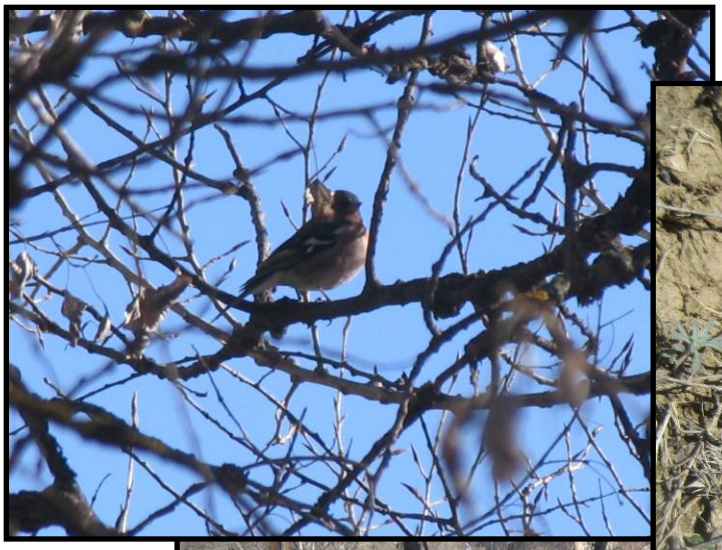
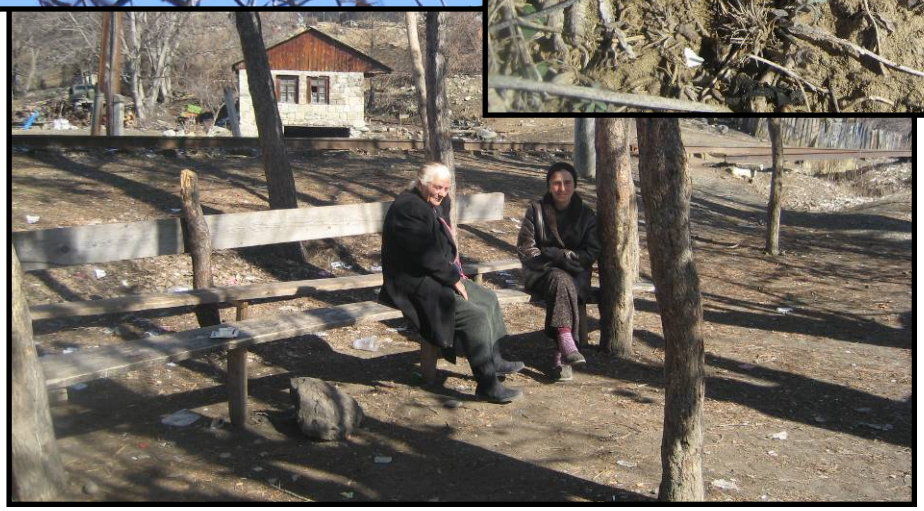
MTKVARI HYDROELECTRIC POWER PLANT PROJECT

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA) REPORT





ENVIRONMENTAL CONSULTANCY CO.

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NON-TECHNICAL SUMMARY

TABLE OF CONTENTS

		Page
1.	PROJECT BACKGROUND	2
2.	PROJECT DESCRIPTION	5
3.	ENVIRONMENTAL BASELINE CONDITIONS	7
3.1.	Physical Environment	7
3.2.	Biological Environment	9
3.3.	Socio-economic Environment	11
4.	ENVIRONMENTAL IMPACTS AND MITIGATION	14
4.1.	Impacts on Physical Environment	14
4.2.	Impacts on Biological Environment	22
4.3.	Impacts on Socio-Economic Environment	27
5.	ANALYSIS OF ALTERNATIVES	31
6.	ENVIRONMENTAL AND SOCIAL ACTION PLAN (ESAP)	36
6.1.	Mitigation Plan	36
6.2.	Monitoring Plan	36

1. PROJECT BACKGROUND

The Mtkvari Project site is located in southeast of Georgia, on River Mtkvari, near the city of Akhaltsikhe. The powerhouse will be located at a distance of 1 km to the Sakuneti Village (Akhaltsikhe District) while the location of headworks is 3 km away from the Village Rustavi (Aspindza District). Mtkvari River which is one of the significant surface water resources of Georgia rises in Turkey flows through southeast of Georgia. The river turns to eastwards near the town Akhaltsikhe and flows from there towards east through the capital city Tbilisi, onwards into Azerbaijan and into the Caspian Sea.

Mtkvari HPP Project is to be built as a part of the project of “Greenfield Investments in Hydropower Plants” of Government of Georgia (GoG). GoG has approved the standard terms and conditions for the Greenfield Investments in Hydropower Plants (HPPs) in April 2008. The Ministry of Energy (MoE) announced the solicitation of expressions of interest by investors in Greenfield HPPs and other renewable energy plants under the build-operate-own structure. The list of prospective Greenfield HPP sites, with an individual capacity ranging from 5 to 60 MW, has been published and regularly updated by the Ministry of Energy on its website.

The feasibility studies and the design for the project are prepared by Verkis IF and Ukrhydroproject Ltd. The reports are completed in July and August 2009, respectively.

Mtkvari HPP Project which is planned to be constructed on Mtkvari River with a capacity of 43 MW is located near the city of Akhaltsikhe. It will contribute to the development of the national economy, with an annual production of 245 GWh. The economic life of the project is predicted as 50 years. JSC Caucasus Energy and Infrastructure is the owner of the project. Funding for the project investment will be obtained from international finance sources.

Mtkvari HPP Project will be constructed according to the design of UkrhydroProject Ltd., consisting of a concrete dam (with a height of approximately 25 m from the riverbed), a surface type powerhouse, and the associated switchyard site.

The preparation of an Environmental Impact Assessment Report (Environmental Impact Statement) for Mtkvari HPP Project is required under the Georgian Law on Environmental Impact Permit. In addition, all project activities will need to comply with the requirements of all other environment related Georgian laws and regulations in force.

Additionally, this Environmental and Social Impact Assessment Report (ESIA) was prepared to fulfill the requirements of international lending organizations involved in financing of the project investment. The preparation of the ESIA Study was guided by the relevant EBRD policies and IFC performance standards.

2. PROJECT DESCRIPTION

The facilities those will be implemented within the context of Mtkvari HPP Project are composed of headworks, headrace tunnel, pressure tunnel, surge shaft, powerhouse, tailrace canal, control room and switchyard. The electricity generated at hydroelectric power plant will be transmitted to Akhaltsikhe Station by 110 kV energy transmission line that is approximately 8 km long and from that place it will be connected to the interconnected system. The details of the project salient features are:

- **Headworks:** Mtkvari HPP dam reservoir will have a limited area for making regulation. The structures in the headworks area are intake pond, diversion canal, main dam, cofferdam, spillway and intake structure. The crest level of the spillway and the highest regulating level is 1012 masl. The intake pond is some 3 km long with a maximum width of approximately 0.6 km. The lowest regulating level is 1010 masl.

- **Headrace tunnel:** The length of the headrace tunnel that would transmit the water that is obtained from Mtkvari Dam to the powerhouse is about 9.6 km with an optimized diameter of 6.0 m. For construction of the headrace tunnel, TBM method will be applied.

- **Pressure tunnel:** The pressure tunnel branches from the headrace tunnel some 100 upstream from the powerstation. The tunnel diameter will be a 6 m horseshoe section for about 70 m or where this otherwise distribute onto each power generating unit. The pressure tunnel, extending from the headrace tunnel down to the distributor will be inclined about 10%.

- **Surge Shaft:** The dimensions of the surge facilities are based on the presumed shut down time of the turbines, the pertinent size of the waterways and other relevant issues. The surge shaft and overlying basin will be located some 200 m upstream of the powerhouse cavern in the headrace tunnel.

- **Powerhouse:** According to initial investigations, a surface type powerhouse was considered to be a more feasible option. However, in the feasibility study it was determined that an underground powerhouse would be more economical by cutting steel lining and pressure tunnel concrete costs. Therefore, an underground powerhouse is proposed in the feasibility report. On the other hand, the project developer prefers to construct a surface type powerhouse.

- **Tailrace:** Harnessed river water will flow from the draft tubes onward into the tailrace. From each draft tube, tailrace tunnel branches merge into approximately 100 m long tailrace tunnel with the same size. The tunnel is followed by the canal that extends to the Mtkvari river course.

- **Switchyard and Transmission Line:** The switchyard will be located on the riverbank within the powerhouse yard area, parallel to the tailrace canal, and guarded by a 40 x 26 m safety fence. Two power transformers along with the

necessary substation equipment will be located within the switchyard area. The electricity, which is converted to 110 kV at the switchyard, is proposed to be transmitted to Akhaltsikhe substation that is 8 km away, by the 110 kV energy transmission line to be distributed to the consumption centers.

- The road along the river will be raised approximately 10 m over a length of about 2,150 m.

Mtkvari HPP will be linked into a new 110 kV transmission line connection from the Mtkvari switchyard to Akhaltsikhe Substation along 8 km distance.

Operation Mode: The Mtkvari Project is comprised of a concrete dam and a 9.6-km long headrace tunnel diverting the inflow to a powerhouse, by-passing an approximately 27-km long reach of the Mtkvari River. The Project having a very small reservoir will be operated in run-of-river mode, in which the inflow is directly used for power generation and the surplus water is released from the spillway.

Implementation Schedule: According to the proposed schedule, construction of the project will take approximately 36 months considering the sequence of activities, from decision to commissioning of the first unit. The critical path for the construction of hydropower plants is the construction of the powerhouse and installation and testing of the hydromechanical equipment.

Project Cost: The total funding requirement of the Project up to commissioning is estimated to be 93,815,662 US$.

3. ENVIRONMENTAL BASELINE CONDITIONS

3.1. Physical Environment

Topography: The region surrounding the project area is presented by middle mountainous, erosive-denudational relief. The project area is located in the western edge of Trialeti ridge of sublatitudinal direction, which is confined from three sides (southern, western, and northern) by the Valley of Mtkvari River. The dam and the reservoir area cover a 3.5 km long segment of Mtkvari River. In general, the eastern part of the project area is covered by mountains wit peak elevations of 1,400-1,500 m. In the northern part of the project area, where the powerhouse will be located, the elevations range between 916 m and 1,026 m. In the southern part of the project area where the intake facilities and dam axis are located, the elevations range between 999 m and 1,027 m.

Geology: The study area broadly consists of unstable clayey and sandy tuffogenic formations dated back to the Upper Eocene. The Middle Eocene volcanogenic and sedimentary units of commonly seen media can be lithologically divided into three series which are layered tuffogenic series of sediments, tuff-breccia series and layered tuffogenic series. The oldest formation of the studied area is 1,036 m thick Middle Eocene Formation. Above the Middle Eocene formation, there exists 400 m of Middle Eocene Series consisting of tuff layers and thin layers of andesite and argillites, mainly. Above the Middle Eocene Series there exists 200 m Middle Eocene Upper formation consisting of sandstone and relatively thinner tuff layers. Onto the Middle Eocene Upper formation, Upper Eocene series sits with an approximate thickness of 625 m. Upper Eocene series consist of tuffs, argillites and sandstones. Overlying the Upper Eocene series, 300-1,000 m Upper Miocene Lower Pliocene Kisatib formation is present. Kisatib formation consists of doleritic and andesite lavas and their pyroclastics with diatomite layers in places at the upper part. At the top of all series, there exist 20 m Quaternary dolerite stream and Quaternary sediments of terraces, alluvium, diluvium and prolluvium. Morphologically the study area is mainly positioned on the Erusheti upland, which is described as a form of tectogenic relief and the volcanogenic processes in the region matching the project area are of

secondary importance. Since the floodplain terrace of the Mtkvari at the dam axis area is formed with highly permeable alluvial shingle, the dam will be based on the less permeable, but water saturated rocks underlying the shingle. The permeability level of the bedrock is generally weak, but there are some zones with increased permeability due to physical effects. Thus, once the comparatively high permeability bedrock zones are treated, it can be stated that the reservoir area is relatively watertight and the possible main leakage paths will be through the dam foundation and abutments.

Historical and instrumental analysis of seismological data shows that the region is of moderate seismicity. In this region, strong earthquake with magnitude up to 7 and macro-seismic intensity IX (see Table IV.2) may occur. No significant mineral, or thermal or geothermal resources are located in the Project area.

Slope Stability: In the area of the future reservoir, landslides occur on both banks of Mtkvari River. In general, landslides are observed in clayey-detrial diluvial-proluvial surface sediments. On the other hand, in the headrace tunnel area there are no active geological processes and hazards in the route and vicinity of the headrace tunnel. However, rock slide might occur in the upstream from southern portal, from the right bank of the Mtkvari.

The right bank of the HPP area is protected from side erosion by the protruding rocks sitting at the upstream and downstream ends of the area. Since the right bank in HPP area consists of loose-fragmental clayey soils of the alluvial terrace and the debris cone, the river will erode from the right bank and threaten the stability of the dam related facilities in case of unfavourable hydraulic regime change. In addition to that, the floodplain and other terraces around the north part of the project area contain sandy-clayey sediments. This content and the general inclination from floodplain and other terraces towards Mtkvari promote minor landslides in the region.

Erosion: The study area that is 85 km^2 of land covers the locations of all project related structures. The area is mainly formed with unstable clayey and sandy tuffogenic formations dated back to the Upper Eocene. The banks of the Mtkvari

River within the reservoir area are built by alluvial-proluvial loose-fragmental soils with sandy or intermediately plastic clay and low plastic silt matrix. This content causes erosion and landsliding in many locations along the banks of the Mtkvari and some lateral ravines.

Erosion mainly caused landslide hazards in the study area. Other than that, erosion has also formed gully bodies through the slopes of the studied area ridges. However, the studies showed that erosion geohazard is insignificant through headrace tunnel route.

Soils: Generally, in Akhaltsikhe; cinnamon soils are very common. However, around the centre of Akhaltsikhe, brown forest soils and mountine-forest peat soils are dominant. On the other hand, mountine chernozems are common in Rustavi, while brown forest soils are mostly seen in Sakuneti. The slopes at the dam axis and reservoir area range between 1.5% and 34% with an average of 9.8%. The slopes at the powerhouse area are in the range of 7% - 36.5% with an average of 19.8%.

Land Use: The steep topography of the Mtkvari Valley at the dam site is typical of steppe vegetation, and affects the formation and distribution of vegetation in the project area. The natural forests in the area were generally destroyed by the settlers for the cultivation of potato, which is the major source of income in the region. Examples of natural forest free of anthropogenic effects are found only on the steep slopes and cliffs that cannot be used for the cultivation of hazelnut.

Climate and Air Quality: The project is located between two warm seas namely, the Black Sea and the Caspian Sea, in the subtropical latitudes. However, the climate of the Kura River basin is mainly influenced by its location in the mountainous area isolated from the subtropical affects of the warm seas and the cold air masses from the north of Eurasia. As a result, the typical climate observed in the project area can be described as cold winters with small amount of snow and long warm summers. The annual precipitation is 520 mm in Aspindza and increases to about 560 mm in Akhaltsikhe.

The highest precipitation is observed in June in both Akhaltsikhe and Aspindza Districts with about 82 mm and 81 mm of rainfall, respectively. Meanwhile, the lowest precipitation is observed in January and February (32 mm) in Akhaltsikhe and in December (22 mm) in Aspindza. The annual mean temperatures in Akhaltsikhe and Aspindza are 9.0 ^{o}C and 9.4 ^{o}C, respectively, August being hottest and January being coldest. The direction of the prevailing wind is from west and northwest in Akhaltsikhe and Aspindza, respectively. Additionally, the wind speeds recorded in Akhaltsikhe and Aspindza Weather Stations are 1.6 and 2.0 m/sec, respectively.

Hydrology: The drainage areas of Minadze Flow Monitoring Station and dam axis are 8,208 ha and 7,950 ha, respectively. The average flow of Minadze station is 57.65 m^3/sec based on hydraulic data for 1938-1973 period. Based on the flow data obtained from Minadze station, monthly average flow at the dam site for the period of 1964-1973 is calculated as 58.15 m^3/sec.

Sediment Transport: There is no glacier in the catchment area of Mtkvari and Mtkvari River is carrying rather low levels of suspended material to the dam site. Thus, the total suspended sediment load at the dam site is rather low. The reservoir is rather limited in size, but considering that the bottom elevation of the headrace tunnel intake is about 5 m above the riverbed here, allows trapping of considerable amount of sediments (about 1.5 million m^3) without affecting the flow in the intake.

Water Quality: The surface waters of the project area are classified according to their treatment needs for utilization using the regulation on “Surface Water Quality to be used or planned to be used as drinking water” document as reference.

According to the results of in-situ tests and laboratory analyses of the surface waters, all the waters taken from sampling points excluding headworks area, are classified as Category A1 with respect to high DO concentrations. Headworks area surface waters belonged to Category A2 in respect to its relatively lower DO concentration value.

Additionally, neither phosphate nor nitrate levels observed in the samples analyzed exceed Regulation on the Quality of Surface Waters Used or Planned to be Used for Drinking Water.

Fecal coliform level at Potsckhovi River indicates that Potsckhovi River water is in A1 category. On the other hand, fecal coliform levels in other waters (i.e. Mtkvari-powerhouse area, Uravelli Stream, Mtkvari-headworks area) exceed the level of A1 category. However, fecal coliform levels at those stations are not beyond the level of A2 M category.

As a consequence of chemical analyses of samples from Mtkvari River water, it is determined that Mtkvari River water is not suitable for drinking water and domestic purposes but may be utilized for agricultural irrigation.

Groundwater: Groundwater quality in the project area is influenced by the geological background, no significant sources of pollution are known. Groundwater use is basically non-commercial for domestic and irrigation purposes.

Surface Water Use: Mainly springs and groundwater are used for agricultural purposes in the villages. The river is used by the fauna species and by livestock to some extent. There are a number of alluvial water wells for irrigation purpose located close to Akhaltsikhe. Therefore, there is no significant use of river water by the locals living in the area for drinking, irrigation or production purposes.

3.2. Biological Environment

Flora and Vegetation Communities

The steep topography and riparian habitats of the Mtkvari Valley at the dam site is typical of the South Caucasus Region, and affects the formation and distribution of vegetation in the project area. The natural forests in the area were generally destroyed by the settlers for cultivation. Examples of natural forests free of

anthropogenic effects are found only on the steep slopes and cliffs that cannot be used for the cultivation.

The steep slopes in the project area are covered with scattered vegetation. In general, scattered trees exist at small villages and along the river, and there are irregular short trees on mountain sides. The hills and slopes that are covered with vegetation are occupied by shrubs and juniper and oak communities. In addition to these, shrubby forms of tamarisk, berry, and rose were also recorded in this zone. Occasionally, berries are observed. This limited vegetation is suitable habitats for various mammals, reptiles and birds.

The area is located in Europe-Siberia (Euro-Sib) phytogeographic region. Most of the species identified in the project area are widespread. The others are generally elements of European-Siberian floristic region.

As a result of the studies, 80 plant species belonging to 26 families have been identified from the samples and from literature sources. Among these 80 species, 3 species; "*Dianthus caucasicus*, *Anthyllis lachnophora*, *Thymus collinus*" (3.75 %) are Caucasian endemic. When the endemism ratio of Georgia (20%) is considered, it is clear that the endemism ratio in the area (3.75 %) is much lower. According to Georgian Red Data Book, these endemic species are not classified under any threat categories and they are generally spread all over Georgia. Also, none of 80 species are categorized in IUCN, BERN and CITES lists.

Fauna and Habitats

In the field studies, a total of 108 mammal, 78 bird, 19 reptile, 6 amphibian, and 13 fish species were identified in the study area.

Mammals: In Georgia there are 108 species of mammals. These species are associated in 64 genera of 28 families that belong to 7 orders.

Two species of the mammals are listed in Annex 2 of the Bern Convention, while 8 of them are listed in Annex 3. In addition, 17 species are classified by some IUCN category. Among these, 1 species (*Spalax leucodon*; lesser mole rat) is classified as DD (data deficient), 1 species (*Lutra lutra;* otter) is listed as NT (near threatened) and 15 species are classified as LC (Least concern).

Additionally, two species (*Canis lupus;* grey wolf and *Lutra lutra;* otter) are categorized in Appendix 1 of CITES. *Cricetulus migratorius* (grey hamster) and *Lutra lutra* (otter) are classified as VU (vulnerable) according to GRDB (Red Data Book of Georgia).

Birds: In the study area 78 bird species have been identified through observations and confirmed by the other identification methods. There is no bird species classified by IUCN and CITES categories. However, 45 species are included in the list of protected fauna species in accordance with the Annex 2 of the Bern Convention. Furthermore, 27 species are included in the list of protected fauna species in Annex 3 of the Bern Convention. In addition, 3 species (*Ciconia ciconia;* white stork, *Tadorna feruginea*; ruddy shelduck and *Buteo rufinus;* long-legged buzzard) are classified as VU (vulnerable) according to GRDB.

Reptiles: In Georgia 54 species of reptiles were recorded. In the study area, In the list of reptiles, 8 species are listed in Bern Convention Annex 2, while 11 of them are classified in Annex 3. According to IUCN, 9 species are classified as LC (Least Concern). No reptilian species are listed in GRDB and CITES categories.

Amphibians: There are 12 species of amphibians found in Georgia and 6 of them are distributed within the study area. According to Annex 2 of Bern Convention, 2 of them are strictly protected fauna species while 4 of them are listed as protected fauna species in Annex 3. In addition, 1 (*Mertensiella caucasica:* Caucasian salamander) amphibian species are classified as VU (vulnerable) in IUCN Red List and GRDB.

Fish: 13 fish species were identified in the project area. However, none of these fish species are endemic for Georgia. Due to the nature of the project, the potential

impacts on the fish species are more important when compared with the possible impacts on other biological resources. Therefore, the biological characteristics of the fish species are given special importance.

The studies revealed that Cyprinidae Family, Balitoridae Family, and Salmonidae Family exist in the Mtkvari River System. Among those families; *Alburnoides bipunctatus (*Spirlin), *Aspius aspius (Asp), Barbus lacerta (*Kura barbel), *Capoeta capoeta (*Transcaucasian barb), *Chondrostoma cyri (*Kura nase), *Gobio gobio* (Gudgeon), *Squalius cephalus* (European Chub), *Tinca tinca* (Tench); *Barbatula brandtii* (Kura loach) and *Salmo trutta fario* (Brown trout) are listed in Annex 3 of Bern Convention. Moreover, *Salmo trutta fario* which is considered to exist in the tributaries of the main Mtkvari River is classified as “VU: Vulnerable” in GRDB.

3.3. Socio-economic Environment

Project affected settlements that are Rustavi and Sakuneti Villages are within the borders of Aspindza and Akhaltsikhe Districts, respectively and in the region of Samtskhe-Javakheti which is one of 12 administrative regions in Georgia. It is located in the southern part of the country, bordering Armenia and Turkey. The administration of Samtskhe-Javakheti region is headquartered in Akhaltsikhe.

There are 353 settlements in the region including 6 cities – (Adigeni, Akhalkalaki, Akhaltsikhe, Borjomi, Vale and Ninotsminda), 7 towns (Bakuriani, Bakuriani Andesite, Tsagveri, Akhaldaba, Adigeni, Abastumani, Aspindza) and 254 villages.

According to 2002 census, the overall populations are 46,134 and 13,010 in Akhaltsikhe and Aspindza Districts, respectively. Among those populations, females constitute 51.7% and 51.4% while males constitute 48.3% and 48.6% in Akhaltsikhe and Aspindza Districts, respectively.

More specifically, the project affected settlements are far from urban areas. Sakuneti and Rustavi Villages are the closest settlements to the construction area of Mtkvari HPP facilities.

In Sakuneti Village, there are 162 households in this village as per 2001 Census. The total population of the village is 918 and total agricultural land has an area of 2,118 ha. The average household size in Sakuneti Village is above the average of the country. While Georgia's average rural household size is 4.3 persons, it is 5.7 persons in the Sakuneti Village.

In Sakuneti, major occupation of the villagers is farming and mainly potato is cultivated. Livestocking is also conducted in the village. Some of the households in the village are involved in fishing as well. However, according to the villagers, the fish catch in the area has been declining.

On the other hand, there are 153 households in Rustavi Village as per census 2001. The total population of the village is 812 inhabitants and its agricultural land is 914 ha. The average household size in Rustavi village is above the average of the country. While Georgia's average rural household size is 4.3, it is 5.3 in the Rustavi Village.

Similar to Sakuneti, agriculture and animal husbandry are the most important income sources. Within agricultural products, tomato and potato are mostly cultivated. In animal husbandry, cattle are commonly preferred. In addition, apiculture is also widespread. Some of the households in the village are involved in fishing as well.

In both of the Villages, all the people in the village follow Christianity. The literacy level is 100% and women and men have equal rights. In the Villages, primary education of 11 years is obligatory for all the children. There is no emigration or immigration and one school and one small clinic exist in neither of the Villages, currently. There are no private doctors; however, Sakuneti and Rustavi Villages are about 13 and 12 km from Akhaltsikhe, respectively and are connected with an asphalt road. Therefore, the health institutions in Akhaltsikhe can be used by the

villagers. The villages have electricity, phone, and shops. The houses in the villages were connected with supply of tap water.

Furthermore, the livestock population is not very high due to lack of fodder. Agriculture is the main occupation of the people in the villages and fishing is done by some for self-consumption. Some small amount of land of the villagers would be partially affected by the project.

In terms of social composition, there are no indigenous people and no ethnic minorities or no clan or tribal structure in the project area potentially affected by Mtkvari HPP Project. The potentially affected persons are all Georgians.

The field studies and survey of relevant literature show that there are no significant cultural or historical assets/sites in the project and impact area including the villages of Sakuneti and Rustavi.

4. ENVIRONMENTAL IMPACTS AND MITIGATION

4.1. Physical Environment

Impact on Topography and Loss of Land

With the filling of the reservoir, the area upstream of the dam will be converted to a water body. The area of physical land take by the Project includes the reservoir area and the footprint of the construction sites and facilities (dam site, camp facilities, access roads etc). The reservoir covers an area of 0.5 km^2. Approximately 2.150 m of the roads along the river will be raised about 10 m.

The area to be inundated is covered with mostly steppe vegetation. No loss of forestry areas is of concern. Loss of agricultural land is negligible. Additionally, no loss of land will be an issue along the headrace tunnel as the structure will be

constructed underground. The areas for switchyard and owners camp facilities outside of the reservoir consist of semi-arid shrubs.

Impacts on the Geological Underground

As the site has sufficiently firm geological characteristics, subsidence due to the weight of the reservoir water is not anticipated to be an issue of concern, neither is watertightness.

Triggering of strong earthquakes by the impoundment reservoir is considered unlikely based on the findings of the engineering studies. Project engineering design will ensure that the effect of seismicity on the project during construction and operation is accounted for. The alluvial and bedrock materials in the foundations for the various project features have been characterized and tested sufficiently to provide the required information to develop a safe and conservative design. The foundations will provide adequate support for the loads applied to them by the dam and spillway at the headworks. The Mtkvari Dam will be designed so as to have a structure that meets all the engineering standards. In any case, seismicity will be monitored by the measuring devices (strong motion accelerographs) installed in the dam and its foundation.

Landslide and Erosion

Construction activities may increase the potential of occurrence of landslides and erosion in various ways, which include destabilization of rock masses by cuts in slopes, improper stockpiling of materials, destruction of vegetative cover during site clearing and uncontrolled surface run-off (slope wash) during storms.

The banks of the Mtkvari River at the reservoir area are composed of alluvial-proluvial loose-fragmental soils with sandy or intermediately plastic clay and low plastic silt matrix. Thus, the content may cause erosion and landslides at various points along the banks of Mtkvari River and in some lateral ravines. These are the

main geohazards which could cause difficulties with geodynamic stability of facilities and the environment.

Reservoir Sedimentation

Carried suspended material by Mtkvari River to the dam site is limited. The size of the reservoir is relatively small. However, the bottom elevation of the headrace tunnel intake that is about 5 m above the riverbed, allows trapping of considerable amount of sediments (about 1.5 million m^3) without affecting the flow in the intake.

In this scope, considering that the reservoir is to divert the water to the headrace tunnel but not for water storage, the Mtkvari Project will not significantly hinder the transport of sediment, thus nutrients and alluvium to the delta. Therefore, sedimentation in the Mtkvari Reservoir would neither affect the downstream water quality nor the delta significantly.

Impacts on Soil

During construction, for the minimization of erosion at sites and sediment run-off to the rivers mitigation measures will be taken. These measures will be detailed and a site specifically developed Erosion and Sediment Control Plan will be prepared for construction site. Stockpiles, including construction materials, such as concrete aggregates, filter material and sand will be properly handled and stockpiled separately from disposal areas, where surplus or waste excavated materials will be disposed. Additionally, topsoil will be stockpiled properly in order to reuse it for vegetation activities. Topsoil material will be salvaged to the extent possible to minimize loss through erosion. Moreover, the surface drainage systems will be used to direct the site runoff to settlement ponds before discharging to watercourses.

Impacts on Local Climate

The concern regarding the impacts of dam and reservoir projects on local climate is microclimate changes. The significance of this change is related to the surface area

and volume of the reservoir and to the prevailing climatic conditions in the area. The phenomenon is generally storing energy of the reservoir from solar radiation received during summer in the upper water body and dissipating this stored heat during the winter. This is a general moderating effect causing a trend of milder conditions resulting in increases in humidity and increased average winter temperatures and less hot conditions in summer. The effect of colder air from the slopes meeting the relatively warmer reservoir water surface might also result in a tendency to mist and fog occurrence especially in winter. However, Mtkvari Project will have a very small reservoir (0.5 km²), so it will not lead to a significant change in the climate of the area or the region.

Global Warming Relevance

In particular; shallow, tropical reservoirs with high volumes of residual organic compounds in the flooded reservoir, intensive aquatic primary production and high influx of organic material by their tributaries are of concern in global warming relevance. Mtkvari reservoir area however, is very small and only sparsely covered with vegetation, has a weak soil cover and low influx of organic material. Furthermore, the climate of the project area of Mtkvari HPP is not favorable for contribution to the greenhouse gas emissions. As a result, Mtkvari HPP project will not contribute to the climate change.

Ambient Air Impact

Impacts on air quality are of concern only during the construction phase. The gaseous and particulate matter emissions during construction activities were estimated by modeling studies based on the provided construction schedule (detailing construction activities and their durations), construction work plan (detailing amounts of fills and excavations). The results of the model include both the maximum values of the annual average and the maximum value of the daily average. None of these maximum values are predicted to occur at the settlements. These were observed at the receptors closest to the sources (construction sites). When the results for other locations are analyzed, it is seen that they are substantially lower.

In order to evaluate the significance of the impacts of PM emissions, the calculated PM concentrations are compared with the EU Directive of 2008/50/EC and WHO Guidelines. As a result of this comparison daily PM_{10} concentration is above the limit values indicated in the EU Directive, while it is under the limit value of the WHO Guidelines. PM_{10} concentrations are much lower near the settlements closest to the construction sites. It has been noted that these maximum values reflect the worst case close to the source and under adverse conditions (i.e. maximum values generally occur at calm conditions when dispersion is minimum and conservative assumptions for the vehicle fleet). Furthermore, it should be pointed out that the nearest settlement to the dam site, Rustavi Village, is about 3 km to the north-east of the dam site and the nearest settlement to the powerhouse, Sakuneti Village, is about 1 km to the south of powerhouse.

Noise Impact

The noise levels were estimated to be below the 55 dBA limit for construction works set out in Environmental, Health, and Safety (EHS) Guidelines (General EHS Guidelines: Environmental Noise Management) of International Finance Corporation of the WB. Noise levels exceed the maximum allowable in neither of the project affected villages.

It should also be pointed out that due to the fact that the noise level estimations are based on a worst case scenario in which the set of machinery is assumed to operate at the same place and at the same time (that is in fact physically impossible), actual noise level are expected to be much lower.

The only noise source of the Project foreseen in operation phase will be generator and turbines located in the powerhouse. However, there will not be any considerable noise nuisance since they will be located in a closed building. In addition, it will be somewhat an isolated facility since it will be located at a distance of 1245 m to Sakuneti Village, which is the nearest settlement.

Impacts on Hydrology

Construction Impact:

For construction, the Mtkvari River will be diverted to diversion tunnel via cofferdam to create a dry work area at the dam site. The natural flow pattern will not be affected by this.

Impoundment Impact:

Reservoirs having a relatively large storage capacity with respect to inflow generally have large surface areas exposed to solar heating and a long enough detention time. Thus, they develop stratification and the consequent changes in temperature, dissolved oxygen, and nutrient content. However, Mtkvari reservoir will have a very small surface area and will be rather shallow, since the purpose of the Project is not water storage, but just diverting the river. Therefore, problems that are anticipated in deep reservoirs due to stratification will not occur in Mtkvari Project.

Excessive nutrient (carbon, phosphorus, nitrogen) content promotes the growth of algae in lakes and large reservoirs. The decomposition of algae may create anaerobic conditions in the bottom waters (hypolimnion) and even in midwaters (metalimnion). Turbidity increases due to these processes. As a result, algal activity is prohibited due to the reduced light penetration. Thus, the amount of dissolved oxygen provided by the algae decreases with depth and the algae concentrate on the surface and form algal blooms. This process, termed eutrophication, is mainly affected by incoming carbon, nitrogen and phosphorus to the reservoir. Phosphorus is generally the limiting parameter of eutrophication. According to the results of the chemical analyses of Mtkvari River water, the levels of phosphorus and nitrogen are quite low. Thus, the Mtkvari Reservoir will not be under risk of eutrophication and will not pose a water quality problem in the reservoir or downstream.

Operation Impact:

The Mtkvari HPP Project will be operated in a run-of-river mode, with very limited water storage. The inflow will be diverted to the powerhouse by a power tunnel, bypassing approximately a 27 km reach of Mtkvari River. However, it should be

pointed out that Uraveli and Potschkovi Rivers, which have considerable flows, join Mtkvari River at distances of 8 km and 9.2 km downstream of dam axis, respectively.

The decrease in the existing flow can decrease the tolerance of the river to pollution and also can adversely impact the continuity of the aquatic ecosystem. In order to maintain existing water quality and the biological resources in the by-passed reach; it is necessary to release a minimum flow from the reservoir to the bypass reach. For that purpose, a study was carried out to calculate the minimum flow to be released to the riverbed. The results of the study revealed that the minimum flow to be provided in the by-pass reach is 5.8 m^3/sec (10% of the average flow).

Impacts on Water Quality

At the construction phase of the project the water usage will be due to concrete preparation, washing the concrete aggregate material, preventing dust and the domestic uses of the workers. The water required for the concrete batch plant, washing the aggregate material and preventing dust would be taken from Mtkvari River. Drinking water will be supplied from the groundwater sources of the villages in the vicinity; otherwise, the water will be purchased and brought to the project site.

The daily water requirements for domestic purposes and washing aggregate material and concrete mixers are calculated as 18.75 and 26 m^3, respectively. Water consumption for dust prevention is also taken into account considering that “10% moisture will be maintained at the topsoil layer”.

If it is accepted that the whole of the water required for the domestic usage of the workers will be converted to domestic wastewater, the daily generation of the domestic wastewater will be 18.75 m^3. Throughout the construction phase due to washing the concrete aggregate and mixers, 52 m^3 of wastewater that has high suspended solid amount will be produced daily.

For the protection of the water quality at the construction sites, a wastewater management plan will be implemented.

Sanitary Risk

According to the studies and statistics, none of the parasitic diseases is found in Georgia due to climatic conditions. The risk combined with realization of this dam project can also be assessed by observing similar projects in the same region. No such adverse health impacts have been reported to occur as a result of developed dam projects in the region. As the primary function of the Mtkvari Project will be power generation and not drinking water supply for the people in its vicinity, development and spreading of bacterial diseases, such as diarrhea, are not anticipated. Because of these reasons, the Mtkvari Project will not impose any increased risk to human health.

4.2. Impacts on Biological Environment

Impacts on Flora and Terrestrial Fauna

The vegetation at and around the dam site and other construction areas will be destroyed by the construction activities and the plant populations below the high water level of the reservoir will be lost. The destruction of the vegetative cover in turn affects the terrestrial fauna that depends on these habitats.

The construction of access roads, diversion and power tunnels and the dam can have negative impacts on biological environment, as existing habitat in and around these areas would be degraded to some extent. Most medium to large mammals and birds will leave the area, due to noise, dust, and human activity of construction. Such activities, however, will take place in a limited area and therefore will affect a limited population in the project area. In addition, since the vegetative cover is rather homogeneous and evenly distributed throughout the project area, the destruction of vegetation at tunnel adits will not cause the loss of any critical habitat for the biological species living in the area. Based on these findings and the project characteristics, the impacts of the project on flora species would be insignificant.

In the development of water resource projects, feeding, breeding, resting and dwelling habitats of terrestrial animals are destroyed by construction activities and inundated by the filling of the reservoir. In most cases, self-rehabilitation takes place since terrestrial fauna elements escape to suitable habitats in the vicinity after impoundment. This in turn, may push the carrying capacity of the receiving sites to its limits, overloading the ecosystems for a certain period of time. As the area to be inundated by Mtkvari dam is only 0.5 km^2, impacts on both the terrestrial fauna and the flora will be quite limited. In addition, the proposed reservoir is only 3.5 km long and, hence will not pose a significant obstruction for terrestrial animals to cross to the other side of the river.

The Mtkvari Project will be operated as run-of -river and therefore no significant changes in surface elevation of the Mtkvari Reservoir are anticipated. The development of water dependent vegetation along the shoreline, which may occur in hollows and depressions, is beneficial for water birds and some mammals. For biological species, this water dependent vegetation will serve as a nesting place and feeding area.

Fish:

The changes in aquatic habitats and biota due to the formation of the Mtkvari Reservoir will be to a limited extent, in accordance with its small size. Most of the fish species identified are adaptable to living in lakes as well as rivers. Thus, formation of a very small reservoir, which will develop slightly lentic conditions, will not have a significant impact on the fish species of the river.

Among the fish species *Salmo trutta fario* (brown trout) is a sensitive species to water quality and river habitat. This species can be found in the tributaries joining the Mtkvari River and hence the small reservoir of Mtkvari will not have a considerable effect on this species.

Ten fish species (Asp, Kura barbel, Spirlin, Transcaucasian barb, Kura bleak, Kura nase, European Chub, Gudgeon, Tench and Kura loach) identified in the project area

are listed in Annex 3 of the Bern Convention. The habitats of these species include stony and sandy bottoms, which form the river bottom of the Mtkvari River throughout the project area. Due to the presence of these types of habitats evenly throughout the bypass reach, it is expected that this situation will not be altered significantly during the operation of Mtkvari Project, as long as the critical flow is maintained.

As stratification and the consequent changes in temperature, dissolved oxygen (DO) and nutrient content will not be of concern in the operation phase of the project, no conditions related to thermal stratification will be developed due to the small reservoir size. In relatively small reservoirs, long detention times and solar heating due to large surface areas is not observed. As a consequence, it is highly unlikely that thermal stratification will occur in the Mtkvari Reservoir, which has a surface area of only 0.5 km^2 and a maximum depth of approximately 25 m. Therefore, Mtkvari Reservoir is expected to remain isothermal throughout the year and will not pose any adverse impacts on the water quality and the aquatic biota downstream of the powerhouse.

4.3. Impacts on Socio-Economic Environment

Demographic Impacts

The impacts on demography will be of concern mainly for construction phase and would be related with the mobility of the population. Considering the construction phase, it is possible to speak of two different kinds of population mobility. Former is the forthcoming workers coming for construction and other staff. Latter is the population mobility due to the construction in the area.

It has been planned to employ 250 workers in the construction activities of Mtkvari Project. The required staff will first be chosen among local people. For the rest of the staff, worker dormitory, engineer dormitory and guesthouse will be constructed nearby. For the workers to be selected among local people, the impact of migration mobility will be limited. In addition, those who will come to work in the construction will be directed to work in the determined parts of the project; and this will also

reduce the negative impact of migration mobility. The low rate of workers coming from outside compared to local population will additionally decrease the impact on the socio-cultural structure of the region. It is not expected that there will be migration to or from the area resulting from positive or negative effects of the project. Since the construction activities will be held in a limited area, and there is no loss of settlements, local people are not forced to emigrate. Therefore, the impact of the project on the demography and any migration movement is extremely low, which can be called as insignificant.

In addition to this, the migration movement that takes place in the operation phase is different from those in construction phase. Within the operation phase, the number of workers will be just 10% of all workers employed in the construction. Considering the low number of staff at the operation phase, no significant impact on the local population is anticipated.

Economic Impacts

As the workers and staff coming to the region for construction activities would increase, the demand for the goods and such is also expected to increase. Thus an increase in demand might cause an increase of prices for certain goods at the regional level. However, the limited incoming population and the economically integrated character of region to the bigger settlement areas are predicted to reduce the inflationist impact resulting from demand increase and finally would remain at low level. On the other hand, this would bring the opportunity for trade in the area. The goods and services needed during project activities will be purchased from the region. Therefore, trade in the region will increase as a result of construction activities. If all activities are conducted simultaneously, a significant increase in the economy of the region is expected. In addition, transportation infrastructure for the project activities within the region will be improved and this will allow local people to reach easily to the district centers. As a result, the economic integration will increase, which is a positive impact.

As the agricultural land loss due to project activities constitutes a very small percentage of the total agricultural lands, it is expected that the households doing agriculture will not lose their economic gains. In addition, the areas to be used by project facilities are not utilized by animal husbandry activities either. No one living in the region will lose his/her house, job, and social networks because of project activities. On the contrary, project activities will create a source of job opportunities and enable people to participate more actively to the social networks, and finally social integration will increase. In addition to that, the improved transportation network will additionally give increase to the dynamic social structure. Within and across region, the interaction will be increased. With the realization of the project, local people are expected to join and participate to the civil society related with the project.

Impacts on Social Structure

In the respect of construction of Mtkvari HPP, the social network would receive a limited impact. The selection of workers from the local people and the construction of houses in the construction area for workers coming from outside will reduce this impact.

The transportation facilities made up for construction will additionally give rise to a more dynamic social structure. Within and across region interaction will be increased. With the start of the project, local people are expected to join and participate to the civil society organizations related with the project. Within the project, the improvement of the transportation infrastructure in the construction and operation phases and the increase in the environmental and social awareness will be effective in the formation of active participation of local people to the social life. It has been analyzed that improved social relations will positively influence the region.

Impacts on Landscape

Anthropological stress is not of concern in the project area and its vicinity. However, the most significant formations that affect the natural landscape characteristics are

the Chitakhevi HPP which is at a distance of approximately 20-25 km in the downstream of Mtkvari HPP and limited agricultural and animal husbandry activities that compose the sources of income of the locals.

Natural landscape elements are observed at the headworks and powerhouse areas of the Mtkvari Project. Some of the landscape characteristics will be altered temporarily with the construction period, while some of them will be irreversibly changed by the formation of the reservoir and starting of the operation period.

There would be visual disturbance during the construction phase of the project due to construction operations. This impact, which would be experienced close to the construction sites, will only be local. However, this impact will be temporary, such that disturbances on local population would be only during the construction phase.

The most significant visual change in the area will be formation of a reservoir, despite the small size of it. This will have a positive visual impact due to the small surface area of the reservoir to be formed. Furthermore, reservoir formation will not change the landscape characteristics of the surrounding area significantly.

There are no houses in the immediate downstream of the dam site, whose views would be blocked due to the dam. Therefore, no settlements would be affected due to the blocking of the view by the dam body. The transmission line would be built for connecting the electricity produced to the national system. Also, a switchyard would be constructed for connecting to the transmission lines. The switchyard would be a new structure in the landscape. The visual impacts of the transmission line would not be significant, since the route is selected to be as far from settlements as possible considering the vegetation and land use characteristics. The switchyard will be located at a rather visible site, but would be a part of the power plant structure and the visual impact would be permanent, but local.

The Mtkvari Project is not located within any areas of designated landscape importance, such as landscape protection area, at either a local or regional/national/international scale. The impact on landscape would not be

significant since the reservoir is rather small. In fact, water bodies, such as lakes or reservoirs, may be considered to create pleasant scenery.

4.3. Impacts of Transmission Line

The electric transmission line (ETL) to be built for transmission of the electricity produced by Mtkvari Project is rather a short (8 km) low voltage line (110 kV), which is factor decreasing the potential adverse impacts of the ETL. The ROW is selected as the shortest possible route both technically, economically and environmentally.

Negative environmental impacts of transmission lines are caused by construction, operation and maintenance of transmission lines. Clearing of vegetation from sites for the towers and ROWs and construction of service roads, and substations are the primary sources of construction related impacts. Furthermore, fauna disturbance and loss of land use are also adverse environmental impacts of transmission line. Runoff and sedimentation from grading for tower pads and alteration of hydrological patterns due to maintenance roads and erosion potential pose risk for the physical environment. Additionally, dust and noise emissions, solid wastes due to construction machinery are also of concern during construction phase of the project. Concerns regarding generation of domestic wastewaters due to workers are also valid for the transmission line construction. Avian hazards due to bird deaths and visual impacts are of concern during operation phase. However, as migrating birds fly high about 100 m from the land surface electrocution of birds will be prevented. Additionally, the route of the transmission live is selected by considering cultural and aesthetic resources and hence there is no area with high landscape/visual value on the ROW or its close vicinity.

Another considerable impact of operation phase is the induced effects from electromagnetic fields due to magnetic field created by the current in the lines and cables. Since the voltage of the line is rather low a significant impact is not expected.

5. ANALYSIS OF ALTERNATIVES

The construction of Mtkvari HPP is planned to be performed by JSC Caucasus and Energy Infrastructure. Within the scope of the feasibility study and the geotechnical studies of the Mtkvari HPP project it is determined that the proposed project is economically and technically feasible.

The project alternatives are evaluated based on four different aspects: project type, project location and size, tunnel construction methods and type of powerhouse and operating mode. In the scope of analysis, alternatives that are analyzed in the feasibility study in addition the no action alternative are discussed. This includes a summary of the main rationales given in the feasibility report and further evaluations and comparisons, including environmental evaluations, where possible.

Project Type

The potential environmental impacts of the Mtkvari HPP Project were evaluated by considering a standard-type coal fired thermal power plant as an alternative facility. When the potential basic environmental impacts of this alternative type of project and those of Mtkvari HPP Project are considered, it is clear that hydroelectric projects do not give rise to the inherent environmental impacts of thermal power plants, such as the effects of flue gas emissions on air quality and greenhouse gas emissions on climate change, and the effects of cooling systems on aquatic ecology. The operating and maintenance costs of thermal power plants are generally higher than those of hydroelectric power plants. In addition, the costs of pollution control equipment, such as electrostatic precipitators and flue gas desulphurization units add to the overall cost.

A major difference between these projects is that the thermal power plant uses a non-renewable resource to produce energy whereas Mtkvari HPP Project uses a renewable resource. Today, in addition to coal; natural gas fired thermal, nuclear, geothermal, wind, solar and biomass power plants could be considered as alternatives to the Mtkvari Hydropower Project. Concerns about disruptive fossil fuel

markets and uncertain pricing, the current difficulties in political and public acceptance of nuclear energy (unresolved questions over risks involved and the disposal of nuclear wastes), and the global environmental consequences of using thermal energy sources (particularly the emission of greenhouse gasses) have all placed greater emphasis on sustainable energy policies, which include the development of renewable energy supplies, of which hydropower is one of the most important and reliable.

Hydropower at present is the only domestic source of Georgia, which can provide reliable low cost energy, which in addition is renewable. Thus, the Mtkvari Project is more viable, when compared to alternative thermal power generation from today's perspective, first in the sense that it will be using a renewable resource for electricity production and providing more sustainable means of energy generation and secondly based on the economics of the project.

Project Location

Mtkvari Hydroelectric Power Plant which is located in the southeast of Georgia on the River Mtkvari near the city of Akhaltsikhe is one of the several hydroelectric projects proposed as part of the Greenfield hydropower plants investment program initiated by the Ministry of Energy. The location of Mtkvari Power Plant depends on the effective head available via the Mtkvari Dam and the headrace tunnel to produce the maximum amount of energy. Accordingly, powerhouse locations were studied and the powerhouse site was selected to be 1 km upstream of Sakuneti Village and it will be located on the right bank of Mtkvari River. For both of the headworks alternatives explained below, the powerhouse near the village Sakuneti is foreseen.

In Option 1, location of headworks is downstream of Rustavi Village. At this dam site the minimum water level in the river is 970 m with maximum flood level at about 973 masl. The level can be raised to a maximum of 977 m and should not reach higher during floods. The proposed headrace tunnel alignment is a straight line from the intake to a location some 600 m upstream of the village Sakuneti at 910 m elevation. The tunnel length will be about 7.5 km.

In Option 2, location of headworks is upstream of Rustavi. At this dam site the minimum water level will be about 992 m. The water level may be raised to about 1,012 m with even higher flood level. The site thus favours a 100-150 m long fixed ungated overflow spillway. In general, the conditions for a tunnel intake and dam are more favourable here than at the lower dam location. Since the intake pond will have more volume, the intake can be located deeper.

The comparison between these two options revealed that Option 2 is more beneficial. Main reasons for selecting Option 2 can be summarized as:

- The location of intake calls in Option 1 is relatively expensive gated spillway solution compared to the more cost effective overflow weir at the Option 2 location.
- The difference in head and thus in energy output amounts some 53% to the favour of Option 2, as compared to the corresponding figure for the headrace tunnel length is 27% to the favour of Option 1 (9.6 km for Option 2 instead of 7.5 km for Option 1).

These in turn show that Option 2 is economically more viable than Option 1 with similar environmental consequences.

Tunneling Methods

In the context of alternative tunnelling methods, Tunnel Boring Machine (TBM) and conventional Drill and Blast (D&B) methods are of concern. For a comprehensive comparison, the findings of the Geotechnical Investigation Report are also taken into consideration.

In comparison of the two alternative tunnelling methods, it is considered that TBM method may result in ingress of water, squeezing of soils, crossing difficult fault zones and spalling rock conditions. On the other hand, D&B method requires more

time in construction period and it is more risky when the geological conditions are considered. Furthermore, the environmental impacts of D&B are much more significant compared to TBM method.

As a conclusion, TBM method is considered to be the best alternative for tunnelling as it is faster, cheaper and less risky in addition to less environmental problems to be created.

Type of Powerhouse

For the construction of the powerhouse to be located in Sakuneti, surface type and underground type powerhouse are compared. In comparison of the two alternatives, the dimensions, contingencies and other costs are taken into consideration. Including all these factors, the cost comparison was made with the sum of the pertinent features for both alternatives:

- Pressure tunnel, powerhouse building and tailrace for surface type powerhouse
- Pressure tunnel, powerhouse, tailrace, control building and access area for the underground type powerhouse.

According to the cost comparison performed for underground and surface type powerhouse, underground powerhouse seems less costly. However, the cost difference is minor when compared to the overall costs involved and grand investment cost of the project. Thus, the project developer selected the construction of a surface type powerhouse for Mtkvari HPP Project based on its previous experience and the technical practicalities.

Modes of Operation

The Mtkvari Project is comprised of a concrete dam and a 9.6-km long headrace tunnel diverting the inflow to a powerhouse, by-passing an approximately 27-km long reach of the Mtkvari River. The Project having a very small reservoir will be operated

in run-of-river mode, in which the inflow is directly used for power generation and the surplus water is released from the spillway.

The effect of the Mtkvari Project on the reach of the Mtkvari River to be by-passed will be the most significant impact because of the nature of the project. Varying tailwater levels will not cause any notable effect on the aquatic ecosystem downstream of the powerhouse, since two important (big) tributaries, namely Potsckhovi and Uravelli joins the Mtkvari in the do called bypass reach. The selection of this mode was made largely on technical and economic grounds, however, the adverse impacts on aquatic ecology in the river reach between the dam site and the powerhouse will be mitigated by maintaining a constant minimum release from the dam, except during periods of spilling.

No Action Alternative

When the no action alternative is considered, it can be said that this alternative is generally not preferred for energy production aimed projects that will generate public benefits to the country. When the no-action alternative is chosen (if Mtkvari project is not realized), the following consequences may take place:

- Need of establishment of alternative plants, such as thermal or nuclear power plants, or the utilization of gasoline, diesel and fuel-oil fueled individual gensets which are less economic, have other adverse impacts on the environment, and are not as sustainable as using a renewable source for energy production.
- Limitation of social and economic development in the country.
- Loss of employment opportunities for 250 people in construction phase and 30 people in operation phase.
- No adverse ecological impacts, such as effects on existing river hydrology, especially in the by-pass reach, and aquatic life, that would be caused by the realization of the Mtkvari Project.

6. ENVIRONMENTAL AND SOCIAL ACTION PLAN

The environmental and social action plan covers mitigation measures for the identified adverse environmental impacts, the monitoring and institutional requirements. These measures outlined in the main ESIA report will be detailed for the specific issues, and implemented accordingly, in the consequent stages of the project implementation by the responsible parties.

6.1. Mitigation Plan

The mitigation measures for the minimization of the possible impacts of the project are summarized above. The key organization for the implementation of ESAP is the project developer JSC Caucasus Energy and Infrastructure during pre-construction construction and operation phases.

6.2. Monitoring Plan

The monitoring activities to be performed during construction and operation will be carried out in coordination of JSC Caucasus Energy and Infrastructure.

During construction an environmental site manager will be designated, who will be responsible for the monitoring issues. During operation, an environmental coordinator will be assigned for this purpose. In case the findings of monitoring indicate any deviation from the implementation of the outlined plans aiming at the protection of the environment, or any environmentally unsatisfactory condition should be encountered the environmental site manager will advise corrective actions as necessary. Monitoring records will be kept by the environmental site manager during construction and environmental coordinator during operation phases. Generally, reports will be prepared bi-annually or annually to describe the monitoring activities and their results (including any need for improvement and the means of achieving this). These reports will be available to relevant governmental agencies, when required, and to the public as appropriate. Compliance with national environmental regulations will be strictly adhered to in all phases of the project and for monitoring

activities independent consultants can also be employed, when necessary. In the scope of environmental coordination efforts for the construction phase, environmental training of the construction workers will be an important component.

In addition to the above mentioned monitoring requirements, specialists from various ministries, including the Ministry of Environmental Protection and Natural resources may also inspect the project activities, beginning with the construction, till the end of the economic life of the Project. This monitoring will aim to verify whether or not the project activities are conducted in accordance with the requirements of relevant regulations.

TABLE OF CONTENTS

	Chapter-Page
TABLE OF CONTENTS	i
LIST OF TABLES	vii
LIST OF FIGURES	xi
LIST OF PHOTOGRAPHS	xiii
LIST OF APPENDICES	xiv
LIST OF ABBREVIATIONS	xv
I. INTRODUCTION	I-1
I.1. Energy Sector in Georgia and Policy Background	I-1
I.1.1. Overview	I-1
I.1.2. Energy Policy of Georgia	I-3
I.1.3. Role of Hydropower in Georgia	I-4
I.2. Greenfield Hydropower Plants Project Identification and Development Background	I-5
I.2.1. General Information about the Project	I-5
I.2.2. Salient Features of the Project	I-11
I.3 Regulatory Background	I-12
II. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK	II-1
II.1. National Legal and Regulatory Framework	II-1
II.1.1. Administrative Framework	II-1
II.1.2. Environmental Legal Framework	II-6
II.1.3. Environmental Impact Assessment Procedure in Georgia	II-8
II.2. Land Use Legislation	II-10
II.3. Labour Legislation	II-11
II.4. Related National Strategies and Plans	II-12
II.5. Other International Agreements	II-12
II.6.1 World Bank Requirements	II-12
II.6.2 EBRD Requirements	II-13
II.6.3 IFC Performance Standards	II-14

Chapter-Page

III. PROJECT PURPOSE AND DESCRIPTION III-1
III.1. Present Situation and Objectives in Energy Sector III-2
III.2. Project Description III-3
III.2.1. Project Location III-3
III.2.2. Description of Structural Components III-7
III.3. Economical and Social Aspects of the Project III-14
III.3.1. Cost Calculations III-14
III.3.2. Construction Schedule III-15
III.3.3. Cost-Benefit Analysis of the Project III-19

IV. BASELINE DATA IV-1
IV.1. Physical Environment IV-2
IV.1.1. Topography IV-2
IV.1.2. Geology IV-3
IV.1.2.1. General Geology IV-3
IV.1.2.1.1. Lithology and Stratigraphy IV-5
IV.1.2.1.2. Structural Geology IV-6
IV.1.2.1.3. Seismicity IV-9
IV.1.2.2. Geology at the Dam Site and in the Reservoir Area IV-14
IV.1.2.2.1. Lithology and Stratigraphy IV-14
IV.1.2.2.2. Water Tightness and Slope Stability IV-17
IV.1.2.2.3. Mineral Resources IV-21
IV.1.2.2.4. Soils, Erosion and Land Use IV-23
IV.1.3. Climatology IV-29
IV.1.4. Hydrology IV-36
IV.1.4.1. Outline of Mtkvari Basin IV-36
IV.1.4.2. Estimation of Run-off at Project Site IV-38
IV.1.4.3. Water Quality IV-40
IV.1.4.4. Groundwater and Springs IV-48
IV.1.4.5. Existing Water Use in the Project IV-51

Chapter-Page

Area

IV.1.5. Noise IV-52

IV.1.6 Landscape IV-53

IV.1.7 Air Quality IV-61

IV.2. Biological Environment IV-63

IV.2.1. Legal Framework IV-65

IV.2.2. Flora and Vegetation Communities IV-68

IV.2.2.1. Materials and Methods IV-68

IV.2.2.2. Flora IV-73

IV.2.2.3. Vegetation Communities IV-80

IV.2.3. Terrestrial Fauna IV-81

IV.2.3.1. Mammals IV-82

IV.2.3.2. Birds IV-85

IV.2.3.3. Reptiles IV-91

IV.2.3.4. Amphibians IV-93

IV.2.4. Fish Species in the Study Area IV-95

IV.2.5. Aquatic Habitat Characteristics IV-111

IV.2.6. Species of International Concern IV-112

IV.3. Socio-Economic Environment IV-117

IV.3.1. General Information about Georgia IV-117

IV.3.2. General Information about Samtskhe-Javakheti Region IV-121

IV.3.3. Project Affected Villages (Sakuneti and Rustavi Villages) IV-126

IV.3.3.1. Social Composition in Affected Villages IV-129

IV.3.3.2. Governance Issues IV-130

IV.3.3.3. Land Ownership and Tenure IV-132

IV.3.3.4. Economic Activities IV-133

IV.3.3.5. Education IV-134

IV.3.3.6. Vulnerable Groups and Gender Issues IV-135

IV.3.3.7. Cultural Heritage and Tourism IV-137

IV.3.3.8. Community Health IV-138

IV.3.4. Considerations Related to the Realization of the Project IV-138

Chapter-Page

IV.3.4.1. Public Participation Meeting and General Considerations IV-138

IV.3.4.2. Advantages and Disadvantages of the Project IV-142

V. ENVIRONMENTAL AND SOCIAL IMPACTS V-1

V.1. Physical Environment V-1

V.1.1. Physiography V-2

V.1.2. Geology and Soils V-2

V.1.2.1. Water tightness V-5

V.1.2.2. Seismic Risk and Reservoir Induced Seismicity V-6

V.1.2.3. Dam Safety V-7

V.1.2.4. Landslides and Erosion V-7

V.1.2.5. Sedimentation in the Reservoir V-9

V.1.3. Climatology V-11

V.1.3.1. Impacts on Local and Regional Climate V-11

V.1.3.2. Greenhouse Gas Emissions from Mtkvari Reservoir V-11

V.1.4. Hydrology V-12

V.1.4.1. Water Quality V-13

V.1.4.1.1. Impacts of Project Construction V-13

V.1.4.1.2. Impacts of Impoundment V-13

V.1.4.1.3. Sedimentation V-15

V.1.4.1.4. Impacts of Flow Diversion in the Bypass Reach V-15

V.1.4.2. Evaporative Loss and Effects of Downstream Releases on Water Quality V-19

V.1.4.3. Sanitary Risk V-19

V.1.4.4. Groundwater and Springs V-21

V.1.5. Impacts on Air Quality V-21

V.1.5.1. Assessment Approach and Methodology V-21

V.1.5.2. Sources of Air Pollution during Construction V-22

Chapter-Page

V.1.5.3. Impacts on Ambient Air Quality during Construction V-24

V.1.6. Impacts of Noise during Construction and Operation V-32

V.1.6.1. Sources of Noise V-32

V.1.6.2. Estimation of Noise Levels V-32

V.1.6.3. Limit Values and Evaluation Standards V-34

V.1.6.4. Impacts of Noise during Construction V-35

V.1.6.5. Impacts of Noise during Operation V-45

V.2. Impacts on Biological Environment V-45

V.2.1. Impacts on Aquatic Species V-46

V.2.1.1. Effects of Reservoir on the Aquatic Biota V-46

V.2.1.2. Effects of Headrace/Power Tunnel on the Aquatic Biota V-47

V.2.1.3. Effects of Releases on Downstream Biota V-48

V.2.2. Impacts on Flora and Terrestrial Fauna V-49

V.2.3. Impacts on Species of International Concern V-51

V.3. Impacts on Socio-Economic Environment V-53

V.3.1. Scope of Social General Impact Categories and Study Approach V-53

V.3.2. Social Impacts and Issues V-58

V.3.3. Impacts on Water Use V-62

V.3.4. Impacts on Landscape V-63

V.4. Transmission Line V-64

VI. ANALYSIS OF ALTERNATIVES VI-1

VI.1. Project Type VI-1

VI.2. Project Location and Size VI-4

VI.3. Tunnelling Methods VI-6

VI.4. Type of Powerhouse VI-7

VI.5. Modes of Operation VI-8

VI.6. No Action Alternative VI-9

Chapter-Page

VII. ENVIRONMENTAL AND SOCIAL ACTION PLAN VII-1
VII.1. Mitigation Plan VII-1
VII.1.1. Catastrophic Failure VII-1
VII.1.2. Construction Phase VII-2
VII.1.2.1. Erosion and Sedimentation VII-2
VII.1.2.2. Landscaping and Top Soil Utilization VII-4
VII.1.2.3. Air Quality VII-6
VII.1.2.4. Noise VII-8
VII.1.2.5. Water Quality and Water Use VII-9
VII.1.2.6. Waste Management VII-12
VII.1.2.7. Management of Biological Environment VII-15
VII.1.2.8. Socio-economy VII-17
VII.1.2.9. Cultural and Historical Assets VII-18
VII.1.2.10. Health and Safety VII-19
VII.1.3 Operation Phase (including Impoundment) VII-20
VII.1.3.1. Erosion in the Catchment Area and Reservoir Sedimentation VII-20
VII.1.3.2. Water Quality VII-21
VII.1.3.3. Waste and Wastewater Management VII-22
VII.1.3.4. Biological Environment VII-22
VII.1.3.5. Health and Safety VII-22
VII.2. Monitoring Plan VII-23
VII.2.1. Objectives VII-23
VII.2.2. Environmental Monitoring Coordination VII-24

APPENDICES

LIST OF TABLES

		Chapter-Page
Table I.1.	Existing Hydropower Plants in Georgia	I-6
Table I.2	Potential Large Scale Hydropower Plants in Georgia	I-6
Table I.3	The Projects those are projected within the Scope of Greenfield HPPs	I-8
Table III.1.	Coordinates and Altitudes of the Powerhouse and Headworks	III-4
Table III.2.	Technical Data of Mtkvari HPP Project	III-13
Table III.3.	Average Energy Cost as a Function of Interest Rates	III-19
Table IV.1.	Locations and Types of Tectonic Structures by Names	IV-9
Table IV.2.	MSK-64 Earthquake Intensity Scale	IV-12
Table IV.3.	Locations, Magnitudes and Depths of Earthquakes by Dates	IV-13
Table IV.4.	Thicknesses and Locations of Dam Site Geological Units by Geological Descriptions	IV-15
Table IV.5.	Active and Stabilized Landslides in the Reservoir Area	IV-19
Table IV.6.	Mineral Resources	IV-22
Table IV.7.	Average Temperature, Average Lowest Temperature, Average Highest Temperature, Highest Temperature and Lowest Temperature in the Project Area (Akhaltsikhe Weather Station)	IV-31
Table IV.8.	Average Temperature, Average Lowest Temperature, Average Highest Temperature, Highest Temperature and Lowest Temperature in the Project Area (Aspindza Weather Station)	IV-31
Table IV.9.	Monthly Rainfall Observed at Akhaltsikhe and Aspindza Meteorological Stations	IV-32
Table IV.10.	Number of Rainy Days According to the Intensity of the Rain in Aspindza Station	IV-33

Chapter-Page

Table IV.11.	Monthly and Annual Distribution of Wind Blowing Numbers According to Their Direction Recorded at Akhaltsikhe Meteorological Station	IV-34
Table IV.12.	Monthly and Annual Distribution of Wind Blowing Numbers According to Their Direction Recorded at Aspindza Meteorological Station	IV-34
Table IV.13.	Monthly and Annual Wind Speeds Recorded at Akhaltsikhe and Aspindza Meteorological Stations	IV-35
Table IV.14.	Seasonal Flow Data of Mtkvari River based on the Records of Minadze Flow Gauging Station during 1938-1973	IV-38
Table IV.15.	In-situ Water Quality Measurement Results (February 2009)	IV-40
Table IV.16.	In-situ Water Quality Measurement Results (June 2009)	IV-41
Table IV.17.	Results of Water Quality Analysis of Samples taken in February 2009	IV-43
Table IV.18.	Results of Water Quality Analysis of Samples taken in June 2009	IV-43
Table IV.19.	Limit Values in the Regulation on the Quality of Surface Waters Used or Planned to be used for Drinking Water	IV-46
Table IV.20.	Elevations by Terrace Numbers	IV-49
Table IV.21.	Noise Measurement Results	IV-52
Table IV.22.	PM concentrations in Akhaltsikhe	IV-62
Table IV.23.	Main Environmental Laws of Georgia	IV-67
Table IV.24.	IUCN Red List Categories and Criteria According to Published Years	IV-73
Table IV.25.	Distribution of the Species According to Their Phytogeographic Region	IV-75
Table IV.26.	Flora List for the Study Area	IV-76
Table IV.27.	Status of Identified Species According to IUCN, Bern, CITES and GRDB Lists	IV-82
Table IV.28.	Mammal (Classis: Mammalia) Species Identified in the Study Area	IV-83
Table IV.29.	Bird Species (Classis: Aves) Identified in the Study Area	IV-86
Table IV.30.	Reptilians (Classis: Reptilia) Identified in the Study Area	IV-92

Chapter-Page

Table IV.31.	Amphibians (Classis: Amphibia) Identified in the Study Area	IV-94
Table IV.32.	Freshwater Fish (Pisces) Species Identified in the Mtkvari River System	IV-96
Table IV.33.	Facts Sheet of *Acanthalburnus microlepis*	IV-97
Table IV.34.	Facts Sheet of *Alburnoides bipunctatus*	IV-98
Table IV.35.	Facts Sheet of *Alburnus filippii*	IV-99
Table IV.36.	Facts Sheet of *Aspius aspius*	IV-100
Table IV.37.	Facts Sheet of *Barbus lacerta*	IV-101
Table IV.38.	Facts Sheet of *Capoeta capoeta*	IV-102
Table IV.39.	Facts Sheet of *Chondrostoma cyri*	IV-103
Table IV.40.	Facts Sheet of *Cyprinus carpio*	IV-104
Table IV.41.	Facts Sheet of *Gobio gobio*	IV-105
Table IV.42.	Facts Sheet of *Squalius cephalus*	IV-106
Table IV.43.	Facts Sheet of *Tinca tinca*	IV-107
Table IV.44.	Facts Sheet of *Barbatula brandtii*	IV-108
Table IV.45.	Facts Sheet of *Salmo trutta fario*	IV-109
Table IV.46.	Demographic Status of Georgia	IV-119
Table IV.47.	Real GDP Growth by Sectors	IV-121
Table IV.48.	Population Distribution of the Samtskhe-Javakheti Region	IV-123
Table IV.49.	Population Distribution by Gender	IV-123
Table IV.50.	Dynamics of the Number of Births, 1998-2003	IV-124
Table IV.51.	Birth Rate per 1000 of Population	IV-124
Table IV.52.	Birth and Death Numbers, and Natural Growth for six months in 2004	IV-124
Table IV.53.	Population by Age in the Districts	IV-125
Table IV.54.	Population of Working Age by Gender	IV-125
Table IV.55.	Socio-Cultural Composition in Project Affected Villages (Sakuneti and Rustavi villages)	IV-131
Table V.1.	Average Monthly Flows at Mtkvari Dam Axis	V-18
Table V.2.	Main Parasitic, Viral, or Bacterial Diseases in Georgia	V-20
Table V.3.	The Excavation and Fill Amounts for the Project Units	V-23

		Chapter-Page
Table V.4.	Calculated Maximum Annual and Daily Average Ground Level Concentration Values and Relevant International Standards (Limit Values)	V-25
Table V.5.	Distribution of the Construction Equipment (Noise Sources) to Working Areas	V-33
Table V.6.	Noise Levels of the Equipments to be used in Construction Phase (L_w)	V-34
Table V.7.	International Reference Noise Limit Values	V-35
Table V.8.	Change of Noise Levels with Distance (for Location 1)	V-37
Table V.9.	Cumulative Noise Level expected at the Closest Settlement (Rustavi Village) to the Mtkvari Dam Axis	V-38
Table V.10.	Change of Noise Levels with Distance (for the Powerhouse Site)	V-40
Table V.11.	Cumulative Noise Level expected at the Closest Settlement (Sakuneti Village) to the Mtkvari Powerhouse Site	V-41
Table V.12.	Summary of the Cumulative Noise Levels (dBA) Calculated for Rustavi and Sakuneti Villages	V-43
Table V.13.	Investigation Methods for Affected Villages/Communities: Assessment Items, Indicators, Methods and Objectives	V-56
Table VI.1.	Comparison of the Main Potential Impacts of an Alternative Thermal Power Plant and Mtkvari HPP Project	VI-2
Table VI.2.	Comparison of Costs for the Powerhouse Type Alternatives	VI-8
Table VII.1	Environmental and Social Action Plan	VII-26
Table VII.2	Monitoring Plan	VII-35
Table VII.3.	Limit Values for Discharge of Wastewaters during Construction and Operation Phases	VII-10

LIST OF FIGURES

		Chapter-Page
Figure I.1.	Projected HPPs in Georgia	I-7
Figure III.1.	Location of the Project Area in Georgia	III-5
Figure III.2.	Location of Mtkvari HPP Project	III-9
Figure III.3.	Construction Schedule of Mtkvari HPP Project	III-17
Figure IV.1.	The Elevation Map of the Project Area	IV-4
Figure IV.2.	The Geological Map of the Project Area	IV-7
Figure IV.3.	The Generalized Stratigraphical Cross-section of the Project Area	IV-8
Figure IV.4.	Arabian-Eurasian Plate Collision Zone	IV-10
Figure IV.5.	Compilation of Existing Zonation Maps in the Caucasus-Kopetdagh Region	IV-11
Figure IV.6.	Land Use and Vegetation Map of the Project Area and Vicinity	IV-26
Figure IV.7.	Soil Map of the Project Area and Vicinity	IV-27
Figure IV.8.	Slope Map of the Project Area and Vicinity	IV-28
Figure IV.9.	Average Temperature, Average Lowest and Average Highest Temperatures Recorded at Akhaltsikhe Station	IV-30
Figure IV.10.	Average Temperature, Average Lowest and Average Highest Temperatures Recorded at Aspindza Station	IV-30
Figure IV.11.	Wind Directions According to the Annual Frequency of Blowing Recorded at Akhaltsikhe and Aspindza Meteorological Stations	IV-35
Figure IV.12.	The Hydrology Map of the Project Area and Vicinity	IV-37
Figure IV.13	Long-Term Average Flow Rate (m^3/sec) of Mtkvari River at Minadze Station	IV-39
Figure IV.14.	Flow Data Derived for the Period of 1964-1973 at Mtkvari Dam Axis	IV-39
Figure IV.15.	Annual Real GDP Growth Rate	IV-119

Chapter Page

Figure V.1.	The Potential Impact Area of Mtkvari HPP Project	V-4
Figure V.2.	Daily Equivalent Concentration Curves for NO_x for the Construction Phase (μg/m^3)	V-26
Figure V.3.	Daily Equivalent Concentration Curves for SO_X for the Construction Phase (μg/m^3)	V-28
Figure V.4.	Daily Equivalent Concentration Curves for HC for the Construction Phase (μg/m^3)	V-29
Figure V.5.	Daily Equivalent Concentration Curves for PM for the Construction Phase (μg/m^3)	V-30
Figure V.6.	Change of Noise Levels with Distance from Headworks	V-38
Figure V.7.	Change of Noise Levels with Distance from Adit 2	V-39
Figure V.8.	Change of Noise Levels with Distance from Concrete Batch Plant	V-39
Figure V.9.	Change of Noise Levels with Distance from Powerhouse Construction Area	V-42
Figure V.10.	Relative Locations of the Construction Sites (Noise Sources) and Closest Settlements	V-44

LIST OF PHOTOGRAPHS

		Chapter-Page
Photograph III.1.	Photograph from the Field Survey	III-4
Photograph III.2.	Photograph from Chitakhevi Regulator	III-6
Photograph III.3.	Area of Outlet of the Headrace Tunnel of Mtkvari HPP	III-8
Photograph III.4.	Powerhouse Area of Mtkvari HPP	III-8
Photograph III.5.	Panoramic Photograph of the Reservoir Area	III-10
Photograph III.6.	Panoramic Photograph of the Powerhouse Area	III-10
Photograph IV.1.	A Photograph Taken from Powerhouse Area	IV-55
Photograph IV.2.	Powerhouse Area Looking Upstream	IV-57
Photograph IV.3.	Mtkvari Headrace Tunnel Exit Area and HPP Construction Site Excluding Tailrace Canal	IV-58
Photograph IV.4.	Soil Surface in the Reservoir Area	IV-59
Photograph IV.5.	Reservoir Area	IV-60
Photograph IV.6.	Mtkvari River and Habitats in the Vicinity	IV-64
Photograph IV.7.	Headworks Area (Rustavi Environs)	IV-69
Photograph IV.8.	Powerhouse Area (Sakuneti Environs)	IV-70
Photograph IV.9.	Mtkvari Watercourse	IV-70
Photograph IV.10.	Headrace Tunnel Area	IV-71
Photograph IV.11.	The Public Participation Meeting, Participants (1)	IV-141
Photograph IV.12.	The Public Participation Meeting, Participants (2)	IV-141
Photograph VII.1.	A View of the Valley Formation that shall be used for Storage of Excavated Materials	VII-5

LIST OF APPENDICES

Appendix 1. List of Preparers and Contributors

Appendix 2. Drawings

Appendix 3. Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia Geotechnical Investigation Report

Appendix 4. Public Consultation and Disclosure Plan

Appendix 5. Effects of Mtkvari HPP Project On Air Quality

Appendix 6. Emergency Action Plan

Appendix 7. Bibliography

LIST OF ABBREVIATIONS

Bern Convention	Convention on the Conservation of European Wildlife and Natural Habitats
BOD	Biological Oxygen Demand
BTC	Baku-Tbilisi-Ceyhan
CEDAW	Convention on the Elimination of all Forms of Discrimination against Women
CEI	JSC Caucasus Energy and Infrastructure
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
COD	Chemical Oxygen Demand
CR	Critically Endangered
Dba	Decibels
D&B	Drill & Blast
DD	Data Deficient
DO	Dissolved Oxygen
EBRD	European Bank for Reconstruction and Development
EC	Electrical Conductivity
EHS	Environmental Health, and Safety
EMF	Electromagnetic Fields
EN	Endangered
ENE	East-northeast
EPCM	Engineering, Procurement and Construction Management
ERL	IUCN (European) Red List
ESIA	Environmental and Social Impact Assessment
ESAP	Environmental and Social Action Plan
ETL	Electric Transmission Lines
EU	European Union
GCCW	Georgian Centre for Wildlife Conservation
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GIS	Geographic Information Systems
GoG	Government of Georgia
GRDB	Georgian Red Data Book

GWP	Global Warming Potential
HH	Household
HPP	Hydroelectric Power Plant/Powerhouse
ICPD	International Conference on Population and Development
IEA	International Energy Agency
IFC	International Financial Corporation
IFI	Interntaional Financial Institution
IP	Indigenous People
IRPA	International Radiation Protection Association
ISCST3	Industrial Source Complex – Short Term 3
ISTC	The International Science and Technology Center
IUCN	International Union for the Conservation of Nature and Natural Resources
L_{eq}	Noise Level Equivalent
masl	Meters Above Sea Level
MoE	Ministry of Environment Protection and Natural Resources
MPN	Most Probable Number
MSK	Medvedev-Sponheuer-Karnik
MW	Mega Watt
NGO	Non-Governmental Organization
OECD	Organization for Economic Cooperation and Development
O&M	Operation & Maintenance
PAP	Project Affected Person
PGR	Phyto-Geographic Region
PM	Particulate Matter
PR	Performance Requirement
ROW	Right of Way
SCP	South-Caucasus Pipeline
SE	Southeast
SEE	State Ecological Examination
SIA	Social Impact Assessment
SS	Suspended Solids
TBM	Tunnel Boring Machine
TDS	Total Dissolved Solids
TIG	Transparency International Georgia
TKN	Total Kjeldahl Nitrogen
TPP	Thermal Power Plant

TSS	Total Suspended Solids
TUBITAK	Scientific and Technical Research Council of Turkey
UNDP	United Nations Development Programme
UNEP	United Nations Environment Program
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
USSR	Union of Soviet Socialist Republics
VAT	Value Added Tax
VU	Vulnerable
WB	World Bank
WCD	World Commission on Dams
WEC	World Energy Council
WHO	World Health Organization
WREP	Western Route Export

CHAPTER I

INTRODUCTION

I. INTRODUCTION

I.1. Energy Sector in Georgia and Policy Background

I.1.1. Overview

Before independence, Georgian energy sector was mainly governed by the requirements of the Soviet Union. Soviet countries were dependent on each other in terms of energy as the demands had been imported from neighbouring republics occasionally, while Georgian energy system exported energy for peak demands of other Soviet republics. Therefore, the non-stop delivery of electrical power was served for the consumers. However, serious power shortages had been of concern since 1985. In Georgia, power generation and industrial and household consumption had been steadily increasing until 1980s. In the period of 1970-1990 energy production was increased by 2.3 times from 45.9 billion kWh up to 108.3 billion kWh. In that period, energy yield of Georgian electric power plants amounted to 14 billion kWh, in which waterpower plants constituted of 8 billion kWh while thermal power plants constituted of 6 billion kWh (UNEP, 2002).

As expected, after independence, due to the collapse of the Soviet Union, centralized energy system of Georgia suffered from serious energy shortages since the energy distribution system was not appropriate for independent operation. Additionally, the demand of consumers increased and consumption pattern was changed and hence the existing power generation capacity was not sufficient to meet the demands. The total annual output of all electric power plants was decreased to 6-8 billion kWh at most, with less than half of it produced at thermal power plants. Besides, fuel import was interrupted for a period due to political problems with the exporting countries. Therefore, prices of electricity had increased as thermal power plants were operated by the imported fuel. On the other hand, power generation declined considerably from 7.6 to 7.2 billion kWh during 1995-98 (UNEP, 2002). Furthermore, as the supply could not meet the demand and the distribution system was overloaded, the power supply system faced regular disruptions. Especially; demand of electricity increased in winter season, due to heating purposes as the former heating systems were stopped in

the districts. In addition to electricity, people used wood, gas, kerosene and similar materials for heating purposes. However, use of electricity and other abovementioned energy sources lead to environmental and economical problems such as excess distortion of trees, overloading power system that is already tense, increasing costs of heating purposes for the households and indoor air quality problems (ISTC, 2003).

