the one hand, continuous passage of established environmental flow downstream of headwork will be ensured, and flows of quite large tributaries existing on the project sections will be added (impact on hydrological mode is detailed in paragraph 5.5.2.2.1.).

On the other hand, arrangement of a pool type fish passage, having dimensions established by international standards (FAO) is considered. The gradient of fish pass, number and sizes of pools have been selected according to the relevant methodology in order to achieve maximum effect. This will ensure conditions similar to natural conditions for fish migration.

Diagram 5.7.4.2.1.



Risks Related to Getting Fish into Intake and Fish Damage/Death Risks:

According to the environmental legislation of Georgia, installation of fish protective devices is essential on water intakes of all hydraulic structures. This measure reduces risks of fish entrance into the water inlet of turbine (including protected species), as well as, risks of their death and damage. According to the project, for prevention of fish occurrence in the penstock, it is considered to arrange the protective fine screen. Similar screen is arranged on the headwork of Paravani HPP. According to the monitoring results, there were no facts of fish mortality in Paravani HPP discharge water

Water Quality Deterioration and Possible Impact:

As it was mentioned above, water quality deterioration is less expected in the operation phase. Such risks can be connected with negligence of service personnel and malfunction of technological equipment.

Taking into consideration aforementioned, on operation phase the impact on fish fauna and associated damage can be assessed as High. In order to reduce the impact it is necessary to carry out effective mitigation measures, which will reduce the impact significance to the level lower than medium.

5.7.4.3 Mitigation Measures

Tangible effective mitigation measures for minimization of impact on fish fauna are as follows:

Construction Phase:

- Relevant measures will be taken during construction works of the headwork, in order to prevent wide spreading of river stream (accordingly water depth reduction) and/or creation of small ponds separately from common stream. Temporary gabions/river sediment will be effectively used for this purpose so that to create single channel deep riverbed;
- Water flow diversion from natural riverbed to artificial riverbed will be provided as long as possible to avoid sudden effect, in order to enable fish adaptation to the new environment;

- Junctions of artificial and natural riverbeds will be arranged so that to avoid creation of artificial barriers for fish migration;
- On headwork construction sites riverbed will be regularly cleaned from wood waste;
- Banks and slopes will be strengthened against negative events (soil getting into water, mudflow, etc.). All works will be implemented in riverbed with special cautiousness in order to avoid river turbulence;
- While working near the river all measures against noise propagation will be carried out;
- All measures will be taken in order to maintain water quality.

Operation Phase:

- Liquid flow management will be effectively provided. Established environmental flow will be permanently released downstream of headworks;
- According to the project, a fish pass structure (fish ladder), designed in compliance with the international standards, will be arranged at headwork. Technical functionality of fish pass will be regularly monitored and waste will be removed, which is especially important for prevention fish movement restriction;
- Technical functionality and operation of fish passage will be effectively monitored;
- In order to minimize the risk of fish damage (death), a steel protective mesh (screen) will be arranged on water intake and its cleaning from floated sediments will be provided;
- During the first 2years of operation, species of ichthyofauna will be monitored in order to develop additional mitigation measures if required;
- Within the framework of fish fauna monitoring, special attention will be drawn to checking of sensitive points. The control mainly considers checking how much is the continuity of the water flow is preserved in conditions of environmental flow. If required, riverbed management measures will be implemented on critical points, which involves cleaning of mentioned sections from sediments and removal of boulders that hinder free flow movement;

Additionally, following will be considered:

- All mitigation measures in order to avoid deterioration of surface water quality (see relevant paragraph);
- Staff will be properly instructed on prohibition of illegal fishing.

5.7.5 Impact on Protected Areas

Due to significant distances between the project corridor and the protected areas direct negative impact on them is not expected.

5.7.6 Impact Assessment

Table 5.7.6.1. Summary of impact on Biological Environment

Description of impact and its sources	Impact receptors	Residual Impact Assessment					
		Nature	Probability of occurrence	Influence area	Duration	Reversibility	Residual impact
Construction Phase:							
Damage/Destruction of the Vegetation; Habitat loss/fragmentation: • Direct impact: ○ Tree felling; ○ Construction of infrastructure and access roads. • Indirect impact: ○ Water pollution; ○ Soil pollution and erosion.	Wildlife Population	Direct and indirect Negative	Medium risk	• Direct impact area – construction sites and penstock corridor; • Indirect impact area – areas adjacent to work sites	Medium term. In some directions - long-term	Reversible in some cases - irreversible	**Medium** Considering mitigation measures - **Low**
Impact on terrestrial fauna, including: • Direct Impact: ○ Direct impact by people or equipment; ○ Change of illumination background at night; ○ Vehicle collision, falling into trenches, etc.; ○ Illegal hunting. • Indirect impact: ○ Preparation of construction sites; ○ Ambient air pollution; ○ Acoustic background change; ○ Possible pollution of surface and ground water; ○ Soil pollution and erosion; ○ Visual Impact.	Animal species living within the project implementation region.	Direct and indirect Negative	High risk	Areas adjacent to the work sites, especially while working in the vicinity of riverbed	Duration is limited with the construction phase	Mainly reversible	**Medium or high** Considering mitigation measures - **Low**
Impact on Fish Fauna	Biological environment of Paravani and Korkhi rivers	Mainly indirect, negative	Low or medium risk	The section of the river near the construction sites/camps	Duration is limited with the construction phase	Reversible	**Medium** Considering mitigation measures - **Low**

Operation phase:							
Damage/Destruction of the Vegetation; Habitat loss/fragmentation	Wildlife Population	Direct Negative	Low risk	The area of influence is mainly limited within the repair sites for powerhouses	Long term	Reversible	**Very low**
Impact on terrestrial fauna, including: • Water debit reduction within the project section; • Illegal hunting; • Soil contamination and erosion; • Visual impact, etc.; • Reduced forest cover.	Animal species inhabiting within the HPP communication region	Direct and indirect Negative	Medium risk	Areas adjacent to the HPP communications, ETL corridors	Long term	Mainly irreversible	**Medium Low**
Impact on fish fauna • Direct impact sources: ○ Change of hydrological regime of the river; ○ Existence of headworks; ○ Illegal fishing; ○ Implemented maintenance works. • Indirect impact sources: ○ Surface water pollution; ○ Contamination of bottom sediments.	Biological environment of Paravani and Korkhi rivers	Direct and indirect Negative	• Direct impact risk - high • Indirect impact risk - low	Project sections of of Paravani and Korkhi rivers	Long term	Mainly irreversible	**Medium Low**

5.8 Impact Related to Distribution of Electromagnetic Fields

5.8.1 General Overview

Electrical and magnetic fields (also known as electromagnetic fields) are lines of invisible force that are radiated from any type of electrical equipment, including ETL and electrical installations. The tension of the field increases with increase of voltage and is measured in volt/meter (V/m). Electrical fields are blocked or screened by conductive substances and other materials, such as trees and buildings. Their density increases with the increase of voltage and are measured in Gauss (G) and Tesla (T) units (1T=10.000 G). Magnetic fields penetrate most substances and are difficult to screen. Just as electrical, magnetic fields reduce with distance.

Even though public and scientific approach towards the potential harm of electromagnetic field on human health exists (not only from HV ETL and substations, but also household consumption of electricity), empirical data suggesting harmful effects of ETL and equipment of human health is limited. Although the basis for harmful risks for human health is little, consideration of electromagnetic field radiation is rational for this EIA.

Significant radiation of electrical or magnetic fields on population or environment due to construction and operation of the project is not expected. The World Health Organization (WHO) published the latest review of electromagnetic fields in June of 2007, where experts concluded that electromagnetic field does not have a long-term negative effect on human health. (WHO. 2007).

Radiation of electromagnetic field from the project ETL on the edge of alienation line may even be less than a radiation from equipment used daily within the households. The level of electrical field will not change throughout the whole period of ETL operation; magnetic field levels, however, may vary in accordance with load schedules of hours, days, weeks, and seasons.

Activities considered by the project that are related with the generation of electromagnetic fields, include operation of transmission line and substations under electrical voltage. Typically frequency of ETL electromagnetic field is 50-60 Hz, and is considered to be an extremely low frequency (ELF).

5.8.2 Impact of Electromagnetic Fields of Human Health

Number of studies have been conducted for the last 30 years in the US and in other countries of the world in order to measure exactly when can electromagnetic fields have an impact on human health. Influence of electromagnetic field impact is mainly determined in accordance with types of electrical sources and distance to these sources. Scientific studies are focused on magnetic fields, since objects like trees and walls act like a physical barrier that easily block and screen electrical fields.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) reviewed epidemiological and experimental data and concluded that there is no basis for elaboration of limiting standards of long-term impact from electromagnetic fields. On the contrary, the guidelines include higher limits for human health protection in case of short-term exposure (e.g. stimulation of nerves and muscle tissue, shock-like effect) established in 1998, than it is known for highest impact. ICNIRP recommends limits of **833 mG** for population and **4200 mG** of professional radiation (ICNIRP, 1998). Additionally, International Commission on Electromagnetic Safety (ICES) recommends that exposure of community should be limited with **9040 mG** (ICES, 2002). Both standards are developed and considered for wide range of safety.

Exposure of population working in vicinity of the project ETL (e.g. those engaged in agricultural activities) must be lower than the limits. Typical levels of electromagnetic filed in accordance with the report on Electric and Magnetic Fields Associated with the Use of Electric Power published by National

Institute of Environmental Health Sciences in June of 2002 (EMF, Electric and Magnetic Fields Associated with the Use of Electric Power) (NIEHS, 2002) are:

- **29,4 mG** for 15 m from 500 kW TL, which reduces to **12,6 mG** on a distance of 30 m;
- **19,5 mG** for 15 m from 230 kW TL, on a distance of 30 m- **7,1 mG**;
- **6,5 mG** for 15 m from 115 kW TL, on a distance of 30 m - **1,7 mG**.

According to Article 3 of Technical Regulation on "Rules of Protection of Linear Construction of Transmission Network and Their Protection Zones" approved by the Georgian Government with decree #366 of on December 24, 2013, protection zone for 35 kV EL is 15 m wide from the outer wires.

In case of Akhalkalaki HPP, distance from the nearest house will be at least50 m. Accordingly, considering the above mentioned factors, impact on population associated with distribution of electromagnetic fields does not need any mitigation measures.

The HPP substation is located in 350-400 m distance from the nearest settlement and practically, there is no risk of impact.

5.8.3 Impact of Electromagnetic Fields on Biological Environment

Industrial frequency of electromagnetic field does not have ionizing effect, and normally it does not have thermal effect either. Electromagnetic field within ETL frequency is too weak to damage molecules or decompose DNA, it cannot cause mutation or cancer. However, it can scare animals and limit habitat area.

During animal surveys, scientists have carried out tests on rats and mice using electrical and magnetic fields. After that, they compared illnesses with the illnesses of animals that were not exposed to the fields (WHO. 2007). On June 2007 WHO concluded in the report on Electromagnetic Fields and Health, that no harmful impact (including cancer) was observed in the animals as the result of exposure. Based on the survey, we can assume that the planned activity will have no adverse impact on the biological environment.

5.8.4 Impact Assessment

Summarizing of information provided in the previous paragraph, the possible impact related to distribution of electromagnetic fields can be assessed as very low. Consequently, determination of mitigation measures was not considered as appropriate.

5.9 Impact on Topsoil, Soil Contamination

5.9.1 Impact Assessment Methodology

Impact volume on the soil is assessed by the following parameters:

- Impact intensity, area and duration;
- Towards changes of their sensitivity;
- Their ability to restore.

Table 5.9.1.1. Impact assessment criteria on soil and ground

Ranking	Category	Destruction of the fertile soil layer	Soil/Ground Pollution
1	Very Low	Less than 3% of the project area has been destroyed forever	Soil/ground background conditions have changed unnoticeably
2	Low	3%-10% of the project area has been destroyed forever	The concentration of pollutants have increased with less than 25%, but less than the permitted value, 6 months will be needed for the soil/ground quality restoration

3	Medium	10%-30% of the project area has been destroyed forever	The concentration of pollutants have increased with 25-100%, but less than the permitted value, 6-12 months will be needed for the soil/ground quality restoration
4	High	30-50% of the project area has been destroyed forever; small areas are damaged outside of the project area, recultivation of which is possible after completion of the construction works	The concentration of pollutants have increased with more than 100%, or exceeds the permitted value, 1-2 years will be needed for the soil/ground quality restoration
5	Very High	More than 50% of the project area has been destroyed forever; small areas are damaged outside of the project area, recultivation of which is possible after completion of the construction works	The concentration of pollutants have increased by more than 100%, or exceeds the permitted value, more than 2 years will be needed for the soil/ground quality restoration

5.9.2 Impact Description

5.9.2.1 Construction Phase

Topsoil damage and disturbance of stability is mainly expected during the preparatory and construction works that will be mainly related to the vehicles movement in frames of arrangement of the HPP and the ETL infrastructure, earth works, arrangement of temporary and permanent infrastructure and final disposal of waste rocks.

However, as it was mentioned during description of baseline condition of the environment, the topsoil cover is very sparse on the project area (due to local relief conditions – high inclination of slopes). Besides, specificity of areas, where main works will be implemented, should be considered, namely: main works within the headwork will be carried out in active riverbed and nearby. Pipeline corridors pass in parallel of the existing road, along the riverbed. Bedrocks and stone-gravel soil are observed on the territories of powerhouses and a substation.

Topsoil is presented on the construction camp territory of Akhalkalaki 2 HPP and on that part of the ETL running through the agricultural land plots of Diliska village. Maximum depth of topsoil is 15 cm and area 4800 m^2 on the construction camp territory. Consequently, removable topsoil volume will be 720 m^3. Topsoil layer is not presented on the territory of Akhalkalaki 1 HPP construction camp.

Topsoil is observed on the territory of 8 towers within the ETL corridor and considering the maximum land area (96 m^2) required for erection of one tower, area of the territory, where removal of topsoil layer will be available, is ≈768 m^2. Taking into account of 20 cm thickness of topsoil, totally 153 m^3 volume of topsoil will be removed within the ETL corridor.

Totally, 773 m^3 topsoil can be removed on the construction phase. Topsoil will be disposed in the vicinities of each specific tower through the ETL corridor; later it will be used for the recultivation purposes. Topsoil layer removed from the construction camp territory of Akhalkalaki 2 HPP will be disposed on the camp area and will be used in recultivation.

Soil/ground contamination is expected on the preparatory, as well as in the construction process.

Improper waste (both, solid and liquid) management, violation of storage rules of fuel-lubricant and construction materials, as well as spill of fuel-lubricants from the construction vehicles can also affect the soil/ground quality. On the construction phase, there are higher risks of soil contamination on the territories of construction camps (parking lot and other polluting sources will be arranged there).

Secondary (indirect) impact risks are noteworthy in terms of soil/ground contamination; for example: groundwater contamination due to the movement of pollutants into the deep soil layers (it should be noted that the rocks of the project territory are characterized by high water permeability), as well as

washing of pollution by the surface runoff and their occurrence into the river. Consequently, appropriate preventive measures will be carried out within the project implementation process.

5.9.2.2 Operation Phase

Arrangement of large reservoir is not planned at the headworks. It should be noted that the headworks alignment is not a wide area of the valley (it is wider at the headwork of Korkhi River). Accordingly, flooding of considerable territories by the upstream impoundments is not expected.

On the HPP operation phase, soil/ground can be contaminated by the following reasons:

- Violation of the fuel and lubricants storage-usage rules;
- Oil spill from transformers or other equipment due to leak, damage, during adding or changing the oil;
- Improper household and other solid waste management on the HPP area (polluted rags used for cleaning of equipment, oily sawdust, dirty gloves, etc.);
- Turbine oil spill.

Hence, risks of soil contamination are the highest on the territories of powerhouse, namely within substation and oil storage areas.

The impact is also expected during the maintenance-repair works. In order to prevent the soil pollution during the maintenance works, mitigation/preventive measures considered for the construction phase are to be implemented.

5.9.3 Mitigation Measures

Following environmental requirements should be considered while working on work sites in order to avoid additional damage to soil and soil/ground contamination:

- Removal of topsoil layer and recultivation will be carried out in compliance with the requirements of the technical regulation, approved by the Decree N424 of GoG, dated as December 31, 2013, on “Topsoil Removal, Storage, Usage and Recultivation Rules”;
- Removed topsoil will be disposed in a location far from the water impact, separate from non-humus layers. After the works are completed, humus layer will be used for the recultivation works;
- Strict adherence of the boundaries of construction sites in order to prevent possible contamination of neighbouring areas, damage and compaction of topsoil
- Determination of routes for vehicles and machinery and restriction of off-road movement;
- In case of identification of fuel/oil leak damage must be fixed immediately. Damaged vehicles will not be allowed on the work sites;
- Materials /waste should be disposed so that to prevent erosion and wash off with surface runoff;
- Proper management of domestic- fecal wastewater;
- In case of spillage of pollutants, spilled material should be localized and contaminated site should be immediately cleaned. Staff should be provided with appropriate means (adsorbents, shovels, etc.);
- In case of large spill contaminated soil and ground for further remediation should be removed from the territory by the contractor holding an appropriate permit for such activities;
- Prior to works staff will undergo training;
- Area will be cleaned and recultivated after the completion of works.

Following measures will be implemented during HPP operation phase:

- Means for liquidation of spill consequences will be available at the areas of powerhouses;

- Control of the fuel/oil storage and usage rules;
- Control over implementation of measures, considered by the waste management plan;
- In case of fuel/oil spill, cleaning of the territory and withdrawal of the contaminated soil and ground for further remediation;
- Personnel will undergo training prior to recruitment and once every year after that.

5.9.4 Impact Assessment

Table 5.9.4.1. Summary of impact on soil/ground

Description of impact and its sources	Impact receptors	Residual Impact Assessment					
		Nature	Probability of occurrence	Influence area	Duration	Reversibility	Residual impact
Construction phase:							
Impact on integrity and stability of soil. ***Lose of topsoil*** • Vehicle and construction equipment movement; • Earth works, arrangement of various facilities; • Waste management (including waste rock).	Vegetation cover, animals, population	Direct, Negative	High risk, taking into account mitigation measures – medium risk	Construction sites and corridors of roads for vehicles	Medium or long term	Reversible. On some sections - irreversible	**Medium-low.** taking into account mitigation measure – **low or very low**
Soil contamination • Spillage of oil or other chemical substances, pollution by waste.	Vegetation cover, surface and ground water.	Direct, Negative	Medium risk	Construction sites, mainly local spills are expected	Medium-term (Limited to the duration of the construction phase)	Reversible	**Medium** - taking into account mitigation measures – **low, very low**
Operation phase:							
Soil contamination • Spillage of oil or other chemical products (e.g. paint, transformer oil), pollution by waste.	Vegetation cover, surface and ground water.	Direct, Negative	Low risk	Mainly the areas adjacent to power house (near the substation and oil storage area)	Long term	Reversible	**Low** or **very low**

5.10 Visual-Landscape Impact

5.10.1 Impact Assessment Methodology

Visual-landscape impact assessment is more or less subjective. Impact area and duration, as well as the relative ecological value of the landscape are taken as evaluation criteria.

Table 5.10.1.1. Assessment criteria of visual-landscape impact

Ranging	Category	Impact on visual receptors	Duration of landscape changes and spatial boundaries / landscape quality and value
1	Very low	Unnoticeable change in the view	Unnoticeable change in the landscape, or landscape is not valuable
2	Low	Some slight change of view is observed from certain points, which is easily adaptable	Insignificant change in the landscape, or landscape restoration takes 1-2 years
3	Medium	The view has changed noticeably from many points of view, though it is easily adaptable	Some sites of the natural landscape have changed, or landscape restoration takes 2-5 years
4	High	The view has changed noticeably from most of the points, though it is easily adaptable	A large area of natural or high-value landscape has changed, or landscape restoration takes 5-10 years
5	Very high	The view has completely changed from every place, hardly adaptable impact on receptors is expected.	A large area of natural or high-value landscape has changed, or landscape restoration is not possible

5.10.2 Impact Characterization

5.10.2.1 Visual Impact

During preparation and construction works some visual alteration is expected due to increase of traffic flows, equipment operating on construction sites, presence of people, constructing structures, construction materials and waste. While assessing the visual impact, first of all, the project collocation with the impact receptors should be considered, in particular, whether the impact sources are within the eyesight or no.

The project corridor of Akhalkalaki HPP, especially Akhalkalaki 1 HPP corridor, will be located in parallel to Akhaltsikhe-Akhalkalaki highway, along the second bank of the river. Thus, local population and passengers and tourists driving on the highway will be the receptors of visual-landscape alteration.

As for Akhalkalaki 2 HPP, the power house will be visible from the highway; Orja village population and passengers moving on the highway will be receptors of potential alteration on the sites of the construction camp and headwork locations.

After completion of the construction, machinery and equipment, material and waste will be removed from the construction sites and the construction camp. Recultivation of the area is envisaged. On operation phase, power houses and impoundments at headworks will be mainly noticeable. The best way for impact mitigation can be painting of structures in colors, suitable with the environment.

As it is given in the present report, the vegetation cover and high-value landscapes is not actually represented within the project corridor. The landscape is mainly homogeneous. Landscape alteration related to the penstock construction will be mainly connected to the earth work implementation; however, this impact will be fully eliminated within the penstock corridor after completion of works and recultivation.

In general, it can be stated that averagely sensitive landscape will get within the impact area and thus, according to the impact assessment criteria (see Table 5.10.1.1.) the "Medium" impact is expected. Mitigation measures must be carried out for impact reduction, which are given in the following paragraph.

The impact is also expected during repair/maintenance works. This impact is similar to that on construction phase, but with smaller scale. Impact "magnitude" is depended on scale and type of works. However, with implementation of corresponding mitigation measures, the impact will not exceed low significance.

5.10.3 Mitigation Measures

Impact on visual landscape will be mitigated by implementation of the following measures:

- The design of permanent structures at both the construction and operation stages will be selected in a way that is consistent with the environment;
- Temporary structures, materials, and waste should be disposed at less noticeable areas;
- Protection of sanitary and environmental conditions during construction and operation phases;
- Recultivation works should be implemented after the completion of construction works (especially on waste rock disposal areas);
- Local species should be planted-grown on areas adjacent to the powerhouse after completion of construction works.

5.10.4 Impact Assessment

Table 5.10.4.1. Summary of visual-landscape impact

Description of impact and its sources	Impact receptors	Residual Impact Assessment					
		Nature	Probability of occurrence	Influence area	Duration	Reversibility	Residual impact
Construction Phase:							
Visual-landscape impact: • Construction camp and temporary structures; • Waste rock and other waste disposal; • Construction and transportation operations.	Animals, population and tourists	Direct Negative	Medium risk	Settlements, areas adjacent to construction camps and sites. (impact distribution area depends on local relief, i.e. visibility conditions)	Medium term	Reversible	**Medium**- considering corresponding mitigation measures - **Low**
Operation Phase:							
Visual-landscape impact: • Change in river debit; • HPP infrastructure; • Maintenance works.	Animal species inhabiting in the vicinity, population and tourists	Direct Negative.	Medium risk	Areas adjacent to the HPP infrastructure (impact distribution area depends on local relief, i.e. visibility conditions)	Long term	Eventually reversible	**Low** – eventually easily adaptable.

5.11 Impact Caused by Waste Generation and Distribution

Under the requirements of "Waste Management Code", article 14, paragraph 1, "Those individuals and legal entities that produce more than 200 tons of non-dangerous waste a year or more than 1000 tons of inert materials or more than 120 kg of hazardous waste, are obliged to develop company's waste management plan". Waste Management Plan is updated at least every 3 years or in case of significant changes in types and amounts of waste and the processing.

Since non-hazardous and inert waste, as well as hazardous waste is expected to be generated due to the planned activities, waste management plan has been developed for Akhalkalaki HPP construction and operation phases and is presented in Annex 5 of the EIA report.

Violation of rules of waste management may cause a number of negative impacts on different receptors of the environment, for example:

- Incorrect management of waste (dumping into water, scattering) may lead to water and soil pollution, as well as to deteriorated sanitary conditions and adverse visual changes, negative impact on the health and security of population, etc.;
- Improper disposal of construction waste and waste rock may cause blockage of the roads and may lead to erosion processes, resulting various indirect impacts, etc.;

5.11.1 Mitigation Measures

Measures considered in the waste management plan will be implemented during HPP construction and operation phases, including:

- Spoil grounds will be allocated for disposal of waste rocks. Waste rock will be disposed according to special rules. Prior to usage of the spoil ground, a detailed report will be agreed with the Ministry;
- Labeled hermetic containers should be arranged in corresponding places for collection of hazardous waste;
- Special storage facility should be arranged for temporary disposal of hazardous waste:
  - Storage facility will be marked and protected from the impact of atmospheric precipitation and unauthorized encroachments;
  - The floor and walls of the storage facility will have a solid cover;
  - Storage should be equipped with wash stand and tap, trap for intake;
  - Shelves and racks for waste disposal will be arranged;
  - Waste will be disposed in the storage only in hermetic containers with a relevant marking.
- Appropriately trained personnel will be hired for waste management; they will undergo periodic training and testing. They will keep a Register for recording of quantities and types of such waste as well as further management activities.

5.12 Impact on Socio-Economic Environment

5.12.1 Impact Assessment Methodology

Following factors should be considered while discussing the impact on socio-economic environment during the construction and operation of Akhalkalaki HPP:

- Impact on land ownership and use, limitation of resources;
- Impact on tourism;
- Positive and negative impacts associated with employment;
- Input to economy;
- Impact on transport infrastructure;
- Health and safety risks.

Impact is assessed according to three categories - **low impact, medium impact and high impact**. Criteria are provided in Table 5.12.1.1.

Table 5.12.1.1. Assessment criteria of the impact on socio-economic environment

Ranking	Category	Socio-economic impact
Positive		
1	Low	– Employment rate in region has increased by less than 0.1%; – Average income of the local population has increased by 10%; – Budget revenues of the region have increased by 1%; – Local infrastructure/power supply has been slightly improved, resulting in improved local population living/subsistence and economic environment.
2	Medium	– Employment rate in region has increased by 0.1%-1%; – Average income of the local population has increased by 10-50%; – Budget revenues of the region have increased by 1-5%; – Local infrastructure/power supply has been significantly improved, resulting in significantly improved local population living subsistence and economic environment, which contributes to the economic development of the region.
3	High	– Employment rate in region has increased by 1%; – Average income of the local population has increased by more than 50%; – Budget revenues of the region have increased by more than 5%; – Local infrastructure / power supply has been significantly improved, resulting in significantly improved local population living / subsistence and economic environment, which contributes to the economic development of the region.
Negative		
1	Low	– A short time delay in the availability of resources or infrastructure is expected, though it will not affect the income of the local population. In addition, it will not be followed by long-term negative impacts on the economic activity of the local population; – Quality of life of the local population will be lowered for a short period of time, though it will not be followed by long-term negative results; – Health will not be affected; – Impact on safety is negligible; – A long-term, but easily adaptable impact on environment is expected; – Local population will increase by 10% due to invited workforce.
2	Medium	– A short time delay in the availability of resources or infrastructure is expected, due to which the local population will have to change their lifestyle for a short period of time. However, it will not have any long-term negative impact on the economic activities of the local population; – Quality of life of the local population will be lowered for a short period of time, though it will not be followed by long-term negative results; – A certain impact on health is expected, but there is no increased mortality risk; – There are some risks related to safety; – Complaints from citizens are expected about some of the impacts; – Local population will increase by 10-30% due to invited workforce.
3	High	– A short time delay in the availability of resources or infrastructure is expected, due to which the local population will have to change their lifestyle for a short period of time, which will have a long-term negative impact on their economic activities; – Quality of life of the local population will be significantly lowered; – There is a significant impact on health. There is a high risk of increasing mortality rate; – There are some risks related to safety; – Corrupt deals related to employment or nepotism; – People are constantly complaining about the influence of certain factors. In this regard, conflicts arise between residents and staff; – Local population will increase by 30% due to invited workforce. Cultural environment for the local population is significantly changed. Creation of new settlements is expected.

5.12.2 Impact Characterization

5.12.2.1 Impact on Land Ownership and Use

The project HPP infrastructural facilities and temporary structures will be arranged on state lands. It is noteworthy that the project corridor will not cross Forest Fund lands..

It is noteworthy that temporary and permanent project structures will be arranged on state lands. Only one private land plot with 2500 m^2 area will get within the impact area, namely the Akhalkalaki 1 HPP penstock corridor; it is non-agricultural land plot (cadastral code 63. 14. 34. 004, owner Vigen Larakhanyan). This land plot was allocated for arrangement of penstock of the small HPP, which was planned previously, but the project was not implemented. AIS LTD reached an agreement with the land owner on purchasing the land in compliance with established rules.

In addition to that what is going to get within the impact area, the project implementation impact will be related also to water supply tapping structure of the trout farm and about 200 m long section of the pipeline. Prior to the start of the construction, reconstruction of the tapping structure and arrangement of the new pipeline is planned.

Considering aforementioned, the project implementation will not be related to the physical resettlement, and only one land plot will be subject to economic resettlement. Land will be purchased on the basis of mutual agreement in compliance with the rule, established by the Legislation of Georgia.

Taking into consideration above-mentioned, no significant impact is expected on land ownership and usage.

5.12.2.2 Limitation of Access to Local Resources

On construction phase, usage of local resources, mainly insignificant area of pastures, may be restricted (on about initial 600 m long section of Akhalkalaki 2 HPP headwork and penstock). After completionof works and recutlivation of the area the initial state of the site will be restored.

On operation phase, it should be noted that the water flow will be reduced in the river. Accordingly, usage of water resources by population will be restricted. Irrigation water pumping station operates downstream from Akhalkalaki 1 HPP headwork, from where irrigation water is supplied to agricultural land plots on the left bank plateau of Paravani river. The maximum flow of the plumbing station is 0.85 m^3/s, which is considered in HPP energetic flow calculations.

Due to water flow reduction on the project sections of the rivers, amateur fishing conditions will be changed; the impact will be partly compensated by arrangement of impoundments upstream from the headworks, where there will be favorable conditions for fish. Besides, fish ways will be arranged on both headworks and established environmental flows will be released.

On construction and operation phases Complaint Book will be available. Elimination of discontent (if any) from the side of population/entrepreneurs will be provided on the basis of effective mutual consultations. Based on consultations, it is possible to solve conflicts by providing corresponding compensation or helping to find alternative resources. In addition:

- Population will be provided in advance with information on those decisions, which will temporarily restrict access to local resources;
- Works, restricting local resources and movement in the river valleys, will be carried out in the shortest possible period.

5.12.2.3 Positive and Negative Impacts Related to Employment

On construction phase, employment related positive impact should be highlighted first of all. As it was mentioned about 100 people will be employed on construction, the majority of which will be from local population. This is quite a significant positive impact in terms of employment of local population and improvement of their social conditions.

However, attention should be paid to the risks of certain types of negative impact related to the employment, in particular:

- Employment expectations and dissatisfaction of local population;
- Violation of workers' rights;
- Reduction of employment and dissatisfaction after the completion of the construction works;
- Risk of conflict between the local population and non-local employees.

In order to avoid conflicts with employed personnel and local population, the following measures should be implemented:

- Staff recruitment policy will be developed and agreed with local government;
- Employment on the basis of relevant testing;
- Signing individual work contract with each employee;
- Agreement signed with personnel will include issues on every plan and procedure and mitigation measures, as well as on safety plan monitoring and accidents;
- Every employee will be informed about their work;
- All non-local employees should be informed about local habits and culture;
- While purchasing various materials, preference should be given to local products (including inert material) in order to support local enterprises;
- Grievance mechanism of personnel will be developed and practiced.
- Grievance Book of personnel will be practiced

Number of people employed for HPP operation phase will be insignificant. Accordingly, at the given stage both positive and negative impact risks are lower.

5.12.2.4 Input to Economy

The implementation of the project of the HPP construction and operation will significantly contribute to social and economic development of the region.

Mainly local resources of construction materials will be used for the construction of the HPP, which will contribute to the activation of the local production of construction materials.

After HPP commissioning, the state power system will be supplied with extra power, which is important for the achievement of energy independence of the country.

Additional funds will enter the local budget in the result of the project implementation. Property tax should be singled out among them, which will be used for development of regional infrastructure and various social projects.

In addition, satellite business (trade, service, transportation, food production, etc.) activities will be activated in order to provide service for the staff employed on the construction, which shall be considered as an additional source of employment.

5.12.2.5 Impact on Local Transport Infrastructure and Impediment of Movement

During HPP construction phase, traffic flows will be significantly intensified, road surface may be damaged. This can hinder traffic flow (especially during elevation works of Akhaltsikhe-Akhalkalaki highway level, area adjacent to Akhalkalaki 1 HPP headwork) and cause discontent of population.

Considering the fact that the project corridor joins well-developed road network and it is possible to use bypass roads, the project implementation will not have significant impact on baseline conditions.

Construction works will be planned in a manner to reduce similar impacts to a minimum, namely:

- Restrict the movement of the machinery (especially caterpillar equipment) on public roads as much as possible;
- Population should be provided with the information about the time and duration of works;;
- All damaged sections of the road should be recovered in the shortest possible time, in order to make them available for population;
- Specially designated personnel (flagman) will control the movement of vehicles, if necessary;
- Relevant warning, indicating and restricting signs will be installed nearby the construction sites;
- Complaints will be recorded and relevant actions must be carried out.

As for the operation phase, it is noteworthy that transport operations will be of low intensity and accordingly, the negative impact risk is not actually expected.

5.12.2.6 Health and Safety Risks

In addition to the indirect impact (deterioration of air quality, noise distribution and others described in the relevant subsections), expected during implementation of construction works, there are direct risks of impact on health and safety (residents and staff working within the project) during the construction phase. From population main receptors of the impact are residents of Diliska, Orja and Korkhi villages.

Direct impacts may be: vehicle collision, electrical shock, falling from height, injuries while working with construction equipment and others. In order to prevent direct impact, safety measures in the conditions of strict supervision will be followed:

- Personnel should to be trained on safety and labor protection issues;
- Personnel must be equipped with personal protection means;
- Prohibiting, warning and indicating signs will be placed on areas dangerous for health;
- Fencing of areas dangerous for health;
- Presence of standard first-aid kit on areas dangerous for health and on construction camp;
- Ensure technical functionality of the vehicles and equipment;
- Maximum observance of safety rules during transport operations, speed limitations;
- Limited use of roads passing through populated areas;
- Control and prohibition of unauthorized and unprotected access to the construction site;
- In-situ assessment of risks to determine specific risk factors for population and for proper management of such risks;
- Insurance of staff working on heights with ropes and special fasteners;
- Incidents and accidents should be recorded in special Register.

Besides,

- Implementation of all measures in order to prevent ambient air, water and soil pollution. Implementation of mitigation measures against noise distribution (see relevant paragraphs.).

On operation phase, risks related to electro-magnetic radiation is one of the main factors of impact on population. However, as it is mentioned in the given report, ETL corridor is in not less than 40 m from the nearest residential zone and the substation – in 350-400 m. Accordingly, no negative impact is expected. Additional preventive measures for health and safety impacts are considered in “Emergency Response Plan”.

5.12.3 Impact Assessment

Table 5.12.3.1. Socio-economic impact summary

Description of impacts and impact sources	Impact receptors	Residual Impact Assessment					
		Nature	Probability of occurrence	Influence area	Duration	Reversibility	Residual impact
Construction Phase:							
Impact on land ownership, limitation to resource accessibility: • Impact on neighboring land owners - implementation of any type of activities on their lands, or damage to their property; • Limited use of water and forest resources.	Local popoulation	Direct Negative	Medium risk	Adjacent settlements (villages: Korkhi, Diliska, Orja)	Duration is limited with the construction phase	Reversible	Considering mitigation measures - **Low**
Positive impact of employment	Local population	Direct Positive	High probability	Akhalkalaki municipality (villages: Korkhi, Diliska, Orja)	Duration is limited with the construction phase	Reversible	**Medium**
Negative impact related to employment:: • Employment expectations and dissatisfaction of local population; • Violation of workers' rights; • Reduction of employment and dissatisfaction after the completion of the construction works; • The risk of conflict between the local and non-local employees.	Construction personnel and local population	Direct Negative	Medium risk	Construction sites and nearby populated areas(villages: Korkhi, Diliska, Orja)	Duration is limited with the construction phase	Reversible	**low**
Input to economy • Stimulation/development of construction business and its satellite business activities; • Creation of job-places; • Increased budget revenues.	Regional economy, construction and other business activities, the local population	Direct Positive	High probability	May be of regional scale	Duration is limited with the construction phase. Number of impacts will be long-term (e.g.: improvement of infrastructure)	-	**Medium, positive**

Damage to the road pavement • Movement of heavy equipment; ***Overloaded traffic flow*** • Movement of all types of vehicles and equipment; ***Limitation of movement*** • Closing the local roads for the security purposes.	Local infrastructure, population	Direct Negative	Medium risk	Roads used for the project activities, as well as by the population	Duration is limited with the construction phase	Reversible	**Medium** considering mitigation measures **Low**
Risks of health and safety deterioration • Direct (e.g.: accidents, electrical shock, falling from heights, injuries from construction equipment, etc.); and • Indirect (emissions, increased acoustic background, climate change, contamination of water and soil).	Construction staff and the local population	Direct or indirect, negative	Medium risk, considering mitigation measures – low risk	Construction sites, adjacent settlements	Duration is limited with the construction phase	Reversible	**Medium** considering mitigation measures **Low**
Operation phase:							
Resource accessibility • Reduction of Korkhi and Paravani river runoff	Local population, for which the accessibility to resources will be limited	Direct Negative	Medium risk	Adjacent settlements (villages: Korkhi, Diliska, Orja	Long-term	Irreversible	**Low**
Resource accessibility: • Road rehabilitation (positive social impact)	Local population	Indirect, positive,	Medium probability	Adjacent settlements (villages: Korkhi, Diliska, Orja)	Long-term	-	**Low**
Improvement of transport infrastructure	Local infrastructure, population	Direct positive	Medium probability	Adjacent settlements (villages: Korkhi, Diliska, Orja)	Long-term	Reversible	**High**
Input to economy and employment • Creation of job-places; • Increased budget revenues. • Power generation	Economic conditions of the country, local production and population.	Direct positive	High probability	Impact area may be of regional or country scale.	Long-term	-	At regional level - **High;** At country level - **medium**

5.13 Impact on Historical-Cultural and Archaeological Monuments

5.13.1 Impact Assessment Methodology

Table 5.13.1.1. Cultural heritage impact assessment criteria

Range	Category	Damage/destruction of the cultural heritage
1	Very Low	The risk of impact is insignificant because of the large distance from the object or because of the used method of construction/operation
2	Low	1-10% of the insignificant object may be damaged/destroyed
3	Medium	10-25% of locally significant object may be damaged/destroyed
4	High	25-50% of locally significant object may be damaged/destroyed, or the object of regional significance may be damaged
5	Very High	50-100% of locally significant object may be damaged/destroyed, object of regional significance may be damaged, national or international significance protected object may be damaged

5.13.2 Impact Characterization

According to literary sources and field surveys, there are no proved historical-cultural or archaeological monuments within the project impact zone.

During implementation of excavation works some late chance finds may be discovered. In this case a constructor contractor is obliged to invite specialists from agencies, authorized for such activities by Georgian legislation in order to assess archaeological site importance and make decision about continuation of works.

Since project does not consider arrangement of a large reservoir increase of humidification of cultural sites of the region is not expected.

Due to large distance from the facility and method used duing construction/operation, residual impact on cultural heritage monuments is not expected.

5.13.3 Mitigation Measures

In case of discovering any artifact, construction process will be suspended.Expert-archaeologists will be invited to examine the chance finding and based on their recommendation, the company will support site conservation or removal to the depository. Works will be renewed after obtainment of the corresponding permit.

5.14 Cumulative Impact

During EIA process, no construction works were carried out within the region of Akhalkalaki HPP project implementation and according to the information, provided by Akhalkalaki municipality city hall, construction of new facilities are not planned for the nearest future. Thus, risks of cumulative impact related to the construction are not expected.

Paravani HPP headwork operates in about 300 m downstream from the project Akhalkalaki HPP, from where water is supplied to the power house, located in Mtkvari river valley, upstream from Khertvisi village. Accordingly, significant reduction of the natural runoff takes place on the section downstream of headwork till the confluence with Mtkvari river.

Besides, downstream of the bridge, located at the entrance of Akhalkalaki city, at about 1651 m elevation, a small HPP weir is in operation, which does not have a fish way. Considering aforementioned, on operation phase of Akhalkalaki HPP, risks of cumulative impact are expected. Following should be highlighted from these risks:

- Cumulative impact on Paravani river hydrological mode and aquatic biodiversity;
- Cumulative impact on employment and economic conditions, etc.

Change of hydrological mode of the river and impact on aquatic biodiversity: In case of Akhalkalaki HPP project implementation, in total, about 21 km section of Paravani river will be used for energetic purposes, from which about 17.5 km long section gets within Paravani river impact zone, about 350 m – within the impact zone of the small HPP, and ≈3.7 km long section will get within Akhalkalaki HPP impact zone. Hydrological mode of the river will be changed on the mentioned 21 km long section. In order to mitigate the impact, established minimum environmental flow will be released from Paravani HPP and Akhalkalaki HPP headworks. It is noteworthy that Paravani river has no significant tributary on the project sections except Korkhi river, which joins the river between headworks of mentioned HPPs.

As it was shown from environmental flow analysis, this situation plays an important role for maintenance of conditions, necessary for ecological function of the river and aquatic biodiversity. It should be noted that there are no significant water consumers observed within the above-mentioned 21 km long section.

Pool-type fish way operates at the headwork of Paravani HPP. According to environmental monitoring results, carried out during past operation years of HPP, the fish way ensures upstream and downstream movement of fish.

Impact on sediment transportation conditions: It is not planned to arrange high dams at Paravani, as well as Akhalkalaki HPP headworks. Accordingly, large reservoirs will not be created. So, sediment accumulation in large amounts is not expected upstream of weirs. According to the project, upstream areas of weirs will be periodically cleaned from sediments. Considering the fact that Paravani and korkhi rivers are not distinguished with large amount of sediments, risks of sediment accumulation upstream will not be significant.

5.15 Residual Impact

Following should be singled out from the project-related residual impacts:

- Reduction of natural runoff, impact on aquatic biodiversity;
- Natural landscape environment alteration in the result of construction works and presence of HPP infrastructures.

All above-listed negative impact scales can be reduced by effective implementation of mitigation measures, given in EIA report and by providing environmental monitoring. In general, the scales of negative impact will not be high and irreversible changing of certain environmental receptors is less expected.

6 Environmental Impact Mitigation and Monitoring

6.1 General Overview

The information contained in the Environmental Mitigation Plan is based on the data presented in the individual paragraphs of the EIA report. Mitigation measures to be implemented are outlined in accordance with the work to be done and the expected impacts during these works.

Environmental mitigation measures are ordered as follows:

- Impact avoidance /prevention
- Impact reduction
- Impact mitigation
- Damage compensation

Impact can be avoided and risks can be reduced by using best construction and operation practices. Designed project considers some measures of mitigation. However, as not every impact can be avoided, a plan of mitigation measures for every phase is worked out to ensure maximum environmental safety of the project.

The plan is "live" document and is to be amended and corrected on the basis of monitoring/observation.

Responsible for the implementation of environmental mitigation measures, as well as all associated documentation (Waste Management Plan, Emergency Response Plan) is the responsibility of the implementer of the activity - Aisi Ltd.

6.2 Institutional Mechanisms to Control the Implementation of Environmental Measures

The quality of the works performed by the contractor during the construction phase of the HPP and the state of compliance with environmental norms will be monitored by the implementing company through the technical and environmental supervisor and, where necessary, contractors. The supervisor appointed will have the responsibility to maintain strict control over the performance of the work and to monitor the progress of the work. The supervisor will have the right to inspect the quality of environmental performance, identify violations and determine which environmental and social issues arise during construction.

In turn, the State Supervisory Body of the company carrying out the activity is the Environmental Supervision Service. Who will carry out inspections in the area of impact as needed. Examine the state of compliance of environmental measures and permit conditions set out in the EIA. In addition, oversight bodies may be international financial organizations.

Monitoring during construction involves visual inspection and instrumental measurements when needed. All monitoring results, environmental documents and records should be kept in the office of the contractor.

The construction contractor will be required to prepare and submit to the client the following key environmental documents and records:

- Scope of work program and schedule;
- Environmental permits and licenses (if required);
- Records related to environmental issues raised;
- Water supply and wastewater scheme of construction sites;
- Records on the quantity and quality of wastewater;
- Waste management records;
- Written designations of waste disposal sites and waste transport instructions issued by local authorities;
- Records of supplies and consumption of required materials;

- Grievance registration logs;
- Incident registration logs;
- Reports on corrective actions;
- Equipment control and maintenance logs;
- Records on workplace training.

After the contract is signed with the construction contractor, the construction contractor will develop and submit to the client the following thematic management plans:

- Detailed waste management plan;
- Detailed health and safety management plan;
- A detailed emergency response plan;
- Reclamation project.

The environmental oversight body will be the main body overseeing the implementation of environmental mitigation measures during the operational phase.

6.3 Impact Mitigation Measures

The following tables provide information on the mitigation measures required for the project implementation and the required monitoring activities, in particular:

Column I provides a description of the impacts by individual receptors and because of what type of work it is expected to occur;
Column II - Description of the main tasks of mitigation measures;
Column III - A list of mitigation measures that reduce or eliminate the significance (quality) of expected impacts;
Column IV -

- Responsible for implementation of mitigation measures;
- At what stages of the project implementation will be the most effective mitigation measures?
- Estimate the costs required for mitigation. (Cost estimates were approximated by 3-point classification: **„Low“** - <25000$; **„Average“** - 25000-100000$; **„High“** - >100000$);

Column V - General description of required monitoring activities.

6.3.1 Mitigation Plan for the Construction Phase

Impact / Impact description	Task	Mitigation measures		Monitoring
		Description	Responsibility, terms and costs	
<u>Propagation of inorganic dust in ambient air:</u> • dust generated by earthworks; • Dust generated by moving vehicles; • Dust generated during loading and unloading of inert materials and waste rocks; • Dust generated during construction work; <u>Distribution of combustion products in ambient air:</u> • Exhaust of machinery, construction equipment; • Exhaust of generators and other equipment; • Welding aerosols.	<u>Minimize dust emissions.</u> <u>Reduce such environmental impacts as:</u> • Human (population, service personnel) distress and adverse health effects; • Animal disturbance and migration; • Cover of vegetation with dust and slow down their growth.	• Ensure proper maintenance of machinery, as well as stationary facilities; transportation means and equipment, the exhaust of which is expected to be significant (due to technical malfunctioning) will not be allowed to the work site; • Turning off engines or working on minimum rpm, when they are not used (in particular this is related to the equipment, operating on the construction camp); • Providing optimal speed of vehicles (especially, on earth roads); • Vehicles and machinery will be located far away from the sensitive receptors (residential zone, forest zone) as much as possible; • Restriction using motorways through the populated zones (mainly Diliska village is meant), (population will be informed in advance on intensive movement of transportation means); • Corresponding measures (e.g.: watering of work sites, following bulk material storage rules, etc.) will be carried out in order to reduce dust emissions in dry weather conditions; • During the earth works and loading/unloading materials, precautions will be considered in order to avoid excessive dust emissions (e.g.: throwing material from height during loading/unloading will be restricted); • Personnel will be instructed prior to wok start; • Register/recording complaints and providing proper response considering above-listed measures.	**Responsible for mitigation:** Aisi LLC. Construction site managers **Deadlines for mitigation:** • periodically before and after work; • during transport operations; • Occasionally, especially in dry and windy weather; • During earthworks and materials loading and unloading. **Mitigation Costs:** Implementation of measures will be linked to "<u>low</u>" costs.	Environmental and Safety Manager will conduct daily visual inspection, inspect transportation operations. Maintains service records for vehicles. Monitoring is not associated with additional costs.

Noise propagation • Noise and vibration caused by vehicles; • Noise and vibration caused by construction equipment and construction operations.	Minimize noise emission. Reduce such environmental impacts as: • Impact on human health; • Animal disturbance and migration.	• Ensure proper maintenance of machinery; prior to the start of each working day, the technical functionality of the machinery will be checked; transportation means and equipment, the noise level of which is expected to be significant (due to technical malfunctioning) will not be allowed to the work site; • Noise-generating activities will be carried out only during the day. If work implementation at night is decided, the population will be informed in advance about it; • Prior to the start of noisy activities near the residential zone (transport operations are meant here), the population will be informed and corresponding explanations will be provided; • Noisy devices and machinery will be located far away from the sensitive receptors (residential houses) as much as possible; • If required, the personnel will be provided with the protective means (earmuffs); • In case of the entry of complaints, they will be registered/recorded complaints and properly responded considering above-listed measures.	**Responsible for mitigation:** Aisi LLC. Construction site managers **Deadlines for mitigation:** Constantly; • Before and during noisy work; • Once every 6 months before and after work **Mitigation Costs:** Implementation of measures will be linked to "low" costs.	Maintenance of machinery / equipment; Instrumental measurements when needed (when performing intense noise) Costs will be related to instrumental measurements.
Activating Dangerous Geodynamic Processes: • Destruction of rocks and activation of landslide processes during construction; • Destruction of rocks, sedimentation, activation of erosive processes during preparation of foundations of buildings and other excavations. While working; • Disposal of waste	• Maintain rock stability. Reduce the risk of activation of erosive processes. Protecting construction sites from damage	• Engineering-geological conclusions and recommendations, outlined in par. 4.2.2.6., will be considered during the project implementation; • Construction works will be implemented under the strict supervision of engineer- geologist. If required, additional preventive measures will be carried out on the basis of his recommendations; • Borders of the work corridor will be protected; • Materials and waste will be disposed so that to avoid erosion and their removal from the construction site by surface water runoff. The height of the ground pile will not be more that 2 m; pile sides will have proper inclination angle (450); drainage channels will be arranged on the perimeter;	**Responsible for mitigation:** Aisi LLC. Construction site managers **Deadlines for mitigation:** At the preparatory and construction stages • After construction works **Mitigation Costs:** Overall mitigation may be related to "average" costs.	Regular visual observation by engineer-geologist on rock stability. Hiring additional staff will be associated with low costs.

rocks		• After completion of the construction works, recultivation and landscaping of the construction sites will be carried out. • In order to prevent rockfall process activation, prior to the construction, slopes of the construction sides will be cleaned from boulders and blocks in active dynamic. Implementation of the slope cleaning works will be required regularly, on the basis of monitoring results; • Strengthening of the sites, bearing high rockfall risks (slopes adjacent to power houses, slopes adjacent to Akhalkalaki 1 HPP penstock corridor and slopes, adjacent to the last section of Akhalkalaki 2 HPP penstock) will be provided using wire mesh (see Figure 5.4.3.1).; • Slopes adjacent to the construction sites and the perimeter of the spoil grounds will be provided with proper drainage systems; • Foundation of main HPP facilities will be carried out on the basis of engineering-geological surveys.		
Contamination of surface waters: • Pollution while working in or near the riverbed; • Pollution due to improper management of solid and liquid waste; • Fuel / oil spill-related pollution.	Prevention of contamination of surface waters and consequently reduction of such environmental impacts as: • Impact on water biodiversity; • Groundwater pollution; • Impact on water-related receptors (animals, population).	• During arrangement of the construction camp and storage areas, conditions outlined in the Technical Regulation – on "Water Protection Zone", approved by the governmental resolution #440, dated as December 31, 2013, should be considered; • Ensure technical functionality of machinery/equipment; • Arrangement of machinery and potentially polluting material in not less than 50 m from water bodies (where possible). If it is impossible, strict control will be established and safety measures will be carried out to avoid water contamination; • Prohibit washing of vehicles in riverbeds; • Cesspools will be arranged for collection of generated sanitary-fecal water (The construction of biological treatment plants will also be discussed. The final decision will be made by the	**Responsible for mitigation:** Aisi LLC. Construction site managers **Deadlines for mitigation:** • Before and during the work; • After construction works **Mitigation Costs:** Implementation of measures will be linked to "low" costs.	Inspection / control of equipment maintenance; Control over the implementation of the waste management plan; Visual control of soil and water and wastewater status.

		construction company); • Potentially polluting sites of storm water will be roofed with the shed-like structure; • Fuel tank will be confined with water-proof barrier; • Prior to the decision of wastewater discharge into the river, the project on MPC standards will be developed and agreed with the Ministry; • After completion of works, all potential pollutant material will be removed. In case of fuel/lubricant spill, polluted site will be localized/cleaned; • Personnel will be provided with corresponding instructions.		
Impact on groundwater • deterioration of quality with contaminated surface water or soil; • Fuel / lubricant spill during construction work (especially earthworks).	Reduction of impacts on receptors (population, biodiversity) depending on groundwater resources	• Ensure technical functionality of machinery/equipment; • In case of identification of fuel leakage, malfunctioning will be promptly solved; • Proper management of sanitary-fecal water; • In case of spillage, localization of spilled material and immediate cleaning of the polluted area. Personnel will be equipped with corresponding means (adsorbents, shovels, etc) • After completion of works all potentially pollutant material will be removed. In case of fuel/lubricant spillage contaminated site will be localized/cleaned;	**Responsible for mitigation:** Aisi LLC. Construction site managers **Deadlines for mitigation:** • During construction works **Mitigation Costs:** Will not be related to additional costs	Technical performance control; Control over the implementation of the waste management plan; Visual control of soil and water status; Lab control if needed.
Violation of soil / ground stability and destruction of fertile layer, pollution: Violation of stability during road laying and construction works; • Destruction of the fertile layer during the clearing of construction site preparation areas. • Soil contamination with waste;	Prevention of soil / soil contamination and consequently reduction of such indirect environmental impacts as: • deterioration of the living environment of animals; • Indirect impacts on vegetation; • Pollution of ground and surface waters;	• Removal of topsoil layer and recultivation will be carried out in compliance with the requirements of the technical regulation, approved by the Decree N424 of GoG, dated as December 31, 2013, on "Topsoil Removal, Storage, Usage and Recultivation Rules"; • Removed topsoil will be disposed in a location far from the water impact, separate from non-humus layers. After the works are completed, humus layer will be used for the recultivation works; • Strict adherence of the boundaries of construction sites in order to prevent possible	**Responsible for mitigation:** Aisi LLC. Construction site managers **Deadlines for mitigation:** • Regularly during construction work; • in case of pollution; • Periodically before and after work. • After completion of construction works. **Mitigation Costs:**	Regular visual inspection of construction sites, slopes, road surfaces, lifted soil layers. Monitoring is not associated with additional costs.

• Pollution in the event of spillage of fuel, oils or other substances.		contamination of neighbouring areas, damage and compaction of topsoil • Determination of routes for vehicles and machinery and restriction of off-road movement; • In case of identification of fuel/oil leak damage must be fixed immediately. Damaged vehicles will not be allowed on the work sites; • Materials /waste should be disposed so that to prevent erosion and wash off with surface runoff; • Proper management of domestic- fecal wastewater; • In case of spillage of pollutants, spilled material should be localized and contaminated site should be immediately cleaned. Staff should be provided with appropriate means (adsorbents, shovels, etc.); • In case of large spill contaminated soil and ground for further remediation should be removed from the territory by the contractor holding an appropriate permit for such activities; • Prior to works staff will undergo training; • Area will be cleaned and recultivated after the completion of works.	Implementation of measures will be linked to "low" costs.	
Visual-Landscape change: • Visual-landscape change due to the presence of construction sites and construction camps. • visual-landscape change due to increased traffic flow;	• Reduce human dissatisfaction; • Prevention of changes in the habitat of animals and migration of animals.	• The design of permanent structures at both the construction and operation stages will be selected in a way that is consistent with the environment; • Temporary structures, materials, and waste should be disposed at less noticeable areas; • Protection of sanitary and environmental conditions during construction and operation phases; • Recultivation works should be implemented after the completion of construction works	**Responsible for mitigation:** Aisi LLC. Construction site managers **Deadlines for mitigation:** • at the preparatory stage and during the follow-up work; • during transport operations; • After completion of works.	Visual monitoring to control the sanitary-ecological condition of the area.

• Visual change due to tree-trimming.		(especially on waste rock disposal areas); • Local species should be planted-grown on areas adjacent to the powerhouse after completion of construction works.	**Mitigation Costs:** Will not be related to additional costs	
Impact on flora. Habitat loss, damage, fragmentation. • Cleaning of the project area from vegetation / forests; • Noise caused by construction work, change of lighting background; • Impact related to the arrangement of construction camp and temporary infrastructure.	• Minimizing the risks of habitat loss and damage; • Habitat conservation and proper management,	• Personnel will be instructed on the issues of protection of vegetation cover prior to the works are launched; • Vegetation resource removal works will be carried out so that to reduce number of cutting trees and scrubs at minimum; • Boundaries of the working zone should be adhered, in order to avoid additional (excessive) damage of vegetation cover (herbaceous plants). Working boundaries should be marked in advance; • To compensate damage of vegetation cover, trees and vegetation will be planted at the adjoining territories of the power facilities. Given the harsh local climate, local species will be used for the landscaping works; • Period of earth works (arrangement of foundations) will be limited at maximum and excavated pits will be filled in short terms as far as possible; • Artificial crossing • In order to reduce the risk of habitats fragmentation, especially, in frames of the penstock corridor, artificial overpasses will be arranged as far as possible (wooden boards will be put on the penstock trenches especially, at night); • After completion of the construction works recultivation of the temporary used areas will be carried out that will significantly reduce the impact related to the habitats fragmentation; • Safety measures will be adhered to prevent fires; • Implementation of mitigation measures developed for construction phase during large	**Responsible for mitigation:** Aisi LLC. Construction site managers **Deadlines for mitigation:** • Before construction during clearing the work area from vegetation; • During vegetation clearance work; • Recultivation stage; • During the construction phase, especially at night. **Mitigation Costs:** Overall mitigation may be related to **"average"** costs.	Daily monitoring of work areas during vegetation clearance to protect working boundaries.

		scale repair and prophylactic works; • Promotion of growing-development of artificially planted trees and vegetation; • Strict control for elimination of illegal cuts by the personnel and for adhering of the boundaries of the HPP's corridor.		
Impact on Animal species: • Decrease in breeding ability and normal animal activity. Animal migration; • Direct impact - animal death, injury.	• Minimize direct and indirect impacts on animal species.	• Prior to the construction works, access roads, river crossings (esp. headwork sites) will be checked in order to find bird nests and traces and holes of predator mammals; • Transport movement will be restricted near the sensitive sites and movement speed will be reduced; • In the case of species listed on the Red List of Georgia or protected under international agreements are detected during the monitoring process, the project executor will address the Ministry of Environment Protection and Agriculture of Georgia in written form and will continue the further activities in accordance with instructions from the Ministry; • Personnel hired for the construction will be instructed and corresponding warning will be provided to them on sanctions in case of damage to animals; • Construction corridor will be protected in order not to exceed the marked zone and not to damage additionally the holes, bird nests and bat shelters. Earth works will be controlled by the personnel, having appropriate knowledge; • Transport movement route will be protected; • Optimum speeds of movement will be selected in order to reduce the likelihood of the direct impact (collision) on animals; • Holes, trenches will be fenced in order to avoid animal falling into it; • Activities (e.g. causing high level noise), causing excessive disturbance of animals will be carried out in the shortest possible time; • After completion of the construction works,	**Responsible for mitigation:** Aisi LLC. Construction site managers **Deadlines for mitigation:** • Before work commences; • During work and transport operations; • Upon completion of construction work. **Mitigation Costs:** May be related to low costs	Waste management control; Periodic inspection of drivers and service personnel. Monitoring is not associated with additional costs.

		recultivation of areas, adjacent to communications and access roads will be carried out, which will significantly reduce the impact related to habitat fragmentation; • For prevention of poaching, the personnel employed for the construction will be instructed and warned, in compliance with the Ministerial Order №95 (27.12.2013) on "Hunting Rules" and Technical Regulation on Fishing and Protection of Fish Stock" approved by the Governmental Resolution №423; (31.12.2013); • Proper waste management; • Implementation of mitigation measures for water, soil and ambient air pollution, noise propagation, etc.		
Impact on fish fauna: • Drying of certain sections of the river; • blocking migration routes; • river overflow, turbulence change; • Noise impacts; • Chemical pollution of water.	Minimize direct and indirect impacts on ichthyofauna.	• Relevant measures will be taken during construction works of the headwork, in order to prevent wide spreading of river stream (accordingly water depth reduction) and/or creation of small ponds separately from common stream. Temporary gabions/river sediment will be effectively used for this purpose so that to create single channel deep riverbed; • Water flow diversion from natural riverbed to artificial riverbed will be provided as long as possible to avoid sudden effect, in order to enable fish adaptation to the new environment; • Junctions of artificial and natural riverbeds will be arranged so that to avoid creation of artificial barriers for fish migration; • On headwork construction sites riverbed will be regularly cleaned from wood waste; • Banks and slopes will be strengthened against negative events (soil getting into water, mudflow, etc.). All works will be implemented in riverbed with special cautiousness in order to avoid river turbulence; • While working near the river all measures against noise propagation will be carried out; • All measures will be taken in order to maintain	**Responsible for mitigation:** Aisi LLC. Construction site managers **Deadlines for mitigation:** • Before work commences; • During work and transport operations; • Upon completion of construction work. **Mitigation Costs:** May be related to low or average costs	Monitoring of mitigation measures will be carried out.

		water quality.		
Risks of Environmental Pollution with waste: • Construction waste (waste rocks, etc.); • Hazardous waste (fuel-lubricant waste, etc.); • Household waste.	Prevention of untreated waste in the environment and consequently reduction of such environmental impacts as: • Negative impacts on human health and safety; • Pollution of the water environment; • Direct adverse effects on animals; • negative visual-landscape change; • etc.	• Proper amount of construction and other materials that are needed for the project goals; • Part of waste rocks will be used for the project goals (for arrangement the roadbeds, etc.) and the rest will be stored on the initially selected sites; • Drainage systems will be arranged on the perimeter of the spoil disposal areas; • Recultivation works for the surfaces of the disposal areas of the waste rocks; • Reuse of wastes if it is possible; • Special warehouses should be arranged for temporary storage of the hazardous wastes on the territory of the construction camps and marked , airtight containers should be disposed on the construction sites; • Following security rules during the waste transportation (covering the vehicle body, etc.); • Transportation the hazardous wastes for the further management will be carried out by a licensed contractor; • Introduction of a special registration mechanism for the process of waste generation, their temporary storage and further management, as well as establishment special register book for these purposes; • Special instructed personnel will be allocated for the waste management; • To instruct the personnel.	**Responsible for mitigation:** Aisi LLC. Construction site managers **Deadlines for mitigation:** • at the preparatory stage; • In the process of waste management; • After disposal of waste rocks; • Periodically before and after work. **Mitigation Costs:** Overall mitigation may be related to **"average"** costs.	Control of the waste management plan by the special allocated staff for this process, Register amount and type of wastes, establishment the special register book. Costs of the monitoring may be related to the employment the additional staff.
Temporary appropriation of private property, including land	• Exclude dissatisfaction of the local population	• Negotiate with the owner; • Satisfying the owner with appropriate compensation or finding alternative resources.	**Responsible for mitigation:** Aisi LLC. **Deadlines for mitigation:** • At the preparatory stage **Mitigation Costs:** Overall mitigation may be related to **"average"** costs.	Introduce a proper grievance and settlement mechanism.

Employment and risks of negative impact, namely; • Employment expectation of the local population and discontent; • Violation of employees rights; • Reduction of jobs related to the completion of the project works and discontent; • Tension relations between the locals and employees (none locals)	• To prevent discontent of the employed personnel and the local population.	• Establishment the employment policy and its publication on local (office), municipal (office of the municipality, etc.) and regional levels; • Employment based on passing special tests; • To sign individual working contract with each employee • The contract should include those articles related to all plans, procedures and mitigation measures, as well as, those articles that refer to the monitoring of the security plans and issues on the accidents; • All staff members should be informed about their duty; • All foreign staff members should be informed about the local habits and culture • To prefer local products during purchasing different materials and to support the local enterprisers; • Establishment consideration mechanisms of complaints of the staff and their usage into the practice; • Establishment register book of complaints of the personnel.	**Responsible for mitigation:** Aisi LLC. **Deadlines for mitigation:** • Before launching works (before employment of the staff and during the mentioned process). In case of employment the new staff member during the ongoing construction works; • During works **Mitigation Costs:** Overall mitigation may be related to **"low"** costs. (difference in prices)	Establishment of corresponding registration mechanism for the complaints and their resolution. Making disciplinary entries.
Impact on transport infrastructure: • Damage of road surface; • Overloading of traffic flow; • Movement restriction;	• Preserving the road surfaces and support of the free movement; • To minimize transport threats and traffic jams; • To prevent discontent of the population.	• Maximum restriction of movement of the caterpillar vehicles; • Population should be informed about the time and duration of the construction works; • Maximum restoration of all damaged section of the road to become available for the population; • If necessary, the movement of motor vehicles will be controlled by specially designated personnel; • Appropriate warning, pointing and prohibition signs will be placed near the construction sites; • Recording complaints and proper response	**Responsible for mitigation:** Aisi LLC. Construction site managers **Deadlines for mitigation:** • during the works and transport operations; • After completion the works; • After receiving the complaints. **Mitigation Costs:** Overall mitigation may be related to **"low"** costs.	Permanent monitoring of the road quality

Risks related to the health and security: • Expected impact on the human health and security; • Expected impact on the health and security of the personnel.	• Providing human health and security	• To provide instruction on the security and labor issues; • Medical insurance for the personnel; • Providing the personnel with individual protection means; • To install warning, indicator and prohibition signs on the dangerous sites and roads; • Fencing dangerous sites for the health; • Standard medical boxes should be placed within the dangerous sites and construction camps; • Providing technical maintenance of the machinery and vehicles; • Abidance by the security rules during the transport operations and speed restriction; • Restriction using the roads within the populated zones; • Control the movement of foreigners within the construction site and restriction their entering the construction zone without special protection means; • Risk assessment to ascertain the risk factors for the population and to manage them • Personnel should be protected by the ropes and special equipment during the working on the height; • Register book for incidents and accidents; • Implementation all measures to avoid deterioration of the ambient air, water and soil quality, as well as mitigation measures of noise propagation;	**Responsible for mitigation:** Aisi LLC. Construction site managers **Deadlines for mitigation:** • Before and after the construction works, several times in a year; • before launching works;; • Before works and permanent renovation; • Permanently during the works. **Mitigation Costs:** Overall mitigation may be related to **"average"** costs.	Control of technical maintenance of machinery and vehicles. Making entries on the incidents and accidents. Unplanned inspection of the personnel
Impact on historical, cultural and archeological monuments: • Damage of the cultural heritage monuments within the construction works;	• To minimize risks of damage/destruction of the cultural heritage monuments	• In case of discovering any archetype, construction works will be stopped and experts-archeologists will be invited for the further researches according to their recommendations, the company will support conservation of a monument or carry to the special storage.	**Responsible for mitigation:** Aisi LLC. Construction site managers **Deadlines for mitigation:** In the process of construction work; If any artefact is found.	Observation of the condition of the nearby church. Service staff control. Visual control of the earthwork process.

• Damage of unregistered archeological monuments during the earthworks		Works will be renovated after obtaining a special permit.	**Mitigation Costs:** Will not be related to costs	

6.3.2 Plan of Mitigation Measures on the Operation Phase

Impact / Impact description	Task	Mitigation measures		Monitoring
		Description	Responsibility, terms and costs	
Noise propagation within the working zone. Impact on other receptors : • Noise propagation due to operation of the hydraulic units and power transformers.	To minimize noise propagation. To reduce the impact on the environment, such as: • Impact on the human health; Disturbance of animals and their migration	• Hydraulic units will be disposed in the closed power house, in a special covers and noise propagation levels won't exceed the standard values; • In the machinery hall, operation building must be arranged with special noise-insulation material; • Providing special ear-protectors for the personnel; • Frequent change of personnel working for the noisy installation	**Responsible for mitigation:** Aisi LLC. **Deadlines for mitigation:** • On the construction phase; • Before coming into operation; • Within the operation phase. **Mitigation Costs:** Overall mitigation may be related to "low" costs.	Control of the technical maintenance of the installations. Instrumental measurements if necessary
Activation of hazardous geodynamic process (erosion, landslide, etc.): • Activating landslides and erosion processes within access roads and other infrastructure facilities; • Risks of wash out the bank line	Preserve the rock stability. To reduce risks of activation the geological processes. To protect HPP structures from the damage	• Preparation of foundations of the HPP main structures will be carried out based on engineering-geological researches, in the main rocks; • Special protection structures will be arranged on the area of the headwork, as well as the powerhouse and on the side of the surge tank; • Within the all sensitive sites monitoring of the hazardous geological processes will be carried out, especially, for the first 2-3years. Personnel of a special competence (engineer-geologists) will participate in the monitoring works. In case of necessity, corresponding preventive measures will be conducted within the short-term period (geological study, project processing and reinforcement works);	**Responsible for mitigation:** Aisi LLC. **Deadlines for mitigation:** • on the design and construction phases; • After completion the construction works and on the operation phase, especially, within the first several years (in case of risks of the activation geodynamic processes revealed after the monitoring) **Mitigation Costs:** Overall mitigation may be related to "average" costs.	Permanent observation on the geological stability of the sensitive sections. Monitoring costs may be assessed as "low".
Change of the hydrological regime, reduction of water	• To preserve sufficient water current for social	• On construction and operation phases, constant observation will be established	**Responsible for mitigation:** Aisi LLC.	Monitoring of the natural flow of River.

flows in the river:	and economic usage; To preserve sufficient water current in terms of the ecology – less impact on the biological environment of water	on river runoff. Besides, downstream release of the environmental flow will be controlled (monitoring over environmental flow will be carried out on a daily basis). Results of monitoring over natural runoff and environmental flow will be quarterly submitted to the Ministry of Environmental Protection and Agriculture of Georgia; • In case of flow equal to or less than the environmental flow in the river, power plant(s) will stop operation and full volume of water flow will be released in tailrace of the headwork(s); • During the first 2 years of operation, fish fauna of project rivers will be monitored and the report will be submitted twice a year to the Ministry of Environment Protection. Additional mitigation measures will be taken, if necessary; • Within the framework of fish fauna monitoring, special attention will be drawn to checking of sensitive points, existing within the project impact zone. The control mainly considers checking how much is the continuity and the thickness of the water flow is preserved in conditions of environmental flow. If required, riverbed management measures will be implemented on critical points, which involves cleaning of mentioned sections from sediments and boulders, hindering free flow movement;	**Deadlines for mitigation:** • On the construction and operation phase, • Permanently on the operation phase, • In accordance with the necessity. **Mitigation Costs:** Will not be related to additional costs	Permanent monitoring on the release of the environmental flow (especially, in shallow periods).
Impact on sediment transportation : Due to the weir and reduction the water current in the riverbed	To preserve dynamic of the riverbed of project Rivers and stability of the bank line	• During floods flush gates will be fully opened in order to ensure downstream passage of sediments; • Twice a year, after the floods of spring and autumn, passage of sediments in the	**Responsible for mitigation:** Aisi LLC. **Deadlines for mitigation:** • Flooding during the exploitation phase;	Monitoring on the sediment transportation in the weir section

		headwork sections will be monitored; • According to the results of this monitoring, if it is revealed that the sediment downstream release is limited, appropriate measures will be taken (e.g. cleaning the upstream by excavator, etc.);	• Twice a year, after spring and autumn floods on the operation phase; • In case of necessity **Mitigation Costs:** Overall mitigation may be related to **"low"** costs.	
Contamination of surface waters: Contamination of surface waters by wastes, untreated wastewaters	Prevention of contamination of the surface waters and to reduce the impact on the environment, such as: • Impact on the water biodiversity; • Contamination of the underground waters; Impact on the receptors depended on the water resources (animals, population).	• Permanent control of the measures considered by the waste management plan; • Permanent inspection on the rules of fuel/oil storage; • In case of emergency spill of fuel/oil, the polluted site should be localized and preventive measures foe surface water contamination; • To instruct the personnel on the issues of the environmental protection and security	**Responsible for mitigation:** Aisi LLC. **Deadlines for mitigation:** • after oil spill in short-term period; • Permanently on the operation phase. **Mitigation Costs:** Overall mitigation may be related to **"average"** costs.	Control of the waste management plan, rules of storage and usage of fuel/oils, as well as, visual control of the soil and water
Reduction of underground water flow: will be related to the reduction of the natural run off from the area of headwork to the power house.	To reduce impact on the receptors depended on the underground water resources (population, biodiversity).	Release of the environmental flow in the downstream and permanent inspection;	**Responsible for mitigation:** Aisi LLC. **Deadlines for mitigation:** Obligatory environmental flow should be permanently released in the downstream of the weir. **Mitigation Costs:** Costs related to the water loss of energy value,	Permanent monitoring on the environmental flow.
Visual-landscape changes: • Visual changes due to infrastructural objects of the HPP; • Pollution with wastes; • Due to the reduction of water flow.	• To prevent human discontent; • To minimize changes of the animal shelters and their migration	• Using natural materials, proper selection of colors during arrangement the arrangement of the HPP structures; • Recultivation and landscaping works; • Permanent inspection on release of the environmental flow in the downstream; • Proper waste management	**Responsible for mitigation:** Aisi LLC. **Deadlines for mitigation:** • On the construction phase and after coming into operation; • Permanently on the operation phase.	Control of the waste management plan. Visual monitoring to inspect the sanitary-ecological situation on the territory. Control of release of the environmental flow.

			Mitigation Costs: Overall mitigation may be related to **"low"** costs.	
Impact on the behavior of species: Deterioration of ordinary lifestyle due to the reduction of water level and sparse forests. Migration of animals.	• To minimize direct and indirect impact on the animal species	• Planting/growing forest groves to compensate the damage on the vegetation cover; • Release of obligatory environmental flow in the downstream; • Improvement of the night illumination systems; • As well as, • Proper waste management; • Mitigation measures of water, soil and ambient air pollution (see the corresponding paragraph	**Responsible for mitigation:** Aisi LLC. **Deadlines for mitigation:** • On the recultivation phase; • Permanently on the operation phase. **Mitigation Costs:** Overall mitigation may be related to **"average"** costs.	Control of vegetation cover. Control of release of the environmental flow.
Impact of water biodiversity of water: • Permanent restriction of movement of fish fauna in the upstream; • Deterioration of the living environment –decrease of the water level, increase of pollutants in the water; • Risk of fish mortality and entering the intake.	Maximum preserve of the water biodiversity.	• Liquid flow management will be effectively provided. Established environmental flow will be permanently released downstream of headworks; • According to the project, a fish pass structure (fish ladder), designed in compliance with the international standards, will be arranged at headwork. Technical functionality of fish pass will be regularly monitored and waste will be removed, which is especially important for prevention fish movement restriction; • Technical functionality and operation of fish passage will be effectively monitored; • In order to minimize the risk of fish damage (death), a steel protective mesh (screen) will be arranged on water intake and its cleaning from floated	**Responsible for mitigation:** Aisi LLC. **Deadlines for mitigation:** • On the construction phase; • Permanently on the operation phase, especially during spawning and migration period of fish. **Mitigation Costs:** Overall mitigation may be related to **"average"** costs.	Recurrent monitoring on maintenance and efficiency of fish passages. Control of release of the environmental flow. Control of waste management plan. Monitoring of the biological environment

		sediments will be provided; • During the first 2years of operation, species of ichthyofauna will be monitored in order to develop additional mitigation measures if required; • Within the framework of fish fauna monitoring, special attention will be drawn to checking of sensitive points. The control mainly considers checking how much is the continuity of the water flow is preserved in conditions of environmental flow. If required, riverbed management measures will be implemented on critical points, which involves cleaning of mentioned sections from sediments and removal of boulders that hinder free flow movement; • All mitigation measures in order to avoid deterioration of surface water quality (see relevant paragraph); • Staff will be properly instructed on prohibition of illegal fishing.		
Risks of environmental pollution by wastes: • Hazardous wastes (used oil of turbines and transformers); • Household wastes.	Prevention of waste distribution in the environment and reduction the impacts, such as: • Negative impact on human health and security; • Pollution of water environment; • Impact on the animals; Negative visual-landscape change and others	• Arrangement of corresponding warehouses for temporary storage of the wastes on the territory of the powerhouse; • Arrangement of special containers for the household wastes on the territory of the powerhouse; • Instructed personnel will be allocated for the waste management, they will be trained and pass special tests; • To instruct the personnel; • Reuse the wastes if it is possible; • Special licensed contractor will carry out transportation the hazardous wastes from the territory for the further management	**Responsible for mitigation:** Aisi LLC. **Deadlines for mitigation:** • On the construction phase and before putting into operation; • Permanently on the operation phase. **Mitigation Costs:** Overall mitigation may be related to "low" costs.	Control of the waste management plan by the special instructed personnel, recording amount and type of wastes, making special register book
Employment and risks of	• To prevent discontent of	• Establishment the employment policy	**Responsible for mitigation:**	Establishment resolution

negative impact, in particular: • Employment expectation of the local population and discontent; • Violation of employees rights; • Tension relations between the locals and employees (none locals).	the employees and the local population on the operation phase	and its publication on local (office), municipal (office of the municipality, etc.) and regional levels; • Employment based on passing special tests; • To sign individual working contract with each employee; • The contract should include those articles related to all plans, procedures and mitigation measures, as well as, those articles that refer to the monitoring of the security plans and issues on the accidents. • All staff members should be informed about their duty; • All foreign staff members should be informed about the local habits and culture ; • Establishment consideration mechanisms of complaints of the staff and their usage into the practice; • Establishment register book of complaints of the personnel.	Aisi LLC. **Deadlines for mitigation:** • Before works (before employment and in the process of employment). As well as, in case of receiving new staff members during the construction works; • Within the construction process. **Mitigation Costs:** Will not be related to additional costs	mechanisms of the complaints; making disciplinary entries.
Risks related to health and security: • Expected impact on the human health and security • Expected impact on the health and security of the personnel	• Providing human health and security	• To provide instructions on the security and labor issues; • Medical insurance for the personnel; • Providing the personnel with individual protection means; • To install warning, indicator and prohibition signs on the dangerous sites and roads; • Fencing dangerous sites for the health; • Standard medical boxes should be	**Responsible for mitigation:** Aisi LLC. **Deadlines for mitigation:** • During taking the personnel and after, several times in a year; • Before launching construction works; • Before starting works and permanent renovation; • Permanently during the works.	Control of technical maintenance of machinery and vehicles. Making entries on the incidents and accidents Unplanned inspection of the personnel

		placed on the headwork; • Providing technical maintenance of the installation; • Control the movement of foreigners within the construction site and restriction their entering the construction zone without special protection means; • Risk assessment to ascertain the risk factors for the population and to manage them; • Register book for incidents and accidents. • Implementation all measures to avoid deterioration of the water and soil quality, as well as mitigation measures of noise propagation (see corresponding paragraphs);	**Mitigation Costs:** Overall mitigation may be related to **"low"** costs.	

Except the measures listed in the preceding paragraph, the operator company will recurrently carry out maintenance/repair works for the certain objects of the HPP infrastructure. Such measures are significant for the proper and regular operation of the hydro power plant and for prevention of sudden damage of the infrastructure. The listed measures also reduce different negative impact on the environmental receptors as a result of some unexpected accidents and the risks related to the human security:

- Recurrent inspection of the installations of the headwork and regulation in case of necessity (cleaning, painting);
- Cleaning of Setting basin from sediment;
- Periodic inspection of the diversion / pressure system;
- Detection of water leakage within the diversion / drainage system by means of a comparison of the measured flow at the inlet and outlet;
- Seasonal maintenance works of the HPP:
    - Inspection of the main technological (turbines, generators) and auxiliary installations (valves, cranes, pumps, etc.);
    - Fencing of structures, arrangement of gates, warning signs, lightning and organizing the territory if necessary;
    - Checking and repairing of electrical installations;
    - Visual monitoring of transformers and switches and repairing in case of necessity;
    - Change/adding oil in the transformers;
    - Mowing of the grass, control of the weeds along the fence;
- Ensure proper maintenance of the access roads.

7 Environmental Monitoring Plan

7.1 General Review

In the framework of the HPP construction and operation, the process of environmental monitoring aims at resolution of the following objectives:

- Confirming that the construction and exploitation procedures are carried out in compliance with the environmental legislation;
- Providing control of the risks and environmental impacts;
- Providing stakeholders with relevant environmental information;
- Confirmation of the process of minimizing/mitigating the negative impacts, determination of their effectiveness and making necessary adjustments if necessary.
- The permanent environmental control during the project implementation (construction and operation).

Environmental Monitoring Plan for HPP construction and operation phases is given in paragraphs 7.1.1. and 7.1.2. It should be noted that the given plan is general and it can be detailed and corrected in some directions. The project executor- Aisi LLC takes responsibility for performance of Environmental Monitoring Plan.

7.2 Monitoring Plan on the Construction Phase

Subject of Control/ Controlling activity	Control/Sampling point	Method	Frequency/Time	Goal	Responsibility
1	2	3	4	5	6
Ambient air quality					
Air (Dust and emission)	• Construction camp; • Construction sites; • Access roads to the construction site;	• Visual; • The technical checkup of the machinery and equipment	• Regularly, during the earth works in a dry weather; • During the construction works; • Through the intensive transport operations, in a dry weather; • Technical checkup before the work start;	• Minimal disturbance of population; • Ensuring safety of the personnel; • Minimal disturbance of the vegetation/flora and fauna; • Development and implementation of the additional mitigation measures (e.g. watering the roads, filling of vehicles).	• Executor company - Aisi LLC
Noise and vibration	• Construction camp; • Construction sites; • Access roads to the construction sites.	• Technical checkup of the machinery.	• Technical checkup before the work start	• Ensuring the compliance with the health and safety regulations; • Ensuring the comfortable working conditions for personnel; • Minimal disturbance of fauna; • Determination necessity of the additional mitigation measures	• „----------“
	• Residential houses near the construction camp	• Instrucmental measurement of noise	• Once ina month during noise generating works on the territory of the camp	• Determination necessity of the additional mitigation measures	• „----------“
Geological environment, ground stability, hazardous geodynamic and hydrological processes:					
Landslide processes	• Landslide site on the left bank; • Headwork section; • Penstock corridor; • Other more or less sensitive sites of the valley project section	• Observation on development probability of active landslide processes; • Observation on development of hazardous geodynamic processes; • Inspection of slope stability.	• Permanently during the construction works; • Permanently during excavation the penstock corridor; • After extremely intense precipitations; • During intensive traffic movement; • Inspection by the engineer-geologist after the completion of works	• Ensuring the stability of the slopes; • Preventing the damage of the facilities under construction and human injuries; • Maintaining the ground resources (soil, flora, habitats); • Development and implementation of the additional mitigation measures (terracing, reinforcement)	• „----------“
Hazard of rockfall	• More or less sensitive sites of the project corridor	• Observation on activation of rockfall	• Permanently, during the construction works; • Permanently, during	• Ensuring the stability of the slopes; • Preventing the damage of the	• „----------“

			excavation of the penstock corridor; • Especially, after extreme precipitations; • During intensive traffic movement; • Inspection by the engineer-geologist after the completion of works.	facilities under construction and human injuries; • Maintaining the ground resources (soil, flora, habitats); • Development and implementation of the additional mitigation measures.	
Riverine erosion, stability of banks	• Bank line of the headwork upstream and downstream; • Penstock and road sites near the riverbed; • Powerhouse site along the entire riverbed.	• Observation on scales of erosive processes; • Observation on safety of the constructing structures;	• Recurrently, especially, prior to te spring and autumn floods, during the floods and after the flood season.	• Maintaining of the bank line stability; • Pprotection of constructing structures and access roads from damage; • Development and implementation of additional mitigation measure (bank protection structures)	• „----------“
Soil/ground:					
Stability of spoilgrounds	• Disposal area of waste rocks	• Observation on development of erosive processes (scouring)	• Inspection after extreme precipitations on the construction phase; • Inspection after completion of the construction and recultivation works.	• Prevention of development of erosive processes and preservation of a stockpile stability;	• „----------“
Soil/ground quality	• Construction camp; • Construction sites; • Disposal areas of materials and wastes.	• Control, supervision; • Control of technical • functionality of machinery/vehicles; • Lab control	• Periodical inspection; • Inspection after the construction works;. • Lab survey – if spillage of polluting substances	• Maintain of soil/ground quality	• „----------“
Aquatic environment:					
Natural rnoff of Paravani and Korkhi rivers	Headwork location	• Use of flow meters or level meters	• Permanently on the construction phase. Submitting to the Ministry – once in a quarter	• Specification of natural flows of the project rivers	• „----------“
Surface water quality	• Construction camp; • Construction sites – near the water bodies	• Visual; • The technical checkup of the machinery and equipment; • Monitoring over the solid and liquid waste	• Through the arrangement of the construction sites (near the water bodies), especially after the rain/snow; • Through the working process (near the water bodies);	• Providing water quality protection	• „----------“

		management; • Monitoring over the domestic-fecal water management; • Lab control	• During the transporting/warehousing of the solid waste; • Technical checkup before the work is started; • Lab survey – after spill of pollutants		
Vegetation cover:					
Vegetation cover within the project corridor	• Within the headwork corridor; • Penstock corridor; • Location of the powerhouse; • Corridor of access roads; • Construction camps and other working sites	• Visual control • Control over protection of boundaries of the construction sites;	• Monitoring through the process of the vegetation removal; • At the other construction sites – unscheduled control; • Inspection of vegetation cover after completion of works, control over their recovery measures.	• Maintaining the vegetation cover. Minimum disturbance of the fauna/ population; • Minimizing the negative impacts on the animals	• „----------“
Wildlife:					
Sensitive habitats, inhabiting or visitor animals of the project corridor surroundings (especially, endangered species)	• The surroundings of the construction camps and construction sites; • Riverbank line; • Access road corridors.	• Identification/recording of hoes, nests and roosts of bats; • Observation over the animal species and comparing to the baseline state; • Visually observation over the pits, trenches made for the foundations	• Identification/recording of hoes and nests prior the construction works and inspection after completion the construction process; • Observation over the animal species frequently during the construction and after the works are finished; • Inspecting the pits and trenches before backfilling	• Minimizing the negative impacts on animals; • Assessment of effectiveness of the mitigation measures; • Determination of compensation measures and additional mitigation measures if necessary.	• „----------“
Performance of mitigation measures by the construction contractor	• Surroundings of construction camp and construction sites; • Transport corridors;	• Supervision over the personnel; • Unscheduled inspection	• Inspection prior and after the construction works; • Supervision - permanently (especially, at the preparatory stage); • Inspecting - unscheduled	• Confirmation of fulfillment of the mitigation measures by the personnel; • Providing additional trainings and explanations for the personnel; • Prevention facts of poaching	• „----------“

Aquatic biodiversity (especially, red-listed species)	• River section under the impact zone	• Research provision by the ichthyologist and submitting the report to The Ministry of Environment Protection and Agriculture of Georgia	• Twice a year during the construction	• Impact assessment on fish fauna due to the ongoing construction works. Determination of additional mitigation measures if necessary; • Assessment of effectiveness of the defined mitigation measues	• „----------“
Wastes:					
The state of waste management	• Construction camp and its surroundings; • Construction sites; • Waste disposal areas landfills	• Visual observation of the area; • Waste management control	• Regularly, especially during the windy weather; • Within the landfill – after the flood or precipitations	• Maintaining the soil, water quality; • Minimum effect on the biodiversity; • Less visual-landscape change.	• „----------“
Occupational safety:					
The status of the compliance with the safety standards by the personnel	• Working area	• Inspection; • The existence of the personal protective equipment, regular control over the functionality; • Monitoring the technical functionality.	• Regular control in the working process; • Unscheduled inspection	• Ensuring the compliance with the health and safety standards; • Avoiding/minimizing the injuries	• „----------“
The monuments of the archeological and cultural heritage:					
The possible late discovery of the archeological artifacts during the construction	• The working area	• Visual observation	• Regular observation during the earth works; • Inspecting the arranged pits before taking further actions	• Prevention the accidental damage of the archeological monuments	• „----------“

7.3 Monitoring Plan for the Operation Phase

Subject of Control/ Controlling activity	Control/Sampling point	Method	Frequency/Time	Goal	Responsibility
Ambient air:					
Noise	• Powerhouses	• Ensuring the technical functionality of the equipment; • Instrumental measurement.	• Regular control; Instrumental measurement – in case of entry of complains or after repair works.	• Ensuring the compliance with the health and safety regulations; • Minimal impact on fauna	• Operator company
Geological environment, soil stability, hazardous geodynamic processes:					
Landslide-	• Project corridor. Especially	• Monitoring over the	• Visual observation after the	• Ensuring the stability of the	• „----------“

gravitational processes and other hazardous geological events	sensitive sections, identified in advance or during the construction process	development of geodynamic hazards; • Monitoring of slope stability	intensive precipitations; • Inspection by the engineer-geologist twice a year during the first few years of operation.	slopes; • Preventing the damage of the facilities and the human injuries; • Maintaining the ground resources (soil, flora, habitats); • Development and implementation of the additional mitigation measures.	
Protective structures.	• Protecting walls arranged at the slopes and river side through the project corridor and the surrounding sides.	• Inspection of technical functionality of protective structures; • Inspection of development of erosive or other processes through the surrounding sites	• Inspection by the engineer-geologist twice a year	• Providing the slope stability; • Preventing the damage of the facilities and the human injuries; • Maintaining the ground resources (soil, flora, habitats); • Development and implementation of the additional mitigation measures (terracing, reinforcement);	• „----------“
Soil/ground:					
Soil/ground quality	• Territory of powerhouses; • Waste disposal sites.	• Visual control • Lab testing	• After adding/ changing the transformer oil; • Lab research – in case of oil spill.	• Maintaining the soil quality; • Preventing the surface water pollution by the runoff; • Preventing the ground water pollution.	• „----------“
Aquatic environment:					
Natural runoff of the river	• At the section of headwork location	Measurement by using of flow meters installed at the headwork	• Operation phase – regularly; • Submission of the results to the Ministry – once in a quarter.	• Specification of the natural runoff.	• „----------“
Environmental flow release	• Downstream of headwork	• Measurement of the environmental flow by using of flow meters or level meters	• Every day – on the operation phase. • Submission of data to the Ministry - once in a quarter.	• Ensure constant environmental flow release downstream and minimizing the impacts related to the water receptors	• „----------“
Solid flow release	• Upstream and downstream of headwork	• Inspection of sediment accumulation upstream and defining possibility of transit release of sediments downstream.	• Periodically, during shallow water; • Inspection twice a year after spring and autumn high waters	• Providing sediment release from upstream to downstream; • Maintain stability of banks; • Cleaning of upstream with excavator if necessary.	• „----------“
Biological environment:					
Sensitive habitats, inhabiting or visitor	• Neighboring sites of the HPP area;	• Observation on animal species and comparison with	• For 2 years after commissioning twice a year.	• Assessment of effectiveness of mitigation measures;	• „----------“

animals of the corridor's surroundings (especially, endangered species)	• Corridors of access roads;	baseline state;		• Determination of compensation measures and additional mitigation measures, if necessary.	
Aquatic biodiversity	• The section within the impact zone (especially the sensitive sections, described in the EIA report)	• Research provision by the ichthyologist and submitting the report to The Ministry of Environment Protection and Agriculture of Georgia	• For 2 years after commissioning twice a year	• Prediction of fish fauna damage and determination of additional mitigation measures, if necessary • Assessment of effectiveness of developed mitigation measures.	• „----------“
Effectiveness of technical functionality of a fish pass and its operation	• Fish pass	• Inspection by an engineer.	• Prior to the fish migration.	• Possibility of upstream fish migration	• „----------“
Wastes	• Headwork area; • Powerhouse site; • Waste disposal areas	• Visual observation of the territory; • Monitoring over the waste management	• Recurrently	• Maintaining the soil, water quality	• „----------“
Occupational safety	• Work implementation area	• Inspection; • The existence of the personal protective equipment regular control over the functionality;	• Regular control in the working process.	• Ensuring the compliance with the health and safety regulations; • Avoiding/minimizing the injuries.	• „----------“

8 Possible Emergency Situations and Catastrophic Events Cased by Natural Processes

In frames of the planned activity manmade emergency situations can be as follows:

- Emergency situations associated with damage of hydrotechical structures, including: including damage of the water intake and the penstock;
- Risks of accidental spill of pollutants;
- Fire (including landscape fire);
- Traffic accidents;
- Injury (traumatism) of the personnel.

In addition, due to specificity of the location, expected natural disasters should be considered and the appropriate response plan should be determined. Following natural processes can be developed within the HPP area and endanger stability of the HPP engineering structures and the human safety:

- River flooding due to the long-term unfavorable meteorological conditions and releasing of catastrophic water flow at the headwork and the bridges at the powerhouse section;
- Development of landslide-gravitational processes (landslide, avalanche) through the HPP corridor and direct damage of the engineering facilities;
- Development of landslide-gravitational processes upstream of the HPP, which blocked the riverbed, breakdown of the river blocking weir was observed and uncontrolled flow/debris flow of the stony-muddy mass was developed through the HPP corridor;
- Earthquake.

Preventive measures against catastrophic incidents/emergency situations expected due to development of similar natural process were considered on the HPP designing process.

Response plan for the emergencies as well as catastrophic events caused by the natural processes expected in the HPP construction and operation process is provided in the Annex 6.

9 Determination of Ways and Means to Restore Former Environmental Conditions in Case of Termination of HPP Operation

9.1 Short-Term Cessation of Operation or Repair of the HPP

In case of temporary cessation of operation of the HPP or any certain object, or in case of repair works (minor and major) of the existing facilities, operation service will develop operational plan related to a temporary suspension of activities or repair works, which firstly includes security requirements and should be coordinated with the local authorities and all interested legal persons.

9.2 Long-Term Cessation of Operation or Conservation of the HPP

In case of long-term cessation of the HPP or conservation, administration will establish a liquidation body, which will develop the plan for long-term cessation or conservation. The plan, major content of which must be safety requirements, should be coordinated with the authorized agencies (including the Ministry of Environment Protection and Agriculture of Georgia).

The following measures are to be carried out before the termination of the activities:

- Internal audit of the area – to record the technical condition of infrastructure, to identify the risks of emergency situations, as well as environmentally problematic areas and to solve the problem;

- Temporary demobilization of supporting infrastructure – to remove the stockpiled material and waste from the warehouse, and to allocate a special area for equipment and vehicles;
- To provide warning and prohibition signs throughout the outer perimeter of the area.

9.3 Decommissioning

In case of liquidation of the HPP a special project identifying the ways and means of restoring previous conditions of the environment must be developed.

Such project must be developed by the operator company. Under the current rules, a special project of termination should be agreed with the competent authorities and the information should be provided to all stakeholders (physical and legal entities). The project shall cover rules and the sequence of termination of technological processes, dismantle of facilities and equipment, terms and conditions of demolition works, safety and environmental measures, terms and conditions of neutralization and disposal of hazardous waste, recultivation works and other issues.

10 Public Information and Study of Public Opinion

According to the requiremenets of the Law of Georgia "Environmental Assessment Code", public hearing of scoping report and EIA report of the planned activities will be ensured by the Ministry of Environment Protection and Agriculture of Georgia. Public meetings with regard the scoping report was held in Akhalkalaki municipality, in the administrative building of the City Hall. information on the response to the issues required by the scoping conclusion is given in the Table 10.1.

The public hearing of this EIA report will be held in accordance with Articles 11 and 12 of the "Environmental Assessment Code", namely:

- Within three days after the application has been registered, the Ministry shall have the application and the attached documents placed on its official website and on the notice board of the executive body and/or representative body of a respective municipality, and upon request, shall make printed copies available under a procedure established by the legislation of Georgia;
- Within three days after an application for obtaining an environmental decision has been registered, the Ministry shall establish an expert commission provided for by Article 42 of this Code to review the EIA report. The expert commission shall prepare and submit to the Ministry an expert opinion on the EIA report within 40 days after the establishment of the commission;
- The public may, within 40 days after the placement of the application under the procedure established by Article 11(3) of this Code, submit to the Ministry opinions and comments under the procedure established by Article 34(1) of this Code with respect to the EIA report, the planned activity and the conditions to be included in the environmental decision. When making an environmental decision or a legal act refusing the carrying out of the activity, the Ministry shall ensure the review of the opinions and comments submitted and, if there are appropriate grounds, take them into account;
- Not earlier than the 25th day and not later than the 30th day after the placement of the application under the procedure established by Article 11(3) of this Code, the Ministry shall hold a public review of the EIA report. The Ministry shall be responsible for organising and holding reviews. Public reviews shall be led, and the minutes of public reviews shall be drafted, by a representative of the Ministry. The Ministry shall be responsible for the accuracy of the minutes. Information on the public review shall be published not later than 20 days before the public review is held, in

accordance with Article 32 of this Code. Public reviews shall be held in the building of the appropriate administrative body located closest to the location of the planned activity or in the territory adjacent to the building. If it is planned to carry out the activity within the administrative boundaries of a self-governing community, public reviews shall be held in the building of the appropriate administrative body located closest to the location of the planned activity or in the territory adjacent to the building; or if it is planned to carry out the activity within the administrative boundaries of a self-governing city, public reviews shall be held in the building of the appropriate administrative body determined by the Ministry or in the territory adjacent to the building. Public reviews shall be open and any member of the public may participate in them.