In short, after Georgia gained independence in 1991, energy has been a significant issue due to energy shortages suffered in the country despite the substantial energy resources of the country. The available energy resources were not efficiently used by Georgian government. Serious systematic and political problems arouse and as consumers were not willing to pay for energy, the energy system suffered from significant damages which resulted in serious reduction of domestic energy generation. Hence, Georgia became an energy importing country. However, from 2000-2003, fuel and power imports were hardly implemented because of financial limitations of the country. For that reason, Georgian electricity sector was forced to primarily rely on its own hydropower. However, Georgia suffered from other problems in utilizing its own energy sources. One of the major problems was that the energy supply could be obtained from Western Georgia, while the majority of demand was in Eastern Georgia. Moreover, the electricity transmission lines connecting East-West were not maintained. As system stability and supply reliability could not be achieved, Georgia experienced severe shortages in electricity supply in all regions. (USAID, 2005) Furthermore, the sector almost bankrupted due to non-payments of the consumers and debts to neighbouring countries that supplied energy before and use of funds in order to import energy instead of investing in energy sector.

After Rose Revolution in 2003, the new Georgian government initiated a number of reforms and took active measures for the improvements in energy sector. The major goal of those reforms was to improve energy status of country from power importing to utilizing its own independent resources sustainably which is expected to contribute to the Country economy also.

One of the priorities of Georgian energy policy was energy security. For that purpose, Ministry of Energy has taken significant steps such as funding of rehabilitation projects to improve power sector infrastructure. (USAID, 2005) The State Budget allocated 77.5 Million and 200 Million GEL for energy sector, infrastructure development and rehabilitation activities in 2004 and 2005, respectively. The investments in energy sector included rehabilitation of hydro and thermal power plants, electricity transmission lines and distribution networks, gas and electricity metering systems and better regulation of the entire sector. The major goal was to increase local power generation capacity to minimize imports from neighbouring countries (URL-1).

I.1.2. Energy Policy of Georgia

In June 2006, the Parliament of Georgia adopted the Resolution on Main Directions of Georgia's State Energy Policy, based on the Law of Georgia on Electricity and Natural Gas (1997), that explains the concept of the state energy policy, sets out the ways and means of its implementation. The major purpose of the policy is "full satisfaction of industrial and communal demand on energy resources by maximum utilization of local hydropower resources in the electricity sector through diversification of the supply sources, achievement of economic independence and sustainability of the sector and provision of security (of technical, economic and political factors)" (Parliament of Georgia, 2006). Within the framework of the Policy, the main focus is improvement of outdated energy units and infrastructure and creating new and modern ones. Moreover, developing alternative energy sources appropriate for Georgia such as wind, solar and geothermal energy is considered to be a contribution to the improvement of energy sector of the Country. Furthermore, due to strategic location of Georgia in terms of energy transmission, regional infrastructure inclusion of energy sector via maintenance of existing transmission lines and pipelines and construction of new ones are of concern (TIG, 2007).

The fossil fuel energy resources in Georgia are sub-bitumen coal and lignite which have a reserve capacity of 350 million and 76 million tons, respectively. However, as the quality of Georgian coal is low and exploration of coal is difficult due to geological laying-out of coal layers, and the cost of those activities is high, coal is not regarded as a significant energy source. On the other hand, oil and gas extraction is considered to be increased in eastern Georgia and Black Sea. It is declared that 28 million tons of oil reserve exists in Georgian territory and an oil potential capacity of 70 million to 1.3 billion barrels is estimated in Black Sea shelf (URL-1) (Gochitashvili, 2006). Additionally, investments in the energy sector both by the government and private sector increased, taking some significant and strategic steps increasing the importance of the country in energy sector such as construction of strategic Baku-Tbilisi-Ceyhan oil (BTC), Western Route Export (WREP) and South-Caucasus gas pipelines (SCP) transporting energy resources from Azerbaijan through Georgia to Turkey and other western countries.

Hydropower comprises the major energy resources in Georgia as it is one of the richest countries in the world in terms of hydropower resources. Currently, approximately 80% of electricity demand has been met by hydropower plants in Georgia while thermal power plants meet 17% of the demand and the rest is supplied by imports from neighbouring countries (URL-2). Hence, the sector of hydropower has the potential to be developed instead of construction of new thermal power plants.

As a consequence, hydropower is obviously one of the major energy sources in order to meet the increasing electricity demand of Georgia when increasing trend of electricity consumption in industrial and public purposes due to development of economics is of concern.

I.1.3. Role of Hydropower in Georgia

The hydraulic energy, which is one of the renewable energy types, poses lower risk of environmental, economic and political problems when compared to other energy sources defined above. For being the owner of the whole source,

dependence on other countries reduce and significant advantages which are not comparable with other energy sources such as petroleum, natural gas and nuclear power are of concern.

According to the data presented in the report prepared by International Energy Agency, World Energy Outlook 2006, the share of renewable energy sources (hydro, wind, biomass and waste, geothermal, solar and tide and wave) consumed in electricity generation was 18% in 2004, globally (IEA, 2006). Share of electricity generation from renewable energy sources worldwide is predicted to grow further up to 19% and 21% in 2015 and 2030, respectively. Between, 1990-2004, global total primary energy consumption increased 1.4% annually, whereas utilization of modern renewable energy sources increased 19.1%, modern biomass sources (urban waste, biogas) increased 7.6% and geothermal energy increased 2.3%, annually in the same period. (IEA, 2004)

Meanwhile in Georgia, electricity generation at the HPPs has increased, mainly due to better operating conditions and upgrades across the sector. The share of TPPs and imports in Georgia's energy sector is set for a steady decline. Today, the technical potential of Georgian water resources and associated water-power resources, amounts to 80 billion KWh per annum (ISTC, 2003) from which 40-50 billion kWh/year is economically feasible (UNDP, 2004). Installed hydropower capacity is only 26% of total available hydropower potential in the country (URL-2).

I.2. Greenfield Hydropower Plants Project Identification and Development Background

I.2.1. General Information about the Project

The Government of Georgia (GoG) has approved, in April 2008, the standard terms and conditions for the Greenfield Investments in Hydropower Plants (HPPs). The Ministry of Energy announced the solicitation of expressions of interest by investors in Greenfield HPPs and other renewable energy plants under the build-operate-own structure. The list of prospective Greenfield HPP sites, with an

individual capacity ranging from 5 to 60 MW, has been published and regularly updated by the Ministry of Energy on its website. The HPPs listed on the web site of MoE are expected to be run-of-the-river facilities. Current hydropower plants are listed in Table I.1 while the projected large scale hydropower plants are listed in Table I.2 with the capacities given and presented in Figure I.1. Additionally, 83 small and medium size hydropower plants that are projected within the scope of the Project are listed in Table I.3 below.

Table I.1. Existing Hydropower Plants in Georgia

Name	Capacity (MW)
Enguri HPP	1300
Vardnili HPP	220
Vartsikhe Cascade of HPPs	184
Ladjanuri HPP	112
Gumati HPP	66.8
Shaori HPP	38.4
Dzevruli HPP	80.0
Atsi HPP	16.0
Rioni HPP	48.0

Source: URL-4

Table I.2. Potential Large Scale Hydropower Plants in Georgia

Name	Capacity (MW)
Khudoni	637
Namakhvani Cascade – Namakhvani	250
Namakhvani Cascade – Zhoneti	100
Namakhvani Cascade – Tvishi	100
Oni Cascade	276

Source: URL-4

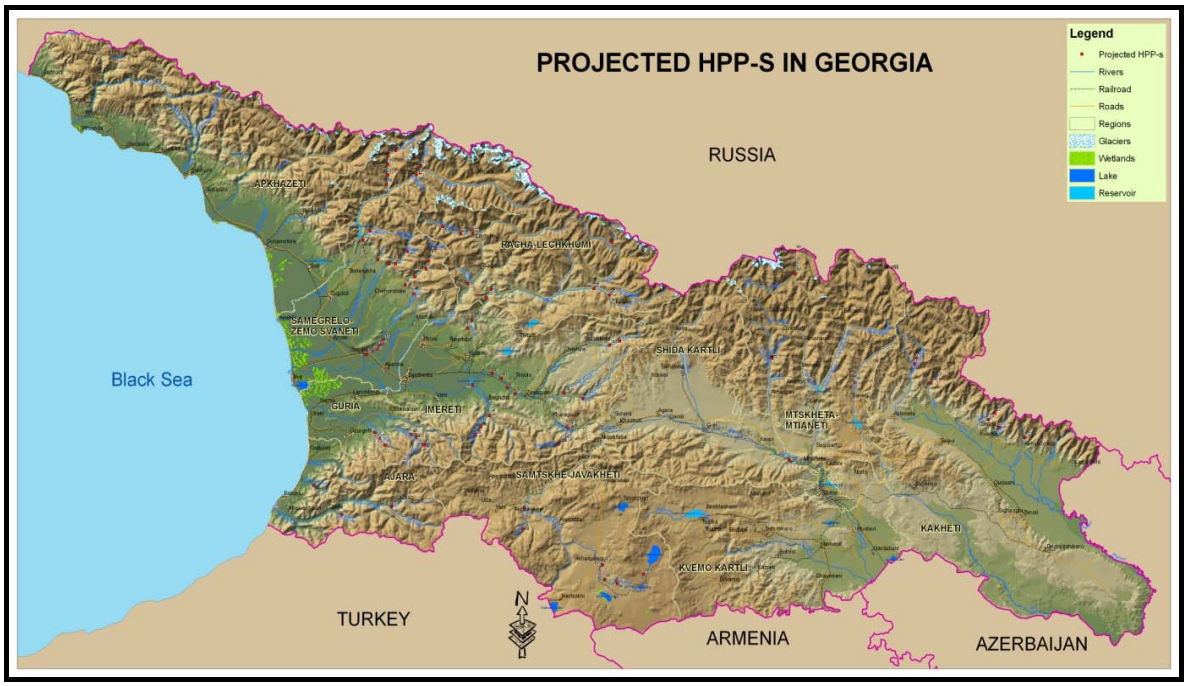


Figure I.1. Projected HPPs in Georgia (Source: URL-4)

Table I.3. The Projects those are projected within the Scope of Greenfield HPPs

Project Name	River Name	Projected Installed Capacity (MW)	Regulation Type	Project Name	River Name	Projected Installed Capacity (MW)	Regulation Type
Magada	Magana	21.3	Reservoir	Kheledula 3	Kheledula	12.0	Run-of-River
Legarde	Magana	20.0	Run-of-River	Stori 1	Stori	10.0	Run-of-River
Medani	Chanis Tskali	4.4	Run-of- River	Cheshura I&II	Chesura	8.5	Run-of -River
Lebarde 1	Lebarde	4.56	Run-of- River	Samitso	Jejora	10.0	Run-of -River
Lebarde 2	Tekhuri	4.16	Run-of- River	Jejora	Jejora	15.8	Run-of -River
Erja	Tekhuri	24.4	Run-of- River	Khobi 1	Khobis Tskali	27.0	Run-of -River
Tskhimra	Tekhuri	29.0	Reservoir	Khobi 2	Khobis Tskali	25.0	Run-of –River
Nobulevi	Tekhuri	18.5	Reservoir	Khobi 3	Khobis Tskali	11.1	Run-of -River
Lechakha	Tekhuri	18.8	Reservoir	Janauli	Janauli	13.0	Run-of -River
Lesulkhe	Tsachkhuru	6.7	Run-of -River	Alpana	Rioni	69.0	Reservoir
Tekhuri 1-6	Tekhuri	19.2	Run-of -River	Chala	Kvirila	9.14	Run-of -River
Nakra	Nakra	19.6	Run-of -River	Jria	Kvirila	9.2	Run-of -River
Nankra	Nakra	29.2	Run-of –River	Boriti	Dumala	6.4	Run-of -River
Nenskra 1	Nenskra	22.38	Run-of -River	Tsablari I	Tsablaristskali	5.8	Run-of -River

Table I.3. The Projects those are projected within the Scope of Greenfield HPPs (cont'd)

Project Name	River Name	Projected Installed Capacity (MW)	Regulation Type	Project Name	River Name	Projected Installed Capacity (MW)	Regulation Type
Nenskra 2	Nenskra	14.0	Run-of -River	Tsablari II	Tsablaristskali	10.2	Run-of -River
Nenskra 3	Nenskra	10.8	Run-of -River	Khan-Tsablari III	Khani/ Tsablaristskali	8.3	Run-of -River
Nenskra 4	Nenskra	25.43	Run-of –River	Khani VII	Khanistskali	6.4	Run-of -River
Nenskra 5	Nenskra	14.7	Run-of -River	Zestafoni I	Kvirla	10.0	Run-of -River
Khumpreri	Khumpreri	16.37	Run-of -River	Zestafoni II	Kvirla	11.9	Run-of -River
Kheledula 1	Kheledula	8.5	Run-of -River	Zestafoni III	Kvirla	15.9	Run-of -River
Kheledula 2	Kheledula	8.0	Run-of -River	Zestafoni IV	Kvirla	15.9	Run-of -River
Tazara	Shavi Tskali	6.0	Run-of –River	Dariali	Tergi	50.0	Run-of -River
Sakhvlari	Shavi Tskali	5.3	Run-of -River	Samkhuri I	Samkhuris Tskali	12.4	Run-of -River
Khunevi	Dzirula	11.3	Reservoir	Samkhuri II	Samkhuris Tskali	22.2	Run-of -River
Gubazeuli VI	Gubazeuli	5.0	Closed	Avani	Avanis Khevi	4.6	Run-of -River
Bakhvi 1	Bakhvis Tskali	15.0	Reservoir	Duruji	Duruji	1.74	Run-of -River

Table I.3. The Projects those are projected within the Scope of Greenfield HPPs (cont'd)

Project Name	River Name	Projected Installed Capacity (MW)	Regulation Type	Project Name	River Name	Projected Installed Capacity (MW)	Regulation Type
Bakhvi 2	Bakhvis Tskali	20.0	Run-of- River	Uraveli	Uraveli	5.0	Run-of -River
Bakhvi 3	Bakhvis Tskali	6.0	Run-of- River	Arakli	Paravani	18.2	Reservoir
Khala	Chaqvis Tskali	13.0	Reservoir	Ninotsminda	Paravani	9.4	Reservoir
Merisi	Akavreta	11.5	Run-of- River	Abuli	Paravani	12.5	Reservoir
Skalta	Skhalta	5.3	Run-of- River	Poka	Paravani	0.5	Reservoir
Iori	Iori	9.7	Run-of- River	Stori 2	Stori	10.0	Run-of -River
Dzegvi	Mtkvari	10.0	Run-of- River	Chelti 1	Chelti	4.8	Run-of -River
Tergi	Tergi	11.4	Run-of- River	Chelti 2	Chelti	4.8	Run-of -River
Ksani 1	Ksani	4.2	Run-of- River	Bakhvi 4	Bakhvis Tskali	1.0	Run-of -River
Ksani 2	Ksani	2.1	Run-of- River	Bakhvi 5	Bakhvis Tskali	2.0	Run-of -River
Ksani 3	Ksani	3.2	Run-of- River	Lukhuni 1	Lukhunis Tskali	10.8	Run-of -River
Ksani 4	Ksani	3.6	Run-of- River	Lukhuni 2	Lukhunis Tskali	12.0	Run-of -River
Ksani 5	Ksani	6.0	Run-of- River	Lukhuni 3	Lukhunis Tskali	7.3	Run-of -River
Marelisi	Bjholis Khevi	4.6	Run-of- River	**Mtkvari**	Mtkvari	42.0	Run-of -River

Source: URL-4

I.2.2. Salient Features of the Project

Mtkvari HPP Project which is planned to be constructed on Mtkvari River with a capacity of 43 MW is located near the city of Akhaltsikhe. It will contribute to the development of the national economy, with an annual production of 245 GWh. The economic life of the project is predicted as 50 years.

The existent project layout comprises; the upper works, the headrace tunnel and the lower works. In more details, the facilities those will be implemented within the context of Mtkvari Project are composed of the headworks, diversion tunnel, leveling tank, and powerhouse with two units, outlet channel, voltage build-up substation and the transmission line. The facilities those will be constructed within the context of the project and their explanations are given in detail below.

Headworks: Mtkvari HPP's dam reservoir will have a limited area for providing water regulation. The structures in the headworks area are intake pond, diversion canal, main dam, cofferdam, spillway and intake structure.

The crest level of the spillway and the highest regulating level is 1015 masl. The intake pond is some 3.5 km long with a maximum width of approximately 0.6 km. The lowest regulating level is 1010 masl.

Headrace tunnel: The length of the headrace tunnel that would transmit the water that is obtained from Mtkvari Dam to the powerhouse is about 9.6 km with an optimized diameter of 5.6 m. However, it should be noted that the optimum diameter calculations were performed based on the assumption of excavation with drill and blast (D&B) method which is a less cost effective method than Tunnel Boring Machine (TBM) method. In such a case, it is concluded that the optimum diameter of the headrace tunnel will be less than 5.6 m as TBM method will be applied.

Pressure tunnel: The pressure tunnel branches from the headrace tunnel some 100 upstream from the power station. The tunnel diameter will be a 5.6 m

horseshoe section for about 70 m or where this otherwise distribute onto each power generating unit. The pressure tunnel, extending from the headrace tunnel down to the distributor will be inclined about 10%.

Surge Shaft: The dimensions of the surge facilities are based on the presumed shut down time of the turbines, the pertinent size of the waterways and other relevant issues. The surge shaft and overlying basin will be located some 200 m upstream of the powerhouse cavern in the headrace tunnel.

Powerhouse: According to initial investigations, a surface type powerhouse was considered to be a more feasible option. However, an underground powerhouse is proposed in the feasibility report. On the other hand, the project developer selected the construction of a surface type powerhouse for Mtkvari HPP Project based on its previous experience and the technical practicalities.

Tailrace: Harnessed river water will flow from the draft tubes onward into the tailrace. From each draft tube, tailrace tunnel branches merge into approximately 100 m long tailrace tunnel with the same size. The tunnel is followed by the canal that extends to the Mtkvari river course.

Switchyard and Transmission Line: The switchyard will be located on the riverbank within the powerhouse yard area, parallel to the tailrace canal, and guarded by a 40 x 26 m safety fence. Two power transformers along with the necessary substation equipment will be located within the switchyard area. The electricity, which is converted to 110 kV at the switchyard, is proposed to be transmitted to Akhaltsikhe substation that is 8 km away, by the 110 kV energy transmission line to be distributed to the consumption centers.

I.3 Regulatory Background

This Environmental and Social Impact Assessment (ESIA) was prepared to fulfill the requirements of the Georgian Legislation and Project Lenders. The report was

prepared in accordance with Georgian laws and requirements, and the requirements of European Bank of Reconstruction and Development (EBRD) as contained in the Environmental and Social Policy (2008) and Public Information Policy (2008), for Category A projects and also in accordance with IFC Performance Standards.

An interdisciplinary team of experts took part in the preparation of the ESIA report. Both private consultants and experts from Hacettepe University participated in the preparation of the ESIA report (see Appendix A). The overall coordination and preparation of the ESIA was carried out by ENCON Environmental Consultancy Co, Turkey.

Various documents were consulted during the preparation of the ESIA, including policy and legal reports, laws and regulations, technical and economical feasibility reports, publications on land use, natural resources, geology, socio-economic features of the project area, maps, various data on water quality, hydrology, climatology obtained from different agencies (governmental, non-governmental, etc.). In addition, field studies were carried out to collect baseline data on the physical, biological and socio-economic environments. Basic information to identify and evaluate the impacts of the project was gathered during these studies.

Also, a series of meetings were held to facilitate interagency coordination and to learn the concerns of the related governmental and non-governmental organizations, affected groups and the public. Surveys and public meetings were carried on in the region that is going to be affected by the project to gain an understanding of the views of the people living in the area (local people).

CHAPTER II

POLICY, LEGAL AND ADMINISTRATVIE FRAMEWORK

II. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

The Environmental and Social Impact Assessment (ESIA) Report for Mtkvari Hydroelectric Power Plant Project has been prepared in reference to the Georgian laws and requirements, IFC Performance Standards and EBRD's requirements as contained in Environmental and Social Policy (2008) and Public Information Policy (2008), for Category A projects.

II.1. National Legal and Regulatory Framework

The legal framework for environmental protection is based on the Constitution of Georgia. The Constitution guarantees the legal framework for public access to information, stating that an individual has the right to obtain full, unbiased, and timely information regarding his working and living environment (Parliament of Georgia, 1995).

II.1.1. Administrative Framework

In Georgia, Ministry of Environment Protection and Natural Resources (MoE) is the responsible body for all environmental issues. The Ministry is responsible for the implementation of policies adopted for protection and conservation of the environment, and for sustainable development and management of natural resources (URL-5). The major responsibilities of the Ministry are to control the activities that have a potential to have adverse impacts on the environment and natural resources, to issue environmental based licenses and permits and to monitor the implementation of the projects that are responsible for utilization of natural resources (URL-5).

MoE is functioning with six regional units (i.e. east central, west central, Kakheti, Kvemo Kartli, Samtskhe-Javakheti, Samegrelo and Zemo Svaneti) affiliated to the center office. The divisions, representing the MoE in administrative units, function

in line with the Constitution of Georgia, related international agreements and contracts, Georgian Laws, Decrees and Orders of the President. The responsibilities of the Regional Divisions are listed as follows:

- To avoid urgent ecological situations and to work out activities for liquidation of results, state control on administration of primary registering of water resources and their usage;
- To participate in the processes of allocating lands, their management, changing assignment with a purpose and changing forest categories,
- To organize rising ecological education of population;
- To organize interconnection with environmental organizations and environmental community;
- To coordinate activities related to numerical restoration of endemic, rare and endangered species of Georgian flora and fauna and to take direct participation in it and take part in working out proposals on creating protected areas and hunting reserves (URL-5).

The head office of the Ministry is organized into sub-divisions that are listed as follows:

1. General Inspectorate
2. Legal Department
3. Services of Licenses and Permits
4. Administrative Department
5. Service of Biodiversity Protection
6. Department of Environmental Policy and International Relations
7. Service of Nuclear and Radiation Safety
8. Executive Personnel of Minister
9. Service of Public Relations
10. Service of Geodesy and Cartography
11. Department of Integrated Environmental Management

On the other hand, State Sub-Agency Organizations of the Ministry can be listed as follows:

1. Inspection of Environmental Protection: Inspection of Environmental Protection is a sub-agency organization of the MoE of Georgia established on 20th September, 2005. The major responsibilities of the Inspection can be summarized as follows:

   - to carry out the state control for environmental protection;
   - to expose and suppress the facts of illegal use of natural resources and environmental pollution;
   - to control conditions of licenses/permits issued by the Ministry;
   - to control the implementation of international commitments under its competence for environmental protection;
   - to expose and prevent violations of administrative law for environmental protection;
   - to implement monitoring in line with the related laws;
   - to create data base of regulation units among them;
   - to analyze reports of implementing licenses/permits conditions presented by regulation units;
   - to plan and coordinate state control for environmental protection;
   - to prepare systematic and manual documents for the state control of environmental protection;
   - to inform public about the activities of the Inspectorate (URL-5).

2. Forestry Department: Forestry Department is a state sub-agency organization of the MoE. The major responsibilities of the Department are summarized as follows:

   - to implement state policy of forest fund protection, restoration of forests and utilization of forest resources;
   - to protect forests from fire, illegal impairs, hazardous insects and diseases;

- to conduct activities for saving and qualitative improvement of forests via soil-conserving, water retention, climate regulation, sanitary-hygiene, recreation and other functions;
- to provide appropriate system for registration of state forest resources,
- to monitor and implement ongoing state programs activities and other activities allowed by law on the territory of state forest fund;
- to participate in international relations on sustainable development of state forest fund within its competence area;
- to cooperate with scientific and non-governmental organizations (URL-5).

3. Department of Investigation: Department of Investigation is a sub-agency organization of the MoE of Georgia that the major responsibility is to fight against crime focused on the governance of utilization of natural resources and environmental protection and preliminary investigation of criminal law cases in environmental sphere. The main functions of the Department are as follows: entitlement according to procedural legislation of Georgian criminal law in order to expose and suppress crime focused on the rule of utilization of natural resources and environment protection, coordination of investigation activities within its competence area, organization of working with security information and implementation of protection of demands proved by the legislation of working with security information (URL-5).

Additionally, there are several units functioning as legal entities of pubic law under the presidency of MoE.

1. Sustainable Development Projects Implementation Agency: Sustainable Development Projects Implementation Agency is legal entity of pubic law which was established on May 8, 2006. The main tasks of the agency is to support sustainable development system for forestry and protected areas in Georgia, to assist the economical utility, programmes of forestation and forest recovery, importing new techniques and technologies, to support establishment of ecologically efficient protected areas, to assist

establishment and development of integrated management of the Black Sea coast (URL-5).

2. National Environmental Agency is responsible for:

- Preparation of normative and/or informational documents, forecasts, warnings regarding existing and expected hydro meteorological and geodynamic processes, engineer-geo-ecological conditions of geological environment and environment pollution conditions on the territory of Georgia, in river basins, water reservoirs, in territorial waters of the Black Sea, on the continental shelf, and in the special economical zone and their distribution in accordance with established rules;
- Monitoring over hydrodynamic and morphodynamic processes in coastline zones, permanent mapping of the territory, risk zoning and forecasting of coastline developments, management of coasting forming processes using engineer activities;
- Creation of environmental databases and metadata and ensuring its organizational management (database on natural components and engineered infrastructure in coastline zones; database created on the basis of the information kept in geological, geodesic, cartographic and land resource state databases; unique database on forest resources; state balance and cadastre database on mineral deposits and exposures;
- Preparation of inventory and registration of industrial and scientific geological activities and other activities carried out within the scope of forestry sector of Georgia;
- Implementation of international liabilities taken by Georgia, within the scope of information distribution, regarding hydrometeorology, environment pollution monitoring, marine and river morphodynamics and protection, mineral deposit resources and environmental pollution conditions;
- Meteorological maintenance of civil aviation (URL-6);

3. Agency of Protected Areas is responsible for ensuring functioning of administrations of Strict Nature Reserves, National Parks, Natural

Monuments and Managed Nature Reserves and monitoring of rules established by the law, planning and development of new Protected Areas, popularization of Protected Areas and development of ecotourism, planning and arrangement of Protected Areas infrastructure (URL-5);

4. Basic Sapling Forestry: Basic Sapling forestry is a legal entity of public law within the system of the MoE. The responsibilities of the entity are to provide producing planting material, to organize seed-growing activities and to develop them independently under state control.

II.1.2 Environmental Legal Framework

The environmental laws that are considered to be related to the Mtkvari HPP Project are listed as follows:

- Law on Environmental Protection
- Law on Environmental Impact Permit
- Law of Soil Protection
- Law on Natural Resources
- Law on Wildlife
- Law on Water
- Law on State Ecological Expertise
- Law on Hazardous Chemicals
- Law on State Complex Expertise and Approval of Construction Projects
- Law on Protection of Ambient Air
- Forest Code
- Law on Protection of Cultural Heritage
- Law on Red List and Red Book of Georgia
- Law on Licenses and Permits
- Law on Ecological Examination

The most relevant Laws on environmental protection are explained in detail as follows:

1. Law of Georgia on Environmental Protection: This Law regulates the legal relationship between the bodies of the state authority and the physical persons or legal entities within the scope of environmental protection and in the use of nature on all Georgian territory including territorial waters, airspace, continental shelf and special economic zone. The major purpose of the Law is to promote education and scientific research in the context of environment, environmental management, licensing, environmental impact assessment and related issues. Protection of natural ecosystems, protected areas, global and regional administration of environmental protection, and protection of ozone layer, biodiversity and protection of the Black Sea against pollution are the major issues are also regulated by the Law. Furthermore, international treaties and agreements regarding environmental protection are also mentioned in the Law (Parliament of Georgia, 1996).

2. Law of Georgia on Environmental Impact Permit: Within the scope of this Law, a comprehensive list of activities subjected to mandatory ecological examination and the legal bases for public participation and awareness in the decision-making processes is given (Parliament of Georgia, 2007).

3. Law of Georgia on Ecological Examination: This Law defines the ecological assessment as a mandatory process for obtaining environmental impact permits. The major objective of this Law is to “secure the maintenance of ecological balance in conformity with the environmental protection requirements, the environmental conservation and sustainable development principles” (Parliament of Georgia, 2007).

4. The Law of Georgia on Licenses and Permits: This Law is to provide conformity in issuance of licenses and permits for organized activities or actions posing risk for the sake of national and public interests and national resources. The Law includes types of licenses and permits and sets out the rules for issuing, amending and cancelling permits (Parliament of Georgia, 2005).

II.1.3. Environmental Impact Assessment Procedure in Georgia

In the Law of Georgia on Environmental Protection, the general scope of environmental impact assessment is mentioned in Chapter 10, “Environmental Protection Requirements in Decision Making on the Activity and in the Implementation of the Activity”. Within this scope, “environmental permit”, “state ecological examination” and “environmental impact assessment” procedures are mentioned.

According to the Law, the environmental permit is the key procedure for implementation of an activity on the territory of Georgia. The permit takes ecological, social and economic interests of the public and the state into consideration in order to protect human health and natural and cultural assets and heritage. Regarding the environmental permit, the Law refers to the Law of Georgia on Environmental Impact Permit. In this context, establishment of a hydroelectrical power station with 2 MW or higher installed capacity is one of the activities that are subject to an ecological examination which is determined as the decision-making tool on the issuance of an environmental permit. The procedure for the state ecological examination is designated by the Georgian Law on the Ecological Examination. According to this law a state expert opinion will be mandatory for a decision on the issuance of an Environmental Impact Permit. The MoE is responsible for the state ecological examination through a committee of experts after the ESIA is submitted and the public hearing process is completed.

An important part of the permitting process is the preparation of an ESIA. According to Decree No. 154, a developer seeking a permit prepares the ESIA within the desired timeframe and according to the provided procedures, organizes its public discussion and takes other measures as appropriate. The developer should invite the MoE to take part in the process and afterwards apply to the MoE for a permit. The Decree specifies documents to be submitted, and provides the details on the procedure of permit issuance and the role of the MoE and the developer in this process. In the permitting process and when carrying out an ESIA, the following steps should be followed (Parliament of Georgia, 2005 (b)):

First of all, the ESIA document is prepared by either the investor or an environmental consulting company hired by the investor. The prepared report is published through announcements in newspaper at regional and central level. The announcement should include goals for the planned activity, project title and location, address where the public can access the ESIA report, deadline (45 days for submitting written comments and recommendations), location, date and time for the public hearing, investor's contact information for submission of written comments and suggestions on the ESIA report. Later on, a hard copy and an electronic version of the ESIA should be submitted to the MoE no later than 7 days after the publication. The public is allowed to submit objections to the ESIA within 45 days after the date of publication. Furthermore, a public hearing regarding the ESIA should be held in the administrative centre of the region in no later than 60 days after publication. Affected local and central public bodies should attend to the meeting. Within 5 days after the hearing the project developer should prepare a public hearing protocol including all comments and recommendations received and expressed during the public hearing. The protocol should be signed by the investor, ESIA report compiler, the representative from the local municipality and the representative from the MoE. If any comments are presented, the developer should consider them. It is up to the investor's decision whether or not to take into account the suggested comments in the final ESIA report. In case the investor do not take the comments into account, he is responsible to provide written arguments to the authors of these comments. He should also submit a short report, summarizing the arguments to the administrative body issuing permits together with the ESIA report and the public hearing protocol. An application form

on environmental permit should then be submitted to the MoE together with it the following documentation: 5 hard copies and 1 electronic version of the final ESIA report, the public hearing protocol, the situation plan of the place where the project is planned to be implemented, a report on the types and volumes of possible and permissible emissions, project on emission/discharge norms (4 copies) and a summary of planned activity. MoE has 20 days after all the documentation is submitted to carry out an SEE and issue a permit. The approval of other Ministries relevant for the project is a prerequisite for the issuance of the permit. There would likely have been some contact between the authorities and the developer during the preparation of the ESIA, where signals about mitigating measures etc. would be given (Parliament of Georgia, 2005 (b)).

In addition, the plant will require Construction Permission from the Ministry of Economic Development. Furthermore, a Water Consumption Permission would be needed. Depending on the scale and location of the project, the construction permit may also require approval from the Ministry of Culture, Monument Protection and Sports of Georgia stating that the planned plant is not within a zone of historic heritage or an archaeological dig. The Law of Georgia on the protection of Cultural Heritage specifies that costs for archaeological activities, supervision, preliminary investigation, historic-cultural heritage determination, scientific research, publication and protection should be included in design and construction costs.

II.2. Land Use Legislation

Four major laws govern the land use issue namely, Law on Land Registration of 1996, Law on Agricultural Ownership of 1996, Law on Privatization of State-Owned Agricultural Lands of 2005 and Law on Soil Protection of 1994. Furthermore, regarding expropriation, Law of Georgia on the Procedure for Expropriation of Property for Necessary Public Needs (adopted on 23rd of July 1999) governs expropriation issues where necessary. According to this Law, the Republic of Georgia can expropriate any property that is within the scope of the projects that are crucial for public needs. The expropriation procedure can be

resulted in decision realized through a Regional Court that is preceded by a Presidential Decree indicating the significance of public need. The description of the property to be expropriated and the instructions on the necessity to pay due compensation are included in the decision. The properties to be expropriated should be confiscated by negotiation as much as possible.

Another legislation regarding the land use is the Law of Georgia on Payment of Substitute Land Reclamation Cost and Damages in Allocating Farm Land for Non-Farming Purposes (adopted on 2nd of October, 1997). Compensation procedure for affected landowners (fixed and variable costs for the land according to its location and quality) is defined in the extent of this Law. According to the Law, certain payments must be done for compensation of profit losses in the case of cultivation of a parcel if the agricultural use of the land is changed.

II.3. Labour Legislation

Within the scope of Mtkvari HPP Project, Georgian Labour Laws that are explained below are of concern:

1. Labour Code of Georgia (2006) governs the rights of the employees in all enterprises, institutions and organizations. In this context, requirements regarding human rights and creation of safe and healthy working environment including health and safety conditions, social security and insurance, working schedule are established.
2. Law of Georgia on Employment (2001) regulates the employment policy of the country including protection of the unemployed in terms of economic, social and legal issues. For the protection of the unemployed, this law promotes employment programs in various scales.

II.4. Related National Strategies and Plans

Regarding environmental issues, National Biodiversity Strategy and Action Plan (2005), an obligation within the scope of Convention on Biological Diversity, aims protecting the biodiversity, ensuring sustainable use and enabling fair access to the benefits of biodiversity. The plan provides a framework through which to organise and coordinate priority conservation activities, and a means to share information about the current state of biodiversity, and the key threats facing Georgia's natural environment within the scope of the responsibilities to Convention on Biological Diversity.

Another significant source to be taken as a basis for environmental assessment is the Georgian Red List which was approved in May 2006. The Red List has been prepared in accordance with the International Union for the Conservation of Nature.

II.5. Other International Agreements

The ESIA report has been prepared in accordance with the requirements of International Finance Institutions (IFIs) within the scope of Mtkvari HPP Project. It is required by the lenders that the Project must be in compliance with the environmental and social policies and guidelines adopted by IFIs as well as the national legislations and requirements. Within the context of the standards of IFIs, the following requirements have been taken into account.

II.6.1. World Bank Requirements

According to the World Bank screening criteria, described in Operational Policy 4.01, projects are classified as Category A, Category B and Category C based on their potential environmental impacts. These categories can be summarized as follows:

Category A – Projects with potential significant adverse social or environmental impacts those are diverse, irreversible or unprecedented.

Category B – Projects with potential limited adverse social or environmental impacts that are few in number, generally site-specific, largely reversible and readily addressed through mitigation measures.

Category C – Projects with minimal or no social or environmental impacts.

The Mtkvari HPP Project is a Category "A" Project.

II.6.2. European Bank for Reconstruction and Development (EBRD) Requirements

The purpose of Environmental and Social Policy of EBRD is to provide environmental and social sustainability by integration of environmental and social issues into the activities, establishing environmental and social performance requirements to the clients, defining roles and responsibilities for the Bank itself and the clients and promoting projects that are environmentally and socially sound. It should be noted here that generally European Investment Bank (EIB) also follows the same sort of policy. In short, EBRD has adopted a set of "performance requirements" regarding social and environmental issues and impact for its clients to be met. Thus, the following "performance requirements" are of concern in the Project.

PR 1: Environmental and Social Appraisal and Management
PR 2: Labor and Working Conditions
PR 3: Pollution Prevention and Abatement
PR 4: Community Health, Safety and Security
PR 5: Land Acquisition, Involuntary Resettlement and Economic Displacement
PR 6: Biodiversity Conservation and Sustainable Natural Resource Management
PR 7: Indigenous Peoples
PR 8: Cultural Heritage
PR 9: Financial Intermediaries
PR 10: Information Disclosure and Stakeholder Engagement

II.6.3. International Finance Corporation (IFC) Performance Standards

IFC adopted 8 Performance Standards on Social and Environmental Sustainability in order to manage social and environmental risks and impacts and to enhance development opportunities in its private sector financing in its member countries eligible for financing. Clients shall meet the Performance Standards throughout the life of an investment. These Performance Standards are as follows:

Performance Standard 1: Social and Environmental Assessment and Management System
Performance Standard 2: Labor and Working Conditions
Performance Standard 3: Pollution Prevention and Abatement
Performance Standard 4: Community Health, Safety and Security
Performance Standard 5: Land Acquisition and Involuntary Resettlement
Performance Standard 6: Biodiversity Conservation and Sustainable Natural Resource Management
Performance Standard 7: Indigenous Peoples
Performance Standard 8: Cultural Heritage

Among these Standards, Performance Standard 1, Social and Environmental Assessment and Management System, is the main standard to be considered. In addition, Performance Standard 5, Land Acquisition and Involuntary Resettlement would be a concern for the Project with respect to land acquisition based on the present information that resettlement would not be a concern for the project. Thus, the requirements of Performance Standard 1 are summarized below.

Performance Standard 1- Social and Environmental Assessment and Management System: This Standard establishes the importance of; (i) integrated assessment to identify the social and environmental impacts, risks, and opportunities of projects; (ii) effective community engagement through disclosure of project-related information and consultation with local communities on matters that directly affect them ; and (iii) the client's management of social and environmental performance throughout the life of the project. The objectives of this Standard are as follows:

- To identify and assess social and environment impacts, both adverse and beneficial, in the project's area of influence,
- To avoid, or where avoidance is not possible, minimize, mitigate, or compensate for adverse impacts on workers, affected communities , and the environment,
- To ensure that affected communities are appropriately engaged on issues that could potentially affect them,
- To promote improved social and environment performance of companies through the effective use of management systems.

The other environmental agreements and conventions that Georgia is a party of are listed as follows:

- Convention on Biological Diversity (2000)
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973)
- Convention on Wetlands of International Importance Especially as Waterfowl Habitat (1971)
- Vienna Convention for the Protection of the Ozone Layer (1985)
- Convention on the Protection of the Black Sea Against Pollution
- United Nations Framework Convention on Climate Changes
- Convention on Access to Information, Public Participation in Decision Making and Access to Justice in Environmental Matters (1998)
- Convention on Long-Range Transboundary Air Pollution (1979)
- United Nations Convention to Combat Desertification (1994)
- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989)
- Convention on the Conservation of Migratory Species of Wild Animals (1979)
- Agreement on the Conservation of Bats in Europe (EUROBATS) (2001)
- Agreement on the Conservation of African-Eurasian Migratory Waterbirds (2001)

- UN (Rio) Convention on Biological Diversity
- Paris Convention on the Protection of the World Cultural and Natural Heritage
- European Convention on the Protection of the Archaeological Heritage
- Convention for the Protection of the Architectural Heritage of Europe

CHAPTER III

PROJECT PURPOSE AND DESCRIPTION

III. PROJECT PURPOSE AND DESCRIPTION

The Republic of Georgia, as a developing country, is in the period of rapid growth of economy and the development requires a considerable power demand. Thus, the energy sector remains among top priorities for the government and it is significant to improve the sector for a more productive and sustainable energy system. Just recently, the Ministry of Energy announced the new investment program in Greenfield Hydropower Plants aiming at attracting more private investments into the development of hydropower plants in Georgia in order to take the advantage of the country's largely unutilized abundant water resources. (URL-1) In this context, the Georgian government has included the proposed Mtkvari HPP which is planned to be located on the River Mtkvari near the city of Akhaltsikhe, into potential hydropower plants list of Georgia.

Georgia needs to develop domestic energy sources in order to attain its development goals and activities. Hydroelectric energy is one of the country's most important domestic energy sources, since Georgia has an important potential with its rich surface water resources. Currently, there are 26 000 rivers with a total length of 60 000 km on the territory of Georgia. The overall fresh water supply of Georgia including ice, lakes and water reservoirs is 96.5 x 10^9 m^3. Around 300 rivers are significant in terms of energy production with a total annual potential capacity equivalent to 15,000 MW (URL-4). In addition, hydroelectric energy is a renewable energy resource and if utilized efficiently it comprises a significant step towards sustainable energy production in the long run. Besides, extensive scientific research on the energy resources of the world has shown that fossil energy sources are rapidly being depleted. Therefore, generation of reliable, inexpensive and high quality energy is the main purpose of the realization of hydropower plant projects and hence Mtkvari HPP project. The following sections discuss the energy needs of Georgia associated with the development goals of the country.

III.1. Present Situation and Objectives in Energy Sector

In Georgia, primary energy and electricity consumptions have been diverse since independence. Energy consumption reached to 8.3 TWh in 2006 and 8.5 TWh in 2007 (IEA, 2006; GoG, 2006). Meanwhile, the gross electrical energy consumption per capita increased from 506 kWh (1992) to 564 and 670 in 2000 and 2005, respectively (URL-7). It is seen that this value is lower than the world average, which is 2,500 kWh/capita. On the other hand, primary energy production was increased to 1.20 Mtoe in 2006 (IEA, 2006).

In 2006, electrical energy production was 7,287 GWh of which 27.1% (1,972 GW) was supplied from thermal and 72.9% (5,315 GWh) from hydroelectric power plants (URL-10). The most significant developments in production were observed in hydropower plants, and to an extent thermal energy and other renewable energy sources. Today, the technical potential of Georgian water resources and associated water-power resources, amounts to 80 billion kWh per annum (ISTC, 2003) from which 40-50 billion kWh/year is economically feasible (UNDP, 2004). The total number of rivers is 26,000 of which 300 of those are considered to be noteworthy for energy generation. The annual potential of those rivers are calculated to be 15,000 MW. However, by the end of 2008, the total installed power in Georgia was 4700 MW of which 80% of electricity is produced by hydropower plants (URL-1). On the other hand, despite rich sub-bitumen coal and lignite reservoirs existing on the territory of Georgia, investments on energy generation from fossil fuels were not considered to be cost effective as the quality of Georgian coal is low and exploration of coal is difficult due to the geology of the country.

In 2003, the Government initiated a number of reforms in energy sector which are expected to contribute to development of the country economy via liberalising energy market and privatisation of the sector. In this context, Government of Georgia and the Ministry of Energy took significant steps towards sustainable energy production by allocating 77.5 Million GEL in 2004 and 200 Million GEL in 2005 for energy sector. Furthermore, the Government and Ministry of Energy encouraged private sector by engaging projects on hydroelectric production. One

of the significant reasons for promoting hydropower is the financial and political limitations in fuel imports and limited local thermal sources. Meanwhile, energy demand had increased due to economic development of the country. As a consequence, Georgia had to rely on its own hydropower sources and hydropower became the prior energy resource for electricity production (USAID, 2005).

With the implementation of the Mtkvari HPP project, annual energy production will increase by 245 GWh. When it is considered that the annual energy requirement of Georgia reached up to 8,500 GWh in 2007, this amount of generated energy can supply 2.88% of energy consumption.

III.2. Project Description

Mtkvari Hydroelectric Power Plant Project is proposed by the Ministry of Energy, Georgia. “Mtkvari Hydroelectric Power Plant Feasibility Report” is prepared by. Icelandic company, Verkis HF and “Mtkvari Hydroelectric Power Plant Design Report” is prepared by Ukrainian company Ukrhydroproject.

III.2.1. Project Location

The Mtkvari Project site is located in southeast of Georgia, on River Mtkvari, near the city of Akhaltsikhe. The powerhouse will be located at a distance of 1 km to the Sakuneti Village (Akhaltsikhe District) while the location of headworks is 3 km away from the Village Rustavi (Aspindza District). The coordinates of the planned powerhouse site and headworks site were recorded during the field survey (see Photograph III.1) and shown in Table III.1.

Table III.1. Coordinates and Altitudes of the Powerhouse and Headworks

Location	Coordinates	Altitude (m)
Powerhouse	0343092 E 4617008 N	913
Headworks	0345588 E 4607171 N	1002

Photograph III.1. Photograph from the Field Survey

The location of the project area in Georgia is given in Figure III.1. The project area is located within the provincial boundaries of Akhaltsikhe in the southeast of Georgia. Currently, Chitakhevi regulator is located 20-25 km downstream of the powerhouse area. In Photograph III.2, a view of operating Chitakhevi regulator is given.

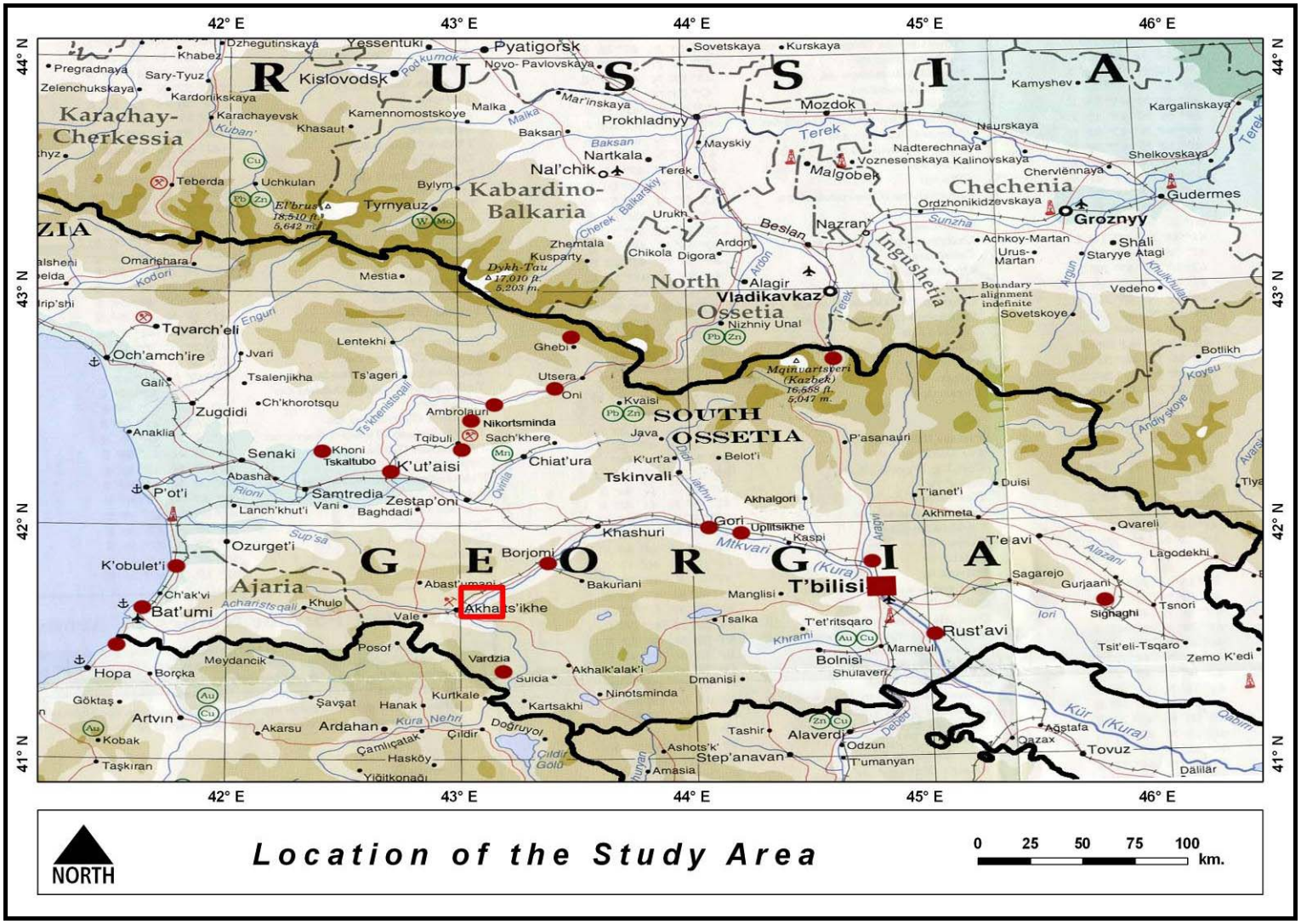


Figure III.1. Location of the Project Area in Georgia

Photgraph III.2. Photograph from Chitakhevi Regulator

Mtkvari HPP Project is a run-of-the-river type power plant project that will be located at a horseshoe shaped section of Mtkvari River near Akhaltsikhe. The elevation of the headworks area is determined to be from 992 masl up to 1015 masl while the powerhouse and tailrace area on the right bank of Mtkvari is at an elevation of 910 masl. Additionally, adits that the excavation material will be extracted are at about 1055 masl (Adit 2) and 1020 masl (Adit 1) (Verkis, 2009 (b)).

The photographs of the area that the outlet of headrace tunnel is indicated and the powerhouse area are given in Photograph III.3 and III.4. The location of the project area is given in Figure III.2.

III.2.2. Description of Structural Components

The facilities those will be implemented within the context of Mtkvari HPP Project are composed of headworks, headrace tunnel, pressure tunnel, surge shaft, powerhouse, tailrace canal, control room and switchyard. The electricity generated at hydroelectric power plant will be transmitted to Akhaltsikhe Station by 110 kV energy transmission line that is approximately 8 km long and from that place it will be connected to the interconnected system (Verkis, 2009 (b)).

The dimensions of the closed and open areas determined for the units those will be constructed within the context of the project are defined below. Panoramic photographs of the reservoir area and the powerhouse are presented in Photograph III.5 and Photograph III.6, respectively.

The headworks of Mtkvari HPP consist of an intake pond, diversion canal, main dam, cofferdam, spillway and intake structure. The crest level of the spillway and the highest regulating level is selected to be 1012 masl while the water level can reach up to 1015.2 masl during floods. The length of the intake pond is 3 km and the maximum width of the pond is 0.6 km. The lowest regulating level is selected to be 1010 masl.

In construction period, the river will be diverted via diversion canal at an appropriate location in order to provide dry area for the construction of the main dam and power intake. The canal will be about 220 m long and 12 m wide at the bottom. The canal will be permanently closed with a rockfill dam at the end of construction.

The main dam will be about 300 m long with a maximum height of 25 m (rising from 991 to 1016 masl). The foundation is composed of sound rock. The dam will be a conventional type earth-rockfill structure. In order to divert the river, cofferdam will be constructed. The construction will be implemented with rocks on the banks of the river in the low flow season. The spillway will be a low and long overflowing weir extending between the diversion canal and the main dam. The approximate length of the concrete spillway will be 120 m (Verkis, 2009 (b)).

Photograph III.3. Area of Outlet of the Headrace Tunnel of Mtkvari HPP

Photograph III.4. Powerhouse Area of Mtkvari HPP

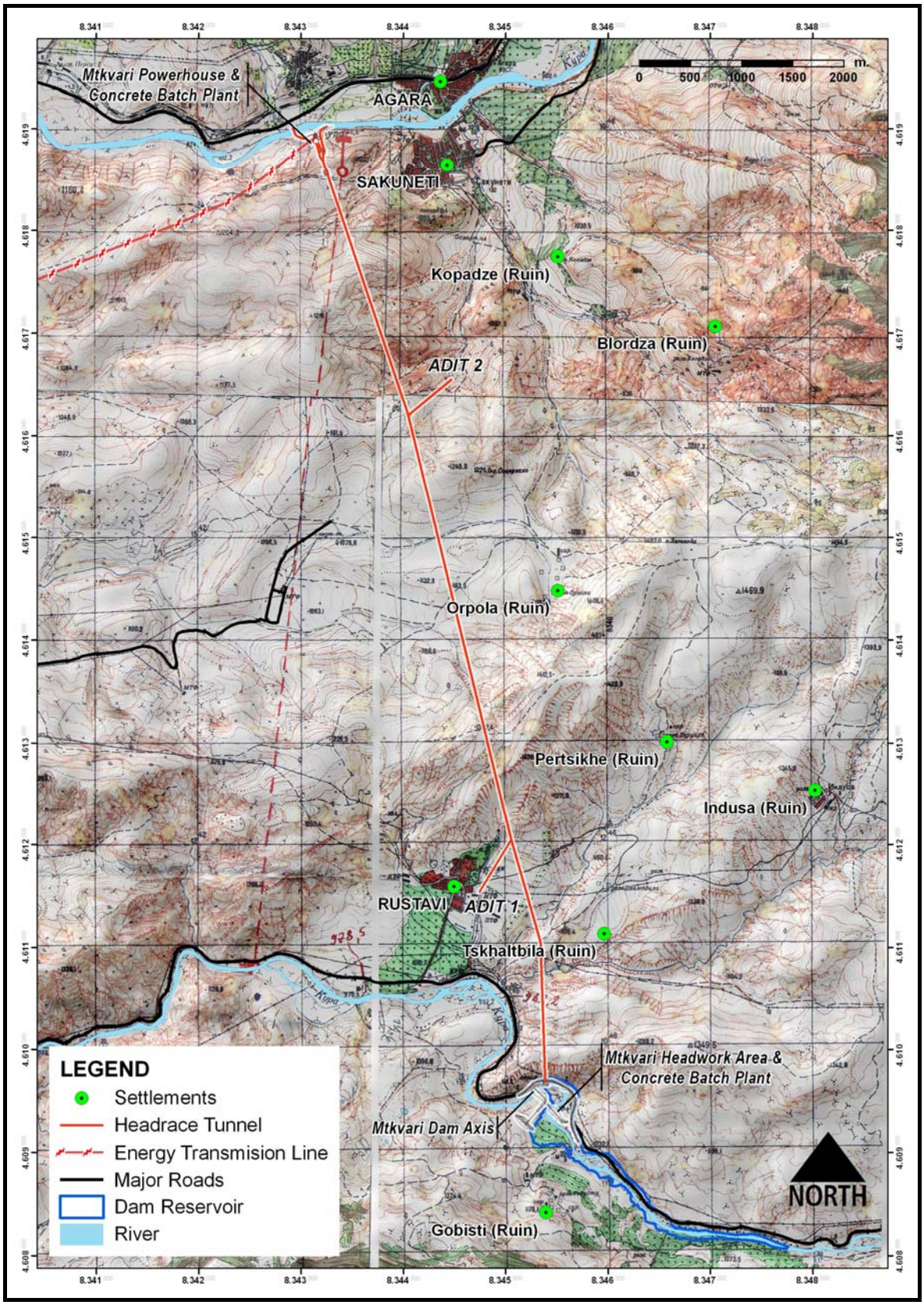


Figure III.2. Location of Mtkvari HPP Project

Photograph III.5. Panoramic Photograph of the Reservoir Area

Photograph III.6. Panoramic Photograph of the Powerhouse Area

As the last structure in the headworks area, headrace tunnel intake will convey the harnessed river water from the intake pond into the headrace tunnel. The intake will be of concrete structure. Within the context of intake structure, trashracks that favour prevention of trash/debris entering into the waterways will be constructed. The trashracks will be composed of three panels each having a size of 3.4 m x 5.6 m. Additionally, bulkheads will also be constructed in order to enable the headrace tunnel to function properly. The bulkhead will be composed of two panels having an opening of 4.8 m x 5.6 m.

In addition to the construction of the major structures in the headworks, relocation of existing roads and construction of permanent roads will be of concern. According to the investigations, a road system will be required to connect the works areas on the mountain to the existing roads.

The headrace tunnel will be constructed via TBM or roadheader method. The headrace tunnel will be approximately 9.6 m in length and 5.6 m in diameter (gross).

The pressure tunnel will be extending from the headrace tunnel down to the distributor. The structure will located at 100 m upstream from the powerstation. The tunnel diameter will be 5.6 m in the horseshoe section at a length of 70 m. The pressure tunnel will be composed of a 30 m. distributor and valves. The distributor will be made of concrete embedded steel pipe with a diameter of 3.4 m cleaving into two concrete embedded steel sections with a diameter of 2.3 m.

The surge shaft of the powerhouse is dimensioned in accordance with the presumed shut down time of the turbines, the pertinent size of the waterways and other relevant issues. The facilities will be located approximately 200 m upstream of the powerhouse cavern in the headrace tunnel (Verkis, 2009 (b)).

In terms of safety, the shaft basin will be covered with a circular concrete wall graded with steel cover. Additionally, a safety fence will surround the entire basin.

According to the feasibility study, there are two options for the type of the powerhouse namely, underground and surface type powerhouse. In the feasibility study, those two options are compared in terms of technical and economical details and it is proposed that a conventional underground type powerhouse is appropriate for the whole system. The details of the alternatives are provided in Chapter VI. The underground powerhouse will be located at a depth of 120 m. Access to the powerhouse will be provided via a 90 m long and 6 m wide tunnel perpendicular to the powerhouse axis. The powerhouse cavern will be 51 m long at 918.3 masl and 13 m wide and 30.5 m high at 900.5 masl up to 931.0 masl. Two identical generation units (2 x 21.5 MW) and relevant appurtenances will be located in the underground station. For that purpose, each unit will be facilitated with a draft tube gate that will be 5.6 m x 2.8 m in dimensions, for turbine maintenance. However, it should be noted that a surface type powerhouse is preferred by the project developer.

The water flows to the tailrace canal that extends into the Mtkvari River course at approximately 100 m downstream from the tunnel portal. The maximum water velocities in the cases of filling of the canal with rock and loose material are 1.5 and 1 m/sec, respectively.

The switchyard will be located on the riverbank parallel to the tailrace canal and be guarded with safety fence that is 40 m x 26 m in dimensions. Additionally, the control building will be located between the switchyard and the powerhouse access tunnel portal. The area of the control building will be 130 m^2 including not only control equipments but also necessary personnel facilities such as coffee room, toilets, locker room etc (Verkis, 2009 (b)).

The significant technical data regarding Mtkvari HPP is presented in Table III.2. Furthermore, technical drawings of units are presented in Appendix 2.

Table III.2. Technical Data of Mtkvari HPP Project

Hydrological Data	Mean River Flow at Intake	52.8 m^3/sec
	Rated Turbine Discharge	55 m^3/sec
	Average Discharge through Station	34.3 m^3/sec
	Preliminary Design Flood	1,500 m^3/sec
	Max. Recorded Flow (18th of April, 1968)	1,110 m^3/sec
Intake Pond	Highest Regulated Water Level (HRL)	1012 masl
	Minimum Operating Level (MOL)	1010 masl
	Highest Flood Water Level (FWL)	1015.2 masl
	Empty Pond	991 masl
	Total Volume	4.9 x 10^6 m^3
	Regulated Volume	1.0 x 10^6 m^3
Headrace Tunnel Intake	Sill Level	1000 masl
	Bulkhead	5.2 x 6.1 m^2
	Trashrack	6 x 9.5 m^2
Spillway	Crest Elevation	1012 masl
	Length of Concrete Overflow Weir	120 m
	Capacity at Water level 1015.2 masl	1,500 m^3/sec
Main Dam	Crest Elevation	1016 masl
	Length	300 m
	Volume	152,000 m^3
	Max. Height	25 m
Headrace Tunnel	Headrace tunnel, length	9.6 km
	Diameter	5.6 m
	Inclination	Variable
	Water Velocity	1.71 m/s
Adits	Adit 1, length	600 m
	Adit 1, inclination	10%
	Adit 2, length	550 m
	Adit 2, inclination	10%
	Diameter	6.0
Surge Shaft	Diameter of Shaft	3.5 m
	Basin Bottom Level (200 m^2)	990 masl
	Basin Surface Level (875 m^2)	1020 masl
	Total Height of Shaft and Basin	93 m
Pressure Tunnel	Steel Lining, length	30 m
	Steel Lining, diameter	3.4/2.3 m

Table III.2. Technical Data of Mtkvari HPP Project (cont'd)

Powerhouse	Units and Installed Capacity	2 x 21.5 MW
	Type	Vertical Francis
	Rated Speed	333.3 rpm
	Rated Generator Capacity	2 x 24 MVA
	Size of Powerhouse	13 x 51 m
Tailrace Canal	Canal Length	120 m
	Canal diameter	5.6 m
	Length of Canal	120 m
	Bottom Width of Canal	6.0/5.0/var. M
	Minimum Tailwater Elevation	909 masl
	Average Tailwater Elevation	910 masl
	Maximum Tailwater Elevation	915 masl
Transmission Line	Length	8 km
	Voltage	110 kV
Power & Energy	Gross Head	102 m
	Total Headloss at Rated Discharge	14.5 m
	Net Head at Rated Discharge	87.5 m
	Mean Annual Output	245 GWh
	Nominal Max. Power	43 MW

Source: Verkis, 2009 (b)

III.3. Economical and Social Aspects of the Project

III.3.1. Cost Calculations

The cost estimates explained below are based on construction of 43 MW Mtkvari Hydroelectric Power Plant consisting of a diversion canal, cofferdam, spillway, main dam, road works, intake structure, 9.6 m long headrace tunnel, surge facilities, powerhouse, tailrace tunnel and tailrace canal, switchyard and an 8 km long transmission line to Akhaltsikhe.

In order to prevent the variability of the overall costs, the cost estimate excluded escalation and currency fluctuations. In this respect, the prices are set at a certain level (i.e. level of May 2009). Exclusions also include VAT, customs and duties,

cost of capital (interests during construction), cost of land and water rights and other costs of the project developer (Verkis, 2009 (b)).

For the calculation of the costs, the following assumptions are made:

1. The prices for civil work have been obtained from Landsvirkjun that is the national Power Company of Iceland hydro power cost model.
2. The cost estimates are carried out according to the price levels in May 2009.
3. The exchange rate between the USD and EUR is set at 1 USD = 0.76 EUR
4. Labour costs are estimated according to the information obtained from local contractors.
5. Transportation costs are included in the direct costs.
6. Engineering, Procurement and Construction Management (EPCM) costs are estimated as 14% of the contractor's cost.
7. Contingency conditions are also included in cost calculations in order to account for non-identified items and unforeseen events or effects leading to a cost increase.

Based on the method of calculation and assumptions and exclusions, the cost of the project implementation is estimated as 93,815,662 USD.

III.3.2. Construction Schedule

The ultimate aim of the construction schedule prepared is to minimise the total construction time and bring the power plant into full commercial operation in approximately three years. The critical path for the construction of hydropower plants is the construction of the powerhouse and installation and testing of the hydromechanical equipment (Verkis, 2009 (b)).

The construction schedule of Mtkvari HPP Project is prepared within the scope of the feasibility studies. According to the construction schedule shown in Figure III.3, the construction will take approximately 36 months considering the sequence of

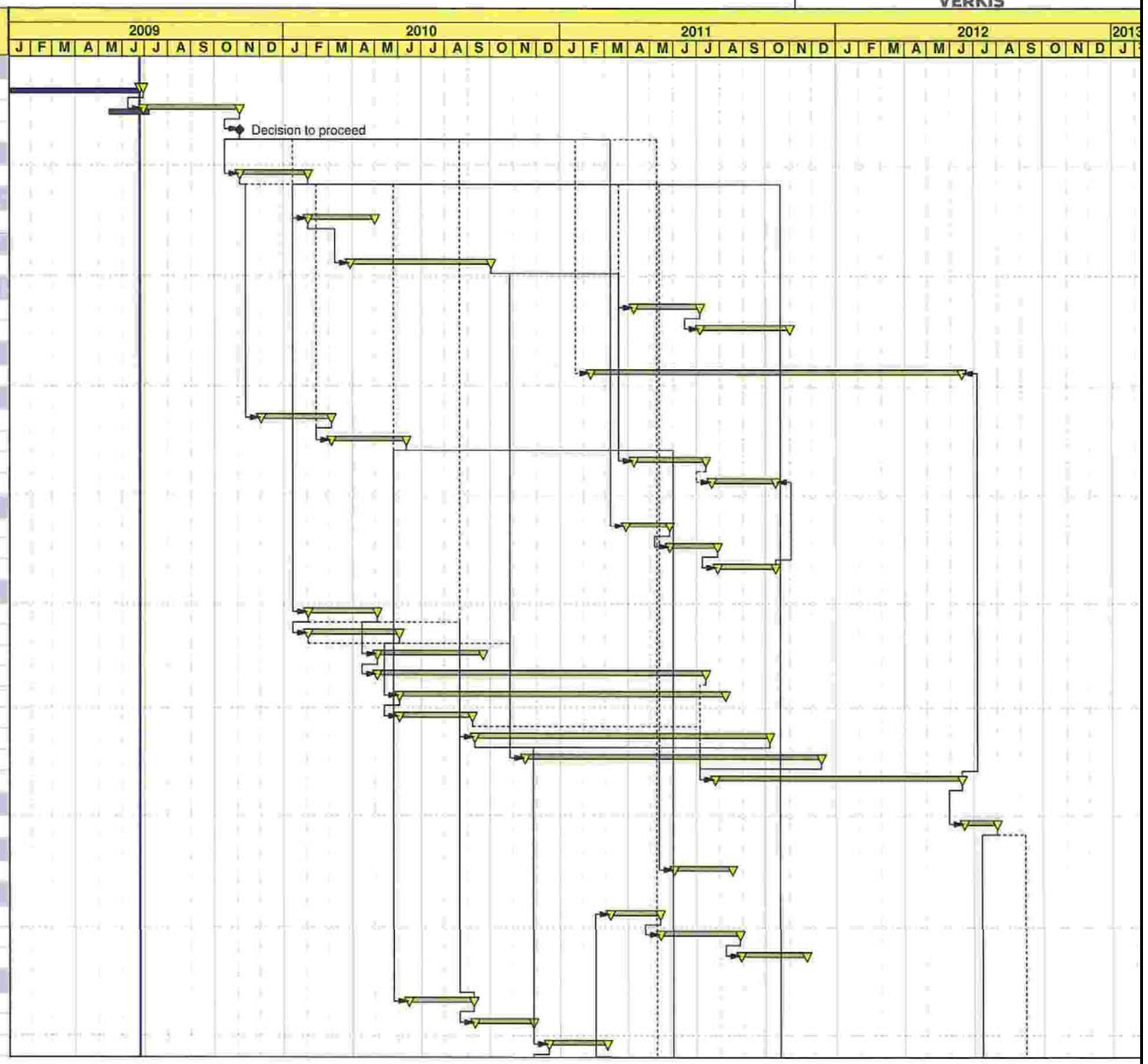
activities, from decision to commissioning of the first unit. However, it should be noted that the following criteria should be met for implementation of the construction schedule (Verkis, 2009 (b))

- The work will not be discontinued.
- Four simultaneously working drillings will be of concern for underground excavation.
- For prompt installation of the hydromechanical and electromechanical equipment, design and manufacturing phases will be completed.
- The construction of the headrace tunnel will proceed at the rate of 40 m per week per heading.

MTKVARI HEP GEORGIA - CONSTRUCTION SCHEDULE

VERKÍS

Activity Name	Original Duration	Start	Finish
00 General	208	05-Jan-09 A	04-Nov-09
Feasibility study	118	05-Jan-09 A	29-Jun-09
Contracting (EPCM)	96	15-May-09 A	04-Nov-09
Decision to proceed	0	04-Nov-09	
10 Mobilisation & Site Installation	59	04-Nov-09	01-Feb-10
Mobilization, construction power plants & workshops	59	04-Nov-09	01-Feb-10
20 Diversion Canal	60	01-Feb-10	30-Apr-10
Diversion Canal - Excavation	60	01-Feb-10	30-Apr-10
30 Cofferdam	124	29-Mar-10	01-Oct-10
Cofferdam - Fill of cofferdam	124	29-Mar-10	01-Oct-10
40 Spillway	140	08-Apr-11	01-Nov-11
Spillway - Excavation	56	08-Apr-11	05-Jul-11
Spillway - Concrete work	84	05-Jul-11	01-Nov-11
50 Main dam	336	10-Feb-11	15-Jun-12
Main dam	336	10-Feb-11	15-Jun-12
60 Road works	461	02-Dec-09	14-Oct-11
Access road - Bridge	62	02-Dec-09	04-Mar-10
Access road - Road to powerhouse	65	04-Mar-10	11-Jun-10
Road work - Excavation and fill	62	08-Apr-11	13-Jul-11
Road work - Pavement	60	21-Jul-11	14-Oct-11
70 Headrace tunnel intake	137	28-Mar-11	14-Oct-11
Power intake - Excavation	40	28-Mar-11	26-May-11
Power intake - Concrete work	43	26-May-11	29-Jul-11
Power intake - Installation of equipment	54	29-Jul-11	14-Oct-11
80 Headrace tunnel D=6,0m	588	01-Feb-10	15-Jun-12
Adit 1, excavation	61	01-Feb-10	03-May-10
Adit 2, excavation	81	01-Feb-10	02-Jun-10
Drive A 1.1	95	04-May-10	21-Sep-10
Drive A 1.2	294	04-May-10	13-Jul-11
Drive A 2.1	293	02-Jun-10	09-Aug-11
Drive A 2.2	66	02-Jun-10	07-Sep-10
Drive I	268	10-Sep-10	06-Oct-11
Drive II	269	15-Nov-10	13-Dec-11
Support and finishing	225	25-Jul-11	15-Jun-12
90 Adit plug	32	18-Jun-12	01-Aug-12
Adit plug	32	18-Jun-12	01-Aug-12
100 Surge shaft	52	01-Jun-11	18-Aug-11
Surge shaft	52	01-Jun-11	18-Aug-11
110 Pressure tunnel	179	09-Mar-11	23-Nov-11
Pressure tunnel excavation	44	09-Mar-11	13-May-11
Steel lining - Installation	72	13-May-11	26-Aug-11
Steel lining - Embedment	63	29-Aug-11	23-Nov-11
120 Powerhouse	499	14-Jun-10	14-Jun-12
Power house - Surface excavation	60	14-Jun-10	09-Sep-10
Power house - Access tunnel excavation	55	10-Sep-10	26-Nov-10
Power house - Cable tunnel excavation	53	16-Dec-10	04-Mar-11



Remaining Work ◆ Milestone
Critical Remaining Work % Complete

Page 1 of 2

01-Jul-09

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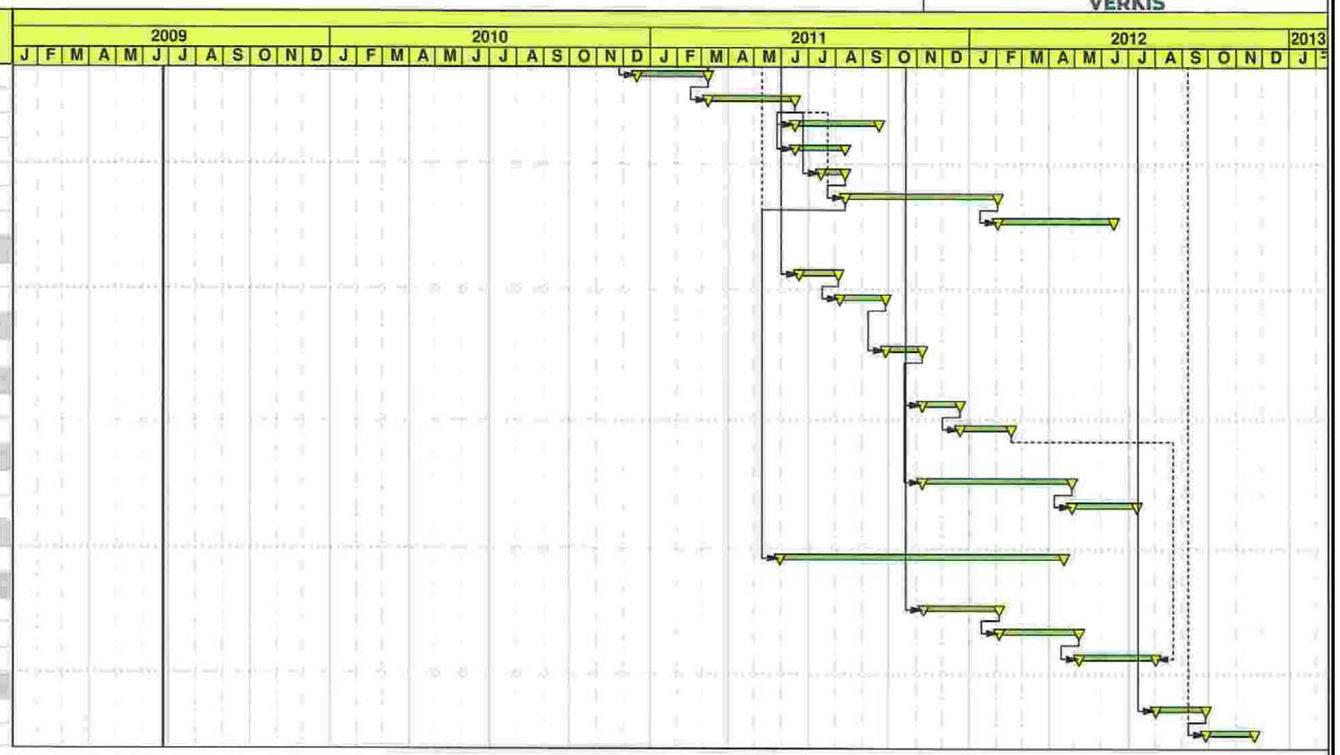
Figure III.3. Construction Schedule of Mtkvari HPP Project (Source: Verkis, 2009 (b))

MTKVARI HEP GEORGIA - CONSTRUCTION SCHEDULE

VERKÍS

Activity Name	Original Duration	Start	Finish
Power house - Powerhouse excavation	55	16-Dec-10	09-Mar-11
Power house - Concreting, Power house superstructure	65	09-Mar-11	15-Jun-11
Power house - Architectural & Finishing work	66	15-Jun-11	19-Sep-11
Power house - Draft tube gates erection	40	15-Jun-11	11-Aug-11
Power house - Overhead crane installation	20	14-Jul-11	12-Aug-11
Power house - Turbine erection	122	12-Aug-11	01-Feb-12
Power house - Generator erection and auxiliaries	89	02-Feb-12	14-Jun-12
130 Tailrace tunnel	69	20-Jun-11	26-Sep-11
Tailrace - Open cut excavation	33	20-Jun-11	04-Aug-11
Tailrace - Tunnel excavation	36	05-Aug-11	26-Sep-11
140 Tailrace canal	31	26-Sep-11	07-Nov-11
Tailrace canal	31	26-Sep-11	07-Nov-11
150 Switchyard	72	08-Nov-11	17-Feb-12
Switchyard - Foundations	30	08-Nov-11	20-Dec-11
Switchyard - Equipment Installation	42	21-Dec-11	17-Feb-12
160 Control building and access area	167	08-Nov-11	10-Jul-12
Control house - Building	117	08-Nov-11	26-Apr-12
Control house - Installation of equipment	50	27-Apr-12	10-Jul-12
170 Electromechanical equipment	223	30-May-11	18-Apr-12
Electromechanical equipment	223	30-May-11	18-Apr-12
180 Transmission lines	180	09-Nov-11	31-Jul-12
Transmission line - Foundations	60	09-Nov-11	03-Feb-12
Transmission line - Master erection	60	03-Feb-12	04-May-12
Transmission line - Lines installation	60	04-May-12	31-Jul-12
Testing and commissioning	80	01-Aug-12	22-Nov-12
Unit 1	40	01-Aug-12	27-Sep-12
Unit 2	40	27-Sep-12	22-Nov-12



Remaining Work ◆ Milestone
Critical Remaining Work % Complete

Page 2 of 2

01-Jul-09

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Figure III.3. Construction Schedule of Mtkvari HPP Project (cont'd) (Source: Verkis, 2009 (b))

III.3.3. Cost-Benefit Analysis of the Project

In order to determine the profitability of the project, energy generation and the value of produced energy are compared. Within this scope, the efficiency of the plant is calculated as 92%. Based on this efficiency, the average energy generation is calculated as 245 GWh/year.

In addition, the value of the produced energy is estimated as 4 US¢/kWh throughout the period of April-September and 6 US¢/kWh throughout October-March by the project developer. Accordingly, when the amount of energy produced and its value is taken into consideration, it is concluded that the annual average income from energy production is 11.8 million USD. Besides, the energy production fluctuates in accordance with the variation in flow from 212 GWh/year to 306 GWh/year generating income from 10.1 million USD/year to 14.7 million USD/year, respectively (Verkis, 2009 (b)).

In order to determine the profitability of the project, the energy cost is the most significant concern. In this context, energy cost is mostly governed by the interest rate (capital cost). For instance, with an annual interest rate of 6%, annual O&M cost of 1% and 40 years of plant operation, the energy cost is calculated as 2.8 US¢/kWh (Verkis, 2009 (b). The change of energy cost with the interest rate is presented in Table III.3.

Table III.3. Average Energy Cost as a Function of Interest Rates

Annual Interest Rate (%pa)	Average Energy Cost (US ¢/kWh)
5	2.55
6	2.84
7	3.15
8	3.46
9	3.78
10	4.09

Source: Verkis, 2009 (b)

CHAPTER IV

BASELINE DATA

IV. BASELINE DATA

The baseline data on the physical, biological and socio-economic environments are discussed separately in the following sections, so as to provide a detailed outline of the present environmental conditions in the project area. The limits of the study area for each category (physical, biological and socio-economic environments) vary as the impacts of the project on these environments extend over different geographic areas. In the studies for the physical, biological and socio-economic environments, the following resources were given primary importance:

- resources close to the headworks area, powerhouse area, and the route of electric transmission line,
- resources in the bypassed reach of Mtkvari River,
- resources primarily affecting the project, and
- resources being primarily affected by the project.

For water resources, the data obtained from the gauging stations of the National Environmental Agency were used. The climatological conditions of the area were determined using the data from the meteorological gauging stations in the Mtkvari HPP Project area and surroundings (i.e. Akhaltsikhe and Aspindza). These data were also used in the design of the Mtkvari Hydroelectric Power Plant Project.

For the biological resources, headworks area, powerhouse area and the bypassed reach of the Mtkvari River were mainly studied as these are the areas of main concern with regard to project impacts. In these studies, special emphasis was given to the aquatic species in the bypass reach because the change in flow in this reach will affect them.

The socio-economic characteristics in the project area were determined using the data obtained from Department of Statistics of Georgia in addition to the information obtained from field surveys. Resettlement will not be a concern in the development of the Mtkvari Project because no settlements will be inundated and

no important income resources will be affected. Socio-economic studies show that there are positive expectations of the locals from the project, such as job opportunities.

IV.1. Physical Environment

Baseline physical conditions, under which the Mtkvari HPP Project would be realized, are discussed in this section. The discussion is divided into subsections on topography, geology, climatology and hydrology.

IV.1.1. Topography

Mtkvari HPP will be located on River Mtkvari, in the South of Georgia near the city of Akhaltsikhe. The headworks will be located at a distance of 3 km from the village Rustavi, while the location of the powerhouse will be at a distance of 1 km from the village Sakuneti. River Mtkvari originates in Turkey (named as Kura River in Turkey) and flows into Georgia from southwest at an elevation exceeding 1,100 m above sea level (asl). The river turns to eastwards near the town Akhaltsikhe at about an elevation of 950 masl and flows from there towards east through the capital city Tbilisi, onwards into Azerbaijan and into the Caspian Sea.

The region surrounding the project area is presented by middle mountainous, erosive-denudational relief. The project area is located in the western edge of Trialeti ridge of sublatitudinal direction, which is confined from three sides (southern, western, and northern) by the Valley of Mtkvari River. Therefore, this section of the river has a form of “loop”, that is the main promoting factor for construction of the hydroelectric plant. The dam and the reservoir area cover a 3.5 km long segment of Mtkvari River. From the headworks, water will be diverted towards the village Sakuneti, where a generating station will be established at a distance of 1 km to the west of the village through a 9.6-km long power tunnel.

In general, the eastern part of the project area is covered by mountains wit peak elevations of 1,400-1,500 m. In the northern part of the project area, where the

powerhouse will be located, the elevations range between 916 m and 1,026 m. The average elevation in this region is 952 m. In the southern part of the project area where the intake facilities and dam axis are located, the elevations range between 999 m and 1,027 m. The maximum elevation at the dam axis area is 1,040 m. Steeper slopes are dominant in the southern part of the project area whereas the slopes in the northern part of the project area are gentler. Figure IV.1 shows the elevation map of the project area.