Table10.1. Information on performance of conditions determined by the scoping conclusion

N	Conditions	Executor
1	The EIA report should include information determined by the third part of the Article 10 of the Environmental Assessment Code;	Gamma Consulting LTD
2	Documentation determined by the fourth part of the Article 10 of the Environmental Assessment Code should be attached to the EIA report;	Gamma Consulting LTD
3	Survey results indicated (determined, implemented) in the scoping report, as well as obtained and studied information, detailed studied impacts within the EIA process and appropriate reduction/mitigation measures should be presented in the EIA report;	Gamma Consulting LTD
3.1	Pursuant to the second part of the Article 10 of the Environmental Assessment Code, signatures of the persons, including consultant (if any) participated in the EIA preparation process should be provided in the report;	Gamma Consulting LTD
4	Following items should be presented in the EIA report:	
	• Substantiation of the project necessity;	Project
	• Project description;	Project
	• Impact and impact assessment on socio-economic environment, land ownership and use, restriction of natural recourses, health and safety related risks and appropriate mitigation measures;	Gamma Consulting LTD
	• Assessment of cumulative impact with regard to similar existing or/and planned activities on the adjacent territory of the project (including in the region) in terms of impact on water as well as on any other environmental component, including, cumulative impact along with Paravani HPP (500 m) downstream of the design HPPs should be considered.	Gamma Consulting LTD
	• Description of the HPP substation and the ETL infrastructural facilities;	Project
	• HPP main technical parameters (diameter, thickness, etc of a diversion pipeline /penstock);	Project
	• Shape files of the HPP facilities, access roads, spoil grounds and construction camps;	Client and Gamma Consulting LTD
	• Table of main technical characteristics of the design HPP, substation and ETL and the project explanatory note, with description of all hydro-technical structures;	Project
	• Project alternatives: with appropriate substantiation, including no-action alternative, as well as alternatives of location of the HPP infrastructural facilities (headwork, penstock, power house) and the alternative selected in terms of the environmental viewpoint;	Gamma Consulting LTD
	• Detailed description of the fish pass and fish excluders and information about its operation, including the fish pass upstream and downstream elevations, parameters, results of hydraulic calculation (to be available prediction of impact on fish fauna);	Project
	• Description of the substation and ETL infrastructural facilities and the technological equipment;	Project
	• Alternatives of the substation and the ETL: technological alternatives with appropriate substantiation, substantiated alternative selected in terms of environmental viewpoint with shape files;	Project

	• GIS coordinates of the substation and the ETL locations;	Project
	• Geological, hydrological and hydrogeological surveys of the substation and the ETL locations;	Project
	• Specified information on the private owners get within the RoW of the design ETL selected alternative, as well as information about the linear structures (technical solution);	Client and Gamma Consulting LTD
	• Specified information on the private owners get within the RoW of the design ETL selected alternative, as well as information about the linear structures (technical solution);	Project
	• Basic physical characteristics of the substation and the ETL (capacity, scale);	Project
	• Information about the groundwater based on the engineering-geological survey;	Project
	• Description of the construction sites and disposal areas of materials;	Project and Gamma Consulting LTD
	• Description of expected emergency situations on the construction phase and their management plan;	Gamma Consulting LTD
	• Data about the waste types and amount expected on the construction and operation phases and further management measures;	Gamma Consulting LTD
	• Issues related to the topsoil removal, disposal, use and recultivation in relation with the arrangement of the HPP infrastructure (pursuant to the requirements of the technical regulation on "topsoil removal, disposal and recultivation").	Gamma Consulting LTD
	• Transportation route and scheme of the construction vehicles;	Project
4.1	Information on the construction works implementation, namely: Issues related to necessity of access roads and construction of these roads: • Sequence (with deadlines) of construction of the HPP, substation and ETL, as well as their infrastructure; • Total number of employed personnel on the project construction and its operation process, including share of local employees; • List and number of machinery-vehicles used in the framework of the HPP construction; • What methods are used for construction of the diversion pipeline and the reason of selection of this method with appropriate substantiation; • Way of waste rocks removal (with band conveyor or trucks, etc.); • How generated waste rocks will be managed. Whether they are planned to be used as inert materials in road or HPP infrastructure construction or not. If it is planned, approximate calculation in percentages and detailed information on the infrastructure; • Where temporary and final disposal of waste rocks is planned. In particular: location coordinates of waste rocks disposal area (spoil grounds) and project of the spoil grounds with a structure protecting them from scouring; • Area of obtainment of inert material essential for construction of the facilities; • Parameters (length, diameter, section and others) of water conveyance channel from the power house to the river; • Information about supply of the HPP powerhouses with potable water (individually and from water	Project

	supply system) and drainage of industrial-fecal wastewaters;	
4.2	Information about arrangement of the main construction camp, including: • Master plan of the construction camp; • Coordinates and area of the camp's location; • List and characterization of existing and considered infrastructure essential for construction of the HPP and the ETL; • Description of water supply project with appropriate drawings, how will the HPP powerhouse and the construction camp be supplied with potable-industrial water (individually or from water supply system); • Management issue of wastewater generated on the territory of the construction camp and the HPP; capacity of a cesspool considered on the territory; weather arrangement of sedimentation ponds is planned for industrial wastewaters or not; • Type and capacity of a fuel tank considered at the main construction camp.	Project
4.3	Geological survey report of the project corridor that should include the following information: • Geological structure of the project site; • General geological map of the region; • Relief (geomorphology); • Map of geodynamic processes of the construction area with marking of potential landslide hazard sites; • Engineering-geological map of the project corridor, engineering-geological sections; • Description of geomorphological, geological, hydrogeological, seismic and tectonic conditions of the project territory; • Results of engineering-geological survey, implemented through the project corridor. Including, special attention should be drawn to the locations and descriptions of the complicated areas in terms of hazardous geodynamic territories (landslide, erosion, rockfall) through the project corridor. Implementing preventive measures (protective structures, slopes terracing and others) should be provided in the report; • Detailed engineering-geological surveys to be implemented through the project corridor prior to the construction (number of boreholes, location, lab tests, results of soil lab tests, etc.); • Conclusions and recommendations developed based on the geological survey results;	Project
4.4	Hydrological survey report should include the following: • Hydrology of Paravani and Korkhi rivers; • Detailed information on the rivers average annual flows and interannual distribution of the runoff; • Detailed information on the maximum runoff, minimum runoff; • Information on solid sediment (of each river); • Environmental (sanitary) flow (as well as methodology of its calculation); • Detailed information on amount of water to be used by the HPP for 10%, 50% and 90% provisions;	Project

	• Information about permanent and temporary streams crossing the penstock corridor; • Information on debris flows and related preventive measures if necessary; in addition, information about the riverbed processes and the bank protective works;	
4.5	Information about the stilling basins for surplus water released downstream of the headwork should be provided;	Gamma Consulting LTD
4.6	Information about prevention of potable water pollution risks should be given in the EIA report. So, the following issues should be presented in the EIA report: • Detailed description of hydro turbines planned in the power house with consideration of the risks of oil mix with used water; • Description of hydro turbines cooling system and the water management issues used in cooling system;	Project
4.7	Biological environment: detailed description of flora and vegetation cover of the project territory; rare and red-listed species of Georgia, which are observed within the planned project corridor; terrestrial fauna; animal species of the project corridor included in the Red List of Georgia; study area and field survey methods, sensitive areas, field survey results;	Gamma Consulting LTD
4.8	Fish fauna of Paravani and Korkhi rivers	Gamma Consulting LTD
4.9	Environmental impact assessment for each environmental component and summary of potential impacts, expected in the result of the project implementation, including: • Impact on ambient air on construction and operation phases, emissions during operation f the construction equipment, emissions from construction material producing devices, emission report; • Noise propagation and expected impact on construction and operation phases and corresponding mitigation measures; • Impact on geological conditions on construction and operation phases and hazardous geodynamic processes and corresponding mitigation measures; • Determination of possible activation of the hazardous geodynamic processes during construction-operation of the facility and corresponding mitigation measures; • Impact on underground/groundwater and mitigation measures; • Impact on surface water on construction and operation phases, surface water contamination risk, reduction of flow in the riverbed, necessary environmental flow and corresponding mitigation measures, besides, consideration of water level meter (for constant measurement of water flow); impact on sediment movement; • Impact on biological environment and impact assessment construction and operation phases; • Impact on vegetation cover and habitat integrity, impact on wildlife, characterization of impact on fish fauna (including red-listed species), corresponding mitigation measures; • Information about plants on the project area: in case of impact (cut, flooding) on them, the information should be provided about impacted plants, indicating their specie composition and	Gamma Consulting LTD

	quantity; • Impact on species, protected by the national legislation and international treaties, and their habitats. Impact avoidance and compensation measures, including habitat restoration measures, if required; • Potential damage to fish stock during construction (river blockage with cofferdams) and flushing of settling and compensation measures for it; • A chapter about corresponding mitigation measures of impact on specific biodiversity components; • Based on above-mentioned surveys, the monitoring plan should reflect the issue of observation on specific biodiversity component; • Waste management plan, impact expected by waste generation; • Impact on historical-cultural and archaeological monuments; • Mitigation measures plan, to be implemented on construction and operation phases; • Monitoring plan to be implemented on construction and operation phases; • A detailed emergency response plan; • Public awareness on scoping stage and assessment of public comments and opinions; • Main conclusions developed within EIA framework and main measures to be performed during the project implementation; • A layout scheme of HPP location (with relevant indications); • Design drawings of HPP constituent facilities (indicating dimensions), namely: a general plan of HPP (with explication), plan and section of headworks; • Plan and section of powerhouse; plan and section of fish way; • Plan of the substation; typical cross section, plan and section of the penstock (with relevant indications);	
5	Following should be presented in EIA report: • Main technical parameters of HPP infrastructural facilities in the form of unified table; • Information on issues considered by scoping opinion (in the form of unified table, with reference of corresponding pages); • Information on literature and regulatory documents used during environmental impact assessment; • Printed and electronic versions (A3 format; Shape file with WGS_1984_37N(38N) projection) of the project area schematic map, depicted on aerophoto (with high resolution), where following will be presented: • HPP infrastructural facilities (headwork, diversion pipeline, reservoir, power house, penstock, construction camp, access road, construction sites, spoil grounds); • Information on minimum and maximum absolute river flows based on historical or/and observation data; • Paravani and Korkhi river length and width (both total and within the project section); • Information on tributaries within the project area, both downstream and upstream from weir, indicating distances and flows, released by mentioned tributaries;	Gamma Consulting LTD

	• Assessment of irreversible environmental impact and justification of its necessity, which considers counterweight of the loss, caused by irreversible environmental impact, and received gain from the environmental, cultural, economic and social point of view. • In the EIA report, submitted for obtainment of the environmental decision, the mitigation measure chapter and monitoring plan should be developed in details and provided, where issues on observation over the impact on certain biodiversity components will be reflected. • In the EIA report, submitted for obtainment of the environmental decision, it is necessary to present a detailed survey (taxation) of specie composition and characteristics of plants, which are planned to be cut. If red-listed species of Georgia are subject to removal, the report should reflect the location of cutting and amount of species to be cut; • The information, prepared based on corresponding survey, should be presented in the EIA report, submitted for obtainment of the environmental decision, about animals within the project impact zone (special attention should be drawn to species, protected under international treaties and Red List of Georgia) and their habitats, about potential impact on them, impact avoidance and if required, compensation measures. In addition, results of above-mentioned surveys must be presented with photo-materials. • The information, prepared based on corresponding survey, should be presented in the EIA report about water and water-depended biodiversity within the project impact zone, including fish fauna, about potential impact on them, impact avoidance and if required, compensation measures. Besides, in the regard with fish fauna, arrangement of fish way and fish excluder should be discussed in EIA report. • For protection of the surface and groundwater against contamination, EIA report must provide a detailed description of all specific sections of the whole route of the diversion tunnel arrangement, with consideration of the preventive measures against river contamination.	

11 Conclusions

Following main conclusions have been developed within the framework of environmental impact assessment:

1. The project considers construction and operation of the diversion-type non-regulated HPP on Paravani and Korkhi Rivers, in Akhalkalaki municipality. The project is the part of the state energy development program;
2. Natural and social environment baseline conditions of the project area have been studied within the scope of the EIA, for which, literary sources, the fund materials and also the results of the fieldworks of the project area have been used. After environmental baseline studies it was revealed that geological conditions and biological environment (including aquatic biodiversity) are the main sensitive receptors within the study area;
3. Paravani HPP headwork is located downstream of the project HPP location corridor;
4. Considering work specificity EIA is implemented for two main stages of the project: construction and operation phases;
5. According to calculations conducted within the EIA process, impact on local population related to noise propagation and harmful substance emissions on construction phase is less expected. Impact caused by noise and harmful substance emissions will be relatively significant on wildlife, however, the impact will be temporary and reversible. After HPP commissioning, environmental impact related to noise and harmful substance emissions will be much lower;
6. In terms of impact on water quality, the most sensitive sites are: in the construction process – construction sites locating near the riverbed. In the operation process – locations of powerhouses. With consideration of the targeted environmental management and implementation of planned mitigation measures, considerable deterioration of water quality is not anticipated on the construction and operation phases;
7. Hydrological change (shallow water) in the project sections of river on the operation phase must be considered as significant impact on the environment;
8. In order to reduce the impact on fish fauna, caused by existence of dams on operation phase, it is considered to arrange fish ladder and fish excluder net. Environmental flow will be released through fish way;
9. Implementation of the construction works and water level decrease in the river project section will cause impact (restriction of habitat) on some species of mammals, birds, reptiles and some species of amphibians typical for the valley. However, high impact on species under special protection and their habitats is not expected;
10. Due to considerable distance from the project sites to the protected areas, the project implementation is not related to risks of negative impact on them;
11. No visible historical-cultural monuments are observed within the project corridor. No direct impact is expected on them;
12. The project corridor passes through the lands in the state ownership. But temporary, less expected, permanent utilization of the private land parcels can be unavoidable. In such case, the executor company will hold negotiations with the land owners and based on the appropriate agreement the company will provide the compensation measures;
13. On construction phase transport operations will cause growth of local traffic flows. It is possible to minimize the impact by selecting various alternative transport routes, warning population in advance and agree transport activities with local government;

14. Local natural resources (sand-gravel reserves, water resources for potable-sanitary and technical purposes, forest resources, etc.) may be used for construction, which is also significant in terms of the impact on local environment;
15. As a result of project implementation, low or medium residual impact is expected on certain environmental receptors by considering proper mitigation measures. Impact on biological and hydrological conditions of the river can be deemed as the most significant impacts.
16. In addition: According to the project documentation and analysis of the baseline condition of the environment, it is determined that with consideration of corresponding mitigation measures, impact on separate receptors of the natural and social environment on construction and operation phases is not expected;
17. Construction and operation project implementation will be related to the significant positive impact, namely:
    - Temporary and then permanent job-places will be created for the construction and operation of the infrastructural facilities, which is very important for local population employment (mainly locals will be recruited for low-qualification job-places by selection of the contingent from local population);
    - Construction and operation project implementation results in positive effect for socio-economic development of the region, as well as of the whole country.

Major Environmental Measures to be implemented through the Work Process:

1. The project executor company and construction contractor will set the strict control over the implementation of mitigation measures considered in the EIA report and over performance of the license conditions considered by the conclusion of ecological examination;
2. Relevant paragraphs will be reflected on fulfillment of environmental norms/obligations in the agreement concluded with the construction contractor;
3. Personnel hired for construction and operation will be periodically trained and tested on environmental and occupational safety issues;
4. Personnel hired for construction and operation will be provided with personal protective means;
5. Temporary structures will be arranged near the construction sites in order to minimize the intensity of traffic flows near population;
6. Cultivation of the construction sites and landscaping of the powerhouse sites will be considered in project documentation in order to compensate the damage caused towards the vegetation cover during construction of infrastructural facilities;
7. Sediment discharge from upstream towards downstream within the headworks section will be monitored twice a year, after spring and autumn floods;
8. Hydrological parameters of the river will be recorded systematically within the headworks axis. Downstream release of environmental flow will be controlled and the information will be provided to the corresponding agency;
9. In case of inflow of the river flow equal or less than the environmental flow, the HPP operation will be suspended and full volume of water will be released downstream of the headworks;
10. The environmental flow will be also released through the fish pass, creating the conditions for fish migration, that is close to the natural conditions;
11. The technical functionality and effectiveness of the fish pass will be monitored, which is especially important during the reproduction and migration period of the fish;
12. During the project implementation, observation over the fish fauna will be carried out according to the monitoring plan, with the aim of development of additional mitigation measures, if required;

13. The measures considered in the Waste Management Plan, given in the present report, will be carried out;
14. With the purpose of optimization of storage and usage rules for oil, used on the operation phase, special storage sites will be arranged on the powerhouse sites. Storage sites will be equipped with the devices against oil spill and distribution on the site;
15. In order to minimize dangerous geodynamic process development risks, corresponding preventive measures will be implemented and protective structures will be arranged (it is noteworthy that prior to the construction, it is planned to carry out additional surveys within the project corridor – arrangement of boreholes, based on which foundation conditions for the project facilities will be specified, as well as parameters of the protective structures);
16. Extraction of inert material will be carried out only based on the license for extraction of natural resources

AIS LTD is responsible for performance of environmental measures in the construction and operation process of Akhalkalaki HPP.

12 Referances

Ambient Air

- საქართველოს შრომის, ჯანმრთელობისა და სოციალური დაცვის მინისტრის 2003 წლის 24 თებერვლის ბრძანება №38/ნ «გარემოს ხარისხობრივი მდგომარეობის ნორმების დამტკიცების შესახებ».
- საქართველოს მთავრობის 2013 წლის 31 დეკემბრის დადგენილება № 435 „დაბინძურების სტაციონარული წყაროებიდან ატმოსფერულ ჰაერში გაფრქვევების ფაქტობრივი რაოდენობის განსაზღვრის ინსტრუმენტული მეთოდის, დაბინძურების სტაციონარული წყაროებიდან ატმოსფერულ ჰაერში გაფრქვევების ფაქტობრივი რაოდენობის დამდგენი სპეციალური გამზომ-საკონტროლო აპარატურის სტანდარტული ჩამონათვალისა და დაბინძურების სტაციონარული წყაროებიდან ტექნოლოგიური პროცესების მიხედვით ატმოსფერულ ჰაერში გაფრქვევების ფაქტობრივი რაოდენობის საანგარიშო მეთოდიკის შესახებ ტექნიკური რეგლამენტის დამტკიცების თაობაზე“.
- საქართველოს მთავრობის 2013 წლის 31 დეკემბრის №408 დადგენილება „ატმოსფერულ ჰაერში მავნე ნივთიერებათა ზღვრულად დასაშვები გაფრქვევის ნორმების გაანგარიშების ტექნიკური რეგლამენტის დამტკიცების თაობაზე“.
- «Методическое пособие по расчету, нормированию и контролю выбросов загрязняющих веществ в атмосферный воздух», СПб., 2005.
- «Методическое пособие по расчету выбросов от неорганизованных источников в промышленности строительных материалов», Новороссийск, 2001;
- Временные методические указания по расчету выбросов загрязняющих веществ (пыли) в атмосферу при складировании и перегрузке сыпучих материалов на предприятиях речного флота», Белгород, 1992.
- Методическое пособие по расчету, нормированию и контролю выбросов загрязняющих веществ в атмосферный воздух, СПб., НИИ Атмосфера, 2005.
- Методика проведения инвентаризации выбросов загрязняющих веществ в атмосферу автотранспортных предприятий (расчетным методом). М, 1998.
- Дополнения и изменения к Методике проведения инвентаризации выбросов загрязняющих веществ в атмосферу автотранспортных предприятий (расчетным методом). М, 1999.
- УПРЗА «ЭКОЛОГ», версия 4. Copyright © 1990-2018 ФИРМА «ИНТЕГРАЛ»

Geology

- საქართველოს გეომორფოლოგია. საქართველოს სსრ მეცნიერებათა აკადემია, გამომცემლობა ,,მეცნიერება“, თბილისი 1971;
- სსრკ გეოლოგია. ტომი X, საქართველოს სსრ, ნაწილი I, გეოლოგიური აღწერა;

- საქართველოს სსრ მეცნიერებათა აკადემია. გეოლოგიური ინსტიტუტის შრომები. გეოლოგიური სერია. ტომი X(XV);
- მარუაშვილი ლ. ნ. სამხრეთ საქართველოს ვულკანური ზეგანი. თბილისი, 1951.
- პაპავა დ. ი. – მდ. მტკვრის შუა დინების აუზის გეოლოგიური რუკა, მასშტაბი 1:100000, 1976წ.

- .**Hydrology:**
- Ресурсы поверхностных вод СССР, том 9, Закавказье и Дагестан, выпуск 1, Западное Закавказье. Гидрометеоиздат, Ленинград, 1974 г. стр. 578
- Справочник по климату СССР, выпуск 14 (влажность воздуха, атмосферные осадки, снежный покров). Гидрометеоиздат, Ленинград, 1970 г. стр. 426
- Технические указания по расчету максимального стока рек в условиях Кавказа. Закавказский региональный научно-исследовательский институт (Зак НИИ), Тбилиси, 1980 г., стр. 71.

Flora

- გიგაურიგ. 2000. საქართველოს ტყეების ბიომრავალფეროვნება. თბილისი.
- კეცხოველინ. 1960. საქართველოს მცენარეული საფარი. თბილისი, საქ. სსრმეცნ. აკად. გამომცემლობა.
- კეცხოველინ., გაგნიძერ. [რედ.],1971-2001. საქართველოს ფლორა, ტ. 1-13. მეცნიერება, თბილისი.
- საქართველოს კანონი „საქართველოს „წითელი ნუსხისა“ და „წითელი წიგნის“ შესახებ 06/06/2003
- საქართველოს პრეზიდენტის №303 (2006) წლის 2 მაისის ბრძანებულება. „საქართველოს ,,წითელი ნუსხის“ დამტკიცების შესახებ“
- Akhalkatsi, M., Tarkhnishvili D. 2012. Habitats of Georgia, Natura 2000 Guideline.
- Arabuli G., Mosulishvili M., Murvanidze M., Arabuli T., Bagaturia N., Kvavadze Er. 2007. The Colchic Lowland Alder Woodland with Buxwood Understory (Alneta barbata buxosae) and their Soil Invertebrate Animals. Proc. Georgian Acad. Sci., Biol. Ser. Vol. 5, No.2: 35-42
- Bonham, Ch. D., 2013. Measurements for Terrestrial Vegetation. ISBN: 0470972580. A John Wiley & Sons, Ltd. 260 pp.
- Braun-Blanquet, J., Fuller G.D., Conard H.Sh., Blanquet J.B. 1965. Plant Sociology: The Study of Plant Communities. Authorized English Translation of Pflanzensoziologie by J. Braun-Blanquet. Transl., rev. and Ed. by George D. Fuller and Henry S. Conard. Hafner Pub.
- Czerepanov, S.K. 1995,Vascular plants of Russia and Adjacent states (the former USSR) //Cambridge University press. 516 pp.
- Doluchanov A..G. 2010. Forest vegetation of Georgia, ('Lesnoi rastitelnost Gruzii'), Universali, Tbilisi.. (In Russ.).
- EBRD 2014. Environmental and Social Policy (ESP); The Document of European Bank for Reconstruction and Development.
- Gagnidze, R. 2005. Vascular plants of Georgia a nomenclatural checklist, ,,Universal'' Press..
- IUCN. 2003. Guidelines for Application of IUCN Red List Criteria at Regional Levels: Version 3.0. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.
- IUCN. 2010, Guidelines for Using the IUCN Red List Categories and Criteria, retrieved 2012-09-05 Brief information about IUCN categories and criteria
- KfW IPEX-Bank, 2015. Sustainability Guideline: Guideline of KfW IPEX-Bank GmbH For environmentally and socially sound financing
- Peet, R.K. and Roberts, D.W., 2013. Classification of Natural and Semi-natural Vegetation. Vegetation Ecology, Second Edition, pp.28-70.
- Pokryszko B.M., Cameron R.A.D., Mumladze L., Tarkhnishvili D. 2011. Forest snail faunas from Georgian Transcaucasia: patterns of diversity in a Pleistocene refugium. Biological Journal of the Linnean Society 102 (2), 239-250.
- Solomon, J.C., Shulkina, T.V. and Schatz, G.E. eds., 2014. Red list of the endemic plants of the Caucasus: Armenia, Azerbaijan, Georgia, Iran, Russia, and Turkey. Missouri Botanical Garden Press.
- The Plant List Vers. 1, 2010. Published on the Internet; http://www.theplantlist.org/ (accessed 1st January).

Fauna

- გურიელიძე ზ. 1996. საშუალო და მსხვილი ძუძუმწოვრები. წიგნში: „საქართველოს

- ბიომრავალფეროვნების პროგრამის მასალები". თბილისი: 74-82.
- მუსხელიშვილი თ. 1994. საქართველოს ამფიბიებისა და რეპტილიების ატლასი. თბ., WWF, 48გვ.
- თარხნიშვილი დ. 1996. ამფიბიები. კრებ./მასალები საქართველოს ბიომრავალფეროვნებისთვის./თბ. გვ. 64-67.
- ჯანაშვილი ა. 1963. საქართველოს ცხოველთა სამყარო. ტ. III. ხერხემლიანები. თსუ-ს გამომცემლობა, თბილისი: 460 გვ.
- ბუხნიკაშვილი ა., კანდაუროვი ა., ნატრაძე ი. 2008. საქართველოს ხელფრთიანთა დაცვის სამოქმედო გეგმა. გამ. "უნივერსალი", თბილისი: 102 გვ.
- Бакрадзе М.А., Чхиквишвили В.М.1992. Аннотированный список амфибий и рептилий, обитающих в Грузии.//საქართველოს სსრ მეცნიერებათა აკადემიის მოამბე, თბილისი CXLVI, №3 გვ.623-628
- Arabuli A. B. 2002. Modern distribution and numeral condition of Hoofed Animals in Georgia. Prosidings of the institute of Zoology, Vol. XXI. pp. 306-309.
- Arabuli G., Mosulishvili M., Murvanidze M., Arabuli T., Bagaturia N., Kvavadze Er. 2007. The Colchic Lowland Alder Woodland with Buxwood Understory (Alneta barbata buxosae) and their Soil Invertebrate Animals. Proc. Georgian Acad. Sci., Biol. Ser. Vol. 5, No.2: 35-42
- Bolqvadze B., Machutadze I., Davitashvili N. 2016. Study of Freshwater Pond Taxa Marsilea quadrifolia & Salvinia natans in Kolkheti Lowland Black Sea Coastline Bull. Georg. Natl. Acad. Sci., vol. 10, no. 2,
- Bukhnikashvili A. K., Kandaurov A. S. 2001. The Annotated List of Mammals of Georgia. Prosidings of the institute of Zoology, Vol. XXI. pp. 319-340.
- Bukhnikashvili, A. & Kandaurov, A., 2002. The annotated list of mammals of Georgia. Proceedings of the Institute of Zoology, Tbilisi, XXI: 319-336
- Tarkhnishvili, D., A. Kandaurov & A. Bukhnikashvili, 2002. Declines of amphibians and reptiles in Georgia during the 20th century: virtual vs. actual problems. Zeitschrift fur Feldherpetologie 9: 89-107.
- Yavruyan, E., Rakhmatulina, I., Bukhnikashvili, A., Kandaurov, A., Natradze, I. and Gazaryan, S., 2008. Bats conservation action plan for the Caucasus. *Publishing House Universal, Tbilisi*.
- CBS, 2012. Ecoregion Conservation Plan for the Caucasus. Edited by: Nugzar Zazanashvili, Mike Garforth, Hartmut Jungius, Tamaz Gamkrelidze with participation of Cristian Montalvo. Revised and updated version. Caucasus Biodiversity Council (CBS). http://wwf.panda.org/?205437/ecoregion-conservation-plan-for-the-caucasus-revised
- Didmanidze E. 2004. Annotated List of Diurnal Butterflies (Lepidoptera: Rhopalocera) of Georgia and edjascent territory from Southern Caucasus. Raptors and Owls of Georgia. GCCW and Buneba Print Publishing. Tbilisi. Georgia.
- Doluchanov A..G. 2010. Forest vegetation of Georgia, ('Lesnoi rastitelnost Gruzii'), Universali, Tbilisi.. (In Russ.).
- EBRD 2014. Environmental and Social Policy (ESP); The Document of European Bank for Reconstruction and Development.
- EU, 2016. Environmental Impact Assessment: Technical consultation (regulations on planning and major infrastructure), Department for Communities and Local Government.
- IUCN. 2003. Guidelines for Application of IUCN Red List Criteria at Regional Levels: Version 3.0. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.
- IUCN. 2010, Guidelines for Using the IUCN Red List Categories and Criteria, retrieved 2012-09-05 Brief information about IUCN categories and criteria

- IUCN 2019. *The IUCN Red List of Threatened Species. Version 2019-1.* http://www.iucnredlist.org. Downloaded on 21 March 2019.
- IUCN (International Union for Conservation of Nature) 2019. Ochotona iliensis. The IUCN Red List of Threatened Species. Version 2019-1. http://www.iucnredlist.org. Downloaded on 21 March 2019.
- Merkviladze M. Sh., Kvavadze E. Sh. 2002. List of Ladybirds (Coleoptera, Coccinellidae) of Georgia. Prosidings of the institute of Zoology, Vol. XXI. pp. 149-155.
- Muskhelishvili, T. Chkhikvadze, V. 2000. Nomenclature of amphibians and reptiles distributed in Georgia. Proceedings of Institute of Zoology; Vol. 20. pp. 222-229. (In Geo.)
- Tarkhnishvili D. Chaladze G. [Editors] 2013. Georgian biodiversity database [http://www.biodiversity-georgia.net/index.php].
- Tarkhnishvili D., Kikodze D. (Eds.). 1996. Principal Characteristics of Georgia Biodiversity. In: Natura Caucasica (publication of the NGO CUNA Georgica), v. 1, No. 2.
- WWF Global, 2006. Ecoregion Conservation Plan for the Caucasus, Second edition. Contour Ltd. 8, Kargareteli street, Tbilisi 0164, Georgia. http://wwf.panda.org/what_we_do/where_we_work/black_sea_basin/caucasus/?193459/Ecoregional-Conservation-Plan-for-the-Caucasus
- Birds of Europe: Second Edition by Lars Svensson and Dan Zetterström და Collins Bird Guide. 2Nd Edition.
- David W. Macdonald and Priscilla Barrett, 1993 "Mammals of Britain and Europe" (Collins Field Guide)
- Howell, J.A. and J.E. DiDonato. 1991. Assessment of avian use and mortality related to wind turbine operations, Altamont Pass, Alameda and Contra Costa Counties, California, September 1988 through August 1989. Final report. Prep. for U.S. Windpower, Inc., Livermore, CA.
- Johnson, G.D., Erickson, W.P., Strickland, M.D., Shepherd, M.F., Shepherd, D.A. and Sarappo, S.A., 2003. Mortality of bats at a large-scale wind power development at Buffalo Ridge, Minnesota. The American Midland Naturalist, 150(2), pp.332-343.
- Winkelman, J.E. (1985) Bird impact by middle-sized wind turbines on flight behaviour, victims, and disturbance. Limosa, 58, 117–121.
- Osborn, R.G., Dieter, C.D., Higgins, K.F. & Usgaard, R.E. (1998) Bird flight characteristics near wind turbines in Minnesota. American Midland Naturalist, 139, 20–38.
- Nelson, H.K. & Curry, R.C. (1995) Assessing avian interactions with windplant development and operation. Transactions of the North American Wildlife and Natural Resources Conference, 60, 266–287.
- Orloff, S. & Flannery, A. (1992) Wind Turbine Effects on Avian Activity, Habitat Use, and Mortality in Altamont Pass and Solano County Wind Resource Areas (1989–91). Final Report. Planning Departments of Alameda, Contra Costa and Solano Counties and the California Energy Commission, BioSystems Analysis Inc., Tiburón, CA
- Baerwald, E.F., D'Amours, G.H., Klug, B.J. and Barclay, R.M., 2008. Barotrauma is a significant cause of bat fatalities at wind turbines. Current biology, 18(16), pp.R695-R696.

Fish fauna

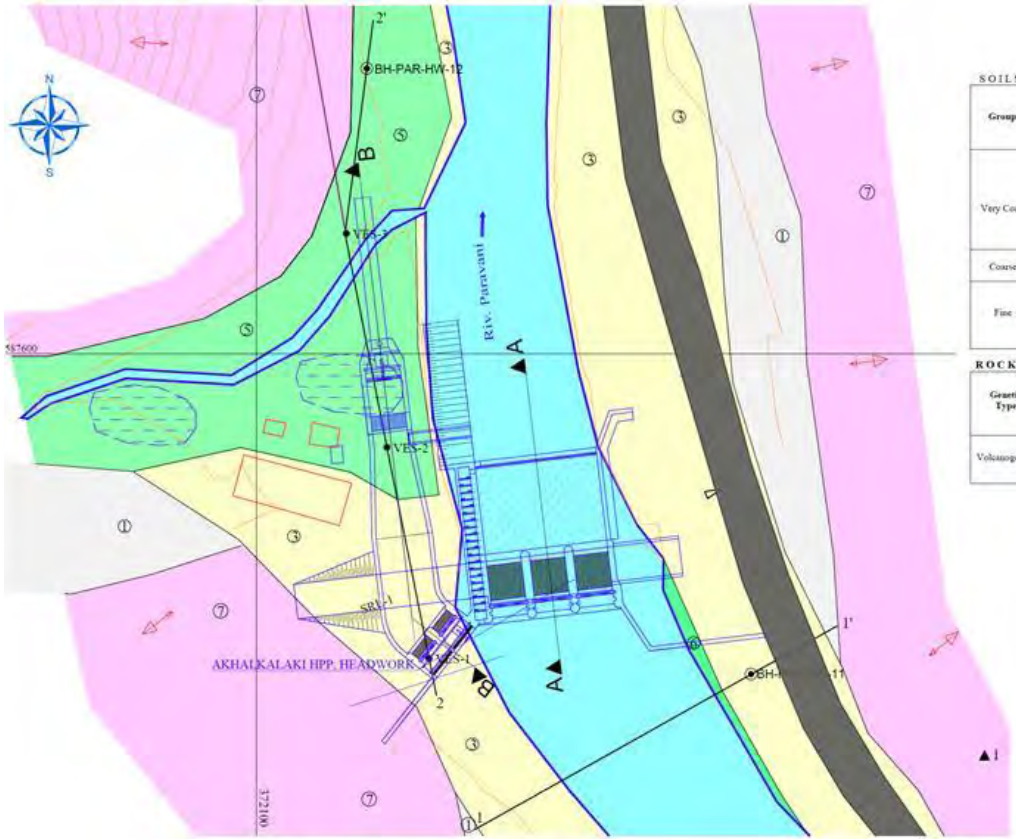
- ნარგიზ ნინუა, ბელა ჯაფოშვილი, ვერა ბოჭორიშვილი, საქართველოს თევზები. გამომცემლობა „წიგნი ერი", საქართველო, თბილისი, 2013.
- საქართველოს ცხოველთა სამყარო, IV. გამომცემლობა „მეცნიერება", თბილისი, 1973.
- რ. ელანიძე, საქართველოს შიდა წყალსატევების ჰიდრობიოლოგია და იქთიოლოგია, მდინარე ბზიფის იქთიოფაუნა, ნაკვეთი II, რიწის ტბა, გამომცემლობა „მეცნიერება", თბილისი, 1965.
- საქართველოს პრეზიდენტის ბრძანებულება, №303 2006 წლის 2 მაისის საქართველოს „წითელი ნუსხის" დამტკიცების შესახებ.

- Павлов Д.С., Скоробогатов М.А. Миграции рыб в зарегулированных реках. — М.: Товарищество научных изданий КМК. 2014. 413 с.
- Р. Ф. Эланидзе, Ихтиофауна рек и озер Грузиии. Академия наук Груинзской ССР, «Мецниереба», Тбилиси, 1983.
- Поддубный А. Г., Малинин Л. К., Терещенко В. Г. О точности оценки абсолютной численности рыб во внутренных водоемах. Сб. « Оценка погрешностей методов гидробиологических и ихтиологических исследований»; тр. ин-та биологии внутренных вод. Рыбинск; АН СССР, 1982. Вып. 49(52). С. 83-102.
- Ресурсы поверхностных вод СССР, гидрографические описания рек, озер и водохранилищ. Том 9, закавказье и дагестан, выпуск I, западное закавказье. Гидрометеоиздат. Ленинград, 1974. Стр. 219-233.
- Правдин И. Ф. Руководство по изучению рыб (преимущественно пресноводных) (4-е изд.). М.: Пищевая промышленность , 1966 г.
- Барач Г. П. Рыбы пресных вод. Акад. наук Груз. ССР. Зоол. Ин-т. Тбилиси : Изд-во Акад. наук Груз. ССР, 1941. - 287
- Правдин И.Ф. - Руководство по изучению рыб (преимущественно пресноводных). Издательство “Пищевая промышленность”, Москва 1966Г.
- Константинов А.С. - Общая гидробиология. Издательство “Высшая школа”, Москва 1986Г.

13 Annexes

13.1 Annex 1. Engineering-geological maps and sections of Akhalkalaki HPP project structures

Akhalkalaki-1 HPP headworks



ENGINEERING-GEOLOGICAL CLASSIFICATION OF SOILS

SOILS

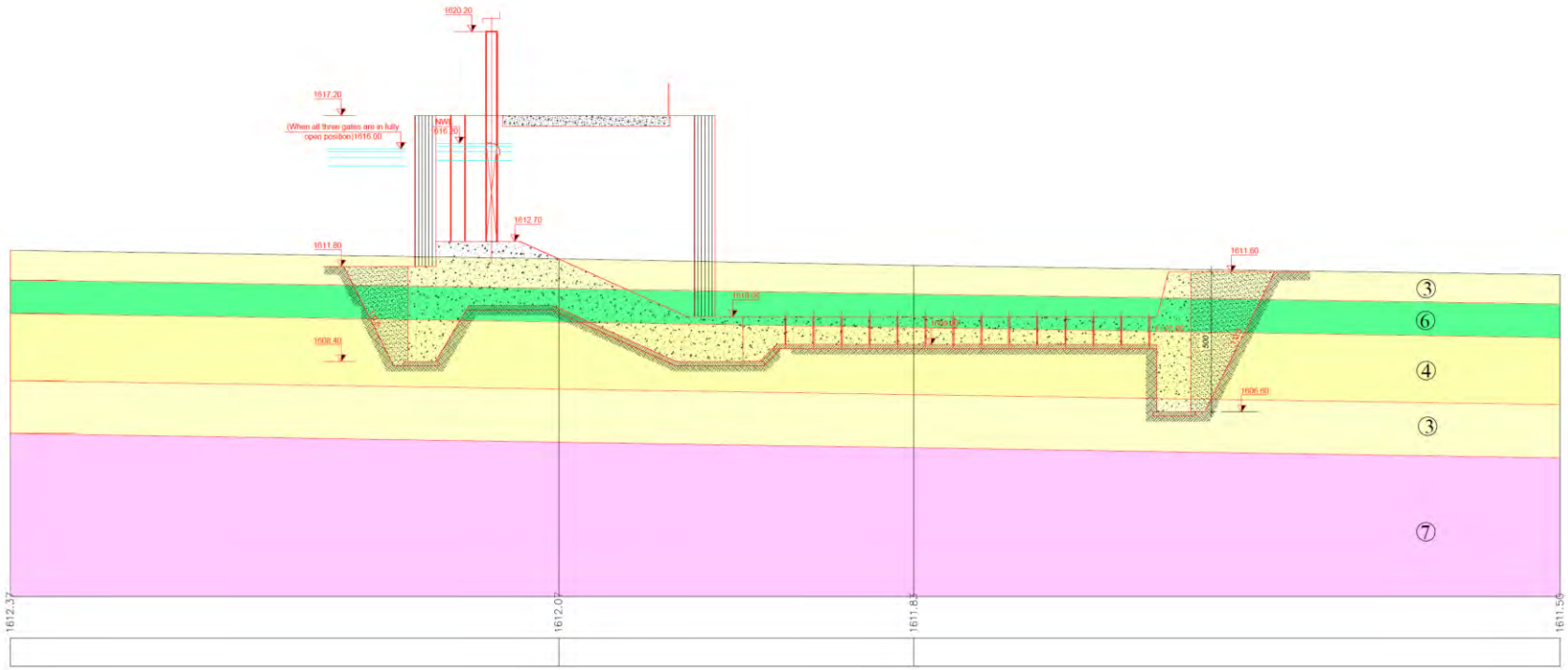
Group	Genetic Type	Symbol and Geological Index	Stratum No.	Description of Soils
Very Coarse	Colluvial	cQ_{IV}	1	Angular COBBLES and angular GRAVEL with boulders content and with intermediately plastic clay matrix
		cQ_{IV}	2	Large size BOULDERS and angular COBBLES with angular gravel and intermediately plastic clay matrix
	Alluvial	aQ_{IV}	3	BOULDERS, angular COBBLES, sub-rounded boulders and cobbles with intermediately plastic clay matrix
Coarse		aQ	4	Saturated, dense GRAVEL with cobbles inclusions, with sand and sandy silt matrix
Fine	Lacustrine	lQ	5	Reddish-brown, stiff CLAY with angular gravel and angular cobbles inclusions
		lQ	6	Greenish-gray, stiff CLAY with angular gravel and angular cobbles inclusions

ROCKS

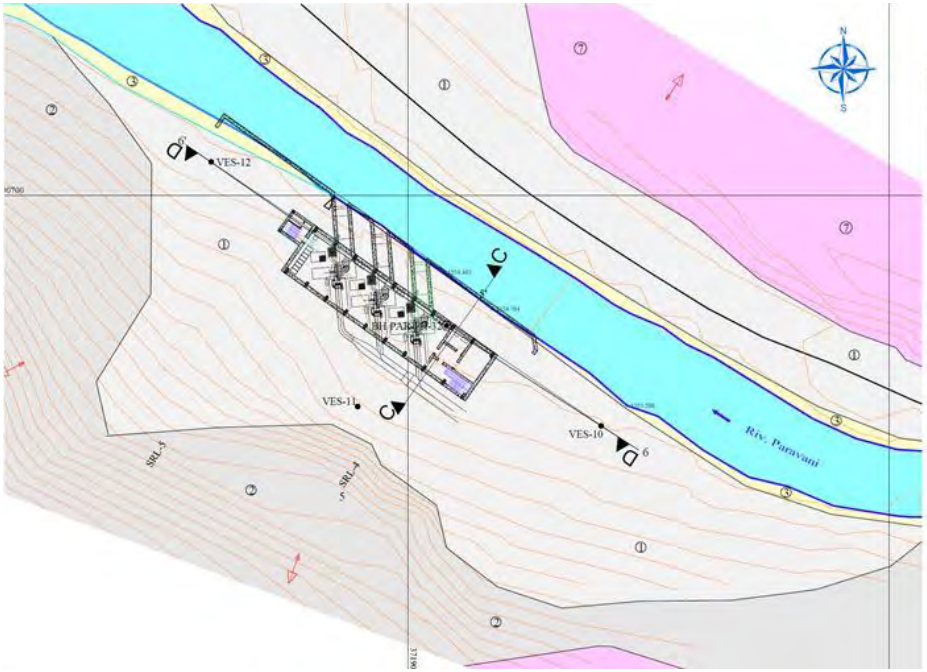
Genetic Type	Strength	Symbol and Geological Index	Stratum No.	Description of Rocks
Volcanogenic	Moderatly strong and strong	βN_2^3-Q_I	7	Slightly weathered, fissured ANDESITE and BASALT

LEGEND:

- ⑤ Stratum No.
- Border between strata
- Landslide stabilized
- Rock fall
- Wetland
- 0.15 L/SEC Spring and water discharge
- BH-PAR-HW-12 Borehole and its number
- TP-KOR-PS-53 Trial Pit and its number
- VES 01 Vertical Electrical Sounding test location and its number
- ▲1 Location of sampling from outcrop and its number
- 1 Water sampling location and its number


1620.20
1617.20
(When all three gates are in fully open position)1616.00
NW
1616.00
1612.70
1611.80
1608.40
1611.60
1606.60
500
③
⑥
④
③
⑦
1612.37
1612.07
1611.83
1611.56

Akhalkalaki 1 HPP powerhouse



ENGINEERING-GEOLOGICAL CLASSIFICATION OF SOILS

SOILS

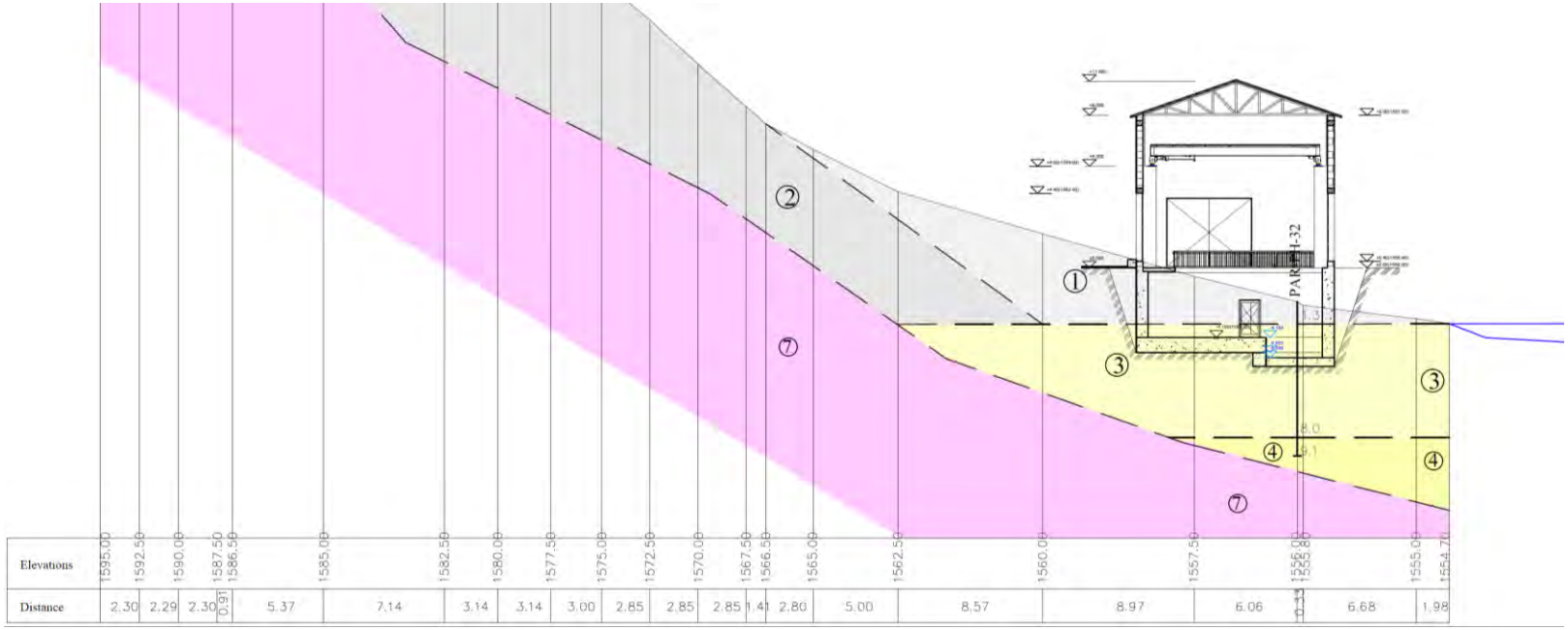
Group	Genetic Type	Symbol and Geological Index	Stratum No.	Description of Soils
Very Coarse	Colluvial	cQ_{IV}	1	Angular COBBLES and angular GRAVEL with boulders content and with intermediately plastic clay matrix
		cQ_{IV}	2	Large size BOULDERS and angular COBBLES with angular gravel and intermediately plastic clay matrix
	Alluvial	aQ_{IV}	3	BOULDERS, angular COBBLES, sub-rounded boulders and cobbles with intermediately plastic clay matrix
Coarse		aQ	4	Saturated, dense GRAVEL with cobbles inclusions, with sand and sandy silt matrix
Fine	Lacustrine	lQ	5	Reddish-brown, stiff CLAY with angular gravel and angular cobbles inclusions
		lQ	6	Greenish-gray, stiff CLAY with angular gravel and angular cobbles inclusions

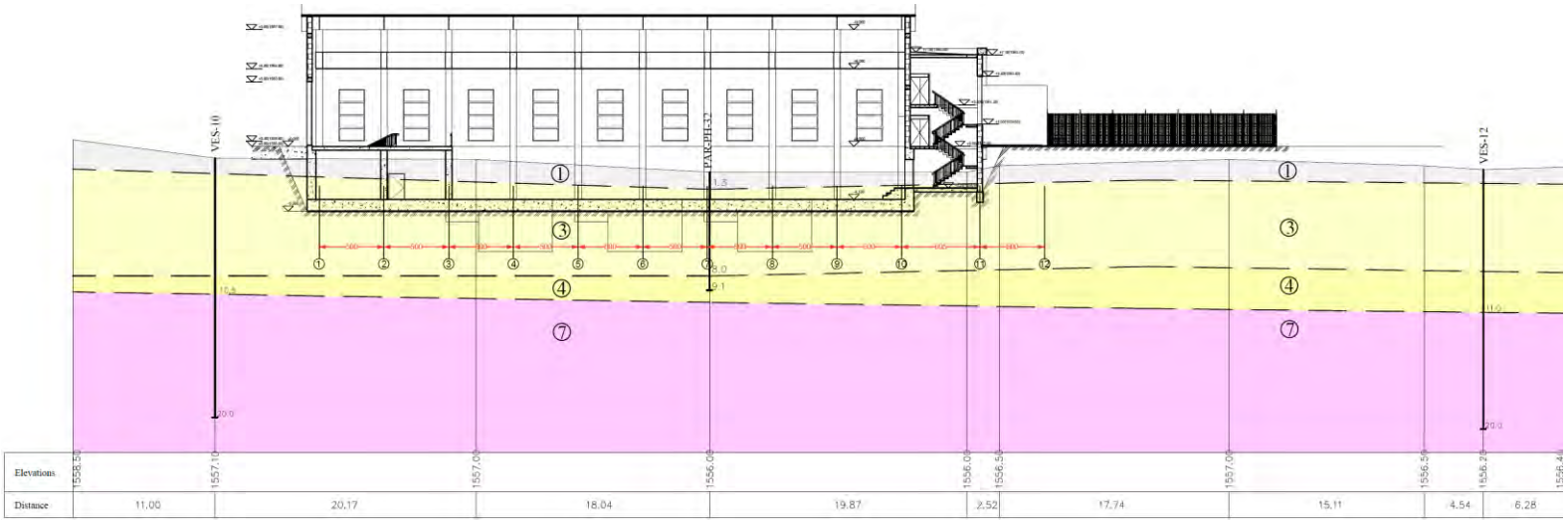
ROCKS

Genetic Type	Strength	Symbol and Geological Index	Stratum No.	Description of Rocks
Volcanogenic	Moderately strong and strong	βN_2^3-Q_I	7	Slightly weathered, fissured ANDESITE and BASALT

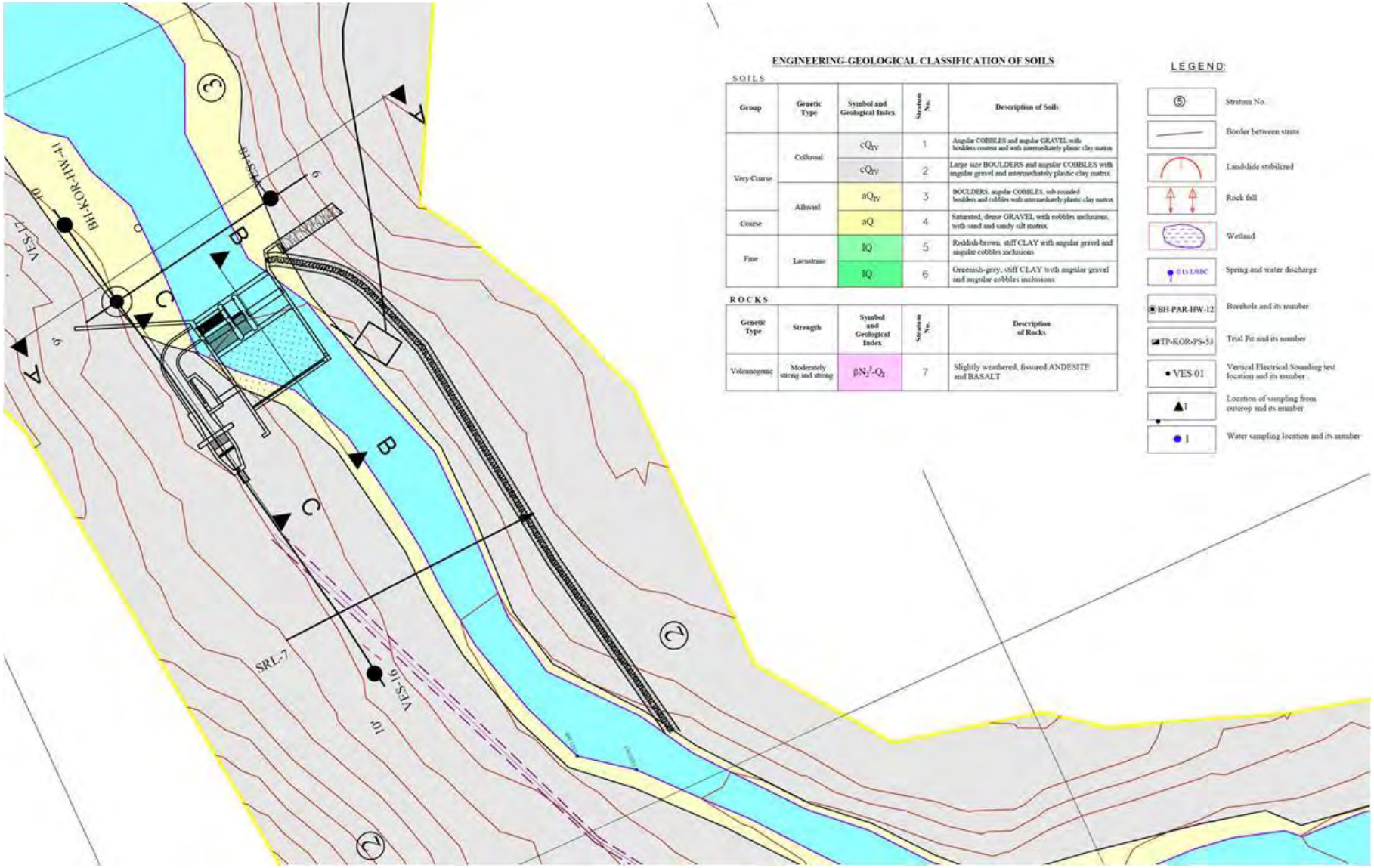
LEGEND:

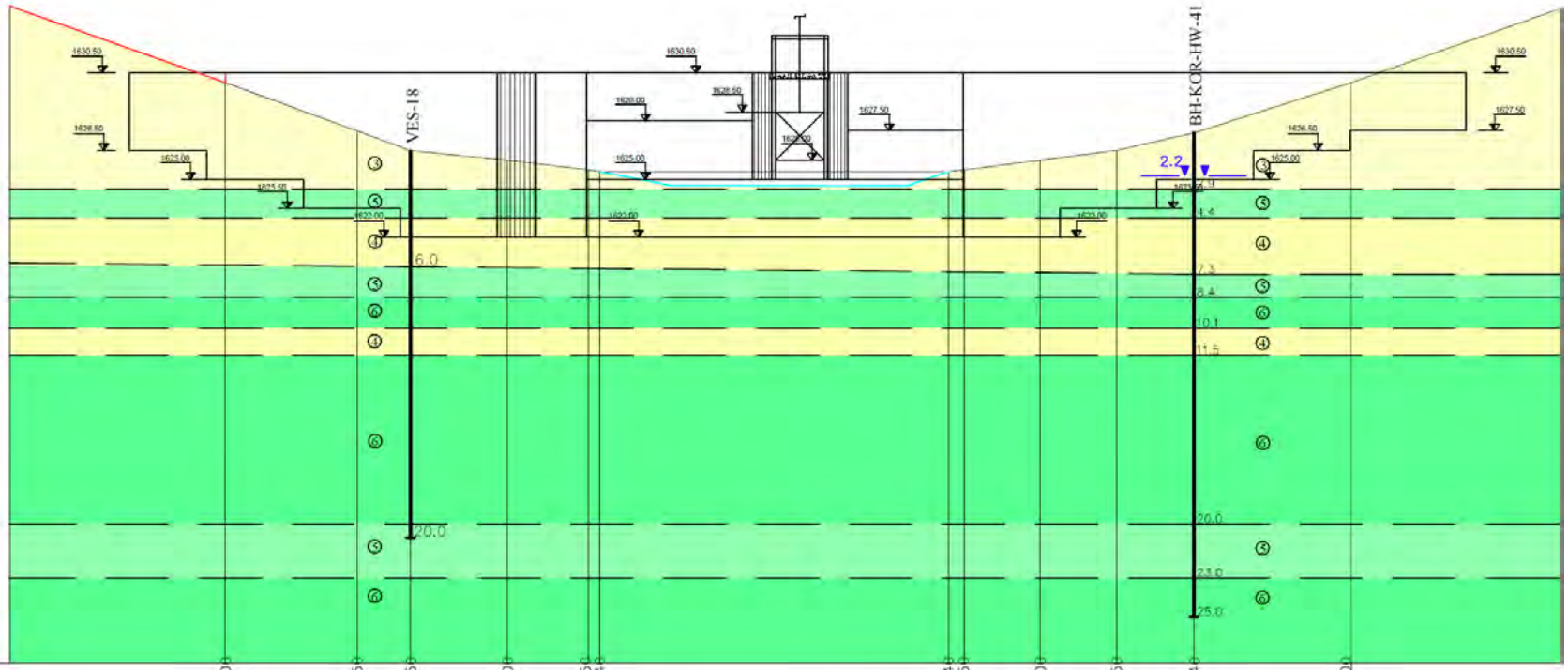
⑤	Stratum No.
	Border between strata
	Landslide stabilized
	Rock fill
	Wetland
0.15 L/SEC	Spring and water discharge
BH-PAR-HW-12	Borehole and its number
TP-KOR-PS-53	Trial Pit and its number
VES 01	Vertical Electrical Sounding test location and its number
1	Location of sampling from outcrop and its number
1	Water sampling location and its number


Elevations
1595.00
1592.50
1590.00
1587.50
1586.50
1585.00
1582.50
1580.00
1577.50
1575.00
1572.50
1570.00
1567.50
1566.50
1565.00
1562.50
1560.00
1557.50
1556.00
1555.00
Distance
2.30
2.29
2.30
0.91
5.37
7.14
3.14
3.14
3.00
2.85
2.85
2.85
1.41
2.80
5.00
8.57
8.97
6.06
6.68
1.98

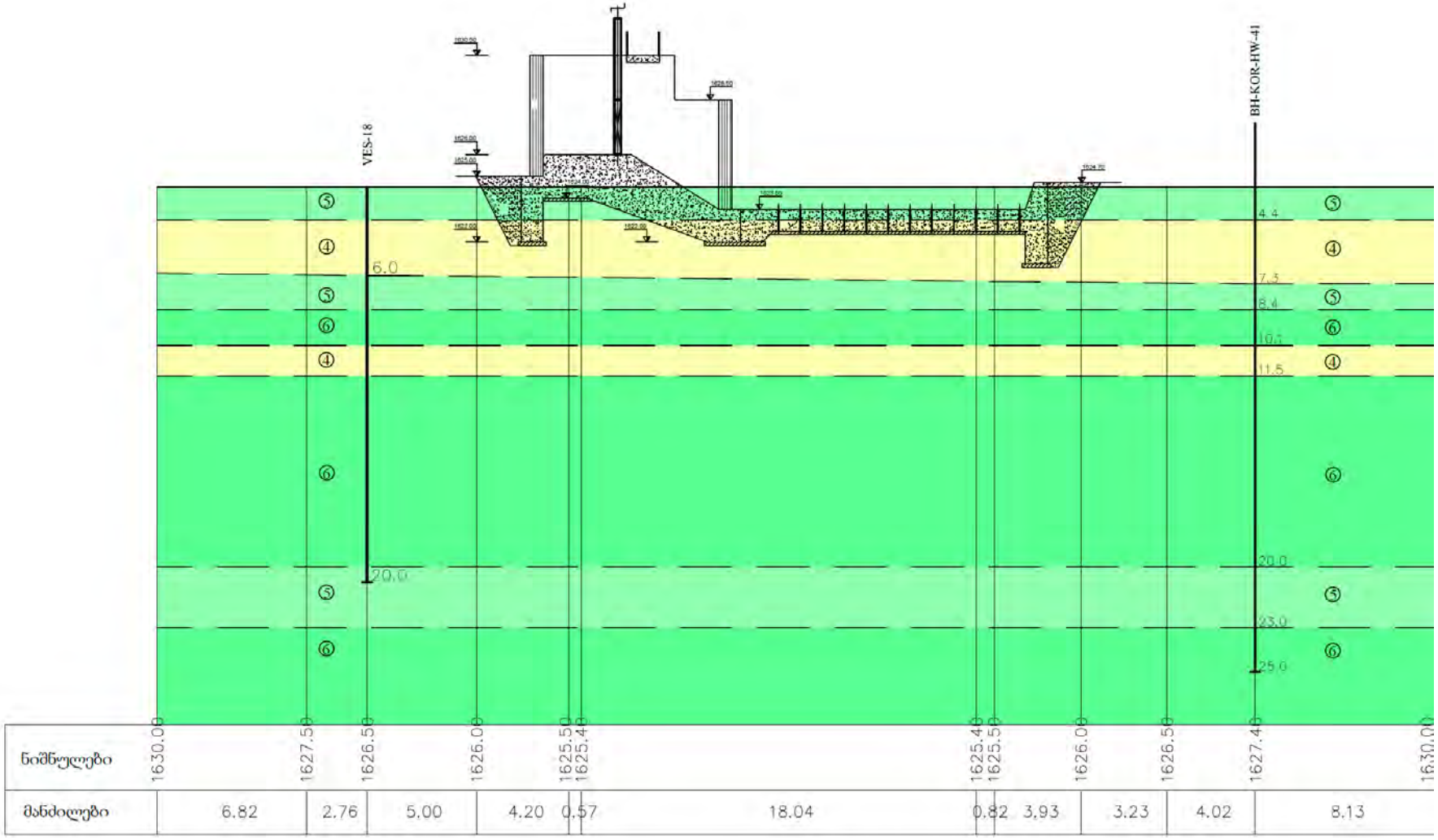

VES-10
VES-12
Elevations
1558.50
1557.10
1557.00
1556.00
1556.50
1557.00
1556.50
1556.29
Distance
11.00
20.17
18.04
19.87
2.52
17.74
15.11
4.54
6.28

Akhalkalaki 2 HPP headworks

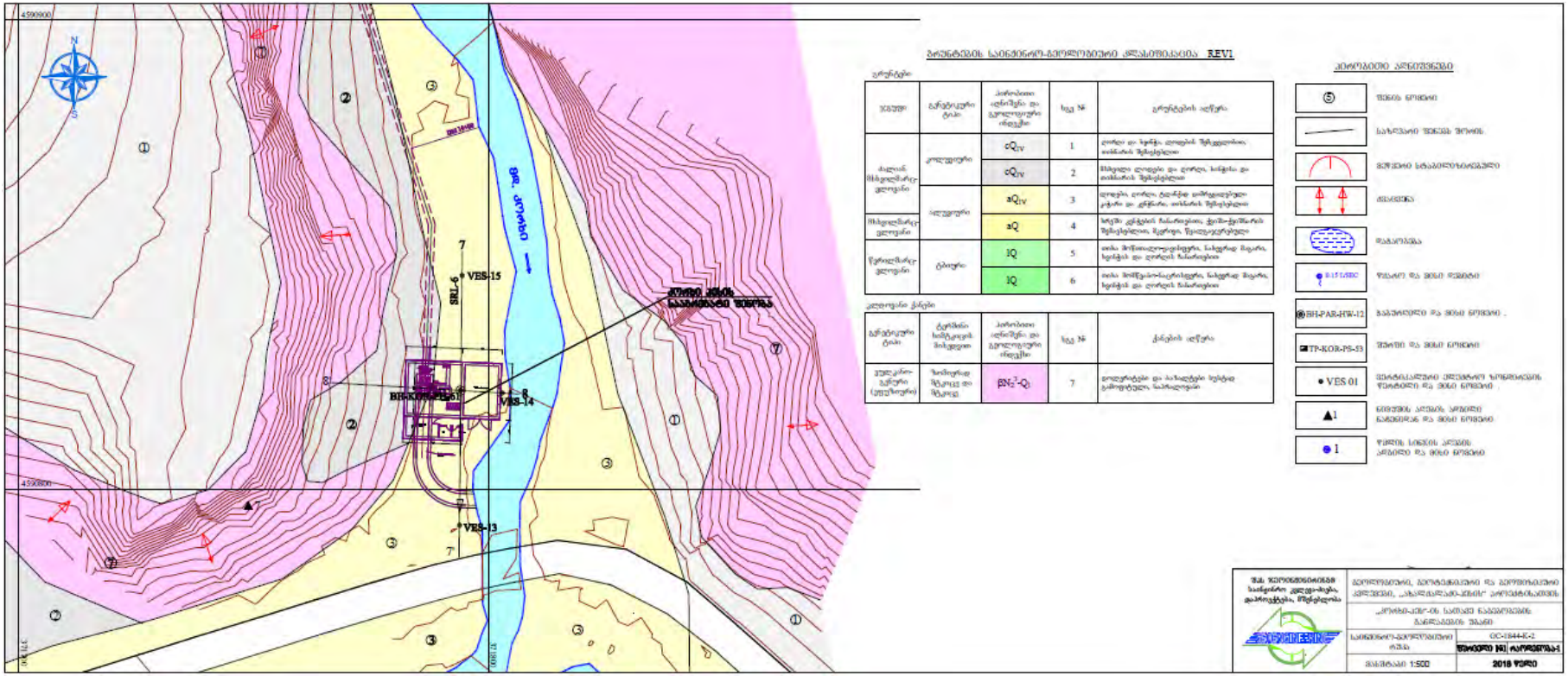




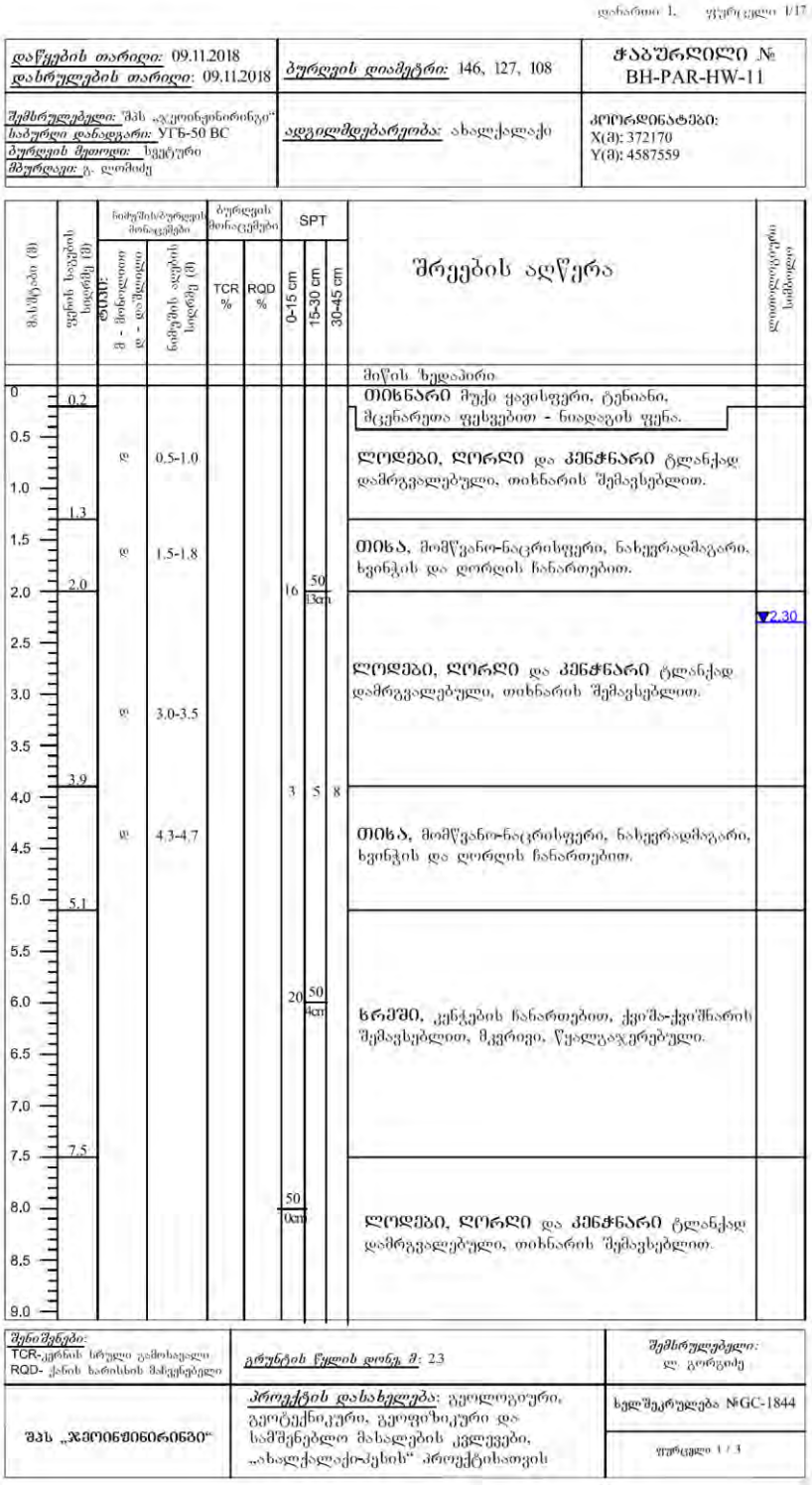
ნიშნულები	1630.0	1627.5	1626.5	1626.0	1625.5	1625.4	1625.4	1625.5	1626.0	1626.5	1627.4	1630.0
მანძილები	6.82	2.76	5.00	4.20	0.57	18.04	0.82	3.93	3.23	4.02	8.13	


VES-18
BH-KOR-HW-41
6.0
20.0
4.4
7.3
8.4
10.1
11.5
20.0
23.0
25.0
ნიშნულები
1630.00
1627.50
1626.50
1626.00
1625.50
1625.40
1625.40
1625.50
1626.00
1626.50
1627.40
1630.00
მანძილები
6.82
2.76
5.00
4.20
0.57
18.04
0.82
3.93
3.23
4.02
8.13

Akhalkalaki 2 HPP powerhouse



13.2 Annex 2. Lithological Columns of Boreholes and Trial Pits



დანართი 1. ფურცელი 1/17

დაწყების თარიღი: 09.11.2018 *დასრულების თარიღი:* 09.11.2018	*ბურღვის დიამეტრი:* 146, 127, 108	ჭაბურღილი № BH-PAR-HW-11
შემსრულებელი: შპს „ჯეოინჟინირინგი" *საბურღი დანადგარი:* УГБ-50 ВС *ბურღვის მეთოდი:* სველური *მბურღავი:* გ. ლომაძე	*ადგილმდებარეობა:* ახალქალაქი	*კოორდინატები:* X(მ): 372170 Y(მ): 4587559

სიმაღლე (მ)	ფენის სიღრმე (მ)	ნიმუშისაღებვის მონაცემები: მ - მონოლითი დ - დაშლილი	ნიმუშის აღების სიღრმე (მ)	ბურღვის მონაცემები TCR %	RQD %	SPT 0-15 cm	15-30 cm	30-45 cm	შრეების აღწერა	ლითოლოგიური სიმბოლო
									მიწის ზედაპირი	
0	0.2								**თიხნარი** მუქი ყავისფერი, ტენიანი, მცენარეთა ფესვებით - ნიადაგის ფენა.	
0.5		დ	0.5-1.0						**ლოდები, ღორღი** და **კენჭნარი** ტლანქად დამრგვალებული, თიხნარის შემავსებლით.	
1.0	1.3									
1.5		დ	1.5-1.8						**თიხა,** მომწვანო-ნაცრისფერი, ნახევრადმაგარი, ხვინჭის და ღორღის ჩანართებით.	
2.0	2.0					16	50 / 13cm			
2.5									**ლოდები, ღორღი** და **კენჭნარი** ტლანქად დამრგვალებული, თიხნარის შემავსებლით.	▼2.30
3.0		დ	3.0-3.5							
3.5	3.9									
4.0						3	5	8		
4.5		დ	4.3-4.7						**თიხა,** მომწვანო-ნაცრისფერი, ნახევრადმაგარი, ხვინჭის და ღორღის ჩანართებით.	
5.0	5.1									
5.5										
6.0						20	50 / 4cm		**ხრეში,** კენჭების ჩანართებით, ქვიშა-ქვიშნარის შემავსებლით, მკვრივი, წყალგაჯერებული.	
6.5										
7.0										
7.5	7.5									
8.0						50 / 0cm			**ლოდები, ღორღი** და **კენჭნარი** ტლანქად დამრგვალებული, თიხნარის შემავსებლით.	
8.5										
9.0										

შენიშვნები: TCR-ბურღის სრული გამოსავალი RQD- ქანის ხარისხის მაჩვენებელი	*ბურღის წყლის დონე მ:* 23	*შემსრულებელი:* ლ. გორგიძე
შპს „ჯეოინჟინირინგი"	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და სამშენებლო მასალების კვლევები, „ახალქალაქ-ჯესის" პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 1 / 3

დაწყების თარიღი: 09.11.2018 *დასრულების თარიღი:* 09.11.2018	*ბურღვის დიამეტრი:* 146, 127, 108	ჭაბურღილი № BH-PAR-HW-11
შემსრულებელი: შპს „ჯეოინჟინირინგი" *საბურღი დანადგარი:* УГБ-50 ВС *ბურღვის მეთოდი:* სველური *მბურღავი:* გ. ლომაძე	*ადგილმდებარეობა:* ახალქალაქი	კოორდინატები: X(მ): 372170 Y(მ): 4587559

მასშტაბი (მ)	ფენის სიღრმის სიღრმე (მ)	ნიმუშის/ბურღვის მონაცემები: ტიპი: მ - მონოლითი, დ - დიამეტალი	ნიმუშის აღების სიღრმე (მ)	ბურღვის მონაცემები: TCR %	RQD %	SPT: 0-15 cm	15-30 cm	30-45 cm	შრეების აღწერა	ლითოლოგიური სიმბოლო
									მიწის ზედაპირი	
0	0.2								**თიხნარი** მუქი ყავისფერი, ტენიანი, მცენარეთა ფესვებით - ნიადაგის ფენა.	
0.5		დ	0.5-1.0						**ლოდები, ღორღი** და **კენჭნარი** ტლანქად დამრგვალებული, თიხნარის შემავსებლით.	
1.0	1.3									
1.5		დ	1.5-1.8						**თიხა,** მომწვანო-ნაცრისფერი, ნახევრადმაგარი, ხვინჭის და ღორღის ჩანართებით.	
2.0	2.0					16	50 / 13cm			
2.5										▼2.30
3.0									**ლოდები, ღორღი** და **კენჭნარი** ტლანქად დამრგვალებული, თიხნარის შემავსებლით.	
3.5		დ	3.0-3.5							
4.0	3.9					3	5	8		
4.5		დ	4.3-4.7						**თიხა,** მომწვანო-ნაცრისფერი, ნახევრადმაგარი, ხვინჭის და ღორღის ჩანართებით.	
5.0	5.1									
5.5										
6.0						20	50 / 4cm		**ხრეში,** კენჭების ჩანართებით, ქვიშა-ქვიშნარის შემავსებლით, მკვრივი, წყალგაჯერებული.	
6.5										
7.0										
7.5	7.5									
8.0						50 / 0cm			**ლოდები, ღორღი** და **კენჭნარი** ტლანქად დამრგვალებული, თიხნარის შემავსებლით.	
8.5										
9.0										

შენიშვნები: TCR-კერნის სრული გამოსავალი RQD- ქანის ხარისხის მაჩვენებელი	*გრუნტის წყლის დონე მ:* 23	*შემსრულებელი:* ლ. გორგაძე
შპს „ჯეოინჟინირინგი"	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და სამშენებლო მასალების კვლევები, „ახალქალაქი-პესის" პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 1 / 3

დანართი 1. ფურცელი 2/17

დაწყების თარიღი: 09.11.2018 *დასრულების თარიღი:* 09.11.2018	*ბურღვის დიამეტრი:* 146, 127, 108	ჭაბურღილი № BH-PAR-HW-11
შემსრულებელი: შპს „ჯეოინჟინირინგი" *საბურღი დანადგარი:* УГБ-50 ВС *ბურღვის მეთოდი:* სველური *მბურღავი:* გ. ლიმოძე	*ადგილმდებარეობა:* ახალქალაქი	კოორდინატები: X(მ): 372170 Y(მ): 4587559

მასშტაბი (მ)	ფენის სიღრმის სიღრმე (მ)	ნიმუშის/ბურღვის მონაცემები: მ - მონოლითი; ფ - დაშლილი	ნიმუშის აღების სიღრმე (მ)	ბურღვის მონაცემები TCR %	RQD %	SPT 0-15 cm	15-30 cm	30-45 cm	შრეების აღწერა	ლითოლოგიური სიმბოლო
9.0	9.4								**ლოდები, ღორღი** და **კენჭნარი** ტლანქად დამრგვალებული, თიხნარის შემავსებლით.	
9.5										
10.0						50 / 6cm				
10.5										
11.0				98	15					
11.5										
12.0									**დოლერიტები** და **ბაზალტები**, სუსტად გამოფიტული, ნაპრალოვანი.	
12.5									<u>ნაპრალები:</u>	
13.0				99	23				<u>10.7-12.0 მ</u> - 2 ნაპრალი - 15-20°; 5 ნაპრალი - 45-50°; 1 ნაპრალი - 65°; 2 ნაპრალი - 80-85°;	
13.5									<u>12.0-14.0 მ</u> - 1 ნაპრალი - 45°; 2 ნაპრალი - 60-65°; 6 ნაპრალი - 80-85°;	
14.0									<u>14.0-16.0 მ</u> - დაშლილი ზონა;	
14.5									<u>16.0-18.0 მ</u> - 2 ნაპრალი - 45°; 4 ნაპრალი - 60-65°; 10 ნაპრალი - 80-85°.	
15.0				98	6					
15.5										
16.0										
16.5										
17.0				99	12					
17.5										
18.0										

შენიშვნები: TCR-კერნის სრული გამოსავალი RQD- ქანის ხარისხის მანვენებელი	*გრუნტის წყლის დონე, მ:* 2.3	*შემსრულებელი:* დ. გორგიძე
შპს „ჯეოინჟინირინგი"	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და სამშენებლო მასალების კვლევები, „ახალქალაქოპესის" პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 2 / 3

დაწყების თარიღი: 09.11.2018 *დასრულების თარიღი:* 09.11.2018	*ბურღვის დიამეტრი:* 146, 127, 108	ჭაბურღილი № BH-PAR-HW-11
შემსრულებელი: შპს „ჯეოინჟინირინგი“ *საბურღი დანადგარი:* УГБ-50 ВС *ბურღვის მეთოდი:* სვეტური *მბურღავი:* გ. ლომიძე	*ადგილმდებარეობა:* ახალქალაქი	კოორდინატები: X(მ): 372170 Y(მ): 4587559

მასშტაბი (მ)	ფენის საზღვრის სიღრმე (მ)	ნიმუშის/ბურღვის მონაცემები: ტიპი: მ - მონოლითი დ - დაშლილი	ნიმუშის აღების სიღრმე (მ)	ბურღვის მონაცემები TCR %	RQD %	SPT 0-15 cm	15-30 cm	30-45 cm	შრეების აღწერა	ლითოლოგიური სიმბოლო
18.0 18.5 19.0 19.5				98	26				**დოლერიტები** და **ბაზალტები**, სუსტად გამოფიტული, ნაპრალოვანი. **ნაპრალები:** **18.0-20.0 მ** - 1 ნაპრალი - 20°; 2 ნაპრალი - 60-65°; 1 ნაპრალი - 70-75°; 12 ნაპრალი - 80-85°.	
20.0	20.0									
20.5 21.0 21.5 22.0 22.5 23.0 23.5 24.0 24.5 25.0 25.5 26.0 26.5 27.0										

შენიშვნები: TCR-კერნის სრული გამოსავალი RQD- ქანის ხარისხის მაჩვენებელი	*გრუნტის წყლის დონე, მ*: 2.3	*შემსრულებელი:* ლ. გორგიძე
შპს „ჯეოინჟინირინგი“	*პროექტის დასახელება*: გეოლოგიური, გეოტექნიკური, გეოფიზიკური და სამშენებლო მასალების კვლევები, „ახალქალაქი-ჰესის“ პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 3 / 3

დანართი 1. ფურცელი 4/17

დაწყების თარიღი: 10.11.2018 *დასრულების თარიღი:* 11.11.2018	*ბურღვის დიამეტრი:* 146, 127, 108	**ჭაბურღილი №** BH-PAR-HW-12
შემსრულებელი: შპს „ჯეოინჟინირინგი" *საბურღი დანადგარი:* УГБ-50 ВС *ბურღვის მეთოდი:* სვეტური *მბურღავი:* ვ. ლომაძე	*ადგილმდებარეობა:* ახალქალაქი	**კოორდინატები:** X(მ): 372131 Y(მ): 4587559

მასშტაბი (მ)	ფენის სიღრმე (მ)	ნიმუშის/ბურღვის მინაცემები: ტიპი: მ - მინელილი, დ - დაშლილი	ნიმუშის აღების სიღრმე (მ)	ბურღვის მონაცემები: TCR %	RQD %	SPT 0-15 cm	15-30 cm	30-45 cm	შრეების აღწერა	ლითოლოგიური ხიბლილი
									მიწის ზედაპირი	
0	0.3								**თიხნარი** მუქი ყავისფერი, ტენიანი, მცენარეთა ფესვებით - ნიადაგის ფენა.	
0.5										
1.0		დ	1.0-1.3						**თიხა**, მოწითალო-ყავისფერი, ნახევრადმაგარი, ხვინჭის და ღორღის ნანართებით.	
1.5	1.7									
2.0						50 10cm				▼2.20
2.5										
3.0										
3.5										
4.0						50 6cm				
4.5		დ	4.0-5.0							
5.0									**ღორდები, ღორღი** და **კენჭნარი** ტლანქად დამრგვალებული, თიხნარის შემავსებლით.	
5.5										
6.0						50 2cm				
6.5										
7.0										
7.5										
8.0						50 3cm				
8.5										
9.0										

შენიშვნები: TCR-კერნის სრული გამოსავალი RQD- ქანის ხარისხის მაჩვენებელი	*გრუნტის წყლის დონე, მ:* 2.2	*შემსრულებელი:* ლ. გორგაძე
შპს „ჯეოინჟინირინგი"	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და სამშენებლო მასალების კვლევები, „ახალქალაქი-ჰესის" პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 1 / 3

დაწყების თარიღი: 10.11.2018 *დასრულების თარიღი:* 11.11.2018	*ბურღვის დიამეტრი:* 146, 127, 108	**ჭაბურღილი № BH-PAR-HW-12**
შემსრულებელი: შპს „ჯეოინჟინირინგი" *საბურღი დანადგარი:* УГБ-50 ВС *ბურღვის მეთოდი:* სველური *მბურღავი:* გ. ლომიძე	*ადგილმდებარეობა:* ახალქალაქი	*კოორდინატები:* X(მ): 372131 Y(მ): 4587559

მასშტაბი (მ)	ფენის სიღრმის სიღრმე (მ)	ნიმუშის/ბურღვის მონაკვეთი: ტიპი: მ - მონოლითი დ - დაფენილი	ნიმუშის/ბურღვის მონაკვეთი: ნიმუშის სიღრმე (მ)	ბურღვის მონაკვეთი: TCR %	ბურღვის მონაკვეთი: RQD %	SPT 0-15 cm	SPT 15-30 cm	SPT 30-45 cm	შრეების აღწერა	ლითოლოგიური სვეტილი
9.0–10.7	10.7					50 / 2cm			**ლიდები, ღორღი** და **პენჭნარი** ტლანქად დამრგვალებული, თიხნარის შემავსებლით.	
10.7–11.5	11.5	დ	11.0-11.5						**ხრეში,** კენჭების ნანართებით, ქვიშა-ქვიშნარის შემავსებლით, მკვრივი, წყალგაჯერებული.	
11.5–18.0		მ	14.0-14.2	98	7	50 / 6cm			**ღოლერიტები** და **ბაზალტები,** სუსტად გამოფიტული, ნაპრალოვანი. **ნაპრალები:** **12.0-14.0 მ** - ნაპრალი >30 - 80-85°; **14.0-16.0 მ** - ნაპრალი >30 - 80-85°; **16.0-18.0 მ** - ნაპრალი >25 - 80-85°.	
				98	6					
				97	0					
		დ	17.5-17.7							

შენიშვნები: TCR-ქვრნის სრული გამოსაყალი RQD- ქანის ხარისხის მაჩვენებელი	*გრუნტის წყლის დონე, მ:* 2.2	*შემსრულებელი:* ლ. გორგაძე
შპს „ჯეოინჟინირინგი"	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და სამშენებლო მასალების კვლევები, „ახალქალაქი-შესის" პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 2 / 3

დანართი 1. ფურცელი 6/17

დაწყების თარიღი: 10.11.2018 *დასრულების თარიღი:* 11.11.2018	*ბურღვის დიამეტრი:* 146, 127, 108	**ჭაბურღილი №** BH-PAR-HW-12
შემსრულებელი: შპს „ჯეოინჟინირინგი" *საბურღი დანადგარი:* УГБ-50 ВС *ბურღვის მეთოდი:* სვეტური *მბურღავი:* გ. ლიმიძე	*ადგილმდებარეობა:* ახალქალაქი	**კოორდინატები:** X(მ): 372131 Y(მ): 4587559

მასშტაბი (მ)	ფენის სიღრმის (სიღრმე) (მ)	ნიმუშის/ბურღვის მონაცემები ტიპი: მ - მონოლითი დ - დაფენილი	ნიმუშის აღების სიღრმე (მ)	ბურღვის მონაცემები TCR %	RQD %	SPT 0-15 cm	15-30 cm	30-45 cm	შრეების აღწერა	ლითოლოგიური სვეტი
18.0 18.5 19.0 19.5 20.0	20.0	მ	19.0-19.2	98	0				**ᲓᲝᲚᲔᲠᲘᲢᲔᲑᲘ** და **ᲑᲐᲖᲐᲚᲢᲔᲑᲘ,** სუსტად გამოფიტული, ნაპრალოვანი. **ნაპრალები:** **18.0-20.0 მ** - ნაპრალი >25 - 80-85°.	
20.5 21.0 21.5 22.0 22.5 23.0 23.5 24.0 24.5 25.0 25.5 26.0 26.5 27.0										

შენიშვნები: TCR-კერნის სრული გამოსაღები RQD- ქანის ხარისხის მაჩვენებელი	*გრუნტის წყლის დონე, მ:* 2.2	*შემსრულებელი:* ლ. გორგიძე
შპს „ჯეოინჟინირინგი"	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და სამშენებლო მასალების კვლევები, „ახალქალაქი-პეხის" პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 3 / 3

დანართი 1. ფურცელი 7/17

დაწყების თარიღი: 09.11.2018 *დასრულების თარიღი:* 09.11.2018	*ბურღვის დიამეტრი:*	ჭაბურღილი №PAR-PS-22
შემსრულებელი: შპს „ჯეოინჟინირინგი" *საბურღი დანადგარი:* УРБ 2А2 *ბურღვის მეთოდი:* სველური *მბურღავი:* ა. ახიოშვილი	*ადგილმდებარეობა:* ახალქალაქი	კოორდინატები: X(მ): 371929 Y(მ): 4588435

მასშტაბი (მ)	ფენის სიღრმე სიღრმე (მ)	ნიმუშის/ბურღვის მონაცემები: მ - ძირეული, დ - დაშლილი	ნიმუშის აღების სიღრმე (მ)	ბურღვის მონაცემები TCR %	RQD %	შრეების აღწერა	გეოფიზიკური სიბრტყე
						მიწის ზედაპირი	
0 0.5	0.9					**ლოდები, ღორღი და ხვინჭა,** თიხნარის შემავსებლით.	
1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5				67	51	**დოლომიტები** და **ბაზალტები,** სუსტად გამოფიტული, ნაპრალოვანი.	
7.0 7.5 8.0 8.5 9.0							

შენიშვნები: TCR-კერნის სრული გამოსავალი RQD- ქანის ხარისხის მაჩვენებელი	*გრუნტის წყლის დონე, მ:* არ დაფიქსირდა	*შემსრულებელი:* ლ. გორგიძე
შპს „ჯეოინჟინირინგი"	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და ხამშენებლო მასალების კვლევები, „ახალქალაქი-ჰესის" პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 1 / 1

დანართი 1. ფურცელი 8/17

დაწყების თარიღი: 10.11.2018 *დასრულების თარიღი:* 11.11.2018	*ბურღვის დიამეტრი:*	ჭაბურღილი №PAR-PS-27
შემსრულებელი: შპს „ჯეოინჟინირინგი" *საბურღი დანადგარი:* УРБ 2А2 *ბურღვის მეთოდი:* სვეტური *მბურღავი:* კ. კახოშვილი	*ადგილმდებარეობა:* ახალქალაქი	კოორდინატები: X(მ): 372170 Y(მ): 4590223

მასშტაბი (მ)	ფენის სიღრმის სიღრმე (მ)	ნიმუშის/ბურღვის მონაცემები: მ - მონოლითი, დ - დაშლილი	ნიმუშის აღების სიღრმე (მ)	ბურღვის მონაცემები: TCR %	RQD %	შრეების აღწერა	ლითოლოგიური სვეტი
						მიწის ზედაპირი	
0 – 5.0						მსხვილი **ლოდები** და **ღორღი**, ხვინჭის და თიხნარის შემავსებლით.	
5.0 – 6.4		დ	5.4-5.7	80	47	**ლოდები, ღორღი** და **კენჭნარი** ტლანქად დამრგვალებული, თიხნარის შემავსებლით.	
6.4 – 7.0						**დოლერიტები** და **ბაზალტები**, სუსტად გამოფიტული, ნაპრალოვანი.	

შენიშვნები: TCR-კერნის სრული გამოსავალი RQD- ქანის ხარისხის მაჩვენებელი	*გრუნტის წყლის დონე, მ:* არ დაფიქსირდა	*შემსრულებელი:* ლ. გორგაძე
შპს „ჯეოინჟინირინგი"	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და სამშენებლო მახასიათებლების კვლევები, „ახალქალაქ-ჰესის" პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 1 / 1

დაწყების თარიღი: 12.11.2018 *დასრულების თარიღი:* 12.11.2018	*ბურღვის დიამეტრი:*	ჭაბურღილი №PAR-PH-32
შემსრულებელი: შპს „ჯეოინჟინირინგი" *საბურღი დანადგარი:* УРБ 2А2 *ბურღვის მეთოდი:* სველური *მბურღავი:* კ. კახოშვილი	*ადგილმდებარეობა:* ახალქალაქი	კოორდინატები: X(მ): 371908 Y(მ): 4590673

მასშტაბი (მ)	ფენის სიღრმის სიღრმე (მ)	ნიმუშის/ბურღვის მონაცემები: ტიპი: მ - მონოლითი, დ - დაშლილი	ნიმუშის აღების სიღრმე (მ)	ბურღვის მონაცემები TCR %	RQD %	შრეების აღწერა	გეოლოგიური სვეტი
						მიწის ზედაპირი	
0							
0.5							
1.0							
1.5							
2.0							
2.5		დ	2.3-2.5				
3.0							
3.5						**ლოდები, ღორღი** და **კენჭნარი** ტლანქად დამრგვალებული, თიხნარის შემავსებლით.	
4.0				66	33.3		
4.5							
5.0							
5.5		დ	5.4-5.5				
6.0							
		დ	6.2-6.4				
6.5							
7.0							
7.5							
8.0	8.0						
8.5		ლ	8.0-9.0			**ხრეში**, კენჭების ჩანართებით, ქვიშა-ქვიშნარის შემავსებლით, მკვრივი, წყალგაჯერებული.	
9.0	9.1						

შენიშვნები: TCR-კერნის სრული გამოსავალი RQD- ქანის ხარისხის მაჩვენებელი	*გრუნტის წყლის დონე, მ:* არ დაფიქსირდა	*შემსრულებელი:* ლ. გორგაძე
შპს „ჯეოინჟინირინგი"	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და ხამშენებლო მასალების კვლევები, „ახალქალაქი-ჰესის" პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 1 / 1

დაწყების თარიღი: 08.12.2018 *დასრულების თარიღი:* 10.12.2018	*ბურღვის დიამეტრი:* 146, 127, 108	ჭაბურღილი №BH-KOR-HW41
შემსრულებელი: შპს „ჯეოინჟინირინგი" *საბურღი დანადგარი:* УГБ-50 ВС *ბურღვის მეთოდი:* სვეტური *მბურღავი:* გ. ლომაძე	*ადგილმდებარეობა:* ახალქალაქი	კოორდინატები: X(მ): 372267 Y(მ): 4592317

მასშტაბი (მ)	ფენის სიღრმის სიღრმე (მ)	ნიმუშის/ბურღვის მონაცემები: ტიპი: a – მონოლითი g – დაშლილი	ნიმუშის აღების სიღრმე (მ)	ბურღვის მონაცემები TCR %	RQD %	SPT 0-15 cm	15-30 cm	30-45 cm	შრეების აღწერა	ლითოლოგიური სიმბოლო
									მიწის ზედაპირი	
0 – 0.5	0.5								**თიხნარი** მუქი ყავისფერი, ტენიანი, მცენარეთა ფესვებით - ნიადაგის ფენა.	
0.5 – 2.9	2.9	g	2.0-2.8	67	51	50 / 4cm			**ლოდები, ღორღი** და **კენჭნარი** ტლანქად დამრგვალებული, თიხნარის შემავსებლით.	▼2.20
2.9 – 4.4	4.4	8	3.2-3.6			10	9	10	**თიხა,** მოწითალო-ყავისფერი, ნახევრადმაგარი, ხვინჭის და ღორღის ჩანართებით.	
4.4 – 7.3	7.3	g	6.0-7.0			8	12	16	**ხრეში,** კენჭების ჩანართებით, ქვიშა-ქვიშნარის შემავსებლით, მკვრივი, წყალგაჯერებული.	
7.3 – 8.4	8.4					11	13	15	**თიხა,** მოწითალო-ყავისფერი, ნახევრადმაგარი, ხვინჭის და ღორღის ჩანართებით.	
8.4 – 9.0									**თიხა,** მომწვანო-ნაცრისფერი, ნახევრადმაგარი, ხვინჭის და ღორღის ჩანართებით.	

შენიშვნები: TCR-კერნის სრული გამოსავალი RQD- ქანის ხარისხის მაჩვენებელი	*გრუნტის წყლის დონე, მ:* 2.2	*შემსრულებელი:* ლ. გორგაძე
შპს „ჯეოინჟინირინგი"	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და სამშენებლო მასალების კვლევები, „ახალქალაქი-ჰესის" პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 1 / 3

დაწყების თარიღი: 08.12.2018 *დასრულების თარიღი:* 10.12.2018	*ბურღვის დიამეტრი:* 146, 127, 108	ჭაბურღილი №BH-KOR-HW41
შემსრულებელი: შპს „ჯეოინჟინირინგი" *საბურღი დანადგარი:* УГБ-50 ВС *ბურღვის მეთოდი:* სვეტური *მბურღავი:* გ. ლომაძე	*ადგილმდებარეობა:* ახალქალაქი	კოორდინატები: X(მ): 372267 Y(მ): 4592317

მასშტაბი (მ)	ფენის სიღრმის სიღრმე (მ)	ნიმუშის/ბურღვის მონაცემები: ტიპი: მ - მოხლეული ფ - დაშლილი	ნიმუშის აღების სიღრმე (მ)	ბურღვის მონაცემები: TCR %	RQD %	SPT 0-15 cm	15-30 cm	30-45 cm	შრეების აღწერა	ლითოლოგიური სვეტი
9.0										
9.5		მ	9.2-9.6						**თიხა,** მომწვანო-ნაცრისფერი, ნახევრადმაგარი, ხვინჭის და ღორღის ჩანართებით.	
10.0	10.1					10	12	16		
10.5									**ხრეში,** კენჭების ჩანართებით, ქვიშა-ქვიშნარის შემავსებლით, მკვრივი, წყალგაჯერებული.	
11.0										
11.5	11.5									
12.0						12	15	17	**თიხა,** მომწვანო-ნაცრისფერი, ნახევრადმაგარი, ხვინჭის და ღორღის ჩანართებით.	
12.5										
13.0										
13.5		მ	13.2-13.6							
14.0						13	15	20		
14.5										
15.0										
15.5										
16.0						10	14	25		
16.5										
17.0		მ	16.5-16.9							
17.5										
18.0						31	50 / 4cm			

შენიშვნები: TCR-კერნის სრული გამოსავალი RQD- ქანის ხარისხის მაჩვენებელი	*გრუნტის წყლის დონე, მ:* 2.2	*შემსრულებელი:* ლ. გორგიძე
შპს „ჯეოინჟინირინგი"	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და სამშენებლო მასალების კვლევები, „ახალქალაქი-ჰესის" პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 2 / 3

დანართი 4. ფურცელი 12/17

დაწყების თარიღი: 08.12.2018 *დასრულების თარიღი:* 10.12.2018	***ბურღვის დიამეტრი:*** 146, 127, 108	ჭაბურღილი №BH-KOR-HW41
შემსრულებელი: შპს „ჯეოინჟინირინგი" *საბურღი დანადგარი:* УГБ-50 ВС *ბურღვის მეთოდი:* ხვეტური *მბურღავი:* გ. ლომაძე	***ადგილმდებარეობა:*** ახალქალაქი	კოორდინატები: X(მ): 372267 Y(მ): 4592317

მასშტაბი (მ)	ფენის სიღრმე (მ)	ნიმუშის/ბურღვის მონაცემები: ტიპი: მ - მოხლეჩილი, ფ - ფენოვანი	ნიმუშის ადების სიღრმე (მ)	TCR %	RQD %	SPT 0-15 cm	SPT 15-30 cm	SPT 30-45 cm	შრეების აღწერა	ლითოლოგიური სვეტი
18.0–19.5		ფ	19.0-19.4						**თიხა,** მომწვანო-ნაცრისფერი, ნახევრადმაგარი, ხვინჭის და ღორღის ჩანართებით.	
19.5–20.0	20.0					40	48	50 / 5cm		
20.0–21.5		მ	20.6-21.0						**თიხა,** მოყითალო-ყავისფერი, ნახევრადმაგარი, ხვინჭის და ღორღის ჩანართებით.	
21.5–22.0						32	50 / 9cm			
22.0–23.0	23.0									
23.0–23.5		მ	23.2-23.6						**თიხა,** მომწვანო-ნაცრისფერი, ნახევრადმაგარი, ხვინჭის და ღორღის ჩანართებით.	
23.5–24.0						37	50 / 6cm			
24.0–25.0	25.0									
25.0–27.0										

შენიშვნები: TCR-კერნის სრული გამოსავალი RQD- ქანის ხარისხის მაჩვენებელი	*გრუნტის წყლის დონე, მ:* 2.2	*შემსრულებელი:* ლ. გორგიძე
შპს „ჯეოინჟინირინგი"	***პროექტის დასახელება:*** გეოლოგიური, გეოტექნიკური, გეოფიზიკური და საშენებლო მასალების კვლევები, „ახალქალაქი-ჰესის" პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 3 / 3

დანართი 1. ფურცელი 13/17

დაწყების თარიღი: 13.11.2018 *დასრულების თარიღი:* 13.11.2018	*ბურღვის დიამეტრი:*	ჭაბურღილი № BH-KOR-PH-61
შემსრულებელი: შპს „ჯეოინჟინირინგი" *საბურღი დანადგარი:* УРБ 2А2 *ბურღვის მეთოდი:* სგეტური *მბურღავი:* კ. კახოშვილი	*ადგილმდებარეობა:* ახალქალაქი	კოორდინატები: X(მ): 371794 Y(მ): 4590821

მასშტაბი (მ)	ფენის სიღრმის ნიშული (მ)	ნიმუშის/ბურღვის მონაკვეთები: ტიპი: მ - მინიალური, დ - დიამეტრული	ნიმუშის ადების სიღრმე (მ)	ბურღვის მონაცემები: TCR %	RQD %	შრეების აღწერა	ლითოლოგიური სვეტილი
						მიწის ზედაპირი	
0 – 7.0						**ლიდეები, ღორღი** და **კენჭნარი** ტლანქად დამრგვალებული, თიხნარის შემავსებლით.	
		დ	6.6-7.0				
7.0 – 8.0	8.0						
8.0 – 9.0						**ხრეში**, კენჭების ჩანართებით, ქვიშა-ქვიშნარის შემავსებლით, მკვრივი, წყალგაჯერებული.	
		დ	8.0-9.0				
	9.1						

შენიშვნები: TCR-კერნის სრული გამოხვადალი RQD- ქანის ხარისხის მაჩვენებელი	*გრუნტის წყლის დონე, მ:* არ დაფიქსირდა	*შემსრულებელი:* ლ. გორგიძე
შპს „ჯეოინჟინირინგი"	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და სამშენებლო მასალების კვლევები, „ახალქალაქი-ჰესის" პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 1 / 1

დანართი 1, ფურცელი 14/17

დაწყების თარიღი: 11.11.2018 *დასრულების თარიღი:* 11.11.2018	*ადგილმდებარეობა:* ახალქალაქი	**შურფი № PAR-PS-21**
გაყვანის მეთოდი: ექსკავატორი JCB; ჩამჩის მოცულობა 0.5მ³.		კოორდინატები: X(მ): 372032 Y(მ): 4588034

მასშტაბი, მ	შრის სიღრმე, მ	ნიმუში: მახასიათებელი (მ) / დაშლილი (დ)	ნიმუში: სიღრმის ინტერვალი, მ	ლითოლოგიური სვეტი	გრუნტების აღწერა
0 0.5 1.0 1.5 2.0	2.3	დ	2.3		**ლოდები, ღორღი და ხვინჭა,** თიხნარის შემავსებლით.
2.5 3.0 3.5 4.0					

შენიშვნები: ექსკავაცია შეჩერდა დიდი ზომის ლოდების გამო.	*გრუნტის წყლის დონე, მ:* არ დაფიქსირდა	*შემსრულებელი:* ლ. გორგაძე
შპს „ჯეოინჟინირინგი"	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და სამშენებლო მასალების კვლევები, „ახალქალაქჰესის" პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 1 / 1

დაწყების თარიღი: 11.11.2018 *დასრულების თარიღი:* 11.11.2018	*ადგილმდებარეობა:* ახალქალაქი	**შურფი № PAR-PS-22**
გაყვანის მეთოდი: ექსკავატორი JCB; ჩამჩის მოცულობა 0.5მ³.		კოორდინატები: X(მ): 371929 Y(მ): 4588435

მასშტაბი, მ	შრის სიღრმე, მ	ნიმუში: მახასიათებელი (მ) / დაშლილი (დ)	ნიმუში: სიღრმის ინტერვალი, მ	ლითოლოგიური სვეტი	გრუნტების აღწერა
0 0.5	0.4	დ	0.4		**ლოდერიტები** და **ბაზალტები,** სუსტად გამოფიტული, ნაპრალოვანი.
1.0 1.5 2.0 2.5 3.0 3.5 4.0					

შენიშვნები: ექსკავაცია შეჩერდა დიდი ზომის ლოდების გამო.	*გრუნტის წყლის დონე, მ:* არ დაფიქსირდა	*შემსრულებელი:* ლ. გორგაძე
შპს „ჯეოინჟინირინგი"	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და სამშენებლო მასალების კვლევები, „ახალქალაქჰესის" პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 1 / 1

დაწყების თარიღი: 11.11.2018 *დასრულების თარიღი:* 11.11.2018	*ადგილმდებარეობა:* ახალქალაქი	**შურფი № PAR-PS-23**
გაყვანის მეთოდი: ექსკავატორი JCB; ნამნის მოცულობა 0.5მ³.		კოორდინატები: X(მ): 371960 Y(მ): 4588679

მასშტაბი, მ	შრის სიღრმე მ	ნიმუში: ძირითადი (მ) დაშლილი (დ)	ნიმუში: სიღრმის ინტერვალი, მ	ლითოლოგიური სვეტი	გრუნტების აღწერა
0 0.5 1.0 1.5 2.0 2.5	2.5	დ	2.5		**ლოდები, ღორღი და ხვინჭა,** თიხნარის შემავსებლით.
3.0 3.5 4.0					

შენიშვნები: ექსკავაცია შეჩერდა დიდი ზომის ლოდების გამო.	*გრუნტის წყლის დონე, მ:* არ დაფიქსირდა	*შემსრულებელი:* ლ. გორგიძე
შპს „ჯეოინჟინირინგი"	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და საშენებლო მახალების კვლევები, „ახალქალაქი-ჰესის" პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 1 / 1

დაწყების თარიღი: 11.11.2018 *დასრულების თარიღი:* 11.11.2018	*ადგილმდებარეობა:* ახალქალაქი	**შურფი № PAR-PS-24**
გაყვანის მეთოდი: ექსკავატორი JCB; ნამნის მოცულობა 0.5მ³.		კოორდინატები: X(მ): 372018 Y(მ): 4588991

მასშტაბი, მ	შრის სიღრმე მ	ნიმუში: ძირითადი (მ) დაშლილი (დ)	ნიმუში: სიღრმის ინტერვალი, მ	ლითოლოგიური სვეტი	გრუნტების აღწერა
0 0.5	0.7	დ	0.7		**ლოდები, ღორღი და ხვინჭა,** თიხნარის შემავსებლით.
1.0 1.5 2.0 2.5 3.0 3.5 4.0					

შენიშვნები: ექსკავაცია შეჩერდა დიდი ზომის ლოდების გამო.	*გრუნტის წყლის დონე, მ:* არ დაფიქსირდა	*შემსრულებელი:* ლ. გორგიძე
შპს „ჯეოინჟინირინგი"	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და საშენებლო მახალების კვლევები, „ახალქალაქი-ჰესის" პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 1 / 1

დანართი 1. ფურცელი 16/17

დაწყების თარიღი: 11.11.2018 *დასრულების თარიღი:* 11.11.2018	*ადგილმდებარეობა:* ახალქალაქი	**შურფი № PAR-PS-25**
გაყვანის მეთოდი: ექსკავატორი JCB; ნამნის მოცულობა 0.5მ³.		კოორდინატები: X(მ): 372014 Y(მ): 4589382

მასშტაბი, მ	შრის სიღრმის ფ	ნიმუში		ლითოლოგიური სვეტი	გრუნტების აღწერა
		მონიშვნის (მ) დაშვების (დ)	სიღრმის ინტერვალი, მ		
0					ლოდები, ღორღი და ხვინჭა, თიხნარის შემავსებლით.
0.5	0.9	დ	0.9		
1.0					
1.5					
2.0					
2.5					
3.0					
3.5					
4.0					

შენიშვნები: ექსკავაცია შეჩერდა დიდი ზომის ლოდების გამო.	*გრუნტის წყლის დონე, მ:* არ დაფიქსირდა.	*შემსრულებელი:* ლ. გორგიძე
შპს „ჯეოინჟინირინგი“	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და სამშენებლო მასალების კვლევები, „ახალქალაქი-ჰესის“ პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 1 / 1

დაწყების თარიღი: 11.11.2018 *დასრულების თარიღი:* 11.11.2018	*ადგილმდებარეობა:* ახალქალაქი	**შურფი № PAR-PS-26**
გაყვანის მეთოდი: ექსკავატორი JCB; ნამნის მოცულობა 0.5მ³.		კოორდინატები: X(მ): 372011 Y(მ): 4589662

მასშტაბი, მ	შრის სიღრმის ფ	ნიმუში		ლითოლოგიური სვეტი	გრუნტების აღწერა
		მონიშვნის (მ) დაშვების (დ)	სიღრმის ინტერვალი, მ		
0	0.4	დ	0.4		ლოდები, ღორღი და ხვინჭა, თიხნარის შემავსებლით.
0.5					
1.0					
1.5					
2.0					
2.5					
3.0					
3.5					
4.0					

შენიშვნები: ექსკავაცია შეჩერდა დიდი ზომის ლოდების გამო.	*გრუნტის წყლის დონე, მ:* არ დაფიქსირდა	*შემსრულებელი:* ლ. გორგიძე
შპს „ჯეოინჟინირინგი“	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და სამშენებლო მასალების კვლევები, „ახალქალაქი-ჰესის“ პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 1 / 1

ფურცელი 17

დაწყების თარიღი: 11.11.2018 *დასრულების თარიღი:* 11.11.2018	*ადგილმდებარეობა:* ახალქალაქი	შურფი № TP-KOR-PS-53
გაყვანის მეთოდი: ექსკავატორი JCB; ნამწის მოცულობა 0,5მ³.		კოორდინატები: X(მ): 372078 Y(მ): 4592062

ნიმუშები, მ	შრის სიღრმე, მ	ნიმუში: მინიმალური (მ) დაშვებული (დ)	ნიმუში: სიღრმის ინტერვალი, მ	ლითოლოგიური სვეტი	გრუნტების აღწერა
0 – 0.5	0.52	დ	0.52		ლოდები, ლორღი და ხვინჭა, თიხნარის შემავსებლით.
0.5 – 1.0					
1.0 – 1.5					
1.5 – 2.0					
2.0 – 2.5					
2.5 – 3.0					
3.0 – 3.5					
3.5 – 4.0					

შენიშვნები: ექსკავაცია შეჩერდა დიდი ზომის ლოდების გამო.	*გრუნტის წყლის დონე, მ:* არ დაფიქსირდა	*შემსრულებელი:* ლ. გორგაძე
შპს „ჯეოინჟინირინგი"	*პროექტის დასახელება:* გეოლოგიური, გეოტექნიკური, გეოფიზიკური და სამშენებლო მახასიათებლების კვლევები, „ახალქალაქისა" პროექტისათვის	ხელშეკრულება №GC-1844 ფურცელი 1 / 1

13.3 Annex 3. Results of Geophysical Surveys (Seismic Profiling)

13.3.1 Introduction

Geophysical survey results conducted within the Paravani HPP construction territory are presented in the report.