IV.1.2. Geology

IV.1.2.1. General Geology

This section of the ESIA report is based on the Geotechnical Investigation Studies conducted by for the Mtkvari Project by Geoengineering Ltd and presents geological, hydrogeological and geotechnical features of the project area. In the scope of these studies geological, hydrogeological and geotechnical surveys have been carried out, in addition to geophysical surveys for all Mtkvari HPP main facility areas, which include the proposed reservoir area, headworks, headrace tunnel, powerhouse and equalizing reservoir/basin of the Mtkvari HPP.

Generally, the major part of the project structures is located in the centre of the Trialeti upland and only a small part is in the Akhaltsikhe depression. For instance, 9.6-km headrace tunnel from Rustavi to Sakuneti will cross through Trialeti Ridge.

The surveys revealed that the study area broadly consists of unstable clayey and sandy tuffogenic formations dated back to the Upper Eocene. The Middle Eocene volcanogenic and sedimentary units of commonly seen media can be lithologically divided into three series which are layered tuffogenic series of sediments, tuff-breccia series and layered tuffogenic series.

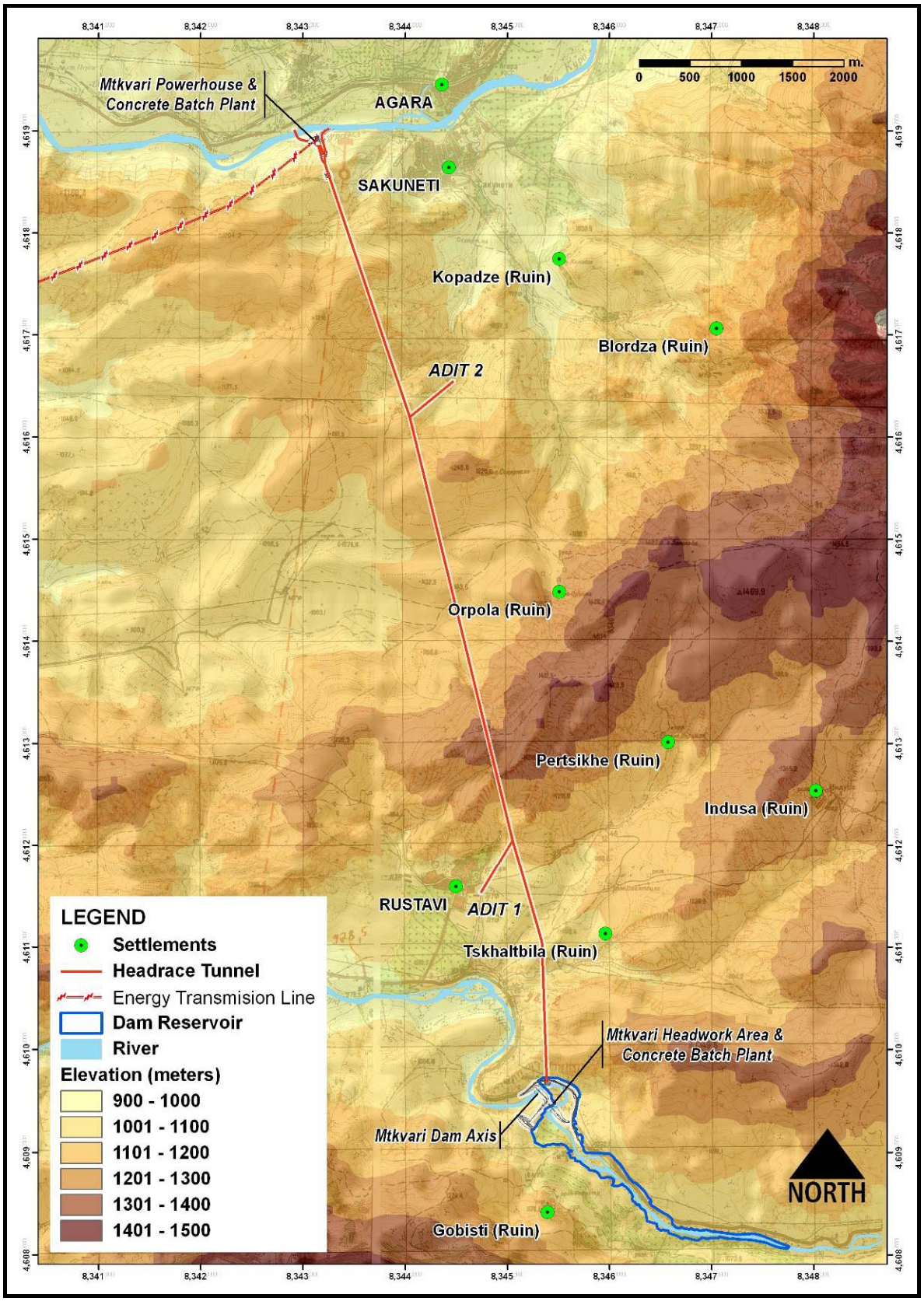

Figure IV.1. The Elevation Map of the Project Area

In the southern part of the area, there exists the Upper Miocene-Lower Pliocene Kisatib formation of doleritic and andesite lavas. At the top of all units, the Quaternary sediments of terraces, alluvium, diluvium and prolluvium, with Quaternary dolerite stream base, exist regionally. There is also some diabase, hornfel, teschenite bodies spread in the project area (Geoengineering, 2009).

IV.1.2.1.1. Lithology and Stratigraphy

According to the Geotechnical Investigations for Mtkvari HPP vertical section of Rustavi-Sakuneti region consists of following members:

1. Quaternary sediments of terraces, alluvium, diluvium and prolluvium.
2. Quaternary dolerite stream.
3. Upper Miocene-Lower Pliocene doleritic and andesite lavas and their pyroclastics with diatomite layers in upper part.
4. Upper Eocene tuffs, argillites and sandstones.
5. Middle Eocene sandstone and relatively thinner tuff layers.
6. Middle Eocene tuff layers and some thin layers of andesite and argillites.
7. Thick layers of Middle Eocene tuff, breccias and andesite; intermediate layers of Middle Eocene sandstone; inclusions of hornstone and diabase bodies.

The oldest formation of the studied area is 1,036 m thick Middle Eocene Formation (Pg_2^{2b}). Tuff, breccia and andesite are forming the thick layers and sandstone is forming intermediate layers of this formation. The argillite layers of this formation range from thin to thick. At some locations, this formation has inclusions of intrusive hornstone and diabase bodies. Above the Middle Eocene formation, there exists 400 m of Middle Eocene Series (Pg_2^{2b-c} –Pg_2^{3}), which mainly consists of tuff layers and some thin layers of andesite and argillites. Above the Middle Eocene Series there exists 200 m Middle Eocene Upper formation (Pg_2^{2c}) consisting of sandstone and relatively thinner tuff layers. Onto the Middle Eocene Upper formation, Upper Eocene series (Pg_2^{3}) sits with an approximate thickness of

625 m. Upper Eocene series consist of tuffs, argillites and sandstones. Overlying the Upper Eocene series, 300-1,000 m Upper Miocene Lower Pliocene Kisatib formation (N_1^2-N_2^1) is present. Kisatib formation consists of doleritic and andesite lavas and their pyroclastics with diatomite layers in places at the upper part. At the top of all series, there exist 20 m Quaternary dolerite stream and Quaternary sediments of terraces, alluvium, diluvium and prolluvium.

As a result of laboratory tests conducted and reported in the Geotechnical Investigation Report of Mtkvari Hydroelectric Power Station (2009), the uniaxial compression strength (saturated) of the media covering the project area was determined to be at medium level. The geological map and generalized stratigraphical cross-section of the project area are presented in Figure IV.2 and Figure IV.3, respectively.

IV.1.2.1.2. Structural Geology

Morphologically the study area is mainly positioned on the Erusheti upland, which is described as a form of tectogenic relief and the volcanogenic processes in the region matching the project area are of secondary importance.

Regarding fault tectonics, Upper Eocene clayey sand and volcanogenic formations of the Mtkvari HPP area have apparent faults and fissures. During site surveys, different rock types were investigated for lithological, physical and mechanical properties at various locations of the project area. Within the context of geotechnical studies, 1,263 measurements were carried out on 15 spots. After the analysis of the fault investigation survey, 6 primary systems of faults and 3 main vectors and some less spread fault systems were identified.

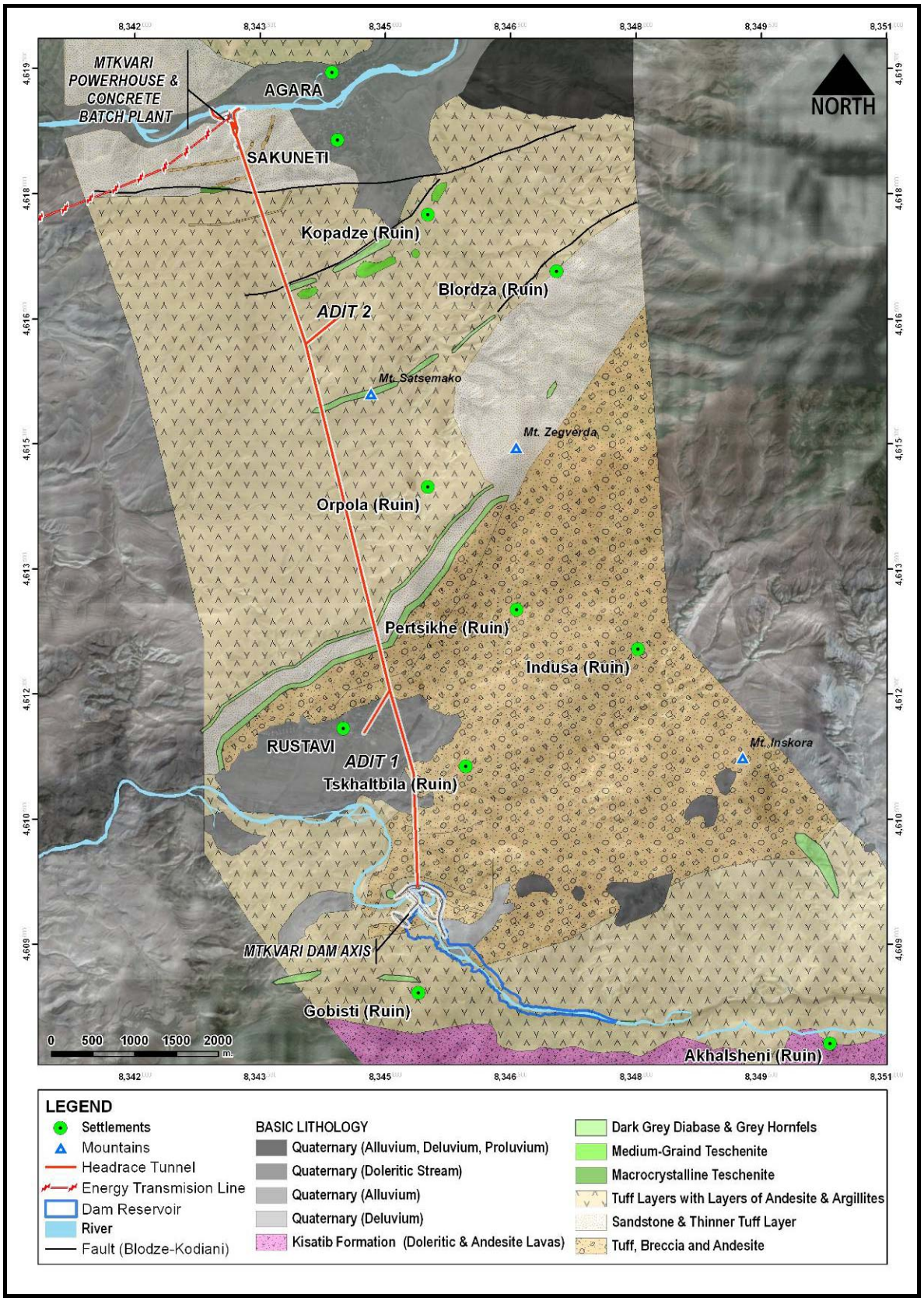

Figure IV.2. The Geological Map of the Project Area

ERA	SUB-LEVEL	INDEX	LITHOLOGY	STRATUM DESCRIPTION
CENOZOIC	QUARTERNARY	Q		Doleritic stream and sediments of terraces, alluvium, diluvium and prolluvium.
	UPPER MIOCENE & LOWER PLIOCENE	N_1^2 - N_2^1		Doleritic and andesite lavas and their pyroclastics with diatomite layers in places at the upper part.
	UPPER EOCENE	Pg_2^3		Tuffs, argillites and sandstones.
	MIDDLE EOCENE (Upper Formation)	Pg_2^{2c}		Sandstone and relatively thinner tuff layers.
	MIDDLE EOCENE (Middle Formation)	Pg_2^{2b} / $Pg_2^{2b\cdot c}$ - Pg_2^3		Thick layers of tuff, breccia and andesite, intermediate layers of sandstone are forming the older members; tuff layers and some thin layers of andesite and argillites are forming the younger members of this formation. The older member has inclusions of hornstone and diabase bodies.

Figure IV.3. The Generalized Stratigraphical Cross-section of the Project Area

The Blordza-Kodiana overthrust in the vicinity the project area is located in between northwest wing of Ortatavi-Sabadura anticline and southwest limb of the Tori-Tadzrisi syncline. This overthrust is visible in between Kodiana pass near the Tori Village (located outside the study area on the east of Blordza Village) and Blordza Village, which are no more inhabited. The overthrust is represented by an intrusive complex of mount called Satsernako. The strike and dipping of the overthrust is to northwest and northwest at 80°, respectively (Geoengineering, 2009).

The project structures to be built in the area all have appropriate design specifications matching the media characteristics and are in line with the national regulations and international standards.

Anticlines-Synclines of the Study Area

Tectonically the study area consists of short, very compressed brancianticlines and wide synclines inclined to the south. Table IV.1 shows types and locations of the tectonic structures by names.

Table IV.1. Locations and Types of Tectonic Structures by Names

Name of Tectonic Structure	Type of Tectonic Structure	Location of Tectonic Structure
Tori-Tadzrisi	Syncline	Main HPP Facility Area
Tsinisi	Anticline	Main HPP Facility Area
Zykilia	Syncline	Main HPP Facility Area
Satsernako	Syncline	Main HPP Facility Area
Satsernako	Anticline	Main HPP Facility Area
Orfola	Anticline	Main HPP Facility Area
Orfola	Syncline	Main HPP Facility Area
Ortatavi-Sabaduri	Anticline	Main HPP Facility Area
Rustavi	Syncline	Main HPP Facility Area
Tskhaltbili	Anticline	Main HPP Facility Area
Blordza-Kodiana	Overthrust	Main HPP Facility Area
Tskhaltbili	Anticline	Reservoir Area
Bakuriani-Oshora	Syncline	Reservoir Area
Teleti-Gumbati	Anticline	Reservoir Area

IV.1.2.1.3. Seismicity

Caucasus is one of the most seismically active regions in Alpine-Himalayan collision belt. The main seismo-tectonic activity is caused by the junction between the Arabian and Eurasian plates (see Figure IV.4.). Historical and instrumental analysis of seismological data shows that the region is of moderate seismicity. In this region, strong earthquake with magnitude up to 7 and macro-seismic intensity IX (see Table IV.2) may occur. According to the historical and instrumental analysis of seismological data, Caucasus is characterized with so-called moderate seismicity. Reoccurrence period for strong events in this area is in the order of 1000 years (URL-8). Figure IV.4 shows the Arabian and Eurasian plate junction and the movement directions caused by the collision.

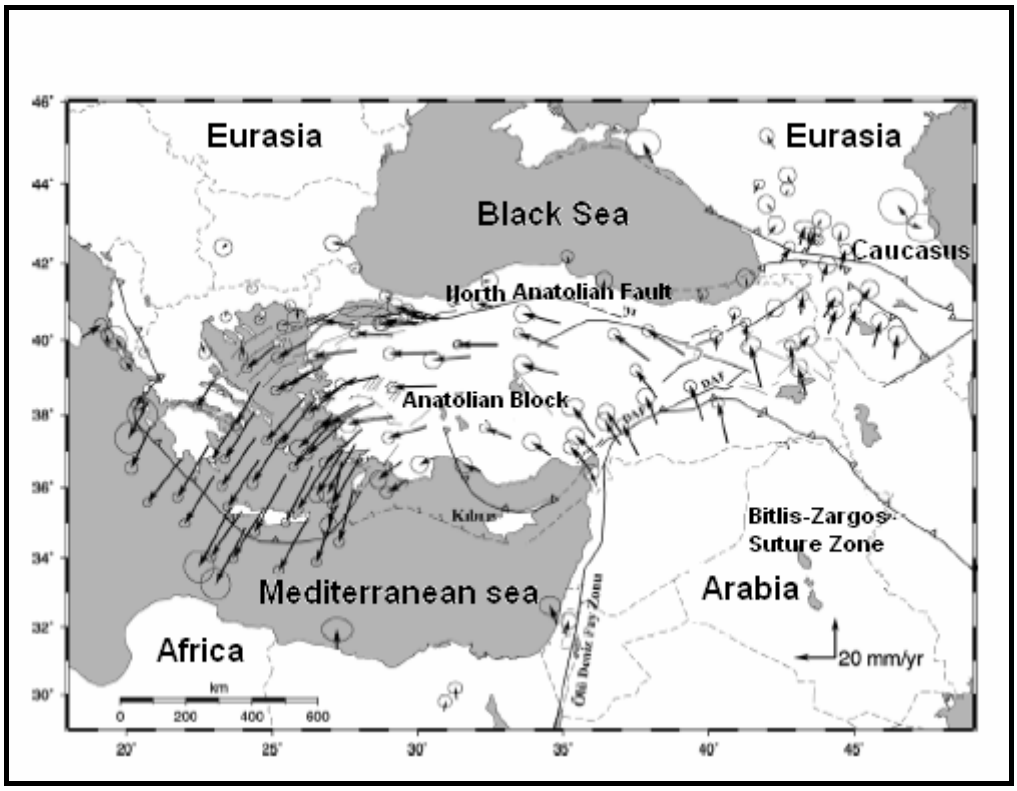

Figure IV.4. Arabian-Eurasian Plate Collision Zone (Tan and Taymaz, 2005)

There are 2 seismic source zones located on the east and on the west of the project area which are capable of generating earthquakes with a maximum magnitude of 7 as can be seen from Figure IV.5. The project area is located on the west of Georgian capital city Tbilisi and inside the earthquake intensity zone IX.

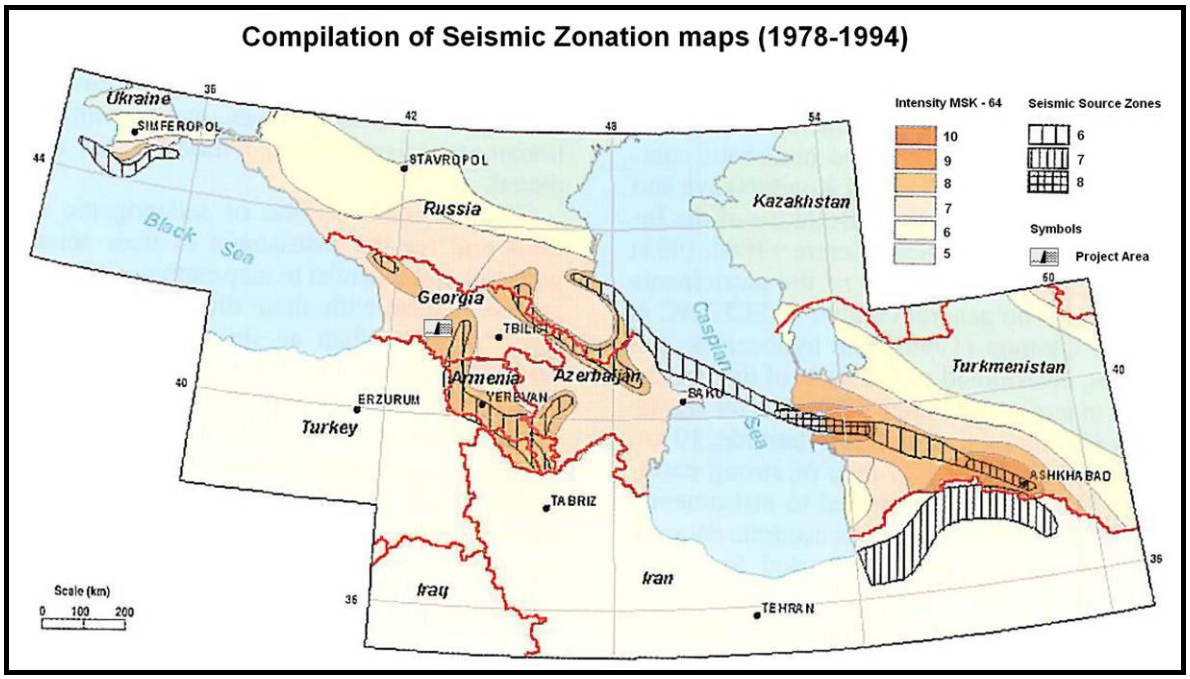

Figure IV.5. Compilation of Existing Zonation Maps in the Caucasus-Kopetdagh Region (Balassanian et al, 1999)

The Medvedev-Sponheuer-Karnik scale, also known as the MSK or MSK-64, is a macroseismic intensity scale used to evaluate the severity of ground shaking on the basis of observed effects in an area of the earthquake occurrence. The scale was first proposed by Sergei Medvedev (USSR), Wilhelm Sponheuer (East Germany), and Vít Kárník (Czechoslovakia) in 1964. With minor modifications in the mid-1970s and early 1980s, the MSK scale became widely used in Europe and the USSR. MSK-64 is still being used in India, Israel, Russia, and throughout the Commonwealth of Independent States.The MSK scale has 12 intensity degrees expressed in Roman numerals (to prevent the use of decimals)(URL-13).

Table IV.2 shows the definitions of MSK-64 Earthquake Intensity Scale (degrees. According to Figure IV.5 the project area is located within IX earthquake intensity degree zone. Based on this information, relevant pre-cautions will be taken to prevent probable earthquake generated rock-fall and landslide related hazards, where necessary.

Generally, the seismicity of the region is related to the active faults of the area designated as Greater Caucasus, with the exception of two earthquakes occurred

in 1920 and 1940. Those earthquakes were connected to the so-called Lesser Caucasus. Some large earthquakes were recorded in Georgia since 1900. For instance, the greatest earthquake with M= 6.9(on Richter scale) occurred in April 1991 and caused damage over thousand square kilometres. Table IV.3 presents information on some earthquakes occurred close to the project area (Verkis, 2009

Table IV.2. MSK-64 Earthquake Intensity Scale (URL-9)

Degree	Force	Behavioural effects	Structural effects	Geologic effects
I	Imperceptible	Not felt	—	—
II	Very light	Felt sporadically	—	—
III	Light	Felt only by people at rest	—	—
IV	Moderate	Felt indoors, many awakened	Windows vibrate	—
V	Fairly strong	Widely felt outdoors	Interior plaster cracks, hanging objects swing, tables shift	—
VI	Strong	Fright	Damage to chimneys and masonry	Isolated cracks in soft ground
VII	Very strong	Many people flee their dwellings	Serious damage to buildings in poor condition, chimneys collapse	Isolated landslides on steep slopes
VIII	Damaging	General fright	Many old houses undergo partial collapse, breaks in canals	Changes in wells, rock falls onto roads
IX	Destructive	Panic	Large breaks in substandard structures, damage to well-constructed houses, underground pipe breakages	Cracks in ground, sand eruptions, widespread landslides
X	Devastating	General panic	Brick buildings destroyed	Rails twisted, landslides on riverbanks, formation of new lakes

Table IV.2. MSK-64 Earthquake Intensity Scale (URL-9) (cont'd)

Degree	Force	Behavioural effects	Structural effects	Geologic effects
XI	Catastrophic	—	Few buildings remain standing, water thrown from canals	Widespread ground disturbances, tsunamis
XII	Very catastrophic	—	Surface and underground structures completely destroyed	Upheaval of the landscape, tsunamis

Table IV.3. Locations, Magnitudes and Depths of Earthquakes by Dates (URL-8)

Date (dd/mm/yy)	Name of Region	Magnitude (M) RICHTER	Depth (km)	Epicenter distance/orientation to Mtkvari Project Area (km / -)
01/07/2009	Akhalqalaqi	4,2	12	35 / SE
03/06/2009	Akhalqalaqi	3,2	12	73 / SE
29/04/1991	Racha	6,9	6	90 / NE
07/05/1940	Javakheti	6	16	60 / E
20/02/1920	Gori	6,2	11	140 / NE

The reoccurrence period for the strong seismic events in Georgia is in the order of 1000 years. In consideration of this statement and based on the previous records and analysis that M=6 and M=6.9 earthquakes are the strongest events of the region, earthquakes of M=6 or bigger might not be expected in the region till the year 2940. Nevertheless, it should be noted that the accuracy of this assumption depends on quantity of recorded earthquake data. Thus, the project structures will be designed and built such that they would be able to resist any such big scale earthquake.

The European Earthquake Standard, Eurocode 8 (FS ENV 1998:1994) will be applied as guidance for the definition of the design spectrum for the project. In the forthcoming stages of the project design, all necessary actions will be taken to meet the appropriate design criteria for earthquake loads and resistance of structures in accordance with the applicable standards and regulations.

IV.1.2.2. Geology at the Dam Site and in the Reservoir Area

IV.1.2.2.1. Lithology and Stratigraphy

Dam Site and Main HPP Facility Site

Dam Site and Main HPP Facility Site include the headworks headrace tunnel, equalizing reservoir and powerhouse structures of Mtkvari Dam. These structures will be located on the right bank of the Mtkvari River excluding the Mtkvari dam axis. The dam axis will be located at the upstream cape where the channel makes a 180-degree turn.

According to the site surveys, dam site consist of mainly 3 series of lithological units in general. These are; Middle Eocene tuff-breccias, which has a thickness of 219.8 m in the northern part of the project area where the HPP and equalizing reservoir will be located. There exists the Middle Eocene tuffogenic series with a total thickness of 180 m in the southern part of the project area where the dam axis, headworks and related structures will be located. The total thickness of Upper and Middle Series Tuff-breccias, laminar tuff, tuff-sandstone in the central part where the power tunnel will be located is 440.5 m. The Upper Eocene laminar tuff and tuff-sandstone interlaid with argillite layer of mentioned region have total thickness of 25 m. Table IV.4 shows geological descriptions at the Main HPP Facility locations (Geoengineering, 2009).

Table IV.4. Thicknesses and Locations of Dam Site Geological Units by Geological Descriptions

Geological Description	Thickness (m)	Location
Middle Eocene Tuff-breccias	220	Northern Part of Project Facilities
Middle Eocene Layered tuffogenic series	180	Southern Part of Project Facilities
Middle-Upper Eocene Tuff-breccias, laminar tuff, tuff-sandstone	440	Central Part, near and around headrace tunnel

Paleocene-Eocene, Upper Eocene, Upper Miocene-Lower Pliocene, Upper Pliocene, Upper Pliocene-Lower Quaternary and Quaternary magmatic cycles were identified in the region according to magmatic cycle identification. Tertiary eruptive rock presence in the project area is of low frequency and can be seen in the form of intrusive bodies.

At the central part of the project area intrusive complex of mount Satsernako and the respective range stretching northeast consist of 40 m alternating andesite (diabase) and 45 m hornstone (pelite). At the intersection with the Elis-gele gorge, there are 15-19 m thick andesite (diabase) outcrops. Furthermore, small outcrops of biotitic-augite camptonite exist on an area of several hundred square meters inside Upper Eocene deposits of the studied area (Geoengineering, 2009).

Reservoir Area

The Mtkvari HPP dam axis will be constructed on a place where Mtkvari valley makes a sharp turn and forms a cape pointing to the north. The reservoir area starts from this point and stretches along approximately 3.5 km section of the river Mtkvari.

Morphologically, the reservoir area is crossed by slopes and built by 4 m thick tuff, 1.5 m thick argillite and 25 m thick clayey sandstone with 1-40 cm thick alternating layers of argillite dating back to Upper Eocene (Geoengineering, 2009).

Intrusive rock is not widely seen in the reservoir area. For instance, on the southeast of village Rustavi (to the North from ruins of village Akhalsheni) at the right bank of the river Mtkvari; bedded intrusion of gabbro-diabase can be seen. This intrusion lies concordantly with tuff-sandstone and argillite of the Upper Eocene. There exist signs of metamorphism along the contact line of the media.

On the southwest of village Rustavi, at a distance of 5 km in the upstream of the dam axis, Gabro-diabase bed intrusion can be seen well on the right bank of the river Mtkvari. The thickness of the vein is 20-30 m. At the contact line, there are signs of weak metamorphism (Geoengineering, 2009).

Headrace Tunnel

The headrace tunnel will pass under the western edge of the Trialeti Ridge, where elevations range between 1200 m (Mount Sarsernako) and 1430 masl (Mount Zegverda). The main part of the headrace tunnel will be at elevations of 1000-1200 masl.

The power tunnel right-of-way is formed by rock and semi-rock of Middle Eocene (Pg_2^2) and Upper Eocene (Pg_2^3). Andesite, sandstone, tuff and argillite prevail in the bedrock strata. The route of the headrace tunnel will pass through layers of volcanogenic deposits and marine deposits of the late palaeogene age. From the southern portal (from the side of the village Rustavi) at a distance of about 2.5 km, the tunnel will transect Tchidila-Dviri set of rocks of the late middle Eocene massive layered volcanic breccias and lava intraformational layers - mainly basaltoids, rarely andesite-basalts, andesites and trachytes. Tuffites, gravelites, tuff-sandstones and marls appear here in some places on upper levels. The middle part of the tunnel from south to north direction with a length of 4.2 km will transect the set of rocks of upper Eocene age, located discordant to the above mentioned rocks, where marls, coarse-grained quartz-arkosic and graywackle sandstones, and slate clays are presented. Basaltic, andesite-basaltic and trachyte lavas and piroclastolithes are transected on some sections. The last part

of the tunnel, with length of 1.4-1.6 km will go through late middle Eocene age set of rocks.

Equalizing Reservoir/Pond and the Powerhouse Area

The equalizing reservoir and the powerhouse structures will be established on rock and semi-rock of the middle series of Middle Eocene (Pg_2^{2b}), primarily by tuff (77%), sandstone (10%), argillite (10%), and andesite (3%). Those structures will be located at the northern foot of Trialeti Ridge, on the right bank of the Mtkvari, near Sakuneti. Geomorphologically, the area is located in the eastern part of the Akhaltsikhe depression.

IV.1.2.2.2. Water Tightness and Slope Stability

Water Tightness of the Reservoir Area and Dam Site

Hydrogeologically, the reservoir area and the dam axis will be constructed on a water saturated alluvial shingle formation. The alluvial shingle sits on a water saturated rock. The main feeding source of groundwater at this location is the river Mtkvari. As mentioned in the earlier sections of this report, the headrace tunnel will pass through the rocks forming the Trialeti Ridge. According to the site surveys, the rocks along the tunnel axis are weakly saturated. The fracture waters of the ridge are fed by precipitation. Groundwater of this massif is discharged through fractures at Mtkvari level. Hydrogeologically, andesite, sandstone, tuff and breccias are characterized by rather high permeability, while the argillites have low permeability (Geoengineering, 2009).

Since the floodplain terrace of the Mtkvari at the dam axis area is formed with highly permeable alluvial shingle (98 m/day), the dam will be based on the less permeable, but water saturated rocks underlying the shingle (Geoengineering, 2009). According to the results of the site surveys, the permeability level of the bedrock is generally weak, but there are some zones with

increased permeability due to physical effects. All necessary actions will be taken to improve the impermeability of the bedrock at dam axis and the reservoir area.

Thus, once the comparatively high permeability bedrock zones are treated, it can be stated that the reservoir area is relatively watertight and the possible main leakage paths will be through the dam foundation and abutments. The construction of dam foundation and abutments will be made such that any leakage will be prevented.

Slope Stability of the Reservoir Area and Dam Site

In the study area, clay and argillaceous sandstone dominates at the upper level of the Upper Eocene series that form the landslide-prone type terrain. This terrain covers a wide strip of 0.3 to 1.5 km on the left side of the river Mtkvari in Rustavi-Aspindza section. Landslide zones of the region are investigated in detail in the Geotechnical Report presented in Appendix 3.

– **Reservoir Area**

Landslides of various sizes are noted at various locations of the reservoir area. The status, locations and causes of the landslides occurred in the area are listed in Table IV.5.

According to the geodynamic conditions of the reservoir area, it can be stated that landslides occur on both banks of Mtkvari River. In general, landslides are observed in clayey-detrial diluvial-proluvial surface sediments. The formation of reservoir and construction of the dam are highly unlikely to cause any complications or environmental changes in the region (Geoengineering, 2009).

Other possible hazardous events that may occur before and/or during construction and impoundment phases could be listed as follows:

- Rock falls on the right steep rocky slope;
- Intensification of landslides;

- New landslide zone formation;
- Roadbed deformation nearby the reservoir area.

Table IV.5. Active and Stabilized Landslides in the Reservoir Area (Geoengineering, 2009)

Location	Current Status	Cause of Landslide	Expected Future Status
HPP Headworks, upstream from the road	Stabilized	-	No signs of becoming active
Along the road 4.5 km distance from the diversion tunnel portal, main slide bench is located in the vicinity of the road	Active	Erosion at the foot of the bank built by loamy material and strongly weathered argillite	Sliding continues as the bank of the foot erodes, and earth roadbed has potential to slide down in future
At a distance of 6.2 km from the tunnel portal, main bench is located above the road /w tongue reaching the river	Stabilized	-	No signs of becoming active
At a distance of 6.5 km upstream from the tunnel portal where the road (parallel to the river) goes in a deep gully	Active	1- Steep slope of a deep cut in the gully 2- Cutting of the bank consisting of rounded cobble of the alluvial terrace and alternating layers of weathered argillite and sandstone	The landslide will not activate after forming of the reservoir, as it is not located inside the inundation zone
At a distance of 7.0 to 7.5 km from proposed tunnel portal where erosion of the bank consisting of deluvial-proluvial sediments and weathered argillite caused instability of the slope	Active	The foot of the instable slope gets eroded and soil masses slide towards the Mtkvari river	Sliding continues as the slope gets eroded
Left bank of reservoir area Mtkvari river (in general)	Active	Erosion of landslide toes	Some of the landslides are stabilized and since the reservoir is rather small, its formation is not expected to activate any significant landslide that is currently stabilized and/or strengthen the currently active ones.

Minor prolluvial events in the mouths of small side ravines might occur in the planned reservoir area. However, these are unlikely to cause any adverse impact (Geoengineering, 2009).

In conclusion, natural conditions in the project area are generally favourable for construction of the Mtkvari Project and will not cause any significant hazard for such a project. In addition, formation of the reservoir will not have significant impact on the local geological conditions. Furthermore, all necessary pre-cautions will be taken during the final design and construction of the project to prevent probable hazards.

- **Main Intake Area**

Main intake area is located on the right bank near a steep slope inside a rock-sliding hazard zone. Morphologically, the landslide body (dlQ_{IV}) is currently stabilized and no activation is expected (Geoengineering, 2009).

- **Headrace Tunnel Area**

There are no active geological processes and hazards in the route and vicinity of the headrace tunnel. However, rock slide might occur in the upstream from southern portal, from the right bank of the Mtkvari. Thus, before getting starting the construction of headwork facilities (including southern tunnel portal), the portal will be cleaned of hanging and/or unstable rocks.

It should also be taken into consideration that during tunnel boring phase separate blocks and soil may fall in the tunnel section, especially while passing through the semi-rock low strength argillites. In order to prevent probable swelling-hazard caused by pre-mentioned low strength zones, tunnel will be supported with lining along its cross-section. According to the geological characteristics of the headrace tunnel route, water ingress would be prevented during execution of the tunnelling works (Verkis, 2009 (b)).

- **Equalizing Reservoir/Pond and the Powerhouse Area**

The right bank of the HPP area is protected from side erosion by the protruding rocks sitting at the upstream and downstream ends of the area. Since the right bank in HPP area consists of loose-fragmental clayey soils of the alluvial terrace and the debris cone, the river will erode from the right bank and threaten the stability of the dam related facilities in case of unfavourable hydraulic regime change. For that reason, hydraulic regime of the river will be monitored during and after construction phases.

In addition to that, the floodplain and other terraces around the north part of the project area contain sandy-clayey sediments. This content and the general inclination from floodplain and other terraces towards Mtkvari promote minor landslides in the region (Geoengineering, 2009).

Finally, before the construction phase is started, special measures will be taken to prevent stones and/or blocks from falling from the steep, precipitous slope above the construction site.

V.1.2.2.3. Mineral Resources

The potential for industrial and energy raw materials in Akhaltsikhe and Aspindza districts is very limited. The major mineral sources near the district of Akhaltsikhe are basalt, sand-gravel, raw stones, gypsum, diatomite, bentonite clay and ceolites, which are low in quantity and quality. Therefore, those resources are not considered as profitable. Furthermore, the only fossil fuel source is brown-coal which is low in economic value and not processed currently. Green agate, selenite and jobbing stones are other sources found in Akhaltsikhe. Additionally, there is a marble quarry near Rustavi Village. Table IV.6 lists the types, reserve amounts and application ranges of mineral resources according to the locations of deposits. As a conclusion, no significant mineral source or fossil fuel resource exist in the project area and vicinity.

Table IV.6. Mineral Resources (URL-11; Geoengineering, 2009; Gehring, 2001)

Mineral/Fossil Fuel Source	Location of Deposits and Exposures	Reserve Amount*	Field of Application
Brown coal (lignite)	Akhaltsikhe; Adjara-Trialeti subterrane	71,000,000 tons	Heat energy
Agate	Akhaltsikhe; Adjara-Trialeti subterrane	3,000,000 kg**	Jewellery gem
Gravel and sand	Vale-1 deposit; 3 km to the west of Akhaltsikhe, the Potskhovi floodplain	7,800	Inert materials
Gravel and sand	Akhaltsikhe-Tsnisi and Minadze deposit, at the juncture of the Mtkvari and Potskhovi	2,000	Inert materials
Gravel and sand	Atskuri exposure; 2,5 km SW, the Mtkvari Floodplain	900	Inert materials
Gravel and sand	Idumali exposure, the Mtkvari Valley, between the villages of Idumala and Rustavi (4 sections)	200	Inert materials
Gravel and sand	Mugareti exposure, the Mtkvari floodplain, 1 km to the south of the village of Mugareti	37	Inert materials
Gravel and sand	Tsnisi exposure, 1 km NE of the village of Tsnisi, the Mtkvari floodplain	25	Inert materials
Presumably volcanogenic materials	Rustavi exposure; 0,8 km NW of the village of Rustavi (synonym 'Kornebis Bode')	50	Inert materials
Scoria	Orgoro exposure; 0.7 km to the west of Orgoro village	20	Light concrete aggregate
Tuff	Chobareti exposure; 5 km NW of Chobareti village	30	Building stone
Tuff-Breccias	Gurkeli exposure; 1 km to the north of Gurkeli village, 1st section	10	Building stone
Tuff-Breccias	Gurkeli exposure; 2nd section	10	Building stone
Basalt (Dolerite)	Indusa exposure, 2 km to the south of Indusa village	10	Building stone
Teschenite	Saukuneti exposure, 3 km SW of Saukuneti village	25	Building and facing stone
Basalt (accumulations of blocks)	Gabieti and Kaliani exposures, 5-7 km NE of Dzveli village, 3 sections	27	Building and facing stone, rubble
Dolerite	Khizabavra deposit, 8-10 km SE of Aspindza, in Khizabavra village environs	28,100	Facing stone and rubble

Table IV.6. Mineral Resources (URL-11; Geoengineering, 2009; Gehring, 2001) (cont'd)

Mineral/Fossil Fuel Source	Location of Deposits and Exposures	Reserve Amount*	Field of Application
Bentonitic clay	Arali deposit	8,795	Chemical industry
Bentonitic clay	Churchuto-Chikheli deposit	16,600	Chemical industry
Brick clays	Akhaltsikhe (Tsintskaro) exposure	-	Ceramics
Brick clays	Clay exposures in the environs of Idumala and Rustavi villages	-	Ceramics

* 10^3 x m^3 unless otherwise specified,

** Including agate deposits in Dmanisi

IV.1.2.2.4. Soils, Erosion and Land Use

Erosion

The study area covers about 85 km^2 of land including the headrace tunnel horizon, transmission line route, and dam and HPP site and the reservoir area.

The study area, which covers the locations of all project related structures, is mainly formed with unstable clayey and sandy tuffogenic formations dated back to the Upper Eocene. The creation of smoothed relief in this area is contributed by weathering and erosion. The banks of the Mtkvari River within the reservoir area are built by alluvial-proluvial loose-fragmental soils with sandy or intermediately plastic clay and low plastic silt matrix. This content causes erosion and landsliding in many locations along the banks of the Mtkvari and some lateral ravines. These are the main geohazards which could cause difficulties with geodynamic stability of facilities and the environment. For instance the geodynamic stability of the Mtkvari right bank located running highway has the potential of erosion, landslide and under-flooding geohazards. Table IV.5 of Section IV.1.2.2.2 of this report shows landslides occurring as a result of erosion hazard. Erosion and landslide hazards of the region are investigated in detail in the Geotechnical Report of Geoengineering Ltd (see Appendix 3).

Erosion mainly caused landslide hazards in the study area. Other than that, erosion has also formed gully bodies through the slopes of the studied area ridges. This type of gullies is visible from distant places in the southern and northern part of the project area. In addition to that, erosion occurring during flood season brought proluvial debris to the right bank of the river as a result of temporary surface flow.

The right bank of the HPP area is protected from side erosion by the protruding rocks sitting at the upstream and downstream ends of the area. Since the right bank in HPP area consists of loose-fragmental and clayey soils of the alluvial terrace and the debris cone, in the event of unfavourable hydraulic regime change, the river will erode the right bank and threaten the stability of the dam related facilities in the mentioned region. For that reason, the hydraulic regime of the river will be monitored during and after construction phases. The powerhouse will be located on a stable rock. The studies showed that erosion geohazard is insignificant through headrace tunnel route.

Soils and Land Use

The study area is in the East Black Sea Region and in the Euro-Siberian phytogeographic area, covering an approximately 20-km long valley extending from Sakuneti to Rustavi. The steep topography of the Mtkvari Valley at the dam site is typical of steppe vegetation, and affects the formation and distribution of vegetation in the project area. The natural forests in the area were generally destroyed by the settlers for the cultivation of potato, which is the major source of income in the region. Examples of natural forest free of anthropogenic effects are found only on the steep slopes and cliffs that cannot be used for the cultivation of hazelnut. The land use and vegetation map of the project area is given in Figure IV.6. Neither the headworks area nor the powerhouse area is in the forestry regions. Consequently, no forestry areas will be affected due to the project.

Generally, in Akhaltsikhe; cinnamon soils are very common. However, around the centre of Akhaltsikhe, brown forest soils and mountine-forest peat soils are

dominant. On the other hand, mountine chernozems are common in Rustavi, while brown forest soils are mostly seen in Sakuneti.

Agriculture and livestock are two significant income sources in Sakuneti. The most important crop is potato. The soils in Sakuneti are moderate to good productivity soils, which are used as arable lands and gardens. Agriculture and livestock are also significant income sources of Rustavi Village. The most important agricultural product is potato followed by tomato. Ovine and bovine breeding are also significant sources for Rustavi.

According to land use and soil maps of Ministry of Agriculture of Georgia, approximately 85% of the southern part of the project area is covered with moderate productivity cinnamonic calcer soils. The rest of the southern part is covered with moderate productivity meadow cinnamonic soils. The northern part of the project area is covered with good productivity alluvial calcareous soils and cinnamonic calcareous soils. Soil types of the project area are shown in Figure IV.7.

The slopes at the dam axis and reservoir area ranges between 1.5% and 34% with an average of 9.8%. The slopes at the powerhouse area are in the range of 7% - 36.5% with an average of 19.8%. Figure IV.8 shows the slope map of the study area.

There are no industries in the vicinity of the project facilities. There is no large settlement in the vicinity of the project facilities. The Sakuneti Village is located at a 1 km distance to the powerhouse area and Rustavi Village is about 3 km to the dam site.

The future reservoir will cover an area of approximately 0.5 km^2 at the maximum water level of 1,015 masl, and a 30 m training dike is foreseen alongside the left bank of the tailrace canal from the yard into the floodway of the river to protect the deepest part of the canal from mud and debris in case of a large flood in the river.

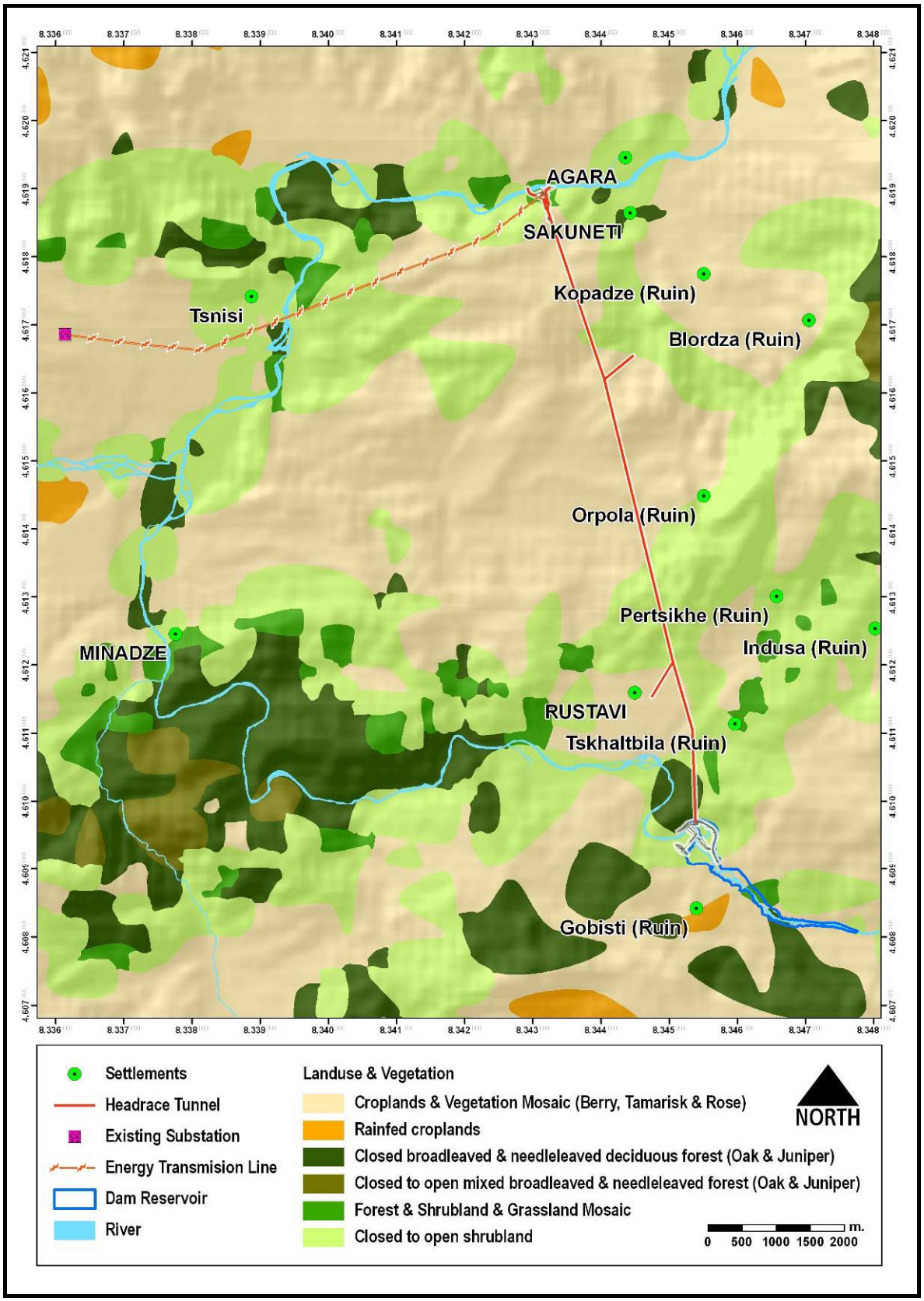

Figure IV.6 Land Use and Vegetation Map of the Project Area and Vicinity

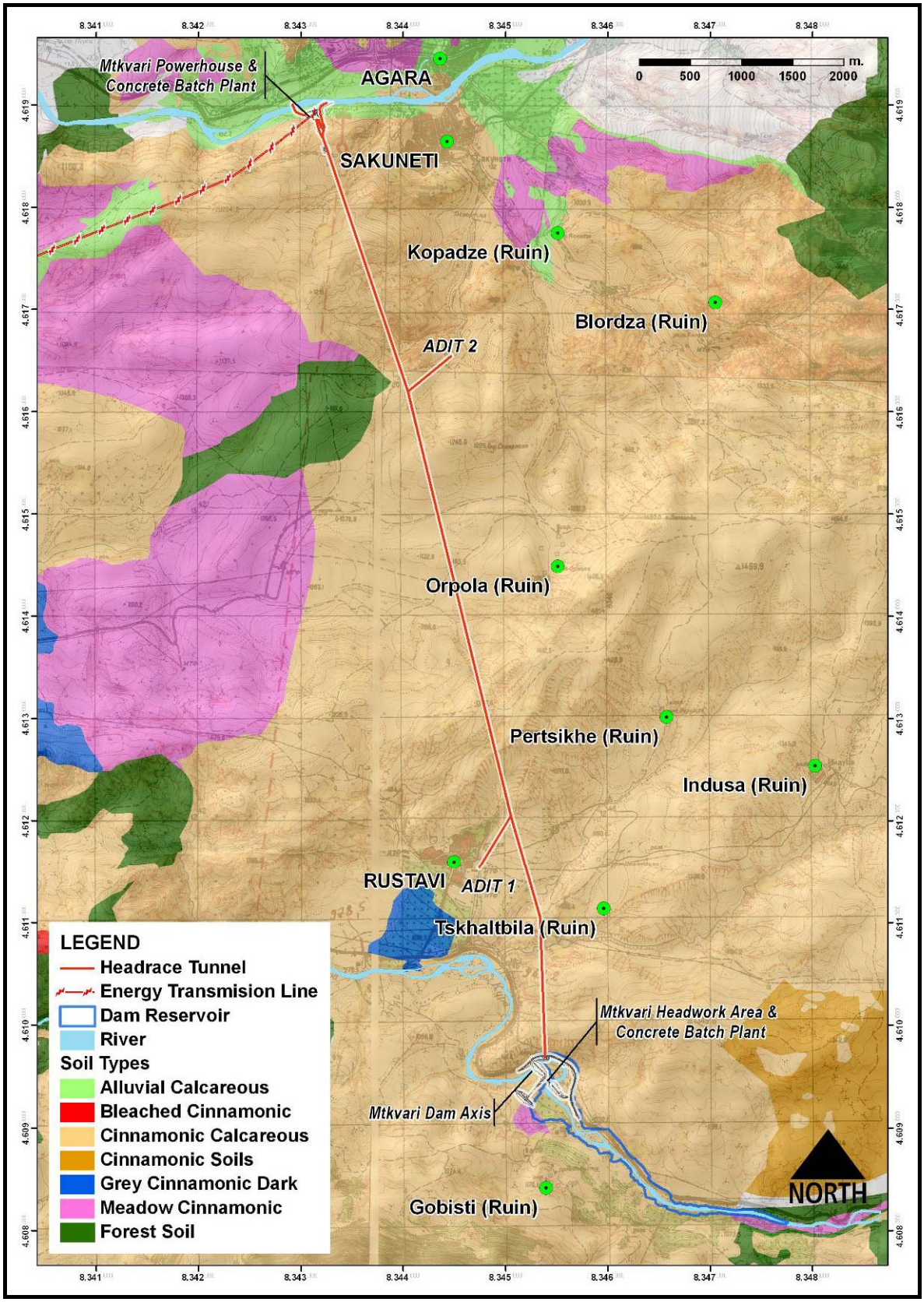

Figure IV.7 Soil Map of the Project Area and Vicinity

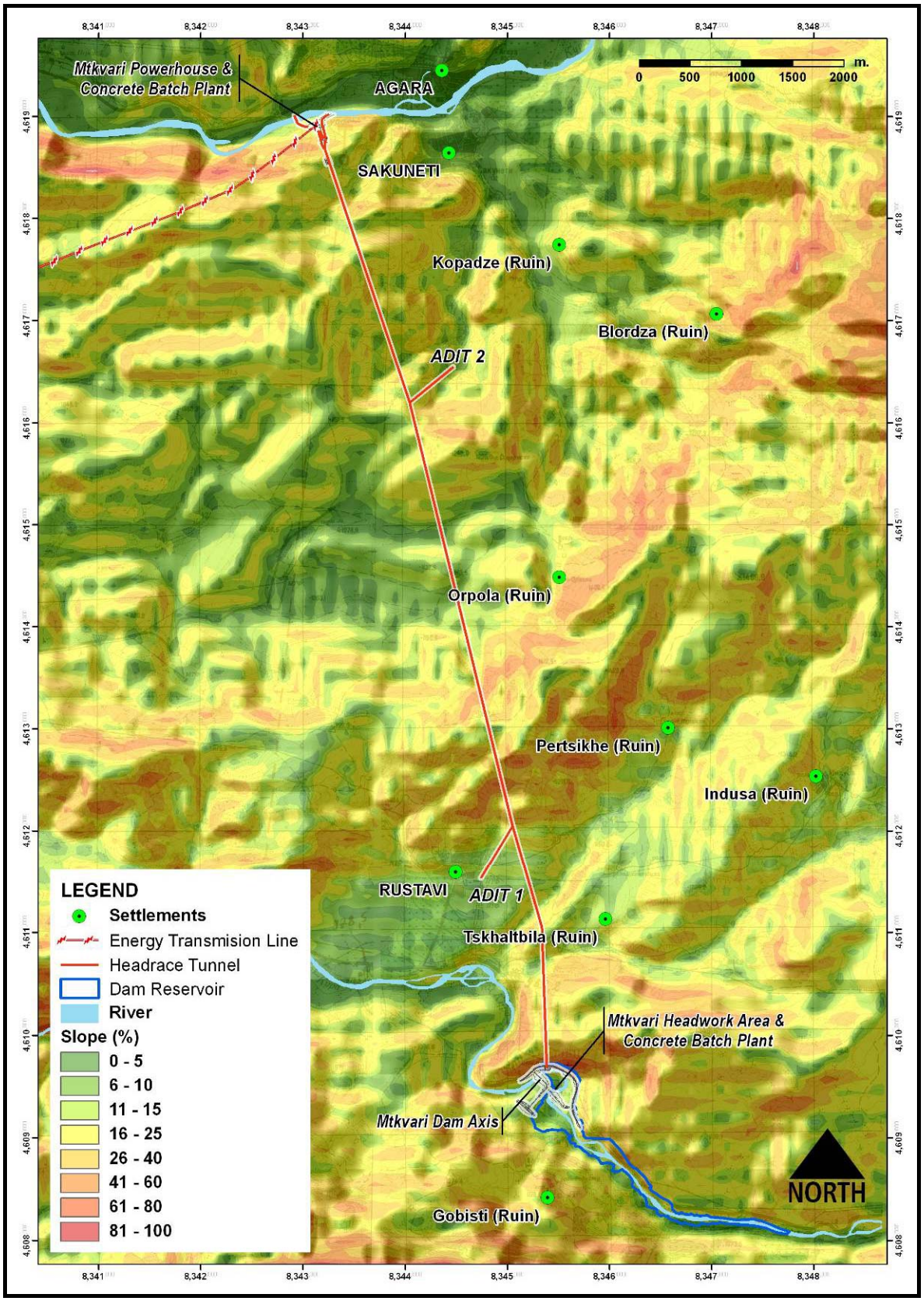

Figure IV.8 Slope Map of the Project Area and Vicinity

IV.1.3. Climatology

The project is located between two warm seas namely, the Black Sea and the Caspian Sea, in the subtropical latitudes. However, the climate of the Kura River basin is mainly influenced by its location in the mountainous area isolated from the subtropical affects of the warm seas and the cold air masses from the north of Eurasia. As a result, the typical climate observed in the project area can be described as cold winters with small amount of snow and long warm summers.

Data used for description of the typical climatology of the project area belong to Akhaltsikhe Weather Station (at 982 masl) in Akhaltsikhe, where the construction site is located 12 km to the east of the town, and Aspindza Weather Station (at 1098 masl) in Aspindza, where construction site is at a distance of about 8 km. Data of Akhaltsikhe Weather Station represents the entire project area and Aspindza Weather Station is used mainly for the reservoir area.

The average annual temperature recorded at Akhaltsikhe Station is 9ºC. The highest temperature was recorded as 39°C in August. The lowest temperature recorded is -32°C (in January). The maximum and minimum monthly temperatures are 20.5ºC in August and -3.8ºC in January, respectively. The average temperatures recorded at Akhaltsikhe and Aspindza Meteorological Stations are presented graphically in Figure IV.9 and Figure IV.10 and numerically in Table IV.7 and Table IV.8.

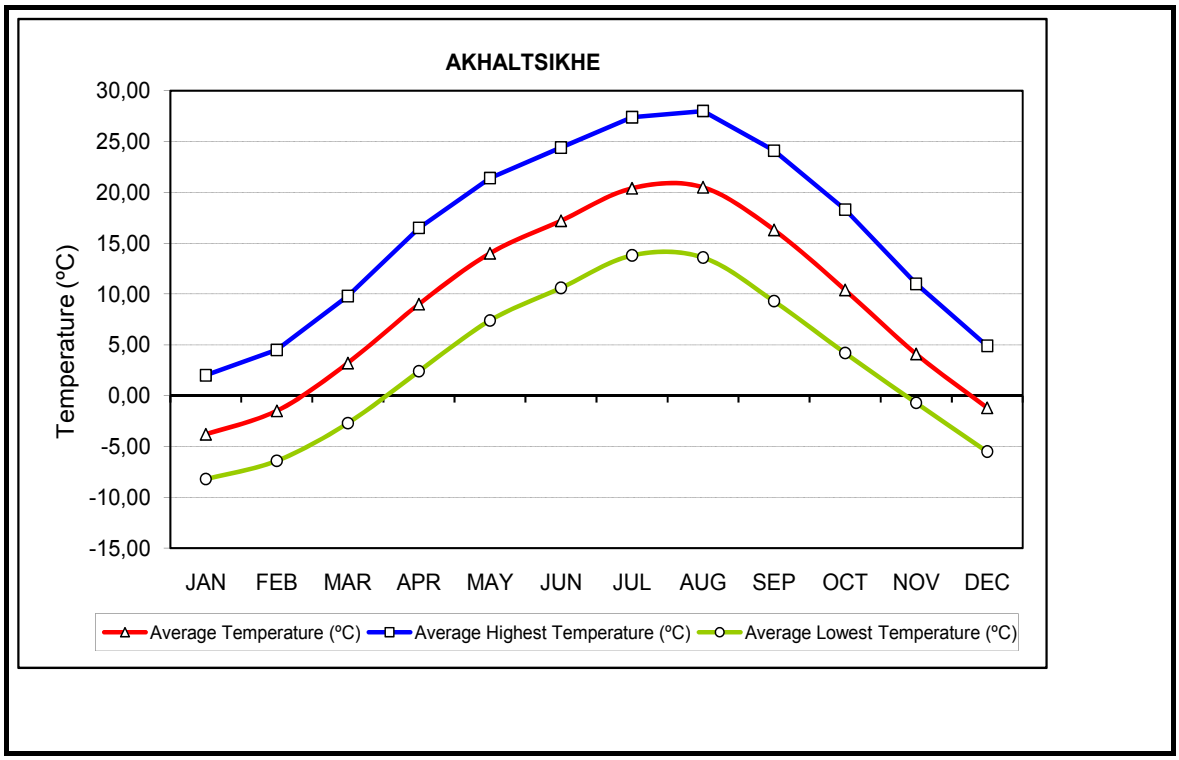

Figure V.9. Average Temperature, Average Lowest and Average Highest Temperatures Recorded at Akhaltsikhe Station

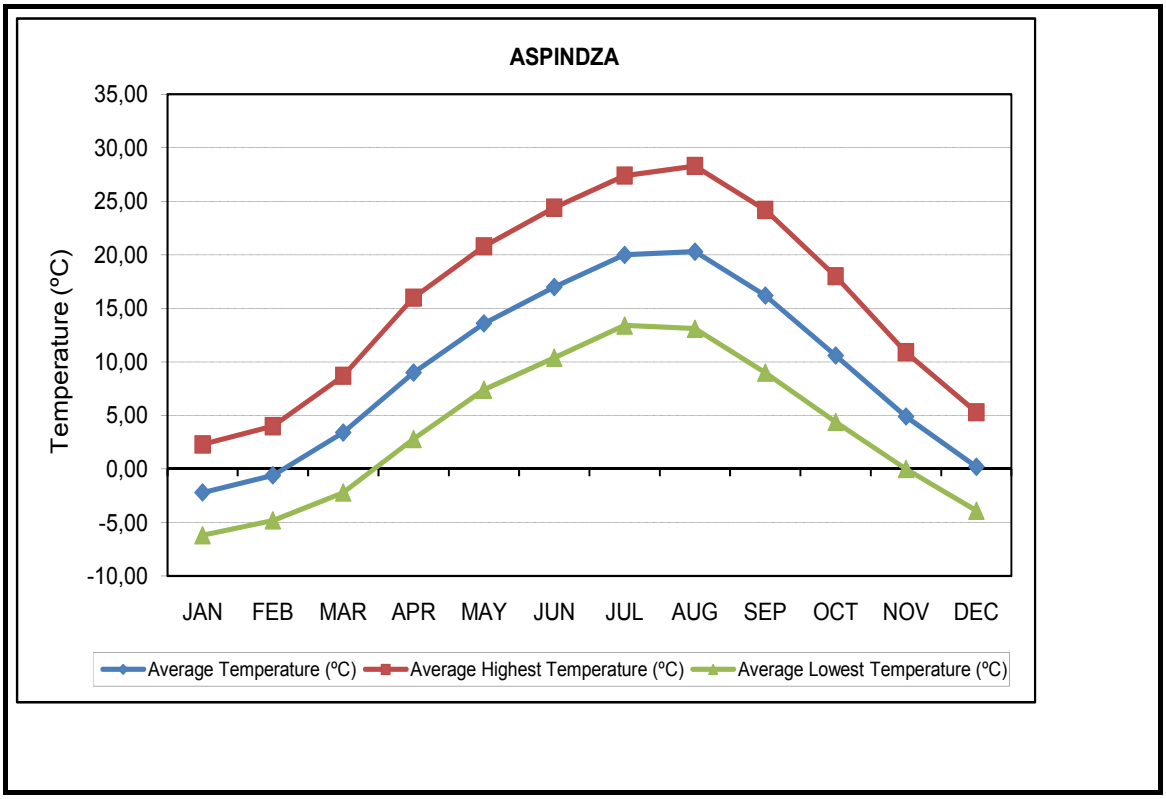

Figure V.10. Average Temperature, Average Lowest and Average Highest Temperatures Recorded at Aspindza Station

Table IV.7. Average Temperature, Average Lowest Temperature, Average Highest Temperature, Highest Temperature and Lowest Temperature in the Project Area (Akhaltsikhe Weather Station)

	Average Temp. (°C)	Average Highest Temp. (°C)	Average Lowest Temp. (°C)	Highest Temp. (°C)	Lowest Temp. (°C)
January	-3.8	2.0	-8.2	15	-32
February	-1.5	4.5	-6.4	18	-23
March	3.2	9.8	-2.7	27	-20
April	9.0	16.5	2.4	30	-13
May	14.0	21.4	7.4	34	-6
June	17.2	24.4	10.6	37	2
July	20.4	27.4	13.8	38	2
August	20.5	28.0	13.6	39	2
September	16.3	24.1	9.3	36	-5
October	10.4	18.3	4.2	33	-11
November	4.1	11.0	-0.7	26	-22
December	-1.2	4.9	-5.5	17	-26
Annual	9.0	16.0	3.2	39	-32

Table IV.8. Average Temperature, Average Lowest Temperature, Average Highest Temperature, Highest Temperature and Lowest Temperature in the Project Area (Aspindza Weather Station)

	Average Temp. (°C)	Average Highest Temp. (°C)	Average Lowest Temp. (°C)	Highest Temp. (°C)	Lowest Temp. (°C)
January	-2.2	2.3	-6.2	15	-29
February	-0.6	4.0	-4.8	18	-22
March	3.4	8.7	-2.2	25	-19
April	9.0	16	2.8	30	-12
May	13.6	20.8	7.4	32	-5
June	17.0	24.4	10.4	35	2
July	20.0	27.4	13.4	38	2
August	20.3	28.3	13.1	39	2
September	16.2	24.2	9.0	37	-5
October	10.6	18.0	4.4	32	-10
November	4.9	10.9	0.0	25	-18
December	0.2	5.3	-3.9	16	-24
Annual	9.4	15.9	3.6	39	-29

The long-term monthly rainfall observed at Akhaltsikhe and Aspindza Meteorological Stations are presented in Table IV.9. The highest monthly precipitation in the project area occurs in June, while January and December are the months with lowest precipitation.

Table IV.9. Monthly Rainfall Observed at Akhaltsikhe and Aspindza Meteorological Stations

	Average Total Rainfall (mm)	
	Akhaltsikhe Station	**Aspindza Station**
January	32	25
February	32	31
March	36	31
April	49	44
May	70	76
June	82	81
July	51	59
August	46	47
September	38	38
October	45	35
November	40	31
December	33	22
Annual	554	520

The catchment area at the Mtkvari Dam axis is 7,950 ha and the annual flow is 697.82 m^3/s. The annual precipitation is 520 mm in Aspindza and increases to about 560 mm in Akhaltsikhe. Precipitation is distributed throughout the year. At maximum, 120 days in a year are rainy in Aspindza. The monthly distribution of the number of rainy days in Aspindza according to the intensity of the precipitation is presented in Table IV.10.

Table IV.10. Number of Rainy Days According to the Intensity of the Rain in Aspindza Station

Precipitation, (mm)	≥ 0,1	≥ 1,0	≥ 5,0	≥ 20,0	≥ 30,0
January	8.2	4.9	1.2	0.1	0
February	10.0	5.7	0.9	0.1	0
March	9.8	5.7	1.4	0.1	0.05
April	10	6.9	2.5	0	0
May	15.3	11.4	5	0.6	0.1
June	14.9	11.2	4.5	0.4	0.05
July	10	7.4	3.3	0.4	0
August	8.4	6	2.3	0.2	0.1
September	8	5.4	2.2	0.1	0.05
October	9.5	6.7	2.5	0.2	0.05
November	9.2	5.6	2.2	0.2	0.05
December	7.4	4.5	1.4	0	0
Annual	121	81	29	4	0.4

The monthly and annual distributions of wind blowing numbers those are recorded at Akhaltsikhe and Aspindza Meteorological Stations are given in Table IV.11 and Table IV.12. As it can be seen from these tables the direction of the prevailing wind is from west and northwest in Akhaltsikhe and Aspindza, respectively. Additionally, the wind speeds recorded in Akhaltsikhe and Aspindza Weather Stations are given in Table IV.13. As can be seen from Table IV.13, annual average wind speeds recorded in Akhaltsikhe and Aspindza Weather Stations are 1.6 and 2.0 m/sec, respectively.

Table IV.11. Monthly and Annual Distribution of Wind Blowing Numbers According to Their Direction Recorded at Akhaltsikhe Meteorological Station

	N	NE	E	SE	S	SW	W	NW	Calm
January	3	5	4	5	6	31	40	6	41
February	4	6	8	7	7	29	32	7	42
March	4	11	15	11	5	24	24	6	38
April	6	17	24	10	5	15	19	4	33
May	7	19	23	10	6	12	18	5	38
June	7	26	23	11	6	10	12	5	38
July	6	30	24	11	5	8	11	5	32
August	6	28	24	12	5	8	13	4	37
September	6	20	25	13	6	11	14	5	41
October	5	13	16	14	10	18	17	7	48
November	4	10	10	15	11	20	22	8	53
December	4	5	8	9	9	25	32	8	58
Annual	5	16	17	11	7	18	20	6	42

Table IV.12. Monthly and Annual Distribution of Wind Blowing Numbers According to Their Direction Recorded at Aspindza Meteorological Station

	N	NE	E	SE	S	SW	W	NW	Calm
January	5	2	7	57	11	2	3	13	52
February	8	2	9	43	15	1	3	19	53
March	9	2	8	39	9	0	8	25	47
April	11	3	4	25	9	2	13	33	53
May	9	4	5	17	8	2	18	37	58
June	17	7	3	11	8	2	19	33	63
July	14	5	4	10	4	2	20	41	59
August	17	5	4	7	4	3	20	40	63
September	15	6	2	10	5	5	18	39	65
October	12	4	4	14	3	3	14	46	70
November	11	5	9	28	9	4	9	25	66
December	5	3	6	52	15	1	4	14	62
Annual	11	4	5	27	8	2	12	31	59

Table IV.13. Monthly and Annual Wind Speeds Recorded at Akhaltsikhe and Aspindza Meteorological Stations

	Akhaltsikhe Station (m/s)	Aspindza Station (m/s)
January	1.4	2.6
February	1.6	2.8
March	1.9	2.8
April	2.1	2.4
May	1.8	2.0
June	1.6	1.6
July	1.9	2.0
August	1.8	1.8
September	1.5	1.4
October	1.3	1.2
November	1.1	1.3
December	1.1	1.8
Annual	1.6	2.0

The annual distributions of wind blowing numbers recorded at Akhaltsikhe and Aspindza Meteorological Stations are given in Figure V.11.

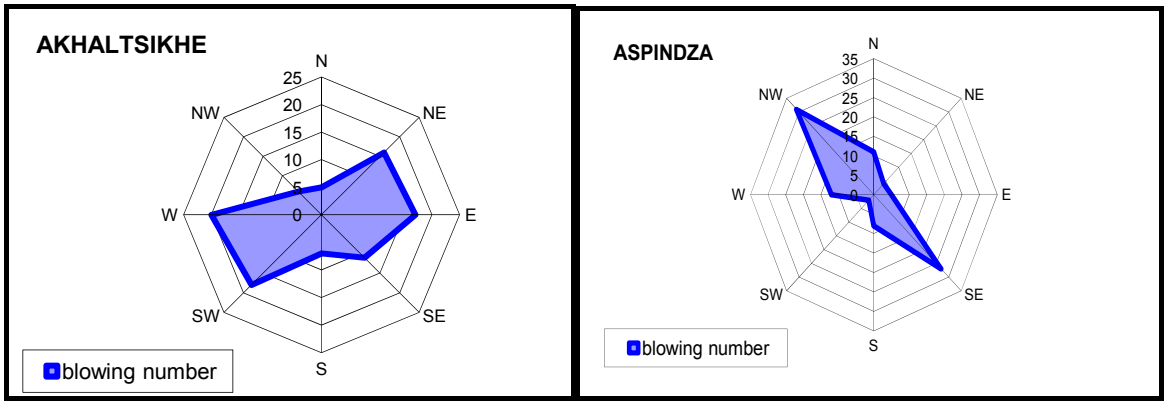

Figure V.11. Wind Directions According to the Annual Frequency of Blowing Recorded at Akhaltsikhe and Aspindza Meteorological Stations

IV.1.4. Hydrology

IV.1.4.1. Outline of Mtkvari Basin

The Mtkvari River is the main water course in the proposed project area. Its main tributaries are the Potsckhovi River near the town of Akhaltsikhe and the Uravelli River near the village of Muskhi. Both tributaries and their confluences with the Mtkvari are located outside the proposed construction site as well as the small river Oshora, which is running into Mtkvari near the village of Idumala upstream of the future reservoir.

There are four minor tributaries in the vicinity of the construction site. Two of them are flowing down the Trialeti ridge and join Mtkvari close to the village of Rustavi, 1 km downstream of the future reservoir. Two other tributaries, streaming down from the same ridge, join the Mtkvari at the edge of Sakuneti Village, 1 km downstream of the power house (Geoengineering, 2009).

The most relevant gauging station for the project is located at the village Minadze, just downstream of the confluence of the Uravelli and Mtkvari. In this study, the flow data of Minadze station recorded during the period of 1938-1973 is used for calculation flow at Mtkvari Dam Axis. The hydrology map of the project area and its vicinity is given in Figure V.12.

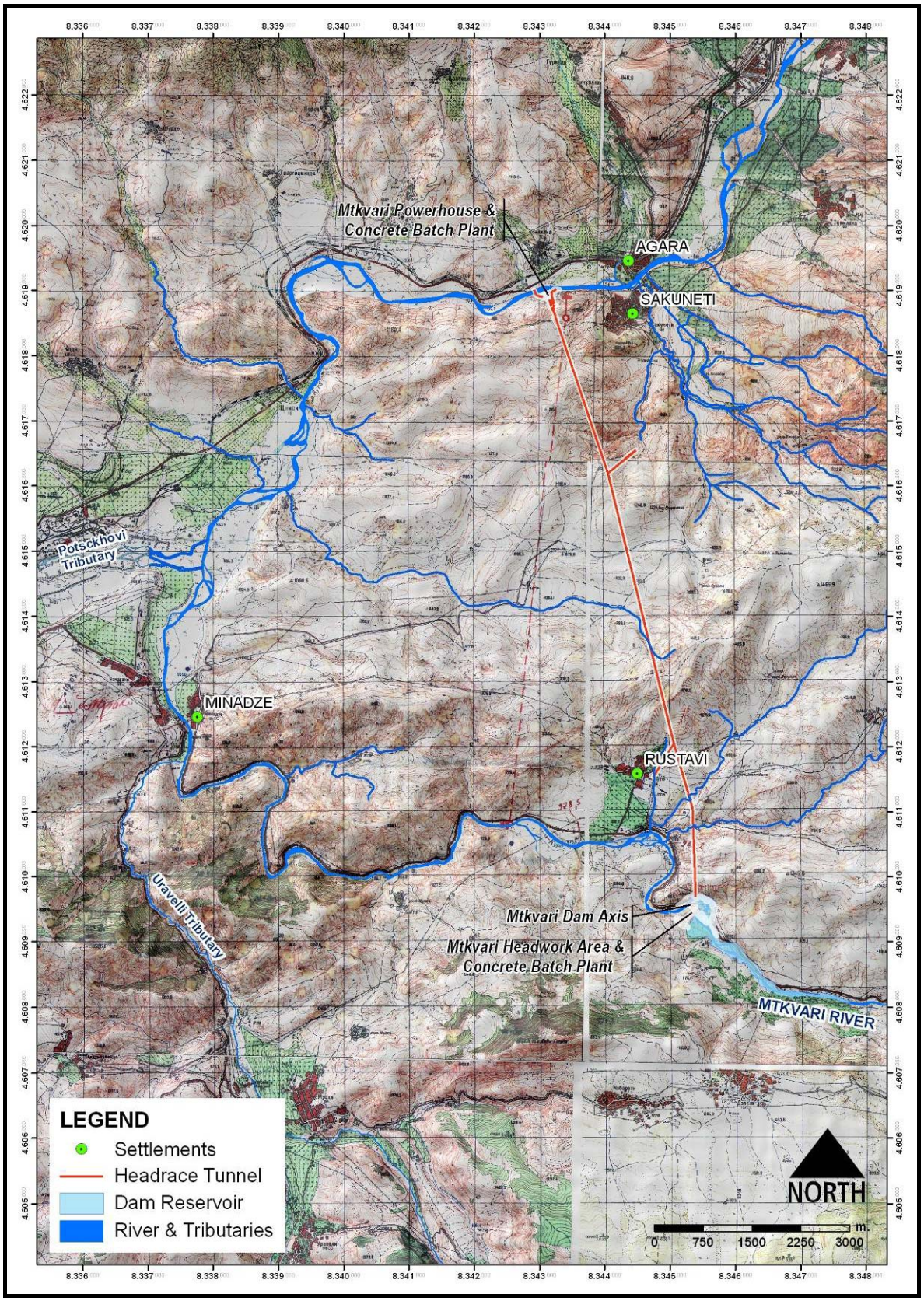

Figure V.12. The Hydrology Map of the Project Area and Vicinity

IV.1.4.2. Estimation of Run-off at Project Site

Daily flow data representing the flow during the period of 1938-1973 is obtained from the Minadze Flow Gauging Station at the downstream of dam axis on Mtkvari River. Minadze Station is located 13 km to the downstream of Mtkvari dam site. Long term average flow data is presented in Figure IV.13. From existing data, it is calculated that the long term monthly average flow datum of Minadze station is 57.65 m^3/sec based on flow data of Mtkvari River obtained from the project developer. Seasonal surface flow data of Mtkvari River at the project site is presented in Table IV.14.

Table IV.14. Seasonal Flow Data of Mtkvari River based on the Records of Minadze Flow Gauging Station during 1938-1973

	Discharge (m^3/sec)			
	Winter (December-March)	**Spring, (April-June)**	**Summer, (July-August)**	**Autumn, (September-November)**
Minimum	26.84	85.98	33.03	29.72
Average	28.79	136.97	38.29	29.51
Maximum	34.08	179.31	43.55	29.88

For the determination of the morphological properties that are necessary for the hydrological analysis of the river basin and the river system, ArcHydro application of ArcGIS 9.3 software was used. Consequently, the drainage areas of Minadze Flow Monitoring Station and dam axis are determined as 8,208 ha and 7,950 ha, respectively. Drainage area ratio is determined by comparing the two areas and the resulting ratio is correlated with the monitored flow measurements. By this method, flow data is extrapolated and expected flow data of Mtkvari dam axis was calculated (Maidment, 1992).

The data representing the flow of Mtkvari River during the period of 1964-1973 at the location of Mtkvari dam axis has been derived accordingly. The data is presented in Figure IV.14.