Seismic profiling was executed by the refracted wave method for information obtainment up to 30 m depth. Physical-mechanical parameters of rocks were evaluated based on the elastic waves (longitudinal and transverse) propagation speeds. 7 seismic profiles of various length were used to 30 m depth – total length 418 m. The study section and the layout scheme of seismic profiles are provided on the Figure 1 (a, b, c, d, e, f)

Arrow of seismic profiles (SRL) corresponds to the end of the profile or 24th geophone and the beginning – to the first geophone.

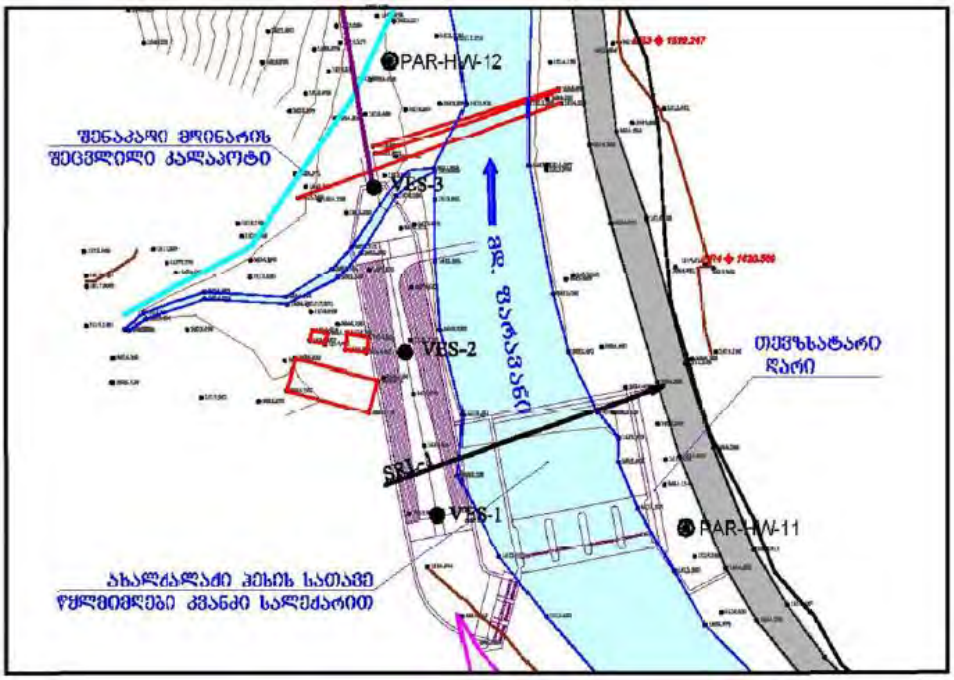


Fig. a. Study section and seismic profiles layout scheme

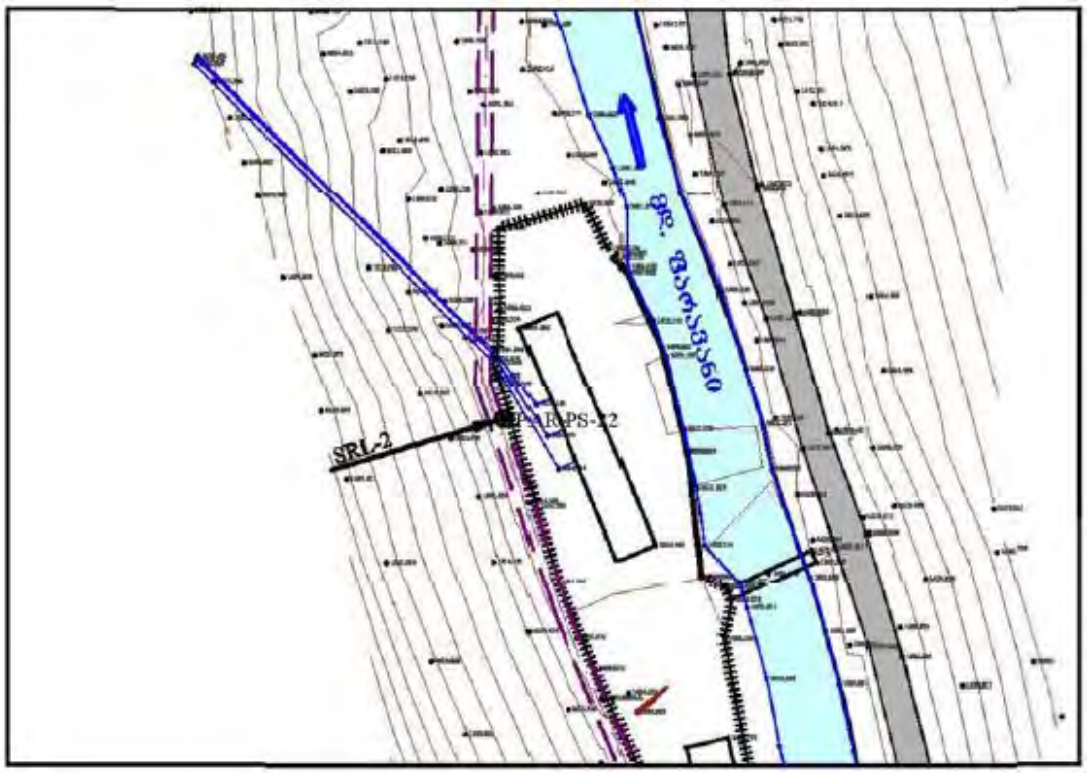


Fig. 1b. Study section and seismic profiles layout scheme

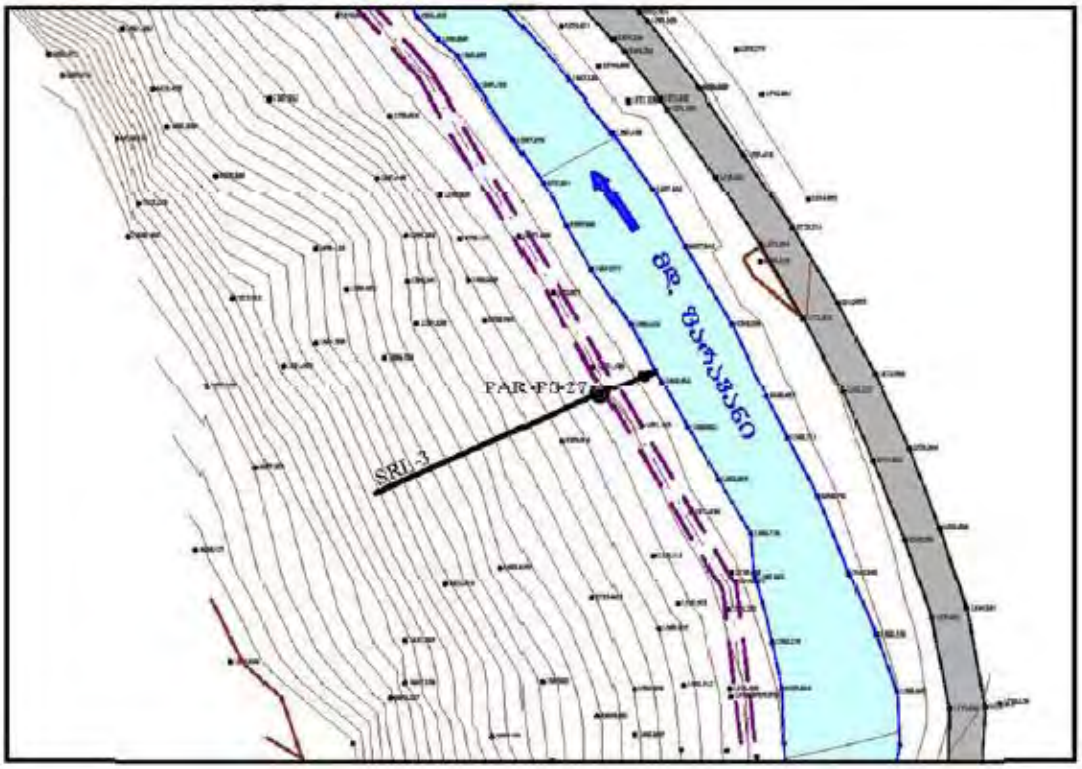


Fig. 1c. Study section and seismic profiles layout scheme

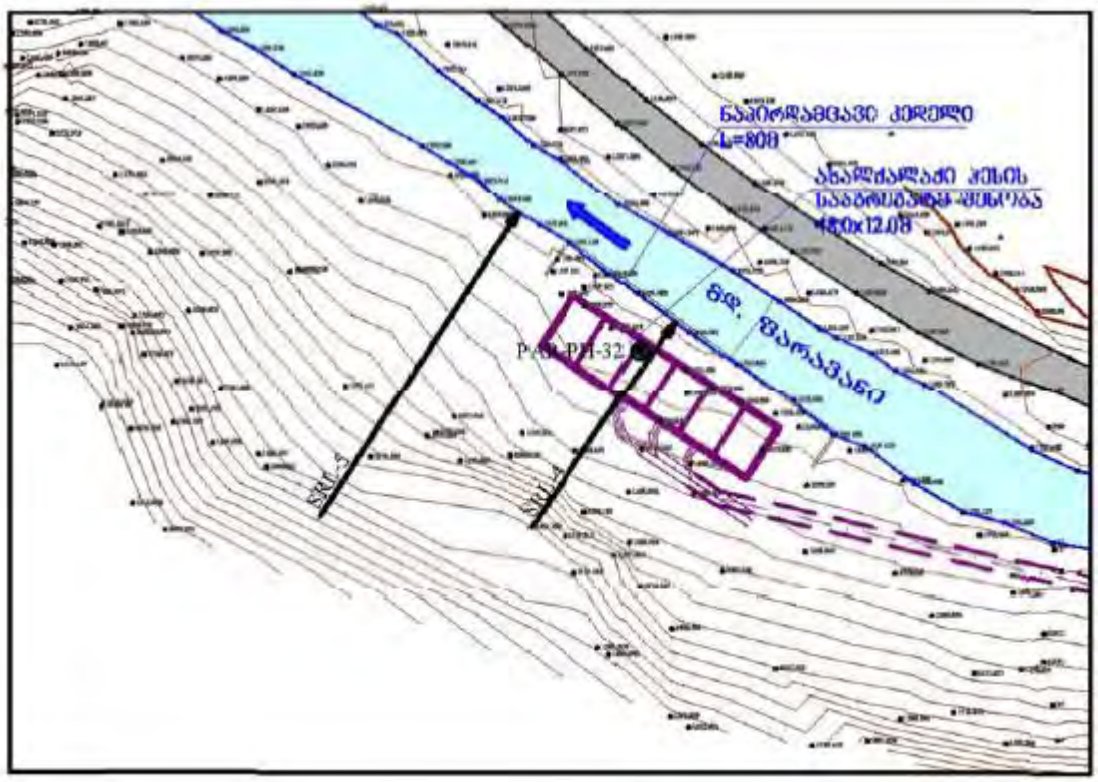


Fig. 1d. Study section and seismic profiles layout scheme

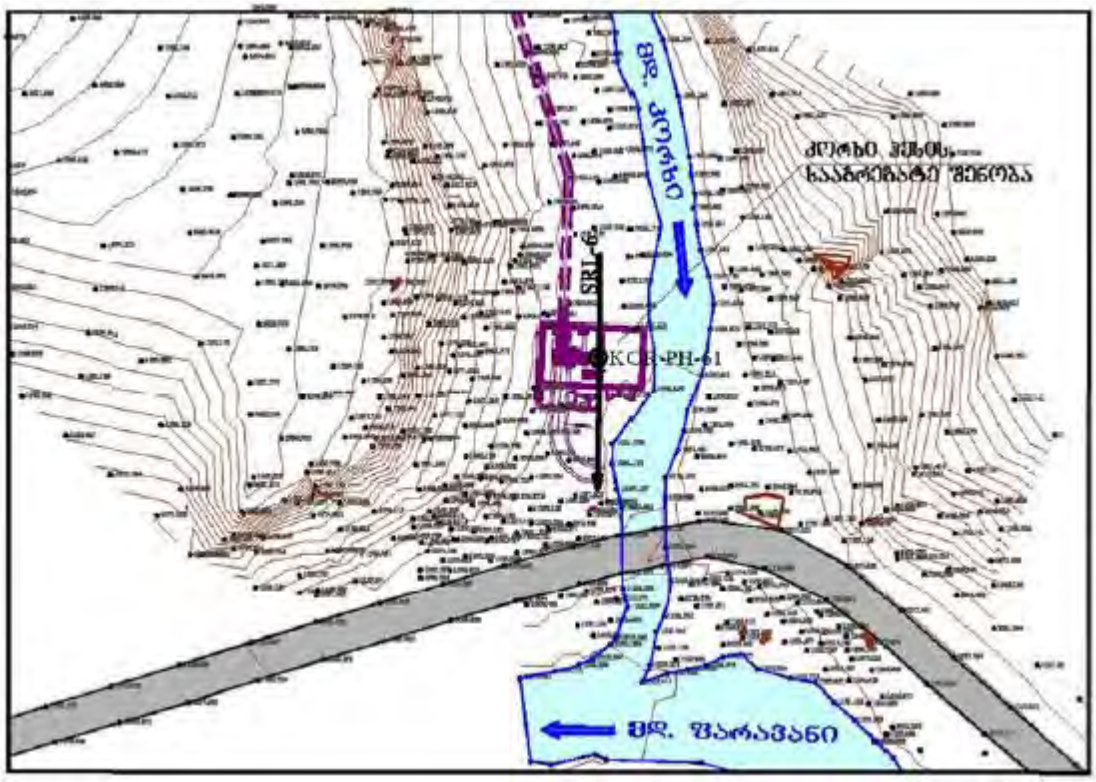


Fig. 1e. Study section and seismic profiles layout scheme

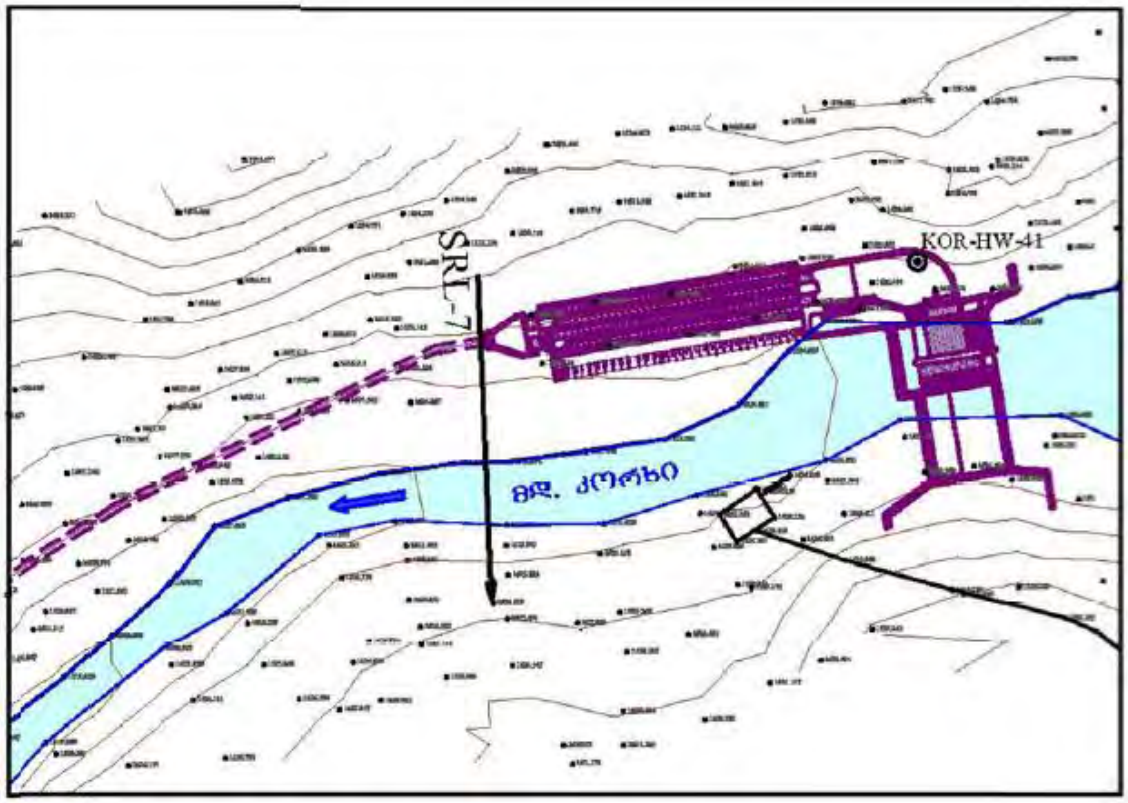


Fig. 1f. Study section and seismic profiles layout scheme

13.3.2 Geophysical Survey

13.3.2.1 Seismic Profiling with Refracted Waves Method

Investigation of rock properties is one of the most significant tasks for solving of engineering seismic searching problems. Our main objective was to investigate structure of the given site and to determine physical-mechanical parameters based on the speed values of longitudinal and transverse elastic waves. Refracted waves field seismic method was selected for this purpose.

Refracted waves method enables us to determine thickness of surface and deeper strata and elastic waves propagation speeds in them. The method is based on determination of the first arrival times of P and S waves from the source of elastic waves to the geophones locating on a single line. Therefore, the survey objective was to identify of the rocks structure up to 30 m depth and to determine the following physical-mechanical parameters in the given structural elements:

Vp m/s	Longitudinal wave velocity
Vs m/s	Transverse wave velocity
Vs/Vp	Speed ratio
ρ g/cm³	Density
μ	Poisson's ratio
Ed MPa	Young's Dynamic Modulus
Gd MPa	Dynamic Shearing Modulus
Kd MPa	Dynamic modulus of uniform compression
D MPa	General deformation modulus
τ MPa	Compression strength

Seismic profiling was carried out with 10 Hertz geophones with distance between them 2-5 m. Seismic waves were induced by hitting of 10 kg hammer on the titanium plates. Geophones and hits were ended by Z-Z and Y-Y orientation points , 5 hits point system has been used, it consisted of 2 hits at the beginning and at the end of the profile, one hit in the middle and two hits beyond the profile. Such system with quite far, outside hits used to enable us to receive information from 30 m depth. Orientation of a hit also used to change, according to the wave type. At the river crossing site, profiling was carried out by using of hermetically sealed geophones at the accessible locations of low velocity flows and in conditions of low water level, when majority of the profile was relatively dry.

The ***GEODE*** 24-channel seismograph manufactured by the American company – ***GEOMETRICS***, used to register waves. Hit direction was changing in accordance with the wave type. Later, interpretation was performed by the licensed ***SeisImager*** program of the same company - ***GEOMETRICS***

Obtained seismogram analysis was performed, profiles were made and appropriate physical-mechanical parameters were evaluated. Profiles' locations are given on the Figure 1 (a, b, c, d, e, f).

13.3.2.2 Geophysical Survey Results

Seven seismic profiles of various length up to 30 m depth with a total length 418 m were executed. The survey site and layout scheme of seismic profiles are given on the Figure 1 (a, b, c, d, e, f).

Vaious engineering-geological elements (EGE) (**Layers**) are singled out based on the geophysical parameters and distribution of wave velocities - V_P , V_S is defined. Values of appropriate physical-mechanical parameters are provided in the Table 1-7 (Fig.:2-8).

On the given profiles five strata with various physical properties are observed according to the geophysical data (identification was performed with consideration of engineering geological results):

Stratum1 – boulders, cobble-stone, grit with loam filling, which includes EGE1 and EGE2, according to the geological data;

Stratum 2 – gravel with pebble intrusions, sand-sandy filling, solid, water saturated, which includes EGE3 and EGE4 according to the geological data;

Stratum 3 – Clay - semisolid with grit and cobble stone intrusions, which includes EGE5 and EGE6 according to the geological data;

Stratum 4 – andesites and basalts, slightly weathered, fractured, which corresponds to EGE7 according to the geological data;

Stratum 5 - andesites and basalts, which corresponds to EGE7 according to the geological data.

Seismic profile SRL1:

Stratum 1 extends up to 0-3 m depth from the surface with the following values of longitudinal and transverse wave velocities: V_P =198 m/s; V_S=122 m/s.

Stratum 1 is bordered by **Stratum 2** from below, thickness of which is 0.5-5m, with following values of longitudinal and transverse waves: V_P =1994 m/s; V_S=628 m/s.

The mentioned stratum is bordered by Stratum 4 from below, which is observed up to 30 m depth with the following values of longitudinal and transverse waves: V_P=3503 m/s; V_S=1618 m/s.

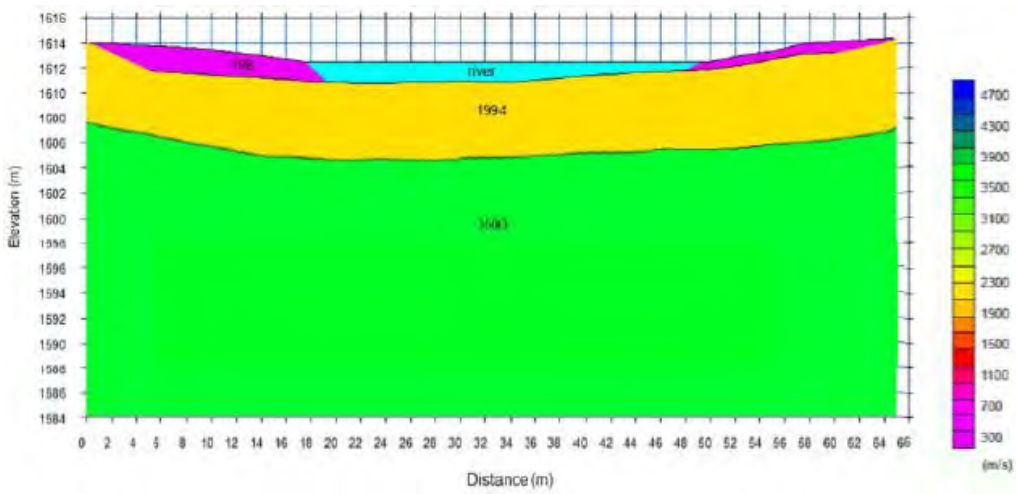


Fig. 2. Seismic profile SRL1

Table 1. Values of physical-mechanical parameters for the profile SRL1

Stratum N	Parameter	Parameter description	Values	Depth, m
1	V_P m/s	Longitudinal wave velocity	198	1.5
	V_S m/s	Transverse wave velocity	122	
	V_S/ V_P	Speed ratio	0.62	
	ρ g/cm³	Density	1.21	
	μ	Poisson's ratio	0.19	
	E_d MPa	Young's Dynamic Modulus	40	
	G_d MPa	Dynamic Shearing Modulus	18	
	K_d MPa	Dynamic modulus of uniform compression	233.83	
	D MPa	General deformation modulus	0.20	
	τ MPa	Compression strength	-	

2	V_P m/s	Longitudinal wave velocity	1994	6.5
	V_S m/s	Transverse wave velocity	628	
	V_S/ V_P	Speed ratio	0.31	
	ρ g/cm³	Density	2.15	
	μ	Poisson's ratio	0.44	
	E_d MPa	Young's Dynamic Modulus	2450	
	G_d MPa	Dynamic Shearing Modulus	849	
	K_d MPa	Dynamic modulus of uniform compression	74238.68	
	D MPa	General deformation modulus	141.92	
	τ MPa	Compression strength	12.12	
4	V_P m/s	Longitudinal wave velocity	3503	22
	V_S m/s	Transverse wave velocity	1618	
	V_S/ V_P	Speed ratio	0.46	
	ρ g/cm³	Density	2.48	
	μ	Poisson's ratio	0.36	
	E_d MPa	Young's Dynamic Modulus	17700	
	G_d MPa	Dynamic Shearing Modulus	6485	
	K_d MPa	Dynamic modulus of uniform compression	217511.57	
	D MPa	General deformation modulus	3365.16	
	τ MPa	Compression strength	92.65	
Vs30, m/s		Average velocity of transverse wave up to 30 m depth	828	

Seismic profile SRL2:

Stratum1 extends up to 0.5-3 m depth from the surface, with the following values of longitudinal and transverse wave velocities: V_P =339 m/s; V_S =206 m/s.

Stratum 1 is bordered by **Stratum4** from below, thickness of which is 1-6 m with following values of longitudinal and transverse waves: V_P =2849 m/s; V_S =902 m/s.

The mentioned stratum is bordered by **Stratum 5** from below, which is observed up to 30 m depth with the following values of longitudinal and transverse waves: V_P =4645 m/s; V_S =2023 m/s.

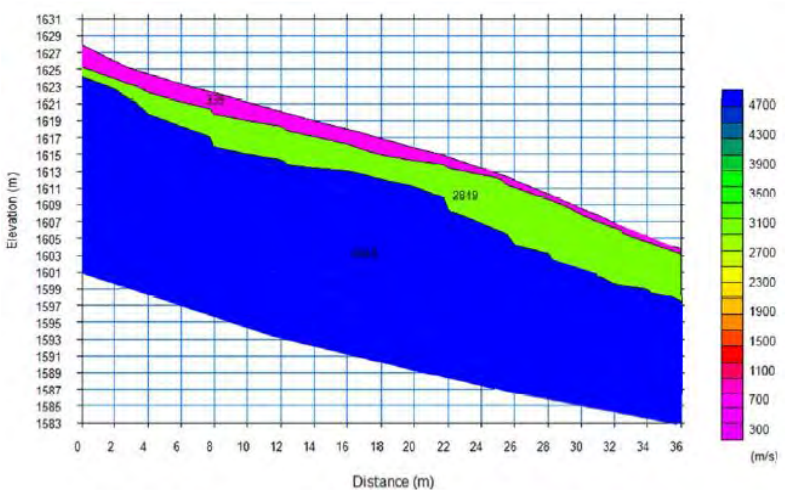


Figure. 3. Seismic profile SRL2

Table 2. Values of physical-mechanical parameters for the profile SRL2

Stratum N	Parameter	Parameter description	Values	Depth, m
1	V_P m/s	Longitudinal wave velocity	339	1.5
	V_S m/s	Transverse wave velocity	206	
	V_S/ V_P	Speed ratio	0.61	
	ρ g/cm³	Density	1.38	
	μ	Poisson's ratio	0.21	
	E_d MPa	Young's Dynamic Modulus	140	
	G_d MPa	Dynamic Shearing Modulus	59	
	K_d MPa	Dynamic modulus of uniform compression	806.06	
	D MPa	General deformation modulus	1.45	
	τ MPa	Compression strength	-	
4	V_P m/s	Longitudinal wave velocity	2849	4
	V_S m/s	Transverse wave velocity	902	
	V_S/ V_P	Speed ratio	0.32	
	ρ g/cm³	Density	2.35	
	μ	Poisson's ratio	0.44	
	E_d MPa	Young's Dynamic Modulus	5530	
	G_d MPa	Dynamic Shearing Modulus	1914	
	K_d MPa	Dynamic modulus of uniform compression	165427.45	
	D MPa	General deformation modulus	522.52	
	τ MPa	Compression strength	27.34	
5	V_P m/s	Longitudinal wave velocity	4645	24.5
	V_S m/s	Transverse wave velocity	2023	
	V_S/ V_P	Speed ratio	0.44	
	ρ g/cm³	Density	2.66	
	μ	Poisson's ratio	0.38	
	E_d MPa	Young's Dynamic Modulus	30090	
	G_d MPa	Dynamic Shearing Modulus	10879	
	K_d MPa	Dynamic modulus of uniform compression	428498.21	
	D MPa	General deformation modulus	7869.62	
	τ MPa	Compression strength	155.42	
Vs30, m/s		Average velocity of transverse wave up to 30 m depth	1259	

Seismic profile SRL3:

Stratum 1 extends up to 0-7 m depth from the surface with the following values of longitudinal and transverse wave velocities: V_P =638 m/s; V_S =386 m/s.

Stratum 1 is bordered by **Stratum 2** from below, thickness of which is 0-7 m with following values of longitudinal and transverse waves: V_P =1097 m/s; V_S=412 m/s.

The mentioned stratum is bordered by **Stratum 4** from below, which is observed up to 30 m depth with the following values of longitudinal and transverse waves: V_P =2796 m/s; V_S=1271 m/s.

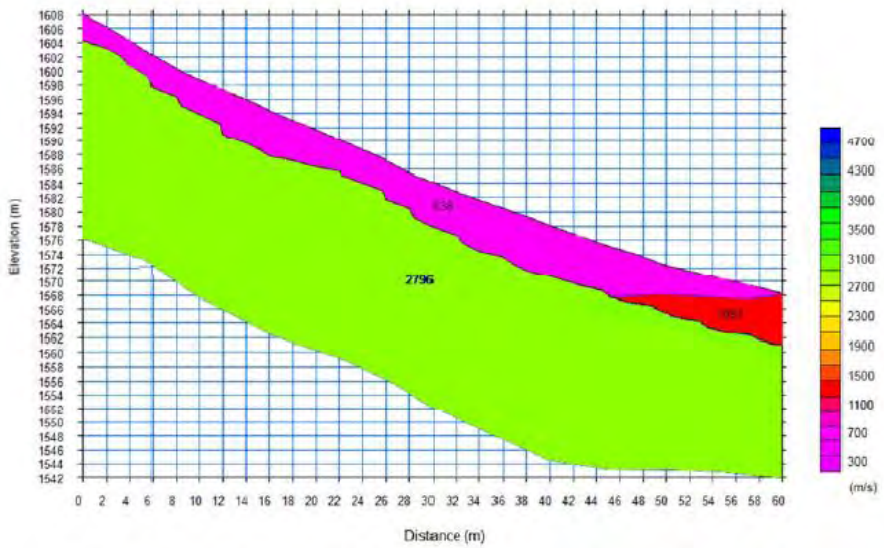


Fig. 4. Seismic profile SRL3

Table 3. Values of physical-mechanical parameters for the profile SRL3

Stratum N	Parameter	Parameter description	Values	Depth, m
1	V_P m/s	Longitudinal wave velocity	638	5
	V_S m/s	Transverse wave velocity	386	
	V_S/ V_P	Speed ratio	0.61	
	ρ g/cm³	Density	1.62	
	μ	Poisson's ratio	0.21	
	E_d MPa	Young's Dynamic Modulus	580	
	G_d MPa	Dynamic Shearing Modulus	241	
	K_d MPa	Dynamic modulus of uniform compression	3372.27	
	D MPa	General deformation modulus	14.13	
	τ MPa	Compression strength	-	
2	V_P m/s	Longitudinal wave velocity	1097	0.5
	V_S m/s	Transverse wave velocity	412	
	V_S/ V_P	Speed ratio	0.38	
	ρ g/cm³	Density	1.85	
	μ	Poisson's ratio	0.42	
	E_d MPa	Young's Dynamic Modulus	890	
	G_d MPa	Dynamic Shearing Modulus	315	
	K_d MPa	Dynamic modulus of uniform compression	18106.70	
	D MPa	General deformation modulus	28.05	
	τ MPa	Compression strength	4.49	
4	V_P m/s	Longitudinal wave velocity	2796	24.5
	V_S m/s	Transverse wave velocity	1271	
	V_S/ V_P	Speed ratio	0.45	
	ρ g/cm³	Density	2.34	
	μ	Poisson's ratio	0.37	
	E_d MPa	Young's Dynamic Modulus	10360	
	G_d MPa	Dynamic Shearing Modulus	3783	

	K_d MPa	Dynamic modulus of uniform compression	132614.19	
	D MPa	General deformation modulus	1427.55	
	τ MPa	Compression strength	54.04	
Vs30, m/s		Average velocity of transverse wave up to 30 m depth	897	

Seismic profile SRL4:

Stratum 1 extends up to 0-2 m depth from the surface with the following values of longitudinal and transverse wave velocities: V_P =195 m/s; V_S=121 m/s.

Stratum 1 is bordered by **Stratum 2** from below, thickness of which is 0-11 m with following values of longitudinal and transverse waves: V_P =1190 m/s; V_S=431 m/s.

The mentioned stratum is bordered by **Stratum 4** from below, which is observed up to 30 m depth with the following values of longitudinal and transverse waves: V_P =2059 m/s; V_S=962 m/s.

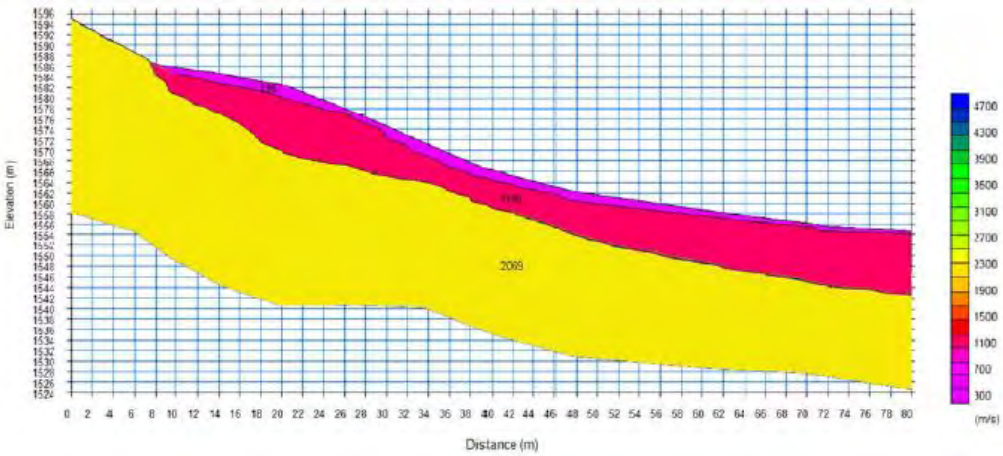


Fig. 5. Seismic profile SRL4

Table 4. Values of physical-mechanical parameters for the profile SRL4

Stratum N	Parameter	Parameter description	Values	Depth, m
1	V_P m/s	Longitudinal wave velocity	195	1
	V_S m/s	Transverse wave velocity	121	
	V_S/ V_P	Speed ratio	0.62	
	ρ g/cm³	Density	1.20	
	μ	Poisson's ratio	0.19	
	E_d MPa	Young's Dynamic Modulus	40	
	G_d MPa	Dynamic Shearing Modulus	18	
	K_d MPa	Dynamic modulus of uniform compression	222.65	
	D MPa	General deformation modulus	0.20	
	τ MPa	Compression strength	-	
2	V_P m/s	Longitudinal wave velocity	1190	7
	V_S m/s	Transverse wave velocity	431	
	V_S/ V_P	Speed ratio	0.36	
	ρ g/cm³	Density	1.89	
	μ	Poisson's ratio	0.42	

	E_d MPa	Young's Dynamic Modulus	1000	
	G_d MPa	Dynamic Shearing Modulus	351	
	K_d MPa	Dynamic modulus of uniform compression	22097.40	
	D MPa	General deformation modulus	33.81	
	τ MPa	Compression strength	5.02	
4	V_P m/s	Longitudinal wave velocity	2059	22
	V_S m/s	Transverse wave velocity	962	
	V_S/ V_P	Speed ratio	0.47	
	ρ g/cm³	Density	2.17	
	μ	Poisson's ratio	0.36	
	E_d MPa	Young's Dynamic Modulus	5460	
	G_d MPa	Dynamic Shearing Modulus	2007	
	K_d MPa	Dynamic modulus of uniform compression	65192.06	
	D MPa	General deformation modulus	511.97	
	τ MPa	Compression strength	28.68	
Vs30, m/s		Average velocity of transverse wave up to 30 m depth	633	

Seismic profile SRL5:

Stratum 1 extends up to 0-3 m depth from the surface with the following values of longitudinal and transverse wave velocities: V_P =252 m/s; V_S =154 m/s.

Stratum 1 is bordered by **Stratum 2** from below, thickness of which is 0-11 m with following values of longitudinal and transverse waves: V_P =1069 m/s; V_S =456 m/s.

The mentioned stratum is bordered by **Stratum 4** from below, which is observed up to 30 m depth with the following values of longitudinal and transverse waves: V_P =2089 m/s; V_S =968 m/s.

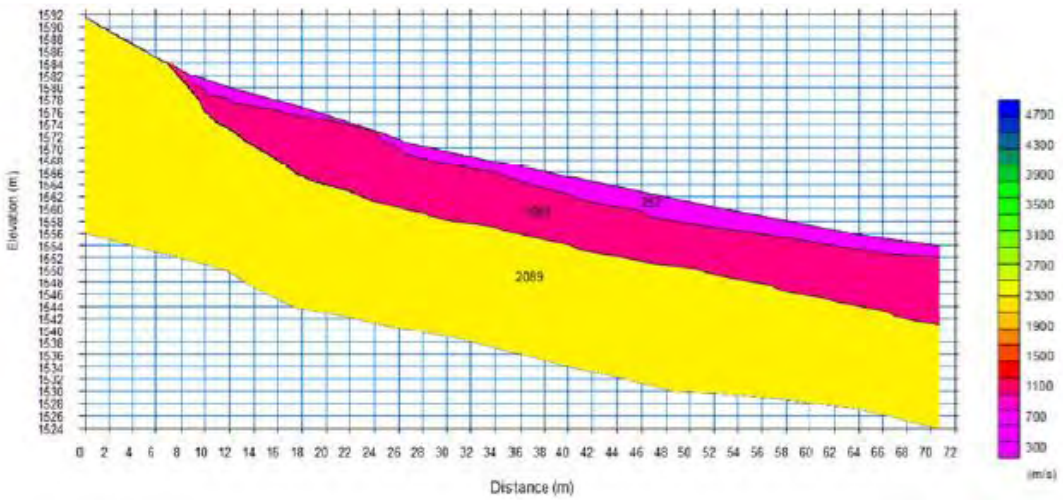


Fig. 6. Seismic profile SRL5

Table 5. Values of physical-mechanical parameters for the profile SRL5

Stratum N	Parameter	Parameter description	Values	Depth, m
1	V_P m/s	Longitudinal wave velocity	252	1.5
	V_S m/s	Transverse wave velocity	154	

	V_S/V_P	Speed ratio	0.61	
	ρ g/cm³	Density	1.28	
	μ	Poisson's ratio	0.20	
	E_d MPa	Young's Dynamic Modulus	70	
	G_d MPa	Dynamic Shearing Modulus	30	
	K_d MPa	Dynamic modulus of uniform compression	409.04	
	D MPa	General deformation modulus	0.48	
	τ MPa	Compression strength	-	
2	V_P m/s	Longitudinal wave velocity	1069	7
	V_S m/s	Transverse wave velocity	456	
	V_S/V_P	Speed ratio	0.43	
	ρ g/cm³	Density	1.84	
	μ	Poisson's ratio	0.39	
	E_d MPa	Young's Dynamic Modulus	1060	
	G_d MPa	Dynamic Shearing Modulus	383	
	K_d MPa	Dynamic modulus of uniform compression	15935.80	
	D MPa	General deformation modulus	37.11	
	τ MPa	Compression strength	5.47	
4	V_P m/s	Longitudinal wave velocity	2089	21.5
	V_S m/s	Transverse wave velocity	968	
	V_S/V_P	Speed ratio	0.46	
	ρ g/cm³	Density	2.18	
	μ	Poisson's ratio	0.36	
	E_d MPa	Young's Dynamic Modulus	5560	
	G_d MPa	Dynamic Shearing Modulus	2040	
	K_d MPa	Dynamic modulus of uniform compression	67801.07	
	D MPa	General deformation modulus	527.07	
	τ MPa	Compression strength	29.14	
Vs30, m/s		Average velocity of transverse wave up to 30 m depth	634	

Seismic profile SRL6:

Stratum 1 extends up to 1-2 m depth from the surface with the following values of longitudinal and transverse wave velocities: V_P =444 m/s; V_S=279 m/s.

Stratum 1 is bordered by **Stratum 2** from below, thickness of which is 8-10 m with following values of longitudinal and transverse waves: V_P =1621 m/s; V_S=716 m/s.

The mentioned stratum is bordered by **Stratum 4** from below, which is observed up to 30 m depth with the following values of longitudinal and transverse waves: V_P =3453 m/s; V_S=1625 m/s.

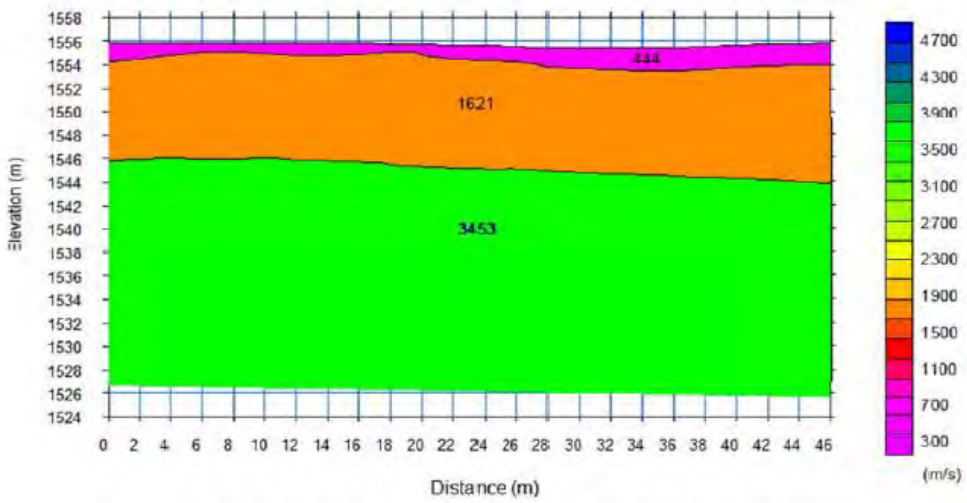


Fig. 7. Seismic profile SRL6

Table 6. Values of physical-mechanical parameters for the profile SRL6

Stratum N	Parameter	Parameter description	Values	Depth, m
1	V_P m/s	Longitudinal wave velocity	444	1.5
	V_S m/s	Transverse wave velocity	279	
	V_S/ V_P	Speed ratio	0.63	
	ρ g/cm³	Density	1.48	
	μ	Poisson's ratio	0.17	
	E_d MPa	Young's Dynamic Modulus	270	
	G_d MPa	Dynamic Shearing Modulus	115	
	K_d MPa	Dynamic modulus of uniform compression	1379.77	
	D MPa	General deformation modulus	4.16	
	τ MPa	Compression strength	-	
2	V_P m/s	Longitudinal wave velocity	1621	9
	V_S m/s	Transverse wave velocity	716	
	V_S/ V_P	Speed ratio	0.44	
	ρ g/cm³	Density	2.04	
	μ	Poisson's ratio	0.38	
	E_d MPa	Young's Dynamic Modulus	2890	
	G_d MPa	Dynamic Shearing Modulus	1047	
	K_d MPa	Dynamic modulus of uniform compression	39721.00	
	D MPa	General deformation modulus	184.88	
	τ MPa	Compression strength	14.96	
4	V_P m/s	Longitudinal wave velocity	3453	19.5
	V_S m/s	Transverse wave velocity	1625	
	V_S/ V_P	Speed ratio	0.47	
	ρ g/cm³	Density	2.47	
	μ	Poisson's ratio	0.36	
	E_d MPa	Young's Dynamic Modulus	17700	
	G_d MPa	Dynamic Shearing Modulus	6518	
	K_d MPa	Dynamic modulus of uniform	207399.22	

		compression		
	D MPa	General deformation modulus	3365.16	
	τ MPa	Compression strength	93.11	
Vs30, m/s		Average velocity of transverse wave up to 30 m depth	1002	

Seismic profile SRL7:

Stratum 1 extends up to 0-2 m depth from the surface with the following values of longitudinal and transverse wave velocities: V_P =205 m/s; V_S=126 m/s.

Stratum 1 is bordered by **Stratum 2** from below, thickness of which is 4-8 m with following values of longitudinal and transverse waves: V_P =870 m/s; V_S=403 m/s.

The mentioned stratum is bordered by **Stratum 3** from below, which is observed up to 30 m depth with the following values of longitudinal and transverse waves: V_P =1404 m/s; V_S=645 m/s.

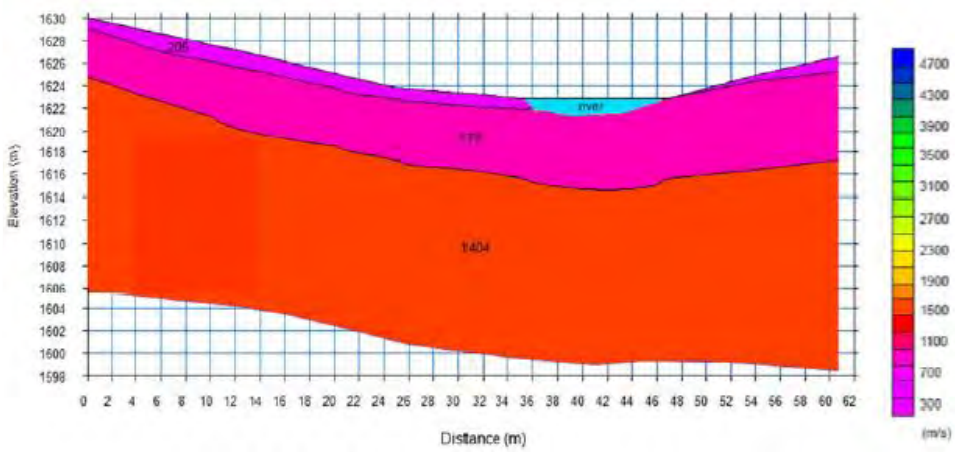


Fig. 8. Seismic profile SRL7

Table 7. Values of physical-mechanical parameters for the profile SRL7

Stratum N	Parameter	Parameter description	Values	Depth, m
1	V_P m/s	Longitudinal wave velocity	205	1.5
	V_S m/s	Transverse wave velocity	126	
	V_S/ V_P	Speed ratio	0.61	
	ρ g/cm³	Density	1.22	
	μ	Poisson's ratio	0.20	
	E_d MPa	Young's Dynamic Modulus	50	
	G_d MPa	Dynamic Shearing Modulus	19	
	K_d MPa	Dynamic modulus of uniform compression	254.12	
	D MPa	General deformation modulus	0.28	
	τ MPa	Compression strength	-	
2	V_P m/s	Longitudinal wave velocity	870	6
	V_S m/s	Transverse wave velocity	403	
	V_S/ V_P	Speed ratio	0.46	
	ρ g/cm³	Density	1.75	
	μ	Poisson's ratio	0.36	

	E_d MPa	Young's Dynamic Modulus	770	
	G_d MPa	Dynamic Shearing Modulus	284	
	K_d MPa	Dynamic modulus of uniform compression	9449.63	
	D MPa	General deformation modulus	22.25	
	τ MPa	Compression strength	4.06	
3	V_P m/s	Longitudinal wave velocity	1404	22.5
	V_S m/s	Transverse wave velocity	645	
	V_S/ V_P	Speed ratio	0.46	
	ρ g/cm³	Density	1.97	
	μ	Poisson's ratio	0.37	
	E_d MPa	Young's Dynamic Modulus	2440	
	G_d MPa	Dynamic Shearing Modulus	820	
	K_d MPa	Dynamic modulus of uniform compression	27920.24	
	D MPa	General deformation modulus	122.96	
	τ MPa	Compression strength	11.71	
Vs30, m/s		Average velocity of transverse wave up to 30 m depth	486	

Parameters are applied by the averaged principle along the entire length on this profile. For the seismic profiles, sections are made with consideration of visually observed local geological situation and geological-geotechnical data.