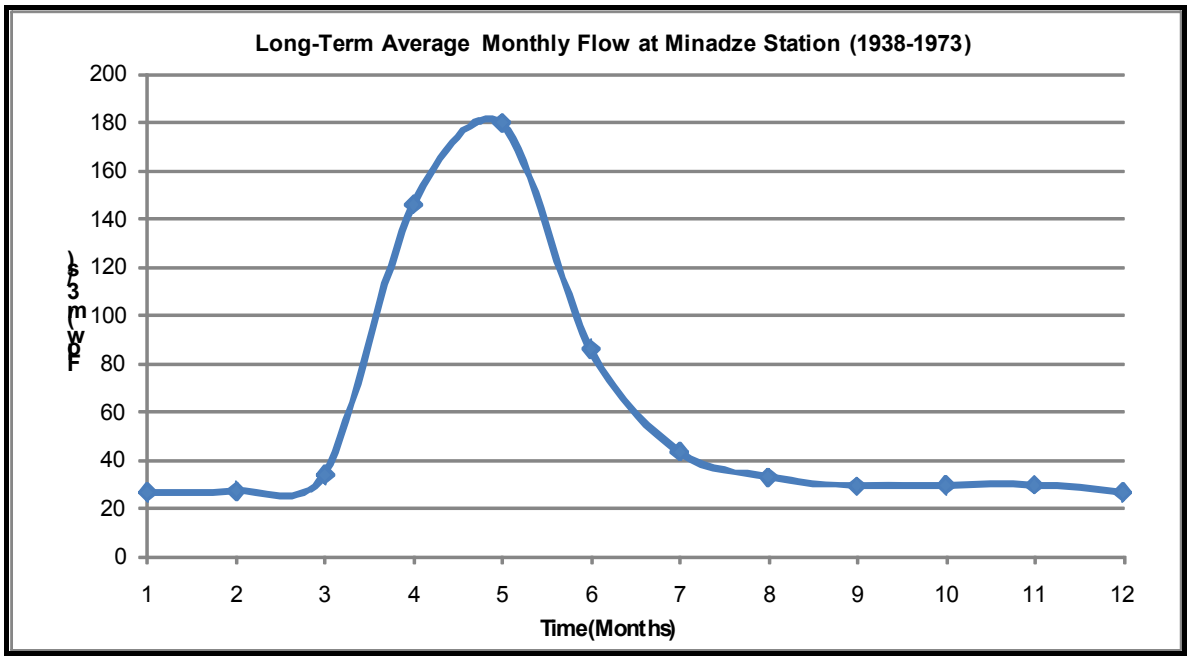

Figure IV.13. Long-Term Average Flow Rate (m^3/sec) of Mtkvari River at Minadze Station

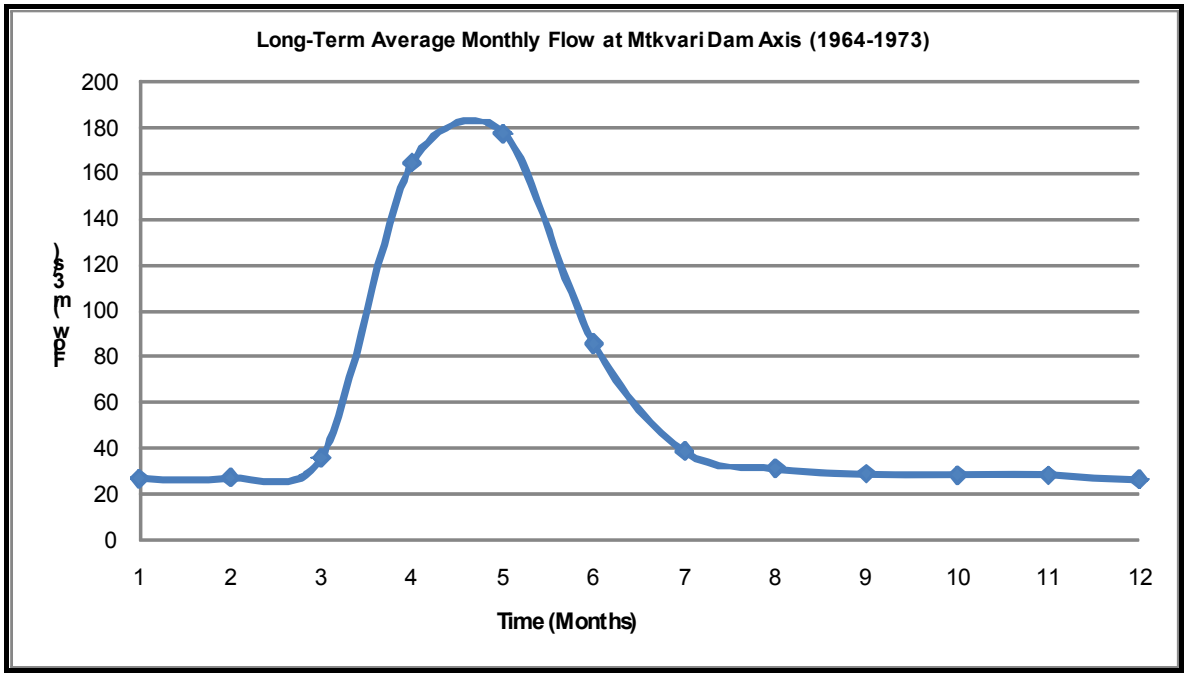

Figure IV.14 Flow Data Derived for the Period of 1964-1973 at Mtkvari Dam Axis

It can be seen that the drainage areas of Mtkvari dam axis and Minadze Flow Monitoring Station are very close, even almost the same, which indicates that the flow of Mtkvari River at those two points are similar. Thus, monthly average flow at

the dam site for the period of 1964-1973 is calculated using the same approach and found as 58.15 m^3/sec.

IV.1.4.3. Water Quality

The project will be implemented on Mtkvari River in the District of Akhaltsikhe. In the district of Akhaltsikhe, no significant industrial plant exists. Therefore, water use or pollution due to industrial activities is not of concern.

Agricultural activities are being carried out in the project area. However, as the most significant agricultural product is recorded to be potato that requires irrigation seldom, the river water is not utilized for irrigation purposes to a high extent that might result in reduction in river flow.

In order to analyze the water quality of Mtkvari River, in-situ measurements were conducted at the powerhouse area and the headworks area, in addition to the measurements done along the River. The results of the measurements conducted during the site visits are provided in Table IV.15 and Table IV.16, respectively.

Table IV.15. In-situ Water Quality Measurement Results (February 2009)

Measurement Station	pH	Salinity (ppm)	Electrical Conductivity (μs/cm)	%DO (mg/L)	TDS (ppm)	Temperature (°C)
Powerhouse Site	8.9	595	1220	95	580	11
Potsckhovi River (upstream of Mtkvari confluence)	8.4	670	1210	77	670	10.8
Uravelli River (upstream of Mtkvari confluence)	8.6	660	1380	81	675	12.3
Headworks Area	8.5	680	1210	63	690	9.3

Table IV.16 In-situ Water Quality Measurement Results (June 2009)

Station Name	pH	Salinity (ppm)	Electrical Conductivity (µs/cm)	%DO (mg/L)	TDS (ppm)	Temperature (^oC)
Powerhouse Site	8.41	-	1063	78	686	14.4
Potsckhovi River (upstream of Mtkvari confluence)	8.45	510	999	97	693	17.6
Uravelli River (upstream of Mtkvari confluence)	7.8	478	959	101	672	16.6
Headworks Area	8.31	552	1030	111	704	16.5

In order to make a classification for surface water quality for Mtkvari River, Georgian Standards have been considered. In this respect, Order # 297/N of the Minister of Labor, Health and Social Protection of Georgia on Approving the Regulations on Environmental Quality Conditions was of concern. However, as the water quality standards are very low, the surface waters of the project area are classified according to their treatment needs for utilization using the regulation on "Surface Water Quality to be used or planned to be used as drinking water" document as reference. This document covers the following surface water categories:

Category A1:

Simple physical treatment and disinfection (e.g. rapid filtration and disinfection).

Category A2:

Physical and chemical treatment and disinfection (e.g. pre-chlorination, coagulation, flocculation, decantation, filtration, disinfection (final chlorination).

Category A3:

Intensive physical and chemical treatment, extended treatment and disinfection (e.g. chlorination to break-point, coagulation, flocculation, decantation, filtration, adsorption (activated carbon), disinfection (ozone, final chlorination)).

All the results of measurements value for pH demonstrate that the taken sample is in A2 G class according to the Regulation on the Quality of Surface Waters Used or Planned to be used for Drinking Water. Total salinity in irrigation water is measured by the electrical current that is conducted by the ions within the solution. This measurement is defined as the electrical conductivity (EC). EC represents the estimated amount of salinity in the solution. Electrical Conductivity (EC) provides a good indication of the mineral salt content of water. The results of the field measurements indicate that electrical conductivities are over limit value. (75/440/EEC) Total dissolved solid is amount of inorganic salts dissolved in water. TDS is directly proportional to electrical conductivity of water.

According to the results of in-situ tests and laboratory analyses of the surface waters, all the waters taken from sampling points excluding headworks area, are classified as Category A1 with respect to high DO concentrations. Headworks area surface waters belonged to Category A2 in respect to its relatively lower DO concentration value.

The water samples taken from the abovementioned stations were analyzed in ENCON Environmental Analysis Laboratory for indicative chemical and biological parameters. The results of these analyses are presented in Table IV.17 and Table IV.18.

Table IV.17. Results of Water Quality Analysis of Samples taken in February 2009

Parameters	Unit	Powerhouse Site (close to Sakuneti Village)	Potsckhovi River	Uravelli River	Headworks Area (close to Rustavi Village)
Biochemical Oxygen Demand	mg/L	12	3	20	10
Chemical Oxygen Demand	mg/L	28	8	36	24
Fecal Coliform	-	25 / 100 mL	20 / 100 mL	50 / 100 mL	50 / 100 mL
Nitrate (NO_3)	mg/L	< 0.442	< 0.442	< 0.442	< 0.442
pH	-	8.85	8.40	8.60	8.50
Temperature	°C	11.00	10.8	12.3	9.3
Total Coliform	-	250/100 mL	250/100 mL	> 250/100 mL	> 500/100 mL
o-Phosphates (PO_4-P)	mg/L	< 0.027	< 0.027	< 0.027	< 0.027
Hardness	mg/L	120	112	76	120
Total Suspended Solids	mg/L	22	18	24	92

Table IV.18. Results of Water Quality Analysis of Samples taken in June 2009

Parameters	Unit	Powerhouse Site (close to Sakuneti Village)	Potsckhovi River	Uravelli River	Headworks Area (close to Rustavi Village)
Biochemical Oxygen Demand	mg/L	6.7	6.9	2.4	1.5
Chemical Oxygen Demand	mg/L	11.3	21.6	5.3	2.1
Fecal Coliform	-	100 / 100 mL	70 / 100 mL	30 / 100 mL	80 / 100 mL
Nitrate (NO_3)	mg/L	< 0.442	< 0.442	< 0.442	< 0.442
pH	-	8.41	8.31	7.80	8.45
Temperature	°C	14.4	16.5	16.6	17.6
Total Coliform	-	> 500/100 mL	> 500/100 mL	> 500/100 mL	> 500/100 mL
o-Phosphates (PO_4-P)	mg/L	< 0.027	< 0.027	< 0.027	< 0.027

Parameters	Unit	Powerhouse Site (close to Sakuneti Village)	Potsckhovi River	Uravelli River	Headworks Area (close to Rustavi Village)
Hardness	mg/L	116	100	76	76
Total Suspended Solids	mg/L	142	144	27	22

Different forms of soluble nitrate in water compose a limiting nutrient for growth of aquatic organisms as nitrogen is a significant nutrient in ecological systems. Additionally, nitrogen indicates the presence of fecal and organic pollution in waters arising directly from decomposition of nitrites and nitrates as a result of microbial activity or ammonium due to decomposition of proteins and amino acids. Therefore, it should be taken into consideration that presence of NH_4 in water is accepted as the indicator of existing pollution and NO_3 concentration is accepted as the indicator for former pollution. In this context, nitrate levels observed in the samples analyzed do not exceed Regulation on the Quality of Surface Waters Used or Planned to be Used for Drinking Water (see Table IV.19).

Phosphates are also significant for organisms. The impact of phosphates on organisms is mostly due to exceeding phosphate emissions from agricultural and mining activities. Phosphates are transported to long distances via surface waters if not removed properly in water treatment operations and processes. According to the results analyses, it is observed that phosphate levels do not exceed Regulation on the Quality of Surface Waters Used or Planned to be Used for Drinking Water (see Table IV.19).

Hard waters with high concentration of calcium and magnesium are not suitable for domestic uses. Conversely, hard water is favourable for agricultural irrigation purposes. Calcium in water favours dispersion of water and hence provides a good physical structure for soil. According to a general classification, water with hardness less than 75 mg/L $CaCO_3$ is soft water while moderate hardness is classified within the range of 75-150 mg/L $CaCO_3$. On the other hand, water with hardness in the range of 150-300 mg/L $CaCO_3$ and more than 300 mg/L $CaCO_3$ is

classified as hard and excessively hard water (Nas and Berktay, 2001). According to this classification, water of River Mtkvari is considered as moderately hard.

The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals. In case of occurrence, the source water may have been contaminated by pathogens or disease producing bacteria or viruses which can also exist in fecal material. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to this water. Fecal coliform level at Potsckhovi River indicates that Potsckhovi River water is in A1 category. On the other hand, fecal coliform levels in other waters (i.e. Mtkvari-powerhouse area, Uravelli Stream, Mtkvari-headworks area) exceed the level of A1 category. However, fecal coliform levels at those stations are not beyond the level of A2 M category.

The term total suspended solids (TSS) can be simply defined as the weight of particles that are suspended in water. Suspended solids in water reduce light penetration in the water column, can clog the gills of fish and invertebrates, and are often associated with toxic contaminants because organics and metals tend to bind to particles. Total suspended solids are differentiated from total dissolved solids by a standardized filtration process as the dissolved portion passing through the filter. According to the Council Directive of 75/440/EEC, waters with TSS concentration lower than 25 mg/L are classified as A1. In this context, Mtkvari Rive and tributaries are low (below 25 mg/L) in TSS concentration in winter, whereas high (above 25 mg/L) in summer due to natural increase in flow regime (see Table IV.19).

As a consequence of chemical analyses of samples from Mtkvari River water, it is determined that Mtkvari River water is not suitable for drinking water and domestic purposes but may be utilized for agricultural irrigation.

Table IV.19. Limit Values in the Regulation on the Quality of Surface Waters Used or Planned to be used for Drinking Water

			Class					
No	**Parameters**		**A1 M**	**A1 G**	**A2 M**	**A2 G**	**A3 M**	**A3 G**
1	pH		6.5- 8.5		5.5-9		5.5-9	
2	Colour (After Flocculation)	mg/l Pt Units	10	20 (İ)	50	100 (İ)		
3	Total Suspended Solids	mg/l SS	25					
4	Temperature	ºC	22	25 (E)	22	25 (E)	22	25 (E)
5	Conductivity	20 ºC µs/cm^{-1}	1000		1000		1000	
6	Odour	(25 ºC dil. fact.)	3		10		20	
7	Nitrates	mg/l NO_3	25	50 (E)		50 (E)		50 (E)
8	Fluorides	mg/l F	0.7-1	1.5	0.7-1.7		0.7-1.7	
9	Total Resolvable Organic Chloride	mg/l Cl						
10	Dissolved Iron	mg/l Fe	0.1	0.3	1	2	1	
11	Manganese	mg/l Mn	0.05		0.1		1	
12	Copper	mg/l Cu	0.02	0.05 (E)	0.05		1	
13	Zinc	mg/l Zn	0.5	3	1	5	1	5
14	Boron	mg/l B	1		1		1	
15	Berilium	mg/l Be						
16	Cobalt	mg/l Co						
17	Nickel	mg/l Ni						
18	vanadium	mg/l V						
19	Arsenic	mg/l As	0.01	0.05		0.05	0.05	0.1
20	Cadmium	mg/l Cd	0.001	0.005	0.001	0.005	0.001	0.005
21	Total Chromium	mg/l Cr		0.05		0.05		0.05
22	Lead	mg/l Pb		0.05		0.05		0.05
23	Selenium	mg/l Se		0.01		0.01		0.01
24	Mercury	mg/l Hg	0.0005	0.001	0.0005	0.001	0.0005	0.001
25	Barium	mg/l Ba		0.1		1		1
26	Cyanide	mg/l CN		0.05		0.05		0.05
27	Sulphate	mg/l SO_4	150	250	150	250 (E)	150	250 (E)

28	Chloride	mg/l Cl	200		200		200	

Table IV.19. Limit Values in the Regulation on the Quality of Surface Waters Used or Planned to be used for Drinking Water (cont'd)

			Class					
No	**Parameters**		**A1 M**	**A1 G**	**A2 M**	**A2 G**	**A3 M**	**A3 G**
29	Surfactans (reacting with methylene blue)	mg/l (laurilsulphate)	0.2		0.2		0.5	
30	Phosphates	mg/l P_2O_5	0.4		0.7		0.7	
31	Phenol (Phenol index) p- nitroanilin 4 aminoantipirin	mg/l C_6H_5OH		0.001	0.001	0.005	0.01	0.1
32	Dissolved Hydrocarbons (after resolvable with petrol ether)	mg/l		0.05		0.2	0.5	1
33	Polysiclic Aromatic Hydrocarbons	mg/l		0.0002		0.0002		0.001
34	Total Pesticides (Parathion, BHC, dieldrin)	mg/l		0.001		0.0025		0.005
35	Chemical Oxygen Demand (COD)	mg/l O_2					30	
36	Dissolve Oxygen	% O_2	>70		>50		>30	
37	Biochemical Oxygen Demand (BOD_5) (20 ºC)	mg/l O_2	<3		<5		<7	
38	Kjeldahl Nitrogen (except NO_3)	mg/l N	1		2		3	
39	Ammonia	mg/l NH_4	0.05		1	1.5	2	4(İ)
40	Resolution matter with Chloroform	mg/l SEC	0.1		0.2		0.5	
41	Total Organic Carbon	mg/l C						
42	TOC after Flocculation	mg/l C						
43	Total Coliform (37	/100 ml	50		5.000		50.000	

	ºC)							
44	Fecal Coliform	/100 ml	20		2.000		20.000	

Table IV.19. Limit Values in the Regulation on the Quality of Surface Waters Used or Planned to be used for Drinking Water (cont'd)

			Class					
No	**Parameters**		**A1 M**	**A1 G**	**A2 M**	**A2 G**	**A3 M**	**A3 G**
45	Fecal streptococci	/100 ml	20		1.000		10.000	
46	Salmonella	5.000 ml	None		None			

M=mandatory,
G=guidance,
E=Exceptional climatic or geographic conditions.

IV.1.4.4. Groundwater and Springs

The main groundwater resources in the study area are the subsoil waters which occur in contemporary alluvial sediments in rivers and also in alluvial zones of volcanogenic formations dated back to Middle Eocene. These weakly mineralized hydrocarbonate-calcium waters occur in thick volcanogenic rocks dated back to the Middle Eocene on the edges of the Akhaltsikhe artesian basin. The thermal waters of the region occur at a depth of 3-5 km from the surface with outlet temperature up to 50°C. The natural reserve of these subsoil waters in the region is 2.3 m^3/sec.

Regarding the hydrogeological characteristics of the project area, the south part (headworks area) of the project area consists of 4 fluvial terraces. The surfaces of fluvial terraces are slightly inclined in the direction of the river, and in broad terms terraces are almost horizontal. In the northern part of the project area (powerhouse area) where Mtkvari River passes through the eastern closure of the Akhaltsikhe depression, Upper and Middle Eocene sand-clay sediment content terrain with stages and terraces are typical. The elevations in this region range between 910 m and 1,430 m. This terrain is described as a multistage ladder form, which was built by a number of alluvial sediment covered fluvial terraces. There are 6 floodplain terraces in the northern part of the project area. Table IV.20

presents floodplain terrace elevations and their relative heights above river Mtkvari by Terrace Numbers given in the Geotechnical Investigation Report (2009, Tbilisi) of Geoengineering Ltd.

Table IV.20. Elevations by Terrace Numbers

Terrace No	Elevation (m ASL)	Relative Height Above Mtkvari River (m)
I	915	5
II	930	20
III	975-1050	65-140
IV	1110-1150	200-240
V	1200-1260	290-350
VI	1300-1350	390-440

Quaternary alluvial and alluvial-proluvial sediment (apQIV) based aquifers are widely spread in the broadened sections of the rivers Potsckhovi, Kavbliani and others. The floodplain widths of these rivers are ranging from 20-300 m to 0.5-15 km. Terraces numbered as I and II are the most saturated terraces of all. The sporadically distributed terraces III and IV are inundated only periodically. Terrace Number I which has an average thickness of 2-30 m, is developed in Mtkvari valley between the villages of Atskuri-Agara; Giorgitsminda-Mugareti; Tsinisi and Minadze. This terrace sits on a less permeable media. For that reason water discharges through the contact of these layers are generally directly into the river. In Rustavi-Vardzia section, loam and less permeable formations are spread. Thus, no underflows occur in this section. The permeability coefficients of Quaternary sediments range between 0.3 and 20 m/day and of alluvial sediments with sandy-clayey are less than 0.2-3 m/day. The groundwaters are generally unconfined in exception with the locations where waterproof clays are spread. In the areas where Upper Eocene formations are spread, the underlying bed has separate fragments of rocks and plaster, this composition prevents formation of groundwater aquifer. The capacity of springs of Quaternary alluvial and alluvial-proluvial sediment media range between 0.8 and 8-12 l/sec.

Lower Pliocene – Miocene volcanogenic continental deposit (N_1^2-n_2^1) based aquifers are widely spread on the Akhaltsikhe lava upland. This media is formed by Kisatib and Goderdzi series consisting of andesite, dacoits, dolerites and their pyroclastolites. The highly permeable Kisatib series builds the left slope of the Mtkvari valley in the southernmost part of the study area. The lava sheet of the Kisatib and Goderdzi series are more saturated than the underlying tuff, tuff sandstone, tuff lavas and lava breccias. At some locations, the underlying stratum serves as a confining bed for the water-bearing Kisatib and Goderdzi series. Unconfined aquifers predominate in the Kisatib series and the complex is mainly fed by precipitation or sometimes by groundwater coming from the lava sheet of the Upper Pliocene-Middle Quaternary period. Regimes of springs occurring in the deep valley are stable.

In the upper reaches of the rivers Kvabiani, Uravelli and others, the depth of water table ranges between 20 m and 100 m. Spring discharges in this region range between 0.01 and 1.0 l/sec. In some regions of Mtkvari valley, higher discharge springs of this type is recorded. Three springs of this type is registered and tested on the left slope of reservoir area.

Lower Miocene – Upper Eocene impervious lagoonal and marine sediments (N_1^1-Pg_2^3) are found mainly through the route of the headrace tunnel. This media has a thickness of 300-1200 m and consists of weakly saturated gypsiferous clay, clay marl and sandstone with interlayers of conglomerates. The discharge rates of occurring thin sandy and tuffogeneous layers of this horizon ranges between 0.01-0.2 l/sec. No water occurred in the boreholes drilled through zones consisting of lagoonal and marine sediments in Akhalgori depression.

Middle Eocene Volcanogenic sediments (Pg_2) are generally permeable. Most of the volcanogenic formations in the study area are permeable in exception with the tuff layers and clays. However the coarse fragmental materials and rather loose and often coarse cement conditions the permeability of the tuff-breccias and tuff-sandstones. In this type of media series, limited distribution interconnected water bearing aquifers are present. In comparison with the lithology of the Middle Eocene formations, water occurring aquifers of this horizon are of fracture-porous

and fracture types. This type of aquifer sourced springs can be seen in the environs of the villages Andriatsminda, Rustavi (two springs), Orpola, Tskaltbila, Pertsikhe and some others.

Since the tuffogenous rocks are mainly of weak permeability in some tuffogenous rock horizons, there are a few springs on the Mtkvari slopes in the Minadze-Rustavi section and in the lower reaches of Mtkvari's tributaries.

The number of springs sharply increases 2-3 km away from the Mtkvari valley. The reason of the increase can be explained by extreme drainage of the slopes nearby the river and flat depression curve of water surface in the tuffogenous strata.

In the deep ravines of Mtkvari's right and left tributaries, in some zones; the river has partially eroded the impervious tuffogenous rock horizons. As a result of erosion, water bearing layers are exposed to the surface and a number of springs have been formed. This kind of springs can be seen in the vicinity of villages Toba, Rustavi, Pertsikhe, Indusa and some others (Geoengineering, 2009).

IV.1.4.5. Existing Water Use in the Project Area

Mainly springs and groundwater are used for agricultural purposes in the villages. The river is used by the fauna species and by livestock to some extent.

There are a number of alluvial water wells for irrigation purpose located close to Akhaltsikhe and a non-operating Rustavi HPP located at 2 km downstream of the reservoir area. Therefore, there is no significant use of river water by the locals living in the area for drinking, irrigation or production purposes. The level of water table at the downstream of the dam axis might decrease to some extent, especially before the confluence of Potsckhovi River, Uravelli River, but it is not expected to adversely affect the amount of water taken from the wells.

The use of water by the biological species (especially fauna) and water supply and wastewater discharge of the settlements are discussed in the relevant sections.

IV.1.5. Noise

With the start of land preparation activities, noise will be generated due to construction works and will be mainly due to the construction machines. Within the scope of ESIA studies for the Mtkvari HPP Project, noise measurements were performed at 8 different locations for determining the existing noise levels. The map showing the selected measurement points is given in Figure IV.15. The results of the measurements to determine the existing noise levels are given in Table IV.21.

Table IV.21. Noise Measurement Results

No	Location	Noise Level (dBA)*
1	Chitakhevi HPP and village	62.5
2	Chitakhevi Dam-Regulator	44.5
3	Sakuneti Village	45.5
4	Mtkvari HPP Site	53.5
5	Potsckhovi	51.2
6	Uravelli	61.5
7	Construction Site	57.5
8	Rustavi Village	43.7

*dBA = It is a noise evaluation unit at which the medium and high frequencies to those the human ear is very sensitive are especially are highlighted. dBA unit that is often used for decreasing or control of noise is about the subjective evaluation of the noise level.

The receptors that can be affected by the noise emissions caused by construction activities of the project are the closest settlements and agricultural land hosting regions, namely; Sakuneti Village and Rustavi Village. These points were chosen as the critical receptor points and were especially taken into consideration in the evaluation of noise impact. Noise impact of the Mtkvari HPP Project on the critical receptors is assessed in Section V.1.6.

IV.1.6 Landscape

Existing Status of the Project Area

The project area is located in the southeast of Georgia, on River Mtkvari, close to the city Akhaltsikhe. The River originates in Turkey and flows into Georgia at elevation exceeding 1,100 m above sea level. The river turns to eastwards near the town Akhaltsikhe at about elevation 950 m asl and flows from there towards east through the capital Tbilisi, onwards into Azerbaijan and into the Caspian Sea.

The location of the project area can be classified as a rural area. The closest settlement to the dam site and future reservoir is Rustavi located at a distance of 3,000 m. Sakuneti Village, which is the closest settlement to the powerhouse area, is at a distance of 1,000 m. A photograph of Sakuneti Village is given in Photograph IV.1.

There is not a strong anthropogenic stress in and around the project area. The most significant stresses on the natural landscape are the Chitakhevi HPP that is 1000 22.3 km (downstream of the Mtkvari HPP. The landscape characteristics of the project area is explained under three major headings namely, powerhouse area, headrace tunnel area and the future reservoir area.

Methodology of Visual Analysis

Visual analysis was performed in the project area in order to determine the landscape characteristics. Observations, photographs taken in different seasons, topographical maps are the major sources used within the scope of the investigation. Within the context of the study, each element forming the landscape characteristics were considered. Hence, different landscape types were identified by visual landscape inventory used. Three main criteria were taken into consideration for the assessment of visual and landscape characteristics of the site, which are physiography, surface cover and cultural elements.

For the visual inspection of the project area, each of the landscape elements that are included in the landscape inventory (topography, vegetative cover, and cultural structures) is taken into consideration with their relevant characteristics (form, colour, texture, scale, harmony and contrast). The evaluation of these criteria is also dependent on the experience, culture, observation distance and background of the observer.

Powerhouse Area

The equalizing reservoir/pond and the powerhouse (Photograph IV.1) will be located on the right bank of the River Mtkvari, inside Sakuneti Village territory. Photograph IV.1 is taken from Powerhouse area. This area is located in front of the hill that headrace tunnel will end. At this point, the river bed elevation is 909 m and the elevation of the hill that the headrace tunnel ends is 1,038 m. The elevation change is composed of about 30 m. At the hill that the end of the headrace tunnel shall be located, the slope increases gradually in the upper levels and reaches up to 50% in patches. During the visual inspections, no erosion marks is observed. The photograph of the area that the powerhouse shall be located is provided in Photograph IV.2.

Photograph IV.1. A Photograph Taken from Powerhouse Area

The area that the powerhouse shall be constructed is covered with herbaceous texture and hence, no significant geological structure or formation is observed. The herbaceous texture is observed in the upper sections of the hill in addition to the slopes, except the river bank. As there is no significant stand in the area, the colour change due to seasonal variations will be directly dependent on the herbaceous texture. Therefore, this can be considered as the most significant visual change in the in between the seasons. Furthermore, herbaceous texture effective on the area prevents the rigid topographical properties and hence a strong texture.

Another significant element that provides visual activity is the River Mtkvari that stands out in the area in terms of colour and formation with flow and colour variations in different seasons and the vegetative cover along the river bank and upper levels.

The current land use of the area can be classified as pasture land. The results of the biological surveys revealed that no significant plant species/vegetation communities or endemic species exist in the powerhouse area and its vicinity, which is considered

as one of the major advantages for the implementation of the project at the selected site. As indicated above, the closest settlement area to the powerhouse is Sakuneti Village, which is a standard medium-size rural area with agricultural and animal husbandry activities.

Headrace Tunnel

The headrace tunnel shall be constructed at a depth of approximately 100 m in the hills. The photograph of the area, where the headrace tunnel will be located, is shown in Photograph IV.3. The project envisages the construction of a 9.6 km headrace tunnel from the dam axis to the powerhouse. The aimed elevation (head) difference between the two points is approximately 102 m.

Photograph IV.2. Powerhouse Area Looking Upstream

Photograph IV.3. Mtkvari Headrace Tunnel Exit Area and HPP Construction Site Excluding Tailrace Canal

Reservoir Area

The topographical change in and around the reservoir area can be described more easily than that in the powerhouse area as the level increases sharply by the river bank of Mtkvari. The slope increases up to 50-70% in this area. However, neither erosion mark nor a geological formation that is visually effective is observed during the studies.

As the elevation increases from the river bank towards the hills, it is possible to observe the herbaceous texture with rock structures. As can be seen from Photograph IV.4, mainly rock outcrops and scattered shrub type vegetation are observed together covering the soil. The panoramic seen of the reservoir area is presented in Photograph IV.5.

Photograph IV.4. Soil Surface in the Reservoir Area

Photograph IV.5. Reservoir Area

In the reservoir area, it is observed that the vegetative texture is denser (more like tree and shrub texture) than that in the powerhouse area. The tree texture is mostly observed in the river banks and it is replaced with the pasture texture as the elevation increases. The tree species are generally composed of populous and willow that are typical on the river banks and create a variable texture with various colours in spring, autumn and summer seasons.

Water surface, rock structure, vegetative cover, trees and the movements of sunlight creates a dynamic view not only within a day, but also in different seasons.

The land use of this area can be classified as pasture land similar to the areas studied for the other project facilities (HPP and headrace tunnel areas). The closest settlement to the reservoir area is Rustavi Village. Rustavi is a typical rural settlement with no deviation from other villages that are in the same class in the region. According to site investigations, there exist no sources that might have a visual significance in the area.

IV.1.7 Air Quality

There are no significant industrial activities in the vicinity of Rustavi and Sakuneti Villages. Additionally, population density is not high in Akhaltsikhe District, which indicates that there are not much emission sources.

There are no sulphur dioxide (SO_2) measurements, which is an indicator of air pollution especially due to fuel use, in the vicinity of the project area or in Akhaltsikhe District. However, particulate matter (PM) measurements are available from National Environmental Agency for some major city centres and larger district centres. In this respect, average PM concentrations measured in Akhaltsikhe Station are presented in Table IV.22. As can be seen from Table IV.22, existing PM concentrations are very low.

Table IV.22. PM concentrations in Akhaltsikhe

Months	Jan	Feb	Mar	June	July	Aug	Sep	Oct	Nov	Dec
PM concentrations ($\mu g/m^3$)	0.36	0.58	0.77	0.39	0.43	1.02	0.93	1.05	0.93	0.68

IV.2. Biological Environment

In this section, the ecological baseline situation in the study area is described. The presentation is divided into subsections on flora and vegetation communities, and terrestrial and aquatic fauna. The objectives of these studies were the identification of the flora and vegetation types, and terrestrial and aquatic fauna (mammals, birds, reptiles, amphibians, fish, invertebrates) within the study area to serve as a basis for determination of the impacts of the Project on biological resources and to develop appropriate mitigation where necessary.

The description of the biological resources and their sensitivity in the study area has been done mainly on the basis of literature, unpublished data, field studies as well as expert experience and knowledge.

The overall Project area includes different botanic-geographic regions (Trialeti, Javakheti, and Meskheti) with diversity of flora and vegetation due to geological, geo-morphological, hydrological and soil conditions. In particular, project and impact area includes riparian habitats along the River Mtkvari; steppes at the by-pass tunnel areas, shrubs; agricultural lands; and other more or less transformed areas Photograph IV.6 shows the Mtkvari River together with the surrounding habitats and a settlement area.

Photograph IV.6. Mtkvari River and Habitats in the Vicinity

In order to assess the ecological characteristics in the study area (including the project and impact area), information on the biological environment was collected by the means of following:

- Review of the pertinent literature.
- Communication with the inhabitants in the study area during the field studies.
- Field studies carried out in the project area.
- Satellite image interpretation

During these studies, site-specific data on flora and fauna were collected for the study area. The data were evaluated and particular attention was given to the species of national (Georgian Red Data Book-GRDB) and international concern (IUCN, BERN, CITES) and their habitats.

Types of ecological information collected in these studies included; species habitat requirements, feeding and breeding characteristics, movements of aquatic and terrestrial fauna and species distribution. For the flora and terrestrial fauna studies the same grid system was used so as to provide a description of habitat types within the project area where the terrestrial species were identified. During the field studies, habitats that could be utilized by the species of concern were also given special attention.

In light of the baseline information and the proposed features of the project, potential impacts of the project on the biological resources were assessed and mitigation measures were evaluated, where appropriate, and presented in the following chapters.

IV.2.1. Legal Framework

Policy-based actions are essential for providing the institutional support, human and financial resources, and legal framework required to ensure effective species conservation. Frequently, such actions occur through the development and implementation of legislation at the national or sub-national levels, or through international agreements. Legislation is sometimes directed at the protection of particular species, such as by regulating the harvesting of individuals, their trade (e.g. CITES), or alterations in their habitat (e.g. Ramsar Convention). Legislation can also promote habitat protection, most noticeably through the creation of protected areas:

Legislation may also protect habitats by regulating land use patterns at a broader scale (e.g. Forest Code), or through the regulation of anthropogenic activities that are frequently the least direct but most pervasive causes of species declines (e.g. pollution generated by industry, transport leading to the introduction of invasive species, consumption of fossil fuels leading to climate change).

The role of multilateral environmental agreements has grown during the last decade, as human impacts intensify and span across national boundaries more often. There

are now more than 500 international treaties that concern the environment and most countries have ratified key international treaties (although significant gaps remain).

These agreements are a means to adopt harmonized approaches and resolve trans-boundary problems with neighboring states. They increasingly offer access to worldwide knowledge, tools and financial resources, and they can give conservation agencies a stronger mandate domestically.

Nevertheless, most conservation actions take place at the national level, and the national legal framework remains crucial in the effective implementation of the vast majority of conservation programs. Naturally, legislation is only useful if adequately implemented and such implementation is lacking in many cases. Policy-based actions are frequently implemented as a top-down approach, but their effectiveness is in many cases hindered by a lack of involvement with the local communities that are the direct users of biodiversity. The following are the Multilateral International Conventions related to nature conservation and biodiversity enforced in Georgia:

- *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (*CITES*; 1975; Universal) regulates international trade of the species listed.
- *Convention on Biological Diversity* (1992; universal) encourages Parties to take a wide range of actions to biodiversity conservation and sustainable use.
- *European Union Habitats Directive* (1992; regional) lists the natural habitats to be maintained at a favorable status, particularly through the creation of a network of protected sites.
- *Convention on the Conservation of Natural Habitats and of Wild Fauna and Flora – Bern Convention.*
- *Convention on Wetlands of International Importance Especially as Waterfowl Habitat* (*Ramsar Convention*; 1975; universal) provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources, in particular through the designation of sites under the Ramsar List of Wetlands of International Importance.

- *Convention concerning the Protection of the World Cultural and Natural Heritage* (*World Heritage Convention*; 1972; universal) provides identification, protection and preservation of cultural and natural heritage (including habitats of threatened species) around the world considered to be of outstanding value to humanity. Countries submit places for designation under the World Heritage List.
- *United Nations Framework Convention on Climate Change* (1994; universal)
- *Kyoto Protocol* (adopted in 1997, not yet into force in Georgia; universal) caps greenhouse gas emissions in participating industrialized nations from 2008 to 2012 and establishes an international market in emissions credits that will allow these nations to seek out the most cost-effective means to reduce atmospheric concentrations of greenhouse gases.

Georgia's general wild flora and fauna conservation measures are regulated by several legislative acts adopted by the Georgian Parliament between 1994 and 2009. Main environmental laws of Georgia are provided in Table IV.23.

Table IV.23. Main Environmental Laws of Georgia

Laws	Dates
Law on Protection of Flora from Harmful Organisms	12.10.1994
The Constitution of Georgia	24.08.1995
Law on Protected Area System	07.01.1996
Law on Normative Acts	29.10.1996
Law on Environmental Protection	10.12.1996
Law on Wildlife	26.12.1996
Law on State Ecological Expertise	01.01.1997
Law on Environmental Permits	01.01.1997
Law on Creation and Management of the Kolkheti Protected Areas	09.12.1998
Law on Changes and Amendments into the Law on Protection of Flora from Harmful Organisms	16.04.1999
The Forest Code	22.06.1999
National Environmental Action Plan of Georgia	19.06.2000
Law on Melioration of Lands	16.10.2000

Table IV.23. Main Environmental Laws of Georgia (cont'd)

Laws	Dates
Law on Special Preservation of State Forest Fund and the Plantation within the Tbilisi City and Neighbouring Territories	10.11.2000
Law on Expantion of Borjomi-Kharagauli National Park	28.03.2001
Law on Red Data List and Red Data Book of Georgia	06.06.2003
Law on State Control of Nature Protection	23.06.2005

IV.2.2. Flora and Vegetation Communities

The steep topography and riparian habitats of the Mtkvari Valley at the dam site is typical of the South Caucasus Region, and affects the formation and distribution of vegetation in the project area. The natural forests in the area were generally destroyed by the settlers for cultivation. Examples of natural forests free of anthropogenic effects are found only on the steep slopes and cliffs that cannot be used for the cultivation. The study area is in the South of Georgia and covers an approximately 30 km long stretch of Mtkvari River including the headworks area and the HPP site, and the starting and ending sites of the headrace tunnel (which would be built about 100 m below the surface) and the adits of the tunnel.

IV.2.2.1. Materials and Methods

To determine the general floristic and faunistic structure of project area field studies were undertaken between February and June 2009 at the above mentioned section of the Mtkvari Basin. With these studies, terrestrial and aquatic environment species, vegetation and plant groups and present habitats were investigated.

The field studies within the context of ESIA were carried out by ecology experts from ENCON Environmental Consultancy and Hacettepe University. Field studies were performed mainly at the headworks area (Photograph IV.7, Rustavi environs),

powerhouse site (Photograph IV.8, Sakuneti environs), Mtkvari watercourse (Photograph IV.9) and headrace tunnel area (Photograph IV.10).

Photograph IV.7. Headworks Area (Rustavi Environs)

Photograph IV.8. Powerhouse Area (Sakuneti Environs)

Photograph IV.9. Mtkvari Watercourse

Photograph IV.10. Headrace Tunnel Area

All of the identified species are assessed in terms of threatening and conservation status. Each species are presented with family, genus and specie names in the relevant tables below. The species in these inventory lists are presented including English common names (if exist), phyto-geographical regions, endemism, and national/global threat/conservation status (according to IUCN, Bern and CITES Conventions), their habitats and abundance situations in the area.

International agreement CITES (signed by 164 nations) aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival. CITES principles are based on the sustainability of the trade, which is important to safeguard ecological resources (various wildlife products obtained from animals and plants, products to add to eatables, exotic skin products etc.) for the future. CITES was signed in 1973 and entered into force on 1 July 1975.

Species in CITES are listed under three distinct appendices according to required conservation level. Appendix I includes those species that are threatened with extinction. These species may not be traded internationally except extraordinary conditions. Appendix II includes those species that, although not necessarily threatened with extinction, may become so unless trade is strictly regulated in order to avoid utilization incompatible with their survival. Appendix III includes those species that are under conservation of at least one Party and needs the cooperation of other Parties to monitor international trade.

Bern Convention was signed by 26 member states of the European Council to protect European wildlife and natural habitats, to protect and increase biological diversity, to promote national policies for the conservation of wild flora, wild fauna and natural habitats, to have regard to the conservation of wild flora and fauna in planning and development policies and in measures against pollution, to promote education related to conservation and to encourage and coordinate studies conducted on this issue.

Contracting parties to Bern Convention that also signed up the Convention on Biological Diversity are obliged to ensure every possible step, to be consistent with their national development, to protect endangered species and fragile habitats. Flora and fauna species that are protected under this convention are listed in Appendix 1 (strictly protected flora species), Appendix 2 (strictly protected fauna species), and Appendix 3 (protected fauna species).

IUCN Red List is published to highlight those species that are facing a risk of extinction. A species may be listed in IUCN Red List after relevant studies on its population and findings regarding a population decrease. As this Red List is based on research, some countries attach more importance to species included in IUCN list than species included in Bern List. The categories of IUCN Red List for 1994 (ver. 2.3) and 2008 (ver. 3.1) are presented in Table IV.24 below.

Table IV.24. IUCN Red List Categories and Criteria According to Published Years

IUCN Red List Categories and Criteria, 1994 (ver. 2.3)		IUCN Red List Categories and Criteria, 2008 (ver. 3.1)*	
EX	: Extinct	EX	: Extinct
EW	: Extinct in Wild	EW	: Extinct in Wild
CR	: Critically Endangered	CR	: Critically Endangered
EN	: Endangered	EN	: Endangered
VU	: Vulnerable	VU	: Vulnerable
LR	: Low Risk		
	cd : conservation dependent		
	nt : near threatened	NT	: Near Threatened
	lc : least concern	LC	: Least Concern
DD	: Data Deficient	DD	: Data Deficient
NE	: Not Evaluated	NE	: Not Evaluated

** The IUCN Red List Categories and Criteria have undergone an extensive review in recent years to produce a clearer, more open, and easy-to-use system. The revised Categories and Criteria (IUCN Red List Categories and Criteria version 3.1) were adopted by IUCN Council in February 2000 and published in 2008.*

Within the scope of the field studies, habitat characteristics, plant communities observed and elevations were recorded during sampling. The average height of the common tree and shrub species were also taken. The samples were identified according to the “Flora of Georgia”. Flora inventory of the study area was organized alphabetically by families and species, indicating the common names in English (if exists), phytogeographic regions, endemism and conservation status for the species. Further, the species were classified according to the “List of Rare and Endemic Plants in Georgia,” which used the well accepted IUCN categories.

IV.2.2.2. Flora

The study area is within the boundaries of Akhaltsikhe District, and close to particularly Sakuneti and Rustavi Villages. The area is located in Europe-Siberia (Euro-Sib) phytogeographic region.

Flora inventory list of the study area is given in Table IV.25. The species in this table are identified through literature survey and field studies. The species are assessed with their status of endemism, threat classes and phytogeographic regions.

Endemism in the flora list is used for the definition of specific species that are only found in Georgia. The flora species that are protected by Bern Convention were investigated along with endemism. Threat classes are presented according to the "List of Rare, Threatened and Endemic Plants in Georgia".

As a result of these studies, 80 plant species belonging to 26 families have been identified from the samples and from literature sources. Among these 80 species, 3 species; "*Dianthus caucasicus*, *Anthyllis lachnophora*, *Thymus collinus*" (3.75 %) are Caucasian endemic. When the endemism ratio of Georgia (20%) is considered, it is clear that the endemism ratio in the area (3.75 %) is much lower. According to Georgian Red Data Book, these endemic species are not classified under any threat categories and they are generally spread all over Georgia. Also, none of 80 species are categorized in IUCN, BERN and CITES lists.

There is no critical flora species in the project and impact area. Hence, the impacts of the project on flora species are expected to be insignificant. This is also supported by the project characteristics (e.g. having a small inundation area, and a headrace tunnel to be constructed under the ground). Furthermore, none of the identified species are within the context of IUCN and BERN lists. Consequently, survival of no flora species will be affected, though the populations of some of the species located at construction sites and the future reservoir will be lost. However, habitat degeneration is expected to occur slowly and hence the populations will be degenerated partially due to project characteristics. On the other hand, vegetation in this area is very dynamic and this region is expected to rehabilitate itself rather quickly.

There will be no considerable change/impact on the microclimate conditions in the area due to the climatic characteristics of the region and relatively small surface area of the Mtkvari Reservoir. Therefore, there will be no major impacts on biotopes, vegetation cover and habitats due to microclimate change.

The region including the project area is basically integrated in the European-Siberian floristic region. Most of the species identified in the project area are widespread. The others are generally elements of European-Siberian floristic region. The distribution of these species according to their phytogeographic region is presented in Table IV.25 .The flora and vegetation of the study area are evaluated and the taxonomic list of floristic species identified in the area is presented Table IV.26, together with the family distribution of the species.

Table IV.25. Distribution of the Species According to Their Phytogeographic Region

Phytogeographic Region	Number of Species	Percent of Species
European-Siberian	13	16.25
Widespread	64	80.00
Unknown	3	3.75

When the distribution of the species is analyzed, it is observed that the widespread elements in the project area are dominant. As a result of the studies, 80 species belong to 26 families were identified and 13 of them belong to Europe-Siberia region. The region of the rest of the 67 species are common (widespread) or unknown.

Table IV.26. Flora List for the Study Area

Family	No	*Taxon*	English Name	P. G. R.	Identification Method	Endemism and GRDB	Bern Annex 1	T.S. IUCN	GRDB	Cites	Habitat				Relative Abundance		
										Appendix 1-2-3	1	2	3	4	1	2	3
Asteraceae	1	*Achillea millefolium*	Common Yarrow	Widespread	L	-	-	-	-	-	X					X	
Asteraceae	2	*Achillea biebersteinii*	-	Widespread	L	-	-	-	-	-	X	X					X
Asteraceae	3	*Inula helenium*	Horse-heal	Widespread	L	-	-	-	-	-	X	X					X
Asteraceae	4	*İnula montbretiana*	Horse-heal	Europe-Siberia	L	-	-	-	-	-		X	X			X	
Asteraceae	5	*Carlina vulgaris*	Carline thistle	Widespread	S-L	-	-	-	-	-		X	X			X	
Asteraceae	6	*Centaurea fischeri*	Knopweed	Widespread	O-L	-	-	-	-	-		X				X	
Asteraceae	7	*Centaurea triumfettii*	Knopweed	Europe-Siberia	O-L	-	-	-	-	-		X			X		
Asteraceae	8	*Taraxacum crepidiforme*	-	Widespread	O-L	-	-	-	-	-		X			X		
Asteraceae	9	*Cichorium intybus*	Common chicory	Widespread	L	-	-	-	-	-	X	X				X	
Berberidaceae	10	*Berberis vulgaris*	European barberry	Widespread	O-L	-	-	-	-	-	X	X				X	
Betulaceae	11	*Alnus barbata*	Alder	Europe-Siberia	O-L	-	-	-	-	-				X	X		
Betulaceae	12	*Betula pendula*	Silver Birch	Europe-Siberia	O-L	-	-	-	-	-				X	X		
Betulaceae	13	*Carpinus orientalis*	Oriental hornbeam	Widespread	O-L	-	-	-	-	-				X	X		
Boraginaceae	14	*Heliotropium europaeum*	European Heliotrope	Widespread	L	-	-	-	-	-	X	X				X	
Boraginaceae	15	*Lappula barbata*	-	Widespread	O-L	-	-	-	-	-	X			X	X		
Boraginaceae	16	*Alkanna orientalis*	Alkanet	Widespread	O-L	-	-	-	-	-				X	X		
Brassicaceae	17	*Aethionema arabicum*	-	-	O-L	-	-	-	-	-		X	X		X		
Brassicaceae	18	*Euclidum syriacum*	Mustard	Widespread	O-L	-	-	-	-	-		X	X		X		
Brassicaceae	19	*Fibigia clypeata*	Roman shields	Widespread	L	-	-	-	-	-							
Caprifoliaceae	20	*Lonicera caprifolium*	Honeysuckle	Widespread	O-L	-	-	-	-	-	X					X	
Caryophyllaceae	21	*Dianthus caucasicus*	Babys breath	Europe-Siberia Widespread in Georgia	L	CE	-	-	-	-		X	X		X		
Caryophyllaceae	22	*Dianthus crinitus*	Babys breath	Widespread	O-L	-	-	-	-	-		X	X		X		
Caryophyllaceae	23	*Dianthus calocephalus*	Babys breath	Widespread	O-L	-	-	-	-	-		X	X	X			
Caryophyllaceae	24	*Silene spergulifolia*		Widespread	O-L	-	-	-	-	-		X				X	
Chenopodiaceae	25	*Chenopodium folisum*	Leafy goosefoot	Widespread		-	-	-	-	-		X			X		
Cornaceae	26	*Cornus mas*	European Cornel	Europe-Siberia	O-L	-	-	-	-	-				X			X
Cupressaceae	27	*Juniperus oblonga*	Juniper	Widespread	S-O-L	-	-	-	-	-	X			X	X		

Table IV.26. Flora List for the Study Area (cont'd)

Family	No	*Taxon*	English Name	P. G. R.	Identification Method	Endemism and GRDB	Bern Annex 1	T.S. IUCN	GRDB	Cites	Habitat				Relative Abundance		
										Appendix 1-2-3	1	2	3	4	1	2	3
Dipsacaceae	28	*Scabiosa caucasica*	Caucasian scabious	Widespread	L	-	-	-	-	-	X	X			X		
Ericaceae	29	*Rhododendoron caucasicum*	Georgian Snow rose	Widespread	O-L	-	-	-	-	-	X			X		X	
Equisetaceae	30	*Equisetum arvense*	Field horsetail	Widespread	L	-	-	-	-	-	X				X		
Euphorbiaceae	31	*Euphorbia macroclada*	-	Europe-Siberia	L	-	-	-	-	-	X	X		X			X
Fabaceae	32	*Astragalus microcephalus*	-	-	L	-	-	-	-	-		X			X		
Fabaceae	33	*Medicago caucasica*	Medick	Widespread	L	-	-	-	-	-		X	X			X	
Fabaceae	34	*Medicago hemicycla*	Burclover	Widespread	L	-	-	-	-	-		X	X			X	
Fabaceae	35	*Coronilla orientalis*	Lassen	Widespread	L	-	-	-	-	-	X				X		
Fagaceae	36	*Quercus iberica*	Quercetin	Europe-Siberia	O-L	-	-	-	-	-		X	X	X			X
Fagaceae	37	*Quercus pedunculiflora*	Pedunculate oak	Widespread	O-L	-	-	-	-	-		X	X			X	
Fabaceae	38	*Trifolium ambiguum*	Kura clover	Widespread	L	-	-	-	-	-	X				X		
Fabaceae	39	*Trifolium arvense*	Rabbitfoot clover	Widespread	O-L	-	-	-	-	-	X				X		
Fabaceae	40	*Trifolium campestre*	Field clover	Widespread	L	-	-	-	-	-	X				X		
Fabaceae	41	*Trifolium repens*	White clover	Widespread	L	-	-	-	-	-	X				X		
Fabaceae	42	*Vicia sativa*	Common vetch	Widespread	O-L	-	-	-	-	-	X	X					X
Fabaceae	43	*Anthyllis lachnophora*	-	Europe-Siberia Widespread in Georgia	L	CE	-	-	-	-	X	X				X	
Geraniaceae	44	*Geranium ibericum*	Caucasian Cranesbill	Widespread	L	-	-	-	-	-	X	X				X	
Lamiaceae	45	*Mentha arvensis*	Wild mint	Widespread	O-L	-	-	-	-	-	X						X
Lamiaceae	46	*Origanum vulgare*	Oregano	Widespread	L	-	-	-	-	-	X				X		
Lamiaceae	47	*Thymus pubescens*	Thyme	Widespread	S-O-L	-	-	-	-	-		X	X				X
Lamiaceae	48	*Salvia glutinosa*	Jupiter's distaff	Widespread	L	-	-	-	-	-	X	X				X	
Lamiaceae	49	*Salvia aethiopis*	--	Widespread	O-L	-	-	-	-	-	X	X				X	
Lamiaceae	50	*Thymus collinus*	Thyme	Europe-Siberia Widespread in Georgia	L	CE	-	-	-	-		X			X		
Liliaceae	51	*Colchicum speciosum*	Crocus	Europe-Siberia	O-L	-	-	-	-	-		X			X		
Liliaceae	52	*Allium kunthianum*	-	Widespread	O-L	-	-	-	-	-		X			X		

Table IV.26. Flora List for the Study Area (cont'd)

Family	No	*Taxon*	English Name	P. G. R.	Identification Method	Endemism and GRDB	Bern Annex 1	T.S. IUCN	GRDB	Cites	Habitat				Relative Abundance		
										Appendix 1-2-3	1	2	3	4	1	2	3
Malvaceae	53	*Tilia caucasica*	Caucasican linden	Europe-Siberia	L	-	-	-	-	-				X	X		
Papaveraceae	54	*Papaver pseudoorientale*	Corn rose	Widespread	O-L	-	-	-	-	-	X	X		X			X
Pinaceae	55	*Picea orientalis*	Oriental spruce	Widespread	O-L	-	-	-	-	-				X	X		
Poaceae	56	*Alopecurus myosuroides*	Blackgrass	Widespread	O-L	-	-	-	-	-	X	X				X	
Poaceae	57	*Bromus inermis*	Hungarian Brome	Widespread	L	-	-	-	-	-	X	X				X	
Poaceae	58	*Poa trivialis*	-	Widespread	L	-	-	-	-	-	X	X				X	
Poaceae	59	*Poa bulbosa*	Bulbous bluegrass	Widespread	O-L	-	-	-	-	-	X	X				X	
Poaceae	60	*Poa nemoralis*	Wood bluegrass	Widespread	L	-	-	-	-	-		X	X			X	
Ranunculaceae	61	*Adonis vernalis*	Pheasant's eye	Widespread	L	-	-	-	-	-	X					X	
Ranunculaceae	62	*Adonis flammea*	-	Widespread	L	-	-	-	-	-	X					X	
Rosaceae	63	*Prunus spinosa*	Blackthorn or sloe	Widespread	O-L	-	-	-	-	-				X	X		
Rosaceae	64	*Crataegus orientalis*	Silver thorn tree	Widespread	O-L	-	-	-	-	-	X			X		X	
Rosaceae	65	*Rosa canina*	Dog rose	Widespread	O-L	-	-	-	-	-	X	X				X	
Rosaceae	66	*Rubus buschii*	Rozanova	-	O-L	-	-	-	-	-	X			X			X
Rosaceae	67	*Rubus caesius*	European Dewberry	Widespread	O-L	-	-	-	-	-	X			X			X
Rubiaceae	68	*Galium odoratum*	Woodruff	Widespread	L	-	-	-	-	-	X				X		
Salicaceae	69	*Populus nigra*	Lombardy poplar	Widespread	O-L	-	-	-	-	-	X				X		X
Salicaceae	70	*Populus tremula*	Eurasian Aspen	Widespread	O-L	-	-	-	-	-	X				X		X
Salicaceae	71	*Salix alba*	White willow	Widespread	O-L	-	-	-	-	-	X					X	
Salicaceae	72	*Salix excelsa*	Willow	Widespread	O-L	-	-	-	-	-	X					X	
Sapindaceae	73	*Acer campestre*	Field maple	Widespread	O-L	-	-	-	-	-				X	X		
Sapindaceae	74	*Acer platanoides*	Norway maple	Widespread	O-L	-	-	-	-	-				X	X		
Scrophulariaceae	75	*Digitalis ferruginea*	Rusty foxglove	Widespread	L	-	-	-	-	-	X	X				X	
Solanaceae	76	*Solanum nigrum*	Black nightshade	Widespread	L	-	-	-	-	-	X					X	
Tamaricaceae	77	*Tamarix spp*	Tamarix	Widespread	O-L	-	-	-	-	-	X					x	
Typhaceae	78	*Typha latifolia*	Bulrush	Widespread	O-L	-	-	-	-	-	X				X		
Urticaceae	79	*Urtica dioica*	Common netle	Europe-Siberia	O-L	-	-	-	-	-	X						X
Valerianaceae	80	*Valeriana officinalis*	Valerian	Widespread	L	-	-	-	-	-	X	X			X		

LEGEND

P.G.R.	**P**hyto-**G**eographic **R**egion
ENDEMISM	**CE**: Caucasian Endemic
HABITAT CLASSES	**1.** Watercourse, valley bed **2.** Steppes **3.** Rocky areas **4.** Woodlands
RELATIVE ABUNDANCY	**1.** Rare **2.** Moderate **3.** Abundant
IDENTIFICATION METHOD	**S:** Survey and questionnaires **O:** Observation **L:** Literature
BERN Annex-1	BERN CONVENTION **Annex – 1:** Strictly Protected Flora Species
T. S. **Threatened Status** (According to IUCN, 2008)	**CR: Critically Endangered**: Facing an extremely high risk of extinction in the wild in the immediate future **EN : Endangered:** Not critically jeopardized but facing a very high risk of extinction in the wild in the near future **VU : Vulnerable:** Not endangered but facing a high risk of extinction in the wild in the medium-term future **NT: Near-Threatened:** Not dependent upon a conservation programmed but close to qualifying for vulnerable **LC: Least Concern:** There are no current identifiable risks to the species **DD: Data-Deficient:** There is inadequate information to make an assessment of the risks to this species **NE: Not-Evaluated:** There is no evaluation to this species
CITES	**Appendix 1:** Species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances **Appendix 2:** Species is not necessarily threatened with extinction but their trade must be controlled to avoid utilization incompatible with their survival. **Appendix 3:** Species protected in at least one country, and their trading is under control by CITES in order to prevent or limit excess usage
GRDB	Georgia Red Data Book

IV.2.2.3. Vegetation Communities

The steep topography and the geological characteristics of the Mtkvari valley at the powerhouse area (Sakuneti environs), headrace tunnel area and the headworks area (Rustavi environs) affect the formation and distribution of the vegetation. The mountains surrounding the reservoir area have peaks at 800-1,200 m above sea level.

The steep slopes in the project area are covered with scattered vegetation. In general, scattered trees exist at small villages and along the river, and there are irregular short trees on mountain sides.

Four different topographic characteristics are observed in the study area:

- Watercourse (valley bed)
- Steppes (valley slopes)
- Rocky areas (valley slopes)
- Woodlands (valley shoulders and the hills)

The existing vegetation between valley bed and the hills was studied in order to find out the vegetation structure in the project area. Average plant dominance and major communities were examined for different aspects of community structure.

Basically, vegetation communities of Mtkvari Project area consist of species that are widespread followed by the ones found in the European-Siberian communities. Plant communities identified in the study area were grouped as plant communities in the valley bed, on valley slopes, and on valley shoulders and the hills.

Valley bed is generally covered by bare rocks and stones. According to the observations, the river banks are covered with limited vegetation. Potato is being cultivated in a limited flat area along the river. In the valley bed, where alluvial deposits were formed, genus of *Alnus, Acer, Quercus, Tamarix, Carpinus, Salix and Populus species* are dominant.

In the vicinity of the settlements orchards are present. These are mostly used for subsistence by the villagers. They are also used for nesting and feeding by some of the fauna species, especially birds. Mainly shrubs and trees such as genus of *Acer, Juniperus, Origanum* are observed on the slopes. Some of these shrubs can be observed in the valley bed as well as the valley slopes. They provide habitat for fauna and some of these are utilized by the villagers for subsistence.

The hills and slopes that are covered with vegetation are occupied by shrubs and juniper and oak communities. In addition to these, shrubby forms of tamarisk, berry, and rose were also recorded in this zone. Occasionally, berries are observed. This limited vegetation is suitable habitats for various mammals, reptiles and birds.

IV.2.3. Terrestrial Fauna

Field studies were conducted and the locals were communicated to determine the current fauna species composition in the study area. To establish the list of the terrestrial fauna species and evaluate the wildlife in the study area, the following methods are used:

- Review of the pertinent literature and published and unpublished databases.
- Communication with the inhabitants in the study area.
- Direct observations.

Also, data and information on the biotopes, biogenetic conservation areas, endemic species, species that under threat and important habitats for wild life was collected and assessed. Protection status of fauna elements is given according to Bern Convention and IUCN categorizations. The number of species that are classified in the IUCN, CITES, Bern and GRDB Lists with various threatening statuses are summarized in Table IV.27.

The habitats that are used by the fauna species consist of riverine habitats along the river, and cultivated lands close to these areas. In addition, there are some natural

habitats including shrubs and scattered trees as well as agricultural lands including orchards.

Table IV.27. Status of Identified Species According to IUCN, Bern, CITES and GRDB Lists

	IUCN							Bern		CITES			GRDB
	CR	EN	VU	LC	DD	NT	Total	Ann 2	Ap3	App 1	App 2	App 3	VU
Mammal	-	-		15	1	-	17	2	8	2	-	-	1
Bird	-	-	-	-	-	-	-	45	27	-	-	-	3
Reptile	-	-	1	10	-	-	11	10	11	2	1	1	1
Amphibian	-	-	1	3	-	-	4	2	4	1	-	-	1
Fish	-	-		6	1	-	7	-	10	-	-	1	1

IV.2.3.1. Mammals

In Georgia there are 108 species of mammals. These species are associated in 64 genera of 28 families that belong to 7 orders. The list of the mammal species is formed as a result of context of broad inventory records, literature surveys, and observations. The mammal species (20 of them) that are determined in the study area are given in Table IV.28 indicating their threatening status according to the national and international criteria.

Two species of the mammals are listed in Annex 2 of the Bern Convention, while 8 of them are listed in Annex 3. In addition, 17 species are classified by some IUCN category. Among these, 1 species (*Spalax leucodon*; lesser mole rat) is classified as DD (data deficient), 1 species (*Lutra lutra;* otter) is listed as NT (near threatened) and 15 species are classified as LC (Least concern).

Additionally, two species (*Canis lupus;* grey wolf and *Lutra lutra;* otter) are categorized in Appendix 1 of CITES. *Cricetulus migratorius* (grey hamster) and *Lutra lutra* (otter) are classified as VU (vulnerable) according to GRDB (Red Data Book of Georgia).

Table IV.28. Mammal (Classis: Mammalia) Species Identified in the Study Area

	Species	English Name	IUCN	Bern	CITES	GRDB	ID. M.	Habitat	Localization	Types of Impacts	Alternative Areas
1	*Sorex caucasicus*	Caucasian Shrew	LC	Ann 3	-	-	L	2-3-4	1-2-3	DC-N-D	E
2	*Pipistrellus pipistrellus*	Common pipistrelle	LC	Ann 3	-	-	S-L	1-2-3-4-5	1-2-3	DC-N-D	E
3	*Lepus europaeus*	Brown hare	LC	Ann 3	-	-	S-L	1-2-3-4-5	1-2-3	DC-N-D	E
4	*Sciurus anomalus*	Eurasian red squirrel	LC	Ann 3	-	-	S-L	4	1-2-3	DC-N-D	E
5	*Cricetulus migratorius*	Grey hamster	LC	-	-	VU	L	1-4-5	1-2-3	DC-N-D	E
6	*Cleithrionomys glareolus*	Bank vole	-	-	-	-	L	1-3-4	1-2-3	DC-N-D	E
7	*Microtus gud*	Caucasian Snow vole	-	-	-	-	L	1-4-5	1-2-3	DC-N-D	E
8	*Spalax leucodon*	Lesser mole rat	DD	-	-	-	S-L	2-5	1-2-3	DC-N-D	E
9	*Apodemus mystacinus*	Broad-toothed field mouse	LC	-	-	-	L	1-2-3-4-5	1-2-3	DC-N-D	E
10	*Rattus rattus*	Black rat	LC	-	-	-	S-L	1-2-3-4-5	1-2-3	DC-N-D	E
11	*Mus musculus*	House mouse	LC	-	-	-	S-L	1-2-3-4-5	1-2-3	DC-N-D	E
12	*Dryomys nitedula*	Forest dormice	LC	Ann 2	-	-	L	1-4-5	1-2-3	DC-N-D	E
13	*Canis lupus*	Grey wolf	LC	Ann 2	App 1	-	S-L	4	1-2-3	DC-N-D	E
14	*Canis aureus*	Golden jackal	LC	-	-	-	S-L	4	1-2-3	DC-N-D	E
15	*Vulpes vulpes*	Red fox	LC	-	-	-	S-L	1-2-4-5	1-2-3	DC-N-D	E
16	*Mustela nivalis*	Least weasel	LC	Ann 3	-	-	S-L	4-5	1-2-3	DC-N-D	E
17	*Martes foinea*	Beech marten	-	Ann 3	-	-	S-L	2-3	1-2-3	DC-N-D	E
18	*Lutra lutra*	Otter	NT	Ann 2	App 1	VU	S-L	1	1-2-3	DC-N-D	E
19	*Sus scrofa*	Feral pig	LC	Ann 3	-	-	S-L	4	1-2-3	DC-N-D	E
20	*Capreolus capreolus*	Roe deer	LC	Ann 3	-	-	S-L	4	1-2-3	DC-N-D	E

LEGEND FOR FAUNA TABLES

HABITAT CLASSES	**1.** Watercourse **2.** Steppe **3.** Rocky areas **4.** Woodlands **5.** Cultivated Areas
IUCN 2008	**CR: Critically Endangered**: Facing an extremely high risk of extinction in the wild in the immediate future **EN : Endangered:** Not critically jeopardized but facing a very high risk of extinction in the wild in the near future **VU : Vulnerable:** Not endangered but facing a high risk of extinction in the wild in the medium-term future **NT: Near-Threatened:** Not dependent upon a conservation programmed but close to qualifying for vulnerable **LC: Least Concern:** There are no current identifiable risks to the species **DD: Data-Deficient:** There is inadequate information to make an assessment of the risks to this species **NE: Not-Evaluated:** There is no evaluation to this species
BERN CONVENTION	**Annex 2 :** Strictly Protected Fauna Species **Annex 3 :** Protected Fauna Species
CITES	**Appendix 1:** Species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances **Appendix 2:** Species is not necessarily threatened with extinction but their trade must be controlled to avoid utilization incompatible with their survival. **Appendix 3:** Species protected in at least one country, and their trading is under control by CITES in order to prevent or limit excess usage
GRDB	Georgian Red Data Book
ID. M.: IDENTIFICATION METHOD	**S:** Survey, questionnaires **O:** Observation **L:** Literature **H:** Habitat Suitability
LOCALIZATION	**1.** Impoundment/Reservoir Area (Rustavi environs) **2.** Watercourse, by-pass area (between HPP and Regulator Area) **3.** Hydro-Power Plant (Sakuneti environs)
TYPES OF IMPACTS	**DC:** Discomfort **N:** Noise **D:** Dust
ALTERNATIVE AREAS	**E:** Exist **N:** Non exist

IV.2.3.2. Birds

In the study area 78 bird species have been identified through observations and confirmed by the other identification methods. The list of the identified species is given at Table IV.29 indicating the protection and threatening status of the birds according to the national and international criteria.

There is no bird species classified by IUCN and CITES categories. However, 45 species are included in the list of protected fauna species in accordance with the Annex 2 of the Bern Convention. Furthermore, 27 species are included in the list of protected fauna species in Annex 3 of the Bern Convention. In addition, 3 species (*Ciconia ciconia;* white stork, *Tadorna feruginea*; ruddy shelduck and *Buteo rufinus;* long-legged buzzard) are classified as VU (vulnerable) according to GRDB.

Table IV.29. Bird Species (Classis: Aves) Identified in the Study Area

	Species	English Name	IUCN	Bern	CITES	GRDB	ID. M.	Habitat	Localization	Types of impacts	Alternative areas
1	*Ardea cinerea*	Grey heron	-	Ann 3	-	-	S-O-H-L	1	2	DC-N-D	E
2	*Ciconia ciconia*	White stork	-	Ann 2	-	VU	S-O-H-L	1-5	1-2	DC-N-D	E
3	*Anser anser*	Greylag goose	-	Ann 3	-	-	S-O-H-L	1	1-2	DC-N-D	E
4	*Tadorna feruginea*	Ruddy shelduck	-	Ann 2	-	VU	S-O-H-L	1	1-2	DC-N-D	E
5	*Anas platyrhynchos*	Mallard	-	Ann 3	-	-	S-O-H-L	1	1-2	DC-N-D	E
6	*Anas crecca*	Teal	-	Ann 3	-	-	S-O-H-L	1	1-2	DC-N-D	E
7	*Buteo rufinus*	Long-legged buzzard	-	Ann 3	-	VU	S-O-H-L	1-2-5	1-2-3	DC-N-D	E
8	*Buteo buteo*	Buzzard	-	Ann 3	-	-	S-O-H-L	1-2-5	1	DC-N-D	E
9	*Falco tinnunculus*	Kestrel	-	Ann 2	-	-	S-O-H-L	1-2-3-5	2-3	DC-N-D	E
10	*Falco peregrinus*	Peregrine falcon	-	Ann 2	-	-	S-O-H-L	1-2-3-5	2-3	DC-N-D	E
11	*Gallinula chloropus*	Moorhen	-	Ann 3	-	-	S-O-H-L	1	2	DC-N-D	E
12	*Fulica atra*	Coot	-	Ann 3	-	-	S-O-H-L	1	2	DC-N-D	E
13	*Grus grus*	Crane	-	Ann 2	-	-	S-O-H-L	5	2	DC-N-D	E
14	*Vanellus vanellus*	Lapwing	-	Ann 3	-	-	S-O-H-L	1-5	2	DC-N-D	E
15	*Tringa hypolecos*	Comman sandpiper	-	Ann 3	-	-	S-O-H-L	1	2	DC-N-D	E
16	*Larus ridibundus*	Black-headed gull	-	Ann 3	-	-	S-O-H-L	1	2	DC-N-D	E
17	*Columba livia*	Domestic pigeon	-	Ann 3	-	-	S-O-H-L	3-5	1-2-3	DC-N-D	E
18	*Streptopelia turtur*	Turtle dove	-	Ann 3	-	-	S-O-H-L	3-5	1-2-3	DC-N-D	E
19	*Asio otus*	Long-eared owl	-	Ann 2	-	-	S-O-H-L	4	1	DC-N-D	E

Table IV.29. Bird Species (Classis: Aves) Identified in the Study Area (cont'd)

	Species	English Name	IUCN	Bern	CITES	GRDB	ID. M.	Habitat	Localization	Types of impacts	Alternative areas
20	*Athene noctua*	Little owl	-	Ann 2	-	-	S-O-H-L	4	1	DC-N-D	E
21	*Tyto alba*	Barn owl	-	Ann 2	-	-	S-O-H-L	4	1	DC-N-D	E
22	*Apus apus*	Swift	-	Ann 3	-	-	S-O-H-L	1-5	1-2-3	DC-N-D	E
23	*Alcedo atthis*	Kingfisher	-	Ann 2	-	-	S-O-H-L	1	2	DC-N-D	E
24	*Merops apiaster*	Bee-ather	-	Ann 2	-	-	S-O-H-L	1-2-5	1-2-3	DC-N-D	E
25	*Upupa epops*	Hoope	-	Ann 2	-	-	S-O-H-L	1-2-5	1-2-3	DC-N-D	E
26	*Dendrocopus syriacus*	Syrian Woodpecker	-	Ann 2	-	-	S-O-H-L	4	3	DC-N-D	E
27	*Galerida cristata*	Crested lark	-	Ann 3	-	-	S-O-H-L	2-5	1-2-3	DC-N-D	E
28	*Eremophila alpestris*	Shore lark	-	Ann 2	-	-	S-O-H-L	2-3	3	DC-N-D	E
29	*Hirundo rustica*	Swallow	-	Ann 2	-	-	S-O-H-L	1-2-5	1-2-3	DC-N-D	E
30	*Riparia riparia*	Sand martin	-	Ann 2	-	-	S-O-H-L	1-2-3	2-3	DC-N-D	E
31	*Ptyonoprogne rupestris*	Crag martin	-	Ann 2	-	-	S-O-H-L	3	3	DC-N-D	E
32	*Delichon urbica*	House martin	-	Ann 2	-	-	S-O-H-L	1-2-5	1-2-3	DC-N-D	E
33	*Motacilla flava*	Yellow wagtail	-	Ann 2	-	-	S-O-H-L	1	1-2-3	DC-N-D	E
34	*Motacilla alba*	Pied wagtail	-	Ann 2	-	-	S-O-H-L	1	1-2-3	DC-N-D	E
35	*Cinclus cinclus*	Dipper	-	Ann 2	-	-	S-O-H-L	1	2	DC-N-D	E
36	*Troglodytes troglodytes*	Wren	-	Ann 2	-	-	S-O-H-L	1	2	DC-N-D	E
37	*Prunella modularis*	Dunnack	-	Ann 2	-	-	S-O-H-L	1-4	3	DC-N-D	E

Table IV.29. Bird Species (Classis: Aves) Identified in the Study Area (cont'd)

	Species	English Name	IUCN	Bern	CITES	GRDB	ID. M.	Habitat	Localization	Types of impacts	Alternative areas
38	*Erithacus rubecula*	Robin	-	Ann 2	-	-	S-O-H-L	1-2-5	1-2-3	DC-N-D	E
39	*Luscinia megarynchos*	Nigtingale	-	Ann 2	-	-	S-O-H-L	1	2	DC-N-D	E
40	*Phoenicurus ochruros*	Black redstart	-	Ann 2	-	-	S-O-H-L	1-2-5	1-2-3	DC-N-D	E
41	*Saxicola torquata*	Stonechat	-	Ann 2	-	-	S-O-H-L	1	2	DC-N-D	E
42	*Oenanthe isabellina*	Isabelline wheather	-	Ann 2	-	-	S-O-H-L	2-3	1-2-3	DC-N-D	E
43	*Monticola saxatilis*	Rock thrush	-	Ann 2	-	-	S-O-H-L	1	1-2-3	DC-N-D	E
44	*Monticola solitarius*	Blue rock thrush	-	Ann 2	-	-	S-O-H-L	1	2	DC-N-D	E
45	*Turdus merula*	Blackbird	-	Ann 3	-	-	S-O-H-L	1-2-5	1-2-3	DC-N-D	E
46	*Turdus pilaris*	Field fare	-	Ann 3	-	-	S-O-H-L	1-2-5	1-2-3	DC-N-D	E
47	*Cettia cetti*	Cetti's warbler	-	Ann 2	-	-	S-O-H-L	1	2	DC-N-D	E
48	*Acrocephalus scheonobaenus*	Sedge warbler	-	Ann 2	-	-	S-O-H-L	1	2	DC-N-D	E
49	*Hippolais pallida*	Olivceous warbler	-	Ann 2	-	-	S-O-H-L	1	2	DC-N-D	E
50	*Sylvia hortensis*	Orphean warbler	-	Ann 2	-	-	S-O-H-L	1	2-3	DC-N-D	E
51	*Sylvia atricapilla*	Blackcap	-	Ann 2	-	-	S-O-H-L	1-4	2-3	DC-N-D	E
52	*Phylloscopus trochiloides*	Greenish warbler	-	Ann 2	-	-	S-O-H-L	1	1-2-3	DC-N-D	E
53	*Muscicapa striata*	Spotted flycatcher	-	Ann 2	-	-	S-O-H-L	1-4	1-2-3	DC-N-D	E
54	*Ficedula albicollis*	Collored flycatcher	-	Ann 2	-	-	S-O-H-L	1-4	1-2-3	DC-N-D	E

Table IV.29. Bird Species (Classis: Aves) Identified in the Study Area (cont'd)

	Species	English Name	IUCN	Bern	CITES	GRDB	ID. M.	Habitat	Localization	Types of impacts	Alternative areas
55	*Parus ater*	Coal tit	-	Ann 2	-	-	S-O-H-L	1-4	3	DC-N-D	E
56	*Parus caeruleus*	Blue tit	-	Ann 2	-	-	S-O-H-L	4	3	DC-N-D	E
57	*Parus major*	Great tit	-	Ann 2	-	-	S-O-H-L	4	2-3	DC-N-D	E
58	*Sitta neumayer*	Rock nuthatch	-	Ann 2	-	-	S-O-H-L	2-3	3	DC-N-D	E
59	*Oriolus oriolus*	Golden oriole	-	Ann 2	-	-	S-O-H-L	1	2-3	DC-N-D	E
60	*Lanius collurio*	Red-backed shrike	-	Ann 2	-	-	S-O-H-L	1-2-5	2	DC-N-D	E
61	*Lanius minor*	Lesser gray shrike	-	Ann 2	-	-	S-O-H-L	1-2-5	2	DC-N-D	E
62	*Garrulus glandarius*	Jay	-	-	-	-	S-O-H-L	1-2-5	1-2-3	DC-N-D	E
63	*Pica pica*	Magpie	-	-	-	-	S-O-H-L	1-2-3-5	1-2-3	DC-N-D	E
64	*Corvus monedula*	Jackdaw	-	-	-	-	S-O-H-L	1-2-3-5	1-2-3	DC-N-D	E
65	*Corvus frugilegus*	Field raven	-	-	-	-	S-O-H-L	1-2-3-5	1-2-3	DC-N-D	E
66	*Corvus corene orientalis*	Hooded	-	Ann 3	-	-	S-O-H-L	1-2-3-5	1-2-3	DC-N-D	E
67	*Corvus corax*	Raven	-	Ann 3	-	-	S-O-H-L	1-2-3-5	1-2-3	DC-N-D	E
68	*Sturnus vulgaris*	Starling	-	-	-	-	S-O-H-L	1-2-3-5	3	DC-N-D	E
69	*Passer domesticus*	House sparrow	-	-	-	-	S-O-H-L	1-2-3-5	1-2-3	DC-N-D	E
70	*Passer montanus*	Tree sparrow	-	Ann 3	-	-	S-O-H-L	1-2-3-5	1-2-3	DC-N-D	E
71	*Petronia petronia*	Rock sparrow	-	Ann 2	-	-	S-O-H-L	2-3	3	DC-N-D	E
72	*Fringilla coelebs*	Caffinch	-	Ann 3	-	-	S-O-H-L	1-2-3-5	1-2-3	DC-N-D	E

Table IV.29. Bird Species (Classis: Aves) Identified in the Study Area (cont'd)

	Species	English Name	IUCN	Bern	CITES	GRDB	ID. M.	Habitat	Localization	Types of impacts	Alternative areas
73	*Carduelis chloris*	Greenfinch	-	Ann 2	-	-	S-O-H-L	1-2-3-5	2-3	DC-N-D	E
74	*Carduelis carduelis*	Goldfinch	-	Ann 2	-	-	S-O-H-L	1-2-3-5	1-2-3	DC-N-D	E
75	*Carpodacus erythrinus*	Scarlet grosbeak	-	Ann 3	-	-	S-O-H-L	4	3	DC-N-D	E
76	*Pyrrhula pyrrhula*	Bullfinch		Ann 3			S-O-H-L	1-4	3	DC-N-D	E
77	*Emberiza melanocephala*	Black-headed Bunting	-	Ann 2	-	-	S-O-H-L	1-2-3-5	1-2-3	DC-N-D	E
78	*Emberiza calandra*	Corn bunting	-	Ann 3	-	-	S-O-H-L	1-2-3-5	1-2-3	DC-N-D	E

IV.2.3.3. Reptiles

In Georgia 54 species of reptiles were recorded. In the study area, 19 reptile species are determined by observations and literature study. The list of identified species is given in Table IV.30 indicating the protection and threatening status according to the national and international criteria.

In the list, 8 species are listed in Bern Convention Annex 2, while 11 of them are classified in Annex 3. According to IUCN, 9 species are classified as LC (Least Concern). No reptilian species are listed in GRDB and CITES categories.

Table IV.30. Reptilians (Classis: Reptilia) Identified in the Study Area

	Species	English Name	IUCN	Bern	CITES	GRDB	ID. M.	Habitat	Localization	Types of Impacts	Alternative areas
1	*Cyrtopodion kotschyi*	Kotschy's Gecko	LC	Ann 2	-	-	L	-	-	DC-N-D	E
2	*Agama caucasica*	Caucasian Agama	-	Ann 3	-	-	L	-	-	DC-N-D	E
3	*Lacerta agilis*	Sand lizard	-	Ann 2	-	-	O-L	-	2-3	DC-N-D	E
4	*Lacerta rudis*	Trabzon's Lizard	LC	Ann 3	-	-	L	-	-	DC-N-D	E
5	*Lacerta parvula*	Red-belied lizard	LC	Ann 3	-	-	L	-	-	DC-N-D	E
6	*Lacerta valentini*	Valentin's Lizard	-	Ann 3	-	-	L	-	2-3	DC-N-D	E
7	*Lacerta strigata*	Caspian green lizard	LC	Ann 3	-	-	O-L	-	-	DC-N-D	E
8	*Lacerta trilineata*	Balkan Green lizard	LC	Ann 2	-	-	L	-	-	DC-N-D	E
9	*Ophisaurus apodus*	European Legless lizard	-	Ann 2	-	-	S-L	-	5	DC-N-D	E
10	*Typlops vermicularis*	Worm snake	-	Ann 3	-	-	L	-	-	DC-N-D	E
11	*Coluber najadum*	Dahl's Whip snake	LC	Ann 2	-	-	L	-	-	DC-N-D	E
12	*Coluber ravergieri*	Mountain racer	-	Ann 3	-	-	L	-	-	DC-N-D	E
13	*Coluber schmidti*	Red snake	-	Ann 3	-	-	L	-	-	DC-N-D	E
14	*Eirenis modestus*	Ring-headed dwarf snake	LC	Ann 3	-	-	L	-	-	DC-N-D	E
15	*Elaphe hohenacheri*	Transcaucasian Ratsnake	-	Ann 3	-	-	L	-	-	DC-N-D	E
16	*Natrix natrix*	Grass snake	LC	Ann 3	-	-	S-O-L	-	1	DC-N-D	E
17	*Natrix tasellata*	Dice snake	-	Ann 2	-	-	L	-	-	DC-N-D	E
18	*Vipera ammodytes*	Transcaucasian Long-nosed viper	LC	Ann 2	-	-	L	-	-	DC-N-D	E
19	*Vipera labetina*	Levantine viper	-	Ann 2	-	-	L	-	-	DC-N-D	E

IV.2.3.4. Amphibians

There are 12 species of amphibians found in Georgia and 6 of them are distributed within the study area. In the study area, 3 common amphibian species (*Pseudepidalea viridis:* European green toad*; Rana ridibunda:* marsh frog *and Hyla arborea:* European tree frog) are determined via observation. Additionally, 3 species (*Mertensiella caucasica:* Caucasian salamander; *Rana camerani:* banded frog; *Pelodytes caucasicus*: Caucasian parsley frog) are identified in accordance with the relevant literature.