Soil categories were determined in the upper 30 m depth stratum (Vs30, averaged value 820 m/s was adopted for the entire construction site) based on the geophysical survey, according to the average velocities of the transverse waves by considering the standards applying in Georgia, as well as the international norms (IBC2006, Eurocode8, ASCE7). It should be noted that according to the applying standards in Georgia, it corresponds to the I category of soil, while based on the international norms, following was determined: Eurocode8 - A class, IBC2006 and ASCE7 – B class. Detailed values are provided in the Table 8.

Table 8. Average values of transverse waves and soil categories

Profile #	Vs30 m/s	Georgian standard	IBC2006	ASCE7	Eurocode8
SRL1	828	I	B	B	A
SRL2	1259	I	B	B	A
SRL3	897	I	B	B	A
SRL4	633	II	C	C	B
SRL5	634	II	C	C	B
SRL6	1002	I	B	B	A
SRL7	486	II	C	C	B

13.3.3 Conclusion

Seismic profiling was carried out with application of refracted waves method on the Paravani HPP construction site.

Seven seismic profiles of various size with total length 418 m were executed up to 30 m depth. The survey site and layout scheme of the seismic profiles are provided on the Figure 1 (a, b, c, d, e, f).

Different engineering-geological elements (strata) are singled out based of the geophysical parameters, distribution values of V_P, V_S velocities is defined. Values of appropriate physical-mechanical parameters are given in the Tables 1-7 (Fig: 2-8).

According to the geophysical data, five strata with various physical properties are observed on the executed profiles (identification was carried out by considering of the engineering-geological results):

Stratum1 – boulders, cobble-stone, grit with loam filling, which includes EGE1 and EGE2, according to the geological data;

Stratum 2 – gravel with pebble intrusions, sand-sandy filling, solid, water saturated, which includes EGE3 and EGE4 according to the geological data;

Stratum 3 – Clay - semisolid with grit and cobble stone intrusions, which includes EGE5 and EGE6 according to the geological data;

Stratum 4 – andesites and basalts, slightly weathered, fractured, which corresponds to EGE7 according to the geological data;

Stratum 5 - andesites and basalts, which corresponds to EGE7 according to the geological data.

Soil categories were determined in the upper 30 m depth stratum (Vs30, averaged value 820 m/s was adopted for the entire construction site) based on the geophysical survey, according to the average velocities of the transverse waves by considering the standards applying in Georgia, as well as the international norms (IBC2006, Eurocode8, ASCE7). It should be noted that according to the applying standards in Georgia, it corresponds to the I category of soil, while based on the international norms, following was determined: Eurocode8 - A class, IBC2006 and ASCE7 – B class. Detailed values are provided in the Table 8

13.4 Annex 4 Seismic Hazard Assessment

ს ა ქ ა რ თ ვ ე ლ ო ს
გეოფიზიკური ასოციაცია
60 თბილისი , მ. ალექსიძის ქ.
ტელ. 233-28-67; ფაქსი: 233-28-67
E-mail: Tamaz.chelidze@gmail.com

GEORGIAN GEOPHYSICAL ASSOCIATION

GEORGIAN
GEOPHYSICAL ASSOCIATION
1 Alexidze str. - Tbilisi 0160 - Georgia
Phone: (995 32) 233-28-67; Fax/phone: (995 32) 233-28-67 ; E-mail: Tamaz.chelidze@gmail.com

Approved: 25th of January, 2019.

Georgian Geophysical Association
Tamaz Chelidze - Director, Academician

Seismic Hazard Assessment of Akhalkalaki and Korkhi HPPs Construction Territories

(Report)
Tbilisi

2019

13.4.1 Introduction

13.4.1.1 Geographic Location and Geomorphological Conditions of the Survey Region

The presented report was prepared based on the seismic hazard detailed assessment results of the significant facilities' construction territories designed in the southern Georgia (facilities – HPP structures: Object 1 – water intake on Paravani River; Object 2 – building of Akhalkalaki hydro power plant; Object 3 – water intake on Korkhi River; Object 4 – building of Korkhi hydro power plant).

Akhalkalaki municipality, where the given facilities are constructed, is situated in the southern part of the country. It extends in the central part of Javakheti plateau. It is a typical young volcanic terrace, most part of which is occupied by the plateau of 1500-2000 m height plain surfaces structured with the upper pliocene and quaternary dolerites, basalts and andesites.

The surrounding area of the construction facility (80 km radius around the facilities, Fig. 1) comprises the parts of two main tectonic units of the Caucasus and six subzones (the list is given from N to S direction): Transcaucasia intermountain lowland (I. Mtkvari lowland); Lesser Caucasus (II. Adjara-Trialeti thrust-fold mountainous belt; III. Javakheti volcanic plateau; IV. Artvin-Bolnisi block; V. Loki-Karabakh-Kapany thrust-fold mountainous belt; VI. Eastern Anatolia-Armenia volcanic plateau).

The study region is characterized by the complicated block structure of the earth crust. The study facilities are located on Javakhati volcanic plateau. Extremely high seismic activity of this plateau significantly determines high seismicity of Akhalkalaki municipality. The study region includes the part of all main seismically active zones of the above mentioned tectonic units.

The current normative map of seismic hazard of Georgia expresses severity of seismic influence in macro-seismic intensity (MSK scale) and peak ground acceleration (PGA) with probability of 2% in 50 years. It was calculated in 1999 and came into force in 2010 after editing.

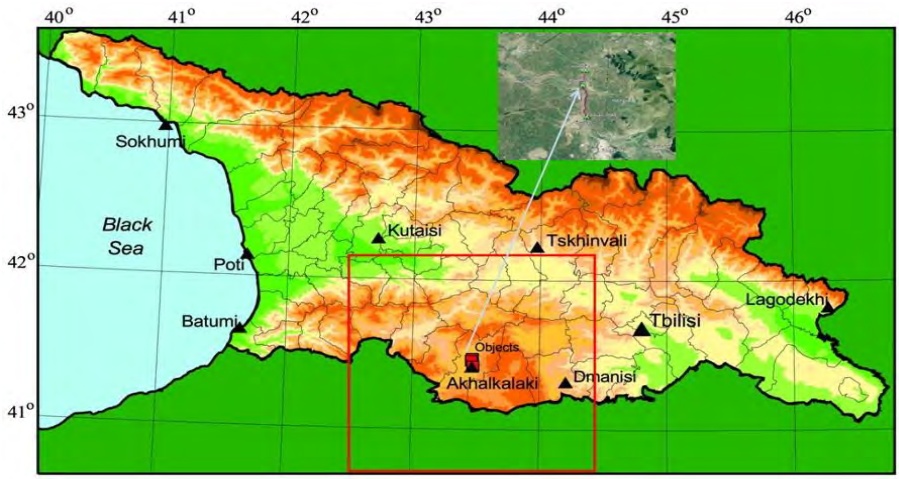


Fig. 1. Geographic location and boundaries of the study region and facilities

13.4.1.2 Estimation of Shaking Levels of the Facilities Base-Grounds during Earthquakes Expected on the HPPs Designing Stage

Akhalkalaki HPP and Korkhi HPP belong to the small HPPs category based on their parameters.

Basic seismic loadings for the projects of new dams or safety estimation of the existing structures are estimated according to levels of expected earthquakes. The first level earthquake is the Operating Basis Earthquake (OBE) and it may occur once during the operation period (or once in 100 or 50 years). As a rule, return period of such earthquake is 475 years (or 19% probability of exceedance for 100 years or 10% probability of exceedance for 50 years) (ICOLD, 2010). This represents the level of ground shaking,

during which only minor damages are expected. A power plant, dam, their structures and equipment must remain in working mode and the damages should be easily repaired, in case of such earthquake.

The second level earthquake is called the Safety Evaluation Earthquake (SEE) and it is characterized with the maximum level of ground shaking on which the HPPs should be calculated. Return period is about 10 000 (or about 1% probability of exceedance for 100 years or 0,5% probability of exceedance for 50 years) (ICOLD, 2010). The SEE level earthquake is a phenomenon, when hydro technical structures should continue functioning so that to maintain unity and safety.

13.4.2 Seismic History of the Study Region

Following catalogues and information were compiled based on the seismic database of the TSU M. Nodia Institute of Geophysics to determine regularity of observed seismicity of the study region: 1) catalogue of all occurred earthquakes from the ancient period to 2019 in this region; 2) moderate and strong earthquakes catalogue of the same period with MS≥3.6 magnitude; 3) macro seismic data catalogue of strong earthquakes and collection of isoseist maps; 4) catalogue of active fractures parameters and 5) collection of strong ground motion prediction equations (GMPE models).

Maps of epicenters of the nearby zone of 25 km radius around the study region and project facilities have been made based on the mentioned materials (see Fig. 2,3). Practically, they show distribution of earthquakes various magnitude on the given territory. All earthquakes from the ancient period to 2018 are provided on these maps. Year of occurring of moderate and strong earthquakes is also given on the maps.

Joint analysis of the maps clearly showed the seismological situation of the study region. In particular, according to the map of epicenters of moderate and strong earthquakes (Fig 2), the entire study region is covered with the earthquake epicenters, but with various density. Area of the highest concentration of epicenters is observed to the southeast direction from the project facilities, in the form of epicentric zones of Akhalkalaki and Armenia plateaus.

Nearby zone of the given facilities is entirely covered with the earthquake epicenters (Fig 3). It is well observed that epicenters' density is increased to the southeast direction from the facilities toward Akhalkalaki and Armenia plateaus. In addition, the facilities are located in the vicinities of the following earthquake epicenters (Epicentric distance 7-20 km): Tmogvi 1088 (M_S=6.5, I_O=9 MSK), Akhalkalaki 1899 (M_S=6.1, I_O=9 MSK), Tskhratskaro 1912 (M_S=5.6, I_O=7 MSK) and Paravani 1986 (M_S=5.6, I_O=8 MSK). In particular, in the points of Akhalkalaki and Orji, Akhalkalaki earthquake had the macro-seismic effect equaling to 7 and 7.5 magnitude MSK intensity. In addition, in the points of Akhalkalaki and Diliska, Paravani earthquake had the effect equaling to 6 magnitude MSK intensity. These facts indicate to the high seismic activity of this local area during the entire historical period of observation.

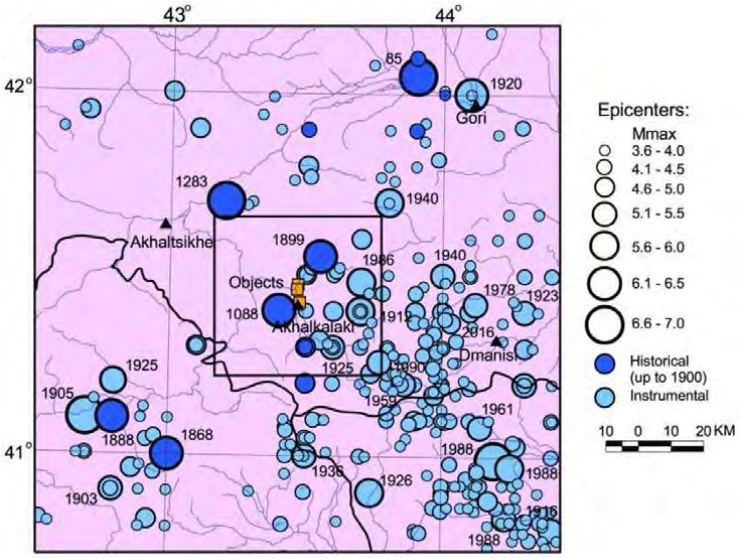


Fig. 2. Map of epicenters of moderate and strong earthquakes (MS≥3.6).

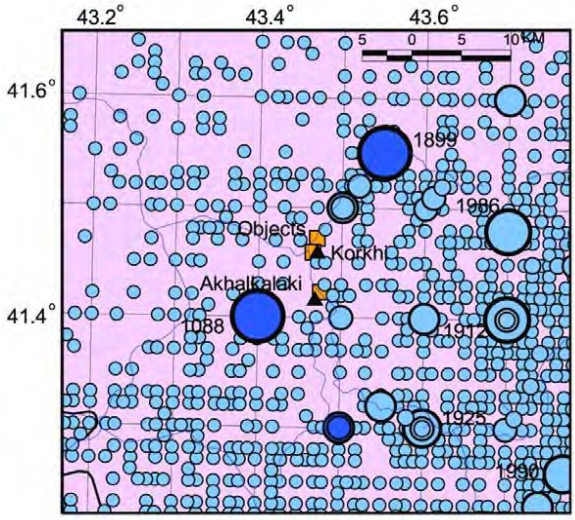


Fig. 3. Map of epicenters of all earthquakes registered in the nearby zone of the study facility

Based on the observed seismic analysis we can conclude that the greatest concentration area of epicenters is to southwest direction from the facility, in the epicenter zones of Javakheti and Armenia plateaus. Zones of the strong historical earthquakes represent the dormant areas at present.

Strong historical and modern earthquakes occurred nearby the project facilities have resulted in a high seismicity (7-9 MSK intensity) of the zone for the past historical period. This is confirmed by observation on the high seismic activity of the surrounding area of the project facilities during the entire historical period.

Description of cases of the two strongest historical earthquakes (Varazanashvili et al., 2011) and evaluation of intensity by the MSK scale is provided below.

April 22, 1088, Tmogvi earthquake

"Bertakana rock avalanche was formed on the right slope of Mtkvari River valley, to the west of the former settlement of the same name. Its formation is associated with Tmogvi earthquake, which destroyed the town. Aftershocks used to occur throughout the year that was also accompanied by active development of landslide-gravitational processes.

Nakalakevi landslide locating on the village territory, on the right slope of Mtkvari River valley, must be linked to the earthquakes of the same period. Nakalakevi seismogenic landslide is separated from the

above described Bertakana rock avalanche by 1 km width Tmogvi terrace. It represents the rock avalanche-landslide type gravitational formation, length of which exceeds 15 km along the river, while the maximum distance from the plane of landslide rupture and the basis reaches 900 m. Area of its uneven hilly terrain exceeds 2 km^2. Most part of the village is located there.

It should be noted that Tmogvi earthquake of 1088 is considered as the average volume earthquake in both editions of the new catalogue (Новый каталог…, 1977; New Catalogueue…, 1982). Based on the detailed investigation of primary sources of its description, it revealed that the magnitude and intensity of this earthquake was not less than Samtskhe earthquake (1283) (Varazanashvili, Papalashvili, 1998). This is primarily confirmed by the description of the Chronicler of David the Builder (the Georgian Chronicles1955). Based on this, Tmogvi earthquake occurred in Javakheti region must have been stronger (Fig 4) than it is given in the new catalogue or even in the paper (Shebalin, Tatevossian, 1997)

Sources:

ჩეჩელაშვილი, გ., ნაფეტვარიძე, რ., პაპალაშვილი, ვ. აივაზიშვილი, ი., მახათაძე, ლ., გუგუშვილი, თ. 1998. მიწისძვრებით გამოწვეული მატერიალური ზარალი საქართველოში. გამომც. მეცნიერება, თბილისი, გვ. 13.

წერეთელი, ჯ. 1969. ჯავახეთის მთიანეთის ვულკანური რელიეფი. საკანდიდატო ნაშრომი. თბილისის სახელმწიფო უნივერსიტეტი. 262 გვ.

Цагуришвили А. Г. и др. 1979. Геологический отчет “Инженерно-геологические исследования в м-бе 1:25000 в долине р. Куры от с. Ацкури до госграницы”. Национальное Агенство Окружаюшей Среды. Том. 1, 310 с.

წერეთელი, ემ., გაფრინდაშვილი, მ. 2007. სამცხე-ჯავახეთის საავტომობილო გზის რეაბილიტაციის პროექტის გარემოზე ზემოქმედების შეფასება. გარემოს ეროვნული სააგენტო. თბილისი, 59 გვ.

Новый каталог сильных землетрясений на территории СССР (Кавказ). 1977. Изд-во Наука, Москва, сс. 69-170.

New Catalogue of Strong Earthquakes in the USSR. 1982. NOAA, USA, 608 pp.

Varazanashvili, O., Papalashvili, V. 1998. Reconstruction of strong earthquake parameters by historicl data of XI-XIV cc. in Georgia. Journal of Georgian Geophysical Society (A), vol.3, pp. 77-84.

Shebalin, N., Tatevossian, R. 1997. Catalogueue of large historical earthquakes of the Caucasus. Historical and prehistorical earthquakes in the Caucasus. Kluwerr Academic Publishers, Dordrecht, pp. 201-232.

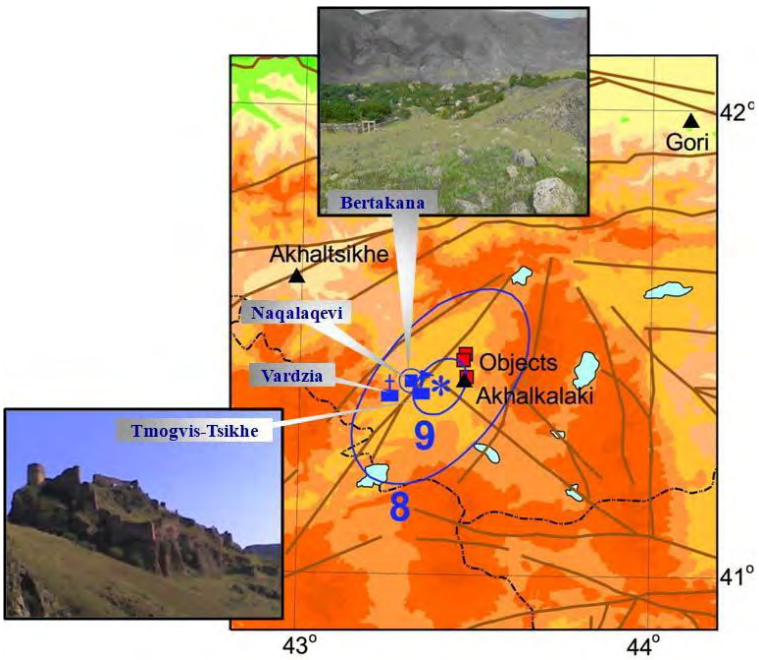


Fig. 4. Intensity distribution map for Tmogvi earthquake of April 22, 1088

Akhalkalaki earthquake, December 31, 1899

Akalkalaki earthquake, which was described in detail in the primary sources (Мушкетов, 1903; Бюс, 1948), was revised and reinterpreted in the paper published in 1997 (Tatevossian et al., 1997). Map of isoseists and basic parameters (including instrumental magnitude MS=6.1, determined by the data of 7 stations) (Ambraseys, Adams, 1989; Abe, 1994) of this earthquake are provided in the paper. Based on the total information of the paper, we made a new map of isoseists for the entire area of this earthquake (Fig. 5). Unlike this paper (Tatevossian et al., 1997), where isoseists are oriented to the NW-SE direction, in our case, isoseists have the NE-SE direction, which better fits the local geological situation.

Sources:

Мушкетов, И.В. 1903. Материалы по Ахалкалакскому землетрясению 19 декабря 1899 г. Труды Геологического комитета, новая серия, вып. 1

Бюс, Е.И. 1948. Сейсмические условия Закавказья, ч. I. Изд-во АН ГССР, Тбилиси, с. 66-74.

Tatevossian, R. E., Albini, P., Camassi, R., Mokrushina, N.G., Shebalin, N.V., Petrossian, A.E. 1997. Analysing and improving supporting data set of the akhalkalak, december 31, 1899, earthquake. Historical and Prehistorical earthquakes in the Caucasus. Kluwer Academic Publishers. Netheralnd. pp. 383-400.

Ambraseys, N. N., Adams, R. D. 1989. Long-term seimicity of North Armenia. EOS, March 7, 152-154.

Abe, K. 1994. Instrumental magnitudes of historical earthquakes, 1892-1898. BSSA, 84, 2, 415-425.

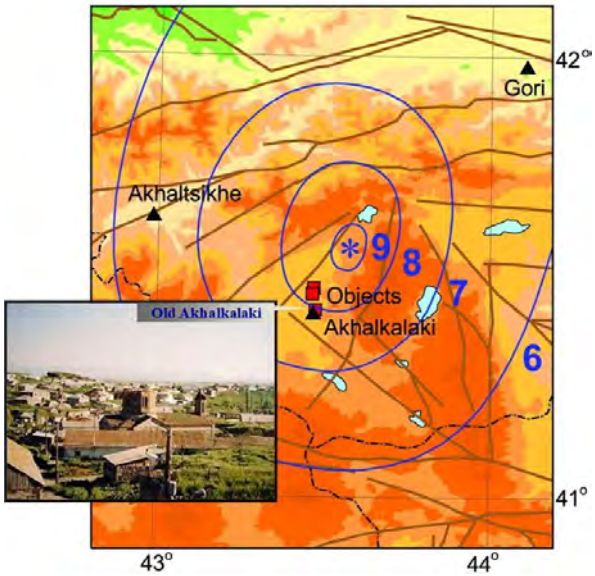


Fig. 5. Intensity distribution map for Akhalkalaki earthquake of December 31, 1899

13.4.3 Seismically Active Faults and Seismic Source Zones of the Study Region

Detailed investigation of seismicity of the given region is impossible without study of regularities of the seismotectonic conditions. Direct result of such investigation is to single out zones of seismic focuses. Method of single out of seismic source zones (Varazanashvili, 1989, 1998) is based on the wide circle of geological-geophysical and seismological data, while its conceptual basis is the complex block structure of the earth crust of the territory of Georgia. Due to the continuous deformation of the earth's crust caused by endogenous processes, braking of relative movement of blocks occur in some inter-block transitional zones, which leads to formation of potential elastic energy accumulation areas. As it is known, this energy can be unloaded by the rapid dynamic faulting or the earthquake. Specification of spatial location of inter-block transient zones is essential for identification of potential locations of seismic sources or the origins of strong earthquakes. Information about the zone of seismically active faults of the study region is necessary to solve the set objective.

13.4.3.1 Seismically Active Faults

The discussing region includes 28 large, seismically active faults or the fault zones (FZ); they are identified based on the geological, geophysical, morphological and seismological data (Fig.6). List of faults of Georgia (G), Armenia (A) and Turkey (T) is provided in the report, they are numbered from 1 to 28, toward N-S direction: Eldari (G1), Kaspi (G2), Surami (G3), Ozurgeti (G4), Keda (G5), Atskuri (G6), Bakuriani (G7), Teleti (G8), north FZ of Khrami (G9), south FZ of Khrami (G10), north FZ of Loki(G11), Dmanisi (G12), Agrikari(G13), Javakheti (G14), Abula (G15), west FZ Tabatskuri (G16), east FZ of Tabatskuri (G17), Madatapa (G18), Posopi (T19), Erzurum (T20), Ardagan (T21), Haskoy (T22), Pambak-Sevan-Sunik (A23), Stepanavan (A24), Shenkaya (T25) Zheltorechka-Sarikhamish (A26), Akhurian (A27), Garni(A28) fault zones. .

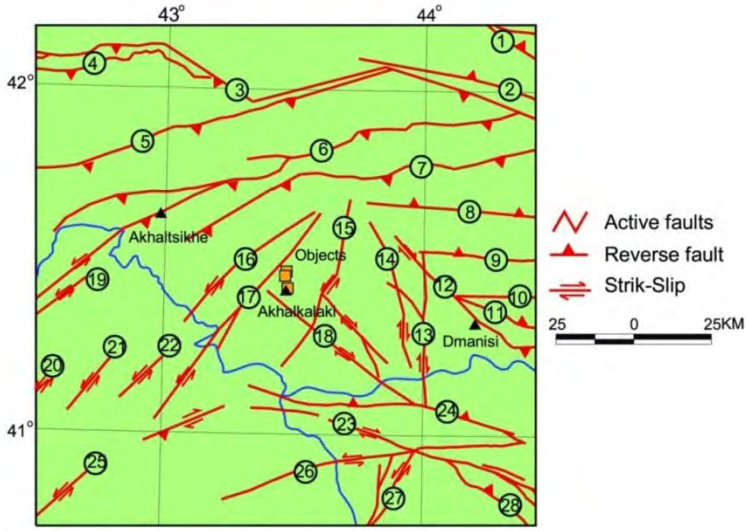


Fig. 6. Seismically active faults or fault zones of the study region

13.4.3.2 Seismic Source Zones

Two types of seismic source zones are recommended to be used for the modern methods of seismic hazard assessment: active faults along with the baseline seismicity and areal (zonal) seismic source zones. Areal seismic source zones are identified based on the database of active faults. In particular, width of their dynamic impact area was determined based on the data of the structure and gradient of separate faults and the thickness of seismically active layer of the region. Then, according to the geometry of the earthquake sources, direction of isoseists, orientation of foreshocks and aftershocks, data of the mechanisms of a source, connection of the earthquake sources to these areas was investigated and the zones of seismic sources were singled out.

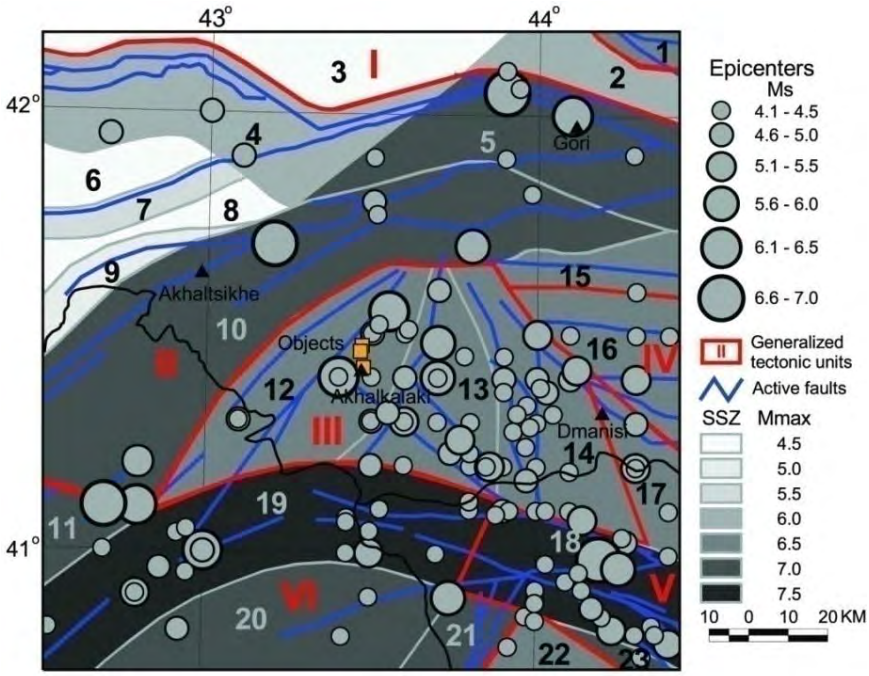


Fig. 7. Map of seismic source zones of the study region

Determination of seismic potential or maximum expected magnitude (M_{Smax}) is the most difficult task in frames of parameterization of the seismic source zones. In the given case, this task was solved in a complex way – by using of five methods, out of which three is seismological and two – geological

methods.

In addition, *a* and *b* parameters were determined for each source zone, they are Gutenberg &Richter Ratio of recurrence law:

$$\lg N = a - bM . \quad (1)$$

Parameter *b* was considered for all large tectonic units (see Fig. 7), which partly comprise the study region and where seismo-statistics was sufficient for reliable determination of this parameter.

Then there was an attempted to determine these parameters in separate source zones, but due to the statistical insufficiency, it was impossible and they were granted the values of *b* parameter of that tectonic unit, where they are located. Parameter *a* was determined for a separate source zone by using of calibration technique of non-representative data.

Investigation of earthquakes depth distribution related to active faults was performed in the above mentioned large tectonic unit. Empirical dependence n(h) between number of earthquakes (n) and depth of earthquakes (h) was made. Figure 8 provides distribution charts of earthquakes distribution for Javakheti plateau, according to the depth, where the project facilities are located.

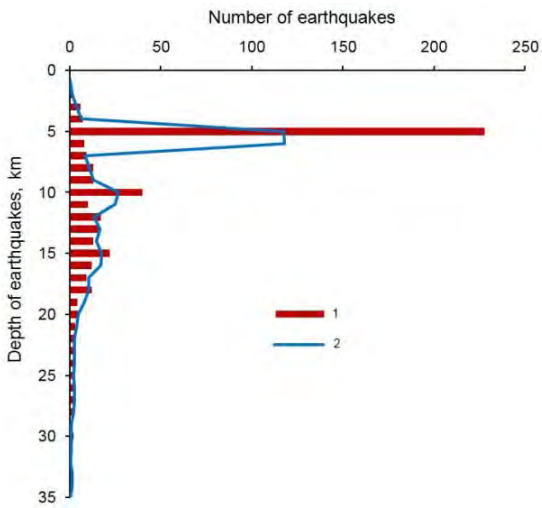


Fig. 8. Distribution of Javakheti plateau earthquakes according to the depth: 1 – n(h) dependency-based histogram for the period of 1900-2015; 2 – chart made by creeping averaging (span 3) for the same period

Based on the analysis of this chart, we can conclude that earthquakes are basically generated from 1 to 30 km depth in the tectonic unit of Javakheti plateau (Fig. 8). However, most of earthquakes occur in a seismic active stratum of 20 km thickness in 5 and 10 km depths. Such information is extremely significant for software calculation of seismic hazards.

Presence of 14 seismic source zones, which can entail considerable seismic impact on the construction sites of the project facilities, requires assessment of probabilistic and deterministic (maximum) values of such impact.

13.4.4 Seismic Hazard Evaluation of the Territory of a Facility

Evaluation of seismic hazard implies prediction of ground motion intensity caused by the expected earthquakes in the study region. Both, probabilistic, as well as deterministic approaches were used to evaluate seismic hazard of the territory of a facility in this report.

13.4.4.1 Probabilistic Seismic Hazard Assessment

Probabilistic seismic hazard assessment implies calculation of expected magnitude of ground motions for the given probability of exceedance during the indicated period. For example, peak ground acceleration with 10% probability (corresponds to 475-year return period) of exceeding for the next 50 years.

Modern methodology of seismic hazard evaluation probability (e.g. Frankel et al., 1996) considers the following steps:

1. Making full catalogue of earthquakes by the unified scale of magnitude;

2. Making database of active faults, determination of areal seismic source zones, assessment of earthquakes' recurrence and maximum magnitude;

3. Assessment regularity of ground motion attenuation;

4. Making curves of seismic hazard.

Computations give numerical values of various parameters of ground motion intensity (e.g. peak acceleration, spectral acceleration, et.al.) for any probability of exceedance or recurrence period.

In frames of probabilistic assessment of seismic hazard, each source zone of both types is considered as the seismic source with its typical seismic potential and the law of the earthquakes' recurrence, as well as with displacement velocity along the active structures. On the expense of the earthquakes occurred in one source zone, average period (T) of recurrence of motions of the given intensity generated at the facility is calculated by the following formula:

$$1/T = 1/T_{Mmax} + \cdots + 1/T_{Mmin} \quad , \qquad (2)$$

Where $M_{min},\ldots,M_{max}$ are magnitudes entailing motions of certain intensity at the facility. The same procedure is performed for other source zones and various values of motions' intensity and the obtained results are summed up, which finally, enables us to make a chart of seismic hazard for the given facility, to determine its analytical image and to calculate the ground motion values corresponding to the given probability.

Ground motion prediction equations (GMPE): database of strong motions for Georgia is quite poor, especially, the strong earthquakes M≥5, which are extremely important in terms of engineering viewpoint. A number of surveys were carried out in the Caucasus (Arefiev et al., 1991a; Arefiev et al., 1991b; Smit et al., 2000; Jibladze et al., 2000) to determine the appropriate equations, but the desired results were not obtained, due to the insufficient data. There was an attempt to increase data based on combination of different regions for this purpose. However, specificity of each region was not taken into consideration and therefore, obtained equations gave the inaccurate results (Ambraseys, 1995; Ambraseys and Simpson, 1996). In some cases, the similarity between individual regions has shown that it is possible to integrate data of strong motions into GMPE for some regions (e.g. the Caucasus, northwestern Turkey, central Italy, etc.) to obtain strong motions' prediction equations (Smit et al., 2000; Slejko et.al, 2008).

Along with selection of appropriate GMPE for reduction of epistemic uncertainty in ground motion prediction in different regions and tectonic regimes, reflection of correspondence of their weights to the survey objectives is essential. Precondition of this process is to obtain as small amount of selected GMPE as possible; however, they should be sufficient for reduction of epistemic uncertainty. Combination of the selected GMPE should include a wide range of magnitudes, distances and frequencies. Therefore, as a rule, ground motion prediction models developed based on the global database (or global models) are more acceptable than the regional models. The latter better reflect the local peculiarities of the ground motion attenuation, but they frequently restrict the model due to absence of sufficient, good quality data.

Software provision used in the analysis: Program - OPENQUAKE (developed in frames of GEM global project) has been used for calculation of seismic hazards. Results have been rechecked by the program EZFRISKTM (developed by the risk American corporation) as well, which has been widely used in similar projects throughout the world. These software programs, as the instruments of seismic hazards analysis, calculate risk of earthquakes for the ground with certain assumptions, specified by a user. These assumptions include location of the expected earthquakes, their parameters and the type of ground motions. The programs perform both probabilistic, as well as deterministic calculations of seismic hazards. Probabilistic calculation result is the annual exceedance value of frequency of the various level ground motions in the targeted area. These programs also calculate the magnitude and distance distribution and average deviation that cause exceedance of the ground motion level. On the other hand, deterministic calculations performed by the programs also evaluate the ground motions (average and ground motion variance for the indicated quintiles) corresponding to the earthquake highest magnitude and occurring in each seismic source zone at a minimum distance to the targeted area.

Results of probabilistic seismic hazard assessment: based on the above described principles, making of the seismic hazard charts is available with peak ground acceleration (PGA) and spectral acceleration (SA).

Probabilistic values of ground motions during the earthquake were obtained for the territories of the facilities; these values correspond to the horizontal components of various recurrence periods for 50-year expectation period for base-grounds (Facility1 – V_{S30}=828 m/s – rocky soil, soil of category A, according to EC8; Object 2 – V_{S30}=633 m/s – firm soil, category B – EC8; Object 3 – V_{S30}=1002 m/s – rocky soil, category A – EC8; Object 4 – V_{S30}=486 m/s – firm soil, category B – EC8). Figures 9 and 16 represent the hazard charts for peak acceleration values calculated for base-grounds of the study facilities and the uniform probabilistic seismic hazard charts. Results provided in the Table 2-5 correspond 475, 975, 2475 and 9950 (~10000) years return periods for the appropriate base-grounds. Ground motion vertical components are accepted as 2/3 horizontal components (ICOLD, 2010).

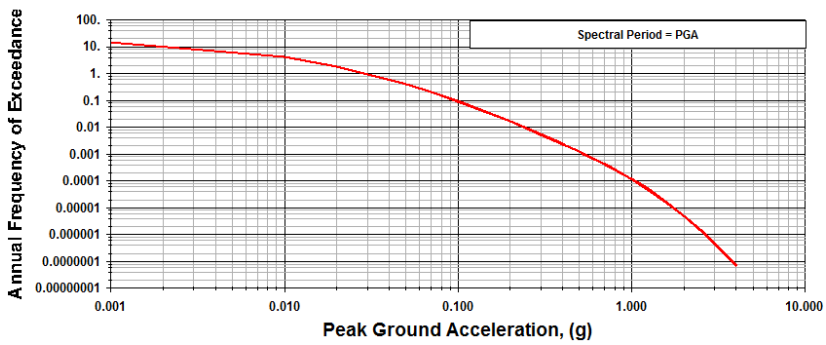


Fig. 9. Seismic hazard chart of the Object 1 with PGA VS30=828 m/s for base-ground

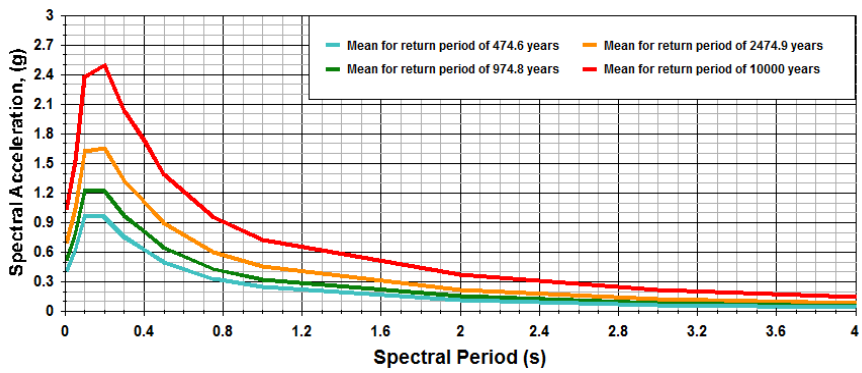


Fig. 10. Uniform hazard spectrum V_{S30}=828 m/s for base-ground

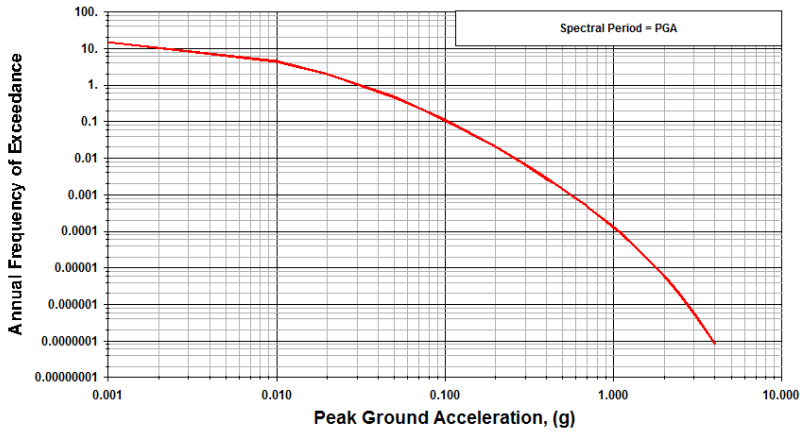


Fig. 11. Seismic hazard chart of the Object 2 with PGA V_{S30}=633 m/s for base-ground

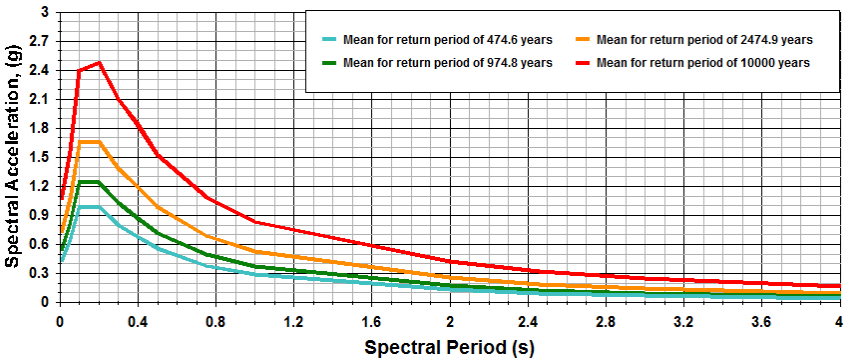


Fig. 12. Uniform hazard spectrum V_{S30}=633 m/s for base-ground

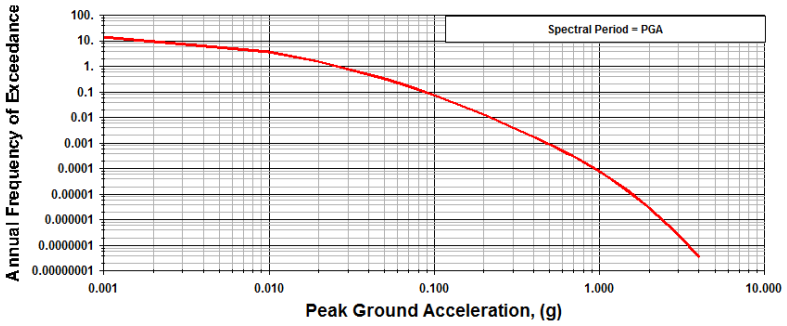


Fig. 13. Seismic hazard chart of the Object 3 with PGA V_{S30}=1002 m/s for base-ground

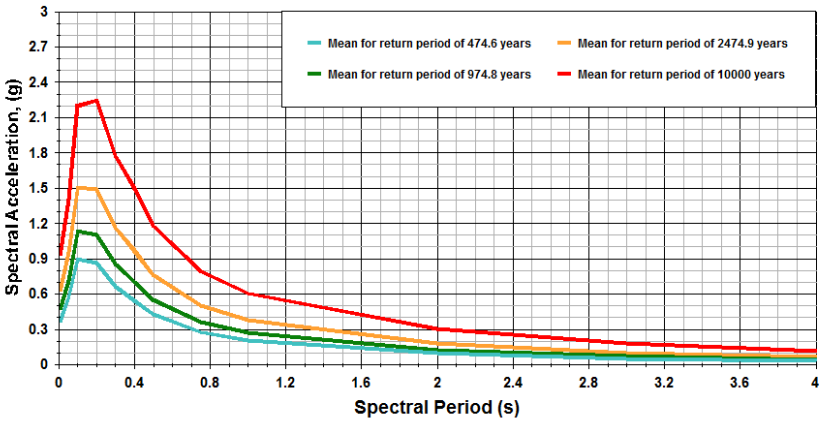


Fig. 14. Uniform hazard spectrum V_{S30}=1002 m/s for base-ground

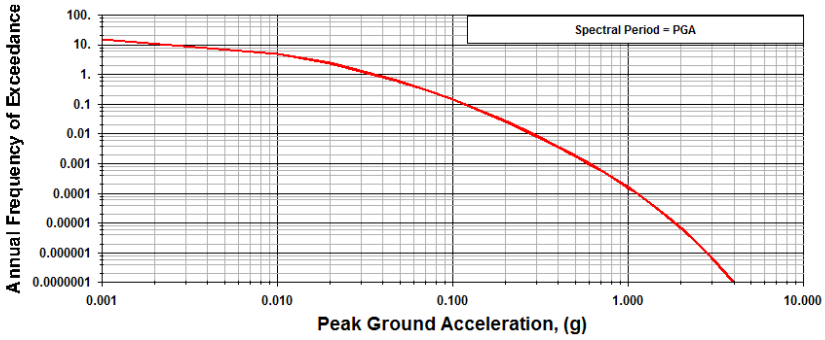


Fig. 15. Seismic hazard chart of the Object 4 with PGA V_{S30}=486 m/s for base-ground

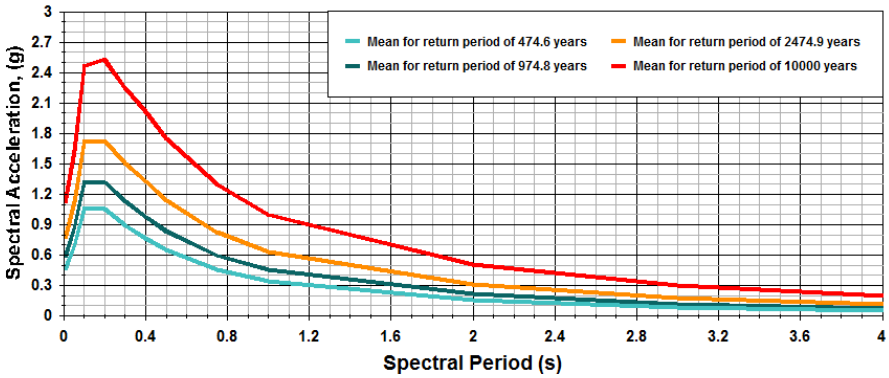


Fig. 16. Uniform hazard spectrum V_{S30}=486 m/s for base-ground

Table 2. Probabilistic seismic hazard assessment of the Object 1 (horizontal component, rocky soil V_{S30}=828 m/s, expectation time 50 years).

P, % (T, year)	10 (475)	5 (975)	2 (2475)	0.05 (9950)
PGAH (g)	0.418	0.530	0.709	1.044
SAH (g) 5% attenuation (T=0.05 s)	0.609	0.774	1.039	1.524
SAH (g) 5% attenuation (T=0.1 s)	0.971	1.225	1.624	2.370
SAH (g) 5% attenuation (T=0.2 s)	0.959	1.225	1.656	2.494
SAH (g) 5% attenuation (T=0.3 s)	0.755	0.970	1.321	2.029
SAH (g) 5% attenuation (T=0.4 s)	0.624	0.808	1.117	1.733
SAH (g) 5% attenuation (T=0.5 s)	0.499	0.648	0.895	1.388
SAH (g) 5% attenuation (T=0.75 s)	0.328	0.430	0.601	0.956
SAH (g) 5% attenuation (T=1 s)	0.247	0.325	0.457	0.728
SAH (g) 5% attenuation (T=2 s)	0.114	0.153	0.221	0.371
SAH (g) 5% attenuation (T=3 s)	0.063	0.085	0.125	0.220
SAH (g) 5% attenuation (T=4 s)	0.040	0.055	0.082	0.147

Table 3. Probabilistic seismic hazard assessment of the Object 2 (horizontal component, firm soil V_{S30}=633 m/s, expectation time 50 years)

P, % (T, year)	10 (475)	5 (975)	2 (2475)	0.05 (9950)

PGAH (g)	0.439	0.553	0.734	1.074
SAH (g) 5% attenuation (T=0.05 s)	0.632	0.800	1.068	1.563
SAH (g) 5% attenuation (T=0.1 s)	0.996	1.251	1.650	2.397
SAH (g) 5% attenuation (T=0.2 s)	0.983	1.243	1.662	2.476
SAH (g) 5% attenuation (T=0.3 s)	0.804	1.025	1.382	2.099
SAH (g) 5% attenuation (T=0.4 s)	0.676	0.869	1.191	1.834
SAH (g) 5% attenuation (T=0.5 s)	0.557	0.720	0.989	1.527
SAH (g) 5% attenuation (T=0.75 s)	0.378	0.494	0.689	1.091
SAH (g) 5% attenuation (T=1 s)	0.286	0.375	0.526	0.832
SAH (g) 5% attenuation (T=2 s)	0.133	0.177	0.255	0.426
SAH (g) 5% attenuation (T=3 s)	0.073	0.098	0.144	0.250
SAH (g) 5% attenuation (T=4 s)	0.047	0.063	0.093	0.167

Table 4. Probabilistic seismic hazard assessment of the Object 3(horizontal component, rocky soil V_{S30}=1002 m/s, expectation time 50 years)

P, % (T, year)	10 (475)	5 (975)	2 (2475)	0.05 (9950)
PGAH (g)	0.377	0.478	0.637	0.939
SAH (g) 5% attenuation (T=0.05 s)	0.559	0.712	0.952	1.371
SAH (g) 5% attenuation (T=0.1 s)	0.896	1.123	1.477	2.187
SAH (g) 5% attenuation (T=0.2 s)	0.866	1.099	1.471	2.233
SAH (g) 5% attenuation (T=0.3 s)	0.665	0.851	1.148	1.758
SAH (g) 5% attenuation (T=0.4 s)	0.542	0.701	0.964	1.466
SAH (g) 5% attenuation (T=0.5 s)	0.425	0.550	0.757	1.161
SAH (g) 5% attenuation (T=0.75 s)	0.275	0.360	0.502	0.792
SAH (g) 5% attenuation (T=1 s)	0.207	0.272	0.381	0.603
SAH (g) 5% attenuation (T=2 s)	0.095	0.127	0.182	0.304
SAH (g) 5% attenuation (T=3 s)	0.052	0.070	0.102	0.178
SAH (g) 5% attenuation (T=4 s)	0.033	0.045	0.066	0.118

Table 5 Probabilistic seismic hazard assessment of the Object 4 (horizontal component, firm soil VS30=486 m/s, expectation time 50 years)

P, % (T, year)	10 (475)	5 (975)	2 (2475)	0.05 (9950)
PGAH (g)	0.476	0.594	0.779	1.125
SAH (g) 5% attenuation (T=0.05 s)	0.676	0.850	1.124	1.629
SAH (g) 5% attenuation (T=0.1 s)	1.055	1.314	1.718	2.468
SAH (g) 5% attenuation (T=0.2 s)	1.051	1.313	1.729	2.526
SAH (g) 5% attenuation (T=0.3 s)	0.895	1.130	1.504	2.244
SAH (g) 5% attenuation (T=0.4 s)	0.767	0.979	1.326	2.015

13.4.4.2 Disaggregation of Seismic Hazard

Geological and seismological information represent the prediction basis for the earthquake scenario, which can be used for the seismic hazard deterministic assessment of a facility's construction site. Seismic event of maximum value is used for the "worst scenario". Earthquake scenario can be also determined as a great earthquake expected within the reasonable period of time. Selection of the earthquake scenario based on the hazard disaggregation practically represents the probabilistic indicator of those events, which are the greatest contributors of hazard (or damage and even loss).

Disaggregation of the probabilistic seismic hazard comprises the concept of a variable earthquake, basically, according to the magnitude, distance and other variable values determining the seismic events and the seismic hazard selected level (McGuire, 1995; Bazzurro and Cornell, 1999).

In frames of assessment of the probabilistic seismic hazard, average percentage of exceedance is calculated for each parameter of the ground motion (indicated as SA(T)); they have the fixed probabilities of exceedance. Disaggregation analysis determines those different SA(T) values, which are major contributors in the total hazard curve (e.g. those ones, which correspond to different probabilities of exceedance).

Disaggregation surveys include the following: single-dimensional 1-D magnitude with M bin, two-dimensional 2-D magnitude and distance with M-R bin and three-dimensional 3-D magnitude, distance and M-R-Epsilon bin. In this case we use 2-D M-R bin to assess magnitude-distance contribution in the given seismic hazard quantifiers (in quantitative relations).

These parameters can be also used to determine the response spectrum of a control event (scenario earthquake) or to select of actual empirical strong motion record for the dynamic analysis of a facility.

Based on the implemented surveys, earthquakes of MW=5.8-6.6 magnitude in 17-20 km distance from the objects are the greatest contributors in the seismic hazard for the all four facilities.

13.4.4.3 Deterministic Seismic Hazard Assessment

Deterministic seismic hazard assessment does not consider the time factor. Assuming the worst earthquake scenario, ground motion evaluation is based on the active faults and seismic source zones of the region.

Maximum seismic impact assessment expected from the source zones at the given facility was carried out by the peak ground acceleration (PGA) and spectral acceleration (SA).

13.4.4.4 Selection Package of Accelerograms for the Construction Sites

Materials obtained from the international databases were used for selection of accelerograms, namely - Internet-site for European Strong-Motion Database, Italian accelerometric archive (Itaca http://itaca.mi.ingv.it), accelerograms in the data bank.

Total 14 accelerograms were found in the mentioned databases. Disaggregation results showed that in frames of assessment of seismic hazard levels selected by the peak, as well as the spectral accelerations, earthquakes within the magnitude range Mw=5.7-6.6 Rjb=17-20 km distance are the major contributors for the all four facilities; here, R_{jb} is Joyner–Boore distance or a distance from the facility to the fault plane.

Deterministic seismic hazard assessment showed that the maximum magnitude of a control zone is 6.5. Therefore, earthquakes of 5.7-6.6 magnitude, at Rjb=0-20 km distance from the regions of appropriate seismic conditions and soil properties, were primarily found in the international database. Due to the lack of data, distances were increased up to 100 km within the searching process.

14 records were found. 7 out of them was for the ground of category A (EC8), which corresponds to the base-grounds of the facilities - V_{s30}=1002 m/s and 828 m/s; the other 7 records belonged to the ground of category B (EC8) corresponding to the base-grounds of the facilities - V_{s30}=633 m/s and 486 m/s.

These found accelerograms are as follows:

1) 20161030 06:40:18 (EMS-20161030_000001) Central Italy - earthquake shake records for the ground of category B*. Mw=6.5, Lat=42.83 Long=13.11, Depth=9.2, Rep=11 km (epicentral distance), Rjb=0.0 km.

2) 20120529 07:00:02 EMILIA_2ND_SHOCK (Italy) records of the second shake for the ground of category B*. Mw=6.0, Lat=44.84 Long=11.07, Depth=8.07 km, Rep=43 km, Rjb=38.89 km.

3) 19900505072119_POTENZA (Italy) earthquake shake records for the ground of category B. Mw=5.8, Ms=5.6, Lat=40.58 Long=15.85, Depth=10.0 km, Rep=29 km, Rjb=26.79 km, V_{s30}=403 m/sec.

4) 19760915 03:15:18 (ID IT-1976_0027) FRUILI (Italy) records of the second shake for the ground of category B. Mw=5.9, Ms=6.0, Lat=46.28 Long=13.20, Depth= 6.8 km, Rep=6.2 km, Rjb=3.5 km, V_{s30}=445 m/s.

5) 19760915 03:15:18 (ID IT-1976_0027) FRUILI (Italy) records of the second shake for the ground of category B. Mw=5.9, Ms=6.0, Lat=46.28 Long=13.20, Depth= 6.8 km, mechanism type – thrust TF, Rep=17 km, Rjb=16 km, V_{s30}=454 m/s.

6) 1976 09 15 09:21:18 Event ID IT-1976-0030 FRUILI (Italy) records of the third shake for the ground of category B. Ms=5.9, Mw=6.0, Lat=46.30 Long= 13.17, Depth=11.3 km, Rep=16.2 km, Rjb=12.96 km, V_{s30}=454 m/s.

7) 1976 09 15 09:21:18 (Event ID IT-1976-0030) FRUILI (Italy) records of the third shake for the ground of category B. Ms=5.9, Mw=6.0, Lat=46.30 Long= 13.17, Depth=11.3 km, mechanism type – thrust TF, Rep=4 km, Rjb=1.15 km, V_{s30}=445 m/s.

8) 20161030 06:40:18 EMS-20161030_000001 Central Italy; shake records for the ground category A*. Mw=6.5, Lat=42.83 Long=13.11, Depth=9.2, Rep=11 km, Rjb=0.0 km.

9) 20161030 06:40:18 EMS-20161030_000001 Central Italy; shake records for the ground category A*. Mw=6.5, Lat=42.83, Long=13.11, Depth=9.2, Rep=12 km, Rjb=4.41 km.

10) 20120529 07:00:02 EMILIA_2ND_SHOCK (Italy) records of the second shake for the ground of categoryA*. Mw=6.0, Lat=44.84 Long=11.07, Depth=8.07 km, Rep=80 km, Rjb=75.47 km.

11) 1976 09 15 09:21:18 Event ID IT-1976-0030 FRUILI (Italy) records of the third shake for the ground of category A. Ms=5.9, Mw=6.0, Lat=46.30, Long=13.17, Depth=11.3 km, Rep=49.6 km, Rjb=5.51 km, V_{s30}=976 m/s.

12) 1976 09 15 09:21:18 Event ID IT-1976-0030 FRUILI (Italy) records of the third shake for the ground of category A. Ms=5.9, Mw=6.0. Lat=46.30 Long=13.17, Depth= 11.3 km, Rep=85 km, Rjb=82.39 km, V_{s30}=1001m/s.

13) 19901213 00:24:26 EVENT_ID: IT-1990-0003 Sicily; records for the ground category A Mw=5.6, Lat=37.19 Long=15.47, Depth= 5 km, Rep=36.9 km, Rjb=24.58 km, V_{s30}=871 m/s.

14) 19901213 00:24:26 EVENT_ID: IT-1990-0003 Sicily; records for the ground category A. Mw=5.6, Lat=37.19 Long=15.47, Depth= 5 km, Rep=63 km, Rjb=68.89 km, V_{s30}=871 m/s.

---

* Ground category is determined by the geological data without V_{s30}.

Triple-component original records of the provided fourteen accelerograms for the horizontal components of maximum peak acceleration are given as e-version (on CD disk) that is attached to the report; while

graphics for some records are provided on the Fig. 17-23.

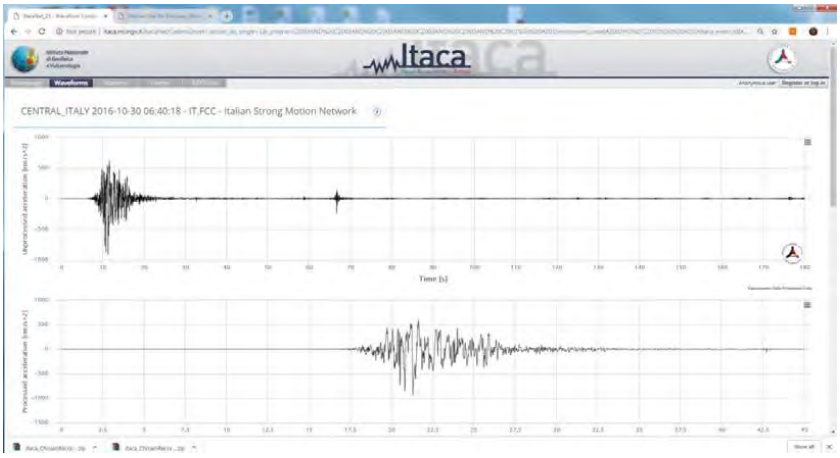


Fig. 17. 20161030 06:40:18 EMS-20161030_000001 Central Italy; shake records on the horizontal components for the ground category A*. Rjb=0.0 km.

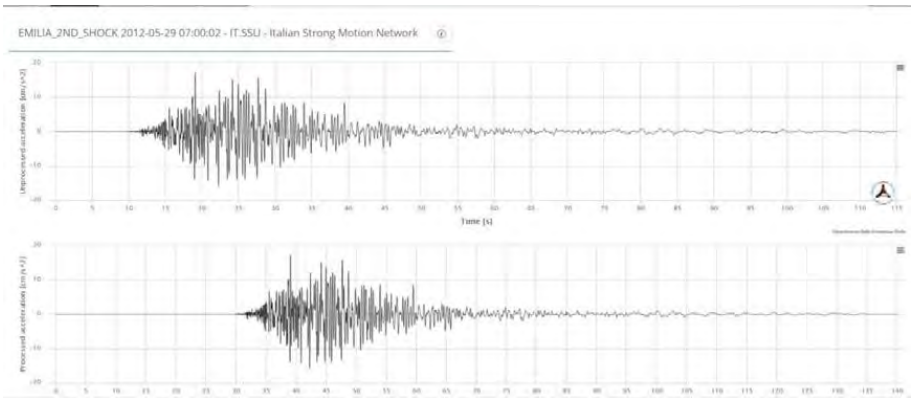


Fig. 18. 20120529 07:00:02 EMILIA_2ND_SHOCK Second shake records on the horizontal components for the ground category B*. Rjb=38.89 km.

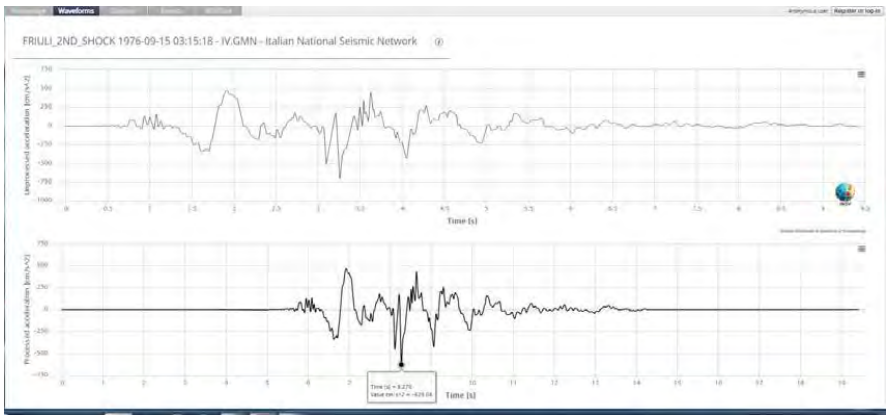


Fig. 19. 19760915 03:15:18 FRUILI (Italy) Second shake records on the horizontal components for the ground category B.
Rjb=3.5 km, Vs_{30}=445 m/s.

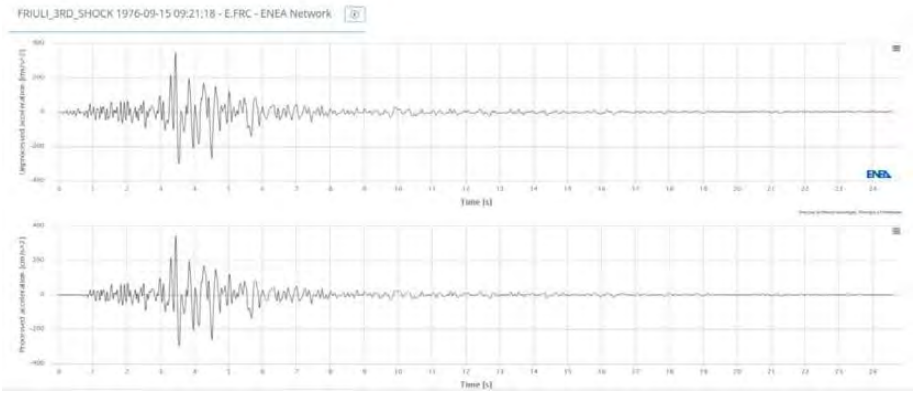


Fig. 20. 1976 09 15 09:21:18 FRUILI (Italy); third shake records on the horizontal components NS. for the ground category B. Rjb=12.96 km, Vs_{30}=454 m/s.

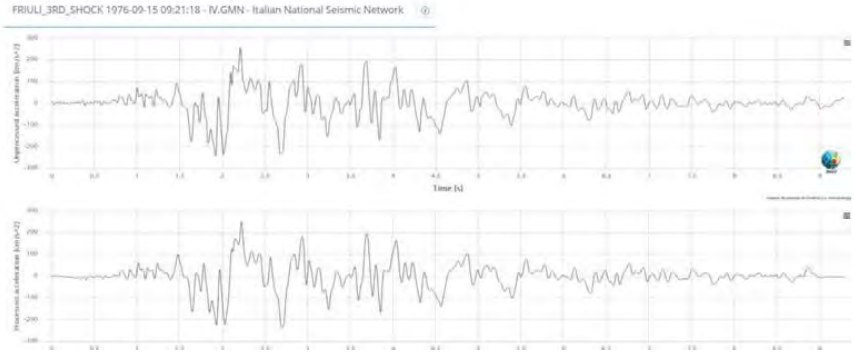


Fig. 21. 1976 09 15 09:21:18 FRUILI (Italy) third shake records on the horizontal components EW. for the ground category B. Rjb=1.15 km, Vs30=445 m/s.

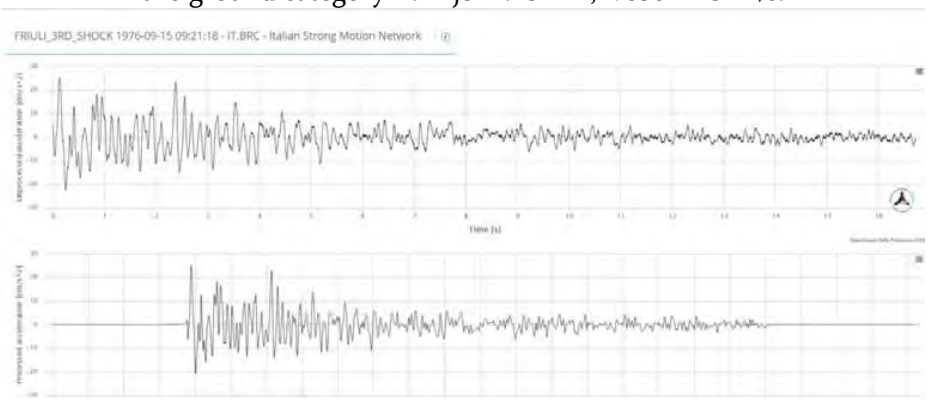


Fig. 22. 1976 09 15 09:21:18 FRUILI (Italy) third shake records on the horizontal components EW. for the ground category A. Rjb=45.51 km, Vs_{30}=976 m/s.

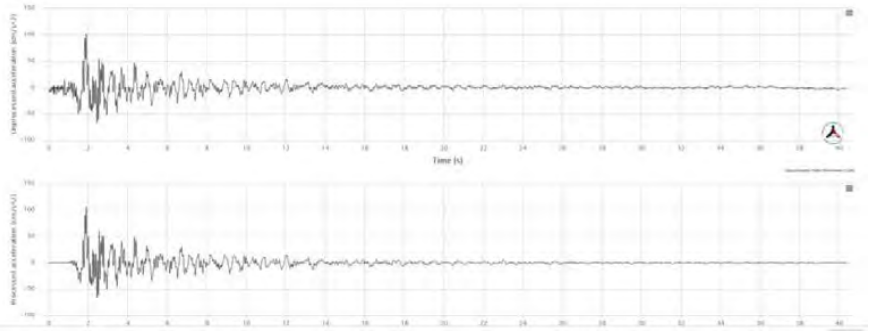


Fig. 23. 19901213 00:24:26 EVENT_ID: IT-1990-0003 Sicily; records on the horizontal components EW. for the ground category A. Rjb =24.58 km, Vs30=871m/s.

13.4.5 Conclusions

Seismicity of the surrounding area of the project facilities has been studied in detail. Based on the

guideline principles of selection seismic parameters for significant hydrotechnical structures, two calculating levels of base-ground motions of the facilities were determined, namely: Operating (period) Basis Earthquake (OBE) (average return period T=475, probability of exceedance P=10%, time of expectation t=50 years) and Safety Evaluation Earthquake (SEE) (T=9950 (~10 000) years, P=0.5%, t=50 years).

Seismic analysis of the observed study region was conducted. Strong historical and modern earthquakes occurred in the vicinities of the project facilities formed the highest seismicity (7-9 MSK) during the past historical period. This indicates to the high seismic activity of the surrounding local area of the facilities within the entire historical period of observation.

28 seismically active faults of the given region have been described to determine regularity of the study region seismotectonical conditions or the seismic source zones. They were revealed based on the geological, geophysical, morphological and seismological data.

Map of seismic source zones was made on the basis of active faults determined by the complex data. The map presents the potential seismic capacities of the study region. 23 source zones were singled out in this region, which are differentiated within seven magnitude range ($4.5 \leq M_{max} \leq 7.5$) of 0.5 bins. Parameterization of the source zones was also carried out.

Seismic hazard assessment of the facilities was implemented by the probabilistic and deterministic approaches, for the peak ground acceleration (PGA) and spectral acceleration (SA) of 0.1,...,4 s periods, for the base-grounds of each facility. In frames of calculation of seismic hazards, well-known European and American programs OPENQUAKE and EZFRISK™ were used.

Appropriate probabilistic values of ground motion calculating two levels for hydrotechnical structures - OBE and SEE - corresponding to the horizontal components of 475 and 9950 return period on base-grounds, are as follows for PGA with 50 expectation period (see tables 2-5): Facility1: 0.42 g, 1.04 g; Object 2: 0.44 g, 1.07 g; Object 3: 0.38 g, 0.94 g; Object 4: 0.48 g, 1.13 g. Ground motion vertical components are accepted as 2/3 of the horizontal components.

Magnitude-distance disaggregation results for the facilities for 475 and 9950 return periods (50 expectation period) and for 5% attenuation are given in the Tables 6-9. Based on the disaggregation results analysis, earthquakes with MW=5.8-6.6 magnitude are the greatest contributors in the seismic hazard for the four facilities; epicenters of these earthquakes are observed in 17-20 km distance from the facilities.

Deterministic seismic hazard assessment of the facilities was carried out for the highest magnitude of all source zones, on the shortest distance to the facility for 0.5 and 0.84 quantiles. According to the deterministic assessment of 0.5 quantile (see Tables 10-13), high seismic hazard is expected from #12 source zone, where the facilities are located: 0.48 g (V_{s30}=828 m/s), 0.50 g (V_{s30}=633 m/s), 0.44 g (V_{s30}=1002 m/s), 0.52 g (V_{s30}=486 m/s). Table 14-21 presents deterministic seismic hazard from #12 control zone for 0.84 quantile. In this case PGA predicting values achieve 0.83 g (V_{s30}=828 m/s), 0.88 g (V_{s30}=633 m/s), 0.78 g (V_{s30}=1002 m/s), 0.91 g (V_{s30}=486 m/s). Calculation results performed by 0.84 quantile exceed the results obtained by 0.5 quantile almost for twice. Such differences somehow restrict use of results obtained by the deterministic method and prefer the results obtained by the probabilistic method (See Tables 2-5).

Materials from the international databases were used for selection of accelerograms package. Namely, 14 records were found. 7 out of them were for the ground of category A (EC8) corresponding to the facilities' base-grounds with V_{s30}=1002 m/s and 828 m/s values and the other 7 records were for the ground category B (EC8) corresponding to the facilities' base-grounds with V_{s30}=633 m/s and 486 m/s values. Comparison of selected strong motion records to our deterministic assessment values revealed positive correlation based on the corresponding magnitudes and distances. It means that use of these

accelerograms is allowed for peak and spectral accelerations for all seismic hazard levels.

13.5 Annex 5. Waste Management Plan Generated during Construction and Operation Process of Akhalkalaki HPP

13.5.1 Introduction

Waste Management Plan generated during the construction and operation process of Akhalkalaki HPP is presented in the given paragraph. Waste Management Plan is prepared based on the current information about the planned activity. Specification and adjustment of certain issues of the plan will be conducted prior to the construction (after selection of the construction contractor and determination of the construction organization issues in details) and after completion the construction works (prior to commissioning the HPP).

The present waste management plan is prepared based on the requirements of "Waste Management Code". Under the paragraph 1, article 14 of this law, "the natural or legal entity, whose activity causes the generation of more than 200 t non-hazardous waste or more than 1000 t of inert waste or hazardous waste more than 120 kg[5], is obliged to develop Waste Management Plan of the company".

The waste management plan should be updated in every 3 years or when substantial amendments will be made to the existing waste types or amounts or to their treatment procedures.

As during planned activities, generation of significant amount of non-hazardous and inert wastes, as well as hazardous waste (more than 120 kg per annum) is expected, the waste management plan is developed for the waste generated during construction and operation of the HPP, which includes the following information, according to the Technical Regulation on Approval of the Rule for Review and Agreement of a Company's Waste Management Plan:

- Information on implementer company;
- Tasks and goals of the Waste Management Plan;
- Hierarchy and principles of the waste management;
- Generated waste;
- Information on measures considered for the waste prevention and recovery;
- Description of waste separation method;
- Methods and conditions for temporary storage of waste ;
- Waste transportation rules;
- Waste treatment methods used. Based on the capabilities existing at this stage, the information about person/organization who will be responsible for further treatment of wastes;
- Requirements for the safe treatment of waste;
- Waste control methods.

Information on the implementer company is given in the table below:

Implementer company	Aisi LLC
Legal address of the comaony	BuildingN1 (lit „a"), Didube Settlement St. #13, Gldani-Nadzaladevi District, Tbilisi, Georgia
Adress of project implementation	Akhalkalaki municipality
Activity	Construction and operation of run-off the river HPPs

[5] Decree №446 of the Government of Georgia; September 16, 2016, Tbilisi, about approval of regulation rule for some obligations, determined by Waste Management Plan. Amendments are introduced. Till January 1, 2020 natural or legal entity is free from the obligation of development of the company's Waste Management Plan, if it carries out the activity, enlisted in the economic activities, determined by the national classifier of Georgia, which is approved by the decree №10 of National Statistics Service of Georgia, July 278, 2016, or other activity, and if the company generates 120kg or less hazardous waste a year.

	and the ETL
Contact detailes of Aisi LLC :	
ID code	400251543
E-mail	tmatitashvili@ais-georgia.ge ;– hsabouri@ais-georgia.ge
Contact person	Teimuraz Matitashvili
Tel:	(+995) 593320216
Consulting company:	Gamma Consulting LTD
Director of Gamma Consulting LTD	Z. Mgaloblishvili
Contact person:	Giorgi Bzhalava
Tel:	(+995) 577641880

13.5.2 Goals and Tasks of Waste Management Plan

The present waste management plan sets the rules for collection, transportation, disposal, neutralization and utilization of waste, generated during the construction and operation process of the HPPs, in compliance with requirements of sanitary-hygienic and epidemiological standards and regulations.

The main objectives of waste management process:

- To provide waste identification according to their types;
- To provide waste separation and collection, to keep rules necessary for their temporary storage, in order to exclude their harmful impact on environment or human health;
- To provide waste transportation so that exclude waste scattering, loss, creating emergency situations, posing threats for the environment or human health;
- To use methods, safe for human health and environment during waste neutralization, reprocessing or utilization;
- To reduce the amount of waste;
- Reusing wastes;
- To define personnel responsibility on waste management;
- To provide industrial and household waste record.

The present plan includes all types of planned activities, when waste will be generated, including:

- Usual work (construction and operation) conditions;
- Unusual work conditions (e.g.: during repairing works);
- Work in emergency situations.

To follow the directives set in the plan is mandatory for all staff members of the executor company –Aisi LLC.

13.5.3 Waste Management Hierarchy and Principles

In Georgia waste management policy and Georgian legislation in waste management field is based on the following hierarchy

- Prevention;
- Preparation for reusing;
- Recycling;
- Other recovery types, including energy recovery;
- Disposal.

When defining certain responsibilities regarding waste management hierarchy, the following should be considered:

- Environmental benefits;
- Technical feasibility by using the best available equipment
- Economic practicability.

The waste management should be implemented avoiding threats to environment and human health, namely, so that waste management:

- Does not pose threats to water, air, soil, flora and fauna;
- Does not cause noise and odor occurrence;
- Does not negatively impact on the entire territory of the country, especially on the protected areas and cultural heritage

Waste management is carried out in consideration of the following principles:

- „The principle of taking preliminary security measure" – The measures should be taken in order to prevent threats to the environment posed by wastes, even when there is no scientifically approved data;
- The principle of "polluter pays" – the waste generator or waste holder is obliged to cover waste management expenses;
- „Proximity principle" – wastes should be treated on the nearest waste treatment facility, considering environmental and economic efficiency;
- "The principle of self-dependence" – integrated and adequate network of municipal waste disposal and recovery facilities should be set up and operate.

13.5.4 Information on the Planned Activity

Akhalkalaki HPP construction and operation project is described in detail in the Paragraph 3, of the given EIA report.

13.5.5 Waste Generated during Project Implementation and Their Approximate Amounts

Waste types, codes, approximate amount and determination of hazardousness of waste, expected during project implementation are given in Table 13.4.5.1.

Table 13.4.5.1. List of waste expected during implementation of the planned activity

Waste code	Name	Waste physical state	Hazardous (yes/no)	Hazard characteristic	Approximate amount of generated wastes as to years			Disposal/recovery operations	Contractor company	Basel code Y
					2020 Construction phase	2021 Construction phase	2022 Operation phase			
08 01 11*	Waste paint and varnish containing organic solvents or other hazardous substances (as well as paint container)	liquid/ solid	Yes	H-3B – „flammable“ H 5 – „hazardous“	30-50 kg/a	50-100 kg/a	20-30 kg/a	D 10	Will be transferred to the properly licensed organizations: (Nasadgomari ltd“[6], Sanitari ltd“[7]).	Y12
12 01 10*	Synthetic machining oils/lubricants (waste of oil products, lubricants (liquid waste generated from used transport vehicles and their maintenance))	Liquid	Yes	H 3-A - „easily flammable“ H 3-B - „flammable“ H 5 - „harmful“	30-50 kg/a	50-100 kg/a	20-30 kg/a	R9	Will be transferred to the properly licensed organization (Sanitari ltd)	Y8
12 01 13	Welding wastes (welding electrodes)	Solid	No	-	10-20 kg	10-20 kg/a	10-20 kg/a	D1/R4	Will be disposed on a household waste landfill or will be transferred to the licensed contractor	-
13 07 03*	Other fuels (including mixtures	Liquid	yes	H 3-A - „easily flammable“ H 3-B - „flammable” H 5 - „harmful“	10-20 kg/a	10-20 kg/a	10-20 kg/a	R9	Will be transferred to the properly licensed organization (Sanitari ltd)	Y8

[6] **Nasadgomari ltd** – aim of activity – disposal of toxic and hazardous wastes, arrangement of their repositories or/and waste recyclying, neutralization. Ground of permit issuing – conclusion of ecological expertise №91; 22.12.2006;

[7] **Sanitari ltd** - aim of activity - „Plant of hazardous waste neutralization (arrangement of a polygon for neutralization of industrial chemical wastes and bioremediation of oil contaminated soil. Ministry of Environment and Natural Resources Protection of Georgia. Environmental Impact Permit №000021, code MD1, 08/10/2013 წ. Ground of permit issuing - conclusion of ecological expertise №51; 07.10.2013.

13 07 08*	Easily biodegradable oils of engines and gears and other oil lubricants	Liquid	Yes	H 3-A - „easily flammable“ H 3-B - „flammable” H 5 - „harmful“	10-20 kg/a	10-20 kg/a	10-20 kg/a	R9	Will be transferred to the properly licensed organization (Sanitari ltd)	Y8
13 07 09*	Other oils of engine and gears and other oil lubricants	Liquid	Yes	H 3-A – “easily flammable“ H 3-B - „flammable” H 5 - „harmful“	10-20 kg/a	10-20 kg/a	10-20 kg/a	R9	Will be transferred to the properly licensed organization (Sanitari ltd)	Y8
15 01 01	Paper and cardboard packaging	Solid	No	-	200-300 kg/a	200-500 kg/a	50-100 kg/a	D1	Will be disposed on a household landfill	-
15 01 02	Plastic packaging (polyethylene wastes, packaging sealing material, pipes, etc.)	Solid	No	-	100-200 kg/a	100-300 kg/a	50-70 kg/a	D1	Will be disposed on a household landfill	-
15 02 02*	absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by hazardous substances	Solid	Yes	H 3-B - „flammable” H 5 - „harmful“	50-100 kg/a	50-100 kg/a	50-100 kg/a	D 10	Will be transferred to the properly licensed organization (Sanitari ltd)	-
16 01 03	end-of-life tyres	Solid	No	-	1000-2000 kg/a	2000-5000 kg/a	200-500 kg/a	R1, R3, R4	Wll be transferred to a sub-contractor having tyres utilization infrastructure	Y13
16 01 07*	Oil filters	Solid	Yes	H 5 - „harmful“ H-15	50-100 kg/a	50-100 kg/a	20-50 kg/a	D10	Will be transferred to the properly licensed organization (Sanitari ltd)	-
16 01 17	Ferrous metal	Solid	No	-	50-100 kg/a	100-200 kg/a	10-20 kg/a	R4	Will be delivered to a scrap metal receiving point	-
16 01 18	Non-ferrous metal	Solid	No	-						
16 06 01*	Lead batteries (lead containing batteries of construction vehicles and special machinery)	Solid	Yes	H 6 – „toxic“ H-15	100-200 kg/a	200-300 kg/a	100-200 kg/a	D9	Will be transferred to the organization authorized management of hazardous waste, (Mart Recycling LLC)	Y31

17 04 11	Cables other than those mentioned in 17 04 10	Solid	No	-	20-50 kg/a	20-50 kg/a	10-20 kg/a	D1	Will be disposed on the construction waste polygon	-
17 05 03*	Soil and stones containing hazardous substances (soil and ground contaminated with oil hydrocarbons)	Solid	Yes	H 5 - „harmful“	Depends on spill scales			D2	Will be transferred to the organization authorized management of hazardous waste	-
17 05 05*	Dredging spoil containing hazardous substances (soil and ground contaminated with oil hydrocarbons)	Solid	Yes	H 5 - „harmful“	Depends on spill scales			D2	Will be transferred to the organization authorized management of hazardous waste (Nasadgomari ltd, Sanitari ltd)	-
17 05 06	Dredging spoil other than those mentioned in 17 05 05 (soil excavated during earth works and arrangememnt of foundations)	Solid	No	-	40-50 thousands m^3	10-20 thousands m^3	-	D1	Part of soil excavated during the earth works will be used for filling of foundations of hydro technical structures, for improvement of roadbeds and other works. The other part will be disposed on spoil grounds (See the Paragraph 3.7.1.) of the EIA report)	-
20 01 21*	fluorescent tubes and other mercury-containing waste	Solid	Yes	H 6 - „toxic“	5-10 kg/a	5-10 kg/a	5-10 kg/a	D 9	Will be transferred to the properly licensed organization (Sanitari ltd)	Y 29
20 03 01	Mixed municipal waste	Solid	No	-	56 m^3/a	56 m^3/a	7 m^3/a	D 1	Waste will be disposed on the household landfill	Y 46
20 03 04	Septic tank sludge	Liquid	No	-	≈855 m^3/a	≈855 m^3/a	330 m^3/a	D 4	Will be transported by a closed body vehicle and discharged in the nearest sewage system	-

13.5.6 Description of Waste Management Process

13.5.6.1 Measures Considered for Waste Prevention and Recovery

Following measures for waste prevention and recovery will be considered during the implementation of the planned activates:

- Any type of building materials, items or substances will be brought into the territory in the amount required for the construction works/ proper implementation of technological process. Long-term storage of the material on the site does not occur;
- A large part of building materials, structures, subjects necessary for technological processes will be brought in finished forms (e.g.: inert materials, timber, etc.);
- During purchasing of building materials, structures, subjects for technological processes the priority will be given to the environmental and quality products. Products will be checked for compliance with international standards (e.g. PCB of Persistent Organic Pollutants in oil products will be controlled);
- Preference will be given to substances that are re-usable or subject to recycling, biologically degradable and safe for the environment, materials and chemical compounds;
- Strict control of borders of the construction corridor, in order not to cross the marked zone and prevent additional generation of inert and vegetation waste;
- Generated waste will be re-used as far as possible (for example: steel structures, polyethylene materials, etc.).

13.5.6.2 Separated Collection of Waste

During the implementation of the planned activities, waste separate collection methods according to their types and hazards will be organized and implemented:

- Two plastic containers of different colors with relevant inscriptions will be arranged on construction camps and construction sites, as well as on the territories of the powerhouses:
  - One of them will be designated for the collection of household waste;
  - The second - for collection of solid hazardous waste such as: Vehicle oil filters, oil polluted rags, other cleaning products, paint containers free from liquid mass, welding electrodes;
- Outdated and malfunctioning batteries (undrained of accumulator acid) will be removed directly to a temporary storage area (storage facility) and disposed in wooden boxes, which will have a metal pallets;
- Liquid hazardous wastes (oil, lubricants, paint remains, etc.), will be collected separately in plastic or closed metal barrels and removed to the temporary storage area;
- Luminescent bulbs and others, mercury-containing items will be placed in well-closed plastic bags and then in a cardboard packaging and will be removed to a temporary storage area;
- Used laser printer cartridges will be placed in well-closed plastic bags and will be removed to a temporary storage area;
- Used tires will be collected on waste generation areas, on open areas with solid pavement;
- Contaminated soil and ground will be stored in the vicinity of the place of occurrence, on an area with solid cover;
- Wood waste will be collected on-site of generation, on a specially designated site; Sawdust-in a shed or on area covered with polyethylene;
- Ferrous and non-ferrous scrap will be accumulated on-site of generation in a specially designated area;
- Polyethylene waste (packaging, sealing materials, pipes, etc.) will be accumulated on-site of generation, in a specially designated area;

<u>Following will be prohibited:</u>

- Accumulation of waste at the site of generation for a long time (more than 1 week);

- Storing hazardous waste in containers designated for solid household waste;
- Collection and storage of liquid hazardous waste on open areas, not protected from precipitation;
- Burning of rubber and other waste;
- Discharging oil, lubricants, electrolytes into river or sewer system;
- Mechanical impact on accumulators and cartridges;

13.5.6.3 Methods and Conditions for Temporary Storage of Waste

Waste rocks generated during the works implementation will be used for the project purposes as far as possible.

Following conditions should be considered for temporary storage sites of waste generated during the planned activities:

- During the construction and operation phases, storage facility will be arranged for hazardous waste, in accordance to the following requirements:
  - Storage facilities will have appropriate signs and will be protected from exposure to atmospheric precipitation and strangers' encroachment;
  - Warehouse floor and walls will have hard covers;
  - Warehouse ceiling will be faced with moisture resistant materials;
  - The facility will be equipped with a wash stand and tap, water intake trap;
  - Shelves and racks will be arranged for placement of waste;
  - Waste will be placed only in sealed packages, which will have the proper labeling.

The sites for temporary storage of waste will meet the following requirements:

- Pavement of the site will be solid;
- The whole perimeter of the site will be fenced in order to exclude spills of harmful substances into the river or soil;
- Convenient access road to the site should be ensured for cars;
- Precipitation and wind exposure to the waste is subject to the effective protection (shed, waste disposal in containers, etc.);
- Appropriate signs will be arranged throughout the perimeter and site will be protected from encroachment of strangers;

13.5.6.4 Waste Transportation Rules

Waste will be transported in full compliance with sanitary and environmental regulations:

- All operations related to waste loading/unloading and transportation will be mechanized and hermetic;
- Loss and scattering of waste during transportation is prohibited;
- During transportation the accompanying person will have the document – "demand on the removal of hazardous waste", which must be approved by the management.
- After the completion of transportation the vehicles should be cleaned, washed and made safe (the vehicles should be washed in the car-washings, existing in the region, washing vehicles in riverbeds is prohibited);
- A vehicle used for waste transportation should have a warning sign.

While transportation of hazardous wastes, waste generator is mandatory to prepare an information sheet of hazardous wastes (see the form of information sheet below) separate for each waste; it should include information on waste generation,classification and hazardous properties, as well as information on safety measures and primary aid in case of accident. The information sheet should also include samples of signs of hazardousness for marking of containers/vehicles. Each transportation of hazardous wastes must be accompanied by this sheet.

Information Sheet of Hazardous Waste

Code of hazardous waste _____			**Name of hazardous waste** _____
Hazardous properties	Classification system	H codes	Hazard defining characteristics
	Main:		
	Additional:		
Process/activity that generate hazardous waste			
Physical properties	Solid ☐ Liquid ☐ Sludge ☐ Gas ☐	Note	
Chemical properties	Acid ☐ Alkaline ☐ Organic ☐ Inorganic ☐ Soluble ☐ Insoluble ☐	Note	
Type of packaging or container _____		Hazard signs that should be used for storage/transportation _____	
First aid _____		Measures for emergency situations _____	

13.5.6.5 Waste Treatment/Final Disposal

Household waste in the containers will be removed (presumably for 2-3 times in amonth) to the nearest landfill (Kutaisi landfill), according to accumulation.

Other types of wood waste (pads, planks, etc.) will be reused if possible or passed on to local authorities / residents after appropriate procedures. The unused portion of the plant waste will be disposed of in the existing landfill.

The scrap metal will be delivered to the scrap metal receiving points.

All types of hazardous waste will be transferred to a contractor with appropriate authorization for further management (contractor will be specified prior to commencement of works).

Waste rocks will be used as much as possible for the purpose of the project (backfilling, reconstruction of roads, etc.). Useless ground will be disposed on spoil grounds. Waste rocks disposal on a spoil ground will be carried out in compliance with the following conditions:

- Natural slope angle of the territories selected for the spoil grounds should be no more than 1:2
- Safe movement of transport vehicles to the spoil ground site will be provided;
- Prior to using of each spoil ground site, trees and vegetation should be cleared and topsoil (if any) should be removed;
- Transportation of waste rocks to the spoil grounds will be carried out with strict adhering of traffic rules; movement speed should be reduced as minimum (5-20 km/h). Traffic movement will be regulated by a special personnel (flag bearer);
- Natural slope angle of the sites selected for the spoil grounds should be no more than 1:2. Tilt angle of piles' slopes will be 40^0;
- Stockpiles will be disposed far from the active riverbed provided that not to disturb hydro-morphological state of a specific section and to provide free release of maximum flood flows;
- Waste rocks will be placed into sections, layer-by-layer;
- Height of each stockpile (filling) will be about 2 m; the second and third layers will be disposed in the same way;
- Boundaries of the spoil grounds territories will be strictly controlled, in order not to occur waste rocks beyond the perimeter and not to damage vegetation cover;
- After filling the spoil grounds, recultivation works are considered on their slopes and surface, namely, topsoil will be placed and loosed on their surfaces;
- After closing of spoil grounds, monitoring on the erosive processes will be proceeded and appropriate adjustment measures will be carried out if necessary.

13.5.6.6 General Requirements for Safe Waste Handling

- Personnel who are engaged in the waste management (collection, storage, transportation, receipt/delivery) would have undergone appropriate training on health and safety issues;
- Staff will be provided with special uniforms, footwear and personal protective equipment. If necessary, staff clothing are subject to special treatment, especially after performing works related to hazardous waste;
- Personnel should be able to carry out first aid in case of poisoning or trauma during working with waste;
- A person who has not taken the proper training, has no special clothing or has signs of sickness, will not be allowed on working area;
- On the site of waste generation, the disposal of waste, more than allowable rate, is prohibited. The waste disposal is not allowed near the igneous and sparking sources.
- In case of disposing several types of waste together, their compatibility will be considered;
- Storing of strange objects, personnel clothing, uniforms, individual protection means, as well as eating on waste accumulation area is prohibited;
- During working with waste, personal hygiene norms should be protected; after finishing the work it is necessary to wash hands with soap and warm water;
- In case there are some signs of poisoning, a person should stop working and must apply to the nearest medical center and notify the authorities of the structural unit;
- Firefighting equipment will be provided on fire hazardous waste collection sites. In such areas, smoking and using open fire is strictly forbidden;

- Personnel should be aware of the waste properties and firefighting rules. Extinguishing of burning easily inflammable or combustible liquids is possible through fire-extinguishers, sand or asbestos tissues;
- To extinguish the burning solvents with water is prohibited

13.5.6.7 Waste Control Methods

During construction and operation phases, properly trained personnel will be designated, who will be periodically trained and tested. The mentioned personnel will keep a special register, special entries will be made. The volume of generated, accumulated and removed waste should be recorded and documented

People responsible for waste management will systematically control the following:

- Suitability of waste collection containers;
- Labeling of the container;
- Condition of temporary disposal sites/storage facilities;
- Volume of accumulated waste and compliance with the established standards (visual control);
- Following of periodicity of waste removal from structural unit area;
- Protection of environmental security and safety protection requirements.

According to the requirement of technical regulation on "Determination and Classification of Waste List as to their Types and Characters" – generator of wastes is obliged to present the e-form of initial inventory document of wastes to the Ministry of Environment Protection and Agriculture of Georgia via the official web page – www.moe.gov.ge.

Accordingly, the person responsible for waste management shall submit the primary waste inventory document as follows:

დანართი 3

ნარჩენების პირველადი ინვენტარიზაცია

ნაწილი 1

ინფორმაცია ნარჩენების წარმომქმნელის შესახებ

კომპანია .....

(დასახელება, რეგისტრაციის ნომერი)

წარმომადგენელი.....

(სახელი, პოზიცია, საკონტაქტო ინფორმაცია)

იურიდიული მისამართი.....

(რეგიონი,მუნიციპალიტეტი, ქალაქი, ქუჩა, ტელეფონის ნომერი, ფაქსი ელექტრონული ფოსტა)

ნარჩენების წარმოქმნის ადგილმდებარეობა.....

(რეგიონი,მუნიციპალიტეტი, ქალაქი, ქუჩა, ტელეფონის ნომერი, ფაქსი ელექტრონული ფოსტა)

საკონტაქტო პირი ნარჩენების წარმოქმნის ობიექტზე

.....

(სახელი, პოზიცია, საკონტაქტო ინფორმაცია)

ნარჩენების წარმომქმნელის საქმიანობის მოკლე აღწერა

.....

ნარჩენის მოკლე აღწერა

ნაწილი 2

ობიექტზე წარმოქმნილი ნარჩენების წუსხა

ნარჩენის კოდი	ნარჩენის დასახელება	სახიფათო (დიახ/არა)	სახიფათოობის მახასიათებელი	განთავსების/აღდგენის ოპერაციები	ბაზელის კონვენციის კოდი (Y)

13.6 Annex 6. Emergency Response Plan for Emergencies and Catastrophic Events during the project Implementation Process

13.6.1 Objectives and Tasks of the Emergency Response Plan

The goal of the given Emergency Response Plan is to create and define guidelines for Akhalkalaki HPP constructing and operator company personnel, in order to ensure the provision of rational, coordinated and efficient activities by the personnel, working within the project and other staff, during the response and liquidation process on manmade accidents and incidents of any scale, as well as protection of staff, population and environment.

Objectives of the given Emergency Response Plan are as follows

- Identify possible emergency types during implementation of planned activities according to its specification;
- Define each emergency response group members, equipment, action plan and responsibilities during emergency situations;

- Identify internal and external communication system, their order, communication ways and methods and ensure delivery of notification (information) about emergency situation;
- Immediate activation of internal resources and if necessary, mobilization of additional resources according to stated rules and definition of relevant procedures;
- Ensure activation of emergency response organizational system;
- Ensure compliance with the legislative, regulatory and industrial safety requirements of the internal code of conduct during emergency response process;

Emergency response plan considers the laws of Georgia and requirements of the legislative acts.

13.6.2 Types of Emergency Situations

Following emergency situations are determined in Georgia in compliance with the national legislation:

- Manmade;
- Natural;
- Social;
- War

In Georgia following levels of emergency situations are identified according to the volume of consequences of the emergency situation, amount of response force and material resources necessary for their eliminations, as well as area and scale of emergency situation:

- National;
- Autonomous;
- Regional;
- Local;
- Object.

The presented document defines the emergency response plan for manmade and natural emergency situations on the object or local level.

Considering the specification of the planned activity, following emergency situations are expected:

- Emergency situations related to damage of hydro technical structure, including damage of the water intake and penstock;
- Risks of emergency risks of pollutants;
- Fire (including, landscape or forest fire);
- Traffic accidents;
- Injury of personnel (traumatism).

In addition, due to the physical-geographical baseline condition of the project area, following natural processes can be developed within the area of Akhalkalaki HPP location and endanger stability of the HPP engineering structures and human safety:

- As a result of long-term unfavorable meteorological conditions, flooding of the river and generating of catastrophic flow though the headwork/power house location section;
- Development of landslide-gravitational processes (landslide, avalanche) within the HPP corridor and direct damage of the engineering structures;
- Development of the landslide-gravitational processes upstream of the HPP, which blocked the riverbed and the risk of sudden breakdown of the weir may arise and uncontrolled flow/debris flows of stony-muddy mass can occur through the HPP corridor;
- Earthquake.

It should be noted that above-mentioned emergency situations may be the concomitant process and one emergency situation can cause the other emergency situation

13.6.2.1 Emergency Situations Related to Hydraulic Structure Damage – Hydro Dynamic Accident

On the operation phase of the HPP, the damage of hydraulic structures and associated accompanying process development is noteworthy.

Damaging factors of the hydraulic structures can be:

- Manmade: design errors, failure to execute construction norms and violation of operation conditions, lack of professionalism of staff, incompetence and negligence, terrorism, acts of war, etc.;
- Natural: extreme water runoff, ice phenomena, hazardous meteorological phenomena, long-term climate change (global warming), earthquakes, landslides, mudflows, avalanches, etc.

On the hydro technical structure, emergency situation can be as follows:

- Damage of headwork;
- Damage of the penstock;
- Damage and malfunction of technological installations-mechanisms (water intake gates)

Considering the location, morphological-geological and climatic conditions, there are the risks of damage of hydraulic structures by the natural factors. But, it should be noted that construction of a high dam and reservoir is not planned that significantly reduce the risks of unfavourable situations and their scales.

13.6.2.2 Accidental Spill of Pollutants

Oil spill risk may be related to violation of storage condition, fuel or oil leakage from vehicles and equipment, etc.

In terms of oil and oil product spill on construction phase of the project sensitive districts are construction camps (mainly warehouses) and all construction sites, where machinery and other equipment are intensively used.

There are following high-risk areas during the operation phase

- Powerhouse territories (spill and distribution of transformer oils, spill and spread of turbine oils into discharge water);
- Storage areas of oils, oil products and other hazardous substances.

Subsequent processes of such emergencies may be:

- Fire/explosion;
- Poisoning of personnel or population

13.6.2.3 Fire/Explosion

Risk of fire distribution and explosion may occur both, during construction and operation phases of the HPP. Considering the natural conditions of the project implementation area, accident causing factor can mainly be man-made, namely: indifference of the construction or service personnel and violation of safety rules, violation of storage and consumption rules of oil products, oils and other flammable/explosive materials, etc. however, explosion and fire may be also cause by natural events.

It should be noted that the project implementation and location of certain structures of the project infrastructure is planned in the vicinities of the dense forests. Consequently, risks of landscape fires, especially, during the construction process are considerably high.

Sensitive site in terms of fire and explosion risks during construction is the Construction camp area, namely storages of inflammable and explosive materials.

Fire/explosion is mainly expected within the areas of the powerhouse.

Subsequent process of fire/explosion may be:

- Activation of geodynamical processes: landslide, erosion, crumble of ceilings and walls in underground spaces;
- Salvo emission/spill of hazardous substances;
- Personnel or population traumatism and health safety-related incidents.

13.6.2.4 Traffic Accidents

Trucks and heavy machinery will be used during implementation of the project. Following risks are expected while using public and access roads:

- Collision with other vehicles, moving on the road;
- Collision with local population;
- Collision with personnel working on the project;
- Collision with other project equipment and machinery;
- Collision with local infrastructure;

High risk of accidents will be associated with relatively intense movement of vehicles and construction equipment. A number of preventive measures must be carried out in order to minimize such risks, including: limitation of speed, placement of warning signs, selection of optimal routes, traffic regulation with help of standard-bearer, etc. Machinery must be accompanied with specially equipped techniques and trained personnel; this will dramatically reduce risks of collisions or digress from the road. Additionally, it is preferable to plan and implement transport operations basing on agreement with management of other projects of the region.

13.6.2.5 Personnel Traumatism

Apart from other accidents traumatism of the personnel may be cause by:

- Incidents related to use of heavy machinery/equipment;
- Falling from slopes or other heights;
- Falling into pits, hollows and trenches;
- Poisoning with used chemicals;
- Electric shock due to work near machinery under high voltage.

13.6.2.6 Natural Emergency Situations (Catastrophic Events)

Proper, timely and orderly response on emergencies of natural character during implementation of planned activities is of great importance, since natural disasters may provoke any type of emergency listed above.

River flooding and mudflow, as well as landslide-gravitational processes, are noteworthy from the natural disasters within the project corridor. Therefore, it is crucial to pay maximum attention and adhere to safety norms while working in complex relief conditions (riverbeds, near the steep slopes), especially in periods of precipitation.

13.6.3 Basic Preventive Measures of Emergencies

Prevention of damage of hydraulic structure:

- Construction/founding of hydro technical structures with consideration of the engineering-geological conclusion. Conduct of reinforcing works on the sites dangerous in terms of development of hazardous geodynamic processes;
- Professional development of staff and training of special personnel in field of emergency situations;
- Organization of monitoring service to supervise hazardous events and technical conditions of hydraulic units;
- Providing monitoring works of development hazardous geodynamic processes on the sensitive sites;
- Adhere to safety norms, correction of engineering solutions for every stage of construction and operation of hydraulic structures, if required;
- Organizing monitoring works on the sediment accumulation and recurrent flushing of the headwork;
- Protection of hydraulic units.

Prevention of oil product or oil spills:

- Strict monitoring over delivering, storage, consumption and disposal procedures of oil products and oils. Verification of suitability of storing containers;
- Periodical inspection of technical condition of oil-containing machinery;
- Discontinue of works as soon as small spill accident is observed to prevent escalation of the incident;
- Each turbine must be equipped with oil level gauge. Such devices must control amount of oil within the hydro-turbines. In the events of significant reduction of oil in the turbine, which indicates on a massive leakage, operation of turbine must be ceased with consideration of relevant procedures and the technical error must be eliminated.

Fire preventive measures:

- Periodical training and testing of staff on fire prevention matters;
- Storage of inflammable and explosive materials in safe areas. Arrangement of special indications on areas of storage;
- Adhering of fire fighting norms and existence of effective fire fighting inventory on the territory;
- Adhering of electrical safety;
- Arrangement of lightning rods and control over their functionality;
- Allocation of safe space for smoking. Such areas must be equipped with relevant fire fighting inventory;
- For the operation phase, arrangement of smoke-sensitive detectors which will signal staff as soon as fire event occurs;
- Unintentionally scattered flammable items must be carefully gathered and placed into litter box. Areas where such items were discovered must be cleaned thoroughly till all remains are removed;
- In order to avoid landscape fire (forest fire) flammable and explosive materials must be stored/consumed on remote areas from dense forests. Such areas must be cleaned from grass and shrubbery.

Prevention of traffic accidents:

- Every vehicle shall pass technical inspection prior to beginning of work. Brakes are a subject to most necessary inspection. Body lifting mechanism is checked on dumpers;
- Selection of optimal routes and speed limitation (speed near the work sites shall not exceed 10 km/h for straight sections and 5 km/h for curves);

- Arrangement of temporary bypass road;
- Improvement of temporary and permanent roads used for construction purposes and maintenance of their technical condition throughout the cycle of the project;
- Arrangement of warning, prohibiting and indicative signs on roads and construction camps;
- Arrangement of curbs in particularly dangerous places on ravine side;
- Movement of special and oversized machinery must be accompanied with specially equipped techniques and trained personnel;
- Work of excavators, cranes and other machinery under transmission lines is prohibited;
- Machinery and vehicles cannot be used in zone of sliding triangle. Systematic observation over sustainability of cave slopes must be established. In case of fault detection unstable mass must be demolished;
- Ground must be loaded on vehicles only from side or back board;

Prevention of personnel traumatism/injury:

- Periodical training and testing of personnel on health and safety issues;
- Equipping staff with means of personal protection (in case of perforation drilling the workers must be equipped with protective goggles and respirators);
- Relevant signs must be arranged in dangerous zones;
- Relevant signs must be arranged in dangerous zones; Dangerous zones must be fenced and indications easily visible at night must be at place (in addition to fencing such visible signs must be placed around pits at night);
- Safety illumination in dangerous zones must ensure minimal light of the working surface within 5% of normalized value of light and no less than 2 lux inside the building and 1 lux outside;
- Trenches with slope angle over 20^0 must be equipped with at least 0,6 m wide ladders and with 1,0 m high railings;
- Personnel must be insured with ropes and special fasteners while working at heights;
- Evacuation posters/evacuation emergency lights must be provided inside the closed spaces (e.g. power house):
    - Evacuation emergency light must be placed above every exit, outside the exit door, above steps of the staircases, at every corner, near medical boxes, in areas where floor levels change, near fire fighting means;
    - Evacuation light must provide minimum illumination of floors, paths or staircases: 0,5 lux within rooms and 0,2 lux on open territories;
- Placement of medical boxes in relevant places;
- Training of special personnel (H&SE[8] officers) that will control performance of safety norms on the working sites and detect violations of such norms.