These species are given in Table IV.31. According to Annex 2 of Bern Convention, 2 of them are strictly protected fauna species while 4 of them are listed as protected fauna species in Annex 3. In addition, 1 (*Mertensiella caucasica:* Caucasian salamander) amphibian species are classified as VU (vulnerable) in IUCN Red List and GRDB. The protection and threatening status of the amphibians identified are given in Table IV.31 according to the national and international criteria.

Table IV.31. Amphibians (Classis: Amphibia) Identified in the Study Area

	Species	English Name	IUCN	Bern	CITES	GRDB	ID. M.	Habitat	Localization	Types of impacts	Alternative Areas
1	*Mertensiella caucasica*	Caucasian Salamander	VU	Ann 3	-	VU	H-L	1		DC-D	E
2	Pseudepidalea viridis	European Green toad	LC	Ann 3	-	**-**	S-O-H-L	1-4-5	1-2-3	DC-D	E
3	*Rana ridibunda*	Marsh frog	-	Ann 3	-	**-**	S-O-H-L	1-5	1-2-3	DC-D	E
4	*Rana camerani*	Banded frog	-	Ann 3	-	**-**	H-L	1-5		DC-D	E
5	*Pelodytes caucasicus*	Caucasian Parsley frog	LC	Ann 2	-	**-**	H-L	1-5		DC-D	E
6	*Hyla arborea*	European Tree frog	LC	Ann 2	App 3	**-**	S-O-H-L	1	1-2-3	DC-D	E

IV.2.4. Fish Species in the Study Area

To determine to the fish fauna in the Mtkvari River System field studies were conducted in the study area, which included observations and surveys conducted with local fishermen. These studies were also supported by literature records (Kuru, 1975; URL-12). As a result of these studies, 13 fish species were identified as provided in Table IV.32.

None of these fish species are endemic for Georgia. Due to the nature of the project, the potential impacts on the fish species are more important when compared with the possible impacts on other biological resources. Therefore, the biological characteristics of the fish species are given special importance. Accordingly, the biological properties of each fish species identified in the study area and their habitat requirements are summarized in detail in Tables IV.33-45.

Table IV.32. Freshwater Fish (Pisces) Species Identified in the Mtkvari River System

	Order	Family	*Taxon*	Name	GRDB	IUCN 2008	BERN	Identification Method	Possibility of Impact	Environment
1	Cypriniformes	Cyprinidae	*Acanthalburnus microlepis*	Blackbrow bleak	-	-	-	L	low	benthopelagic
2	Cypriniformes	Cyprinidae	*Alburnoides bipunctatus*	Spirlin	-	LC	Annex III	O-L-S	low	benthopelagic; potamodromous
3	Cypriniformes	Cyprinidae	*Alburnus filippii*	Kura bleak	-	-	-	L	low	benthopelagic
4	Cypriniformes	Cyprinidae	*Aspius aspius*	Asp	-	LC	Annex III	L	low	benthopelagic
5	Cypriniformes	Cyprinidae	*Barbus lacerta*	Kura barbel	-	-	Annex III	O-L-S	low	benthopelagic
6	Cypriniformes	Cyprinidae	*Capoeta capoeta*	Transcaucasian Barb	-	-	Annex III	O-L-S	low	benthopelagic
7	Cypriniformes	Cyprinidae	*Chondrostoma cyri*	Kura nase	-	-	Annex III	L	low	benthopelagic
8	Cypriniformes	Cyprinidae	*Cyprinus carpio*	Common carp	-	DD	-	O-L-S	low	benthopelagic
9	Cypriniformes	Cyprinidae	*Gobio gobio*	Gudgeon	-	LC	Annex III	L	low	benthopelagic
10	Cypriniformes	Cyprinidae	*Squalius cephalus*	European Chub	-	LC	Annex III	O-L-S	low	benthopelagic
11	Cypriniformes	Cyprinidae	*Tinca tinca*	Tench	-	LC	Annex III	S-L	low	demersal
12	Cypriniformes	Balitoridae	*Barbatula brandtii*	Kura loach	-	-	Annex III	S-L	low	demersal
13	Salmoniformes	Salmonidae	*Salmo trutta fario*	Brown Trout	VU	LC	Annex III	L	low	demersal

KEY

Demersal : A **demersal fish** is a fish that feeds on or near the bottom of the river or a deep lake in the demersal zone. Demersal fish are also known as bottom feeders, ground fish or benthic fish, and may be contrasted with pelagic fish.

Benthopelagic : Relating to, living on, or occurring on the bottom or mid-waters of a body of water, feeding on benthic and free swimming fish.

Table IV.33. Facts Sheet of *Acanthalburnus microlepis*

Species-1	***Acanthalburnus microlepis***
Common Name	Blackbrow bleak
Family	Cyprinidae (Minnows or carps)
Order	Cypriniformes (carps)
Maximum size	25.0 cm Total Length
Environment	Benthopelagic,
Global Importance	None
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years
Distribution	Former USSR: Endemic to the Kura-Aras basin (Ref. 1441). Probably also in Sefid of Iran. Distributed in the upper and middle reaches of Kura with tributaries downstream to Mingetchiaur and of Aras downstream to Karadonly (Azerbaijan).
Biology	Inhabits rivers and lakes
Threatened	NE: Not Evaluated, see IUCN Red List, 2008
Main Reference	Bogustkaya, N.G. 1997
Georgia country information	
Status	Native (FAO, 1996)
Salinity	Freshwater
Uses	No use
Regulation	No regulation
Comments	Type locality: Kura River, near Tbilisi, Georgia)
References	Kuru 1971; Kuru 1975; Bogutskaya 1997; Eschmeyer 1998; Geldiay and Bal k, 2007.

Table IV.34. Facts Sheet of *Alburnoides bipunctatus*

Species-2	***Alburnoides bipunctatus***
Common Name	Spirlin
Family	Cyprinidae (Minnows or carps)
Order	Cypriniformes (carps)
Maximum size	16.0 cm Total Length Max. published weight: 30,0 g
Environment	Benthopelagic; potamodromous; pH range: 7 – 8
Global Importance	Fisheries: of no interest; aquarium: commercial; bait: usually
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years
Distribution	Europe and Asia: basins of Biscay Bay, the North, Baltic, Black, Caspian and Aral seas, in Vardar and Struma rivers of the Aegean basin, in the Tigris-Euphrates river system, in the Reza'iyeh Lake basin, and in some other localities in Iran.
Biology	Inhabits rivers with very calm waters. Feeds on insect larvae and dead insects (as well as on crustaceans and diatoms). Reproduction occurs in April to June
Threatened	LC: Least Concern, see IUCN Red List, 2008 Appendix III of the Bern Convention (protected fauna).
Main Reference	Bogustkaya, N.G. 1997
Georgia country information	
Status	Native (FAO, 1996)
Salinity	Freshwater
Uses	No uses
Regulation	No regulation
References	Kuru 1971; Kuru 1975; Bogutskaya 1997; Geldiay and Bal k, 2007; Reshetnikov et al 1997.

Table IV.35. Facts Sheet of *Alburnus filippii*

Species - 3	***Alburnus filippii***
Common Name	Kura bleak
Family	Cyprinidae (Minnows or carps)
Order	Cypriniformes (carps)
Maximum size	16.0 cm Total Length
Environment	Benthopelagic, freshwater
Global Importance	None
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years
Distribution	Former USSR: Basin of the Kura (from the upper to the lower reaches with the tributaries) and the Aras (also lakes of Chaldyr-gel and Aiger-gel), rivers of the Lenkoran District and Safid-rud
Biology	Inhabits rivers with very calm waters. Feeds on insect larvae and dead insects (as well as on crustaceans and diatoms). Reproduction occurs in April to June
Threatened	NE: Not Evaluated see IUCN Red List, 2008
Main Reference	Bogustkaya, N.G. 1997
Georgia country information	
Status	Native (FAO, 1996)
Salinity	Freshwater
Uses	No uses
Regulation	No regulation
Comments	Typical locality: Upper Kura River
References	Berg 1964; Kuru 1971; Kuru 1975; Geldiay and Bal k 2007.

Table IV.36. Facts Sheet of *Aspius aspius*

Species - 4	***Aspius aspius***
Common Name	Asp
Family	Cyprinidae (Minnows or carps)
Order	Cypriniformes (carps)
Maximum size	100.0 cm Total length Max. published weight: 9,000 g Max. reported age: 11 years
Environment	Benthopelagic; potamodromous ; depth range - 10 m
Global Importance	Fisheries: commercial; aquaculture: commercial
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years
Distribution	European waters, except for Denmark, Great Britain and southern regions. Large rivers draining to North Sea (Weser, Elbe), Baltic Sea (southern tributaries, Norway east of Oslo, southern Sweden, Kokemären drainage in southern Finland), Black Sea, Sea of Azov and Caspian Sea; Aegean Sea basin, from Maritza to Lake Volvi drainages. Introduced in Rhine, Northern Dvina and Lake Balkhash (Asia)
Biology	Adults inhabit lower reaches of rivers and estuaries. Prefer to stay near bridge pillars, near tributaries, under weirs, in deep currents and overgrown parts of river and in quiet bays of river bends. One of the rare cyprinids which are piscivore; also feed on small aquatic birds. Migrate upstream in tributaries for spawning in April-June Juveniles and adults feed predominantly on fish, especially on *Alburnus alburnus* or *Osmerus eperlanus*
Threatened	LC: Least Concern see IUCN Red List, 2008 Appendix III of the Bern Convention (protected fauna).
Main Reference	Vostradovsky, J. 1973
Georgia country information	
Status	Native (FAO, 1996)
Salinity	Freshwater, brakishwater
Uses	No uses
Regulation	No regulation
References	Kuru 1971; Kuru 1975; Vostradovsky 1973; Geldiay and Bal k 2007.

Table IV.37. Facts Sheet of *Barbus lacerta*

Species -5	***Barbus lacerta***
Common Name	Kura barbel
Family	Cyprinidae (Minnows or carps)
Order	Cypriniformes (carps)
Maximum size	37.5 cm Total length Max. published weight: 9,000 g Max. reported age: 11 years
Environment	Benthopelagic
Global Importance	None
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years
Distribution	Europe and Asia.
Biology	Inhabits rivers and lakes
Threatened	NE: Not Evaluated see IUCN Red List, 2008 Appendix III of the Bern Convention (protected fauna).
Main Reference	Berg 1964
Georgia country information	
Status	Native (FAO, 1996)
Salinity	Freshwater
Uses	N
Regulation	No regulation
Comments	Typical locality: Kura R. near Tiflis
References	Kuru 1971; Kuru 1975; Eschmeyer 1998; Geldiay and Bal k 2007.

Table IV.38. Facts Sheet of *Capoeta capoeta*

Species - 6	***Capoeta capoeta***
Common Name	Transcaucasian barb
Family	Cyprinidae (Minnows or carps)
Order	Cypriniformes (carps)
Maximum size	41 cm Total length
Environment	Benthopelagic; potamodromous
Global Importance	Fisheries: commercial
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years
Distribution	Asia: Baluchistan in Pakistan, and western Asia. Also former USSR
Biology	Inhabits mainly the drier parts as well as the upper reaches of rivers in mountains and the lower reaches which sometimes end in marshes or deserts. Feeds primarily on plants. Spawns mostly on stony ground in rivers
Threatened	NE: Not Evaluated see IUCN Red List, 2008 Appendix III of the Bern Convention (protected fauna).
Main Reference	Talwar, P.K. and A.G. Jhingran 1991
Georgia country information	
Status	Native (FAO, 1996)
Salinity	Freshwater
Uses	No uses
Regulation	No regulation
References	Kuru 1971; Kuru 1975; Blanc et al., 1971; Geldiay and Bal k 2007.

Table IV.39. Facts Sheet of *Chondrostoma cyri*

Species - 7	***Chondrostoma cyri***
Common Name	Kura nose
Family	Cyprinidae (Minnows or carps)
Order	Cypriniformes (carps)
Maximum size	21,5 cm Total length
Environment	Benthopelagic
Global Importance	Fisheries: commercial
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years
Distribution	Former USSR: Kura River basin, southeastern Caucasus.
Biology	Feeds on plants, flying insects and larvae of aquatic insects
Threatened	NE: Not Evaluated see IUCN Red List, 2008 Appendix III of the Bern Convention (protected fauna).
Main Reference	Elvira, 1997
Georgia country information	
Status	Native (FAO, 1996)
Salinity	Freshwater
Uses	No uses
Regulation	No regulation
References	Kuru 1971; Kuru 1975; Elvira 1997; Geldiay and Bal k 2007.

Table IV.40. Facts Sheet of *Cyprinus carpio*

Species - 8	***Cyprinus carpio***
Common Name	Common carp
Family	Cyprinidae (Minnows or carps)
Order	Cypriniformes (carps)
Maximum size	• Max. published length: 120 cm Standard Length • Max. published weight: 40.1 kg • Max. reported age: 38 years
Environment	Benthopelagic; potamodromous; pH range: 7 - 7.5
Global Importance	Fisheries: highly commercial; aquaculture: commercial; aquarium: commercial
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years
Distribution	• Europe to Asia: Europe, Russia, China, India and South-East Asia. • Occur at a temperature range of 3-35°C. • Hardy and tolerant of a wide variety of conditions but generally favor large water bodies with slow flowing or standing water and soft bottom sediments. • Common carp thrive in large turbid rivers.
Biology	• They are omnivorous, feeding mainly on aquatic insects, crustaceans, annelids, mollusks, weed and tree seeds, wild rice, aquatic plants and algae; mainly by grubbing in sediments. • Spawn in spring and summer, laying sticky eggs in shallow vegetation. • A female 47 cm in length produces about 300,000 eggs. • Young are probably preyed upon by northern pike, muskellunge, and largemouth bass. • Adults uproot and destroy submerged aquatic vegetation and therefore may be detrimental to duck and native fish populations.
Threatened	DD: Data deficient, see IUCN Red List, 2008
Main Reference	Kottelat, 1997
Georgia country information	
Status	Native (FAO, 1996)
Salinity	Freshwater
Importance	Minor commercial (FAO, 1992)
Aquaculture	Commercial (FAO, 2006)
References	Blanc et al 1971; Kuru 1971; Kuru 1975; ; Geldiay and Bal k 2007.

Table IV.41. Facts Sheet of *Gobio gobio*

Species -9	***Gobio gobio***
Common Name	Gudgeon
Family	Cyprinidae (Minnows or carps)
Order	Cypriniformes (carps)
Maximum size	20 cm Total length
Environment	benthopelagic; potamodromous; pH range: 7 - 7.5
Global Importance	fisheries: commercial; aquarium: commercial; bait: usually
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years
Distribution	Europe: throughout the continent (except Spain, central and southern Italy, Greece, Scotland, Norway, northern Sweden, northern Finland) as far north as 61°40'N; the Volga as far as the delta; absent from Asia Minor; absent from the Pacific slope of Siberian rivers. Occurs as far east as Korea.
Biology	Inhabits fast flowing rivers with sand or gravel bottom but may also occur in still waters. Forms schools. Feeds on insect larvae, mollusks, and crustaceans. Normally active during the day but if they are disturbed, in particular, by predators; they can defer their activity to periods when light intensity is weak. Capable of emitting squeaking sounds. These vocalizations, which are a means by which fish communicate with each other, vary with the degree of activity and the temperature and are independent of the season of reproduction. Eggs are released above substrate and drift with current, sinking to bottom and sticking to substrate. Larvae and juveniles are benthic and prefer detritus-rich sandy habitats and low current.
Threatened	LC: Least Concern see IUCN Red List, 2008 Appendix III of the Bern Convention (protected fauna).
Main Reference	Muus, B.J. and P. Dahlström 1968
Georgia country information	
Status	Native (FAO, 1996)
Salinity	Freshwater
Uses	No uses
Regulation	No regulation
References	Blanc et al 1971; Muus and Dahlström 1968; Kuru 1971; Kuru 1975; Geldiay and Bal k 2007.

Table IV.42. Facts Sheet of *Squalius cephalus*

Species-10	***Squalius cephalus***
Common Name	European Chub
Family	Cyprinidae (Minnows or carps)
Order	Cypriniformes (carps)
Maximum size	60 cm Total length¸ Max. published weight: 8,000 g; Max. reported age: 22 years
Environment	Benthopelagic; potamodromous; pH range: 6 - 7.8
Global Importance	-
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years
Distribution	Eurasia: widely distributed in the basins of the North Sea, the Baltic Sea, the Black Sea and the Sea of Azov, in western Caspian drainage from Volga and Ural to Iran and in the Tigris-Euphrates basin.
Biology	Adults occur in creeks and fast flowing rivers, occasionally in lakes. Enter brackish water in the eastern Baltic. Feed on algae, bits of vegetation and various seeds that have fallen into the water. Also feed on worms, mollusks, crustaceans, and various insect larvae; large chub eat considerable numbers of small fish, such as chub, eels, dace, roach, gudgeon and minnows; also frogs, crayfish, voles and young water birds. Pale yellow eggs are found attached to gravel, weed and stones in flowing water.
Threatened	LC: Least Concern see IUCN Red List, 2008 Appendix III of the Bern Convention (protected fauna).
Main Reference	Kottelat and Economidis,2006
Georgia country information	
Status	Native (FAO, 1996)
Salinity	Freshwater
Uses	No uses
Regulation	No regulation
References	Blanc et al 1971; Kuru 1971; Kuru 1975; Geldiay and Bal k 2007.

Table IV.43. Facts Sheet of *Tinca tinca*

Species -11	***Tinca tinca***
Common Name	Tench
Family	Cyprinidae (Minnows or carps)
Order	Cypriniformes (carps)
Maximum size	70 cm Standard length¸ max. published weight: 7,500 g
Environment	demersal; potamodromous ; depth range - 1 m
Global Importance	Fisheries: commercial; aquaculture: commercial; aquarium: public aquariums
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years
Distribution	Eurasia: all of Europe, including the British Isles. Arctic Ocean drainage, Ob and Yenisei basins, and rarely in Lake Baikal
Biology	Adults inhabit warm lakes and pools with weed and mud bottom. Tolerant of low oxygen saturations. Occur in still or slow-flowing waters, often among dense vegetation In winter, they stay in the mud without feeding. Omnivorous. Adults feed on bottom invertebrates and aquatic insect larvae. Young also feed on algae. Breed in shallow water among dense vegetation, laying numerous sticky green eggs. After hatching the larvae remain attached to the plants for several days. Used as a fodder fish for bass.
Threatened	LC: Least Concern see IUCN Red List, 2008 Appendix III of the Bern Convention (protected fauna).
Main Reference	Kottelat 1997
Georgia country information	
Status	Native (FAO, 1996)
Salinity	Freshwater
Uses	No uses
Regulation	No regulation
References	Blanc et al 1971; Kuru 1971; Kuru 1975; Kottelat 1997; Geldiay and Bal k 2007.

Table IV.44. Facts Sheet of *Barbatula brandtii*

Species-12	***Barbatula brandtii***
Common Name	Kura loach
Family	Balitoridae
Order	Cypriniformes (carps)
Maximum size	6,6 cm Standard length¸
Environment	Demersal; pH range: 7; dH range: 20
Global Importance	None
Resilience	High, minimum population doubling time less than 15 months
Distribution	Former USSR: Armenia and Azerbaijan. Asia: Turkey and Iran.
Biology	Adults inhabit warm lakes and pools with weed and mud bottom. Tolerant of low oxygen saturations. Occur in still or slow-flowing waters, often among dense vegetation In winter, they stay in the mud without feeding. Omnivorous. Adults feed on bottom invertebrates and aquatic insect larvae. Young also feed on algae. Breed in shallow water among dense vegetation, laying numerous sticky green eggs. After hatching the larvae remain attached to the plants for several days. Used as a fodder fish for bass.
Threatened	NE: Not Evaluated see IUCN Red List, 2008 Appendix III of the Bern Convention (protected fauna).
Main Reference	Kottelat 1997
Georgia country information	
Status	Native (FAO, 1996)
Salinity	Freshwater
Uses	No uses
Regulation	No regulation
References	Kuru 1971; Kuru 1975; Baillie and Groombridge 1996; Kottelat 1997; Nalbant and Bianco 1998; Geldiay and Bal k 2007

Table IV.45. Facts Sheet of *Salmo trutta fario*

Species-13	***Salmo trutta fario***
Common Name	Brown trout
Family	Salmonidae (trout's)
Order	Salmoniformes (trout's)
Maximum size	100.0 cm max. published weight: 20.0 kg max. reported age: 8 years
Environment	Demersal; anadromous freshwater; brackish; marine; depth range 0,1–10 m
Global Importance	None
Resilience	High, minimum population doubling time less than 15 months
Distribution	Atlantic, North, White and Baltic Sea basins, from Spain to Chosha Bay (Russia). Present in Iceland and in northernmost rivers of Great Britain and Scandinavia. In Rhône drainage, native only to Lake Geneva basin, which it entered after last glaciation. Native to upper Danube and Volga drainages. Introduced throughout Europe, North and South America, southern and montane eastern Africa, Pakistan, India, Nepal, Japan, New Zealand and Australia. Andorra; Austria; Belarus; Belgium; Croatia; Czech Republic; Denmark; Estonia; Faroe Islands; Finland; France; Germany; Guernsey; Hungary; Iceland; Ireland; Isle of Man; Italy; Jersey; Latvia; Liechtenstein; Lithuania; Luxembourg; Moldova; Netherlands; Norway; Poland; Portugal; Romania; Russian Federation; Serbia; Slovakia; Slovenia; Spain; Sweden; Switzerland; Ukraine; United Kingdom ***Taxonomic Note:*** *Genetic data indicate that S. trutta and some populations of hybrid origin are native in some rivers draining to the Mediterranean, the Black Sea (at least in upper Danube drainage) and the Caspian Sea (at least in upper Volga drainage). The present published data do not always enable to distinguish the head water populations of the different species on the basis of morphological characters (they may be distinguishable, but this simply has not been investigated).*

Table IV.45. Facts Sheet of *Salmo trutta fario* (cont'd)

Species-13	***Salmo trutta fario***
Biology	Cold streams, rivers and lakes. Spawns in rivers and streams with swift water. Lacustrine populations migrate to tributaries and lake outlets, rarely spawning on stone, wave-washed lake shores. Spawning sites usually characterized by downward movement of water into gravel. Sea and lake trout's forage in pelagic and littoral habitats, sea trout's mostly close to coast, not very far from estuary of natal river. Anadromous, Lacustrine and resident ecotypes. Spawns in couples between late October and March, usually in November-December.
Threatened	LC: Least Concern see IUCN Red List, 2008 Appendix II of the Bern Convention (strictly protected fauna).
Main Reference	Svetovidov, A.N. 1984
Georgia country information	
Status	Native
Salinity	Freshwater
Uses	Fish farming
National Status	**VU: Vulnerable**
References	Kuru 1971; Kuru 1975; Svetovidov, A.N. 1984 Baillie and Groombridge 1996; Kottelat 1997; Nalbant and Bianco 1998; Geldiay and Bal k 2007.

IV.2.5. Aquatic Habitat Characteristics

During the field surveys, lots of riparian habitats are observed in Sakuneti (powerhouse area) and Rustavi (headworks area) areas. Foundation of the watercourse is generally formed with pudding stones and large stones, where the river banks are mostly sandy areas.

The studies (including literature survey, field observations and communication with locals) revealed that from Cyprinidae Family; *Acanthalburnus microlepis (*Blackbrow bleak), *Alburnoides bipunctatus (*Spirlin), *Alburnus filippii (*Kura bleak), *Aspius aspius (Asp), Barbus lacerta (*Kura barbel), *Capoeta capoeta (*Transcaucasian barb), *Chondrostoma cyri (*Kura nose), *Cyprinus carpio (*Common carp), *Gobio gobio (*Gudgeon), *Squalius cephalus (*European Chub), *Tinca tinca(*Tench); from Balitoridae Family, *Barbatula brandtii (*Kura loach) and from Salmonidae Family; *Salmo trutta fario (*Brown trout) exist in the watercourse (Mtkvari River System).

Most of the identified fish species are **benthopelagic** *(living on, or occurring on the bottom or mid-waters of a body of water, feeding on benthic and free swimming fish),* **potamodromous** *(migrate within fresh water only)* and **demersal** fish *(feeds on or near the bottom of the river or a deep lake in the demersal zone, also known as bottom feeders, ground fish or benthic fish, and may be contrasted with pelagic fish).* Most of them are able to live in rivers and lakes. Their ecological tolerances are very flexible in accordance with the water quality, so they can live in contaminated and brackish waters. They can also survive in shallow streams and calm parts of the rivers and creeks.

According to literature, one of the most significant fish species in the project area is brown trout (*Salmo trutta fario*, from Salmonidae Family) which is considered to be dominant in project's tributaries (i.e. Uravelli Stream). It is known that brown trout is capable of living at mountain watercourses that is described as trout zone.

The national and international threatening status of the fish species, identified in the study area, are summarized at Table IV.32. Accordingly, *Alburnoides*

*bipunctatus (*Spirlin), *Aspius aspius (Asp), Barbus lacerta (*Kura barbel), *Capoeta capoeta (*Transcaucasian barb), *Chondrostoma cyri (*Kura nase), *Gobio gobio(*Gudgeon), *Squalius cephalus(*European Chub), *Tinca tinca(*Tench); *Barbatula brandtii (*Kura loach) and *Salmo trutta fario (*Brown trout) are listed in Annex 3 of Bern Convention. Moreover, *Salmo trutta fario* which is considered to exist in the tributaries of the main Mtkvari River is classified as "VU: Vulnerable" in GRDB.

The identified fish species at project area are mainly from Cyprinidae Family and their spawning period is between May-July. In this reproductive period, flow of the river is high and fish prefer low flow and shallow areas. Generally the optimum water depth should be 10-50 cm while flow velocity should be 20-50 cm/sec for spawning of these fish species (Cowx and Welcomme, 1998). It was observed that lots of such places/locations exist in the study area and its vicinity to provide the optimum conditions for these species. Except the brown trout, none of the identified fish are migratory. The brown trout travels to upper reaches of the river or its clear tributaries for breeding. As mentioned above, this species mainly exists in the tributaries of the Mtkvari River such as Uravelli Stream and other small creeks and will continue to survive and breed in these tributaries, including the ones upstream of the Mtkvari Reservoir. Accordingly, suitable spawning areas will exist for fish during the operational phase of the project as well. Within the scope of Mtkvari Project, garblers that have suitable pore openings will be located before the stabilization ponds in order to prevent fish escape to grandstands.

IV.2.6. Species of International Concern

Historically, most of the international communities, especially the European Community, have shown a growing interest in protecting native plants, wildlife and fisheries. In the second half of the last century, International Union for the Conservation of Nature and Natural Resources (IUCN) has identified species in need of protection. For that purpose, such species are included in the "IUCN (or European) Red List". Furthermore, Council of Europe enacted the Convention of Bern to protect species of international concern in 1979.

The Convention of Bern is intended to provide broad protection to nature in Europe, for preservation and improvement of the biodiversity, promoting national policies for the conservation of wild flora, fauna and natural habitats, conservation of wild flora and fauna in planning and development and in measures against pollution, promoting conservation education, and encouraging and coordinating research related to these objectives.

In providing broad protection, the Convention of Bern divides the fauna species of concern into three categories, while all plant species protected under the Convention of Bern are listed in Annex 1, “Strictly Protected Flora Species”. Signatory nations agree to prohibit all forms of capture, keeping, and deliberate killing, destruction to breeding or resting areas, disturbance during breeding, rearing, or hibernation, destruction or taking of eggs, and international trade in live or dead animals or their parts (Council of Europe, 1979). No Bern-listed plants were found among the 80 species identified during the field studies. Annex 2 lists fauna species that are to be "strictly protected" that may or may not be threatened or endangered in the designation of the IUCN.

The second category for fauna species is Annex 3, "protected". These species are to be provided legislative and administrative protection to ensure that their populations are maintained. Protection and management of habitat is indicated. Measures specified include closed hunting seasons and/or local prohibition on hunting, regulation of the sale of live or dead wild animals, and regulation of indiscriminate hunting or capture that might affect species in Annex 3.

The third category of species under the Bern Convention is for those not signed for a specific protection. Although the individual species are not listed, the Convention protects these species through the habitat protection aspects of the agreement.

The Georgian Government enacted legislation that addresses the habitat protection concerns of the Convention of Bern, designating areas having special environmental protection. These areas are protected by various regulations to preserve their natural, cultural, or historical values.

The IUCN Red List, on the other hand, is intended to draw attention to species that the populations actually are at risk or in peril. The IUCN places species on the Red List only after a study of its population and the reasons for its decline. Some countries pay greater attention to IUCN-listed species than to Bern-listed species as the Red List relies on more research. In the IUCN Red Listing only the three categories Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) implies threatened species. Thus, this is being used as a key indicator in the impact assessment.

The plant, wildlife and fish species found in the project area are listed in tables of the sections of this ESIA report. Species listed by the IUCN or the Convention of Bern are so designated in the respective tables. None of the species identified in the Mtkvari Project area are listed by the IUCN as critically endangered and endangered or vulnerable, but many are listed by the Convention of Bern as “protected” (Annex 3), or as “strictly protected” (Annex 2). Therefore, project impacts on the habitats of these species (especially those used for breeding) will be given importance, so that the local populations are not extirpated.

The extent to which the various groups of plants and animals in the Mtkvari Project area are protected under the Bern Convention or cited on the Red List varies from one group to another. No plants identified during this study of the project area are listed by the IUCN or the Convention of Bern.

Consequently, within the scope of the mammals, two species are listed in Annex 2 of Bern Convention, while 8 species are included in Annex 3. According to IUCN, a total of 17 species are classified under protection, 1 species (*Spalax leucodon*; lesser mole rat) is classified as DD (data deficient), 1 species (*Lutra lutra;* otter) is classified as NT (near threatened) and 15 species of them are classified as LC (Least concern).

Additionally, two species (*Canis lupus:* grey wolf and *Lutra lutra;* otter) are categorized in Appendix 1 according to CITES. Also Two species (*Cricetulus*

*migratorius: g*rey hamster and *Lutra lutra;* otter) are classified as VU (vulnerable) according to GRDB.

Virtually all the birds of the region are protected under Annex 2 or Annex 3 of Bern Convention with the exception of eleven species that are considered to be crop pests or commensals with human habitation. Hence, it is inevitable that nearly all bird species in the project area are listed by the Convention of Bern. No IUCN-listed birds are known to breed in the project area, however; migration routes of some of the birds could be in the project area or the birds could visit in winter.

There are no birds species classified in IUCN and CITES categories. However, 45 species are included in Annex 2 and 27 species are included in Annex 3 of Bern Convention in the list of protected fauna species. Furthermore, 3 species (*Ciconia ciconia:* white stork, *Tadorna feruginea*; ruddy shelduck and *Buteo rufinus;* long-legged buzzard) are classified as VU (vulnerable) according to GRDB.

In the context of reptilians, 19 species are determined by observations and literature study. Among these, 8 species are listed in Annex 2 and 11 species are included in Annex 3 of Bern Convention. According to IUCN, 9 species are classified as LC (Least Concern). There are no reptilian species listed in GRDB or CITES.

In the study area 6 amphibian species were identified. Among those 6 species, 2 of amphibians are listed as strictly protected fauna species in Annex 2 and 4 of them are listed as protected fauna species in Annex 3 of Bern Convention while *Mertensiella caucasic:* (Caucasian salamander) is classified as VU (vulnerable) in IUCN Red List and GRDB.

When the threatening status of fish species was studied, it was determined that *Alburnoides bipunctatus (*Spirlin), *Aspius aspius (Asp), Barbus lacerta (*Kura barbel), *Capoeta capoeta (*Transcaucasian barb), *Chondrostoma cyri (*Kura nase), *Gobio gobio(*Gudgeon), *Squalius cephalus (*European Chub), *Tinca tinca(*Tench); *Barbatula brandtii (*Kura loach) and *Salmo trutta fario (*Brown trout) are listed in

Annex 3 in Bern Convention. *Salmo trutta fario* which exists in the tributaries of the Mtkvari River is classified under “VU: Vulnerable” category in GRDB.

IV.3. Socio-Economic Environment

The project's socio-economic effects, which might occur during the construction and operation phases, will mostly affect the project area and the surrounding close by settlement areas. Mtkvari HPP Project is taking place within the borders of Akhaltsikhe and Aspindza Districts. During the construction and operation phases of the project, there will be impacts on the people living in the project area and its close vicinity. Settlements, which would be affected by the projects units and activities, are:

- Rustavi Village, Aspindza District (close to the headworks)
- Sakuneti Village, Akhaltsikhe District (close to the powerhouse)

The settlement areas will be partially affected by dam axis and reservoir mainly because of the small-scale expropriation of cultivated land and construction period effects such as dust, noise, and traffic. Similarly, the region around the hydroelectric power plant will be affected by the construction activities. Since the headrace tunnel is underground, the impacts will be associated with the service roads to the adits. Hence, the settlements would be mainly affected due to the construction actions.

In order to assess the socio-economic characteristics of the concerned project (and impact) area and to set the existing socio-economic structure, the results of 2002 census done by Department of Statistics of Georgia is evaluated along with the project data attained by the questionnaire conducted at the settlement areas mentioned above, which will be affected by the project.

IV.3.1. General Information about Georgia

Georgia's main economic activities include the cultivation of agricultural products; manganese and copper mining; and output from a small industrial sector: steel, aircraft, machine tools, electrical appliances, chemicals, wood products, and wine. The bulk of its energy needs are covered through import, including natural gas and oil products. Its hydropower capacity is rather underdeveloped. The country is

pinning hopes for long-term growth on its role as a transit state for pipelines and trade (Georgia ETF Country Plan, 2009).

In 2007, Georgian economy expanded by 12%. GDP growth is expected to be driven mainly by industrial output, construction and investment activities related to the South Caucasus gas pipeline. Georgia ranks 90 out of 131 countries in terms of economy, and further development of the economy and human capital is necessary in order to increase the global competitive index. Economic development is characterized by a large share of individual enterprises, with small employment capacity, and a large informal economy (Statistical Yearbook of Georgia, 2008).

The high poverty level is still a serious challenge with one third of the population living below the poverty line. Despite recent economic growth, about 11% of Georgian students are still living below the poverty line. The main determinants of vulnerability and poverty are unemployment, under-employment, as well as low paid and insecure jobs in the informal economy. Many working people live below the poverty line.

Demographic trends have been marked by high net migration, decreasing natural growth and an ageing population. The population of Georgia dropped from 5.4 million in 1989 to 4.4 million by 2006. Georgia is a multi-ethnic country. The three largest ethnic groups in Georgia are Georgians (83.8% of the population), Azeri (6.5%), and Armenians (5.7%), the latter two being concentrated near Georgia's borders with Armenia and Azerbaijan. The demographic indicators for Georgia are summarized in Table IV.46 (Statistical Yearbook of Georgia, 2008).

Table IV.46. Demographic Status of Georgia

Demographic Indicator	2003	2004	2005	2006	2007
Birth rate (per thousand population)	10.7	11.5	10.7	10.9	11.2
Mortality rate (per thousand population)	10.6	11.3	9.9	9.6	9.4
Infant mortality rate (per thousand live births)	24.8	23.8	19.7	15.8	13.3
Natural increase rate (per thousand population)	0.0	0.2	0.8	1.3	1.8
Stillbirth rate (per thousand births)	17.3	17.2	15.6	14.7	12.7
Marriage rate (per thousand population)	2.9	3.4	4.1	5.0	5.7
Divorce rate (per thousand population)	0.4	0.4	0.4	0.5	0.5

The working age population (age range 15-64) represents 68% of the total. The two extremes of the labour force (younger and older) currently have a greater share than the middle-age groups. Gender misbalance is noticeable in the Georgian population as women predominate in the labour force (currently 52%) and exceed 60% of the older group (Statistical Yearbook of Georgia, 2008).

According to the Department of Statistics, the activity part of the population was about 63% and the unemployment rate was 13.6% in 2006. In this context, economic activity is higher in rural areas (57% of total) and among the male population. Georgia's labour market is characterized by self-employment, which accounted for about 65% of total employment (Statistical Yearbook of Georgia, 2008).

Skills irrelevance is a visible problem in the labour force, despite the level of education. A large proportion of employed people work in occupations not related to their education profile. The occupation/education discrepancy is more frequent in public administration, but also in business sectors such as construction, trade, and agriculture.

In 2008, the real GDP growth rate in Georgia was 7.9, with growth accelerating in industry, transportation; communications, financial intermediation, real estate,

education and healthcare (see Figure IV.15). GDP deflator index increased by 13% in 2008 (see Table IV.47).

Figure IV.15. Annual Real GDP Growth Rate (Statistical Yearbook of Georgia, 2008)

Table IV.47. Real GDP Growth by Sectors

Sectors	2004 (%)	2005 (%)	2006 (%)	2007 (%)	Q1 2008 (%)	Q2 2008 (%)	1H 2008 (%)
Agriculture	-7.9	12.0	-11.7	8.8	9.2	1.5	5.0
Mining and quarrying	-19.9	-7.8	18.7	20.2	28.5	0.3	10.0
Industry	11.6	14.1	22.3	13.7	0.7	8.9	5.9
Electricity, gas and water supply	-4.0	5.1	13.4	5.5	24.8	5.7	15.7
Processing products by household	-1.6	12.4	3.0	15.6	10.7	4.8	7.0
Construction	35.9	14.1	8.5	14.3	11.4	1.1	6.2
Trade and repair services	8.2	9.4	19.7	11.8	16.9	9.4	13.1
Restaurant and hotel services	3.2	17.1	10.5	13.5	15.3	5.0	9.3
Transportation	3.7	3.9	16.8	14.4	-7.9	1.5	-3.1
Communications	17.0	28.7	13.4	9.3	15.0	21.5	18.6
Financial intermediation	12.8	52.8	36.9	14.7	15.8	40.4	28.1
Real estate	28.1	10.6	17.4	14.8	6.2	15.6	11.2
Inputted rent of own occupied dwellings	0.6	0.9	0.2	5.6	1.8	3.9	2.8
Public administration	9.7	-6.3	-2.4	14.4	16.1	14.5	15.3
Education	1.8	13.8	12.0	7.6	5.9	9.5	7.9
Healthcare	4.2	7.6	15.4	11.1	-2.2	1.2	-0.2
Other community, social and personal service activities	6.5	18.3	7.1	5.4	17.8	15.5	16.5
Private households with employed persons	20.5	-18.8	8.5	6.8	17.5	2.1	9.8
Overall Real GDP growth	**5.9**	**9.6**	**9.4**	**12.4**	**9.3**	**7.9**	**8.5**
GDP deflator	**8.1**	**7.9**	**8.5**	**9.6**	**12.3**	**13.0**	**12.6**

IV.3.2. General Information about Samtskhe-Javakheti Region

Samtskhe-Javakheti is one of 12 administrative regions in Georgia. It is located in the southern part of the country, bordering Armenia and Turkey. Geographically, the region is an isolated high plateau, with a harsh climate, set off from the rest of Georgia by the Lesser Caucasus Mountain Range. Samtskhe-Javakheti is comprised of six administrative districts: Adigeni, Akhalkalaki, Akhaltsikhe, Aspindza, Borjomi, and Ninotsminda. The administration of Samtskhe-Javakheti region is headquartered in Akhaltsikhe (Samtskhe-Javakheti Integrated Development Programme, National Human Development Report Georgia, 2001/2002).

During the Soviet era, Samtskhe-Javakheti was an agricultural region, focusing on livestock, dairy production, and potato cultivation. Some building industry and textile factories did also function in the region. As a result of the collapse of the Soviet Union and the transition from a planned to a market economy, the region suffered a host of difficult economic problems common in post communist countries including the disruption of established trade patterns and rapidly decreasing production (Samtskhe-Javakheti Integrated Development Programme, National Human Development Report Georgia, 2001/2002). At present, conditions for the population of Samtskhe-Javakheti are similar to conditions elsewhere in Georgia. Unemployment is recorded to be at the levels of Georgia average. Credit, investment and training are required to stimulate the economy. Fragmented land holdings and decayed agricultural infrastructure lends itself to subsistence rather than commercial agriculture.

There are 353 settlements in the region including 6 cities – (Adigeni, Akhalkalaki, Akhaltsikhe, Borjomi, Vale and Ninotsminda), 7 towns (Bakuriani, Bakuriani Andesite, Tsagveri, Akhaldaba, Adigeni, Abastumani, Aspindza) and 254 villages.

Data about the demographic structure and population distribution patterns in Samtskhe-Javakheti create important background information that is helpful for understanding some of the social issues in the region. Age, settlement type, gender and ethnic data, related to such processes as migration and changes in family structure/size are particularly important. As mentioned above, overall population of Samtskhe-Javakheti according to the 2002 census comprises 207,600 persons or 4.7% of the total population of Georgia, with the highest number of inhabitants in Akhalkalaki district, followed by Akhaltsikhe and then Borjomi, Ninotsminda, while Aspindza claims the smallest population (see Table IV.48).

Table IV.48. Population Distribution of the Samtskhe-Javakheti Region (2002 Census)

NAME of DISTRICT	Total	Percentage
Akhaltsikhe	46,134	22.2
Adigeni	20,752	10.0
Aspindza	13,010	6.3
Borjomi	34,422	15.6
Akhalkalaki	60,975	29.4
Ninotsminda	34,305	16.5
TOTAL	**207,598**	**100**

Female population is 3.2% higher than male population in the region as a whole. Although the districts differ by male/female ratios, in the four of them the difference varies from 2.6% to 3.4%. However, there are two striking exceptions - Ninotsminda where difference is only 1%, and Borjomi with the difference as high as 6.9% (see Table IV.49).

Table IV.49. Population Distribution by Gender (2002 Census)

District	Males	Females	Total	Males (%)	Females (%)
Akhaltsikhe	22,271	23,863	46,134	48.3	51.7
Adigeni	10,101	10,651	20,752	48.7	51.3
Aspindza	6,325	6,685	13,010	48.6	51.4
Borjomi	15,074	17,348	34,422	46.5	53.5
Akhalkalaki	29,642	31,333	60,975	48.6	51.4
Ninotsminda	16,987	17,318	34,305	49.5	50.5
TOTAL	**100,400**	**107,198**	**207,598**	**48.4**	**51.6**

Recently, population in Samtskhe-Javakheti, as elsewhere in Georgia, continued to fall, with the exception of 2001 when it slightly increased. This decrease is due to decreasing birth rate in addition to emigration (see Table IV.50). Furthermore, there is a general decline in the birth rate, as the death rate shows increase (see Table IV.51 and Table IV.52).

Table IV.50. Dynamics of the Number of Births, 1998-2003 (Sumbadze and Tarkhan-Mouravi, 2004)

District	1998	1999	2000	2001	2002	2003
Akhaltsikhe	635	585	555	532	502	486
Adigeni	329	263	205	252	252	224
Aspindza	174	182	122	138	138	124
Borjomi	429	396	340	338	280	253
Akhalkalaki	732	739	586	595	585	537
Ninotsminda	486	442	345	367	347	357
TOTAL	**2,785**	**2,607**	**2,153**	**2,222**	**2,104**	**1,981**

Table IV.51. Birth Rate per 1000 of Population (Sumbadze and Tarkhan-Mouravi, 2004)

District	2002	2003
Akhaltsikhe	10.9	10.5
Adigeni	12.1	10.8
Aspindza	9.5	9.5
Borjomi	8.1	7.3
Akhalkalaki	8.8	8.8
Ninotsminda	10.1	10.4
AVERAGE	**10.1**	**9.5**

Table IV.52. Birth and Death Numbers, and Natural Growth for six months in 2004 (Sumbadze and Tarkhan-Mouravi, 2004)

District	Number of Births	Number of Deaths	Natural growth
Akhaltsikhe	255	249	6
Adigeni	110	123	-13
Aspindza	61	67	-6
Borjomi	172	268	-96
Akhalkalaki	274	213	61
Ninotsminda	141	154	-13
TOTAL	**1,013**	**1,074**	**-61**

The age median for the region is 32.2. As women live longer on average, women are more elderly than men. Median age for women is 33.9, while it is 30.6 for men. Population in Ninotsminda and then Akhalkalaki are recorded to be the youngest, while the population in Borjomi is the oldest population (see Table IV.53).

Table IV.53. Population by Age in the Districts (2002 Census)

District	Males (Median)	Females (Median)	Average
Akhaltsikhe	31.5	36.9	33.9
Adigeni	31.2	33.9	32.5
Aspindza	31.4	33.5	32.4
Borjomi	32.8	37.6	35.8
Akhalkalaki	28.4	32.1	30.6
Ninotsminda	28.0	31.2	30.0
TOTAL	**30.6**	**33.9**	**32.2**

On average, 60.9% of the population of the region is of working age (i.e. in the age range 15-65). The share of working-age males among the total number of men is considerably higher (64.8%) than in the case of females (57.3%). The lowest share of the working-age population, both women and men, is recorded in Aspindza, while the highest is in Ninotsminda. Borjomi claims the highest share of the working age males (see Table IV.54).

Table IV.54. Population of Working Age by Gender (Sumbadze and Tarkhan-Mouravi, 2004)

District	Working Age Males (%)	Working Age Females (%)	Working Age (%)
Akhaltsikhe	64.7	56.5	60.4
Adigeni	63.4	55.6	59.4
Aspindza	60.9	53.1	56.9
Borjomi	67.2	58.8	59.1
Akhalkalaki	64.2	57.4	60.7
Ninotsminda	66.0	59.3	62.6
TOTAL	**64.8**	**57.3**	**60.9**

Family structure/size is an important variable for understanding social processes in the region. In the region, family structure is rather stable. In 2003, 159 marriages and only 4 cases of divorce have been registered. While such a low number of marriages and divorces may only approximately reflect the actual situation, as the low numbers may at least partly be explained by the reluctance to register the status changes, whether for bureaucratic difficulties or for excessive expenses. This factor is expected to be distorted to some extent in addition to the birth and the death rates.

Almost all industrial output of the Samtskhe-Javakheti region is produced in Borjomi, which has quite good transport links with the rest of Georgia. Health resorts of the region are located here as well. The only sugar-refinery in Georgia, with Swiss investment made in previous years, is located in Akhaltsikhe. From the economic standpoint, the region has great potential for the development of tourism and a planned construction of the railway between Akhalkalaki and the Turkish city of Kars seems promising. The main agricultural activities of the region are animal husbandry, potato and fruit growing. Households are mainly engaged in producing fodder (9,000 ha; 136,000 tons) and growing potato (8,000 ha; 76,000 tons). In addition, 79 ha of land are used as pasture fields.

The reasons why the level of socio-economic development of the Samtskhe-Javakheti is below the average rates of the country are that it has a rough land structure and the geographic conditions cannot provide the people with an environment suitable for agriculture and industry. Also, the areas, where farm units can work more effectively and where the productivity can increase are scarce. The migration from the region, which is far from the developed markets, to other regions due to these factors, is an important problem.

IV.3.3. Project Affected Villages (Sakuneti and Rustavi Villages)

The scope of the socioeconomic field survey has been determined by taking two factors into consideration. The first one is that the project area is far from the urban settlements. The second is that Sakuneti and Rustavi Villages that are

located in Akhaltsikhe and Aspindza Districts respectively are geographically the closest settlements to the construction area of Mtkvari HPP facilities. Therefore, Sakuneti and Rustavi Villages would be the directly affected settlements by the project and the socioeconomic conditions of the people living in those villages have been analyzed in detail. The settlement areas of these villages will not be physically affected from any project facility during construction or operation phases. Almost no agricultural or other lands of these villages are affected due to the footprint of proposed project facilities.

Sakuneti Village:

The Mtkvari Project site is located in southeast of Georgia, on River Mtkvari, in the district of Akhaltsikhe. Nearest settlement to the project facilities is Sakuneti Village, which is located 1 km away from the powerhouse site.

As per 2001 Census, there are 162 households in this village. The total population of the village is 918 and total agricultural land has an area of 2118 ha. The average household size in Sakuneti Village is above the average of the country. While Georgia's average rural household size is 4.3 persons, it is 5.7 persons in the Sakuneti Village (2001 Census).

All the people in the village follow Christianity. Additionally, literacy level is 100% and women and men have equal rights. In the Village, primary education of 11 years is obligatory for all the children. Furthermore, there is no emigration or immigration and one school and one small clinic exist in Sakuneti, currently. There are no private doctors in the village. However, the village is about 13 km from Akhaltsikhe and connected with an asphalt road. Thus, the health institutions in Akhaltsikhe are also available for the villagers.

The village has electricity, phone, and provision shops. In addition, the village has been connected with supply of tap water, recently.

Major occupation of the villagers is farming and mainly potato is cultivated. Livestocking is also conducted in the village. Some of the households in the village

are involved in fishing as well. However, according to the villagers, the fish catch in the area has been declining.

Given the size of population, the livestock population is not very high due to lack of fodder. Agriculture is the main occupation of the people in the village and fishing is done by some for self-consumption.

Rustavi Village:

As per 2001 Census, there are 153 households in this village. The total population of the village is 812 inhabitants and its agricultural land is 914 ha. The average household size in Rustavi village is above the average of the country. While Georgia's average rural household size is 4.3, it is 5.3 in the Rustavi Village (2001 Census).

All the people in the village follow Christianity. The literacy level is 100% and women and men have equal rights. In the Village, primary education of 11 years is obligatory for all the children. There is no emigration or immigration and one school and one small clinic exist in Rustavi, currently. There are no private doctors in the village. However, the village is about 12 km from Akhaltsikhe and connected with an asphalt road. Therefore, the health institutions in Akhaltsikhe can be used by the villagers.

The village has electricity, phone, and shops. The houses in the village were connected with supply of tap water.

Similar to Sakuneti, agriculture and animal husbandry are the most important income sources. Within agricultural products, tomato and potato are mostly cultivated. In animal husbandry, cattle are commonly preferred. In addition, apiculture is also widespread. Some of the households in the village are involved in fishing as well.

The livestock population is not very high due to lack of fodder. Agriculture is the main occupation of the people in the village and fishing is done by some for self-

consumption. Some small amount of land of the villagers would be partially affected by the project.

IV.3.3.1. Social Composition in Affected Villages

By definition, Indigenous People (IP) refers to a population with social, cultural, economic, and political traditions and institutions distinct from the mainstream or dominant society and culture. Word Bank uses the following characteristics to define indigenous people:

1. Descent from population groups present in a given area before territories were defined.
2. Maintenance of cultural and social identities separate from dominant societies and cultures.
3. Self identification and identification by others as being part of a distinct cultural group.
4. Linguistic identity different from that of dominant society.
5. Social, cultural, economic and political traditions and institutions distinct from dominant culture.
6. Economic systems oriented more towards traditional production systems rather than mainstream.
7. Unique ties and attachments to traditional habitats and ancestral territories.
8. Essentially, indigenous people have a social and cultural identity distinct from the mainstream society that makes them vulnerable to being overlooked in development processes.

There are no indigenous people and no ethnic minorities or no clan or tribal structure in the project area potentially affected by Mtkvari HPP Project. The potentially affected persons are all Georgians. Therefore, Performance Requirement 7 (PR-7: Indigenous People) is not related to this project. All project affected people are member of the same ethnic group and social structure. Table IV.55 presents the socio-cultural structure of the settlements closest to the project

area. Thus, it can be seen that all potentially affected members have same cultural, economic, and social traditions.

IV.3.3.2. Governance Issues

Samtskhe-Javakheti region consists of an area of 6,413 square kilometres, which makes about 11% of Georgian territory, and has a total population of almost 207,600 that is 4.7% of country's overall population. This is a historical region of Georgia consisting of 6 districts - with regional capital in Akhaltsikhe. The six districts comprising the region are rather different from one. Samtskhe-Javakheti province is among the most ethnically non-homogeneous regions of Georgia. Integrating the two major ethnic groups, Armenians and Georgians, represents a major political challenge for the region. The ethnic composition is mostly characterized by clear-cut ethnic boundaries between different settlement types and the rarity of mixed ethnic settlements. The only truly mixed district in Samtskhe-Javakheti province is Akhaltsikhe (Sumbadze and Tarkhan-Mouravi, 2004)).

Table IV.55. Socio-Cultural Composition in Project Affected Villages (Sakuneti and Rustavi villages)

Name of the Affected Settlement	Descent	Cultural Social Identities	Self Identification	Linguistic Identity	Social Cultural Traditions	Traditional Economic Systems	Traditional Habitants and Ancestral Territories
Sakuneti Village	all the population have same descent	all the population have same cultural social identities	self identification mechanism is same for all population	linguistic identity is same for all population	social cultural traditions are similar for all population	all of the population have same traditional economic system	all people have same traditional habitants and ancestral territories
Rustavi Village	all the population have same descent	all the population have same cultural social identities	self identification mechanism is same for all population	linguistic identity is same for all population	social cultural traditions are similar for all population	all of the population have same traditional economic system	all people have same traditional habitants and ancestral territories

The region, especially the two Armenian-speaking districts of Javakheti, is isolated from the rest of Georgia by informational, political, communicational and economic differences. Technologic modernization helps change the situation gradually. Development of autonomous telecommunication systems (cellular phones, or satellite and cable TV) helps greatly in overcoming informational isolation, serving as a stimulus to cultural exchange and more awareness about neighbouring cultures. While there are special programs assisting to overcome informational isolation through supporting access to TV broadcasts as well as to Internet, cellular telephone networks develop under market pressures. Currently, great hopes are linked to the fundamental reconstruction of the road to the region via Tsalka, planned to start soon within the framework of the American Millennium Challenge program. Equally important will be the construction of the planned railway link with Turkey (Tarkhan-Mouravi, 2003).

IV.3.3.3. Land Ownership and Tenure

Agriculture is of vital importance to the Georgian economy, and its share in GDP accounts for 21%. This indicator reduced from 30% down to 21% during last 6 years. This is caused by the poor agricultural infrastructure of Georgia, low level of agricultural production intensification and lack of modern scientific support and practical achievements in the production. The material-technical base and agricultural equipment need to be re-established. Highly qualified specialists are not being trained and investment activities also face huge barriers. The management and marketing systems are not effective either. The production level of animal food products does not meet the population requirements. Moreover, there is a high risk of contamination of these products, which may cause a serious danger for human health. To ensure safety of human health it is necessary to provide strict controls regarding the quality of animal food products.

The structure of agricultural land ownership underwent a significant transformation in the first stage of the agrarian reforms. After the land reforms, about one million households became the owners of nearly 30% of total agricultural land. From 1990 on, the transition from the centrally planned economy to the market economy

caused a crisis that, on its part, resulted in a reduction of the number of farm animals, decrease in productivity and a down fall in the animal production industry.

As mentioned before, powerhouse of Mtkvari HPP Project is at a distance of 1 km from village Sakuneti in the district of Akhaltsikhe, while headworks are located at a distance of 3 km from village Rustavi in the district of Aspindza. The project area is generally state land except approximately 10 ha of the area, which is private property.

Mountainous chernozems are common in Rustavi while brown forest soils are mostly seen in Sakuneti. In Sakuneti, agriculture and livestock are two significant income sources. The most important crop is potato. The major soil type in Sakuneti is in moderate to good productivity soils which are suitable for cultivation and establishment of gardens. Agriculture and livestock are also significant income sources of Rustavi Village. The most important agricultural product is potato followed by tomato. Ovine and bovine breeding are also significant income sources for Rustavi.

IV.3.3.4. Economic Activities

Subsistence agriculture is the main income generation mean of the locala in the affected villages. The main products are; potato, cabbage, as well as dairy and meat from cattle breeding. Imperfect land privatization left farmers with mostly small plots of about 1-1.5 ha lands - not allowing for high-crop agriculture. Additionally, the production is influenced negatively by limited availability of seasonal credits, poor access to markets and lack of food processing industry. Furthermore, the fragmentation of land plots, lack of mechanization, problems with irrigation that do not allow for full-fledged commercial farming also influenced the decline in agricultural activities. As a result, production costs for some products are higher than for imported analogues. Still, the agricultural potential of the region is significant. Even under current conditions, the Samtskhe-Javakheti region (including affected villages) produced 40.2% of all potatoes produced in Georgia in 2001, with the highest yield of about 15.3 tons per hectare (5.1% of vegetables

with 12.2 tons per hectare, 4.5% of wheat with 2.1 tons per hectare, and 4.8% of maize with 2.2 tons per hectare).

Cattle breeding in the region consist of 8.4% of the total number of cattle in Georgia in addition to 1.8% of pigs, 13.7% sheep and goats, 12.3% of bee families and 5.4% of poultry. The region contributed up to 8.7% of the national production of meat with 10.2% of milk, 4.2% of eggs, 21.4% of wool, and 13.8% of honey (Sumbadze and Tarkhan-Mouravi, 2004).

While overall economic conditions are far from bright, it is important that the majority of the population in affected villages do not consider themselves as poor. Actually, the overwhelming majority (82.3%) of respondents considered their families being of medium affluence - neither rich nor poor (according to 13.6% of respondents their household was poor, while 4.1% considered theirs as rich). It is interesting to note that the respondents living in urban and rural settlements do not differ statistically in the perception of the economic status of their families.

IV.3.3.5. Education

Availability of opportunities for education is one of the key dimensions of the quality of life. Georgia has traditionally scored relatively well in terms of average indicators of educational attainment, and have had low levels of gender inequality by international standards. The population here traditionally paid special attention to the issues of education, and providing children with respective opportunities were always high on the family agenda. It is worth noting that the importance and the need to obtain good education, and the necessity to increase demand for knowledge at schools were universally stressed by the pupils. The question arises, however, whether the systemic difficulties and the lack of clear direction experienced in the last decade, the increasing incidence of poverty, and shrinking government budgets have combined to erode some of the achievements of the pre-transition era in terms of education accessibility and quality.

Current situation in education, school education in particular, puts the population in remote and mountainous areas into particularly disadvantageous position. As a rule, schools are difficult to access, and both the conditions and the quality of education are inadequate. Despite the difficulties, current literacy level is 100% in the region. In each of the project affected villages, there is a school with primary education that is obligatory for children for 11 years.

IV.3.3.6. Vulnerable Groups and Gender Issues

Vulnerable groups merit special attention in assessment of the impacts of development projects. Vulnerable groups are defined by World Bank policies as "people who by virtue of gender, ethnicity, age, physical or mental disability, economic disadvantage, or social status may be more adversely affected than others and who may be limited in their ability to claim or take advantage of assistance and related development benefits." Since the overall objective of ESIA is realizing a development project in a sustainable way with minimizing the impacts of the project and enhancing the benefits on affected communities, it is important to identify any groups or sectors that might be particularly at risk.

Regarding the categories of the vulnerable groups, according to Moser, in current Western theory and practice concerned with low-income communities, there is always a tendency to make two assumptions. First, the household consists of a nuclear family composed of the husband, wife and children. Second, there is a clear sexual division of labour in which the husband of the family, as the breadwinner, is primarily involved in productive works outside the house, while the wife as the homemaker takes the overall responsibility of reproduction and domestic works within the household. The logic that underlies this assumption is that there is an equal control over resources and power of decision-making between the husband and the wife and other members of the household in matters affecting the household's livelihood (Moser, 1993: 85). Moreover, it is also claimed that gender relations are not confined to the domestic arena, despite the fact that households constitute an important institutional site on which gender relations are played out but are made, remade, contested in a range of institutional areas, while Marshall (1994) claims that traditional identities, norms, roles and behaviours exist

and continue to be a determinant in the cultural, social and perpetuation of poverty and these limit women's, disabled people and elderly people's access to resources as well as in decision making power, also make them more vulnerable against poverty.

In many parts of the world, women cannot own property, do not inherit land, are not documented as head of households even if they are the primary income earners, they could hardly take place in working life because of their domestic responsibilities, rigid social norms and traditions. Additionally, they have little contact with representatives of the state or with community leaders (because of low literacy level). The things that are mentioned above make these people more vulnerable against several factors.

Regarding elderly people, in all societies, they can be vulnerable in times of rapid change, because they cannot quickly adjust to changes in their life styles, a new environment or new patterns of employment.

Moreover, people who are excluded from the labour markets, basic services and social networks become more vulnerable in terms of experiencing poverty (Bauman, 1999). The concept has been defined as a multidimensional process, which weakens the links between individuals and the rest of the society (ILO and UNDP, 1996). These links are reflected in economic, legal, political, socio-cultural, and spatial dimensions. The more a person is excluded from these dimensions, the more vulnerable that person becomes. The characteristics of exclusion are much related with access to labour markets, basic services and social networks.

In line with these arguments, gender is one of the important issues, which has to be taken into consideration. Gender equality is a fundamental human right, which is an essential feature for the development, and welfare of men and women. A summary of the International Conference on Population and Development (ICPD) Program of Action published by UNFPA in 1994 states that "empowerment of women and improvement of their status are important ends in themselves and are essential for the achievement of sustainable development". The decisive steps

towards the elimination of discrimination against women were taken after the adoption of the Convention on the Elimination of all Forms of Discrimination against Women (CEDAW) in 1979, and subsequently 179 countries signed the document by 2004.

In a recent assessment of the gender equality situation in the country, it is indicated that despite equality on legal ground, gender equality is far from being achieved in Georgia (Sumbadze, 2008). Nevertheless, gender inequality is not considered as a major issue in Georgia as men and a number of successful women sharing the view that equality is not a problem. A majority (45.4%) of the surveyed persons believe that men and women are equal in Georgia, while 42.1 percent believes that women are oppressed, while 5.5 percent holds the opinion that men fall into that category, and 6.9 percent has no definite answer. There is a significant gender difference in the assessment of equality, in comparison more men (50.9 %) than women (41.1 %) believe in the existence of equality (Sumbadze and Tarkhan-Mouravi, 2004).

The project will not have significant adverse social impacts on the two main close villages to the project area in terms of physical or economic losses since only a very small piece of land being used by the locals would be lost. Otherwise, the project will have positive impacts on these settlements as expected by the villagers. Thus, the vulnerable groups such as elderly, children and women will not encounter significant adverse effects.

IV.3.3.7. Cultural Heritage and Tourism

The field studies and survey of relevant literature show that there are no significant cultural or historical assets/sites in the project and impact area including the villages of Sakuneti and Rustavi.

IV.3.3.8. Community Health

There is a small clinic (medical center) in each of the villages of Sakuneti and Rustavi. The nearest state hospital to these villages is located in Akhaltsikhe, which is at about a distance of 12 km and these villages are connected to this town with an asphalt road. There are no diseases specifically seen in these villages, which cause significant health problems to the local.

The development of reservoirs in hydropower projects can cause some water borne diseases depending on the size of the reservoir and the climatic conditions of the area where such projects are developed. In Georgia no water related parasitic or viral diseases were seen. Based on the climatic conditions of the region and the very small size of the future Mtkvari Reservoir, the project is not expected to cause any water borne diseases, thus will not create such an health impact.

IV.3.4. Considerations Related to the Realization of the Project

IV.3.4.1. Public Participation Meeting and General Considerations

The planned Mtkvari Project is being developed in a way that it meets the required Georgian National criteria, IFC and EBRD standards. Throughout the project implementation consideration will be given to public consultation and information disclosure issues. Thus, a public consultation and disclosure plan is given in Appendix 4 of this report. In this context, during the ESIA studies public consultation/participation meetings are organized in accordance with the Georgian legislations and IFIs requirements. The first public participation meeting concerning the proposed Mtkvari HPP Project was held in Akhaltsikhe District in the Municipality Hall on June 12, 2009. JSC Caucasus Energy and Infrastructure and ENCON Environmental Consultancy were present in the organization and conducting of the meeting that served for providing the available information to the interested stakeholders and answering any questions and concerns, as well as getting the opinion of the public. The number of participants in the meeting was 23.

The purpose of the meeting was to provide information and get the opinions of the locals related to the project. The date, place and the scope of this meeting were announced in the newspaper on June 2, 2009. Also by contacting the related headmen, municipalities and districts, it was secured that the maximum participation to the meeting was obtained. The information of the place and time of the meeting was announced to relevant audience by not only the newspapers, but also announcements made through the web site of JSC Caucasus Energy and Infrastructure (CEI). In addition, on 16-18 February 2009 the headmen of Sakuneti and Rustavi Villages were contacted and the key informant questionnaire was performed with the headmen. During these interviews information about the project was given and information about the properties of the local community and their thoughts about the project were taken. According to the visits before the meeting and the questions during the meeting it was seen that the local community is generally positive and supports the project.

Additionally, within the scope of public consultation activities an informative leaflet about the project details and potential impacts are introduced to the public. Within this scope, before the meeting the leaflet was not only distributed to the public but also published on the web site of CEI for online access in both English and Georgian.

Furthermore, an interim report including further details about the environmental and social baseline conditions and assessment of impacts for the Mtkvari HPP Project was also prepared and provided to public access. The report is also available on the web site of CEI in both English and Georgian.

The meeting held in the Akhaltsikhe Municipality Hall on June 12, 2009, was started with an opening speech of the CEO of CEI, Archil Mamatelashvili. Then, introductory information regarding the project was provided. Afterwards, the interim report prepared was discussed with the participants.

During the meeting, a positive approach to the project was observed. A few questions were asked including; if the water pumps on the left bank of the River

close to the junction of Potsckhovi Stream would be affected from the project or not; and how the unregistered lands, which are considered as private property, would be handled if they are going to be lost due to the reservoir or other project structures. The project affected persons (PAP's) indicated that the project would have an impact on their community, which they expect to be mostly positive. Common areas of impact included economic growth, small size of expansion of the population, employment opportunities and the loss of a small size farmland. Concerns about the project focused on loss of farm land, divisions and conflict within the communities regarding the merits of the Mtkvari HPP Project. In general, however, all of the PAP's from affected settlements expressed expected positive impacts and a general approval for the project.

During the meeting, the questions of the participants were answered in a way that they can understand. It is observed that after the meeting most of the concerns of the participants were disappeared when compared with the state before the meeting. It was declared by the project developer that during the limited expropriation activities for the small agricultural land to be inundated by the reservoir all measures will be taken for not to aggrieve the local community. In addition, it was clearly stated that priority will be given to the local community, while recruiting workers for the construction of the dam.

The meeting was positive in general and it was beneficial for the participants to understand the project and to get first hand answers to their questions about the project. In addition, consideration for taking the suggestions of the local community in the ESIA studies and ensuring that they would be addressed in the ESIA report increased the positive thoughts about the project. The photos of the public participation meeting are presented in Photograph IV.11 and Photograph IV.12. More detailed information about the public participation meeting and the minutes of this meeting are given in Appendix 4.

Photograph IV.11. The Public Participation Meeting, Participants (1)

Photograph IV.12. The Public Participation Meeting, Participants (2)

IV.3.4.2. Advantages and Disadvantages of the Project

There are no residential areas that are directly affected by Mtkvari HPP Project. Thus, resettlement is not an issue of concern related to the project. Only expropriation would be required at a very limited area to be affected from the reservoir and the headwork facilities.

The majority of the locals feel optimistic about Mtkvari HPP Project because of the possible chances of employment to be created during the construction period of the project. Almost all of the locals expressed that the prime advantage to them is the emerging chances of employment. In addition, they are thinking that trading activities will increase and develop with the start of the project activities. As noted earlier, most of the questions and opinions stated were related to the employment opportunities during the construction and operation phases of the project.

CHAPTER V

ENVIRONMENTAL AND SOCIAL IMPACTS

V. ENVIRONMENTAL AND SOCIAL IMPACTS

The environmental impact analysis is based on the project components and activities as described in Chapter III, and the environmental baseline conditions as described in Chapter IV.

The impacts of the project activities are evaluated on three basic environmental components: the physical, biological, and socioeconomic environments. Also, the potential impacts of the environmental conditions on the Project itself are addressed where appropriate. Generally, the impacts are identified and discussed for construction and operation phases. The assessment includes the quantification of losses, where possible, by the project structures and reservoir.

Impacts were analyzed with the state of the art techniques including; predictive mathematical models, geographic information systems (GIS), remote sensing applications, and professional judgment of experts based on their relevant knowledge and experience. For the evaluation of the impacts (impact significance), related Georgian Legislation, national and international standards and guidelines, professional knowledge of similar projects regarding the anticipated impacts, and opinions and experience of interdisciplinary teams of experts were the major means of assessment. The map showing the identified impact area of the Mtkvari HPP Project is given in Figure V.1. This area was the main study area throughout the ESIA studies regarding establishing the baseline and assessing the impacts.

V.1. Physical Environment

The impacts of the project activities and components on the physical environment and the effects of the physical environment on the project are analyzed in this section. All impacts, beneficial and adverse, during construction and operation phases are discussed in the following subsections. The environmental impact analysis and assessment generally follow the outline of the previous chapter in

order to address the impacts based on the baseline data/information provided. This section is divided into six main headings as physiography, geology and soils, climate, hydrology, air quality impacts, and noise.

V.1.1. Physiography

During the construction phase, changes in the topography can be observed. Principally, landform will be changed as a result of the activities for mainly dam construction, construction areas, access roads, and other services to be brought onsite.

The area of physical land take by the Project includes the reservoir area and the footprint of the construction facilities (dam site, powerhouse site, camp facilities and access roads). The reservoir covers an area of only 0.5 km^2, so the overall land take including all the project facilities will be less than 1 km^2. Only about 0.1 km^2 of this area is arable land and the rest is mainly composed of shrubby forms along the river and barren land.

V.1.2. Geology and Soils

Geological investigations show that the geological formation at the project site will provide adequate support as the bedrock for the dam. At the dam site and its vicinity, the main rock is of medium strength and mainly built by tuffogenic rock and semi-rock series. All the dam related structures to be built in the project area will have appropriate design specifications matching the media characteristics, national regulations and international standards.

Mtkvari dam site and powerhouse are located on unstable clayey and sandy tuffogenic formation zone dated back to the Upper Eocene. The oldest rock of the region consists of Middle Eocene tuff, breccias, andesite, sandstone, argillites, intrusive hornstone and diabase bodies.

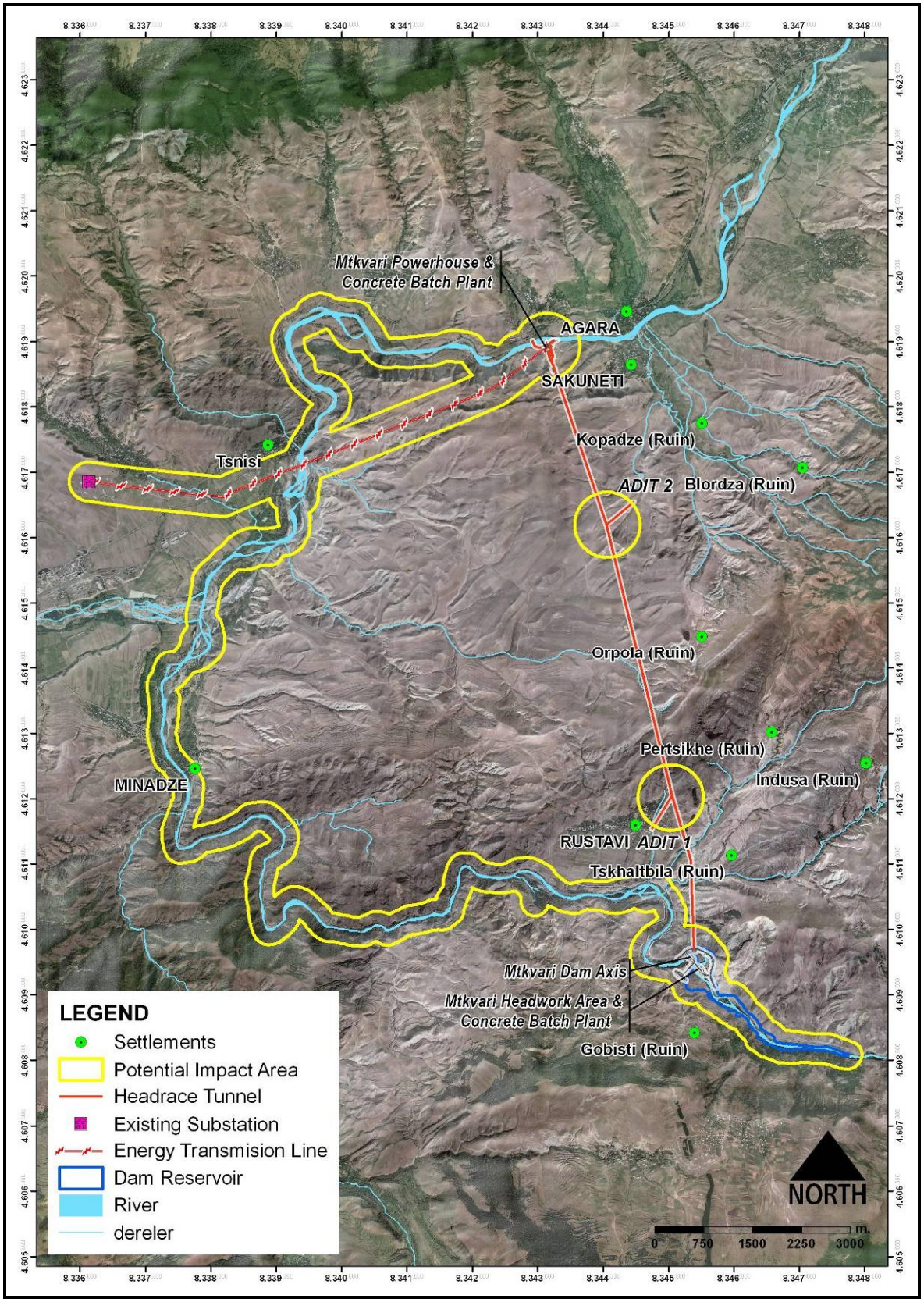

Figure V.1. The Potential Impact Area of Mtkvari HPP Project

The geology of the dam site and the reservoir area has a complex structure. Engineering studies showed that the geological characteristics of the site and the dimensions of the reservoir area are durable for construction as it is determined that the weight of the reservoir water will not pose any risk. The dam axis will be located on a foundation of tuffogenic rocks which has been found of adequate strength. At the Mtkvari dam site, the river bed is filled with water saturated alluvial shingle formation. This poses a potential impact on water tightness as explained in Section IV.1.2.2.2. Based on the further findings regarding this issue, all necessary actions (such as building a cut-off wall, or curtain grouting, if found necessary) will be taken to improve impermeability for the probable high permeability zones present in the dam axis area.

Geological and geotechnical site survey showed that erosion motivated landslides might occur in the region, though they are not expected to be at a large scale. For this reason, pre-construction, construction and operation phases will be implemented pursuant to relevant geo-hazard precautionary measures.

For some zones on the route of the headrace tunnel rock-fall and/or soil-fall seems possible based on the geological studies. In order to prevent low strength argillite zone originated probable swelling and/or such fall hazards, the tunnel will be supported with lining along its cross-section. According to the geological characteristics of the headrace tunnel route, water ingress might be seen during tunnel construction.

V.1.2.1. Water tightness

The reservoir area and dam axis will be found on a zone having water saturated alluvial shingle formation at the top. The permeability of this formation is considerably high (98 m/day). For that reason; the dam axis will be located directly onto the water saturated rocks underlying the shingle. The permeability degree of the riverbed lying rock is generally low. It can be said that the reservoir area is relatively watertight and the possible main leakage paths would probably be through the dam foundation and

abutments. Thus, all necessary actions will be taken to improve the impermeability of possible leakage zones in the dam axis area during construction.

V.1.2.2. Seismic Risk and Reservoir Induced Seismicity

Generally the seismicity of the region is connected to active faults of the area which has designated Greater Caucasus, with the exception of two earthquakes occurred in the year 1920 and 1940. Those earthquakes were connected to the so-called Lesser Caucasus. According to MSK-64 Intensity Scale Degrees, the project area is located in the earthquake intensity zone IX. Additionally, the reoccurrence period for strong events in this area is of order of 1000 years. The magnitude of the strongest earthquake of the region was recorded as M=6.9 (in 1991). This earthquake took place at about 90 km NE of the project area.

The European Earthquake Standard, Eurocode 8 (FS ENV 1998:1994) can be applied as guidance for the definition of a design spectrum for the project. The design will be matching the appropriate design criteria for earthquake loads and resistance of structures in accordance with the applicable standards and regulations.

Regarding fault tectonics, as Upper Eocene clayey sand and volcanogenic formations of the Main HPP project area have apparent faults and fissures, the dam related structures (especially the headrace tunnel) will have appropriate design specifications matching the media characteristics, national regulations and international standards.

Only one earthquake occurred within a radius of 50 km from the dam site with a magnitude of 4.2 and earthquakes of 6 and higher magnitudes have not occurred in this area. Therefore, no significant seismic risk is anticipated for the Mtkvari Project area.

It is generally accepted that impoundment of large reservoirs can induce seismicity, but only in systems that are already near failure. In the Mtkvari HPP Project, the reservoir covers an area of only 0.5 km^2 and the dam is not intended for storage, but for the diversion of the water to the powerhouse through a headrace tunnel. Therefore, reservoir induced seismicity due to the Mtkvari Project is highly unlikely.

V.1.2.3. Dam Safety

The alluvial and bedrock materials in the foundations for the various project features have been characterized and tested sufficiently to provide the required information to develop a safe and conservative design. The foundations will provide adequate support for the loads applied to them by the dam and spillway at the headworks. The Mtkvari Dam will be designed so as to have a structure that meets all the engineering standards.

The Mtkvari Dam is not intended for storage, but for the diversion of the water to the powerhouse through a headrace tunnel. The reservoir area is about 0.5 km^2 and the total volume of the reservoir is only about 4.9×10^6 m^3. Even in the case of a failure, which is very unlikely for such a small structure, this volume of water would correspond to a flow less than the mean annual flow at the Mtkvari dam axis.

V.1.2.4. Landslides and Erosion

The impact of the project on landslides should be considered during the construction and operation phases. Construction activities may increase the potential of occurrence of landslides and erosion in various ways, which include destabilization of rock masses by cuts in slopes, improper stockpiling of materials, destruction of vegetative cover during site clearing and uncontrolled surface run-

off (slope wash) during storms. However, risk of damage caused by the current landslides and rockfalls will be reduced by increasing the level of the road above the dam level.

The banks of the Mtkvari River at the reservoir area are composed of alluvial-proluvial loose-fragmental soils with sandy or intermediately plastic clay and low plastic silt matrix. Thus, the content may cause erosion and landslides at various points along the banks of Mtkvari River and in some lateral ravines. These are the main geohazards which could cause difficulties with geodynamic stability of facilities and the environment.

However, the right bank of the powerhouse area is protected from side erosion by the protruding rocks sitting at the upstream and downstream ends of the area. Since the right bank of Mtkvari River at the powerhouse area consists of loose-fragmental and clayey soils of the alluvial terrace and the debris cone, the river will erode the right bank and threaten the stability of the dam related facilities under unfavourable changes of hydraulic regime. For this reason the hydraulic regime of the river will be monitored during and after construction phases, the powerhouse will be constructed in an area based with sound rocks.

The erosion geohazard seems insignificant through the surface of headrace tunnel. Even at limited zones, the presence of highly fractured - low strength rocks and the angle between the tunnel route and the course of the bedrocks along the route sets favourable conditions for soil-fall, rock-fall, swelling and block-fall hazards. Thus, an optimal tunnel lining technology will be implemented during tunnel boring construction stage.