Preventive measures against natural emergency situations (catastrophic events) are as follows:

- Thoroughly implementation of all mitigation measures provided in the EIA report; they are directed to the risk reduction of development of hazardous geodynamic processes;
- Preservation of trees and vegetation as far as possible. Protection of working corridor.

13.6.4 Estimated Scale of Incidents

With consideration of expected emergencies, incidents, liquidation resources and legislative requirements, accidents and emergency situations are sorted in 3 levels of response. Table 13.6.4.1. provides description of emergency situations according to their levels, indicating corresponding response.

[8] H&SE –Health and Safety officer

Considering the HPP location, scale of the construction works and the HPP operation conditions, 1st and 2nd level emergency situations, less expected 3rd level incidents can occur.

Table 13.6.4.1. Description of Emergency Situation According to their Levels

Emergency Situation	Level		
	I Level	II Level	III Level
General	The internal resources are sufficient for emergency liquidation	External resources and workforce are needed for emergency liquidation	Involvement of regional and country resources for emergency liquidation
Damage of hydraulic structures	Minor damage of hydraulic structures that will temporarily but significantly interrupt HPP operation. The provocation of other emergencies is less expected. HPP personnel will manage to liquidate emergency	Hydraulic structures damage, which significantly impedes functionality of the power plant and may cause other emergency situations	Significant damage to hydraulic structures requiring help of special squad from the region or Tbilisi
Spill of hazardous substances	Local spillage, which does not need external interference and can be eliminated with internal resources. The risks of spreading of the substance on large areas do not exist	Large spills (0.3- 200 tons spill of hazardous substances). There are risks of substance distribution on large area and risk of river contamination.	Large spillage (more than 200 tons).
Fire	Local fire, which does not need any external interference and is easily controlled. The meteorological conditions are not conductive to the rapid spread of the fire. There are no flammable and explosive sections/ warehouses and materials nearby.	Large fires, which spread quickly due to the weather conditions. There are flammable/explosive areas/warehouses and materials nearby. It is necessary to call the local fire squad.	Significant fire, which spreads rapidly. The ignition risk of surrounding neighbourhoods and provocation of other emergencies is high. The involvement of the regional fire service for the liquidation of the incident is necessary.
Landscape fire	The fire originated in one of the construction sites and there is a risk of landscape fire.	Low forest fires. As a result of combustion of coniferous or deciduous shrub stems, live cover of soil surface (moss, grass), dead cover of semi-shrub and soil (dead leaves, branches, tree bark, etc.), i.e. directly on the ground surface or due to burning of trees and plants 1,5-2 m above it. Fire spread speed is not high – during high winds the speed reaches 1,0 km/h.	Is not expected
Traffic accidents	The damage of equipment, vehicles, infrastructure and non-valuable items takes place. Human health is not in danger.	The damage of the equipment, vehicles, infrastructure and valuable objects takes place. There is the threat to human health.	The damage of the equipment, vehicles, infrastructure of special value and vital objects takes place. There is a high risk of development of other emergencies.
Personnel injury/traumatism	• One incident of traumatism; • Light fracture, bruises; • I degree burns (skin surface layer damage);	• Individual cases of accidents; • Severe fracture - a fracture near the joints;	• Several traumatic accidents; • Severe fracture - Articular fracture etc.; • III and IV degree burns (skin,

		• Assistance to injured personnel and the liquidation of the incident is possible by local medical service.	• II degree burns (deep layer of the skin lesions); • There is the need to take the injured personnel to the local medical facility.	hypodermic tissues and muscle lesions); • There is the need to move injured personnel to the regional or Tbilisi medical service centres with relevant profile.
Accidents of natural character	Flow over the spillway	Flood level is almost maximum at the headwork upstream, however, water release is carried out without active erosion processes.	Release of design flow is carried out in parallel with the erosive processes. There is a risk of flooding of power houses and downstream project facilities.	Catastrophic flow is released through the spillway. Flooding of downstream facilities is inevitable.
	Landslides, avalanches through the HPP corridor	Landslide, avalanche that noticeably damage the HPP structures		Landslide, avalanche that significantly damage the HPP structures
	Landslides, avalanches, which blocked the riverbed the HPP upstream	Upstream landslide, avalanche, which partly blocked the riverbed. Risk of sudden breakdown of a weir is quite low, however, implementation of preventive measures is essential (e.g. riverbed cleaning by an excavator).		Considerable upstream landslide, avalanche. Which blocked the riverbed. There is a risk of sudden breakdown of a weir and occurring of uncontrolled flow of stony-muddy mass.
	Earthquake	Measurable earthquakes occurred in70 km radius from the HPP.	Earthquakes causing noticeable damage of the HPP structures	Earthquakes causing uncontrolled flow of water from the HPP.
	Sabotage/vandalism	Damage of the HPP facilities that significantly affects the HPP operation	Considerable damage of the HPP facilities	damage of the HPP facilities, which causes uncontrolled flow of water

Events that can damage of the HPP are the results of age, errors made within designing or construction processes. In extreme weather conditions, when the even exceeds the design rates, considerable flow can be developed in a spillway or overflow a barrier. Reason of a high flow can be a considerable upstream landslide. It should be noted that accidental or deliberate damage of the HPP can lead to the emergency situation. Listing of all emergency situations is impossible, so the HPP operator should be ready to determine whether a specific situation is emergency or not.

13.6.5 Response on Accident

The plan identifies authorized and responsible persons for emergency response, as well as power delegation and granting methods. After arrangement of the area responsible persons and their position must be established; this is considered by the operation sequence plan. This information must be provided to the management of the construction contractor.

In case of accidents following strategic measures must be implemented:

- A unit whose task and objective will be defined beforehand must be established in case of emergency;
- Objectives for fire fighting operations must be established beforehand;
- Procedures to be carried out during emergency and people responsible for them must be also determined;
- Measures to avoid environmental pollution with construction materials or by accidental spill of oil products and other substances must be defined. Hazardous materials must be recorded and this information must be available for every staff member.

For notification of fire or other type of incident to relevant services (fire department, police, ambulance, rescue service) single telephone number has been established in Georgian telephone network – **„112“.**

13.6.5.1 Response on Hydro Dynamic Accident

In case of damage discovery, operator or the head of monitoring service is mandatory to inform the head of HPP immediately

During the hydro dynamic accident, strategic actions of the head operator are as follows:

- After receiving detailed information on damage/accident, analyse the situation, determine the related processes and approximate scale of accident (level);
- To ask the person being in the place of the incident, the information provider or competent staff for immediate implementation of primary preventive measures (closing or opening of culvert gates, etc.), so that there is no threat to their health and safety;
- Competent personnel including, the personnel of other facilities operating within the district), emergency services and, if necessary, other resources should be notified about the incident;
- To ask competent personnel for locking the hydro-turbine vents ;
- To ask competent personnel for regulation of the turbine gates to prevent the hydraulic hammer and water diversion from the chamber into the downstream in this way;
- Visit the accident site and supervision the accident elimination measures (regulation of the gates so that to bypass the water from the accident zone – water intake, penstock) until the rescue crew/external resources appear the area;
- Wait for the rescue crew and after their coming act in compliance with the appropriate order.

Head of the HPP is mandatory to receive the following information from an operator/head of the monitoring service:

- Type of damage/hazardous geodynamic activation processes, accident site, presumable scale of damage (I,II or III), name, surname of the informant, his/her post, data for radio or telephone feedback;
- To notify the response team of the HPP;
- To notify the other personnel of the HPP;
- To notify the population (order the personnel to visit the villages and inform population about the accident by speaking-trumpet);
- To notify the local or regional offices of emergency situations;

- To notify the operator company;

In case of damage of I or II level:

- To ask the personnel for ceasing all works, turning off installations and mechanisms in the appropriate sequence and suspension operation of the HPP;
- To ask the personnel for removing all machineries from the dangerous sites so than not to endanger their health and safety;

In case of damage of III level (if the stability of the power house is endanger):

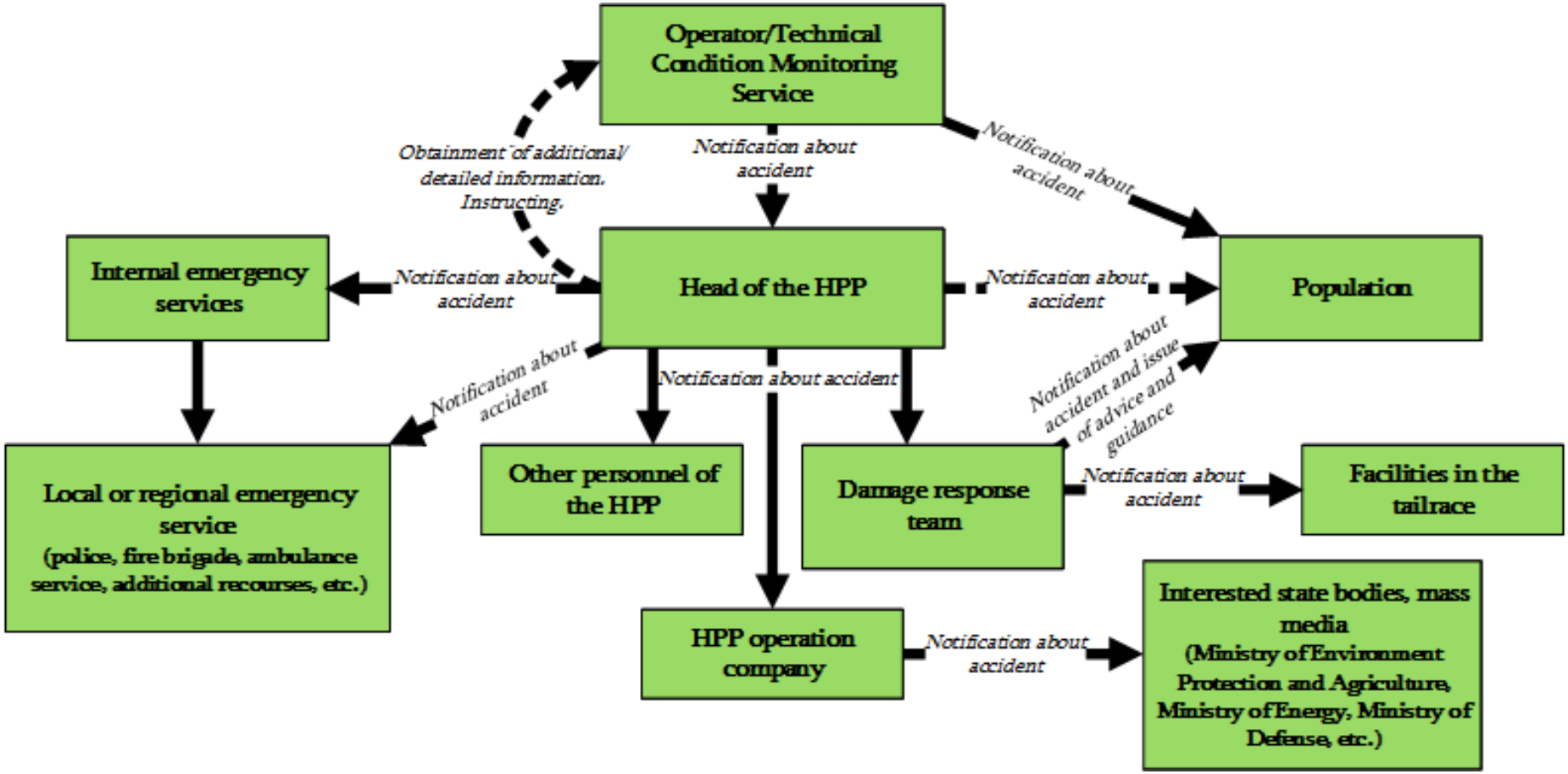
- To ask the personnel for ceasing all works and leave the dangerous zone;

The response team (head of the team) is mandatory:

- To receive detailed information from an informant;
- To transfer information the heads of facilities downstream (including Paravani HPP);
- To visit the downstream villages in an organized way and inform population about the expected disaster with speaking-trumpet ;
- Mobilization of internal resources (transport, machinery, etc.);
- To divide the response team into groups and determine the acting area for each of them;
- To participate in elimination measures of damage or damage results.

HPP Operator Company is mandatory to inform the relevant state bodies and other external organizations, as well as media for informing the society, in case of I and II damage level. Detailed scheme of notification is given in the Table 13.6.5.1.1.

Figure 13.6.5.1.1. Notification scheme for damage of hydro technical structures



13.6.5.2 Response on Accidental Spill of Hazardous Substances

Due to the fact that storage of considerable amount of oil products and other hazardous substances is not planned on the site as on the construction, also on the operation phase, this section discusses only I and I emergency response strategy. The types of hazardous substances spill response are significantly determined by ground surface, also, the initial condition. Consequently, emergency response is presented for the following scenarios:

- Hazardous substances spill on impervious surface (asphalt, concrete cover);
- Hazardous substances spill on pervious surface (ground, gravel, vegetation)
- Spill of the hazardous substances in the river.

In case of hazardous substances (mainly oil products) spill on the impervious surface, it is necessary to implement the following strategic actions:

- Calling on a hot line and informing the H&SE;
- Stopping every device-equipment working on the site;
- Blocking the pollution source (if any);
- Ask personnel to mobilize equipment and personal protection means for emergency response;
- In case of necessity, it is necessary to arrange barriers with suitable impervious material (sand bags, plastic sheets, plastic coat and others) in such way, that it will stop spilled material or limit its movement;
- Barriers must be arranged perpendicular to the sidewalks or in shape of horseshoe, so that the open side will be directed to meet the substances flow;
- Gather the spilled oil products by using brooms and linens;
- For drying in the spilled substances, absorbent pads usage is necessary;
- Gather the oil products in such way, that it will be possible to collect them in container and then removal;
- After absorption of the oil, these pads should be placed in polyethylene bags (if needed, these pads might be reused);
- The site should be completely cleaned from residual oil products, in order to exclude the wash-off of the pollutants by the rain water;
- After completion of cleaning operations, every cleaning material must be collected, wrapped and warehoused in relevantly safe areas.

In case of hazardous substances spill on the pervious surface, it is necessary to implement the following strategic actions:

- Calling on a hot line and informing the H&SE; Stopping every device-equipment working on the site (if oils are spilled on the territory of a substation, turning off all electrical installations - transformers, breakers, etc. nearby the spilled location in an appropriate sequence is necessary)
- Blocking the pollution source (if any);
- Ask personnel to mobilize equipment and personal protection means for emergency response;
- Absorbents should be placed together in such way to create continuous barrier (fence) in front of the edge of moving oil products. Ends of the barrier must be folded in front, so that it will have a shape of a horseshoe;
- Spilled oil products containment place must be covered with polyethylene membrane sheets, in order to prevent the oil occurrence in the lower layers of soil;
- It should be noted, that if it is not available to lay down the polyethylene sheets, then the barrier arrangement will cause the oil accumulation on one place, which in turn will cause soil saturation with oil and oil products occurrence in the lower soil layers;
- For drying in the spilled substances, absorbent pads usage is necessary;
- Gather the oil products in such way, that it will be possible to collect them in container and then remove;

- After absorption of the oil, these pads should be placed in polyethylene bags (if needed, these pads might be reused);
- The site should be completely cleaned from residual oil products, in order to exclude the wash-off of the pollutants by the rain water or oil occurrence in the lower layers of soil;
- After completion of cleaning operations, every cleaning material must be collected, wrapped and warehoused in relevantly safe areas;
- Processing of vegetation and upper layer of the soil on existing on the ground surface must begin right after removal of the pollution source or after stopping the leakage;
- When the whole spilled oil products will be cleaned, removal and remediation works implementation must start under supervision of construction works manager/head of the facility and invited specialists with a relevant competence.

In case of oil products spill in the river or drainage channels, it is necessary to implement the following strategic actions:

- Calling on a hot line and informing the H&SE;
- Stopping every device-equipment working on the site (if turbine oils are spilled in used water, ceasing of hydro turbines' operation in an appropriate sequence is necessary);
- Blocking the pollution source (if any);
- Ask personnel to mobilize the necessary equipment for emergency response and personal protection means;
- Clear the vegetation existing on the river bank with the scythe;
- Immediately fence the polluted section of the river with wood boards. In case of additional necessity (large scale spillage), usage of ground filled bags is available;
- Removal of oil products gathered on the river surface must be carried out with sanitation vehicles;
- Absorbent pads must be used for drying the oil products spilled on the soil;
- After absorption of the oil, pads must be placed in polyethylene bags for waste.

13.6.5.3 Response of Fire

The strategic actions of the person and the personnel detecting fire or smoke are as follows:

- Termination of works except for safety measures;
- Assessment of the situation, reconnaissance of fire hearth and adjacent territories;
- Relocation of equipment and machinery from places where fire distribution is expected; Switch the machinery from the electric source;
- If the fire is fierce and approach to hearth is complicated and explosive or flammable materials are located in vicinity, then:
  - Leave the dangerous zone:
  - Use evacuation scheme/posters of the HPP while evacuating the area;
  - If you must cross smoky indoors bend as the air is cleaner near the floor, place wet cloth on your nose and mouth;
  - If you cannot exit indoors due to burning exit – call for help;
  - Notify senior manager/operator about the accident;
  - Wait for the rescue team and provide them with all the information at hand;
- If the fire is not strong, hearth is approachable and it does not pose risks to human health, however there are risks of fire distribution act in the following manner:
  - Notify senior manager/operator about the accident;
  - Find the nearest fire stand and collect necessary equipment (fire extinguisher, axe, crowbar, bucket, etc.);
  - Try to liquidate fire using fire extinguisher using instructions provided on its body;

- In case there is no fire stand on the territory use sand or water to liquidate fire, or you can also cover fire with less flammable thick fabric;
- Do not use water in vicinity of equipment connected to electric circuit;
- Do not air the room in case of fire in the closed area (unless there is a special need), since clean air stimulates combustion process and increase the fire scale

There are following strategic actions of manager/head operator in case of fire:

- Collection of detailed information on location of fire, equipment/machinery and substances stored/located nearby;
- Transmit information to other personnel and fire fighting service;
- Inspection of the situation, analysis of risks and evaluation of possible scale of fire (I, II or III level).
- Personnel must be requested to mobilize vehicles and existing fire fighting equipment and use;
- Control actions of personnel and guidance.

Strategic actions of manager/head of HPP in case of fire are as follows

- To inform the fire fighting service;
- Control of personnel actions with help of H&SE officer and management prior to arrival of local or regional fire-fighting service (after that, the team is managed by the head of fire-fighting service);
- Support of fire-fighting team actions (need of certain equipment may occur);
- Implementation of liquidation measures with H&SE officer after completion of the accident;
- Preparation of a report and submission to Developer Company of the construction works/HPP operator company.

In case of landscape fire emergency service is participating in fire liquidation measures. As well as HPP personnel (in accordance with the instructions provided by the head of the HPP and H&SE officer), also local population, in case of necessity. During forest fire extinguishing, following basic approaches are used apart from the instructions listed above:

- Sweeping of lower boundaries of the forest fire with green branches, brooms and bag cloths;
- Throwing the ground over the low fire boundaries of the forest with shovels and spades;
- Arrangement of blocking line or channel to stop the fire distribution;
- Extinguish the fire using blasting arrangement of fire blocking channel;
- Blocking channel must be arranged in direction of construction camps, construction sites and the territories where easily flammable and explosive substances are disposed.

Effects of emergency situations caused by landscape fire are liquidated in accordance with Georgian legislation.

Increase of fire hazard may result of announcement of special fire-fighting mode by Georgian government or local authorities.

During such regime additional requirements of existing normative acts related to fire safety are being defined for the relevant territory, including requirements of involvement of population into the fire fighting activities, restriction of forest entry to the physical entities, adoption of additional measures (increase of distance between borders of populated areas, creation of mineralized zones) that will limit forest fire and its distribution outside the populated areas, to adjacent territories.

13.6.5.4 Response on Unplanned Explosion

There are following strategic actions of the personnel nearby the accident:

- Cease of all activities, except for safety measures;
- Observation of the explosion area from the distance, analysis of the situation and determination of following conditions:

  - Number and identities of the injured people;
  - Reason of the explosion;
  - Whether there are any other flammable or explosive materials or areas nearby the accident site and thus, whether there is a risk of recurrence of fire or explosion;
  - Whether there is a risk of wall/ceiling collapse or other risks that causes additional threats to human health;
- If there is a risk of recurrence of explosion, wall collapse or other risks that pose threat to human health, then:
  - Leave the dangerous area immediately;
  - Notify senior manager/operator about the explosion;
  - Wait for rescue team and provide them with all the information at hand.
- If approaching the explosion area does not pose threats to your health, however other member of personnel was injured and there is a chance of further development of risks, then:
  - Notify senior manager/operator about the explosion;
  - Find the nearest fire stand and collect necessary equipment and means of personal protection;
  - Approach the area of accident and remove items that may cause recurrence of explosion;
  - Assist the injured person according to the relevant chapter in the scheme;
  - When approaching try not to find yourself between the dangerous zone and a wall.

In case of explosion, there are following strategic activities of the senior manager/operator:

- Collection of detailed information on location of explosion, equipment/machinery and substances stored/located nearby;
- Transmit information to other personnel and fire fighting service if necessary;
- Inspection of the situation, analysis of risks and evaluation of possible scale of explosion (I, II or III level). Prognosis of further development of the accident;
- Personnel must be requested to mobilize vehicles and existing fire fighting equipment and use if required;
- Control actions of personnel and guidance.

Strategic actions of construction works manager/head of HPP in case of explosion are as follows:

- Control of personnel actions with help of H&SE officer and management prior to arrival of local or regional service (after that the team is managed by the head of response service);
- Require isolation of area from sensitive sites using solid materials (concrete slab or other) from staff, in necessary;
- Support of rescue team actions (need of certain equipment may occur);
- Implementation of liquidation measures with the H&SE officer after completion of the accident (restoration of the damaged areas, debris clean-up, preventive measures against erosion, etc.);
- Preparation of a report and submission to Developer Company of construction works/HPP Operator Company.

13.6.5.5 Response on Traffic Accidents

Following strategic measures should be implemented in case of traffic accident:

- Vehicles/machinery must stop the movement;
- Information must be submitted to the relevant services (police, ambulance, etc.);
- If the accident poses no danger to human health and there are no risks of causing other accidents (e.g. collision with other vehicles, fire, fuel spill, etc.) then:
  - Get out of the vehicle/machinery or move further from the accident and keep a safe distance;
  - Wait for police/rescue team.
- If there is additional threat:

- Get out of the vehicle/machinery or move further from the accident and keep a safe distance;
- In case of fire or fuel spill respond in accordance with strategies provided in relevant paragraphs;
- In case of danger to human health do not try to relocate the body;
- If the injured is lying on the roadway, cover him and mark the area so it is visible from the distance;
- Remove tight items (belt, tie, etc.);
- Assist the injured in accordance with strategies described in relevant paragraphs (however do remember that you may cause additional threat to his health by relocating him).

13.6.5.6 Response to Traumatism of Personnel or Incident Related to Health Safety

The primary response of the person discovering an injured person is an urgent notification about the incident. Before arrival of the rescue team, first aid must be provided in accordance with the strategies described in paragraphs below. Prior to the provision of the first aid, situation must be evaluated and it must be determined whether approaching and assisting the injured person is dangerous or not.

First Aid during Fracture

There are two types of fracture – open and closed:

- Open fracture is characterized by disruption of skin integrity. During such injury wound and bleeding is observed. Open fracture poses carries a high risk of infection. During open fracture:
  - Call for help so that this person can help with immobilization of the injured area while you treat the wound;
  - Cover the wound with clean cloth and apply pressure in order to stop the bleeding. Do not apply pressure over the fractured bone or its fragments;
  - Without touching the wound with fingers carefully limit the wounded area with clean cloth and apply bandage;
  - If bone fragments are observed inside the wound, apply warm cloth around them so, that the bandage does not put pressure over them. Apply bandage so that it does not limit blood flow below it;
  - Immobilize the injured bone as during the closed fracture;
  - Check pulse, capillary filling and sensitivity below the bandage every 10 minutes.
- Closed fraction is observed if the skin integrity is not damaged. Bruises and swelling are signs of fracture. During closed fracture:
  - Ask the injured to lay still and secure the injured area above and below the fracture until it is immobilized;
  - To provide good fixation secure the injured part of the body to the intact body part. In case of arm fracture secure the arm on the torso with a triangle bandage. In case of leg fracture secure the leg on the other one. Tie knots from the side of the undamaged leg;
  - Check pulse, capillary filling and sensitivity below the bandage every 10 minutes. If sensitivity or blood flow is reduced use a less tight bandage.

First Aid during Wounds and Bleeding

There are three types of bleeding:

There is little blood. In this case is risk of infection is higher:

  - Clean the wound of injured person with any colourless liquid suitable for drinking;
- Wrap the wound with clean cloth;
- There is a lot of blood. In this case there is a risk of blood loss:
  - Cover the wound with several layers of cloth and use tourniquet;

  - If the blood is still leaking, put more cloth to the wound (do not take off the blood-drenched cloth) and strongly press on blood source area;
- Blood is pouring like a fountain from the wound. In this case injured person loses blood very fast. To avoid this you must push finger (or fingers) on the artery projection area and then put a tourniquet.
- The areas of pressure on the artery are: the lower third of a shoulder and upper third of the thigh. The tourniquet should be placed like this:
  - Tourniquet can be used only in extreme cases as it may cause irreversible injuries;
  - Tourniquet is fixed above wound;
  - Use tourniquet only on surface covered with clothing. If the injured area is naked clean cloth must be placed under tourniquet;
  - First bond must be tight (must be fixed as much as possible), then tourniquet is tightened around the wounded area 3-4 times (rope, belt and etc. can be used instead);
  - In winter tourniquet must be used for one hour and in summer for two hours. 5-10 minutes later tourniquet must be loosen and placed slightly above the previous location;
  - Check whether tourniquet is placed properly – during proper use of tourniquet pulse does not palpate;
- What must not be done:
  - Touching of the wound;
  - Nothing must be removed from the wound. If an alien object is observed in the wound bandage must be placed around it to fix it in one place.
- Internal bleeding is difficult to identify. Signs of internal bleeding may be shock after the injury, but there is no visible blood loss. During internal bleeding:
  - Place the injured person on his back and raise his legs;
  - Remove tight clothing from neck, chest and waist;
  - Do not give the person food, water or medication. If the person is conscious and is suffering from severe thirst – wet his lips;
  - Keep the person warm – cover him with blanket or cloth;
  - Check breathing, pulse and consciousness every 10 minutes. If the injured is losing consciousness place him in safe location.

First Aid in case of Burn

Burn might be developed by impact with hot objects and steam (thermal burn), by chemical substances impact with the skin (chemical burn) and electricity impact (electrical burn). In order to properly carry out first aid, degree of burn must be properly determined; degree depends on damage depth and damage area (on what part of skin surface is the burn spread).

- First aid measures during burns are as follows:
  - It is dangerous to inhale smoke during burn, therefore if there is smoke and quick ventilation of the room is impossible injured person must be relocated to fresh air;
  - If the clothing of the injured are on fire do not roll him, simply pour water over him (unless it is an electrical burn, in which case use of water near equipment connected to the circuit is strictly forbidden);
  - If there is no possibility to use water cover the body with non-synthetic cloth;
  - It is necessary to start cooling the burnt area in time with cold water (in case of I and II degree burn place the area under running water for 10-15 minutes, in case of III and IV degree burn wrap it with clean wet cloth and then cool it under running water in such wrapped condition);
  - Remove the clothing and other objects from the damaged area which may interrupt blood flow. Do not remove particles of clothing stuck to the damaged area;
  - Cover the damaged area with sterile wrapping. This will reduce the likelihood of infection;

- Inhaling of hot air during burns may cause burns of the respiratory system. Such burns may be identified if the injured person has difficulties breathing, breathing is loud, burns on face and neck are observed, face and nose hair cover is singed, mouth and lips are swollen, person is experiencing coughing, difficulties swallowing and has wheeze voice. In such case wait for the ambulance;
- Constantly check breathing and pulse before the medical service arrives, be prepared to carry out reanimation measures;
- It is prohibited to remove clothing particles from the burned skin as this may worsen the injury;
- Integrity of blebs cannot be violated as this may damage skin surface further creating hospitable environment for infection;
- Do not use ointments, lotions or oils while treating the injured area;
- Injury caused by chemical burn cannot be treated with neutralizing solutions, e.g. Treatment of alkaline burns with acid.

First Aid in Case of Electrical Trauma

There are three types of electrical trauma:

- The trauma caused by high-voltage electricity. The damage developed as a result of high voltage traumas, are fatal in most cases. Severe burns are being developed at this time. Due to the strong muscle compression the injured person is often threw away on a significant distance, which leads to serious injuries. In case of high-voltage power trauma:
  - It is prohibited to get close to the injured person, before the electricity will be turned off and if necessary, the isolation will be made. Remain 18 m radius safe distance. Do not let other witnesses to approach the injured person;
  - After receiving electric trauma, as soon as approaching the injured person, open the breathing ways without moving head back, by moving the lower jaw in front;
  - Check breathing and circulation signs. Be prepared to make reanimation measures;
  - If the injured person is unconscious but is breathing, place him in a safe location;
  - Carry out first aid in case of burns and other injuries.
- The electrical trauma caused by low-voltage electricity. Low-voltage electricity trauma may turn into serious damages and even death reason. Often, this kind of electrical trauma is caused by damaged plugs, wiring and equipment. When standing on a wet floor or touching undamaged electrical wiring with wet hands, the risks of getting the electrical trauma are sharply increasing.
- In case of low-voltage power caused trauma:
  - Do not touch the injured person, if he is touching the power source;
  - Do not use metal object for removing the power source;
  - If you are able, stop power supply (turn off the power switch). If it is not available, turn off the electrical equipment from the power source;
  - If you are not able to switch off the electricity, then stand on dry insulation thing (for example: a plank of wood, on rubber or plastic pad, on book or pile of newspapers);
  - Remove the victim's body from the power source by broom, stick, and chair. You can move the victim's body away from the power source, or vice versa, the power source away from the body, if it is more convenient;
  - Without touching the body of injured person, tie a rope around his foot and shoulders and move away from the power source;
  - At least, grab the injured person in dry not-tight cloth and move him away from the power source;
  - If the victim is unconscious, open the airways, check the breathing and pulse;
  - If the victim is unconscious, is breathing and has a pulse, place in a safe location. Cool the burned areas and wrap it;

  - If the visible injuries are not seen on the victim and he/she feels well, advice to take a rest.
- The electrical trauma caused by lightning/thunder. Various traumas, burns, face and eye damage is often caused by the electrical trauma. Sometimes the lightning may cause a sudden death. Quickly move damaged person form the place of the accident and serve with first aid as in case of different type of the electrical trauma.

13.6.5.7 Response on Emergencies of Natural Type

Response on Earthquake

The response on the earthquake starts when feeling the first fluctuation, if the earthquake is weak stay where you are, do not panic. After the personnel will feel safe, they should act in accordance with the following strategy:

- If the earthquake is weak it is best to stay where you are;
- In case of stronger earthquake while you are in the building:
  - Leave the building immediately via staircases or windows;
  - Stand in the corner of the inner wall, door or solid pole;
  - If the building is old and walls are not safe, climb under bed or table;
- If you are outside:
  - Stand far from the buildings and transmission lines;
  - Do not stand on or under bridges.

After the personnel will feel safe, they should act in accordance with the following strategy:

- Personnel on duty at the headwork must be informed about the event and they must regulate the gates as required;
- Ask the personnel to shut down every construction device-mechanism, as well as turbines during its operation in a relevant order;
- Before rescue team arrives earthquake result liquidation measures are managed by the construction manager/head of construction with the following strategy:
  - Injured must be taken out of the ruins and those remaining in half-destroyed or burning buildings must be saved;
  - Energy and technological line accidents that pose risk to human life must be liquidated;
  - Flammable and explosive materials must be removed to safe areas;
  - Buildings and hydraulic structures must be inspected and their technical conditions must be examined;
  - Damaged buildings or buildings/constructions in dangerous state must be demolished or reinforced;
  - If there is a chance of further collapse it is not permitted to walk over ruins, go inside damaged constructions, be near them unless required otherwise while rescue works;
  - It is required to have a rope around a waist when entering buildings filled with smoke or with blocked passages. The person outside the building must be holding the other end of the rope;
  - Using individual protection means is necessary during rescue or liquidation works.

Response on Mudflow, Landslide, Avalanche

Personnel in vicinity of the natural disaster must act in accordance with the following strategy:

In case of mudflow:

- Immediate evacuation from the dangerous zone;
- Evacuation route must not run along the riverbed, where mudflow is occurred;
- At signs of danger immediate relocation to higher grounds;

- It is not allowed to enter the river responsible for mudflow after one wave has passed, since the second wave may follow;
- Crossing mudflow bed is prohibited;
- It is dangerous to stay inside the building if it is located near the collapsed bank or ground under it was partially washed out.

In case of landslide:

- If the landslide moved on a distance of 0,5-1 m within the first 24 hours, evacuation must be held immediately;
- Take essentials only during evacuation (food, clothing, etc.);

In case of avalanche:

- Avoid areas that pose risk of avalanche;
- Most dangerous period for avalanches is warm days of spring and summer;
- Immediately leave the dangerous zone and relocate to safe area;
- If you cannot avoid the avalanche:
  - Put down your luggage and take a horizontal position with your head directed towards avalanche direction;
  - Bend so that knees touch the stomach and tightly hold your legs (take a snowball form);
- If you are in the avalanche:
  - To protect respiratory system cover your face with gloves, scarf or collar;
  - Try to keep your head above the avalanche mass and move towards the edge of the avalanche by moving your arms;
  - After avalanche flow has stopped try to create enough space around you to be able to breather;
  - Try to find ground surface and move upwards;
  - Save your strength, oxygen and warmth and try not to fall asleep;
  - Do not shout, snow completely suppresses your voice;
    - Remember – they are looking for you.

After personnel feel safe they must act following this strategy:

- If necessary, every equipment must be switched off in relevant consequence;
- Before rescue team arrives disaster relief measures are managed by the construction manager with the following strategy:
  - Relocation of staff from dangerous zone;
  - Removal of flammable and explosive materials from the dangerous zone;
  - Using bulldozers and excavators damaged roads and bridges must be temporarily restored in shortest terms possible;
  - Emergency-restoration works must be carried out, including urgent arrangement of defence earth fills by using blasting;
  - Water flow of the river must be regulated, riverbed must be cleaned, deepened and aligned;
  - Route of equipment used in the liquidation measures must be strictly defined and their movement on steep slopes and other dangerous zones must be prohibited;
  - It is necessary to use individual protection means when implementing rescue and liquidation activities.

13.6.6 Contact information of Emergency Services and Other Stakeholders

Agency/organization	Main contact/position	Adress	Office tel number	Alternative tel numbers
LEPL Technical and Construction Supervision				

Agency				
LEPL Emergency Management Agency				
Meskhet-Javakheti Emergency Management Service				
Akhalkalaki Municipality City Hall				
Supervision Service of Akhalkalaki Municipality City Hall				
Governor of village community				
Ministry of Environmental Protection and Agriculture of Georgia				
National Environmental Agency LEPL				
Akhalkalaki HPP operator company				
Other:				
„---------“				
„---------“				

(will be filled after the works are launched)

13.6.7 Equipment Required for Emergency Response

In process of construction and operation of the HPPs, standard emergency response equipment must exist on high risk sites, namely:

Equipment for quick notification:

- Megaphone;
- Walkie-talkie;
- Mobile phones;
- Each staff member must be informed about phone numbers of the superior persons;

Personal protection means:

- Helmets;
- Safety goggles;
- Uniforms with reflective stripes;
- Waterproof boots;
- Gloves;

Fire extinguishing equipment:

- Standard fire extinguisher;
- Buckets, sand, shovels and etc.;
- Properly equipped fire stands;
- Fire truck – the nearest fire fighters team truck will be used

Emergency first aid equipment:

- Standard medical boxes:
- Ambulance car – the ambulance car of local medical center will be used.

Spill response equipment:

- Heavy duty plastic bags;
- Absorbent pads;
- Gloves;
- Drip trays;
- Buckets;
- Polyethylene tape

13.6.8 Update, Review, Adjustment of the Plan and Trainings

The presented plan is a "live" document. It means that (1) it never ends/completes, (2) it should be discussed at least once a year, (3) discussions require participation of a manager of emergency situation, (4) documents should be updated in a fast mode. Each emergency response system should be recurrently testes, gained experience should be recorded and gaps must be adjusted (the same should be done in case of incident realization).

In addition, trainings are essential – introductory training in emergency response plan should be provided for the whole staff. Personnel training registration system should exist and the appropriate documentation should be kept in offices of the company or contractors.

Discussion:

Minimum annual discussion of the plan includes the following issues:

- Calling the persons provided in the notification list, in order to check whether they till work on a given position or their mobile numbers are correct or not.
- It is important to consider information on people and structures, which are under the risk of downstream flood, in case of HPP damage.

Adjustment:

Changes associated with contacts, responsibilities, services or informing about risks must be made in the plan. The HPP operator is mandatory to update the plan. Copy of the plan keeping with the operator company is deemed as the main copy. In case of making changes, the HPP operator will transfer the modified pages and a sheet of changes to the persons having the Emergency Response Plan. Owners of a document are mandatory to make appropriate changes and update the copies. Old pages will be immediately destructed to prevent further misunderstanding.

Trainings:

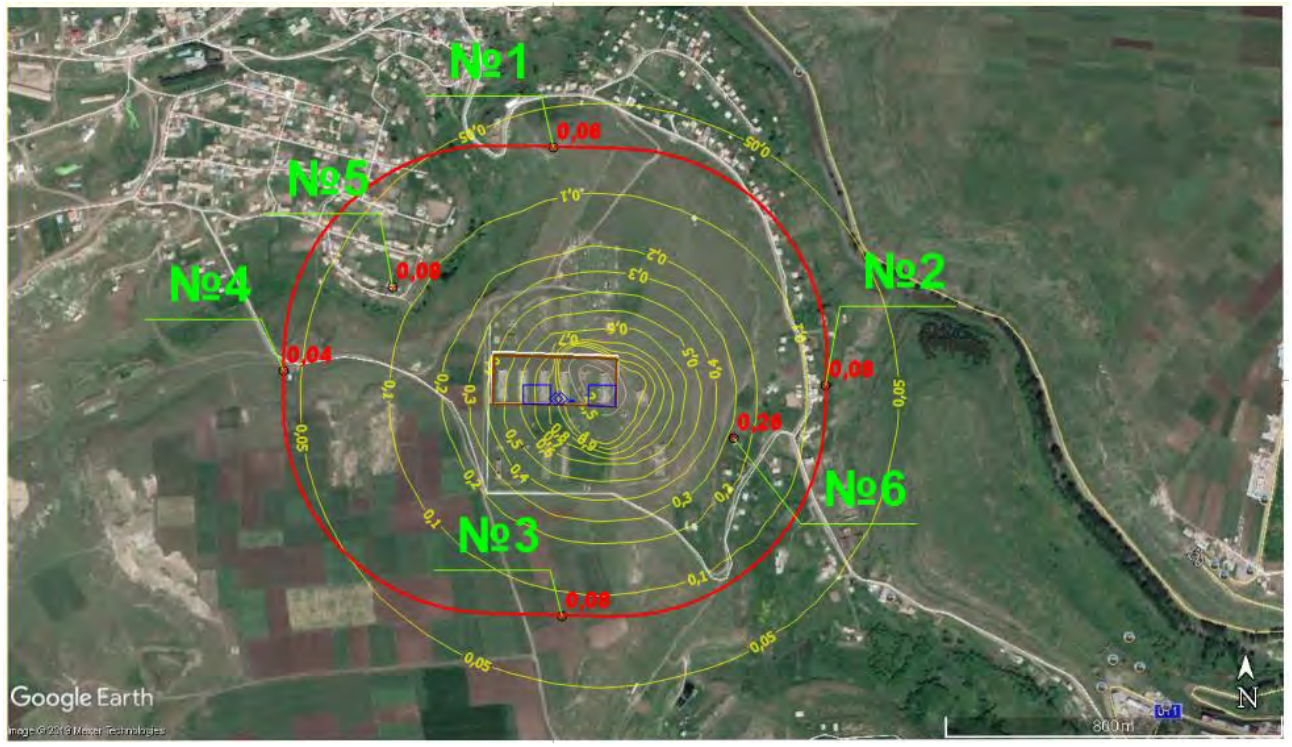
Recurrent trainings and practices will provide the staff's readiness to implement the Plan and to analyze individual duties and functions.
Practices include the following:

- Field practices;
- Telephone practices;

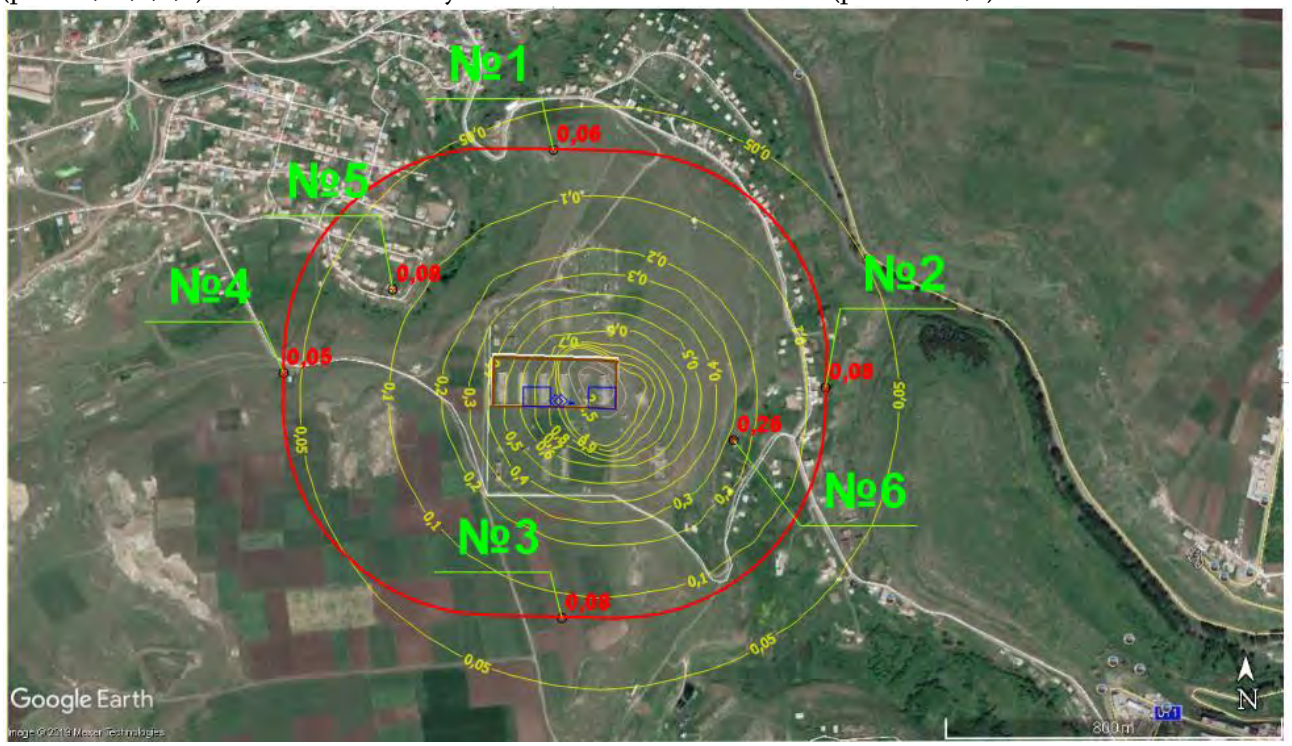
The HPP operator should annually conduct the field and telephone practices. Field practices imply simple gathering, where responsible persons will discuss the functions and responsibilities provided in the Plan. Practices are especially essential for new personnel and leaders.

13.7 Annex 7. Results of calculation of construction camp emissions Graphic image

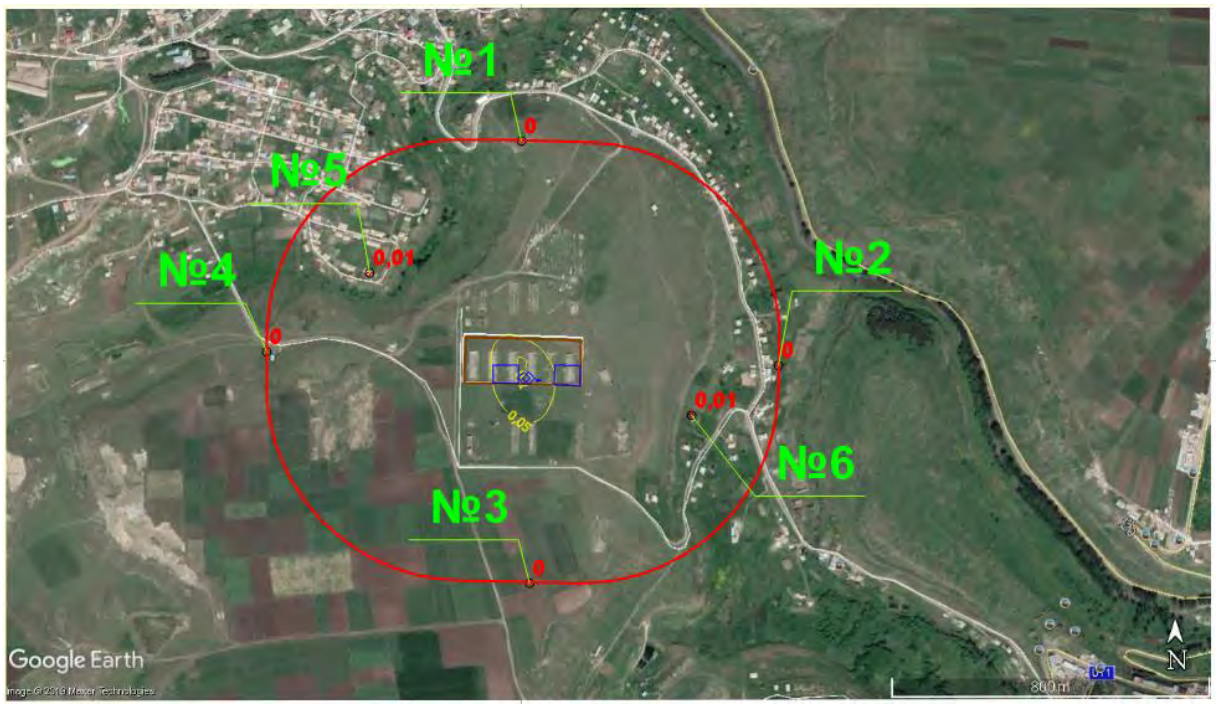
Akhalkalaki 1 HPP construction camp



70-20% of inorganic dust (code 2908) maximum concentrations at the boundary of the 500 m zone (points ,21,2,3,4) and at the boundary of the nearest inhabited zone (points №5,6)

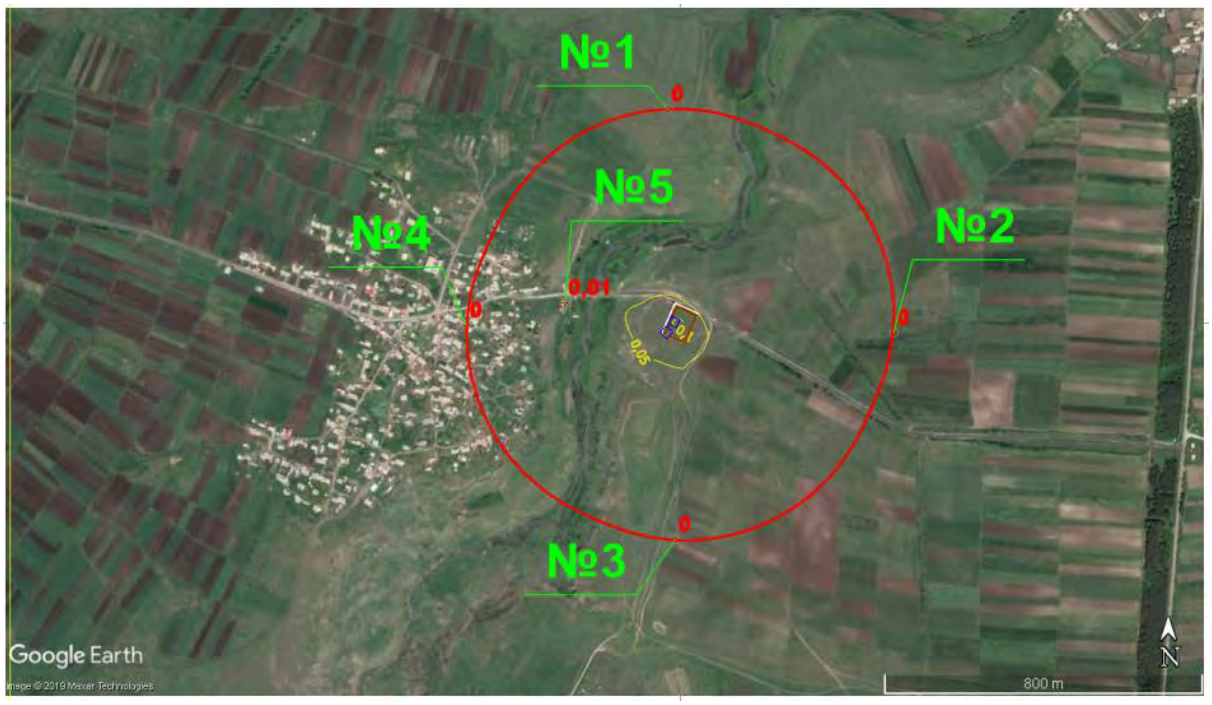


Maximum concentrations of total impact group 6046 (code 337 + 2908) at the boundary of the 500 m zone (points ,21,2,3,4) and the nearest inhabited zone boundary (points № 5,6)



Hydrocarbons (C_{12}-C_{19}) (code 2754) Maximum concentrations at the boundary of the 500 m zone (points ,21,2,3,4) and the nearest populated zone boundary (points №5,6)

Akhalkalaki 2 HPP construction camp



Hydrocarbons (C_{12}-C_{19}) (code 2754) Maximum concentrations at the boundary of the 500 m zone (points № 1,2,3,4) and the nearest populated zone boundary (points № 5)

Note: Calculation results are given only for substances whose ground concentrations are greater than 0.01 mg / m^3 at control points.