Prior to the start of the construction; special measures will be taken to prevent stones or blocks from falling from the steep, precipitous slopes around the construction site. The other issue is the removal of unstable stones from the slope and the soil of the southern tunnel portal. This action will be taken to prevent rock-fall hazards and to place the portal directly onto the stable main rock surface.

Furthermore, the surface of the main rock will be cleaned out from its weathered surface to prevent probable future-stability problems.

V.1.2.5. Sedimentation in the Reservoir

Sediment transport is normally divided into suspended sediments and bed load transport. There is no glacier in the catchment area of Mtkvari and Mtkvari River is carrying rather low levels of suspended material to the dam site. Thus, the total suspended sediment load at the dam site is rather low. The reservoir is rather limited in size, but considering that the bottom elevation of the headrace tunnel intake is about 5 m above the riverbed here, allows trapping of considerable amount of sediments (about 1.5 million m^3) without affecting the flow in the intake.

It is known from other dams and dam schemes in the world that trapping of sediments leads to changes of the morphodynamic processes in the downstream section of the river (World Commission on Dams, 2000). Typical phenomena observed in the downstream of large dams on rivers can be summarized as:

- Increased entrenchment of river channel in the downstream reach (due to the unsaturated transport capacity, i.e. by lack of sediments in the flow);
- Reduced sedimentation rate at the mouth resulting in changes in morphology;
- Changed conditions of sediment dispersion and transport along the coastline, coastal erosion and receding coastlines.

Sediment transport is especially an important issue for the deltas of the large rivers. The trapping of sediments in reservoirs is known to exert serious effects on river deltas, especially when the dam is the first on that river. Having a dam only to serve for diversion of water to the headrace tunnel and not for water storage, the Mtkvari Project will not significantly hinder the transport of sediment, thus

nutrients and alluvium to the delta. Therefore, sedimentation in the Mtkvari Reservoir would neither affect the downstream water quality nor the delta significantly.

V.1.3. Climatology

V.1.3.1. Impacts on Local and Regional Climate

The concern regarding the impacts of dam and reservoir projects on local climate is microclimate changes. The significance of this change is related to the surface area and volume of the reservoir and to the prevailing climatic conditions in the area. The phenomenon is generally storing energy of the reservoir from solar radiation received during summer in the upper water body and dissipating this stored heat during the winter. This is a general moderating effect causing a trend of milder conditions resulting in increases in humidity and increased average winter temperatures and less hot conditions in summer. The effect of colder air from the slopes meeting the relatively warmer reservoir water surface might also result in a tendency to mist and fog occurrence especially in winter.

Mtkvari Project will have a very small reservoir (0.5 km²), so it will not lead to a significant change in the climate of the area or the region.

V.1.3.2. Greenhouse Gas Emissions from Mtkvari Reservoir

Carbon dioxide (CO_2) and methane (CH_4) cause global warming and thus they are commonly denoted as greenhouse gases (GHG). Despite generating electricity without the use of fossil fuel, also reservoir-fed hydropower plants (having reservoirs of large volume and area) may be a significant source of greenhouse gas (GHG) emissions. Both gases are emitted from reservoirs due to decay of inundated vegetation, soils and organic sediments formed by aquatic biomass and particulate or dissolved organic carbon inflows from the catchment. Thus, hydropower plants have their own global warming potential (GWP).

In particular; shallow, tropical reservoirs with high volumes of residual organic compounds in the flooded reservoir, intensive aquatic primary production and high influx of organic material by their tributaries are of concern in this respect. Mtkvari

reservoir area however, is very small and only sparsely covered with vegetation, has a weak soil cover and low influx of organic material. Furthermore, the climate of the project area of Mtkvari HPP is not favorable for contribution to the greenhouse gas emissions. As a result, Mtkvari HPP project will not contribute to the climate change.

V.1.4. Hydrology

Hydropower projects have impacts on the hydrology of the project area and the watershed, upstream and downstream of the dam, during both construction and operation periods. Such changes affect water quality and the seasonal flow pattern of a river. Project area impacts are analyzed in the extent of affected local resources.

The impacts of the Mtkvari HPP Project will be less than those caused by hydroelectric projects storing water in large reservoirs. Because of the small size of the reservoir, hydrological impacts upstream of the Mtkvari HPP Project will be minimal. The major hydrological impact of the Mtkvari HPP Project will be a decrease in flow in the section of the Mtkvari River bypassed by the headrace/power tunnel. The tunnel will bypass a 27-km section of Mtkvari River in which Uravelli and Potsckhovi Rivers join Mtkvari at distances of 8 and 9.2 km downstream of the Mtkvari Dam site, respectively. Thus, Mtkvari Project will alter the river hydrology mainly in the reach till these two big rivers join the Mtkvari, affecting both water quality and seasonal flow patterns. These impacts are discussed in more detail below.

V.1.4.1. Water Quality

V.1.4.1.1. Impacts of Project Construction

An increase in turbidity and sedimentation resulting from the construction activities will be seen in the waters downstream of the project. Excavation of the foundation, construction of roads, processing aggregate, and batching concrete activities are expected to result in turbid or sediment laden wastewaters during construction period. Without treatment, the discharge of such wastewater into a watercourse can adversely affect the downstream water quality for irrigation, and physically harm aquatic biological resources and their uses. Water-related recreational activities in the downstream, such as fishing, can also be adversely affected. Thus, in the construction site drainage system and clarification/sedimentation process will be used for preventing turbid wastewaters to reach the river.

Concrete dams require wastewater treatment in terms of neutralization as well, since in concrete works, the water required to wash aggregate, batch and cure the concrete typically results in highly basic wastewaters with a pH greater than 10.5. For the treatment of wastewaters from concrete operations, concentrated acid can be used as a buffer to reduce the pH close to neutrality. Clarification and neutralization processes will be applied to prevent pollution in the construction phase of Mtkvari Project.

V.1.4.1.2. Impacts of Impoundment

The effects of impoundment on the downstream water quality depend largely on both reservoir properties, and regional and local conditions. Size, depth and operational characteristics of the reservoir, as well as basin elevation, regional geology, and local soil, vegetation and land use conditions determine the water quality in the reservoir, as well as the downstream water. Among these, reservoir

size and mode of operation are the principal parameters affecting the development of seasonal thermal stratification, or the distribution of heat within the impoundment. The distribution of heat largely determines what takes place biologically, chemically and physically in the reservoir (Jeffries, 1994; USCOLD, 1978). If heat is not distributed evenly throughout a reservoir, density differences occur, leading to thermal stratification (dividing the reservoir into horizontal layers of in accordance with relevant temperature and density).

Reservoirs having a relatively large storage capacity with respect to inflow generally have large surface areas exposed to solar heating and a long enough detention time. Thus, they develop stratification and the consequent changes in temperature, dissolved oxygen, and nutrient content. However, thermal stratification does not develop in smaller reservoirs that are operated as run-of-river mode and, consequently, have a relatively high inflow with respect to the total storage capacity.

Mtkvari reservoir will have a very small surface area and will be rather shallow, since the purpose of the Project is not water storage, but just diverting the river. Therefore, problems that are anticipated in deep reservoirs due to stratification will not occur in Mtkvari Project.

Stratification in large reservoirs alters not only the temperature gradient within the impoundment, but also the dissolved oxygen (DO) vertical profile. However, in isothermal reservoirs, the DO concentration does not change significantly with increasing depth. The DO concentrations are affected by water temperature, because the percent saturation of all dissolved gases is temperature dependent. For many other parameters, such as pH, alkalinity, hardness, electrical conductivity, cations and anions, nitrate and phosphate, a reservoir generally has water quality similar to the waters upstream. The major differences in water quality are for turbidity, dissolved oxygen and temperature, especially for thermally stratified large reservoirs. In Mtkvari Reservoir, no thermal stratification is expected to occur. Hence, no changes in water quality released from the reservoir are expected to result from the operation of the project.

Excessive nutrient (carbon, phosphorus, nitrogen) content promotes the growth of algae in lakes and large reservoirs. The decomposition of algae may create anaerobic conditions in the bottom waters (hypolimnion) and even in midwaters (metalimnion). Turbidity increases due to these processes. As a result, algal activity is prohibited due to the reduced light penetration. Thus, the amount of dissolved oxygen provided by the algae decreases with depth and the algae concentrate on the surface and form algal blooms. This process, termed eutrophication, is mainly affected by incoming carbon, nitrogen and phosphorus to the reservoir. Phosphorus is generally the limiting parameter of eutrophication. According to the results of the chemical analyses of Mtkvari River water, the levels of phosphorus and nitrogen are quite low. Thus, the Mtkvari Reservoir will not be under risk of eutrophication and will not pose a water quality problem in the reservoir or downstream.

V.1.4.1.3. Sedimentation

Sedimentation in the Mtkvari reservoir has been discussed previously in Section V.1.2.5. The Mtkvari River carries rather small amount of suspended and bedload sediment to the Mtkvari Dam axis and since the capacity of the Mtkvari Reservoir is very small, the water detention time in the reservoir will be insufficient for the settling of clay and silt which generally comprise about 80% of the sediment load. Therefore, sedimentation in the Mtkvari Reservoir will not of significant concern with regard to downstream water quality.

V.1.4.1.4. Impacts of Flow Diversion in the Bypass Reach

The Mtkvari HPP Project will be operated in a run-of-river mode, with very limited water storage. The inflow will be diverted to the powerhouse by a power tunnel, bypassing approximately a 27 km reach of Mtkvari River. However, it should be pointed out that Uravelli and Potsckhovi Rivers, which have considerable flows,

join Mtkvari River at distances of 8 km and 9.2 km downstream of dam axis, respectively.

During periods of operation when the flow of Mtkvari River exceeds the rated discharge amount for the turbines (55 m^3/sec), excess amount of water will bypass the power tunnel and directly provided to the bypass reach. Based on the hydrographic estimations for the Mtkvari Dam axis, flows exceeding 55 m^3/sec, is observed about 24% of the time. Thus, without any mitigation measure, such a reduction in flow would pose severe adverse impacts on the bypass reach.

The relevant study that resulted in derivation of the flow data of Mtkvari River at the dam axis, and its results are described in Section IV.1.4.2. Within this scope, the minimum flow that should be released to the river bed has been calculated using the current flow data. Within the framework of this approach, the uses of the water in the reach to be by-passed were evaluated. It was found out that no industrial activities are going on throughout the by-pass reach and thus the river water is not consumed for industrial purposes. Along the 27 km reach to be bypassed, use of Mtkvari River water for domestic, drinking water and/or irrigation purposes is very limited. Therefore, the basic use of the river water in the by-pass reach is the biological use. It should be noted that the part of the reach that is of main concern is the section of about 9.2 km till where the Potschkovi River joins the Mtkvari.

The decrease in the existing flow can decrease the tolerance of the river to pollution and also can adversely impact the continuity of the aquatic ecosystem. In order to maintain existing water quality and the biological resources in the by-passed reach; it is necessary to release a minimum flow from the reservoir to the bypass reach. To that end, a study was conducted to determine the required minimum flow for sustaining the water quality and aquatic biota in the by-pass reach. That being done, a minimum reservoir release to supply the minimum flow in the bypass reach at all times was calculated.

Reliable flow data of 36 years (for the period of 1938-1973) for the Mtkvari River has been obtained from Minadze Flow Gauging Station, located just downstream of the dam site on Mtkvari River. Detailed information regarding the flow data and its processing is provided in Section IV.1.4.2.

For determination of minimum flow that should be released to the by-pass reach, it is necessary to estimate the flow at the dam site since there is no continuously working gauge at this site. For this estimation, the drainage area of the flow monitoring station (Minadze Station) and the drainage area of the dam axis are correlated and the obtained coefficient is used for determination of the flow at the dam site.

In order to determine the minimum flow that should be released to the by-passed riverbed to sustain water quality and aquatic environment, Montana Method (Tennant, 1975) is used. According to this method, 10% of the annual average flow of the river (depending on the ecosystem of the river) has to be maintained in the riverbed. In addition, it indicates that if the water has human uses for various purposes more than 10% of the flow should be maintained in accordance with these uses of water as long-term minimum flow.

From the flow data derived for the Mtkvari Dam axis, minimum flow to be maintained in the riverbed to sustain the minimum conditions for the ecosystem are calculated. This minimum flow to be provided in the by-pass reach is calculated as 5.8 m^3/sec (10% of the average flow) by taking flow data for the period of 1964-1973, to cover a 10 year period of reliable record, which is also used for design purposes. In this period the average monthly flows occurred as provided in Table V.1.

Table V.1. Average Monthly Flows at Mtkvari Dam Axis

Month	Flow at Mtkvari Dam Axis (m^3/s)
January	26.62
February	26.99
March	35.69
April	164.59
May	177.47
June	85.55
July	38.56
August	31.13
September	28.81
October	28.19
November	28.18
December	26.04
Annual Average	***58.15***

The minimum flow to be maintained in the by-pass reach has been taken equal to the minimum release from the Mtkvari Dam to be on the safe side. In other words, the temporary and small tributaries feeding the by-pass reach till Uraveli River joins the Mtkvari River and the surface runoff is ignored in defining the minimum release. Annual average flows of Uraveli and Potschkovi Rivers are 3.7 m^3/sec and 21.4 m^3/sec, respectively. Hence the total flow of those two rivers is 25.1 m^3/sec and provides almost 45% of the flow of Mtkvari River water to the Mtkvari riverbed for sustaining the water quality and aquatic habitats in the downstream. Therefore, it is expected that the flow in this reach will be higher than this amount in considerable part of the year. It should also be added that amount of water to be released is higher than 10% of the natural flow in most months (especially dry months) of the year providing better than minimum conditions.

V.1.4.2. Evaporative Loss and Effects of Downstream Releases on Water Quality

When thermally stratified, large reservoirs have low-level intakes below the depth at which the hypolimnion is formed, waters having low temperature and reduced dissolved oxygen levels are released to the downstream river environment. In such a case, however, the evaporative loss would not significantly increase due to the release of cold hypolimnial water. In isothermal reservoirs, evaporative loss is generally not a problem since the temperature of the released water approximates that of the river.

Previous experience indicated that the HPP plants with a small reservoir that is operated in run-of- river mode do not pose risk for thermal stratification of the reservoir. Therefore, Mtkvari Reservoir is expected to remain isothermal throughout the year and the water released to downstream of the powerhouse will not cause any significant impact on river water quality.

In addition, considering its small surface area (about 0.5 km^2), annual evaporation from Mtkvari Reservoir will be negligible. Thus, the evaporative loss will not pose a problem for Mtkvari HPP Project.

The run-of -river mode of operation of Mtkvari HPP Project will cause minimal changes in the present seasonal flow downstream of the powerhouse. Thus, the effects of Mtkvari HPP Project on water quality and aquatic biota downstream the powerhouse area will be insignificant. The major impact of Mtkvari HPP Project, however, will be on the river hydrology and aquatic life in the bypass reach.

V.1.4.3. Sanitary Risk

The main parasitic, viral, or bacterial diseases that could develop or spread due to the development of a reservoir are summarized in Table V.2. According to the studies and statistics, none of the parasitic diseases is found in Georgia due to

climatic conditions. The risk combined with realization of this dam project can also be assessed by observing similar projects in the same region. No such adverse health impacts have been reported to occur as a result of developed dam projects in the region.

As the primary function of the Mtkvari Project will be power generation and not drinking water supply for the people in its vicinity, development and spreading of bacterial diseases, such as diarrhea, are not anticipated. Because of these reasons, the Mtkvari Project will not impose any increased risk to human health.

Table V.2. Main Parasitic, Viral, or Bacterial Diseases in Georgia

Diseases	Means of Transmittal	Presence in Georgia
Parasitic		
Malaria	Mosquitoes (Anopheles) with part of their life cycle in aquatic surroundings	No
Onchocercosis	Transmittal by black flies (simulium spp.) with part of their life cycle in aquatic surroundings	No
Schistosomiases	Molluscs (whelks and planorbid snails) serving as intermediary host	No
Filariasis	Aquatic crustacea (Cyclops) intermediary host of the Guinea worm	No
Viral		
Yellow fever	Mosquitoes (Aedes) with part of life cycle in water	No
Bacterial		
Various infectious cases of diarrhea	Transmitted by means of fecally-contaminated water (and containing for example E.coli, Vibrio, Salmonella, Shigella).	Yes

Consequently, no sanitary risks are estimated to arise due to reservoir formation and operation at Mtkvari project area.

V.1.4.4. Groundwater and Springs

Mtkvari reservoir will probably cause a slight rise in the water table around the reservoir area and slight fall around the by-pass reach. This will lead to slight flow rate increase for the springs gaining water from reservoir area and slighter flow rate decrease for the springs gaining water from the by-pass reach. Mtkvari Reservoir area is rather impermeable, considering that the water saturated highly permeable alluvial shingle is overlying on a relatively impervious tuffogenic layer, except some zones.

For the by-pass reach area, when the available tributaries at Trialeti Ridge, Akhaltsikhe, Aspindza and the catchment area is taken into account; it can be stated that the influence of the project on the groundwater level and spring discharges will be insignificant.

V.1.5. Impacts on Air Quality

Impacts on air quality are of concern basically during the construction phase of the dam. This is because of the fact that during operation there would not be any significant emission source associated by the project. Thus, the following sub-sections deal mainly with the impacts on air quality during the construction phase. The main impact on air quality due to construction activities will be the effect of dust and other (exhaust) gas emissions, especially under windy conditions. Therefore, these emissions are estimated and their consequences/effects are assessed in this section.

V.1.5.1. Assessment Approach and Methodology

To assess the potential impacts of the project related activities on air quality the ISCST3 (Industrial Source Complex - Short Term 3) model, developed by USEPA

(United States Environmental Protection Agency) was used. ISCST3 is one of the most widely used computer models for this purpose and can be considered a standard model used internationally. It provides calculated estimates of hourly, daily and annual ground level concentrations and depositions based on the source emission data. The model deals with different types of sources, such as point, area or volume sources, as well as taking aerodynamic waves, turbulence and deposition into account. Ground level concentrations and amounts of dry deposition as a result of the emissions of Particulate Matter (PM) from various sources relating to construction, aggregate generation, and NO_2, CO, HC, SO_2, and PM from vehicle movements were calculated in the modeling studies taking the topographical and meteorological conditions of the area into account. Both dust and gaseous emissions were taken into account in the assessment.

Sources of air emissions from all activities carried out during construction, including construction of the service roads, dam and other ancillary facilities, and emissions due to construction equipment to and from the site (on access roads and bypass roads) were identified based on the construction work plans. Details about the model setup and the detailed results (including tables and figures) are presented in Appendix 5.

V.1.5.2. Sources of Air Pollution during Construction

Construction activities and the construction schedule are provided in Chapter III. As a worst case scenario, it was assumed in the model that emissions from construction activities, like excavation and fill activities carried out at the dam site and for service roads occur simultaneously with the emissions (dust) caused by the movement of transportation vehicles and construction equipment. The amounts of fills and excavations were used from the construction work plan. The machinery and equipment list for dam construction (including service roads) is given in Table V.5. The substances emitted are the same from all machinery: exhaust gases and dust.

During construction, the potential sources of dust (emission, abrasion) are excavation, loading, unloading and hauling of excavated material, temporary storage of excavated material, traffic of earthmoving machinery and equipment on disturbed surfaces, and wind-generated dust from disturbed surfaces and stockpiled excavation material. Trucks will be moving to and from the crushing concrete facility, the dam site, the headrace tunnel entrances and the powerhouse site causing dust generation on unpaved surfaces.

The construction material that will be needed within the scope of the project will be mainly supplied from the excavated material and from the licensed quarries in the vicinity, so there will be no need for development of a new quarry. The unused excavated material will be stored in suitable areas of barren land, in valley formations to the extent possible not to cause any visual impact. The estimated excavation and filling amounts for various project units are given in Table V.3.

Table V.3. The Excavation and Fill Amounts for the Project Units

Project Unit	Excavation Amount (m^3)	Fill Amount (m^3)
Diversion Canal	28,200	6,000
Cofferdam	-	55,000
Spillway	32,000	-
Dam	8,000	142,000
Roads	-	100,000
Headrace Tunnel	8,600	-
Surge Shaft	9,000	-
Powerhouse	13,900	-
Tailrace	10,800	-
Total	**110,500**	**303,000**

Pollutant Emissions from Construction Vehicle Exhausts

The emissions due to the exhausts of the construction equipment are the second part of the sources that can adversely affect air quality in the area. Primary engine

exhaust emissions from vehicles are NO_2, CO, HC, SO_2, and PM. In this study, concentration estimations for all of these pollutants have been made. The construction machinery itself and heavy vehicles (trucks) will be diesel fuelled and the diesel soot contains hydrocarbons.

V.1.5.3. Impacts on Ambient Air Quality during Construction

The impacts on air quality during construction, where the main concern will be dust (particulate matter) emissions, will be temporary. Particles can vary widely in size and composition. The PM10 (particles measuring less than 10µm diameter) standard identifies those particles likely to affect human health, and PM10 has become the generally accepted measure of particulate material in the atmosphere. In this respect, World Health Organization (WHO) and the EU Council Directive 2008/50/EC set limit values for PM10.

Due to movements of the vehicles on the access roads, the excavation-filling processes, loading of the excavated material to the trucks and transportation of material to the storage areas dust will be formed. While calculating the expected uncontrolled emission amounts during the construction works, the emission factors given below are used:

Excavation emission factor	: 0.025 kg/ton
Loading emission factor	: 0.01 kg/ton
Unloading emission factor	: 0.01 kg/ton

Environmental Protection Agency (EPA) of United States stated that ñthe dust emissions can be reduced at a rate of 70-95% by watering (water spraying)òin the ñSand & Gravel Processingò Chapter of AP 42. Therefore, while calculating the controlled dust emissions, it is assumed that the emissions can be reduced by 70% with watering (by taking the lower value of the internationally excepted range).

ISCST3 model was run with the above mentioned assumptions. The calculated maximum ground level concentrations of NO_2, CO, HC, SO_2, PM and limit values provided in international standards and EU legislation are provided in Table V.4.

Table V.4. Calculated Maximum Annual and Daily Average Ground Level Concentration Values and Relevant International Standards (Limit Values)

Parameter (Maximum)	**Concentration** ($\mu g/m^3$)	**WHO** ($\mu g/m^3$)	**2008/50/EC** ($\mu g/m^3$)
Daily (NO_x)	2.58	200	200
Yearly (NO_x)	0.53	40	40
Daily (CO)	4.28	-	10,000
Yearly (CO)	0.88	-	-
Daily (SO_x)	0.43	125	125
Yearly (SO_x)	0.09	-	-
Daily (HC)	0.83	-	-
Yearly (HC)	0.17	-	-
Daily (PM_{10})	90.20	150	50
Yearly (PM_{10})	8.16	70	40

The table shows both the maximum values of the annual average and the maximum value of the daily average. None of these maximum values are predicted to occur at the settlements. These were observed at the receptors closest to the sources (construction sites). When the results for other locations are analyzed, it is seen that they are substantially lower. The equivalent concentration curves for NO_x, SO_x, HC and PM are provided Figure V.2-V.5 and Appendix 5 for the daily average values, since the daily average values are higher than the annual average values. These values represent the concentration in the close vicinity of the emission sources. Since the settlements are located farther away, values at these receptors are substantially lower.

Ground level concentrations from construction activities are higher in the vicinity of main emission sources such as construction sites and decrease by distance

influenced by local meteorology and topography. Except for daily average PM, all the maximum values are well below relevant standards (Table V.4). It has been noted that these maximum values reflect the worst case close to the source and under adverse conditions (i.e. maximum values generally occur at calm conditions when dispersion is minimum and conservative assumptions for the vehicle fleet).

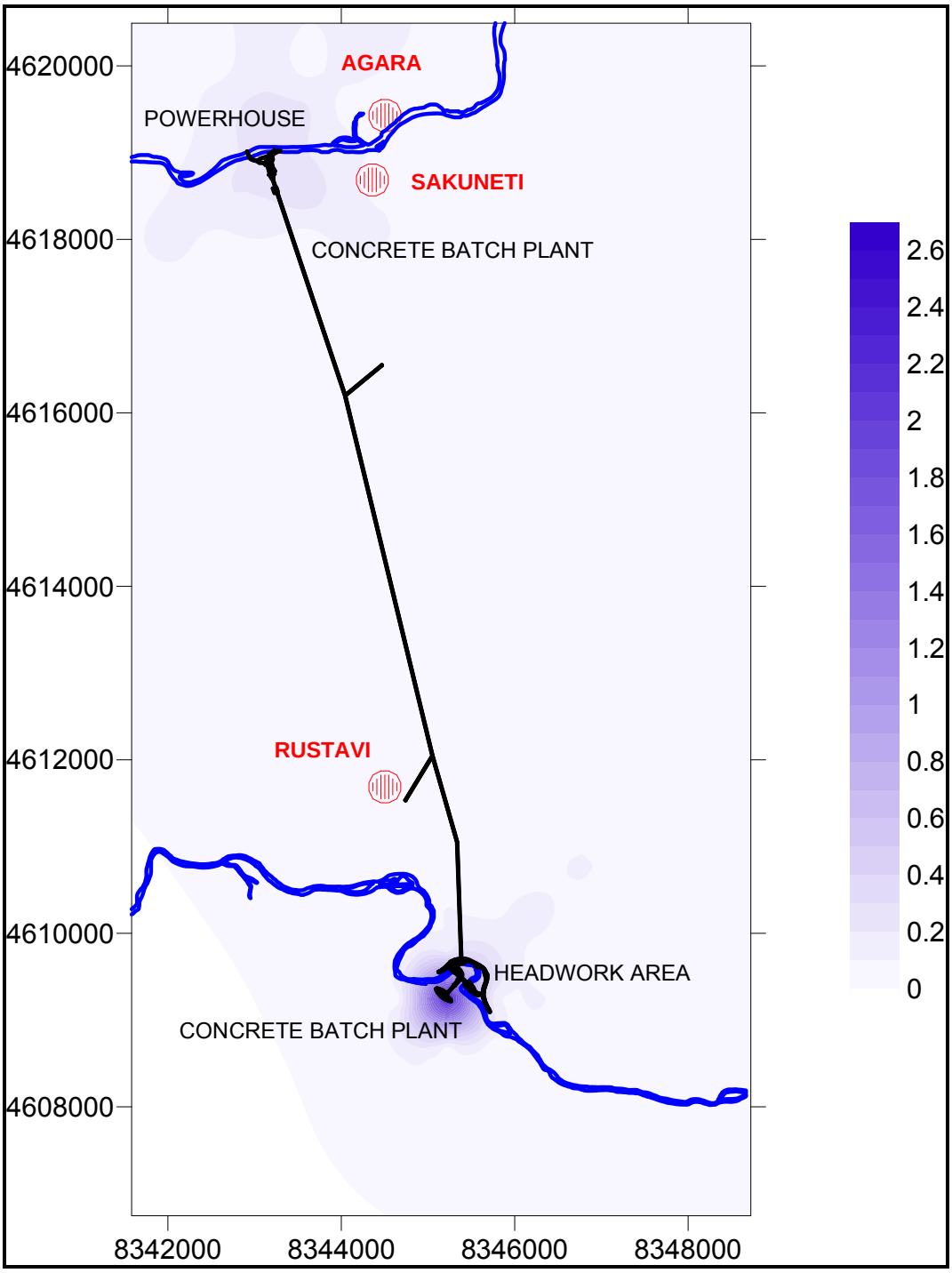

Figure V.2. Daily Equivalent Concentration Curves for NO_x for the Construction Phase (μg/m^3)

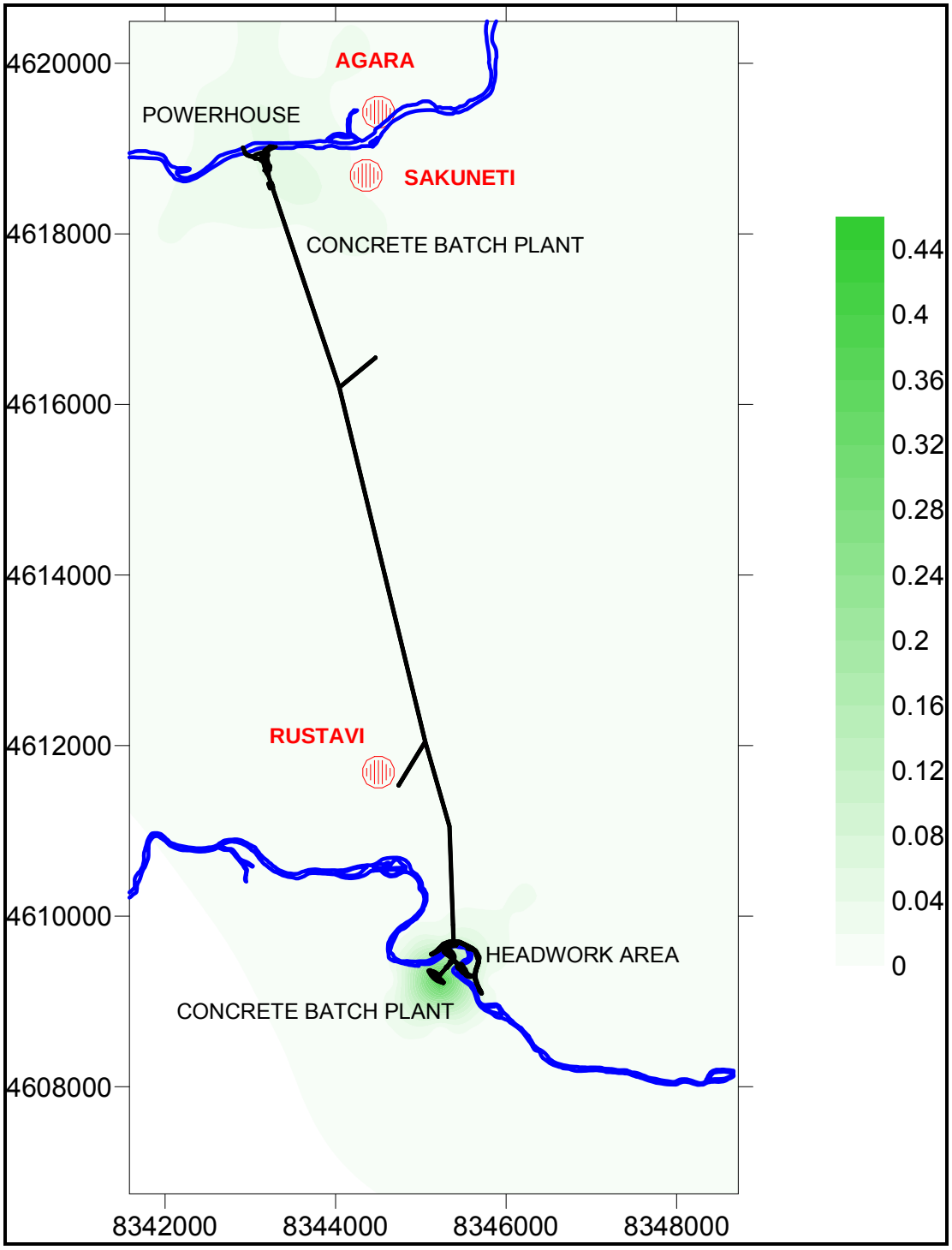

Figure V.3. Daily Equivalent Concentration Curves for SO_X for the Construction Phase ($\mu g/m^3$)

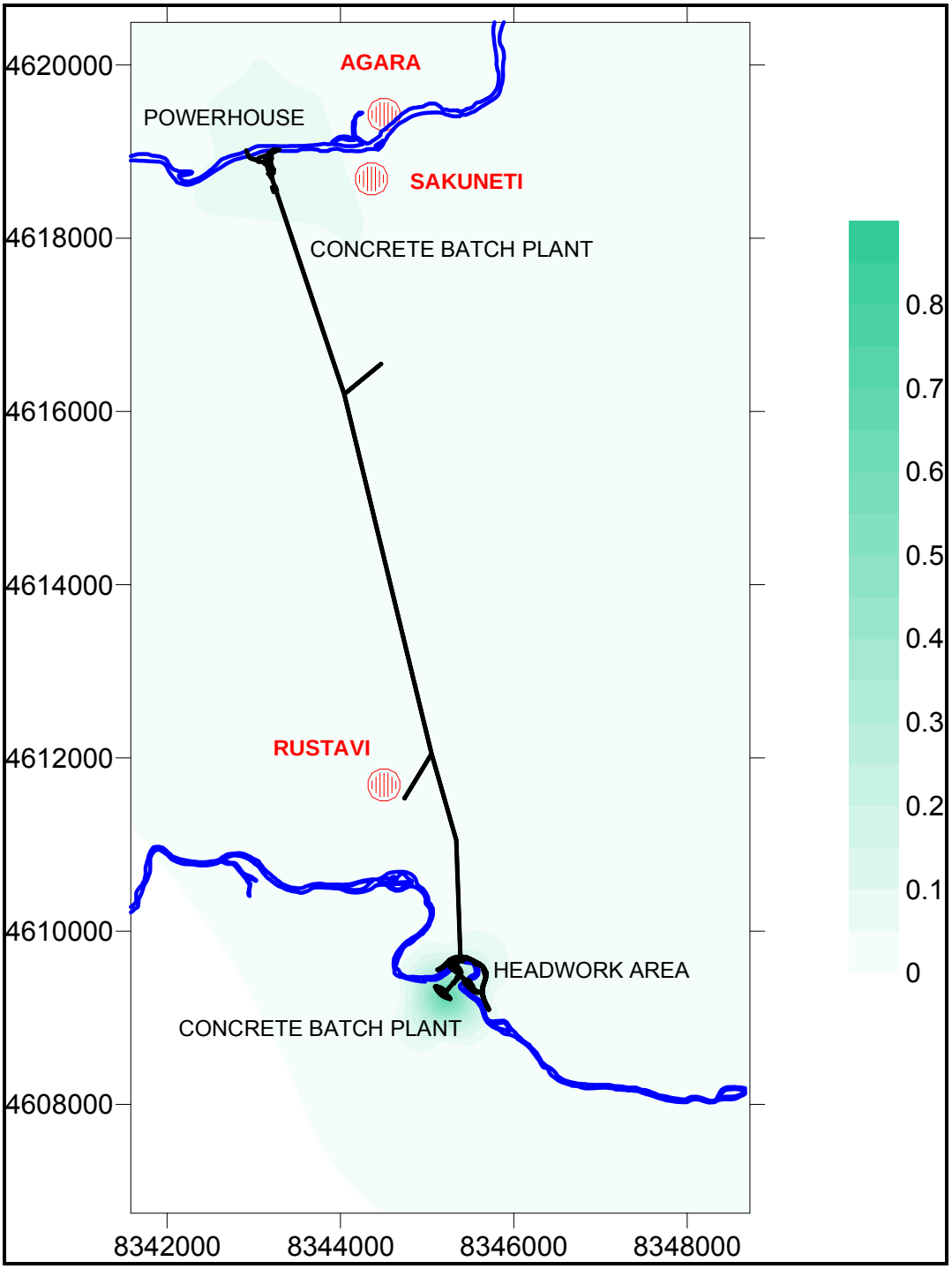

Figure V.4. Daily Equivalent Concentration Curves for HC for the Construction Phase (μg/m^3)

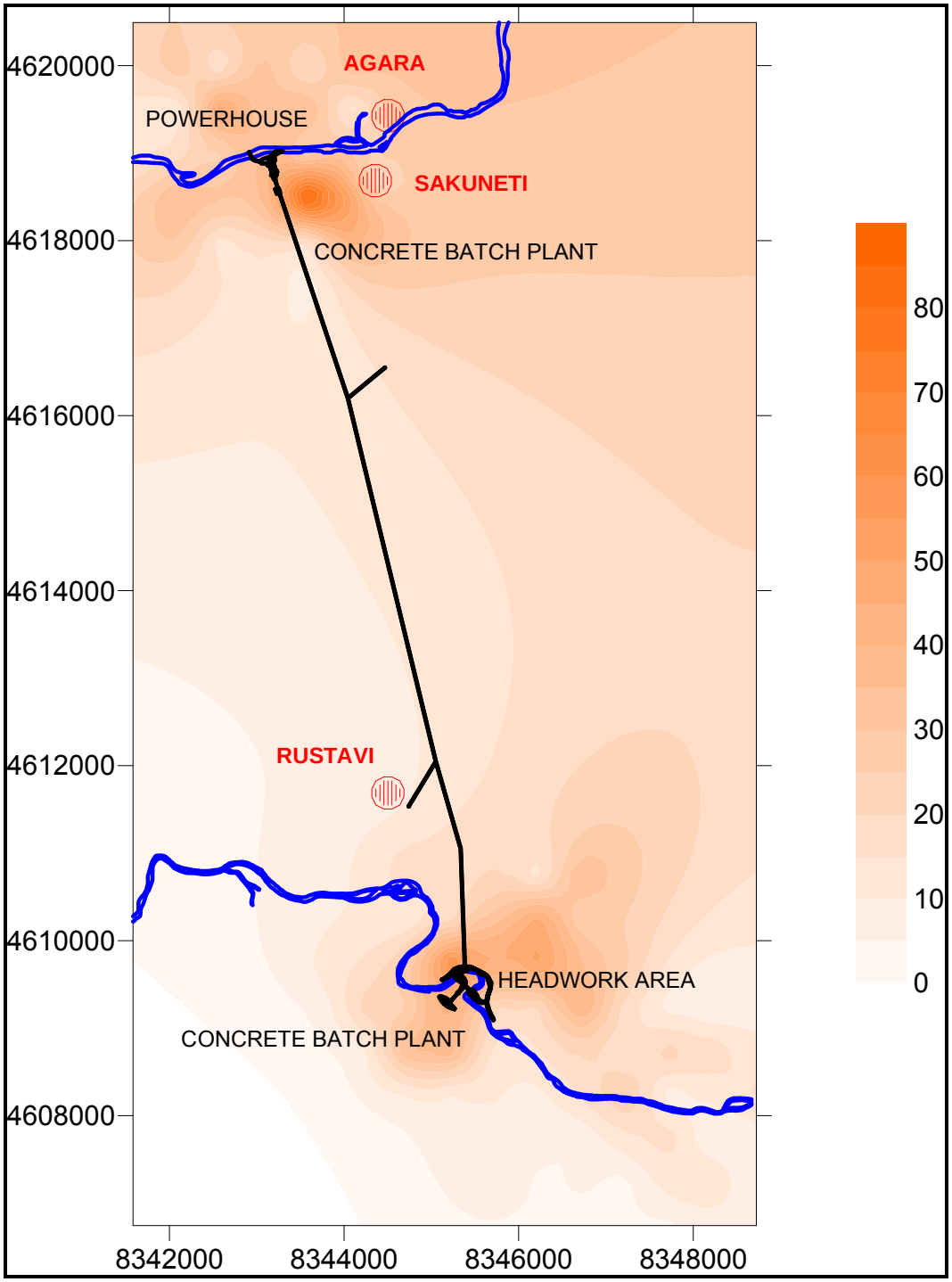

Figure V.5. Daily Equivalent Concentration Curves for PM for the Construction Phase (μg/m^3)

Concentrations of all pollutants calculated from the model are well below the limits of WHO Ambient Air Quality Guidelines. Moreover, these emission values were calculated considering the worst case scenario. Accordingly, the gas emission concentrations of Mtkvari Hydroelectric Powerplant in construction phase will be much lower. In addition, in order to control the air pollutants, some precautions are suggested that are presented in Chapter VII.

In order to evaluate the significance of the impacts of PM emissions, the calculated PM concentrations are compared with the EU Directive of 2008/50/EC and WHO Guidelines. As a result of this comparison daily PM_{10} concentration is above the limit values indicated in the EU Directive, while it is under the limit value of the WHO Guidelines. PM_{10} concentrations are much lower near the settlements closest to the construction sites. The nearest settlement to the dam site, Rustavi Village, is about 3 km to the north-east of the dam site and the nearest settlement to the power house, Sakuneti Village, is about 1 km to the south of power house.

Precautions are to be taken to protect the health of the workers during any operation and from any adverse effects, including those of dust. Respirators will be supplied for the workers who are directly exposed to particulates and the equipment used in construction will be examined periodically for the protection of the health of workers. In addition, the air in underground works will be kept at appropriate conditions for the occupational health and safety. Within this scope, health and safety measures in line with relevant Georgian Legislation, also PR-2: Labour and Working Conditions of EBRDâs Environmental and Social Policy and PS-2: Labour and Working Conditions of IFC's Social and Environmental Sustainability will be taken.

The potential impacts of the Project on air quality were assessed for only the construction phase. This is because there will be no considerable emission generation activity in the operation phase of the project.

V.1.6. Impacts of Noise during Construction and Operation

Noise will be of concern during the construction phase of the dam. By the start of land preparation, noise will be generated due to the works performed during all construction period for dam and HPP. The noise impact will be of concern mainly due to the construction machines and activities.

V.1.6.1. Sources of Noise

During construction, the potentially significant sources of noise emissions are the various earthmoving vehicles (e.g. dozers, excavators, and trucks), stationary equipment such as pumps and generators, as well as the construction activities. At the construction works and concrete production, it is planned to operate 2 dozers, 5 excavators, 4 loaders, 7 trucks, 2 pumpers, 2 compressors, 2 transmixers, 2 tunnel drilling guns, 2 concrete batch plants, 2 concrete pumps, and 2 tunnel ventilation fans.

V.1.6.2. Estimation of Noise Levels

The noise levels were estimated based on the method suggested by UNDP in ñTEM Traffic and Construction Noise Control Reportò published in 1990. This method includes estimation models for area, line and point sources. The estimations are based on the type and number of equipments to be used and their average noise levels (in dBA).

Potential receptors of noise emissions include in particular the settlements nearest to the construction sites which are Rustavi and Sakuneti Villages that are in the vicinity of the headworks and powerhouse areas, respectively. Noise modelling was carried out for these selected settlements, since the noise levels would be lower at the settlements that are located farther from the sources of noise.

The worst case scenario in which all the equipment are used with their full capacity at the same time, was used while calculating the noise levels due to dam body construction, powerhouse construction, concrete batch plants, and power tunnel excavations. The distribution of noises of the construction equipment those are defined above at the relevant construction areas are given in Table V.5.

Table V.5. Distribution of the Construction Equipment (Noise Sources) to Working Areas

Area	Amount	Equipment
Headworks	1	Dozer
	2	Excavator
	2	Loader
	2	Truck
	1	Pumper
Powerhouse	1	Dozer
	3	Excavator
	2	Loader
	3	Truck
	1	Pumper
Power Tunnel (Adit 1, Adit 2)	1 at each	Compressor
	1 at each	Tunnel Drilling Gun
	1 at each	Tunnel Ventilation Fan
	1 at each	Truck
	1 at each	Concrete Pump
At Concrete Batch Plants	1 at each	Concrete Mixing Unit
	2 at each	Transmixer

In order to identify the noise levels of the equipment, several reference values were taken into consideration. Within this scope, permissible sound levels of equipments at Stage II (from 3 January, 2006) of EU Directive 2000/14/EC on the Approximation of the Laws of the Member States relating to the Noise Emission in the Environment by Equipment for Use Outdoors were taken into consideration. However, in order to calculate the noise levels for the worst case scenario, higher

individual noise levels (from experiences in similar projects and countries) were used. Accordingly, the noise levels of the equipments to be used during the construction phase of Mtkvari HPP Project are presented in Table V.6.

Table V.6. Noise Levels of the Equipments to be used in Construction Phase (L_w)

Equipment	Noise Levels (dB)
Dozer	104
Truck	104
Loader	106
Compressor	99
Concrete Pump	104
Tunnel drilling gun	107
Tunnel ventilation fan	99
Excavator	106
Concrete mixing unit	115
Crusher	105
Transmixer	104
Pumper	104

V.1.6.3. Limit Values and Evaluation Standards

There exists no specific regulation or legislation regarding noise emissions in the Georgian Legislation. In addition, the international noise standards do not provide a homogeneous picture and values cannot easily be compared, as some are specific, e.g. for traffic (road, rail) industry, construction, etc. Some international agencies, such as World Bank Group (WB) and WHO, provide general guidance (see Table V.7). For example, the limit values provided in the Environmental, Health, and Safety (EHS) Guidelines (General EHS Guidelines: Environmental Noise Management) of International Finance Corporation of the WB are provided in Table V.7.

Also within the EU regulations and directives, no standardized noise limits exist throughout the member states. For instance in Germany rural areas with agricultural activities (i.e. not purely residential) would be classed as õmixed areasò

Table V.7. International Reference Noise Limit Values

Area Use	WB (general) (dBA)	WHO (general recommendation) (dBA)	Germany (road traffic16. BimSchV) (dBA)
	day	day	day
Residential Areas	55[a]	55	59
Mixed Areas	70[b]	70[b]	64

a) residential, institutional, educational

b) industrial, commercial

Within the scope of the limit values and evaluation standards, the most suitable ones for Mtkvari HPP project are determined to be the standards that are defined by the World Bank and World Health Organization. Therefore, the limit value for noise emissions in the context of Mtkvari HPP Project is determined as 55 dBA. It should be noted that this is the limit for the day-time and it is selected to be used since the construction activities would be carried out during the day time hours.

V.1.6.4. Impacts of Noise during Construction

The change in noise levels (equivalent sound pressure levels) in the construction phase, according to the worst-case scenario (all major machinery to be used during the construction phase near the receptor will work at the same area and at the same time), by distance from the sources was estimated by mathematical modeling. For the Mtkvari HPP Project, noise levels were calculated at two different main construction locations, which are namely, the powerhouse and

headworks. The locations at which the construction works will be performed are classified as follows:

Location 1: Headworks, Adit 2 and the concrete batch plant area.
Location 2: Powerhouse, Adit 1 and the concrete batch plant area.

The noise at these locations will be generated by the working construction equipment to be used at these sits. The equation given below was used for the calculation of the total noise level by using the noise level of each source.

$$L_{wt} = 10 \log \sum_{i=1}^{n} 10^{L_{wi}/10}$$

The noise level (L_{pt}) that is due to the equipments used during construction activities and that reaches to a definite distance was calculated by the equations given below. The noise levels at different distances from the 2 construction locations were calculated by using the following equations and the results are provided in the following tables and figures.

$L_{pt} = L_{wt} + 10\text{Log}\ (Q/4\pi r^2)$
L_{wt}: Noise level at the source
Q: Orientation coefficient
r: Distance from the source

Location 1:

The noise generated at Location 1 will be due to the activities performed at the headworks, Adit 2, and the concrete batch plant. The change of generated noise levels with distance to Location 1 is given in Table V.8.

Table V.8. Change of Noise Levels with Distance (for Location1)

Distance to Location 1	L_{pt} (dBA)		
(m)	Headworks	Adit 2	Concrete Batch Plant
15	82.6	80.4	84.1
50	72.2	70.0	73.7
80	68.1	65.9	69.6
89	67.2	65.0	68.7
100	66.2	64.0	67.7
150	62.6	60.4	64.1
200	60.1	57.9	61.6
250	58.2	56.0	59.7
287	57.0	**54.8**	58.5
300	56.6	54.4	58.1
360	**55.0**	52.8	56.5
400	54.1	51.9	55.6
430	53.5	51.3	**55.0**
500	52.2	50.0	53.7
600	50.6	48.4	52.1
650	49.9	47.7	51.4
700	49.3	47.1	50.8
800	48.1	45.9	49.6
900	47.1	44.9	48.6
1,000	46.2	44.0	47.7

When the calculated values are compared with the values given in Environmental, Health, and Safety (EHS) Guidelines (General EHS Guidelines: Environmental Noise Management) of International Finance Corporation, it is seen that the noise levels generated due to the activities performed at headworks, Adit 2 and the concrete batch plant are at the limit value (55 dBA) at 360 m, 287 m and 430 m distances, respectively. In order to determine the cumulative noise level that will affect the closest settlement to the headworks area, the ambient (without the project) noise levels measured in Rustavi Village were used. As indicated in Section IV.1.5, the existing noise level in Rustavi Village is 43.7 dBA. The cumulative noise level that is expected in Rustavi Village is given in Table V.9.

Table V.9. Cumulative Noise Level expected at the Closest Settlement (Rustavi Village) to the Mtkvari Dam Axis

	Distance of Rustavi Village (m)	Noise Level (dBA) created in Rustavi Village
Headworks Area	2,200	39.3
Adit 2	400	51.9
Concrete Batch Plant	2,200	40.8
Existing Noise Level at Rustavi Village (dBA)		43.7
Cumulative Noise Level (dBA)		**53.6**

As can be seen from Table V.10, the estimated cumulative noise level (present noise + project induced noise) at the Rustavi Village is below the limit values defined by the WB. The change of noise levels with distance from the headworks, adit 2 and concrete batch plant are presented in Figures V.6, V.7 and V.8, respectively.

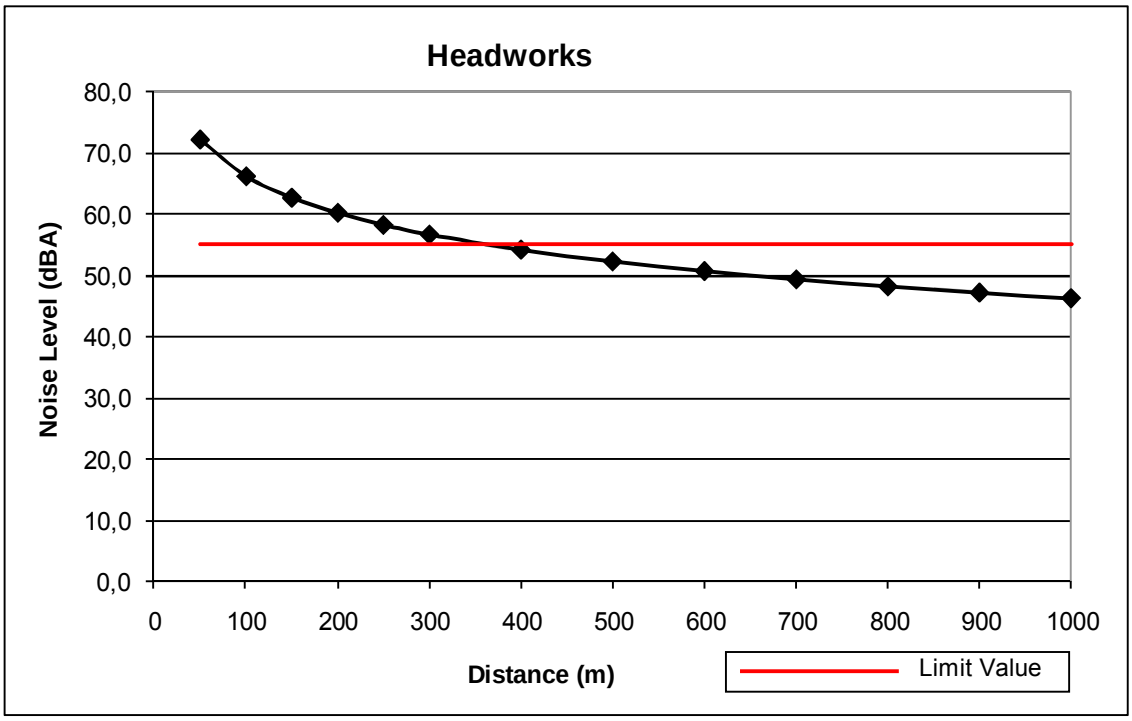

Figure V.6. Change of Noise Levels with Distance from Headworks

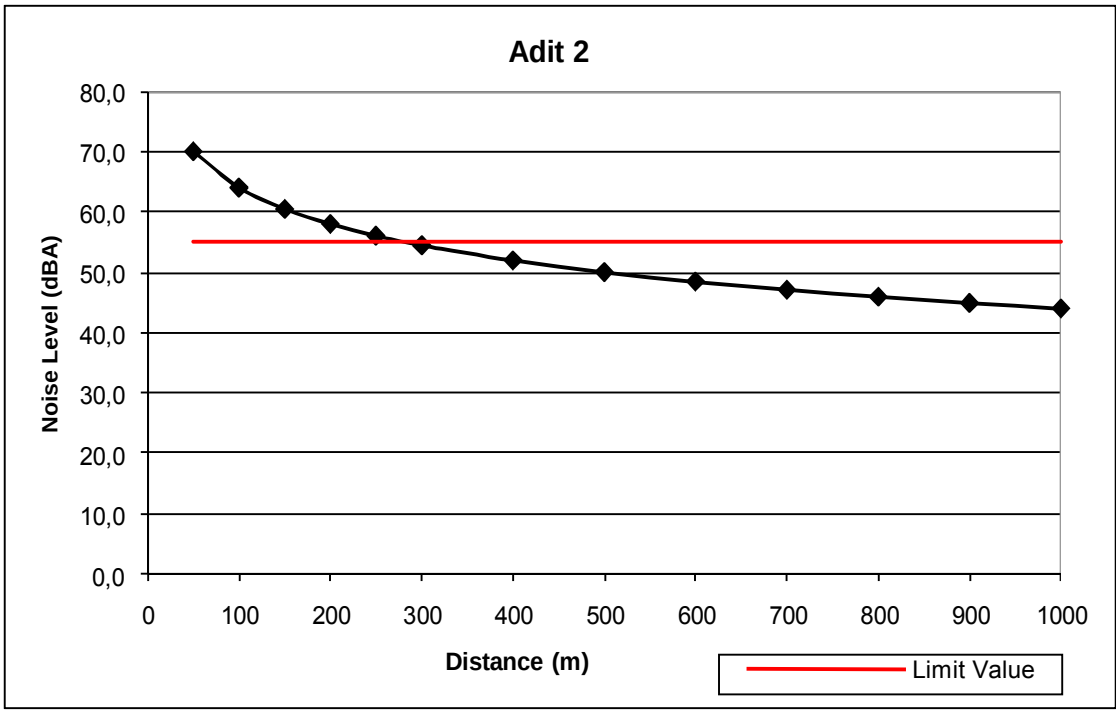

Figure V.7. Change of Noise Levels with Distance from Adit 2

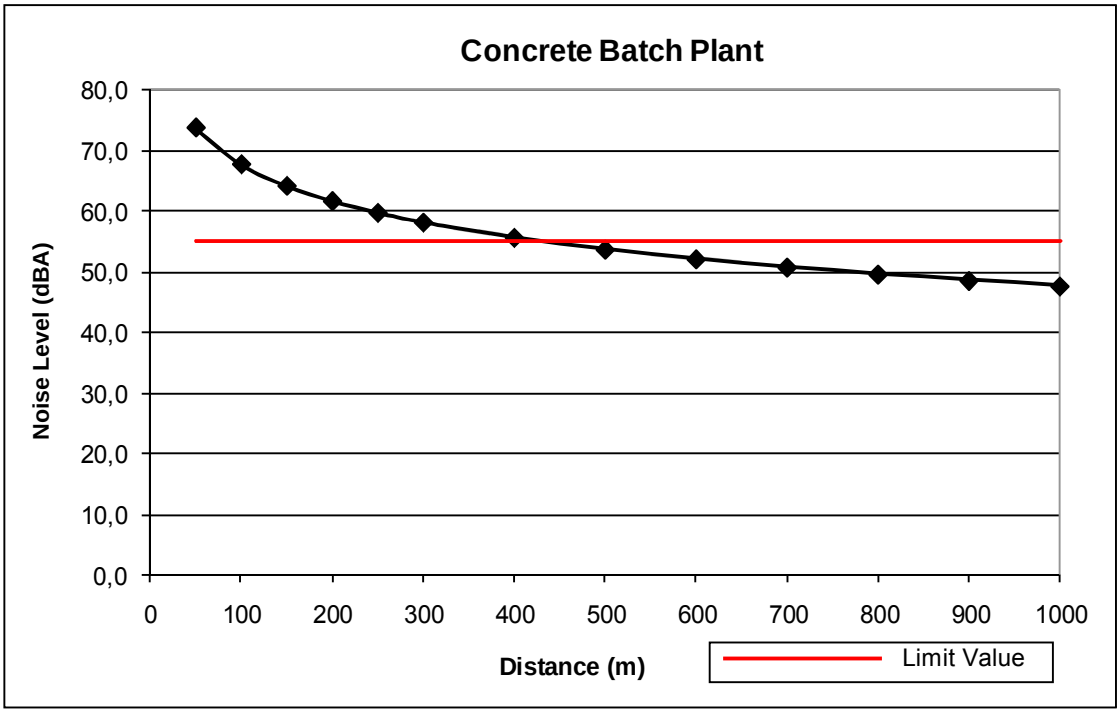

Figure V.8. Change of Noise Levels with Distance from Concrete Batch Plant

Location 2:

The noise at Location 2 will be due to the activities performed at powerhouse, adit 1 and the concrete batch plant area. Since the number and types of equipments those will work at Adit 1 and concrete batch plant is the same with Location 1 the calculated values provided in Table V.8 is the same for Location 2. Thus, in Table V.10 below, only noise generated at the powerhouse construction site is considered and the change of noise levels with distance to the powerhouse site are given in this table.

Table V.10. Change of Noise Levels with Distance (for the Powerhouse Site)

Distance (m)	L_{pt} (dBA)
15	83.6
50	73.2
100	67.1
150	63.6
200	61.1
250	59.2
300	57.6
400	55.1
405	**55.0**
500	53.2
600	51.6
700	50.2
800	49.1
900	48.0
1,000	47.1

When the calculated values are compared with the value given in Environmental, Health, and Safety (EHS) Guidelines (General EHS Guidelines: Environmental Noise Management) of International Finance Corporation of the WB, it is seen that the noise levels generated due to the activities performed at the powerhouse site reach the limit value (55 dBA) at 405 m distance. In order to determine the

cumulative noise level that will affect the closest settlement to the headworks area, the ambient (without the project) noise levels measured in Rustavi Village were used. As indicated in Section IV.1.5, the existing noise level in Sakuneti Village is 45.5 dBA. The cumulative noise level that is expected in Sakuneti Village is given in Table V.11.

Table V.11. Cumulative Noise Level expected at the Closest Settlement (Sakuneti Village) to the Mtkvari Powerhouse Site

	Distance to Sakuneti Village (m)	**Noise Level (dBA) created in Sakuneti Village**
Powerhouse Area (m)	1,245	45.2
Adit 1 (m)	1,730	39.2
Concrete Batch Plant (m)	1,100	46.8
Existing Noise Level (dBA) at Sakuneti Village		45.5
Cumulative Noise Level (dBA)		**50.96**

As can be seen from Table V.11, the estimated cumulative noise level (present noise + project induced noise) at the Sakuneti Village is below the limit values defined by the WB. The change of noise with distance from the powerhouse area is presented in Figures V.9.

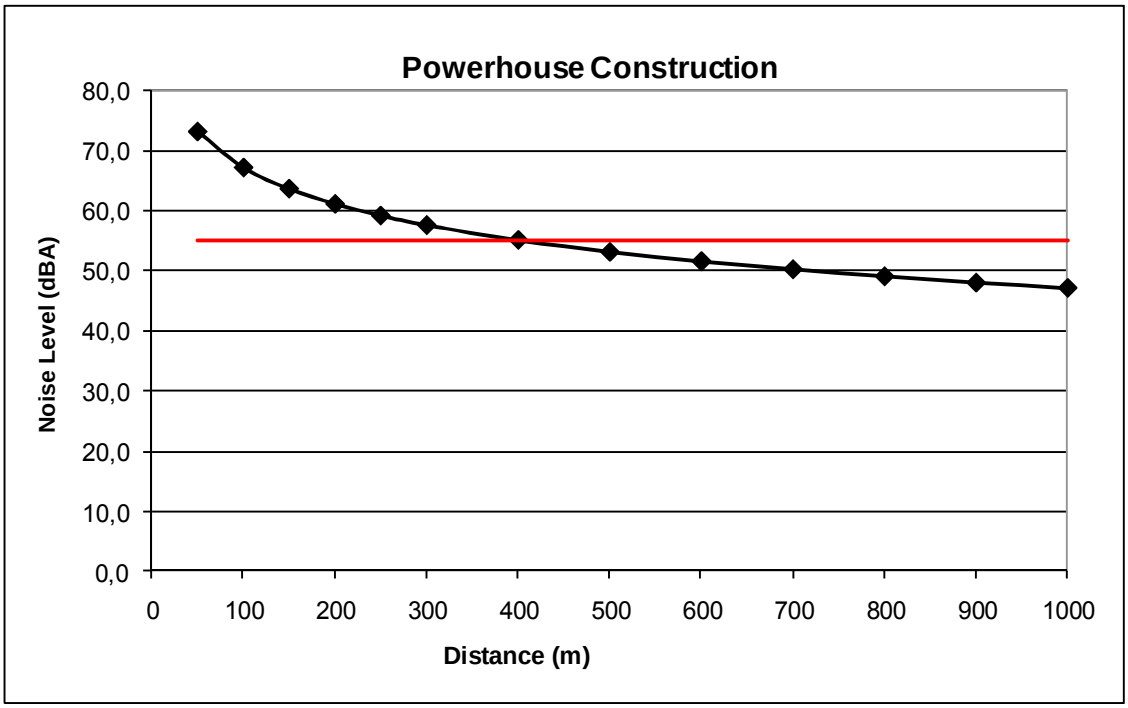

Figure V.9. Change of Noise Levels with Distance from Powerhouse Construction Area

The summary of the noise levels calculated with respect to the noise generated at the construction sites and the cumulative noise levels estimated for Rustavi and Sakuneti Villages area presented in Table V.13. As can be seen from this table, the cumulative noise levels at these two settlements are below 55 dBA, which is the limit value. It should be noted that these calculations were done with a conservative approach by assuming all of the construction equipments are used at the same place at the same time. Consequently it is expected that the noise levels in reality will be much lower than the values given in Table V.12.

Table V.12. Summary of the Cumulative Noise Levels (dBA) Calculated for Rustavi and Sakuneti Villages

Noise Sources	Noise Level (dBA)	
	Rustavi Village	**Sakuneti Village**
Headworks	39.3	-
Adit 2	51.9	-
Concrete Batch Plant 1	40.8	-
Powerhouse	-	45.2
Adit 1	-	39.2
Concrete Batch Plant 2	-	46.8
Present Noise Level	**43.7**	**45.5**
Cumulative Noise Value	**53.6**	**50.96**

The locations of the construction work areas (noise sources) and the closest settlements to these areas are shown in Figure V.10 to give an overall idea about the distances between all these units. This will help top interpret the results of noise modelling studies better.

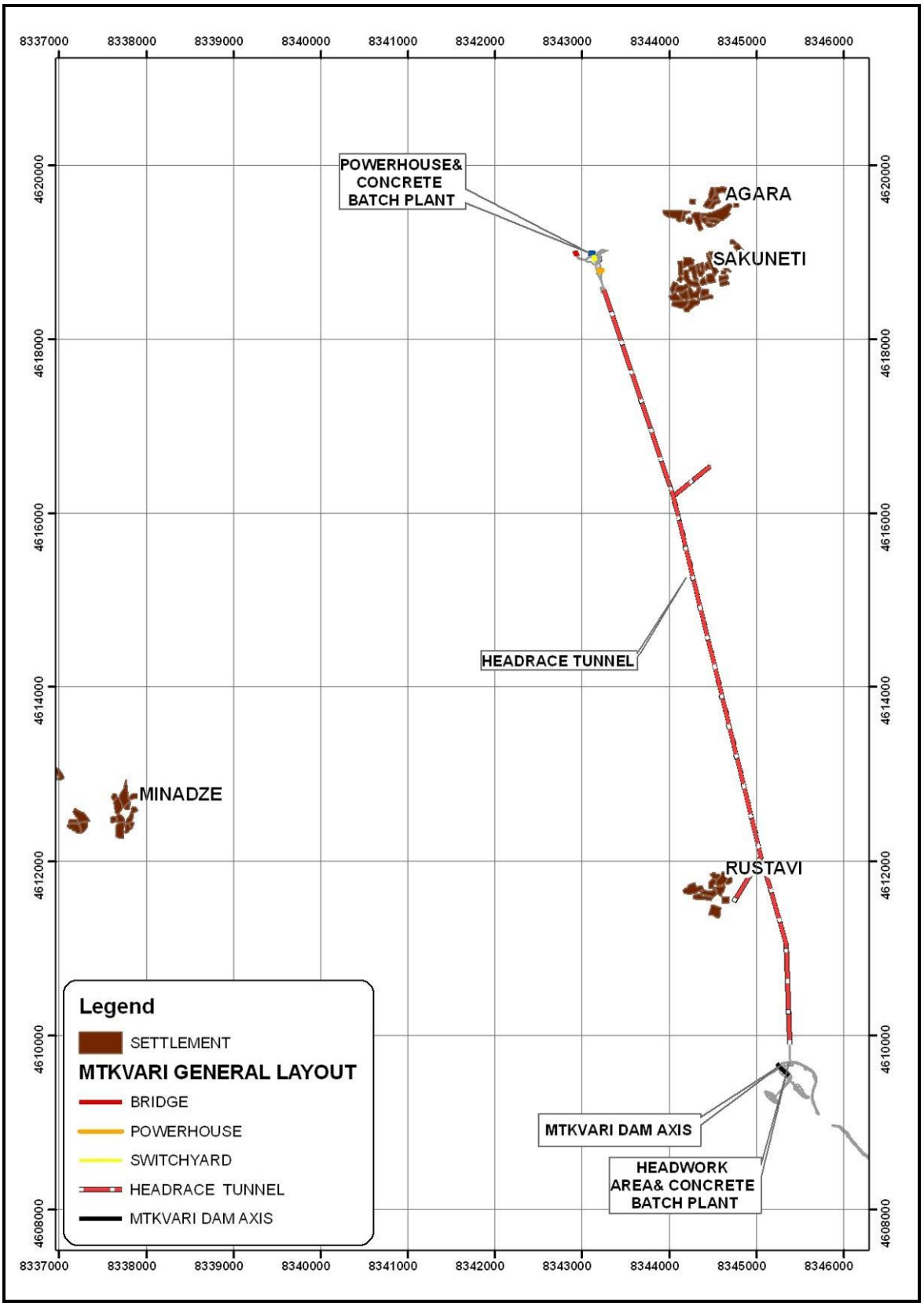

Figure V.10. Relative Locations of the Construction Sites (Noise Sources) and Closest Settlements

The nearest settlement to the headworks, Rustavi Village, is located at about 3 km to the north-west of the site. The nearest settlement to the powerhouse, Sakuneti Village, is located at about 1 km to the north of the powerhouse. Therefore, no significant complaints with regard to noise are expected from the residents. In addition, all the calculations are based on the worst case scenario in which all the equipments are used with their full capacity at the same time. However, the set of machinery assumed in the calculations seldom operate at the same place and at the same time. Hence, even under the worst-case scenario assumptions, as unlikely as they are, the noise generated is anticipated to be within the allowable international limit values. Furthermore, the actual overall noise level will be lower due to the attenuation of noise by air, vegetation and other natural noise barriers that were excluded from the modelling (i.e. as following a worst case scenario, but without considering the reflection from bare rock surfaces either).

V.1.6.5. Impacts of Noise during Operation

The only noise source of the Project foreseen in operation phase will be generator and turbines located in the powerhouse. However, there will not be any considerable noise nuisance since they will be located in a closed building. In addition, it will be somewhat an isolated facility since it will be located at a distance of 1245 m to Sakuneti Village, which is the nearest settlement.

V.2. Impacts on Biological Environment

Dam and hydroelectric power plant projects do not cause significant pollution, although they cause considerable direct and indirect effects on the environment. In the case of large reservoirs designed for water storage, the major change caused by impoundment is the transformation of the riverine and the surrounding terrestrial habitats into a lentic environment. The Mtkvari Reservoir will cover an

area of around 0.5 km^2 and is intended for diverting the water to the powerhouse through the power tunnel and not for water storage. Having such a small intake pond/reservoir, the main impacts of the Mtkvari Project will be on the 27 km long section of the Mtkvari River to be by passed by the power tunnel. It should also be noted that the first 9.2 km of this reach is the main concern since two big tributaries Uraveli and Potchskovi Rivers join the Mtkvari River at about this distance downstream of the Dam Axis.

V.2.1. Impacts on Aquatic Species

The major impacts of the realization of the Mtkvari Project will be on the existing aquatic fauna along the bypass reach where present flow patterns will be altered by project operation. Impacts due to the inundation of riverine habitats will be limited to only approximately 3.5 km segment of the Mtkvari River and a considerable small surface area (totally 0.5 km^2). Water quality in the Mtkvari Reservoir and the releases from the Mtkvari HPP, however, will not be significantly different than that of the Mtkvari River owing to the small size and operational characteristics of the reservoir.

V.2.1.1. Effects of Reservoir on the Aquatic Biota

The dams, in general, regulate the downstream flow based on the size of the reservoir established. Mtkvari Project will not have such a considerable regulating function since it is a run-of-river project with a very small reservoir.

The changes in aquatic habitats and biota due to the formation of the Mtkvari Reservoir will be to a limited extent, in accordance with its small size. Regarding their shorter detention times due to the mode of operation, reservoirs do not act like natural lakes. The topography is also influential on reservoir behavior. Therefore, the water and the nutrients are retained for shorter periods in

reservoirs, compared to natural lakes. This is true especially for the Mtkvari Reservoir to be operated as run-of-river with a low detention time.

Most of the fish species identified are adaptable to living in lakes as well as rivers. Thus, formation of a very small reservoir, which will develop slightly lentic conditions will not have a significant impact on the fish species of the river. Among the fish species *Salmo trutta fario* (brown trout) is a sensitive species to water quality and river habitat. This species was not observed in the vicinity of the project area, but it was determined from literature that it can be found in the tributaries joining the Mtkvari River. This species mainly prefers cold stream and rivers as habitats. Therefore, stagnant water body (reservoir) is not a suitable habitat for this species. However, since it is reported to be living in the higher elevations of the tributaries the small reservoir of Mtkvari will not have a considerable effect on this species.

Alburnoides bipunctatus (Spirlin) that was observed in the project area is a fish that prefers calm (slow running) rivers. Thus, it can adapt to the lake environment, especially since the Mtkvari Reservoir will not be a typical big scale reservoir, but will provide calm waters. In addition, for the species that prefer to spawn on the stones and gravels at the riverbed of the rapidly flowing streams *such as Barbus lacerta (*Kura barbel), *Barbatula brandtii (*Kura loach) there is available sections in the upstream of the future reservoir and in the tributaries both upstream and downstream of the dam site.

V.2.1.2. Effects of Headrace/Power Tunnel on the Aquatic Biota

In the Mtkvari Project, water is diverted to the powerhouse through a 9.6-km long power tunnel. The power tunnel will bypass the Mtkvari River between the dam site and the powerhouse. This characteristic will alter the present flow pattern and quantity along the bypass reach, which in turn will affect the habitat characteristics and hence the aquatic biota. It shall be stated that this whole stretch is about 27 km, at 8 km downstream of the dam site Uraveli River, which

has a considerable flow, joins the Mtkvari riverbed and at 9.2 km downstream of the dam site Potschkovi River joins the Mtkvari riverbed. These two rivers carry flows almost 45% of the flow of Mtkvari River to the Mtkvari flow at the dam site. Thus, the main river reach of concern regarding the by-pass is the first 9.2 km downstream of the dam axis (till the Potchskovi confluence). Furthermore, there are some smaller tributaries in this 9.2-km section as well.

Ten fish species (Asp, Kura barbel, Spirlin, Transcaucasian barb, Kura bleak, Kura nase, European Chub, Gudgeon, Tench and Kura loach) identified in the project area are listed in Annex 3 of the Bern Convention. Accordingly, these species should be protected in such a manner that the project will not be detrimental to the survival of affected populations of these species. Without a minimum flow in the bypass reach to maintain their resting, feeding and breeding habitats, the reduced flows would likely cause the loss of the populations of these fish species from the bypass reach. The habitats of these species include stony and sandy bottoms, which form the river bottom of the Mtkvari River throughout the project area. Due to the presence of these types of habitats evenly throughout the bypass reach, it is expected that this situation will not be altered significantly during the operation of Mtkvari Project, as long as the critical flow is maintained.

To mitigate the adverse impacts described above and maintain the habitats for the fish species in the bypass reach, a minimum flow will be provided in the bypass reach at all times by a water release from the Mtkvari Dam. This minimum flow was estimated as described in Section V.1.4.1.3 and the minimum release from the Mtkvari Dam is accepted as the minimum flow to be maintained in the river reach to be on the safe side. This implies that in a very big part of the year there will be much more flow than the calculated minimum flow in the by-pass reach.

V.2.1.3. Effects of Releases on Downstream Biota

The effects of impoundment on the downstream water quality depend largely on reservoir size and mode of operation. In large reservoirs, stratification and the consequent changes in temperature, dissolved oxygen (DO) and nutrient content

may take place. The relation of the depth of the thermo-cline to the depth of the water intake will affect the downstream biota. Depending on season, the existing fauna might change due to the temperature and DO content of water released by the project. If water is drawn from the epilimnion, the downstream release may be equivalent to, or warmer than, normal river temperatures, and will have DO levels near air-saturation. If drawn from the hypolimnion, the downstream release will be colder than normal river temperature, and may have reduced levels of DO. These physical changes affect the seasonal distribution and abundance of downstream aquatic species.

Such conditions related to thermal stratification do not develop in smaller reservoirs that do not have long detention times or large surface areas exposed to solar heating. These reservoirs usually have a relatively high inflow with respect to the total storage capacity and are operated as run-of- river, like the Mtkvari Reservoir.

As mentioned in the Water Quality section, it is highly unlikely that thermal stratification will occur in the Mtkvari Reservoir, which has a surface area of only 0.5 km^2 and a maximum depth of approximately 25 m. Therefore, Mtkvari Reservoir is expected to remain isothermal throughout the year and will not pose any adverse impacts on the water quality and the aquatic biota downstream of the powerhouse.

V.2.2. Impacts on Flora and Terrestrial Fauna

In water development projects, the major impacts on the terrestrial fauna are related to those on the flora. The vegetation at and around the dam site and other construction areas will be destroyed by the construction activities and the plant populations below the high water level of the reservoir will be lost. The destruction of the vegetative cover in turn affects the terrestrial fauna that depends on these habitats.

The construction of access roads, diversion and power tunnels and the dam can have negative impacts on wildlife, as existing habitat in and around these areas would be degraded to some extent. Most medium to large mammals and birds will leave the area, due to noise, dust, and human activity of construction. Such activities, however, will take place in a limited area and therefore will affect a limited population in the project area. In addition, since the vegetative cover is rather homogeneous and evenly distributed throughout the project area, the destruction of vegetation at tunnel adits will not cause the loss of any critical habitat for the wildlife living in the area.

During the baseline studies 80 plant species were identified in the study area among which 3 are endemic to Georgia. These are *Dianthus caucasicus*, *Anthyllis lachnophora*, *Thymus collinus*. According to Georgian Red Data Book, these endemic species are not classified under any threat categories and they are generally spread all over Georgia. Also, none of 80 species are categorized in IUCN, BERN and CITES lists. Based on these findings and the project characteristics, the impacts of the project on flora species would be insignificant.

In the development of water resource projects, feeding, breeding, resting and dwelling habitats of terrestrial animals are destroyed by construction activities and inundated by the filling of the reservoir. In most cases, self-rehabilitation takes place since terrestrial fauna elements escape to suitable habitats in the vicinity after impoundment. This in turn, may push the carrying capacity of the receiving sites to its limits, overloading the ecosystems for a certain period of time. As the area to be inundated by Mtkvari dam is only 50 hectares, impacts on both the terrestrial fauna and the flora will be quite limited. In addition, the proposed reservoir is only 3.5 km long and, hence will not pose a significant obstruction for terrestrial animals to cross to the other side of the river.

Different types of habitats are formed along the shoreline of a reservoir, depending on the topographical conditions and the annual drawdown in the reservoir. The annual fluctuation in the reservoir surface elevation usually results in a lack of aquatic vegetation in the drawdown zone. The Mtkvari Project will be

operated as run-of -river and therefore no significant changes in surface elevation of the Mtkvari Reservoir are anticipated. The development of water dependent vegetation along the shoreline, which may occur in hollows and depressions, is beneficial for water birds and some mammals. For wildlife, this water dependent vegetation will serve as a nesting place and feeding area.

Due to the limited inundation area of the Mtkvari Reservoir, the effects on the birds observed in the project area, most of which are passerines inhabiting the dense thickets, will be minimal. Birds, such as kingfisher, dipper, wren, yellow wagtail and gray wagtail that nest on the ground near rivers may face partial loss of habitat. However, those birds may continue to use the reservoir margins, as well as the bypass reach, for nesting. Moreover, none of the bird species observed in the project area depend solely on riverine habitat.

Water birds, such as grey herons, ruddy shelduck, mallards, moorhens and coots, mostly observed at the delta, are the bird species that would benefit from the Project. Formation of a reservoir, though small in size, would provide these species an alternative habitat. Many water birds, such as waders and waterfowl, while facing the danger of losing their natural habitats, namely, marshes and ponds, make use of artificial reservoirs and ponds for breeding, resting and migration.

V.2.3. Impacts on Species of International Concern

Flora Species

The list of plant species identified in the study area is given in Table IV.26.The conservation and distribution status of each species is also indicated in this table. In the study area 80 species were identified. Among these 80 species, 3 species ñ*Dianthus caucasicus*, *Anthyllis lachnophora*, *Thymus collinus*ò (3.75 %) are Caucasian endemic. When the endemism ratio of Georgia (20%) is considered, it is clear that the endemism ratio in the area (3.75 %) is much lower. Also, none of these

species are categorized in IUCN, BERN and CITES lists and GRDB. Thus, they are not species of international concern and since the Mtkvari Reservoir will inundate a very small area, the Project will affect only a limited number of species.

Terrestrial Fauna Species

Amphibian, reptile, bird and mammal species identified in Mtkvari Project area are listed in the relevant tables (Table IV.28-29-30-31). In these tables, the status of these species is specified according to Bern Convention and the IUCN categories. Due to limited size of impact area, Mtkvari Project could potentially have an effect on only a small number of individuals of ERL/IUCN, Bern-listed and GRDB species. Some of these may lose some habitat. However, none of these species are confined to the impacted portions of the project area, and would move to suitable nearby habitats. A few Bern-listed species, mainly some water birds, mostly observed at the downstream of Mtkvari River, may benefit from the presence of the Mtkvari Reservoir.

Aquatic Fauna Species

None of the fish species identified in the project area is endemic for Georgia. There are ten fish species of international concern according to Annex 3 of Bern Convention that will be impacted by Mtkvari HPP Project. Under Bern Convention, the populations of these species need to be maintained. As described in Section V.2.1, these speciesôspawning and maintenance habitats in the section of Mtkvari River to be bypassed needs to be maintained. To maintain these habitats, water will be released from Mtkvari Dam so as to provide a minimum flow in the bypass reach. The minimum flow needed in the bypass reach, and the minimum water release from the dam, are calculated and provided in the discussed in Section V.1.4.1.3. Thus, by the provision of the minimum flow the necessary habitats for these species would be maintained in the by-pass reach in addition to the available habitats in the tributaries in this section of the river.

V.3. Impacts on Socio-Economic Environment

The principal impacts of the Mtkvari Project will be on the physical and the biological environments rather than on the socio-economic environment due to its characteristics. There are settlements and agricultural areas in the close vicinity of the dam axis. However, none of those settlements will be adversely affected from the construction activities. There exists no settlements within the area to be flooded; therefore no relocation activities are foreseen. There will not be any significant impact on the transportation network either. Only a very small area of agricultural land loss will take place. In this section, potential socio-economic impacts are discussed.

V.3.1. Scope of Social General Impact Categories and Study Approach

The term ñSocial Impactò means all social and cultural consequences, including changes of peopleôs lift, production, social relations and organization pattern, brought about by any private or public activity, as well as cultural impacts, including changes of peopleôs behavior, the view of value and religion.

The objective of a Social Impact Assessment (SIA) is to assess the possible social impacts that may be brought about by a development project, to understand, manage and control changes, to formulate, implement mitigation measures to minimize adverse social impacts or prevent from extension. In the assessment, the most important key is to carry out social intervention to settle, mitigate and eliminate the adverse impacts and manage the social impacts rationally.

Mtkvari HPP Project is a development project, which is aiming at electricity production. According to the international standards (generally based on relevant Word Bank policies), all people affected by the project and all the impacts on their livelihood associated with the project must be identified and evaluated beforehand in order to develop necessary mitigation measures if any significant adverse

impact is foreseen. Typical effects of development projects may include breaking up of communities and social support networks; loss of dwellings, farm buildings, and other structures (wells, boreholes, irrigation works, and fencing); loss of agricultural lands, trees, and standing crops; impeded or lost access to community resources such as water resources, pasture, forest and woodland, fisheries; loss of business; loss of access to public infrastructure or services; and reduced income resulting from these losses.

In light of above-mentioned information, it is necessary to address and mitigate any of the effects associated with the project in the relevant communities including increased pressure on land, water, natural vegetation (forests, woodlands, grasslands, etc.), plantations, or other common property resources, public infrastructure, and services. These communities should be informed and consulted as a part of the planning process of the subject development projects. Consultation involving representatives of the communities helps to build familiarity and resolve disputes that inevitably arise during and after the implementation of the project.

The impact categories for the project with respect to the project affected persons (PAPs) are first theoretically established in accordance with the relevant international policies (EBRD, WB). Thus, based on these international requirements and the project characteristics the following theoretical impact categories were identified:

- The PAPs whose sources of livelihood are affected.
- The PAPs whose living conditions are affected positively/negatively.

The studies showed that most of the possibly affected households (HHs) are living in Rustavi and Sakuneti villages due to their location with respect to project area. Thus, based on the screening for affected populations, these two villages are found to be affected by the Mtkvari Project. The studies concentrated on these two settlements. A participatory assessment has been conducted and the

methods used in this approach (in these two villages) could be summarized in Table V.13. The objectives of the participatory social impact assessment were defined to provide basis for governments and the project owners to solve the social impacts that are left over because of the hydropower development, and to provide a channel for the affected people or communities to participate in decision making process as well. In this regard a Public Consultation and Disclosure Plan was also prepared and provided in Appendix 4 of this report.

Table V.13. Investigation Methods for Affected Villages/Communities: Assessment Items, Indicators, Methods and Objectives

Research Item	Indicator	Method	Objective
Economic Impact and Poverty	• Impact on economic assets including land • Quantity of labor force • Loss of employment • Employment creation ï temporary as a result of construction, or permanent during operation. • Potential indirect employment creation, for example through sub-contracting • It is particularly important to look carefully at the potential impact on the informal sector. The informal sector is important as changes in this area can have significant consequences on the livelihoods people.	Participatory appraisal approach, resources mapping, statistical data	These indicators can demonstrate the changes of economic development and poverty conditions before and after project, which is helpful to understand the impact of HPP construction on communitiesôeconomic status
Population (and movements)	• Temporary or permanent acquisition of land, property, economic assets • Migration into or out of area	Key person interview	These indicators can demonstrate the change of demographic structure before and after the project, which is helpful to understand the impact of HPP construction on communitiesôdemographic structure
Community Health, Safety and Security	• Potential for increased incidence of communicable diseases • Environmental conditions created by Project which may lead to deterioration in health • The impact of the Project on access to health care.	Statistical data, key person interview	These indicators help to understand the possible adverse impacts on community health that may be brought about by HPP construction, and put forward measures and strategies to improve them.

Table V.13. Investigation Methods for Affected Villages/Communities: Assessment Items, Indicators, Methods and Objectives (contd)

Research Item	Indicator	Method	Objective
Education	The impact of the Project on access to education facilities	Statistical data, key person interview	These indicators help to understand the possible adverse impact on education facilities in affected villages and put forward measures and strategies to improve.
Social Conflict	Conflict analysis	Policies and statistical data, key person interview	This indicator helps to understand the possible adverse impact on social solidarity networks in affected villages and put forward measures and strategies to improve.
Cultural Heritage	The potential impacts of the Project on cultural heritage (assets, sites, etc.)	Available data and information, key person interview	This indicator helps to understand the possible adverse impact on cultural heritage in affected villages and put forward measures and strategies to mitigate.
Gender Issues	Gender analysis is to understand the differential impact on men and women	Statistical data, key person interview	This indicator helps to understand the possible adverse impact on gender differentiation in affected villages that may be brought about by HPP construction, and put forward measures and strategies to mitigate.

V.3.2. Social Impacts and Issues

The major source of social and cultural existence of humankind is to overcome the environmental scantiness. To be aware of the new conditions brought in the long and short term by environmental, socio-cultural and socio-economic change is meant to convert the change into a human development.

Change, an enchanting word today, conveys a totally positive meaning. However, ñchangeò is positive if it brings about universally accepted progress and development. Therefore, it is a must to consider the negative impacts of the change planned to be made in environment, social and cultural spheres, in the long and short terms, and to minimize these impacts. In addition, it is necessary to maximize the positive impacts of the planned change in daily lives. Such an approach to plan a change would be a step further for development of social and cultural existence of mankind.

For the projects in which an environmental change is held during the construction and the operating stages, it is necessary to consider the environmental impacts together with socio-cultural and socio-economic impacts. For instance, if construction/operation activities require change to spatial or environmental indicators, not only the changing environmental conditions should be observed but also changed socio-economic and socio-cultural structures should be analyzed. Similarly, just the opposite of the case should be regarded as well, because environmental and socio-economic impacts cannot be thought independently.

Regarding the Mtkvari Project, the positive and negative impacts to the socio-economic and socio-cultural (that is to say; daily lives) conditions of the people living in project affected villages are assessed in this Section.

Demographic Impacts

The impacts on demography will be of concern mainly for construction phase and would be related with the mobility of the population. Considering the construction phase, it is possible to speak of two different kinds of population mobility. Former is the forthcoming workers coming for construction and other staff. Latter is the population mobility due to the construction in the area.

It has been planned to employ 250 workers in the construction activities of Mtkvari Project, which comprise the preparation of the area and the construction of the units. The required staff will first be chosen among local people. For the rest of the staff, worker dormitory, engineer dormitory and guesthouse will be constructed nearby. For the workers to be selected among local people, the impact of migration mobility will be limited. In addition, those who will come to work in the construction will be directed to work in the determined parts of the project; and this will also reduce the negative impact of migration mobility. The low rate of workers coming from outside compared to local population will additionally decrease the impact on the socio-cultural structure of the region. It is not expected that there will be migration to or from the area resulting from positive or negative effects of the project. Since the construction activities will be held in a limited area, and there is no loss of settlements, local people are not forced to emigrate. Therefore, the impact of the project on the demography and any migration movement is extremely low, which can be called as insignificant.

In addition to this, the migration movement that takes place in the operation phase is different from those in construction phase. Within the operation phase, the number of workers will be just 10% of all workers employed in the construction. Considering the low number of staff at the operation phase, no significant impact on the local population is anticipated.

Economic Impacts

As the workers and staff coming to the region for construction activities would increase, the demand for the goods and such is also expected to increase. Thus an increase in demand might cause an increase of prices for certain goods at the

regional level. However, the limited incoming population and the economically integrated character of region to the bigger settlement areas are predicted to reduce the inflationist impact resulting from demand increase and finally would remain at low level. On the other hand, this would bring the opportunity for trade in the area. The goods and services needed during project activities will be purchased from the region. Therefore, trade in the region will increase as a result of construction activities. If all activities are conducted simultaneously, a significant increase in the economy of the region is expected. In addition, transportation infrastructure for the project activities within the region will be improved and this will allow local people to reach easily to the district centers. As a result, the economic integration will increase, which is a positive impact.

As the agricultural land loss due to project activities constitutes a very small percentage of the total agricultural lands, it is expected that the households doing agriculture will not lose their economic gains. In addition, the areas to be used by project facilities are not utilized by animal husbandry activities either. No one living in the region will lose his/her house, job, and social networks because of project activities. On the contrary, project activities will create a source of job opportunities and enable people to participate more actively to the social networks, and finally social integration will increase. In addition to that, the improved transportation network will additionally give increase to the dynamic social structure. Within and across region, the interaction will be increased. With the realization of the project, local people are expected to join and participate to the civil society related with the project (See Appendix 4 for Public Consultation and Disclosure Plan). It is expected that individual and cumulative social relations will positively influence the region.

Impacts on Social Structure

In the respect of construction of Mtkvari HPP, the social network would receive a limited impact. The selection of workers from the local people and the construction of houses in the construction area for workers coming from outside will reduce this impact.

The transportation facilities made up for construction will additionally give rise to a more dynamic social structure. Within and across region interaction will be increased. With the start of the project, local people are expected to join and participate to the civil society organizations related with the project. Within the project, the improvement of the transportation infrastructure in the construction and operation phases and the increase in the environmental and social awareness will be effective in the formation of active participation of local people to the social life. It has been analyzed that improved social relations will positively influence the region.

General Evaluation

Generally speaking, despite the limited loss of agricultural land due to the project, project activities will affect the economy of the region positively and the income levels of the local people will increase. When these two factors are taken into account, it can be concluded that the economic impacts of the construction activities will be positive in the region. This in turn will be due to the purchase of the good and services from the area/region for the project.

Public participation is a key issue regarding the contribution of the project to social environment and minimizing any impact together with the project affected persons. With the ESIA studies the public consultation and information sharing process was started and positive reactions of the locals regarding the project has already been received. In this context, the locals had a chance to ask questions and to raise their opinions. For example, one of the frequently asked questions by the PAPs is whether the project will cause an accident or not. By providing information regarding the features of the project and construction activities answers for this question were provided during the surveys and consultations with the PAPs. In order to address such concerns, public would be frequently informed about project activities in the following stages of the project as well.

It could be stated that the public participation will increase by sharing information with the public. This transparency will naturally increase the publicâs positive approach to the project and give the chance to determine likely negative social and environmental project impacts and to take necessarily mitigation measures on time.

V.3.3. Impacts on Water Use

Mainly springs and groundwater in the area are used for domestic and agricultural purposes in the villages. The project area lies in a mountainous region and agricultural land is limited. The major agricultural product in the region is potato. The river is used by the fauna species, but there is no considerable domestic use of the river water. In addition, there is no significant use by livestock living in the area. Since Mtkvari HPP Project will have a small reservoir, the change in groundwater level will be negligible around the reservoir after impoundment. The most severe impact on water use will be in the bypass reach, and the aquatic biota and assimilative capacity will be maintained in that reach with the release of a minimum flow to the bypass reach.

A number of alluvial water wells used for irrigation purpose were identified on the left bank of Mtkvari River in the downstream of dam axis approximately 9.2 km away. The level of water table downstream of the dam axis might decrease to some extent, especially before the confluence of Potsckhovi River and Uraveli River, but it is not expected to adversely affect the amount of water taken from the wells.

As a conclusion, taking the project characteristics and purpose into consideration; the impacts of the project on water use issue is expected to be insignificant. This is mainly due to the small reservoir to be formed (and used just for electricity generation) and the presence of flow gains from joining tributaries to the by-pass reach together with the minimum flow to be released to this reach from the dam.

V.3.4. Impacts on Landscape

Project area is in a geographical area that is surrounded with high mountains. Typical continental climate (hot and arid summer, warm and rainy winter) is observed in the area.

Anthropological stress is not of concern in the project area and its vicinity. However, the most significant formations that affect the natural landscape characteristics are the Chitakhevi HPP which is at a distance of approximately 20-25 km in the downstream of Mtkvari HPP and limited agricultural and animal husbandry activities that compose the sources of income of the locals.

Natural landscape elements are observed at the headworks and powerhouse areas of the Mtkvari Project. Some of the landscape characteristics will be altered temporarily with the construction period, while some of them will be irreversibly changed by the formation of the reservoir and starting of the operation period. The alteration of the landscape characteristics are dependent on:

- Topographical changes
- Change in surface cover (in terms of surface water)
- Vegetation cover that will be removed (to a limited extent)
- Project units to be constructed and other uses
- Change in land use pattern

There would be visual disturbance during the construction phase of the project due to construction operations. This impact, which would be experienced close to the construction sites, will only be local. However, this impact will be temporary, such that disturbances on local population would be only during the construction phase.

In order to compensate the small amount of the vegetation lost at construction sites and to prevent erosion as well as to provide a better visual scene, plantation

activities will be performed around the project units including the dam, powerhouse, switchyard, sites and other relevant facilities.

The most significant visual change in the area will be formation of a reservoir, even if small. The change of river to reservoir formation with a small surface area will have a positive visual impact as the most remarkable landscape structure is Mtkvari River in the area. The reason for considering this change as a positive impact is the small surface area of the reservoir to be formed. Furthermore, reservoir formation will not change the landscape characteristics of the surrounding area significantly.

There are no houses in the immediate downstream of the dam site, whose views would be blocked due to the dam. Therefore, no settlements would be affected due to the blocking of the view by the dam body. The transmission line would be built for connecting the electricity produced to the national system. Also, a switchyard would be constructed for connecting to the transmission lines. The switchyard would be a new structure in the landscape. The visual impacts of the transmission line would not be significant, since the route is selected to be as far from settlements as possible considering the vegetation and land use characteristics. The switchyard will be located at a rather visible site, but would be a part of the power plant structure and the visual impact would be permanent, but local.

The Mtkvari Project is not located within any areas of designated landscape importance, such as landscape protection area, at either a local or regional/national/international scale. The impact on landscape would not be significant since the reservoir is rather small. In fact, water bodies, such as lakes or reservoirs, may be considered to create pleasant scenery.

V.4. Transmission Line

Within the scope of the Mtkvari HPP project, a switchyard will be located near the powerhouse to transmit the electricity produced to the national grid system via electric transmission lines (ETL). An 8 km long 110 kV transmission line will be constructed to connect the switchyard to an existing substation of the national grid near Akhaltsikhe.

The baseline study area covered the transmission line alignment and the discussions with regard to the baseline conditions and assessment of the impacts due to the project on the physical, biological and socio-economic environments (as provided in the previous sections of this report) are valid for the ETL route and structures. The relevant mitigation measures for the significant adverse impacts are provided in Chapter VII. This section mainly aims to summarize the potential impacts of the ETL in a concise way.

The transmission line route/right-of-way (ROW), conductors, towers, and supports (e.g., guy wires) and service roads, if new roads need to be built, are of concern with regard to transmission line impacts. Electric power transmission lines may affect natural and socio-cultural resources. The effects of short transmission lines would be localized. In general, the environmental impacts to natural, social, and cultural resources increase with increasing line length. The impacts of transmission lines occur primarily within or in the immediate vicinity of the ROW. Generally, the magnitude and significance of the impacts increase as the voltage of the line increases, requiring larger supporting structures and ROWs. This is also the case for operational impacts such as electromagnetic impacts.

Negative environmental impacts of transmission lines are caused by construction, operation and maintenance of transmission lines. Clearing of vegetation from sites for the towers and ROWs and construction of service roads, and substations are the primary sources of construction related impacts. During operation occasional line repair and maintenance are of concern. These, plus the physical presence of the line itself, can be a source of environmental impact.

The ETL to be built for transmission of the electricity produced by Mtkvari Project is rather a short (8 km) low voltage line (110 kV), which is factor decreasing the potential adverse impacts of the ETL. The ROW is selected as the shortest possible route both technically, economically and environmentally. The construction of new service roads will be kept at a minimum and the present roads, including village roads, will be used. In addition, the ROW has been chosen not to pass through the settlements in order to minimize the social impacts and the possible costs (such as expropriation costs for tower locations).

The potential impacts of the construction, operation and maintenance of the ETL can be summarized as follows:

1. Vegetation damage, habitat loss, fauna disturbance and loss of land use due to construction/preparation activities on the ROW. There are no critical flora species or vegetation community to be affected, as discussed in the previous section and there are suitable habitats for the fauna species that will escape the ROW.

2. Runoff and sedimentation from grading for tower pads and alteration of hydrological patterns due to maintenance roads and erosion risk due to construction activities. The ROW has been determined in order to avoid/minimize the erosion risk areas and river passages.

3. Dust emissions to air due to excavation and fill works and construction machinery. The amount of excavation and fill works would be much smaller when compared with other construction activities in the scope of the project, so any significant adverse impacts is not expected on the workers and local settlements in the vicinity.

4. Noise disturbance due to construction machinery to the local settlements in the vicinity and construction workers. The noise levels from construction activities for the ETL would be much lower than the levels estimated by the modeling studies and since the ROW is rather far to villages, no significant impact is

expected. All necessary protective measures will be taken for the health and safety of the workers and necessary protective equipments will be supplied to the workers and using of these equipments will be obligatory at areas with high noise levels.

5. Induced effects from electromagnetic fields (EMFs) due to magnetic field created by the current in the lines and cables during operation phase. Since this is a rather low voltage line a significant impact is not expected. The impacts of EMFs are being discussed by the scientists, but there are some international and national standards regarding EMFs. The scientific studies such as conducted by the Scientific and Technical Research Council of Turkey (TUBITAK) reported that the magnitude of EMF values for transmission lines of 154 kV and stays well below the limit values stated in international (published by International Radiation Protection Association, IRPA) and Turkish standards [TS ENV 50166 Human Exposure to Electromagnetic Fields, Low frequency (0 Hz to 10 kHz) published by Turkish Standardization Organization]

6. Solid wastes including excavation wastes, construction wastes (metal, plastic etc.), hazardous wastes (waste oil, accumulators etc.), domestic waste from camp facilities and maintenance wastes. These will be handled as presented in Chapter VII in the scope of Solid and Hazardous Waste Management Plans.

7. Wastewater generated from domestic uses of workers during construction, operation and maintenance of the transmission line. These will be handled as presented in Chapter VII in the scope of Wastewater Management Plan.

8. Avian hazards from transmission lines and towers due to bird deaths. Since the migrating birds are flying high about 100 m from the land surface, the ETL (with towers of about 30 m and lines of 15-25 m height from the land surface) will not create collision risks. Bird guards would be mounted on the towers for preventing the electrocution of birds.

9. Impaired aesthetic resources that result in visual impacts. The ROW has been selected by considering also the locations of cultural and aesthetic resources, and there is no area with high landscape/visual value or where any cultural asset exists on the ROW or its close vicinity.

CHAPTER VI

ANALYSIS OF ALTERNATIVES

VI. ANALYSIS OF ALTERNATIVES

The construction of Mtkvari HPP is planned to be performed by JSC Caucasus and Energy Infrastructure. The feasibility study of the Mtkvari HPP project has been prepared by an Icelandic company Verkis HF, while the geotechnical report has been prepared by Geoengineering Ltd. These reports were completed in June 2009 and July 2009, respectively. The proposed project was determined to be economically and technically feasible.

The dam site is located 3 km upstream from the Rustavi Village and the powerhouse site is located .51 km upstream of the Sakuneti Village. An annual energy of 245 GWh is going to be produced at Mtkvari HPP.

In this chapter, four different classes of alternatives were studied:

- project type,
- project location and size,
- tunnel construction methods and type of powerhouse
- operating mode.

In the following sections the above four alternatives to project that are analyzed in the feasibility study and in addition the no action alternative are discussed. This includes a summary of the main rationales given in the feasibility report and further evaluations and comparisons, including environmental evaluations, where possible.

VI.1. Project Type

The potential environmental impacts of the Mtkvari HPP Project were evaluated by considering a standard-type coal fired thermal power plant as an alternative facility. The potential basic environmental impacts of this alternative type of project and those of Mtkvari HPP Project are described in Table VI.1. As can be seen in Table VI.1, hydroelectric projects do not give rise to the inherent environmental impacts of thermal power plants, such as the effects of flue gas emissions on air

quality and greenhouse gas emissions on climate change, and the effects of cooling systems on aquatic ecology. The operating and maintenance costs of thermal power plants are generally higher than those of hydroelectric power plants. In addition, the costs of pollution control equipment, such as electrostatic precipitators and flue gas desulphurization units add to the overall cost. Based on Table VI.1, it can be said that the environmental impacts of a hydroelectric power plant are mostly initial and those of a thermal power plant are mostly during operation.

Table VI.1. Comparison of the Main Potential Impacts of an Alternative Thermal Power Plant and Mtkvari HPP Project

Potential Negative Impact	Thermal Power Plant	Mtkvari Hydroelectric Power Plant
Air emission effects to the environment	Yes	No
Increased noise and vibration	Yes	Yes [1]
Change in surface and groundwater quality	Yes	No [2]
Toxic effects of chemical discharges and spills	Yes	No
Thermal shock to aquatic organisms	Yes	No
Change in surface water flow and discharge	No	Yes
Disruption of traffic	Yes	No
Worker exposure to dust from ash and coal	Yes	No
Worker exposure to toxic gases leaking from boilers	Yes	No
Worker exposure to excessive noise during operation	Yes	No
Effects of power transmission lines	Yes	Yes
Loss of land	No	Yes [3]
Loss of habitat	No [4]	Yes [3]
Sedimentation of reservoir and loss of storage capacity	No	Yes [5]
Vegetation removal	Yes [6]	Yes [3]
Effects on aquatic life	Yes	Yes

1 Only in construction phase.

2 Minor impacts on downstream river water.

3 In a limited area due to the scale of Mtkvari HPP Project.

4 Except indirect effects because of air emissions and water discharge.

5 Sedimentation will not cause a problem in the economic lifetime of Mtkvari HPP Project.

6 Relatively minor loss when compared with hydroelectric projects with large reservoirs.

A major difference between these projects is that the thermal power plant uses a non-renewable resource to produce energy whereas Mtkvari HPP Project uses a renewable resource. Energy is one of the primary inputs for an economy and a primary concern for human welfare. Therefore, the reconciliation of the present economic growth and the continuing productivity of resources should be maintained, which is generally referred to as sustainable development.

Today, in addition to coal; natural gas fired thermal, nuclear, geothermal, wind, solar and biomass power plants could be considered as alternatives to the Mtkvari Hydropower Project. According to the data of World Energy Council (WEC) thermal, hydro, nuclear, and geothermal and various (wind, solar, biomass etc.) power plants have the respective shares; 64.5%, 19%, 16% and 0.5% in the energy production throughout the world. In addition, world consumption of primary energy has the following distribution; oil, gas, coal 74 %, hydro 7 %, nuclear 6 %, traditional 11 % and geothermal and various 2 %. Thus, 85 % of primary energy is produced by combustion with associated large-scale emissions of the greenhouse gasses to the atmosphere, which will lead to major climate changes according to researchers. By 2050, primary energy and electricity consumption will be multiplied by a factor of 2.5 to 3 (WEC, 2003).

Concerns about disruptive fossil fuel markets and uncertain pricing, the current difficulties in political and public acceptance of nuclear energy (unresolved questions over risks involved and the disposal of nuclear wastes), and the global environmental consequences of using thermal energy sources (particularly the emission of greenhouse gasses) have all placed greater emphasis on sustainable energy policies, which include the development of renewable energy supplies, of which hydropower is one of the most important and reliable.

Hydropower at present is the only domestic source of Georgia, which can provide reliable low cost energy, which in addition is renewable. Thus, the Mtkvari Project is more viable, when compared to alternative thermal power generation from today's perspective, first in the sense that it will be using a renewable resource for

electricity production and providing more sustainable means of energy generation and secondly based on the economics of the project.

VI.2. Project Location and Size

Mtkvari Hydroelectric Power Plant is one of the several hydroelectric projects proposed as part of the Greenfield hydropower plants investment program initiated by the Ministry of Energy in order to take advantage of the country's largely unutilized abundant water resources. In this context, the Georgian government has included the proposed Mtkvari HPP, which is located on the River Mtkvari near the city of Akhaltsikhe, into potential hydropower plants list of Georgia. The feasibility study of Mtkvari HPP had been prepared by the Icelandic consulting engineering company Verkis IF at the request of JSC Caucasus Energy and Infrastructure (CEI). The location and power of Mtkvari HPP was selected according to the optimum values determined in this feasibility report.

The project area is located in the southeast of Georgia, on River Mtkvari, near the city Akhaltsikhe. The River originates in Turkey and flows southwest into Georgia at elevation exceeding 1100 m above sea level. The river turns to eastwards near the town Akhaltsikhe at about elevation 950 and flows from there towards east through the capital Tbilisi, onwards into Azerbaijan and into the Caspian Sea. Mtkvari Dam site was selected to use the available head effectively to produce maximum amount of electricity at the Mtkvari HPP.

The location of Mtkvari Power Plant depends on the effective head available via the Mtkvari Dam and the headrace tunnel to produce the maximum amount of energy. Accordingly, powerhouse locations were studied and the powerhouse site was selected to be 1 km upstream of Sakuneti Village and it will be located on the right bank of Mtkvari River.

During the pre-feasibility studies of the proposed Mtkvari Project, a comparison has been made between two alternatives. Both alternatives foresee the

powerhouse near the village Sakuneti. Option 1 utilises the head difference from 977 m to 909 m, involving some 7.5 km long headrace tunnel whereas Option 2 utilises the head difference from 1,012 m to 909 m with a 9.6 km long headrace tunnel.

Option 1: Headworks downstream of Rustavi

At this dam site the minimum water level in the river is 970 m with maximum flood level at about 973 masl. The level can be raised to a maximum of 977 m and should not reach higher during floods. Presumably this option should necessitate a gated spillway. A bulkhead gate and trash racks would be needed at the tunnel intake. An existing road follows the right river bank and in this case the waterway should underlie the road. Additionally, according to a recently completed survey, the road needs to be elevated by some 3-4 m over some 100-200 m length. The proposed headrace tunnel alignment is a straight line from the intake to a location some 600 m upstream of the village Sakuneti at 910 m elevation. The tunnel length will be about 7.5 km.

Option 2: Headworks upstream of Rustavi

At this dam site the minimum water level will be about 992 m. The water level may be raised to about 1,012 m with even higher flood level. The site thus favours a 100-150 m long fixed ungated overflow spillway. However, the road along the river has to be raised approximately 10 m over a length of about 2,150 m. The road is currently in relatively bad condition with neither pavement nor even a gravel surface course. Agreement with the Road Authorities will be made to relocate the road. A bulkhead gate and trash racks will be required at the tunnel intake. In general, the conditions for a tunnel intake and dam are more favourable here than at the lower dam location. Since the intake pond will have more volume, the intake can be located deeper. No gated spillway will be required, river diversion during construction is favourable and the dam can be an embankment dam.

A rough comparison between these two options reveals that Option 2 is more beneficial. The two main reasons for selecting Option 2 can be summarized as:

- The location of intake calls in Option 1 is relatively expensive gated spillway solution compared to the more cost effective overflow weir at the Option 2 location.
- The difference in head and thus in energy output amounts some 53% to the favour of Option 2, as compared to the corresponding figure for the headrace tunnel length is 27% to the favour of Option 1 (9.6 km for Option 2 instead of 7.5 km for Option 1).

These in turn show that Option 2 is economically more viable than Option 1 with similar environmental consequences.

VI.3. Tunnelling Methods

Various tunnelling methods have been taken into consideration in the feasibility studies. Accordingly, the determination of the most cost effective method to excavate the tunnel depends on a number of parameters such as tunnel alignment, diameter, prevailing geology, hydrogeology, availability of construction equipment and time.

In the context of alternative tunnelling methods, Tunnel Boring Machine (TBM) and conventional Drill and Blast (D&B) methods are of concern. For a comprehensive comparison, the findings of the Geotechnical Investigation Report are also taken into consideration. This report states that the existing geology is a rather complex structure with fracture zones and soft geologic units along the tunnel route.

In comparison of the two alternative tunnelling methods, it is considered that TBM method may result in ingress of water, squeezing of soils, crossing difficult fault zones and spalling rock conditions (Verkis, 2009 (b)). On the other hand, D&B method requires more time in construction period and it is more risky when the geological conditions are considered. Furthermore, the environmental impacts of D&B are much more significant compared to TBM method.

As a conclusion, TBM method is considered to be the best alternative for tunnelling as it is faster, cheaper and less risky in addition to less environmental problems to be created. Furthermore, D&B method for construction is not approved by the Government of Georgia.

VI.4. Type of Powerhouse

For the construction of the powerhouse to be located in Sakuneti, surface type and underground type powerhouse are compared in the feasibility studies. Within this scope, it is determined that the construction costs can be reduced to some degree with underground powerhouse, as the steel lining will be shortened and concreting of the pressure tunnel will be reduced. However, for a comprehensive comparison, the alternative options are evaluated in detail.

In comparison of the two alternatives, the dimensions, contingencies and other costs are taken into consideration. Including all these factors, the cost comparison was made with the sum of the pertinent features for both alternatives:

- Pressure tunnel, powerhouse building and tailrace for surface type powerhouse
- Pressure tunnel, powerhouse, tailrace, control building and access area for the underground type powerhouse.

The details of the economic comparison are presented in Table VI.2.

Table VI.2. Comparison of Costs for the Powerhouse Type Alternatives

Alternatives	Contingency	Subtotal US Dollars (USD)	Grand Total US Dollars (USD)
Surface type powerhouse	20.0%	6,499,580	7,799,500
Underground type powerhouse	15.7%	6,214,070	7,189,680
		Cost difference: 609,820 USD	

According to the cost comparison performed for underground and surface type powerhouse, underground powerhouse seems less costly. However, the cost difference is minor when compared to the overall costs involved and grand investment cost of the project. Thus, the project developer selected the construction of a surface type powerhouse for Mtkvari HPP Project based on its previous experience and the technical practicalities.

VI.5. Modes of Operation

In general, there are several alternative operating modes for hydroelectric projects; base load only, peaking or load following only, or a combination of these. In a strictly baseload operation, all generators operate continuously, unless one is out of service for maintenance or repair, or due to insufficient inflow to the reservoir not providing the required minimum head. In a strictly peaking (or load following) operation, operation ceases during an overnight period when energy demand is low, generally from about 8:00 p.m. to about 5:00 a.m. In a combination of baseload and load following, one turbine is in continuous operation and the others operate in response to system demand.

The Mtkvari Project is comprised of a concrete dam and a 9.6-km long headrace tunnel diverting the inflow to a powerhouse, by-passing an approximately 27-km long reach of the Mtkvari River. The Project having a very small reservoir will be operated in run-of-river mode, in which the inflow is directly used for power generation and the surplus water is released from the spillway.

The effect of the Mtkvari Project on the reach of the Mtkvari River to be by-passed will be the most significant impact because of the nature of the project. Varying tailwater levels will not cause any notable effect on the aquatic ecosystem downstream of the powerhouse, since two important (big) tributaries, namely Potsckhovi and Uravelli joins the Mtkvari in the do called bypass reach. The selection of this mode was made largely on technical and economic grounds, however, the adverse impacts on aquatic ecology in the river reach between the dam site and the powerhouse will be mitigated by maintaining a constant minimum release from the dam, except during periods of spilling. The required minimum flow in the by-pass reach was determined as 5.8 m^3/sec by the statistical minimum flow studies. This minimum flow will be released to the bypass reach and small tributaries and surface runoff will increase this amount till the confluence of Uravelli and Mtkvari about 8 km (air distance) downstream of the dam site.

VI.6. No Action Alternative

When the no action alternative is considered, it can be said that this alternative is generally not preferred for energy production aimed projects that will generate public benefits to the country. When the no-action alternative is chosen (if Mtkvari project is not realized), the following consequences may take place:

- The energy demand of the country increases continually and hydropower is the most feasible energy source for Georgia. Not developing this project may result in the need of establishment of alternative plants, such as thermal or nuclear power plants, or the utilization of gasoline, diesel and fuel-oil fueled individual gensets in the case of insufficient grid-based energy supply. These alternatives would be less economic, have other adverse impacts on the environment, and are not as sustainable as using a renewable source for energy production.

- From a broader perspective, failure to make full use of the available low cost and peaking hydropower energy sources may ultimately limit social and economic development in the country.

- Employment opportunities for 250 people in construction phase and 50 people in operation phase would not be provided and expected improvement in the economy of the region, especially starting with the construction phase, would not be realized.

- On the other hand, there would not be any adverse ecological impacts, such as effects on existing river hydrology, especially in the by-pass reach, and aquatic life, that would be caused by the realization of the Mtkvari Project.

CHAPTER VII

ENVIRONMENTAL AND SOCIAL ACTION PLAN

VII. ENVIRONMENTAL AND SOCIAL ACTION PLAN

Environmental and social action plan (ESAP) is mainly based on mitigation and performance improvement measures and actions that address the identified social and environmental issues, impacts and opportunities. Within the scope of the plan, mitigation measures and actions are identified at all the stages of the project (i.e. pre-construction, construction, operation) in compliance with the relevant Georgian Legislations.

The major purpose of ESAP is “to document key environmental and social issues, the actions to be taken to address them adequately, as well as any actions to maximize environmental or social benefits, the schedule and person/unit responsible for implementation and monitoring, and an estimate of the associated costs”. The details of the plan are presented in this chapter.

In Table VII.1 and Table VII.2 (given at the end of this chapter) ESAP for construction and operation phases of the project in addition to relevant monitoring activities are provided.

VII.1. MITIGATION PLAN

A number of impacts are unavoidable, some can be minimized and some losses can be replaced. Thus, mitigation measures may take different forms. The mitigation activities required to avoid or reduce the adverse environmental impacts of the project are presented in this section and the proposed mitigation measures for each phase of project development including dam and transmission line are outlined.

VII.1.1. Catastrophic Failure

Mtkvari Dam is not intended for storage, but for the diversion of the water to the powerhouse through a power tunnel, and has a reservoir area of about 0.5 km^2. Failure of the dam is very unlikely. Nonetheless, although a small structure, Mtkvari Dam will be monitored with regard to dam safety and seismicity through

the use of installed instrumentation. In addition, a draft Emergency Action Plan is prepared and given in Appendix 6 in order to ensure public safety downstream of the reservoir and the powerhouse, as well as the camp facilities. It will establish criteria for various stages of emergency, the actions to be taken at each stage, and the procedures for ensuring that no event at the Project, whether an increase in risk or some sort of failure, endangers the public or the project staff.

VII.1.2. Construction Phase

In the context of mitigation planning construction phase covers the construction of the project in accordance with the final project design, using proper management means, implementing the action plans already prepared, improving and detailing these plans when necessary, sustaining cooperation and coordination between the responsible stakeholders and the public. In the following sections mitigation measures are presented addressing the various impacts.

VII.1.2.1. Erosion and Sedimentation

Erosion can be observed in the area due to the removal of the vegetation cover in construction and operational periods, stripped top soil and slope. Mitigation measures will be taken to reduce erosion and sediment load to the river and other surface waters from construction activities and earthworks. For this purpose the following framework Erosion and Sediment Control Plan is provided.

Erosion and Sediment Control Plan

In accordance with the framework of best practice applications, erosion and sediment control plan is prepared for the construction phase. Precautions as outlined below shall be taken prior to any excavation to reduce erosion and sedimentation risk. The implementation will be monitored to ensure that control measures are in place. Main elements of this plan are:

- Stockpiles, including construction materials, such as concrete aggregates, filter material and sand will be properly handled.

- Materials excavated from open and underground excavations, which are unsuitable for use in other areas, or that are surplus to such requirements, shall be disposed in proper disposal areas. Materials suitable for roads, slope protection, embankment and riprap shall be stockpiled separately from disposal areas for later use.
- Any topsoil excavated that is above the reservoir level shall be stockpiled in a suitable location to be removed and utilized for reforestation and implantation. All stockpiles and disposal area shall be arranged, including provision of drainage and erosion control measures.
- The height of material stockpiles shall be defined on site in accordance with topographic conditions and stockpiles and the disposal area shall not be located in floodway zones.
- Appropriate cut-off ditches on the uphill side will be provided to prevent erosion in the disposal site and stockpiles.
- Flatter surfaces will be obtained at slopes and terraces will be formed in areas where erosion risk occurs and these places will be vegetated. This effort will decrease the flow of soil to the surface water and also will increase the economic life of the dam since it reduces the sediment transport to the reservoir.
- To protect the reforested areas the required signboards will be placed and to limit the entrance to these areas fences or natural barriers will be placed at the required places. While performing reforestation, the dominant vegetation of the region will be taken into consideration and the tree species that will be used in reforestation activities will be selected according to the vegetation.
- Insemination works (before reforestation) will be performed at the places where erosion occurs extensively since they spread rapidly and hold the soil.

VII.1.2.2. Landscaping and Top Soil Utilization

The construction activities at the adits and construction sites will disturb the visual appearance of these sites. The construction site will be inundated by the reservoir, which will form a new landscape in the area. The construction activities outside the future reservoir area will be the regulator construction activities, headrace tunnel and powerhouse construction. These sites will be restored and landscaped after the completion of construction.

To minimize the impacts on the fertile topsoil, at any construction site the soil will be carefully removed and stored in a manner to avoid deterioration taking the weather conditions into consideration. Also, the subsoil that provides the formation of the topsoil will be stripped and stored to protect its horizons. While stripping the topsoil, the impurities will be removed from the soil. In order to preserve soil fertility the piles will be lightly compacted and covered with organic material or green seeding with pioneer plant species. Moreover, the surface of the vegetal soil will be protected against erosion and drying, and will be covered with vegetation like grass, pasture plants etc. to maintain its activity. The stripped vegetal soil will be used at the landscape repair works and at the vegetal landscape arrangement of the recreation areas.

Storage Areas and Landscape

The excavation materials will be extracted from the tunnel at two tunnel adits and stored in valley formations close to the tunnel. 70% of the excavated materials shall be used for bridge, road construction and river rehabilitation activities, whereas the rest of it (30% of the excavation materials) shall be permanently stored. The storage of excavation materials shall be implemented in line with the natural landscape characteristics by considering the environment and human health. Within this scope, the excavation materials will be stored in appropriate side slopes and those areas will be vegetated. The valley formation that will be used for storage of excavation materials from Adit 1 is presented in Photograph VII.1.

Photograph VII.1 A View of the Valley Formation that shall be used for Storage of Excavated Materials

Sliding and rolling of rocks in the storage areas shall be prevented. The storage areas shall be isolated from the surface and rain water in order to prevent dispersion and further, sedimentation will be controlled by considering the side slope stability. Stability will be enhanced by insertion of large materials against the flow direction of water while with smaller materials behind large materials.

Erosion and sediment transport are two significant impacts that will be observed in the storage areas of excavated materials. For that reason, physical stability of the storage areas shall be improved. Rocks and smaller materials that are piled during the construction activities shall be compressed and appropriate side slopes will be obtained by taking the environment into consideration. In order to perform landscape activities and provide the stability of the excavation materials without any other precautions, the appropriate slope shall be 3:1 (horizontal distance: vertical height). Vegetation activities shall be implemented after attaining the appropriate slope of the storage area.

The stripped topsoil shall be applied with a thickness of 40-50 cm on the storage areas. If the existing topsoil will not be sufficient, necessary amount of soil shall be purchased. In order to prevent erosion and landslide, temporary slope breakers shall be used. The slope breakers shall be perpendicular to the direction of the slope in order to reduce the speed of soil flow from upper levels. Furthermore, the breakers shall be constructed appropriately in order to prevent the erosive effect of soil flow until formation of a permanent vegetative cover. Temporary slope breakers shall be on site until the stability of the vegetative cover is ensured. Original cover will be gained after stability of the cover is ensured so as to prevent soil losses, by natural processes.

VII.1.2.3. Air Quality

Adverse air quality impacts that could affect the health of construction workers and be a nuisance for nearby settlements will be mitigated. Dust emitting activities during construction works are excavation works, works performed in concrete batch plant, movements of construction equipment in roads, loading of excavated material to trucks and unloading of trucks and storage of excavated material.

The effects of the pollutants are dependent on the concentration and exposure time. There are limit values similar to WHO Ambient Air Quality Guidelines and Directive 2008/50/EC in many local and national regulations for pollutants. Concentrations of all pollutants calculated from the model are well below the limits of WHO Ambient Air Quality Guidelines. Moreover, these emission values were calculated considering the worst case scenario. Accordingly, the distributed emission concentrations of Mtkvari Hydroelectric Powerplant in construction phase will be much lower. Therefore, the air quality modeling studies revealed that the construction activities will not have significant adverse impacts on the close by settlements due to the fact that they are at a distance that the impacts of emissions and dust will be insignificant. Despite, an emissions and dust control plan will be implemented and within this scope some mitigation measures are proposed.

Emissions and Dust Control Plan

Fugitive dust from site disturbances and emissions from vehicles and plants (e.g. concrete batching) have the potential to negatively affect air quality in the vicinity of the construction sites and access roads. Prevention methods shall be implemented to control dust resulting from construction related activities.

- Water sprays will be used to reduce particulate matter emissions from dust-generating activities (from unpaved roads when construction equipment is active, in areas of major earth excavation, and any other areas, which produces dust), where applicable and justified.
- At the temporary storage areas material shall be graded, moistened and compacted to prevent the material from being carried away by wind. Wetting the material will depend on the seasonal conditions to maintain its optimum moisture level. Upper layers will be kept with moisture content of 10%.
- Dust generation during excavations and fills will be significantly prevented by wetting the material. Loading and unloading will be carried out with care and without scattering.
- While travelling to and from the site, and on public roads trucks that carry particles greater than 10 mm in size will be covered with canvas and there will be a speed limit for trucks.
- Tires of the trucks will be cleaned where necessary to prevent dirt being carried onto the roads.
- Modern equipment and vehicles shall be selected and used for construction such that they will comply with the relevant emission standards.
- The machinery and vehicles shall be inspected with regard to their exhaust systems and emission levels and adjusted to comply with relevant international requirements, and to protect the health of the workers.
- Wind breaker panels will be put or trees will be planted in the area.

For all underground works mechanical/forced ventilation systems shall be installed, to keep the air in underground works in a condition suitable for the health

of the workers, as required by the technical specifications and civil engineering works. Respirators will be supplied for the workers who are directly exposed to particulates and the equipment used in construction will be examined periodically for the protection of the health of workers. This will be also in accordance with the health and safety plan for construction activities.

VII.1.2.4. Noise

Based on the noise modeling studies for construction activities it was estimated that even under the worst case assumptions the noise generated will be within the allowable limits (55 dBA limit for construction works) at the nearest settlements. The results of modeling were compared with General EHS Guidelines: Environmental Noise Management of International Finance Corporation and it was seen that limit values are satisfied at approximately 55 m distance. On the other hand, the closest settlements Rustavi and Sakuneti Villages to the noise sources headworks and powerhouse areas are distances of 2200 m and 1245 m, respectively. The corresponding noise levels at those locations are found to be 43.7 and 45.5 dBA. Under worst-case conditions, the calculated cumulative noise levels (existing noise + construction activity noise) in the nearest settlements that are 53.6 and 50.96 dBA, are found to be below the maximum noise level (55 dBA). Although the expected noise levels due to construction activities are calculated to be low, further preventive measures are proposed in Noise Control Plan as follows.

Noise Control Plan

The following is a summary of the noise control measures that will be applied to stationary and mobile equipment:

- Fitting and maintaining effective silencing equipment.
- Silenced equipment will be used including enclosures, mufflers and other noise reducing features.
- Operating fixed equipment within enclosed structures, to the extent practicable.
- Operating machinery within the designed parameters for efficiency.

- All construction workers shall be provided with adequate hearing protection to be used in the areas. Workers will be trained and instructed accordingly.

VII.1.2.5. Water Quality and Water Use

During construction there will not be any significant adverse impact on water use in the study area. The impact on water quality may be due to wastewaters from construction activities and domestic uses.

At the construction phase of the project the water usage will be due to concrete preparation, washing the concrete aggregate material, preventing dust and the domestic uses of the workers. The water required for the concrete batch plant, washing the aggregate material and preventing dust would be taken from Mtkvari River. Drinking water will be supplied from the groundwater sources of the villages in the vicinity; otherwise, the water will be purchased and brought to the project site. In order to calculate the daily water consumption for domestic uses of the workers, it is assumed that the daily water consumption is 200 L/day-capita (Order # 297/N). As it is considered that 250 workers will be employed in the construction phase of the project, the daily water requirement for domestic purposes will be 50 m^3.

Additionally, daily water consumption for washing aggregate material and concrete mixers is calculated. In this respect, the daily concrete production in each plant is calculated as 200 m^3 when it is considered that the capacity of each plant is 25 m^3/h and the plants will be operated 8 h/day. In order to calculate the daily water consumption, it is assumed that for production of each cubic meter of concrete, 0.13 m^3 of water is utilized (Chini and Mbwambo, 1996). Therefore, daily water consumption for washing aggregate material and concrete mixers is 26 m^3 in each plant.

Furthermore, water consumption for dust prevention is also considered. In this scope, the amount of water required to prevent the dust formed during the construction activities can change with the surface geometry of the transported material, the meteorological conditions of the environment before and after

watering and the topographical conditions of the excavated area. For this purpose, water consumption will be in accordance with the requirement of “10% moisture will be maintained at the topsoil layer”. As a result of these activities; wastewater will be produced from the mixer inside the concrete batch plant and the washing of the mixers of the vehicles carrying ready-mixed concrete and the concrete aggregate. If it is accepted that the whole of the water required for the domestic usage of the workers will be converted to domestic wastewater, the daily generation of the domestic wastewater will be 50 m^3. Throughout the construction phase due to washing the concrete aggregate and mixers, 52 m^3 of wastewater that has high suspended solid amount will be produced daily.

In operation period, domestic wastewater will be produced as a consequence of water consumption by the workers. In this respect, when it is considered that 50 workers will be employed in the operation phase and water consumption per capita is 200 L/day-capita (Order # 297/N), overall water consumption for domestic purposes will be 10 m^3/day.

Wastewater produced during construction and operation phases will be treated and discharged to Mtkvari River in line with IFC’s Environmental, Health, and Safety (EHS) Guidelines on Environmental Wastewater and Ambient Water Quality. The relevant parameters and limit values are presented in Table VII.3 below. Furthermore, by complying with the discharge limits of IFC, the status of Mtkvari River will be maintained in accordance with the requirements of Water Act of Georgia.

Table VII.3. Limit Values for Discharge of Wastewaters during Construction and Operation Phases

Pollutants	Units	Guideline Value
pH	pH	6-9
BOD	mg/l	30
COD	mg/l	125
Total nitrogen	mg/l	10
Total phosphorus	mg/l	2
Oil and grease	mg/l	10
Total suspended solids	mg/l	50
Total coliform bacteria	MPN[a] /100 ml	400

[a]MPN: Most Probable Number

As a consequence, wastewater management plan has been prepared to be implemented during construction for minimizing the potential adverse environmental impacts from wastewater discharges.

Wastewater Management Plan

Within the scope of the wastewater management plan, the following mitigation measures will be taken in order to minimize the adverse impacts of wastewaters:

- Water contaminated by concrete, paint, oil or solvents, or silt shall not be discharged overland, and shall not allowed to flow into any river or drainage line, or to infiltrate into the soil.
- The necessary collection facilities shall be constructed to prevent water pollution from construction activities.
- During the road construction drainage facilities will be provided with stilling pools to trap any sediment carried with surface runoff as well as runoff from any in-situ concrete mixing activities.
- Transmixers delivering concrete shall be washed on a designated area.
- The wastewaters from concrete operations (from aggregate washing, batching concrete, etc.) will be reused for the same purpose after a pretreatment in a settlement pond. The remaining water clarified by settlement pond and neutralized to prevent water pollution can be discharged to Mtkvari River. The settlement pond will provide physical treatment for the wastewater originating from washing aggregate. In general, neutralization is not considered to be necessary, however, the outlet pH level will be monitored and if the pH is high, neutralization with acid is recommended.
- The domestic wastewater due to the workers, the wastewater formed at the construction phase will be treated by a package treatment plant that will be constructed at the construction site and contain physical and biological processes. The treated water will be discharged to Mtkvari River in line with

relevant Georgian Legislations (i.e. Water Act of Georgia) and international requirements.

- Water taken from the concrete batch plant and sedimentation pond will be analyzed and the treatment plant will be controlled. When any substance (dye, oil etc.) is spilled or leaked to Mtkvari River, the required precautions will be taken according to the Emergency Action Plan and the required analysis will be performed.

VII.1.2.6. Waste Management

The wastes generated basically during construction phase will be managed according to related Georgian Legislation, such as Law of Georgia on Compensation for Harm Caused by Hazardous Substances and Law of Georgia on Hazardous Chemical Substances. Solid wastes to be generated during construction can be classified as sanitary (domestic) wastes, construction rubble and waste excavated material, hazardous waste. To handle these wastes properly during construction solid waste and spoil, and hazardous management plans have been prepared.

Solid Waste Management Plan

In order to calculate daily solid waste production due to workers the statistics provided by the EU is considered. In this respect, daily municipal waste production is approximately 1.43 kg/day-capita in EU27 countries according to 2007 statistics (Eurostat News Release, 2009). To be on the safe side, the daily solid waste production is taken as 1.5 kg/day-capita. Considering the numbers of employees in construction and operation phases are 250 and 50, total daily solid waste production is calculated as 375 kg/day and 75 kg/day, respectively.

- Waste shall be systematically collected and all types of waste will be separated for (lumber, scrap metal, etc.) proper handling and disposal.

- No waste shall be disposed of or buried on the site. Illegal dumping, either at the construction camp, along public roads or in the surrounding areas, or into the river shall not be allowed.
- It shall be ensured that construction campsite and surroundings are kept in clean and neat conditions at all times and that windblown litter is cleared on a daily basis.
- Separate waste containers (drums, bins, skips or bags) shall be provided for different types of waste.
- Waste containers shall be provided with lids or netting to prevent wastes being carried around by scavengers or the wind and to prevent animals to be attracted to the waste.
- Domestic solid wastes will be collected and disposed properly by the nearest municipality to the designated disposal site after agreement with the municipality.
- Suitable excavated material will be temporarily stored for further use in fills in other construction activities. Stockpiles of the fine material such as sand, topsoil material, cement, etc. shall be protected from rain runoff and wind. Excess waste excavated material will be disposed to the designated disposal site and any further effect on the environment will be prevented.
- At these disposal sites drainage channels and culverts will be incorporated so that the stored material is not washed out. In this way, both the material will be kept stabilized in place and the river water will be protected against sedimentation.
- Wherever possible, production of construction waste and other solid waste will be minimized by reusing and recycling leftover materials where possible and also through proper planning and design.
- If scrap metal occurs, these scraps either will be reused or will be sold to companies whose main business activity is dealing with scraps.
- Wood and cardboard wastes will be reused if possible.
- Potentially hazardous waste will be segregated from non-hazardous construction site waste and domestic waste. This will be accomplished through training of the project personnel on the types of wastes.

- Construction workers will be instructed in proper construction waste and other solid waste storage and handling procedures.

Hazardous Waste Management Plan

- Hazardous wastes that can be originated due to construction activities can be lubricants, oils, dyes and tyres etc.
- There shall be a register of all hazardous substances present on the site. The register shall detail the type of substance, quantity, storage procedures and pollution prevention measures, handling, and eventual disposal of all potentially hazardous substances.
- There shall be collection systems (i.e. trays or impervious linings) under machinery or equipment (i.e. generators and pumps) that may dispense or leak hazardous substances (i.e. machine oils).
- Handling, temporary storage and final disposal of hazardous wastes shall be carried out in accordance with relevant Georgian Legislation.
- After temporary storage, hazardous wastes will be collected by a licensed company and proper disposal will be applied in accordance with relevant legislation and all records shall be kept.
- Routine maintenance and repairs to vehicles, machinery or equipment shall be undertaken on site when all the measures are taken against any spillage or leaking.
- The areas for refueling shall be established by proper containment against possible spills and/or tank overfills.
- In the event of a hazardous spill, whether accidental, deliberate or through negligence, on site or during transportation of these substances to/from the site, contractor shall immediately implement actions to stop or reduce and contain the spill.
- Emergency action plan is established for dealing with spills or release of these substances and ensure that relevant construction personnel are familiar with these emergency procedures (see Appendix 6).

- Contractor shall comply with all relevant national legislation with regard to safe handling, storage, transport, use and disposal of petroleum, chemical, harmful and hazardous substances and materials.
- The advice of the manufacturer shall be obtained with regard to the safe handling of such substances and materials and also material safety data sheets.
- Construction workers will be instructed in proper collection and segregation of hazardous wastes.

VII.1.2.7. Management of Biological Environment

To determine the general floristic and faunistic structure of the area literature studies were conducted, locals were communicated, and field surveys were carried out in the scope of ESIA studies. The results of the studies provide the main features of the floristic and faunistic characteristics of the project area. Furthermore, the potential adverse impacts on these species due to construction, impoundment and operation have been assessed. The details of floristic and faunistic survey and the potential adverse impacts are given in Chapters IV and V.

According to the results of the studies, population loss in flora and vegetation types is expected in the future reservoir area and construction sites, however, due to limited inundation area, no significant impact on the flora species or the vegetation cover is expected.

During the studies/surveys it is observed that the habitats used by the fauna species consist of riverine habitats along the river, and cultivated lands close to these areas. It was seen that they mainly prefer using the habitats in the project area for feeding and wandering.

The identified fauna species are generally species that are common in Georgia and they have high reproduction potential. None of these species has a protection status. They can be found in the region and out of the region in Georgia. Thus, even though the population of these species would be affected from the project the species survival will not be significantly affected. None of the fish species indicated

is endemic for Georgia. There are ten fish species of international concern according to Annex 3 of Bern Convention that will be impacted by Mtkvari HPP Project. Under Bern Convention, the populations of these species need to be maintained. These species' spawning and maintenance habitats in the section of Mtkvari River to be bypassed would be eliminated by decreased flow unless relevant mitigation measures are taken. To maintain these habitats, water will be released from Mtkvari Dam so as to provide minimum flow in the bypass reach. The details of minimum flow calculations are presented in V.1.4.1.4.

Biological environment in the region might be affected from dust and noise caused by construction activities as well. During construction period, most of the terrestrial fauna species are expected to leave the area that surrounds the construction region and move temporarily to similar areas. These impacts will be seen only during construction and will end by the completion of construction activities. In the meantime (during construction) implementation of relevant management plans (emissions and dust control and noise control plans) will minimize the associated adverse impacts on the wildlife as well.

In order to avoid any unnecessary disturbance of biological environment during construction, the movement of machinery and workers will be limited to the designated construction sites and camp facilities. The construction sites will be secured by temporary fencing, which will also prevent the entrance of fauna elements into these areas. In addition, potential impacts of construction activities on vegetation and habitats will also be mitigated through the measures taken for other components of environment. Some examples of these are; proper disposal of solid wastes and establishing wastewater treatment facilities, which will minimize the potential adverse impacts on aquatic and terrestrial habitats during construction.

In order to sustain the aquatic life in Mtkvari River, the necessity of the fish gate is taken into consideration during environmental and social impact assessment. In this respect, the fish gate was not considered to be necessary at first as Uraveli and Potschkovi Rivers join Mtkvari River at distances of 8 and 9.2 km to the construction area, respectively. However, according to the Law of Georgia (Order

512 of the Minister of Environmental Protection and Natural Resources, approved on December 7, 2005), it is an obligation to construct a fish gate in hydropower projects. In this scope, the design of the fish gate will be supplied by Ukrhydroproject in the final design phase of the project.

The design of the fish gate shall be based on the fish species and their specific properties that are mentioned in the biological survey carried out. According to the results of the survey, the significant fish species identified in the area is brown trout (*Salmo trutta fario*) which is sensitive species to water quality and river habitat. Actually, this species was not observed in the vicinity of the project area, but it was determined from literature that it can be found in the tributaries joining the Mtkvari River. This species mainly prefer of cold stream and rivers as habitats. Therefore, dam structure might affect the living environment of this specie.

In this scope, brown trout (*Salmo trutta fario*) will be of concern in design of the fish gate. According to the literature data, the fish gate must supply a water depth of 20-65 cm and a flow velocity of 33-80 cm/sec (54 cm/sec on average) for brown trout and a water depth of 10-50 cm and a flow velocity of 20-50 cm/sec for other fish species (Cowx and Welcomme, 1998). However, further details and type of the fish gate will be determined in the final design phase.

VII.1.2.8. Socio-economy

Field studies and literature survey have been carried out related to the socioeconomic conditions in the project area. Key informant surveys were conducted and statistical data were obtained from Department of Statistics of Georgia. In addition, public consultation and information disclosure activities have been conducted. Details of the public consultation and participation activities are provided in Appendix 4.

The project area is located within a rural area with no industrial facilities and low population density. The main adverse impacts due to the construction activities would be caused by dust and noise generation. The modelling studies showed that these impacts will not be significant on the close by settlements and the control

measures to be taken as provided in the previous sections (such as emissions and dust control and noise control plans) will ensure the minimization of these impacts.

In addition, some agricultural areas, approximately 10 ha, that belong to nearby settlements will be expropriated. There are no buildings or other structures in the area to be expropriated in accordance with the Law of Georgia on the Procedure for Expropriation of Property for Necessary Public Needs. No activity will start at these areas before the completion of the expropriation process.

None of the PAPs are affected such that they would be physically or economically displaced, so there is no resettlement due to the project.

Construction activities for the project will also have positive impacts on PAPs. Firstly, most of the 250 workers to be employed in the construction phase are planned to be selected from local residents. In construction and operation activities that do not require high skills or special training, local residents would be hired and trained, if necessary. Apart from employment opportunities, equipment and vehicles that will be required during construction activities will be provided from the region, influencing the economy of the region positively. In addition, the newly constructed and improved roads are going to help in transportation of farm products to markets, positively affecting the existing production and incomes.

VII.1.2.9. Cultural and Historical Assets

There are no known archeological or cultural protection sites in the project area. If any archeological or cultural resources are found during construction, the Ministry of Culture, Monuments Protection and Sport of Georgia will be informed, in accordance with Georgian Laws. Necessary actions to protect these resources will be undertaken by the Ministry of Culture, Monuments Protection and Sport of Georgia.

VII.1.2.10. Health and Safety

The project activities should be carried out in accordance with the relevant health and safety issues that are in the scope of EBRD and IFC Standards and Requirements. Furthermore, Labour Law of Georgia also includes the significant issues regarding health and safety of workers. For that purpose, the following health and safety plan is presented.

Health and Safety Plan

- Occupational health and safety measures shall be implemented according to Labour Law of Georgia and requirements of IFIs and shall be communicated to all employees before commencement of and during construction.
- On-site medical/first-aid facilities shall be designed for construction phase to cater for primary health care needs of personnel.
- An ambulance shall be available on-site for emergency situations.
- Workers shall be selected from the workforce and given additional training in occupational health and first aid to form teams of three personnel at each work site. These workers shall be under the supervision of the person responsible for occupational health and safety.
- Personal protective equipments for workers shall be provided, when necessary to minimize health and safety risks.
- Appropriate health and safety signs such as “Danger”, “Entrance Prohibited” shall be placed in proper places.

To minimize the risk of fire and to ensure that incidents are effectively confined, contractor shall implement the following fire management measures.

- All necessary precautions shall be taken to ensure that fires are not started as a result of construction activities on site. Uncontrolled fires shall not be permitted on or off site.

- Smoking shall not be permitted in those areas where there is a fire hazard. Such areas shall include the workshop and fuel storage areas and any areas where there is a potential risk of fire.
- All necessary precautions shall be taken to prevent fires or spills at the fuel store. No smoking shall be allowed inside the stores and within the storage area.
- It shall be ensured that there is adequate and appropriate fire-fighting equipment at the fuel store, in workshops, and camp areas at all times.
- All equipment shall be maintained in good operating order.
- It shall be ensured that all sub-contractors and construction workers are aware of the procedures to be followed in the event of a fire.
- Emergency teams (fire, first aid, communication and rescue) shall be appointed who shall be responsible for ensuring immediate and appropriate actions in the event of a fire.
- A water pump will be available at the site at all the time.

VII.1.3 Operation Phase (including Impoundment)

VII.1.3.1. Erosion in the Catchment Area and Reservoir Sedimentation

Erosion may occur in the area on which powerhouse, switchyard and turbine will be constructed. In addition, economical life of the project would reduce if lots of sediments (due to erosion) reach the reservoir. Thus, measures are required for control of erosion in the catchment area of the reservoir. In this context, terraces will be built at the locations where breaches exist to prevent erosion in these areas, and afforestation and plantation activities will be executed.

Terraces will be constructed by putting up stonewalls and surface runoff will be prevented in order to prevent breach formation in the areas with slopes of 20 % and higher. This implementation is found appropriate for the areas where stone is abundant. Terraces will be constructed as half circles, and trees will be planted on the center.

VII.1.3.2. Water Quality

The small reservoir area of Mtkvari HPP to be formed will cover approximately an area of 50 ha with a maximum depth of approximately 25 m. Therefore, no significant adverse impacts regarding water quality in the reservoir is of concern. However, harvesting of the fields in the reservoir area before impounding will reduce the biomass to be left in the reservoir, which will positively affect the water quality. The villagers will be informed about the commencement date of impounding in advance and they will have a chance to harvest their products.

The villagers will also be allowed to cut and collect the trees in the reservoir area, which will allow the clearance of the vegetation cover to some extent. The remaining trees will be cleared in accordance with the Forest Code of Georgia and the timbers will be collected. On the other hand, if any vegetation is left in the project area it is not estimated that this will create an adverse impact of the water quality since there is not a significant reservoir area for Mtkvari HPP project.

The reservoir water quality is going to be protected from release of pollutants from any source that might adversely impact the water quality. Domestic wastewaters will be discharged to Mtkvari River by application of appropriate treatment techniques. The afforestation activities contribute to increasing the water quality by reducing the erosion in the watershed and hence prevent sediment loss to water.

The main impact on water quality will be in the by-pass reach of about 27 km between the headworks and powerhouse (the reach passed by headrace tunnel). This will be due to the decrease of water in this reach by the diversion of flow by Mtkvari headworks. Thus, the minimum flow that shall be kept in this reach to preserve the water quality and assimilative capacity of this section as well as the aquatic life was estimated.

VII.1.3.3. Waste and Wastewater Management

The wastes generated from hydropower plant operation will be managed according to the relevant Georgian Legislation. Solid wastes to be generated during operation will be mainly domestic wastes and some hazardous wastes, mainly machine oils and fuels. To handle these wastes properly during operation relevant provisions of Waste and Hazardous Waste Management plans prepared will be implemented. The domestic wastes will be disposed to the appropriate sites to be specified by the nearest municipality. The other wastes including any hazardous waste will be temporarily stored and contractors will be commissioned for safe handling, treatment and disposal of these wastes.

Wastewaters that will be produced in the operation phase will be treated by the package treatment plant that will be constructed. The treated wastewaters will be discharged to Mtkvari River.

VII.1.3.4. Biological Environment

The reclamation and landscaping of the construction sites will provide new habitats for the wildlife species such as reptiles and small mammals and birds.

VII.1.3.5. Health and Safety

Relevant health and safety measures will be followed as presented for the construction phase in accordance with the Georgian Legislation, EBRD and IFC requirements during operation as well. As examples of these measures personal protective equipment will be provided for workers, when necessary and warning signs (e.g. danger, entrance prohibited, etc.) will be placed at appropriate locations.

VII.2. Monitoring Plan

VII.2.1. Objectives

Monitoring is an important part of environmental and social management and coordination. In this regard, monitoring activities will provide information on the changes in the environmental conditions by the commencement of the project, the actual level of impacts that are previously estimated, the level of compliance with the mitigation plan and success of the mitigation activities to reduce the adverse impacts to acceptable levels.

By using the information collected through monitoring, environmental and social action plan can be improved when necessary (e.g. adapting mitigation measures to changing situations) throughout project construction and operation to ensure that the anticipated impacts are mitigated. While impact assessment attempts to encompass all relevant potential impacts to identify their significance and include appropriate responses for these impacts, still unanticipated impacts may arise, which can be managed or mitigated before they become a problem using the information obtained through monitoring.

Thus, monitoring will serve the aim of ensuring the implementation of the mitigation plans and optimizing environmental protection through good practice at all stages of the project.

Some of the monitoring requirements for construction and operation phases of the project were already identified during the engineering design studies. During project construction and operation, monitoring will be a part of ensuring compliance with all relevant legislation, contract requirements and effective implementation of mitigation measures.

In this section, the monitoring activities to be performed during construction and/or operation phases are described. The tabular representation of the monitoring plan is given in Table VII.2 at the end of this chapter, which include the responsible parties for the monitoring activities as well.

VII.2.2. Environmental Monitoring Coordination

The success of the mitigation plan can be assessed by the quality of implementation. Within this scope, an environmental coordination unit to be established in JSC Caucasus Energy and Infrastructure will monitor the environmental and social issues discussed in mitigation and monitoring sections. Consultants could also be employed. In this respect, coordination with the relevant agencies will be ensured either by the consultant(s) or the coordination unit. Compliance with environmental regulations will also be rigorously followed and professional assistance may be obtained for this purpose.

According to the proposed mitigation plan, the adverse impacts defined for Mtkvari HPP Project will be remedied or mitigated. All relevant items in the mitigation scenario become commitments of the developer and the monitoring of those are going to be performed according to the monitoring plan and related Georgian Legislations.

During construction an environmental site manager will be designated, who will be responsible for the monitoring issues. During operation, an environmental coordinator will be assigned for this purpose. In case the findings of monitoring indicate any deviation from the implementation of the outlined plans aiming at the protection of the environment, or any environmentally unsatisfactory condition should be encountered the environmental site manager will advise corrective actions as necessary. Compliance with national environmental regulations will be strictly adhered to in all phases of the project and for monitoring activities independent consultants can also be employed, when necessary.

Monitoring records will be kept and regularly prepared by the environmental site manager/environmental coordinator. Generally, reports will be prepared bi-annually or annually to describe the monitoring activities and their results (including any need for improvement and the means of achieving this). These reports will be available to relevant governmental agencies, when required, and to the public as appropriate.

In addition to the above mentioned monitoring requirements, specialists from various ministries, including the Ministry of Environmental Protection and Natural resources may also inspect the project activities, beginning with the construction, till the end of the economic life of the Project. This monitoring will aim to verify whether or not the project activities are conducted in accordance with the requirements of relevant regulations.

Table VII.1. Environmental and Social Action Plan

No	Action	Environmental Risks Liability/Benefits	Legislative Requirement/Best Practice	Investment Needs/Resource/ Responsibility	Timetable Action to be Completed by the End of Year	Target and Evaluation Criteria for Successful Implementation	Comments
Pre-construction Period							
1	Preparation and submission of EIA	Compliance with applicable Georgian Law and satisfying requirements of IFIs	Law of Georgia on Environmental Impact Permit	Administrative charges/project developer will be responsible	Before start of construction (2009)	Environmental Permit obtained from Ministry of Environmental Protection and Natural Resources (MoE)	
2	Obtaining necessary report approvals and permits for construction and use of water	Compliance with applicable Georgian Law	Law of Georgia on Licenses and Permits	Administrative charges/project developer will be responsible	Before start of construction (2009)	Construction Permit from Ministry of Economic Development and Water Consumption Permission from MoE	

Table VII.1. Environmental and Social Action Plan (cont'd)

No	Action	Environmental Risks Liability/Benefits	Legislative Requirement/Best Practice	Investment Needs/Resource/ Responsibility	Timetable Action to be Completed by the End of Year	Target and Evaluation Criteria for Successful Implementation	Comments
Construction Period							
3	Implementation of Emissions and Dust Control Plan	Compliance with relevant Georgian Law and international requirements	Law of Georgia on Ambient Air Protection Best practice World Health Organization (WHO) Air Quality Guidelines and Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 – on Ambient Air Quality and Cleaner Air for Europe	Dust sampling or dust measurement performed by the project developer or subcontractor	During construction period (2009-2012)	Target: Protection of the social and biological environment from adverse impacts of emissions and dust Passing regular monitoring or inspections of relevant authorities successfully Receiving no complaints Positive results of monitoring reports regarding implementation of Emissions and Dust Control Plan	

Table VII.1. Environmental and Social Action Plan (cont'd)

No	Action	Environmental Risks Liability/Benefits	Legislative Requirement/Best Practice	Investment Needs/Resource/ Responsibility	Timetable Action to be Completed by the End of Year	Target and Evaluation Criteria for Successful Implementation	Comments
4	Implementation of Noise Control Plan	Compliance with international requirements	Best practice (General EHS Guidelines: Environmental Noise Management of IFC)	Noise level measurements performed by the project developer with necessary devices	During construction period (2009-2012)	Target: Protection of the environment and workers' health, Receiving no complaints Positive results of monitoring reports regarding implementation of Noise Control Plan	No Georgian Regulation on Noise

Table VII.1. Environmental and Social Action Plan (cont'd)

No	Action	Environmental Risks Liability/Benefits	Legislative Requirement/Best Practice	Investment Needs/Resources/ Responsibility	Timetable Action to be Completed by the End of Year	Target and Evaluation Criteria for Successful Implementation	Comments
5	Implementation of Wastewater Management Plan	Compliance with the applicable Georgian Law and international requirements	Law of Georgia on Water (Water Act of Georgia) Best Practice (General EHS Guidelines: Wastewater and Ambient Water Quality of IFC)	Package treatment plant for domestic wastewater produced during construction activities supplied by the project developer Settlement pond for wastewaters from concrete batch plant	During construction period (2009-2012)	Target: Maintaining of Mtkvari River Water Quality Positive results of monitoring reports regarding implementation of Wastewater Management Plan	
6	Implementation of Solid and Hazardous Waste Management Plans	Compliance with the applicable Georgian Law	Law of Georgia on Compensation for Harm Caused by Hazardous Substances Law of Georgia on Hazardous Chemical Substances	Collection of different types of wastes separately (i.e. hazardous wastes, dyes, domestic wastes etc.) will be supplied by the project developer or subcontractor	During construction period (2009-2012)	Target: Protection of the environment from adverse impacts of hazardous and non-hazardous wastes Positive results of monitoring reports regarding implementation of Solid and Hazardous Waste Management Plans	

Table VII.1. Environmental and Social Action Plan (cont'd)

No	Action	Environmental Risks Liability/Benefits	Legislative Requirement/Best Practice	Investment Needs/Resources/ Responsibility	Timetable Action to be Completed by the End of Year	Target and Evaluation Criteria for Successful Implementation	Comments
7	Implementation of Erosion and Sediment Control Plan	Compliance with the applicable Georgian Law	Law of Georgia on Soil Protection Best practice	None	During construction period (2009-2012)	Target: Protection of soil Positive results of monitoring reports regarding implementation of Erosion and Sediment Control Plan	
8	Implementation measures to protect landscape	Reduction of landscape impacts	Best practice	Management time and cost for soil protection	During construction	Target: Reduction of landscape impacts No complaints regarding landscape	
9	Implementation of health and safety plan	Compliance with the applicable Georgian Law and international requirements	Labour Code of Georgia	Protective equipment and necessary health and safety trainings conducted by the project developer or subcontractor	During construction (2009-2012)	Target : Prevention of injuries and providing safe work place Positive results of monitoring reports regarding implementation of Health and Safety Plan	

Table VII.1. Environmental and Social Action Plan (cont'd)

No	Action	Environmental Risks Liability/Benefits	Legislative Requirement/Best Practice	Investment Needs/Resource/ Responsibility	Timetable Action to be Completed by the End of Year	Target and Evaluation Criteria for Successful Implementation	Comments
10	Monitoring cultural and historical assets	Compliance with the applicable Georgian Law and international requirements	Law of Georgia on System of Protected Areas	Proper management system established by the project developer	During construction period (2009-2012)	Target : Protection of cultural assets Monitoring chance find during construction activities and informing Ministry of Culture, Monument Protection and Sports of Georgia	Georgia signed international conventions indicated in Chapter II
11	Implementation of Monitoring Plan	Compliance with the monitoring plan	Best Practice	None	During construction period (2009-2012)	Target: Successful implementation of management plans Monitoring reports	
Social Management							
12	Finalisation of the Public Consultation and Disclosure Plan	Identification of tasks and responsibilities	Best Practice, IFIs requirements	Management time	By the end of ESIA process (2009)	Final PCDP report	

Table VII.1. Environmental and Social Action Plan (cont'd)

No	Action	Environmental Risks Liability/Benefits	Legislative Requirement/Best Practice	Investment Needs/Resource/ Responsibility	Timetable Action to be Completed by the End of Year	Target and Evaluation Criteria for Successful Implementation	Comments
13	Setting up and operating grievance mechanism	Communication of public complaints regarding environmental and social issues of the project	Best practice	Operational cost of information	During construction and operation phases (2009-2062)	Report of operating grievance mechanism	In accordance with PCDP
14	Implementation of appropriate expropriation procedures	Compliance with relevant Georgian Law Minimization of negative social impacts due to expropriation	IFIs requirements Law of Georgia on the Procedure for Expropriation of Property for Necessary Public Needs	Management time	During construction	Target: Successful completion of expropriation procedure Report on completion of expropriation process Receiving no complaint regarding expropriation	

Table VII.1. Environmental and Social Action Plan (cont'd)

No	Action	Environmental Risks Liability/Benefits	Legislative Requirement/Best Practice	Investment Needs/Resource/ Responsibility	Timetable Action to be Completed by the End of Year	Target and Evaluation Criteria for Successful Implementation	Comments
10	Monitoring cultural and historical assets	Compliance with the applicable Georgian Law and international requirements	Law of Georgia on System of Protected Areas	Proper management system established by the project developer	During construction period (2009-2012)	Target : Protection of cultural assets Monitoring chance find during construction activities and informing Ministry of Culture, Monument Protection and Sports of Georgia	Georgia signed international conventions indicated in Chapter II
11	Implementation of Monitoring Plan	Compliance with the monitoring plan	Best Practice	None	During construction period (2009-2012)	Target: Successful implementation of management plans Monitoring reports	
Social Management							
12	Finalisation of the Public Consultation and Disclosure Plan	Identification of tasks and responsibilities	Best Practice, IFIs requirement	Management time	By the end of ESIA process (2009)	Final PCDP report	

Table VII.1. Environmental and Social Action Plan (cont'd)

No	Action	Environmental Risks Liability/Benefits	Legislative Requirement/Best Practice	Investment Needs/Resource/ Responsibility	Timetable Action to be Completed by the End of Year	Target and Evaluation Criteria for Successful Implementation	Comments
17	Management of biological environment	Ensuring the downstream water quality	Act of Georgia on Wildlife	Monitoring release of minimum flow by flow meter	During operation period	Maintenance of downstream aquatic life	
18	Implementation of health and safety plan	Compliance with the applicable Georgian law and international requirements	Labour Code of Georgia	Protective equipment and necessary health and safety trainings conducted by the project developer or subcontractor	During operation period (2012-2062)	Target : Prevention of injuries and providing safe work place Positive results of monitoring reports regarding implementation of Health and Safety Plan	
19	Implementation of Monitoring Plan	Compliance with the monitoring plan	Best Practice	None	During operation period (2012-2062)	Target: Successful implementation of management plans Monitoring reports	

Table VII.2. Monitoring Plan

No	Phase	What parameter is to be monitored?	Where is the parameter to be monitored?	How is the parameter to be monitored/ type of monitoring equipment?	When is the parameter to be monitored- frequency of measurement or continuous?	Why is the parameter to be monitored?	Source of Funding	Start Date	Finish Date	Institutional Responsibility
1	Construction	On-Site Erosion and Runoff	Construction sites	Visual observation	Continuous controls and monthly reporting	To reduce the risk of siltation of water courses comply with Erosion and Sediment Control Plan	Project Budget	Start of construction works	Completion of construction works	JSC Caucasus Energy and Infrastructure
2	Construction	Proper storage and utilization of topsoil and excavation materials	Construction sites and storage areas	Visual observation	Weekly	To control the effectiveness of the relevant mitigation measures and ensure landscaping and formation of natural habitats	No additional cost	Start of excavation works and soil stripping	Completion of construction works	JSC Caucasus Energy and Infrastructure

Table VII.2. Monitoring Plan (cont'd)

No	Phase	What parameter is to be monitored?	Where is the parameter to be monitored?	How is the parameter to be monitored/ type of monitoring equipment?	When is the parameter to be monitored- frequency of measurement or continuous?	Why is the parameter to be monitored?	Source of Funding	Start Date	Finish Date	Institutional Responsibility
3	Construction	Air Quality (PM)	Construction sites, access roads, concrete batch plant, storage areas, close settlements	Sampling and analysis using portable dust analyzer	Every 6 months Upon complaint	To ensure compliance with international requirements regarding air quality and occupational health and safety	Project Budget	Start of construction works	Completion of construction works	JSC Caucasus Energy and Infrastructure
4	Construction	Air Quality	Trucks and machinery exhausts	Inspection with exhaust measurement devices	Every 6 months	To ensure compliance with emissions and dust control plan	Project Budget	Start of construction works	Completion of construction works	JSC Caucasus Energy and Infrastructure

Table VII.2. Monitoring Plan (cont'd)

No	Phase	What parameter is to be monitored?	Where is the parameter to be monitored?	How is the parameter to be monitored/ type of monitoring equipment?	When is the parameter to be monitored- frequency of measurement or continuous?	Why is the parameter to be monitored?	Source of Funding	Start Date	Finish Date	Institutional Responsibility
5	Construction	Noise	Near settlements	Measuring noise levels via portable sound level meters	Every 6 months and upon complaints by residents of nearby settlements	To ensure compliance with international requirements and noise control plan	Project Budget	Start of construction works	Completion of construction works	JSC Caucasus Energy and Infrastructure
6	Construction	Wastewater (pH, BOD, SS, pH etc.)	Effluent from construction site and concrete batch plant	Laboratory analyses of domestic wastewater and wastewater from concrete batch plant	Once in 3 months	To comply with the wastewater management plan	Project Budget	Start of construction works	Completion of construction works	JSC Caucasus Energy and Infrastructure
7	Construction	Health and Safety	All work places	Observation and inspection	Daily, monthly	To ensure compliance with Health and Safety Plan	Project Budget	Start of construction works	Completion of construction works	JSC Caucasus Energy and Infrastructure

Table VII.2. Monitoring Plan (cont'd)

No	Phase	What parameter is to be monitored?	Where is the parameter to be monitored?	How is the parameter to be monitored/ type of monitoring equipment?	When is the parameter to be monitored- frequency of measurement or continuous?	Why is the parameter to be monitored?	Source of Funding	Start Date	Finish Date	Institutional Responsibility
8	Construction	Water Quality (pH, BOD, oil-grease)	In case of an accident, as a result of spilling waste oil, paint etc. to surface water and groundwater,	Laboratory analyses	When an accident such as spill and leakage is reported	To determine a potential contaminant and to comply with Water Act of Georgia	Project Budget	Start of construction works	Completion of construction works	JSC Caucasus Energy and Infrastructure
9	Construction	Vegetative cover of project area (Cleaning of field)	Impoundment area	Observation	Before start of impoundment	To minimize amount of biomass concentration that affects water quality of impoundment area	No additional cost	Before the Impoundment period	Before the Impoundment period	JSC Caucasus Energy and Infrastructure

Table VII.2. Monitoring Plan (cont'd)

No	Phase	What parameter is to be monitored?	Where is the parameter to be monitored?	How is the parameter to be monitored/ type of monitoring equipment?	When is the parameter to be monitored- frequency of measurement or continuous?	Why is the parameter to be monitored?	Source of Funding	Start Date	Finish Date	Institutional Responsibility
10	Construction	Chance finds of Cultural and Historical Assets	Project area	Visual inspection	During construction activities	To comply with Law of Georgia on System of Protected Areas	No additional cost	Start of construction works	Completion of construction works	JSC Caucasus Energy and Infrastructure
11	Construction	Solid and Hazardous Wastes (paint, waste oil)	Construction site	Visual investigation	Daily/Once in two days	To comply with Law of Georgia on Compensation for Harm Caused by Hazardous Substances and Law of Georgia on Hazardous Chemical Substances	Project Budget	Start of construction works	Completion of construction works	JSC Caucasus Energy and Infrastructure

Table VII.2. Monitoring Plan (cont'd)

No	Phase	What parameter is to be monitored?	Where is the parameter to be monitored?	How is the parameter to be monitored/ type of monitoring equipment?	When is the parameter to be monitored- frequency of measurement or continuous?	Why is the parameter to be monitored?	Source of Funding	Start Date	Finish Date	Institutional Responsibility
12	Operation	Reservoir Sedimentation	Afforestation and plantation sites	Observation	Every 6 months	To reduce the risk of sediment accumulation in the reservoir and control erosion prevention measures	Project Budget	Start of operation	End of operation	JSC Caucasus Energy and Infrastructure
13	Operation	Depth of the sediment in the reservoir	Reservoir	Measurement	Annually	To determine the sediment load in the reservoir	Project Budget	Start of operation	End of operation	JSC Caucasus Energy and Infrastructure

Table VII.2. Monitoring Plan (cont'd)

No	Phase	What parameter is to be monitored?	Where is the parameter to be monitored?	How is the parameter to be monitored/ type of monitoring equipment?	When is the parameter to be monitored- frequency of measurement or continuous?	Why is the parameter to be monitored?	Source of Funding	Start Date	Finish Date	Institutional Responsibility
19	Operation	Hydrology (minimum flow)	Downstream (by-pass reach) of the reservoir	Measurement of, flow rate	Daily	To control flows, to sustain the minimum flow of 5.8 m^3/s in the by-pass reach	Project Budget	Start of operation	End of operation	JSC Caucasus Energy and Infrastructure
20	Operation	Water Quality (DO, temperature etc.)	Downstream of the reservoir (by-pass reach)	Sampling and analyses of reservoir water	Monthly	To monitor changes in downstream	Project Budget	Start of operation	End of operation	JSC Caucasus Energy and Infrastructure
26	Operation	Health and Safety	All work places	Observation, inspection and reporting	Monthly	To ensure compliance with the Health and Safety Plan	Project Budget	Start of operation	End of operation	JSC Caucasus Energy and Infrastructure

Table VII.2. Monitoring Plan (cont'd)

No	Phase	What parameter is to be monitored?	Where is the parameter to be monitored?	How is the parameter to be monitored/ type of monitoring equipment?	When is the parameter to be monitored- frequency of measurement or continuous?	Why is the parameter to be monitored?	Source of Funding	Start Date	Finish Date	Institutional Responsibility
21	Operation	Water Quality (BOD, SS, pH etc.)	At package wastewater treatment plant area	Laboratory analyses	Every 3 months	To ensure compliance with Water Act of Georgia, to comply with the relevant provisions of wastewater management plan	Project Budget	Start of operation	End of operation	JSC Caucasus Energy and Infrastructure

Table VII.2. Monitoring Plan (cont'd)

No	Phase	What parameter is to be monitored?	Where is the parameter to be monitored?	How is the parameter to be monitored/ type of monitoring equipment?	When is the parameter to be monitored- frequency of measurement or continuous?	Why is the parameter to be monitored?	Source of Funding	Start Date	Finish Date	Institutional Responsibility
22	Operation	Solid and Hazardous Waste	Powerhouse	Observation	Weekly	To ensure compliance with Law of Georgia on Compensation for Harm Caused by Hazardous Substances and Law of Georgia on Hazardous Chemical Substances	Project Budget	Start of operation	End of operation	JSC Caucasus Energy and Infrastructure

Table VII.2. Monitoring Plan (cont'd)

No	Phase	What parameter is to be monitored?	Where is the parameter to be monitored?	How is the parameter to be monitored/ type of monitoring equipment?	When is the parameter to be monitored- frequency of measurement or continuous?	Why is the parameter to be monitored?	Source of Funding	Start Date	Finish Date	Institutional Responsibility
24	Operation	Noise	Powerhouse	Portable sound level meters for measuring noise levels	Once a month	To ensure compliance with Occupational Health and Safety requirements of IFC, EBRD and Georgian Legislation	Project Budget	Start of operation	End of operation	JSC Caucasus Energy and Infrastructure

Note: The following regulations will be complied with:

- Law of Georgia on Ambient Air Protection
- Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 – on Ambient Air Quality and Cleaner Air for Europe
- WHO's General EHS Guidelines: Environmental Noise Management of International Finance Corporation
- Water Act of Georgia
- Law of Georgia on Compensation for Harm Caused by Hazardous Substances
- Law of Georgia on Hazardous Chemical Substances
- Law of Georgia on Soil Protection
- Law of Georgia on System of Protected Areas
- Labour Code of Georgia

APPENDICES

APPENDIX 1

LIST OF PREPARERS AND CONTRIBUTORS

APPENDIX 1. LIST OF PREPARERS AND CONTRIBUTORS

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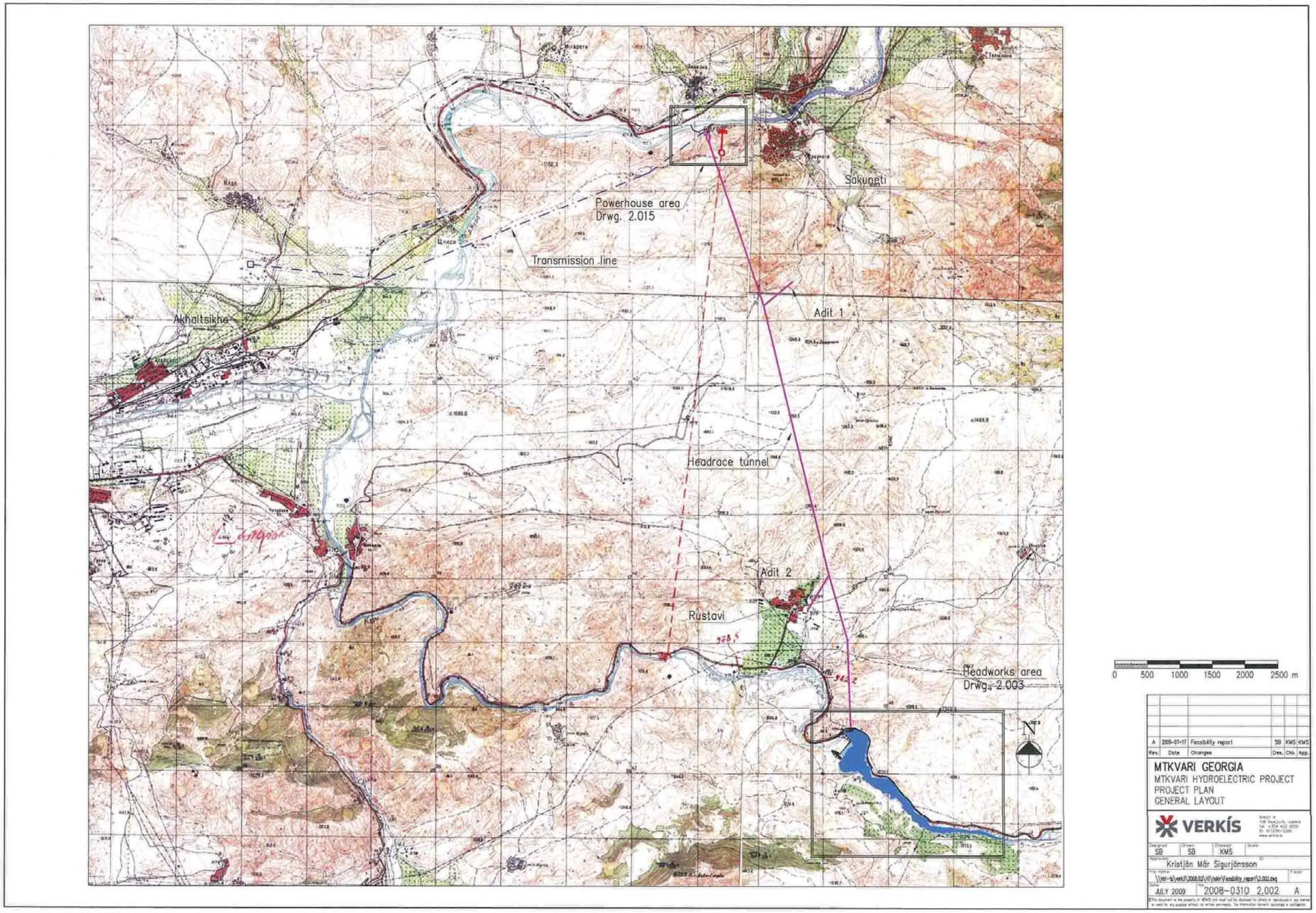
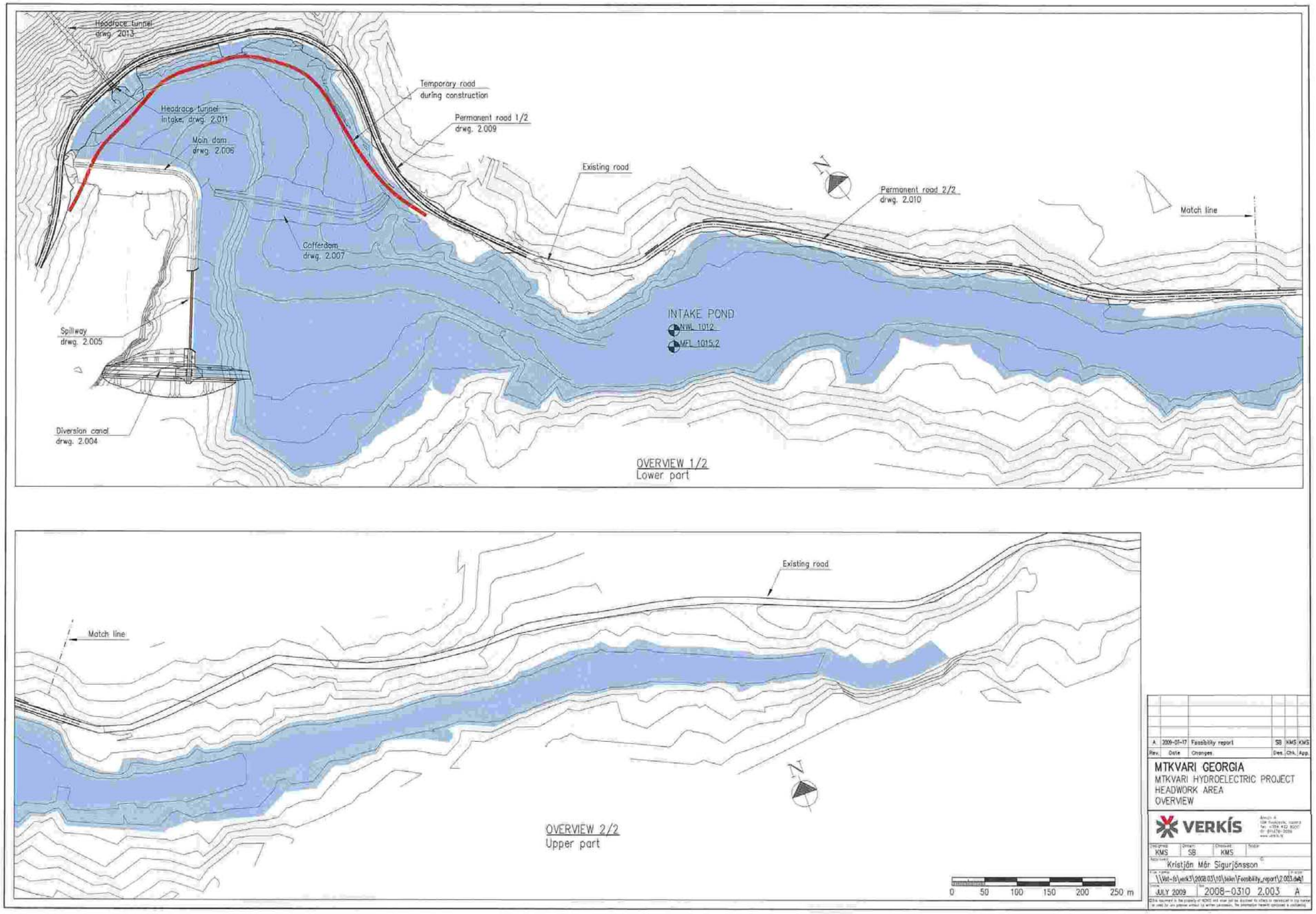
APPENDIX 2

DRAWINGS

APPENDIX 2. DRAWINGS

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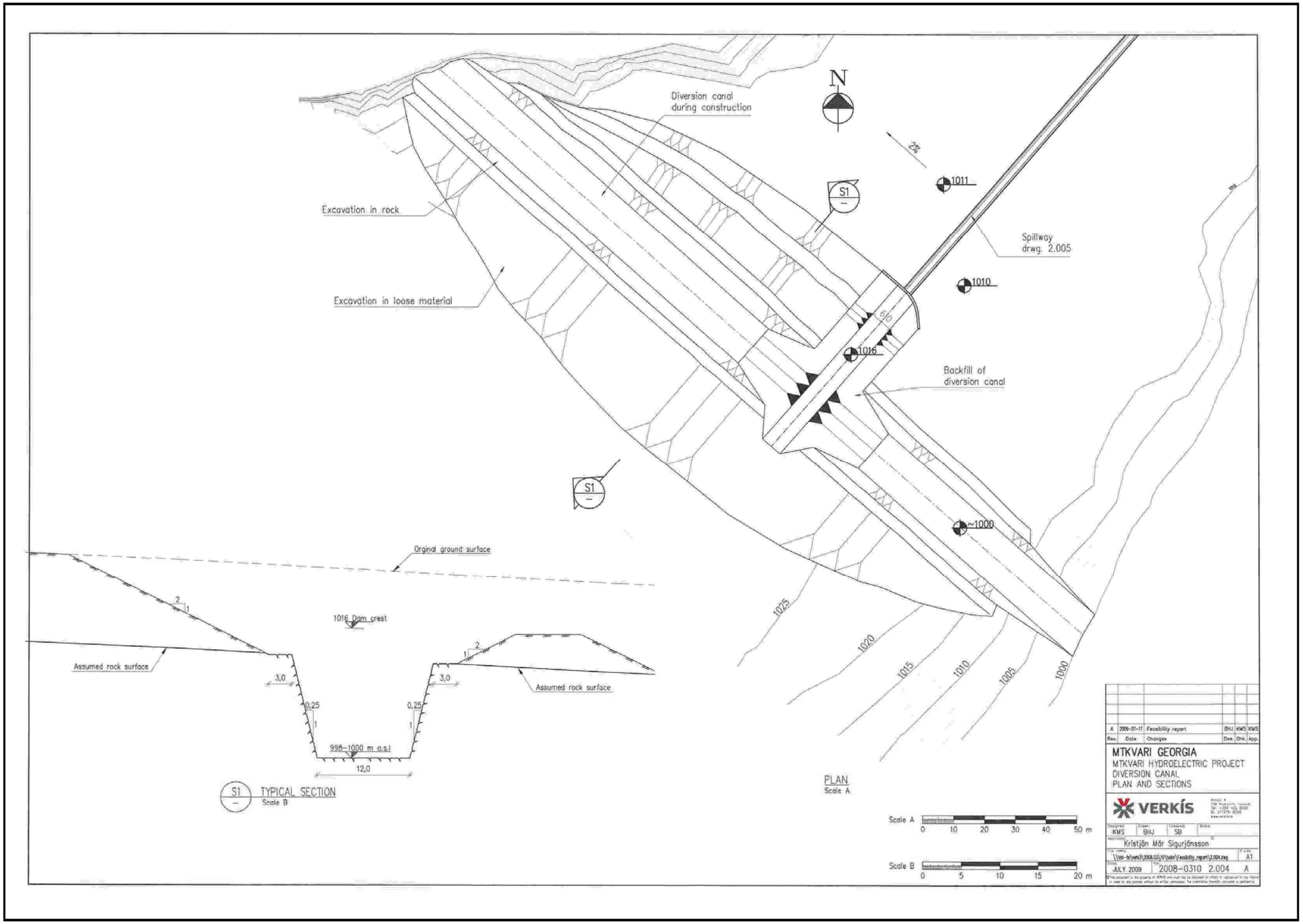
Temporary road
during construction
Headrace tunnel
intake, drwg. 2.011
Permanent road 1/2
drwg. 2.009
Main dam
drwg. 2.006
Existing road
Permanent road 2/2
drwg. 2.010
Match line
Cofferdam
drwg. 2.007
INTAKE POND
NWL 1012
MFL 1015.2
Spillway
drwg. 2.005
Diversion canal
drwg. 2.004
OVERVIEW 1/2
Lower part
Existing road
Match line
OVERVIEW 2/2
Upper part
0 50 100 150 200 250 m
A 2009-07-17 Feasibility report SB KMS KMS
Rev. Date Changes Des. Chk. App.
MTKVARI GEORGIA
MTKVARI HYDROELECTRIC PROJECT
HEADWORK AREA
OVERVIEW
VERKÍS
KMS SB KMS
Kristjón Mór Sigurjónsson
JULY 2009
2008-0310 2.003 A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N
2%
1011
S1
Excavation in rock
Spillway drwg. 2.005
1010
Excavation in loose material
610
1016
Backfill of diversion canal
S1
~1000
Orginal ground surface
1025
1020
1015
1010
1005
1000
1016 Dam crest
Assumed rock surface
3,0
0,25
995–1000 m a.s.l.
12,0
Assumed rock surface
S1 TYPICAL SECTION
Scale B
PLAN
Scale A
Scale A 0 10 20 30 40 50 m
Scale B 0 5 10 15 20 m
A 2009-07-17 Feasibility report EHJ KMS KMS
Rev. Date Changes Des. Chk. App.
MTKVARI GEORGIA
MTKVARI HYDROELECTRIC PROJECT
DIVERSION CANAL
PLAN AND SECTIONS
VERKÍS
KMS EHJ SB
Kristjón Mór Sigurjónsson
A1
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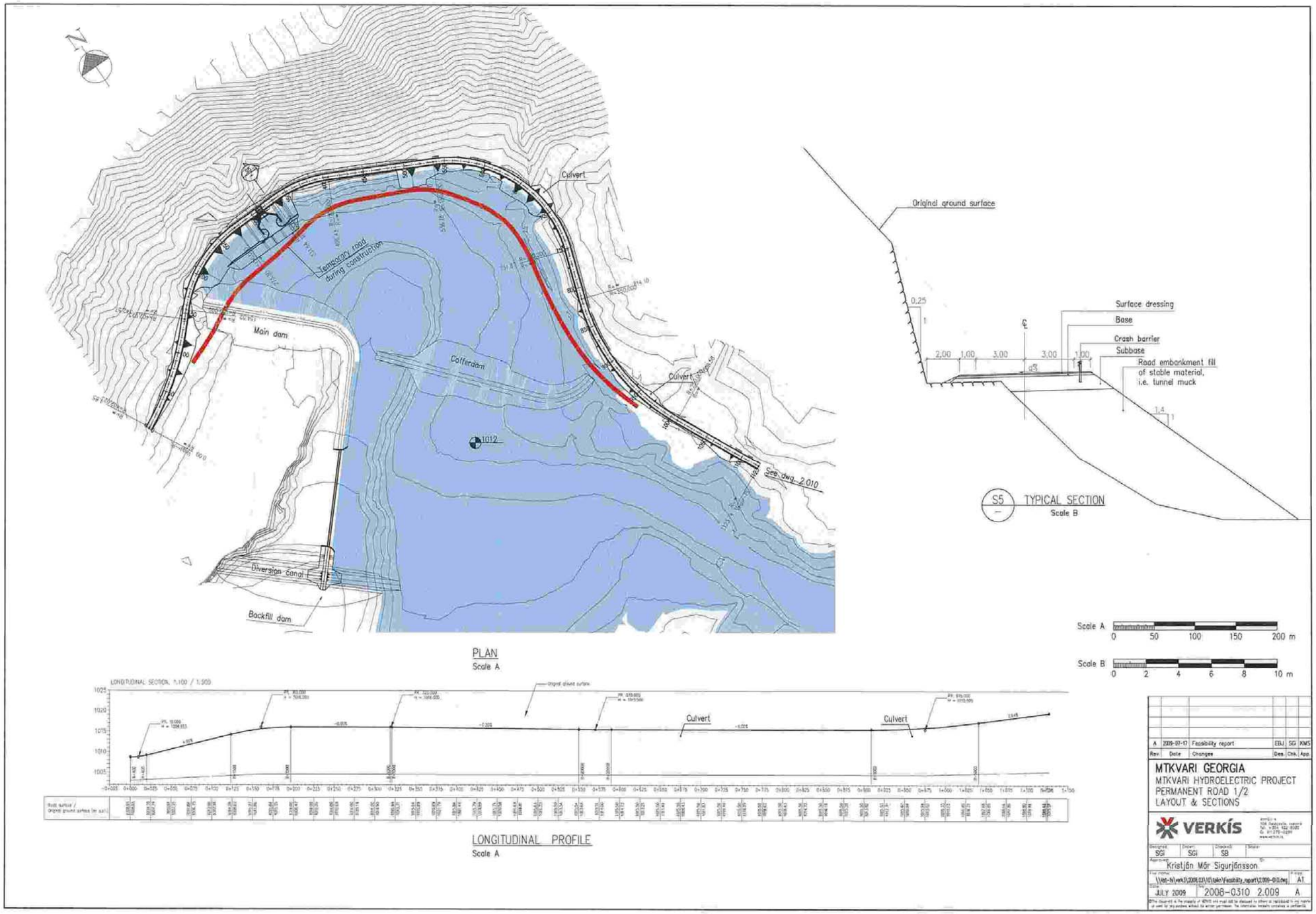
Culvert
Temporary road during construction
Main dam
Cofferdam
Culvert
1012
See dwg. 2.010
Diversion canal
Backfill dam
PLAN
Scale A
Original ground surface
Surface dressing
Base
Crash barrier
Subbase
Road embankment fill of stable material, i.e. tunnel muck
S5
TYPICAL SECTION
Scale B
Scale A
0 50 100 150 200 m
Scale B
0 2 4 6 8 10 m
LONGITUDINAL SECTION, 1:100 / 1:500
Culvert
Culvert
LONGITUDINAL PROFILE
Scale A
A 2009-07-17 Feasibility report EBJ SGI KMS
Rev. Date Changes Des. Chk. App.
MTKVARI GEORGIA
MTKVARI HYDROELECTRIC PROJECT
PERMANENT ROAD 1/2
LAYOUT & SECTIONS
VERKÍS
SGI SGI SB
Kristján Mór Sigurjónsson
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JULY 2009
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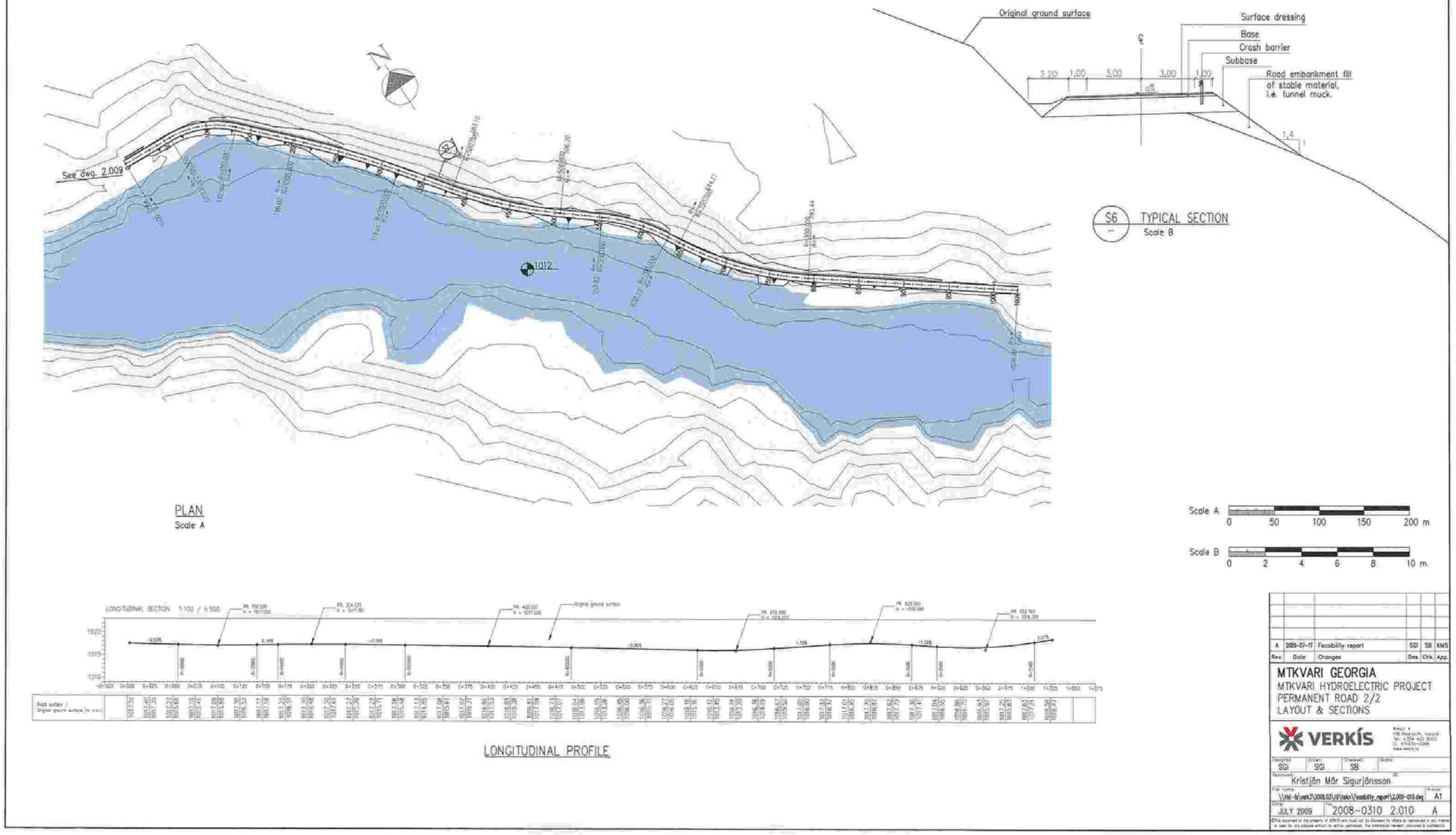
Original ground surface
Surface dressing
Base
Crash barrier
Subbase
Road embankment fill of stable material, i.e. tunnel muck.
3,20
1,00
3,00
3,00
1,00
1,4
1
S6
TYPICAL SECTION
Scale B
See dwg. 2.009
1012
PLAN
Scale A
Scale A
0
50
100
150
200 m
Scale B
0
2
4
6
8
10 m
LONGITUDINAL SECTION 1:100 / 1:500
Original ground surface
LONGITUDINAL PROFILE
A
2009-07-17
Feasibility report
SGI
SB
KMS
Rev.
Date
Changes
Des.
Chk.
App.
MTKVARI GEORGIA
MTKVARI HYDROELECTRIC PROJECT
PERMANENT ROAD 2/2
LAYOUT & SECTIONS
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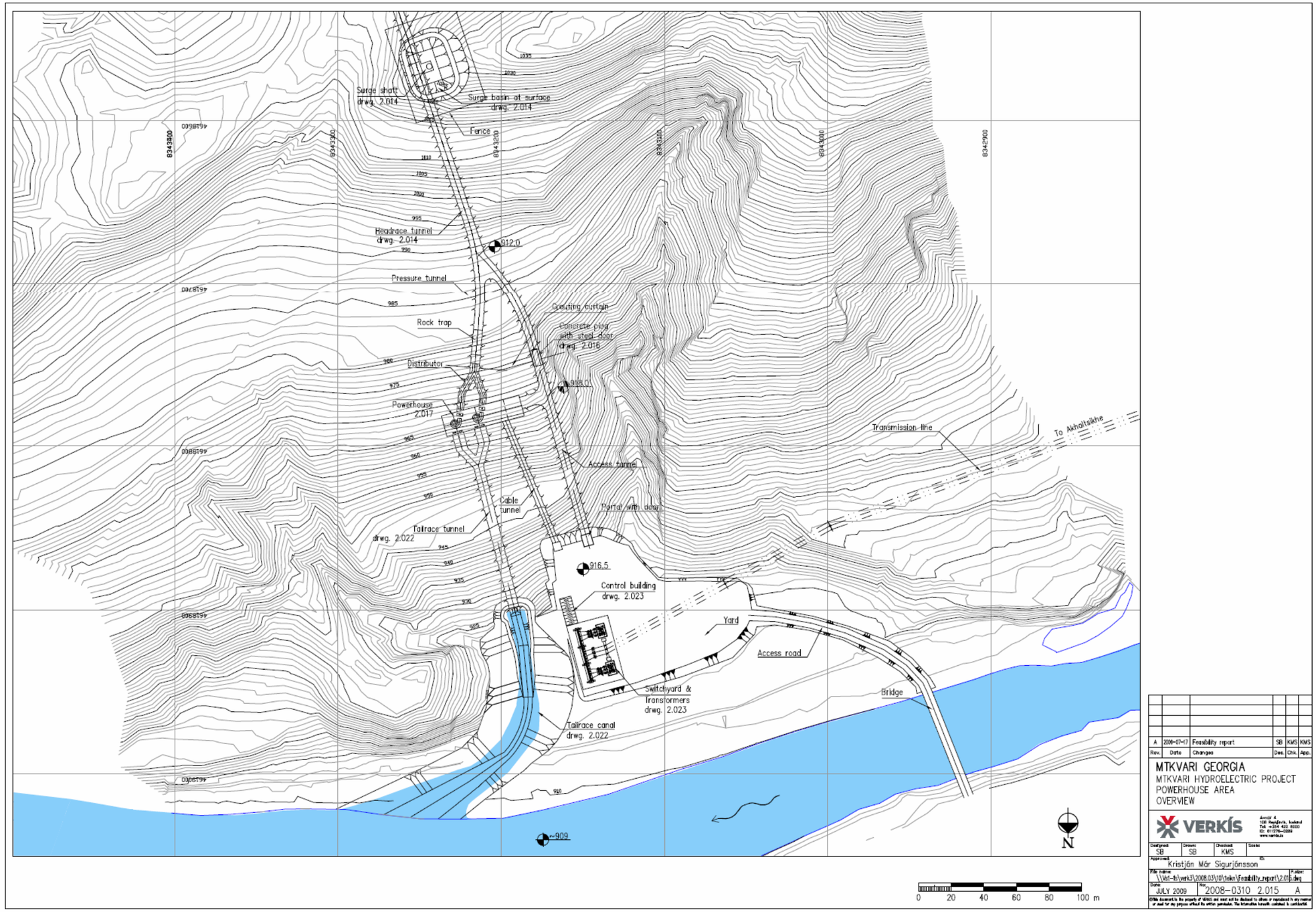
SGI
SGI
SB
Kristján Mór Sigurjónsson
A1
JULY 2009
2008-0310 2.010
A


Surge shaft
drwg. 2.014
Surge basin at surface
drwg. 2.014
Fence
Headrace tunnel
drwg. 2.014
912.0
Pressure tunnel
Grouting curtain
Rock trap
Concrete plug
with steel door
drwg. 2.016
Distributor
918.0
Powerhouse
2.017
Transmission line
To Akhaltsikhe
Access tunnel
Cable
tunnel
Portal with door
Tailrace tunnel
drwg. 2.022
916.5
Control building
drwg. 2.023
Yard
Access road
Switchyard &
Transformers
drwg. 2.023
Bridge
Tailrace canal
drwg. 2.022
~909
N
0 20 40 60 80 100 m
A 2009-07-17 Feasibility report SB KMS KMS
Rev. Date Changes Des. Chk. App.
MTKVARI GEORGIA
MTKVARI HYDROELECTRIC PROJECT
POWERHOUSE AREA
OVERVIEW
VERKÍS
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Drawn: SB
Checked: KMS
Scale:
Approved: Kristján Már Sigurjónsson
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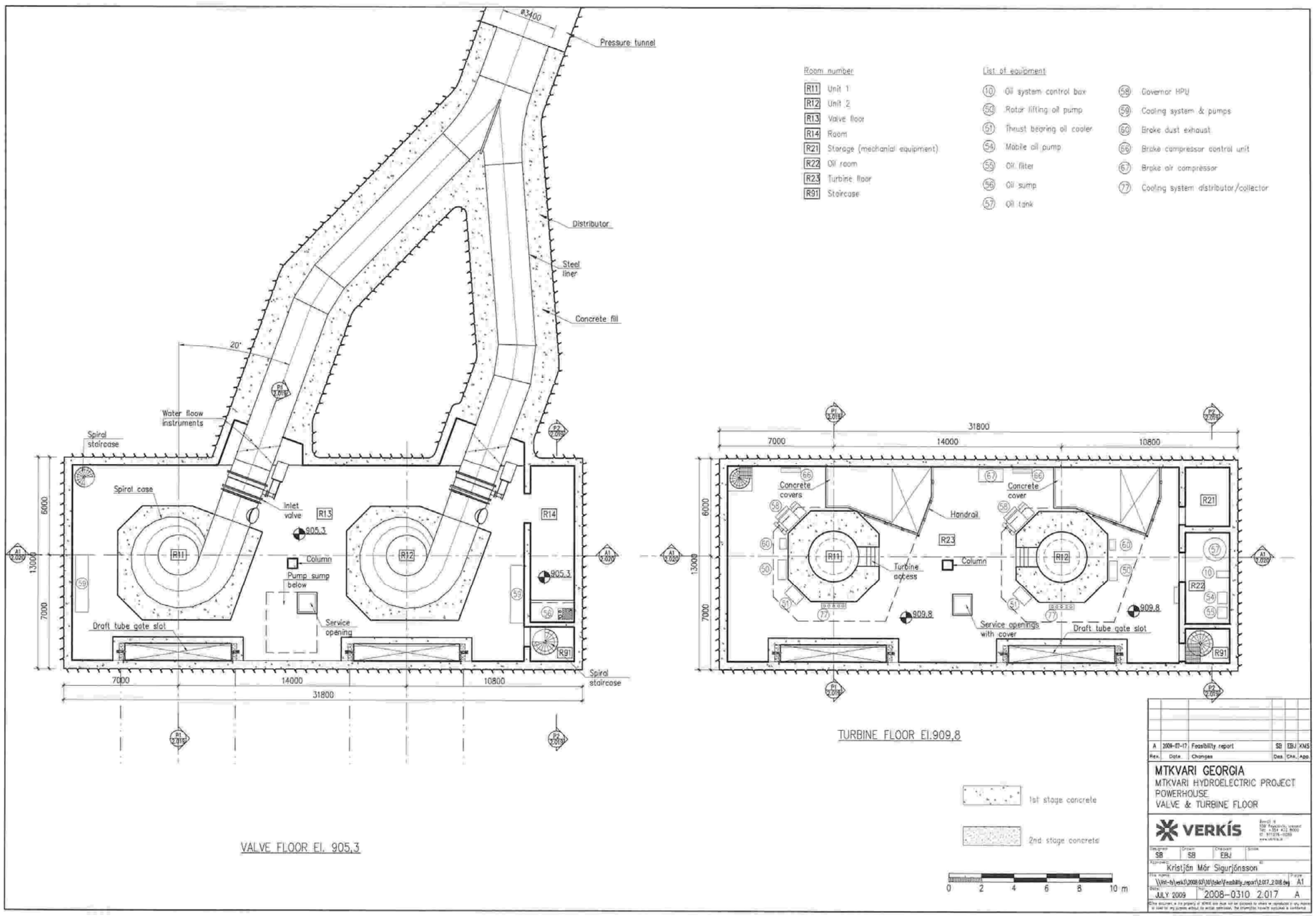
Pressure tunnel
Distributor
Steel liner
Concrete fill
Water flow instruments
Spiral staircase
Spiral case
Inlet valve
Column
Pump sump below
Service opening
Draft tube gate slot
Spiral staircase
VALVE FLOOR El. 905,3
Concrete covers
Concrete cover
Handrail
Turbine access
Service openings with cover
Draft tube gate slot
TURBINE FLOOR El.909,8
Room number
R11 Unit 1
R12 Unit 2
R13 Valve floor
R14 Room
R21 Storage (mechanical equipment)
R22 Oil room
R23 Turbine floor
R91 Staircase
List of equipment
10 Oil system control box
50 Rotor lifting oil pump
51 Thrust bearing oil cooler
54 Mobile oil pump
55 Oil filter
56 Oil sump
57 Oil tank
58 Governor HPU
59 Cooling system & pumps
60 Brake dust exhaust
66 Brake compressor control unit
67 Brake air compressor
77 Cooling system distributor/collector
1st stage concrete
2nd stage concrete
MTKVARI GEORGIA
MTKVARI HYDROELECTRIC PROJECT
POWERHOUSE
VALVE & TURBINE FLOOR
VERKÍS
Kristjón Mór Sigurjónsson
JULY 2009
2008-0310 2:017 A

APPENDIX 3

MTKVARI HYDROELECTRIC POWER STATION (HPS) ON THE RIVER MTKVARI IN GEORGIA GEOTECHNICAL INVESTIGATION REPORT

GEOENGINEERING LTD

Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

- TBILISI -
- 2009 -

Table of Contents

1. Introduction 3

2. Climate 10

3. Local Geography 15

4. Geological structure 18

5. Hydrogeological Conditions 37

6. Composition, Condition, and Physical and Mechanical Properties of Soils 41

7. Geotechnical Conditions 51

8. Local Building Materials 85

Drawings

No.	Drawing Name	Drawing No.	Sheet number
1	Geological Map and Geological-structural Section, 1:25000	GC-0904-MH-1	1
2	Schematic Engineering-geological Map of Water Reservoir Site, 1:25000	GC-0904-MH-2	1
3	Schematic Map of Deposit and Occurrence of Non-metallic Minerals, 1:50000	GC-0904-MH-3	1
4	Engineering-geological Map of Water Reservoir Site, 1:5000	GC-0904-MH-4	1
5	Engineering-geological cross-sections of Water Reservoir Site, 1:500	GC-0904-MH-5	9
6	Topographical Map of Dam Construction Site, 1:1000	GC-0904-MH-6	1
7	Engineering-geological Map of Dam Construction Site, 1:1000	GC-0904-MH-7	1
8	Geological Sections of Dam and Headgate Unit Site, 1:1000	GC-0904-MH-8	2
9	Engineering-geological Map of HPS Building Site, 1:1000	GC-0904-MH-9	1
10	Engineering-geological Sections of HPS Building Site, 1:1000	GC-0904-MH-10	2
11	Engineering-geological Section along Diversion Tunnel Axis, 1:2000.	GC-0904-MH-11	8

Annexes

#	Annex	Sheets
1	Lithological columns (logs) of boreholes and test pits	83
2	Results of laboratory tests of soil and groundwater samples	50
3	Summary Table of Nominal Physical and Mechanical Parameters of Rock	2
4	Results of Field Permeability Tests	20
5	Geophysical survey of the proposed Mtkvari HPS construction area	70
6	Fracturing	31
7	Photographs	81

1. Introduction

This geotechnical report gives a detailed description of geotechnical conditions of the planned area of HPS facilities to be constructed on the Mtkvari River in Georgia

The report is based on results of engineering surveys, conducted during the first phase of the project under the contract № GC-0904 of February 10, 2009 between Mtkvari JSC (Customer) and Geoengineering (Contractor). Geoengineering has carried out geological, hydrogeological and geotechnical surveys, while M.Z. Nodia Geophysics Institute has conducted geophysical (seismological and electrometric) surveys, based on the contract № GC-0904 of February 10, 2009 between Geoengineering (Contractor) and the Geophysics Institute (Subcontractor).

The planned area of Mtkvari HPS facilities is positioned on the territory of the Akhaltsikhe and Aspindza districts of Georgia. It covers the Mtkvari valley section between the villages of Rustavi and Sakuneti, where the river makes a curve around the western edge of the Trialeti ridge. The bow-shaped contour of the valley and the sharp difference in elevations in the upper and lower sections of the riverbed create favorable conditions for the HPS construction.

The project envisages the construction of a 10-km diversion tunnel from Rustavi to Sakuneti that will cross the Trialeti ridge from the western edge with relatively low elevations in order to supply water to the generators.

The main facilities of the Mtkvari HPS are:

- Reservoir;
- Headworks;
- Diversion Tunnel;
- Power House and Equalizing Reservoir;
- Geotechnical surveys have been conducted within the planned areas of all the main HPS facilities.

The surveys aimed at studying the following features of the construction site:

- Climatic conditions;
- Relief, hydrography and geomorphology;
- Geological structure;
- Hydrogeological conditions;
- Soil composition, condition and properties;
- Geological processes and events;
- Gas occurrence and temperature conditions along the diversion tunnel route;
- Seismic conditions.

Tables 1.1-1.4 below show all types of field investigations, laboratory tests and desktop works carried out for investigation of the proposed construction site, as well as periods of their implementation by units (members).

Field investigations, laboratory tests and desktop works conducted for investigation of the planned area of Mtkvari HPS facilities:

Geotechnical Investigations

A Diversion tunnel

Table 1.1

#	Activity	Unit	Quantity	Period
1	Search and analysis of available geological, hydrogeological and hydrometeorological data	-	1	10.02.09-10.03.09
2	*Mobilization and demobilization of staff and equipment*	-	1	13.02.09-12.05.09
3	*Field investigations*			14.02.09-11.05.09
3.1	Geotechnical reconnaissance	km	9	
3.2	Geotechnical survey at 1:25000	km^2	9	
3.3	Core drilling of 1 borehole, dia 152-89 mm, with core recovery, to the depth of 154m	m	154	
3.4	Geotechnical logging of boreholes	m	154	
3.5	Installation of piezometer in borehole	borehole	1	
3.6	Water sampling in borehole	sample	1	
3.7	Investigation of rock faults/fissures in exposed locations	exposure	13	
3.8	Geophysical survey (vertical electrical sounding)	location	-	
3.9	Soil sampling from exposed locations	sample	60	
3.10	Sampling of spring and surface water	sample	8	
3.11	Measurements of temperature and gas occurrence in BH14	borehole	1	
4	*Laboratory tests*			01.03.09-10.05.09
4.1	Physical and mechanical tests of rock			
	- petrographic analysis	test	60	
	- bulk density	test	74	
	- particle density	test	74	
	- uniaxial compression test	test	60	
4.2	Chemical test of water and aggressivity test	test	9	
5	*Desktop works*			01.03.09-14.05.09
5.1	Desktop processing of field and laboratory test data	site	1	
5.2	Geotechnical report	site	1	
5.3	Geotechnical report translation into Russian, design, and printing in 4 copies	site	1	

B - Headworks, power house and equalizing reservoir

Table 1.2

#	Activity	Unit	Quantity	Period
1	*Mobilization and demobilization of staff and equipment*	-	1	13.02.09-12.05.09
2	*Field investigations*			14.02.09-11.05.09
2.1	Geotechnical reconnaissance, identification of locations for test pits and geotechnical survey, identification of geodetic coordinates.	-	1	
2.2	Geotechnical survey at 1:1000	ha	96	
2.3	Study of faults/fissures in exposed rock	exposure	2	
2.4	Core drilling, dia 152-93 mm, with core recovery, to the depth of 20 – 50m, a total of 10 boreholes	m	265.3	
2.5	Geotechnical logging of boreholes	m	265.3	
2.6	Seepage test			
2.6.1	Pump-in test in BH12.3 (headworks site)	interval	7	
2.6.2	Pump-out tests in boreholes	borehole	7	
2.7	Installation of piezometers in boreholes	borehole	7	
2.8	Water sampling from boreholes	sample	10	
2.9	Observation over water level in boreholes during field work period, once in 5 days	borehole	7	
2.10	Geophysical survey (vertical electrical sounding)	location	5	
3	*Laboratory tests*			01.03.09-10.05.09
3.1	Bulk density	test	59	
3.2	Particle density	test	50	
3.3	Natural moisture content	test	21	
3.4	Uniaxial compression test in dry and saturated state	test	50	
3.5	Shear strength	test	5	
3.6	Deformation modulus and Poisson's ratio	test	20	
3.7	Water absorption	test	47	
3.8	Swelling	test	6	
3.9	Soaking	test	11	
3.10	Water-soluble salts in soil	test	10	
3.11	Chemical test of water and aggressivity test	test	5	
3.12	Subsidence	test	2	
3.13	Sieving	test	14	
3.14	Atterberg limits	test	13	
4	*Desktop works*			01.03.09-14.05.09
4.1	Desktop processing of field and laboratory test data	site	1	
4.2	Geotechnical report	site	1	
4.3	Geotechnical report translation into Russian, design, and printing in 4 copies	site	1	

C- Reservoir

Table 1.3

#	Activity	Unit	Quantity	Period
1	Mobilization and demobilization of staff and equipment	-	-	13.02.09-12.05.09
2	*Field investigations*			14.02.09-11.05.09
2.1	Geotechnical reconnaissance, identification of locations for test pits and vertical electrical sounding, identification of geodetic coordinates.	-	-	
2.2	Geotechnical survey at 1:5000	ha	110	
2.3	Excavation of test pits to 3 m, a total of 32 pits	test pit	29	
2.4	Geophysical survey (vertical electrical sounding)	location	3	
2.5	Sampling of spring and surface water	Sample	6	
2.6	Core drilling, dia 152-93 mm, with core recovery, to the depth of 10m, a total of 2 boreholes	Meter	11	
2.7	Geotechnical logging of boreholes	Meter	11	
2.8	Water sampling from boreholes	Sample	2	
3	*Laboratory Testing*			01.03.09-10.05.09
3.1	Bulk Density	test	37	
3.2	Particle Density	test	38	
3.3	Natural moisture content	test	39	
3.4	Atterberg limits	test	26	
3.5	Sieving	test	26	
3.6	Areometer test	test	0	
3.7	Swelling	test	7	
3.8	Subsidence	test	5	
3.9	Soaking	test	17	
3.10	Shrinkage	test	3	
3.11	Fast unconsolidated shear test	test	4	
3.12	Water-soluble salts in soil	test	18	
3.13	Chemical analysis of water and its aggressivity	test	7	
4	*Desktop works*			01.03.09-14.05.09
4.1	Desktop processing of field and laboratory test data	site	1	
4.2	Geotechnical report	site	1	
4.3	Geotechnical report translation into Russian, design, and printing in 4 copies	site	1	

Geophysical Survey

Table 1.4

#	Activity	Period
1	Mobilization and demobilization of staff and equipment	18.02.09 - 01.05.09
2	*Field investigations*	
2.1	Electrical and seismic survey on areas of headworks, power house and equalizing reservoir by DC methods; vertical electrical sounding, electrical seismic profiling, natural electrical field method; and refraction tracking for seismic survey.	
2.2	The same along the diversion tunnel	
2.3	The same in the reservoir area for identifying landslide areas	
3	*Desktop works*	
3.1	Desktop processing of field data	
3.2	Evaluation of seismic risk of the area	
3.3	Reporting	

In the course of the project, additional activities have been carried out at the Customer's and project organization's request in order to specify certain technical issues and alternative sites of some of the HPS facilities. Drilling made up the largest portion of the additional activities. The total meters of drilling increased, as the initially planned activities did not involve the drilling of a borehole to the depth of 115m along the diversion tunnel (borehole #14). Other two boreholes have been drilled to the depth of 20 m each in the alternative site of the planned gravity dam.

All other activities were within the planned limits.

The surveys have been carried out according to reference standards, norms and rules, considering requirements specifications of the project organization - Ukrhydroproject public corporation.

Table 1.5 shows the reference standards of particular activities:

Reference Standards
Table 1.5

#	Test	Index and Unit	Reference Standard
I	**LABORATORY TESTS**		
1	**Rock**		
1.1	Moisture content	W, %	5180-84
1.2	Water absorption	$W_п$, %	
1.3	Bulk density	ρ, g/cm ^{3}	
1.4	Particle density	$ρ_s$, g/cm ^{3}	
1.5	Uniaxial compression strength	R_c, MPa	17245-79
1.6	Spherical indenter loading	R_c, MPa	24941-81
1.7	Uniaxial tensile strength	R_p, MPa	21153.3-85
1.8	Deformation modulus (static)	E_0, MPa	28985-91
1.9	Elasticity modulus (Young's modulus) (static)	E, MPa	
1.10	Poisson's ratio	μ	
1.11	Deformation modulus (dynamic)	$E_{0\cdot D}$, MPa	21537-75
1.12	Elasticity modulus (Young's modulus) (dynamic)	E_D, MPa	
1.13	Rigidity coefficient	F_{rig}, MPa	21153.1-75

#	Test	Index and Unit	Reference Standard
1.14	Angle of internal friction	φ^0	
1.15	Cohesion	C, MPa	
2	**Soils**		
2.1	Grain size distribution	%	12536-79
2.2	Areometer test for clays	%	1253-79
2.3	Organic matter	%	23740-79
2.4	Chemical composition	mg/L	18164-72 4389-72 4245-77
2.5	Swelling		24143-80
	- unlimited swelling	%	
	- swelling pressure	P_{swell}, MPa	
	- swelling moisture content	W_{swell}, %	
2.6	Soaking	%/s	
2.7	Subsidence		23161-78
2.8	Shrinkage		24143-80
2.9	Humidity	W, %	5180-84
2.10	Bulk density	ρ, g/cm ^{3}	
2.11	Dry density	ρ_d, g/cm ^{3}	
2.12	Particle density	ρ_s, g/cm ^{3}	
2.13	Atterberg limits		
	- Liquid limit	W_L, %	5180-84
	- Plastic limit	W_p, %	
	- Plasticity index	I_p, %	
	- Liquidity index	I_L	
2.14	Porosity	n, %	
2.15	Seepage coefficient	K_f, m/day	25584-90
2.16	Angle of internal friction	φ^0	12248-78
2.17	Cohesion	C, MPa	
2.18	Modulus of deformation	E, MPa	23908-79
2.19	Optimum moisture content at max. density	g/cm^3	22733-77
II	**DATA INTERPRETATION**		
1	**Soil classification**		**25100-82**
2	**Statistical processing of test results**		**20522-75**
3	**Nominal values of strength and deformation characteristics**		**2.02.01-83**
4	**Soil classification by ease of excavation**		**IV-5-82**

The activities were carried out by 26 specialists (engineers). Table 1.6 shows the main activities and personnel involved.

Table 1.6

#	Activities	Personnel	Organization
1	Survey management	L. Mikaberidze – General Director G. Seturidze – Director, Engineering Survey Department L. Gorgidze, DPh – Head of Engineering Geology Unit	Geoengineering Ltd
2	Geological, tectonic and lithologic surveys	T. Giorgobiani D. Zakaraia	
3	Hydrogeological surveys	G.Gabechava	
4	Borehole and pit drilling	N. Duluzauri – Manager	
		Team №1 (drill unit URB-2A-2): D. Sirbiladze - Geological Engineer V. Chigogidze – Drill Operator D. Kutsnashvili – Assistant Drill Operator	
		Team №2 (drill unit UGB-1BC): M. Meskhi - Geological Engineer G. Lomidze - Drill Operator M. Duluzauri – Assistant Drill Operator	
		Team №3 – pit drilling M Meskhi - Geological Engineer	
5	Laboratory testing	R. Karvelashvili- Manager T. Gorgitidze- Laboratory Assistant T. Jajanidze - Laboratory Assistant N. Papiashvili - Laboratory Assistant G. Lomidze - Laboratory Assistant G. Baliashvili – Consultant	
6	Geophysical surveys	G. Jashi A. Tarkhnishvili Z. Amilakhvari V. Chichinadze J. Kiria Z. Injia G. Gogichaishvili - Geophysicist	M.Nodia Geophysics Institute

No data on geotechnical surveys earlier conducted in the study area are available. Archive materials and literature on geological, geomorphologic and hydrogeological conditions of the study area have been used during the project. All references are given at the end of corresponding parts of the text.

2. Climate

Climatic features of the proposed Mtkvari HPS area have been obtained from the USSR Climate Reference Book, edition 14, Gidrometeoizdat, Leningrad, 1970, which contains climatic values calculated using statistical data processing. Most of the weather stations in Georgia were unable to conduct systematic observations after the dissolution of the Soviet Union, but it should be acknowledged that the climatic values showed in the handbook are still valid.

Data from two weather stations positioned close to the HPS construction site have been obtained from the handbook. These are: the Akhaltsikhe weather station (982 m asl) in the town of Akhaltsikhe, 12 km to the west of the proposed construction site, and the Aspindza weather station (1098 m asl) in the town of Aspindza, 8-10 km to the east of the site. The construction site is positioned between the two weather stations, of which Akhaltsikhe station's data can be referred to the entire site, while the Aspindza station's data are rather typical for the reservoir site as it is located in the Mtkvari valley close to the reservoir.

Data from the Atskuri weather station (970 m asl) in the village of Atskuri to the northeast of the power house have been also used.

The proposed construction site of the Mtkvari HPS and its environs are positioned in the moderately humid subtropical zone with typical climate of submountain steppe, cold winter with small amount of snow and long warm summer.

Tables 2.1-2.21 below show climatic values of the proposed construction site area and its environs.

I Air Temperature

Average Monthly and Yearly Air Temperature
Table 2.1

#	Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
1	Akhaltsikhe	-3,8	-1,5	3,2	9,0	14,0	17,2	20,4	20,5	16,3	10,4	4,1	-1,2	9,0
2	Aspindza	-2,2	-0,6	3,4	9,0	13,6	17,0	20,0	20,3	16,2	10,6	4,9	0,2	9,4

Mean Minimum Air Temperature
Table 2.2

#	Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
1	Akhaltsikhe	-8,2	-6,4	-2,7	2,4	7,4	10,6	13,8	13,6	9,3	4,2	-0,7	-5,5	3,2
2	Aspindza	-6,2	-4,8	-2,2	2,8	7,4	10,4	13,4	13,1	9,0	4,4	0,0	-3,9	3,6

Absolute Minimum Air Temperature
Table 2.3

#	Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
1	Akhaltsikhe	-32	-23	-20	-13	-6	2	2	2	-5	-11	-22	-26	-32
2	Aspindza	-29	-22	-19	-12	-5	2	2	2	-5	-10	-18	-24	-29

Mean Maximum Air Temperature
Table 2.4

#	Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
1	Akhaltsikhe	2,0	4,5	9,8	16,5	21,4	24,4	27,4	28,0	24,1	18,3	11,0	4,9	16,0
2	Aspindza	2,3	4,0	8,7	16	20,8	24,4	27,4	28,3	24,2	18,0	10,9	5,3	15,9

Absolute Maximum Air Temperature
Table 2.5

#	Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
1	Akhaltsikhe	15	18	27	30	34	37	38	39	36	33	26	17	39
2	Aspindza	15	18	25	30	32	35	38	39	37	32	25	16	39

II Soil Temperature

Mean Monthly, Maximum and Minimum Soil Surface Temperature

Akhaltsikhe
Table 2.6

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Mean	- 5	-3	4	12	18	23	27	26	19	11	3	-3	11
Mean maximum	3	7	21	35	41	47	52	53	42	30	16	6	29
Mean Minimum	-11	-9	-5	0	5	9	12	12	7	1	-3	-8	1
Absolute Minimum	-36	-27	-23	-13	-7	0	0	- 1	-8	-13	-25	-31	-36

Aspindza
Table 2.7

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Mean	- 3	-1	5	11	18	23	26	26	20	12	5	-1	12
Mean maximum	7	10	21	34	43	48	53	54	45	32	19	11	31
Mean Minimum	-10	-7	-4	1	5	8	12	12	7	2	-2	-7	1

First and Last Frost on Soil Surface and Duration of Frostless Period
Table 2.8

Station	Average Frost Dates		Average length of frostless period (days)
	Last Frost in Spring	First frost in Autumn	
Akhaltsikhe	10 V	3 X	145
Aspindza	17 V	5 X	140

III Mean Monthly and Yearly relative Air Humidity (%)

Table 2.9

#	Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
1	Akhaltsikhe	75	74	69	65	66	66	64	63	66	71	76	78	69
2	Aspindza	61	62	62	60	63	65	64	62	66	68	71	65	64

IV Precipitation

Mean Precipitation (mm)
Table 2.10

#	Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
1	Akhaltsikhe	32	32	36	49	70	82	51	46	38	45	40	33	554
2	Aspindza	25	31	31	44	76	81	59	47	38	35	31	22	520
3	Atskuri	33	33	37	51	73	85	54	48	39	47	42	34	576

Mean Decade Depth of Snow (according to permanent rod) (cm)
Table 2.11

#	Station	XII			I			II			III			Max
		1	2	3	1	2	3	1	2	3	1	2	3	
1	Akhaltsikhe	2	3	6	8	9	12	13	11	10	6	3	1	76
2	Aspindza	-	3	3	4	5	6	5	4	3	2	1	-	40
3	Atskuri	4	6	9	9	10	10	12	9	8	4	1	-	55

Dates of First and Last Snow, Formation and Melting of Persistent Snow Cover
Table 2.12

Days with snow cover	Date	Date of first snow	Date of persistent snow cover formation	Start Date of Snow Melting	Final Date of Snow Melting	% winters with no persistent snow cover
Akhaltsikhe						
63	Average	4 XII	24 XII	3 III	28 III	44
	Earliest	1 X	22 XI		17 II	
	Latest	24 I		30 III	30 IV	
Aspindza						
54	Average	2 XII			30 III	62
	Earliest	24 X	22 XI		2 III	
	Latest	13 I		25 III	27 IV	
Atskuri						
75	Average	7 XII	19 XII	3 III	21 III	32
	Earliest	26 X	22 XI		13 I	
	Latest	23 I		7 IV	14 IV	

Maximum Decade Depth of Snow Cover (cm) of different probabilities
Table 2.13

Station	Snow Depth Probability (%)						
	95	90	75	50	25	10	5
Akhaltsikhe	2	3	6	13	30	48	60
Aspindza	3	4	6	9	14	20	33

Start Date of Persistent Snow Cover (cm) of different probabilities
Table 2.14

Station	Probability of these or earlier dates (%)							Earliest
	95	90	75	50	25	10	5	
Akhaltsikhe			10 I	25 XII	11 XII	2 XII	28 XI	22 XI

Start Date of Persistent Snow Cover Melting (cm) of different probabilities
Table 2.15

Station	Snow Melting Probability on these or earlier dates (%)							Earliest
	95	90	75	50	25	10	5	
Akhaltsikhe			10 I	25 XII	11 XII	2 XII	28 XI	22 XI

V Wind

Probability of Wind Directions and Calm (%)

Akhaltsikhe

Table 2.16

Month	N	NE	E	SE	S	SW	W	NW	Calm
I	3	5	4	5	6	31	40	6	41
II	4	6	8	7	7	29	32	7	42
III	4	11	15	11	5	24	24	6	38
IV	6	17	24	10	5	15	19	4	33
V	7	19	23	10	6	12	18	5	38
VI	7	26	23	11	6	10	12	5	38
VII	6	30	24	11	5	8	11	5	32
VIII	6	28	24	12	5	8	13	4	37
IX	6	20	25	13	6	11	14	5	41
X	5	13	16	14	10	18	17	7	48
XI	4	10	10	15	11	20	22	8	53
XII	4	5	8	9	9	25	32	8	58
Year	5	16	17	11	7	18	20	6	42

Aspindza

Table 2.17

Month	N	NE	E	SE	S	SW	W	NW	Calm
I	5	2	7	57	11	2	3	13	52
II	8	2	9	43	15	1	3	19	53
III	9	2	8	39	9	0	8	25	47
IV	11	3	4	25	9	2	13	33	53
V	9	4	5	17	8	2	18	37	58
VI	17	7	3	11	8	2	19	33	63
VII	14	5	4	10	4	2	20	41	59
VIII	17	5	4	7	4	3	20	40	63
IX	15	6	2	10	5	5	18	39	65
X	12	4	4	14	3	3	14	46	70
XI	11	5	9	28	9	4	9	25	66
XII	5	3	6	52	15	1	4	14	62
Year	11	4	5	27	8	2	12	31	59

Average Monthly and Annual Wind Speed (m/s)

Table 2.18

Station	H m	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Akhaltsikhe	12	1.4	1,6	1,9	2,1	1,8	1,6	1,9	1,8	1,5	1,3	1,1	1,1	1,6
Aspindza	11	2,6	2,8	2,8	2,4	2,0	1,6	2,0	1,8	1,4	1,2	1,3	1,8	2,0

Maximum Wind Speed (m/s) of different probabilities

Table 2.19

Station	Wind Speed (m/s), expected once in:				
	1 year	5 years	10 years	15 years	20 years
Akhaltsikhe	17	18	19	19	20

VI Thunderstorms

Average Number of Thunderstorm Days

Table 2.20

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Akhaltsikhe		0,03	0,2	3	12	13	9	10	5	2	0,07	0,03	54
Aspindza		0,04	0,04	2	10	12	8	8	5	2	0,04		47

Maximum Number of Thunderstorm Days
Table 2.21

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Akhaltsikhe		1	4	9	17	24	15	18	13	7	1	1	77
Aspindza		1	1	4	19	23	17	14	14	6	1		65

Reference: USSR Climate Reference Book, edition 14, Gidrometeoizdat, Leningrad, 1970.

3. Local Geography

The study area covers the southern part of the sheet K-38-75-B and the northern part of the sheet K-38-87-A. The area includes the villages of Sakuneti, Agara, Tsnisi, Minadze and Rustavi and also the abandoned villages of Kopadze, Orfola, Pertsikhe, Tskaltbila, Toba and Muskhi. These villages are connected by highways and country roads, which makes the largest part of the area accessible for transport.

The largest part of the study area is positioned in the centre of the Trialeti upland and only a small northern part is located in the Akhaltsikhe depression (absolute elevations: 1000-1200 m). The watershed part of the upland area is positioned to the north of Rustavi (absolute elevations: 1200-1430 m). The peaks of the Zegverda (1427,0m) and Satsernako (1225,0 m) are worth of mentioning in this area. The western edge of the upland borders on the Mtkvari valley, with the Akhaltsikhe depression (absolute elevations: 900-975 m) behind it.

The largest part of the study area, built with unstable clayey and sandy tuffogenic formations dated back to the Upper Eocene, is exposed to weathering and erosion, which has contributed to creation of the smoothed relief. Only the deep, weaving Mtkvari valley (in the Agara-Tsanisi and Minadze-Rustavi sections) with its high steep slopes, has projecting outcrops that allow studying geological structure of the area.

The Mtkvari River is the main water course in the proposed construction site area. Its main tributaries are the Potskhovi River near the town of Akhaltsikhe and the Uraveli River near the village of Muskhi. Both tributaries and their junctions with the Mtkvari are positioned outside the proposed construction site area as well as the small river Oshora, which is positioned near the village of Idumala above the planned reservoir.

There are four minor tributaries within the planned construction site. Two of them are flowing down the Trialeti ridge and join Mtkvari close to the village of Rustavi, 1 km downstream of the reservoir dam. Two other tributaries, streaming down from the same ridge, join the Mtkvari at the edge of the village of Sakuneti, 1 km downstream of the power house.

Morphologically, the largest part of the study area is positioned on the Erusheti upland. L. Maruashvili (19) gives a detailed geomorphologic description of the South Georgian Upland, pointing out different relief types and their spreading areas. He describes the Erusheti Upland as a tectogenic form of relief, stating that volcanogenic processes are of secondary importance.

The following relief or terrain? types have been distinguished in the study area, based on survey of its geological structure and morphological elements:

1. Extremely rugged rocky terrain,
2. Smooth terrain with low hills,
3. Hilly mountain plateaus,
4. Landslide-prone districts,
5. Terraces.

Extremely rugged rocky terrain

This terrain is typical for the areas built with volcanogenic sediments dated back to the Middle Eocene. The terrain forming was conditioned by lithological composition of these sediments and their intensive folding. Different denudation resistance of rocks, forming the Upper Eocene series, has conditioned the forming of massifs and high ridges with steep rocky slopes and sharp edges. Weathering proof porphyritic and andesite surfaces form bare rocky edges with surface run-off.

Tuff breccias are more subject to weathering than the previous formations due to heterogeneity of their lithological composition. They are dissected by a dense network of shallow or dry gullies and ravines, fed by precipitations. There are 1-3m to 6-7m high cones and pillars formed by weathering in the breccia formations.

The rivers, crossing this terrain, have formed deep weaving valleys with high steep (40-60^0) or sheer slopes, such as the Mtkvari Valley section between Rustavi and Minadze and others. The absolute elevations in this area range between 1100m and 2200m, while the relative elevation is 100-600 m.

Smooth terrain with low hills

This type of relief occurs in the southern part of the study, where Upper Eocene sediments form wide complex synclines. The lithologic composition of rocks and tectonics have played the main role in the relief forming. Sandstone, argillaceous sandstone and clay, subject to weathering, conditioned the forming of the smooth terrain with low hills. Outcrops of more massive sandstones form rocky areas and accumulations of coarse-grained diluvium. Clayey formations are cut by shallow gullies with easily eroded edges producing masses of clayey diluvium.

The presence of denudation resistant bedded and cross veins in the Upper Eocene sediments also contributed to the smooth relief forming.

In the area of distribution of this series the Mtkvari forms a wide valley with gentle, easy to access diluvial slopes. Numerous tributaries dissect the area into low oblong ridges with smooth easy to access terrain. Relevant elevation of the watersheds is 30-70m, while absolute elevations range between 1100 and 1500 m.

Hilly mountain plateaus

This terrain is positioned outside the study area.

Landslide-prone terrain

In the study area this kind of terrain mainly occurs in the upper level of the Upper Eocene series, dominated by clays and argillaceous sandstone. Landslide-prone terrain covers a wide strip (0.3-1.5 km) on the left side of the Mtkvari in the Rustavi-Aspindza section. Typical relief with stages, hills and precipices, formed by landslides, is found to the south of the village of Rustavi. Landslides, coming down to the Mtkvari bed, partially block the floodplain terrace in this area. The landslide base is being gradually washed by the river, forming steep cornices of slide-rock bodies.

Fluvial terraces

Terraces cover small areas in the study area. There are four fluvial terraces at different elevations in the southern part. Terrace surfaces are almost horizontal, slightly inclined in the direction of the stream. In the northern part of the study area the Mtkvari valley passes through the eastern closure of the Akhaltsikhe depression. The typical terrain of this locality, with stages and terraces, is built with sand-clay sediments dated to the Upper and Middle Eocene. Absolute elevations range between 910m and 1430m. According to L. Maruashvili (19), this terrain is formed by a multistage ladder, built with a number of fluvial terraces, covered with alluvial sediments and referred to alluvial plain relief. There are 6 floodplain terraces in this area.

Terrace №№	Absolute elevation, m	Relative height above the Riv. Mtkvari., m
I	915	5
II	930	20
III	975-1050	65-140
IV	1110-1150	200-240
V	1200-1260	290-350
VI	1300-1350	390-440

The floodplain and other terraces form a vast plain with clearly distinguishable benches. In the course of the Mtkvari valley deepening, its small tributaries dissected the alluvial plain relief; lithology of rocks started to tell on the terrain. Sandstone forms precipices and low ridges, while dykes and bedded veins make up the oblong hills. The presence of sandy-clayey sediments and the general inclination of the terrain towards the Mtkvari promote minor landslides.

4. Geological structure

4.1. Lithological and Stratigraphic Section of the Mtkvari HPS Headworks, Diversion Tunnel, Equalizing Reservoir, and Power House

The geology of the planned area of main HPS facilities is shown on the geological map and respective geological section of the area at 1: 25000.

Medium-grained volcanogenic and sedimentary soils are spread in the study area. The sediments dating back to Middle Eocene can be lithologically divided into three series: 1) layered tuffogenic series of sediments of different colors, 2) tuff-breccia series, and 3) layered tuffogenic series. The last two were exposed in the study area. Upper Eocene was represented by clayey and sandy facies.

According to our data, the thickness of the Middle Eocene tuff breccias is 1045,7 m, and 219.8 m in the northern part (to the west from village Sakuneti). The thickness of the Middle Eocene laminar tuffogenic series is 180 m in the southern part of the area, yet the series could not be singled out in detail in the central part as it is not exposed well there. The total thickness of the identified middle and upper series is 440.5 m. The upper Eocene laminar tuff and tuff-sandstone interlaid with argillite have the total thickness of 25 m.

The detailed lithological and stratigraphic description of the Rustavi-Sakuneti below is based on data obtained from field investigations. Samples recovered in the field were used to prepare thin sections (30 specimens) for precise identification of the sediments.

Downward section with actual thicknesses:

Q – Quaternary Sediments: terraces, alluvium, diluvium, and prolluvium

Q_{III} – Quaternary; dolerite stream >20 m

N_1^2-N_2^1 – Upper Miocene – Lower Pliocene. Kisatibi series. Dolerite and andesite lavas and their pyroclasts, in the upper part occasionally with diatomite layers – 300-1100 m

Pg_2^{2b} – Middle Eocene. Middle series. Tuff breccia series – 1036,2 m

20. Dark-gray andesite cover with apparent spherical singularities (4 m). .... 23 m

2) Dark-gray andesite cover. .... 19 m

1) Dark-gray andesite cover with apparent spherical singularities. .... 4 m

19. In the upper part, dark-green massive microfragmental and medium-fragmental tuff interlaid with dark-gray argillite and gray fine-grained sandstone (1-15 cm) - 17,2 m. In the lower part, light-green microfragmental tuff interlaid with thin (1-7 cm) alternating layers of gray and green microfragmental tuff, gray argillite and fine-grained sandstone – 48,8 m. .... 66 m

7) Dark-green medium-fragmental tuff. .... 1,5 m

6) Dark-green microfragmental tuff interlaid with dark-gray argillite and gray sandstone (1-15 cm). .... 2,5 m

5) Dark-green medium-fragmental tuff. .... 1,2 m

4) Dark-green microfragmental striate tuff. .... 12 m

3) Alternation of thin (1-7cm) dark-gray argillite, green microfragmental tuff and gray fine-grained sandstone. .... 2 m

2) Light-green microfragmental tuff. .... 3 m

1) Alternation of thin (1-7cm) gray and green microfragmental tuff, gray argillite and gray fine-grained sandstone. .... 43,8 m

18. Dark-gray andesite cover. .... 30 m

17. Dark-brown, occasionally dark-green andesite cover with apparent big crystals. .... over 270 m

16. Light-green microfragmental and medium-fragmental tuff (0,3-1 m) interlaid with light-gray different-grained sandstone and gray argillite (2-15 cm). .... 140 m

15. Grayish-green massive medium-grained, occasionally schistose sandstone. .... 12 m

14. Alternation of thin-layered brown-green microfragmental and macrofragmental tuff, light-green and brown-black silicified argillite and Greenish-gray fine-grained and medium-grained striate sandstone. .... 31 m

11) Brownish-green macrofragmental tuff. .... 17 m

10) Light-green and brownish-black silicified argillite . .... 5 m

9) Greenish-gray medium-grained striate sandstone . .... 2,5 m

8) Brownish -gray massive argillite. .... 0,4 m

7) Light-brownish silicified argillite. .... 1,5 m

6) Light-green fine-grained sandstone . .... 0,5 m

5) Gray argillite interlaid with light-gray fine-grained sandstone. ....1,2 m

4) Brown microfragmental tuff. .... 0,5 m

3) Light-green medium-grained sandstone . .... 2 m

2) Greenish macrofragmental tuff. .... 0.1 m

1) Light-brown microfragmental tuff. .... 0.5 m

13. Dark-gray andesite cover. .... 5 m

12. Gray and greenish-gray different-fragmental tuff interlaid with violet argillite and units of thin alternating layers of dark-red argillite and light-gray sandstone, also with green microfragmental andesite breccias in the lower part. .... 146 m

35) Light-brown medium-grained sandstone . .... 2,5 m

34) Gray massive argillite. .... 7 m

33) Light-brown medium-grained sandstone . .... 4 m

32) Light-green medium-grained massive sandstone . .... 10 m

31) Green medium-fragmental tuff. .... over 12 m

30) Light-gray fine-grained sandstone .... 0,5 m

29) Light-green microfragmental tuff .... 8 m

28) Dark-red striate argillite. .... 0,5 m

27) Light-green microfragmental tuff. .... 4 m

26) Green microfragmental andesite breccias. .... 10 m

25) Light-gray sandstone (tuff). .... 1 m

24) Green medium-fragmental andesite breccia. .... 6 m

23) Alternation of thin layers of dark-red argillite and light-gray sandstone. .... 0,2 m

22) Grayish-green microfragmental tuff .... 0,3 m

21) Dark-green macrofragmental tuff .... 5 m

20) Green medium-fragmental andesite breccias. .... 5 m

19) Alternation of thin layers of gray and dark-red argillite. .... 0,1 m

18) Light-green striate microfragmental tuff. .... 4 m

17) Dark-green macrofragmental andesite breccia. .... 4 m

16) Green medium-fragmental andesite breccia. .... 3 m

15) Dark-red argillite. .... 0,02 m

14) Dark-green microfragmental tuff. .... 0,5 m

13) Green microfragmental andesite breccia. .... 3 m

12) Alternation of thin layers of dark-red and gray argillite. .... 0,15 m

11) Dark-green microfragmental tuff. .... 0,6 m

10) Alternation of thin layers of dark-red argillite and light-green sandstone. .... 0,4 m

9) Dark-green striate microfragmental tuff. .... 0,15 m

8) Dark-red argillite. .... 0,01 m

7) Dark-green striate microfragmental tuff .... 3 m

6) Green medium-fragmental andesite breccia. .... 7 m

5) Alternation of thin layers of green microfragmental tuff and dark-red argillite .... 0,5 m

4) Green striate microfragmental tuff. .... 1,2 m

3) Green medium-fragmental andesite breccia. .... 5 m

2) Green striate microfragmental tuff with rare inclusions of boulders (10x30 cm) of sandstone and rare interbeds of dark-red argillite (1-1,5 cm). ....8 m

1) Green microfragmental andesite breccias. .... 30 m

11. Dark-gray andesite cover. .... 41 m

10. Alternation of (5-60 cm) gray and Greenish-gray argillite and fine-grained sandstone, interlaid with green microfragmental tuff (1,2 m) and gray and Greenish-gray medium-grained massive layers (1-3 m) of sandstone. In the lower part, a unit (2,2 m) of alternating (5-40 cm) dark-gray silicified argillite and gray fine-grained sandstone. .... 45 m

9. Dark-gray andesite cover .... 21-36 m

8. Alternation of Greenish-gray medium-grained sandstone (0,25-1-1,5 m) and gray sandy argillite (6-25 cm). .... 7 m

7. Dark-gray andesite cover, with spherical (10-50 cm) singularities in the lower part. .... 13 m

6. Greenish-gray massive-layered (1,5-5 m), occasionally schistose fine-grained and medium-grained sandstone with occasional interbeds (2-10 cm) of Greenish-gray sandy argillite. .... 25 m

5. Dark-gray andesite cover with spherical singularities. .... 6 m

4. Greenish-gray massive different-grained sandstone and 0,3-6,0 m thick interbeds of gray and greenish-gray medium-fragmental tuff (0,15-1,0 m) and gray and brown argillite (0,1-3,5 m). .... 27,2 m

15) Grayish-green medium-fragmental tuff. .... 1,0 m

14) Gray argillite .... 0,20 m

13) Gray fine-grained massive sandstone. .... 1,3 m

12) Alternation of greenish-gray fine-grained sandstone (up to 0,5 m), brown (up to 15 cm) and dark-gray microfragmental tuff (up to 15 cm). .... 3,6 m

11) Light-brown silicified argillite. .... 3,5 m

10) Gray argillite .... 0,15 m

9) Gray fine-grained massive sandstone. .... 0,6 m

8) Brown argillite .... 0,06 m

7) Greenish-gray massive medium-grained sandstone . .... 3,6 m

6) Gray fine-grained schistose sandstone . .... 0,4 m

5) Gray massive fine-grained sandstone . .... 1,1 m

4) Grayish-green medium-fragmental tuff. .... 1,2 m

3) Dark-green argillite (6-20 cm) and brown and gray fine-grained sandstone (5-10 cm). .... 1,5 m

2) Greenish-gray fine-grained sandstone . .... 6,0 m

1) Alternation of light-green medium-grained sandstone (5-30 cm), greenish microfragmental tuff (up to 15 cm) and brown argillite (5-30 cm). .... 3,0 m

3. Dark-gray andesite layer .... 15 m

2. Greenish-gray massive-layered medium-grained sandstone with occasional interbeds (2-10 cm) of greenish-gray sandy argillites. .... 25 m

1. Gray andesite cover. .... over 72 m

<u>Northern part of the area (the area where the HPS and the equalizing basin are located, to the west from village Sakuneti), 216.0 m</u>

0.4. Dark-gray andesite cover. .... 30 m

0-3. Alternation of green microfragmental and medium-fragmental tuff (0,4-4,5 m) with 0,2-5,3m-thick interlayers of gray and violet argillite (0,05-0,1 m) and gray and greenish-gray fine-grained and medium-grained sandstone (0,01-0,1 m) and microfragmental light-green tuff (0,02-0.05 m). .... 70,0 m

21) Greenish-gray medium-fragmental tuff. .... 4 m

20) Alternation of green microfragmental and medium-fragmental tuff (0,4-0,5-0,6-1 m) with 0,2-0,3-0,4-0,5m-thick interbeds of gray and violet argillite (0,05-0,1 m) and gray and greenish-gray fine-grained and occasionally medium-grained sandstone (0,01-0,1 m) and light-gray small-fragmental tuff (0,02-0.05 m). .... 5,3 m

19) Grayish-green medium-fragmental tuff. .... 3 m

18) Alternation of thin (0,5-3 cm) layers of violet argillite and light-grain fine-grained sandstone .... 0,3 m

17) Grayish-green medium-fragmental tuff. .... 2,5 m

16) Green microfragmental tuff, with thin (7-8 cm) interbeds of violet pelite sandstone at the top and bottom. .... 0,75 m

15) Grayish-green medium-fragmental tuff. .... 2,7 m

14) Dark-gray andesite cover. .... 1,5 m

13) Alternation of light-green and green microfragmental and medium-fragmental tuff (0,1-0,6 m) with units (0,3-0,6 m) alternating gray and violet argillite (0,05-0,15 m) and gray fine-grained and medium-grained sandstone (0,01-0,3 m). .... 3,3 m

12) Grayish-green microfragmental tuff. .... 1 m

11) Green microfragmental tuff. .... 4 m

10) Alternation of thin (0,5-1-2-3-10 cm) layers of gray, green and violet argillite, gray fine-grained sandstone and light-green tuff. .... 1,2 m

9) Grayish-green microfragmental tuff. .... 2 m

8) Violet argillite. .... 0,2 m

7) Green medium-fragmental tuff. .... 4,5 m

6) Alternation of green microfragmental and medium-fragmental tuff (0,15-0,3-0,4 m) with units (0,2-0,3-0,8-3,5 m) of alternating gray and violet argillite (0,05-0,15 m) and gray and Greenish-gray fine-grained, occasionally medium-grained sandstone (0,01-0,08 m). ... 5,65 m

5) Light-green microfragmental tuff. .... 2,5 m

4) Alternation of green microfragmental tuff (0,05-0,1-0,15-0.25-0,6 m) with 0,1-0,2-0,8m-thick interbeds of gray and violet argillite (0,05-0,1 m) and gray and greenish-gray fine-grained and medium-grained sandstone (0,01-0.1 m). .... 2,4 m

3) Alternation of gray thin-layered (1-5 cm) argillite, silicified argillite and greenish-gray fine-grained sandstone. .... 1 m

2) Green medium-fragmental tuff .... 1,5 m

1) Green microfragmental and medium-fragmental tuff (0,5-2,0 m) with interbeds of light-gray and light-brown sandstone (0.1-0,25-0,5 m), occasionally thin (up to 8 cm) beds of gray argillite. .... 21,2 m

0-2. Dark-gray andesite cover (16 m) and gray and dark-gray macrofragmental andesite breccia (25 m). .... 41 m

2) Dark-gray andesite cover. .... 16 m

1) Gray and dark-gray macrofragmental andesite breccia. .... 25 m

0-1. Green massive medium-fragmental and macrofragmental tuff, with beds and lenses of light-gray and gray fine-grained sandstone and 0,1-2m-thick units of alternating thin (1-15 cm) layers of gray and brown-gray argillite and gray fine-grained and medium-grained sandstone. .... over 75 m

14) Green medium-fragmental and macrofragmental tuff, with inclusions and lenses light-gray and gray fine-grained sandstone. .... 5,5 m

13) Alternation of green microfragmental tuff (10-40 cm), Greenish-gray argillite and sandstone (2-15 cm). .... 2 m

12) Grayish-green microfragmental tuff. .... 0,7 m

11) Alternation of green microfragmental tuff (10-30 cm), greenish-gray argillite and sandstone (1-15 cm). .... 1,5 m

10) Grayish-green medium-fragmental tuff. .... 7 m

9) Alternation of thin layers of gray argillite and sandstone. .... 0.1 m

8) Green medium-fragmental tuff. .... 5 m

7) Alternation of green microfragmental tuff (10 cm), violet and gray argillite and gray sandstone (0,5-1,5 cm). .... 0,4 m

6) Green microfragmental tuff. .... 0,5 m

5) Alternation of green medium-fragmental tuff (up to 15 cm), fine layers (5-15 cm) of Greenish-gray argillite and fine-grained sandstone. .... 1 m

4) Green fine-fragmental and medium-fragmental tuff. .... 6 m

3) Green medium-fragmental tuff (0,3-0,5 m) interlaid with units (0,2-0,4 m) of thin (1-15 cm) layers of alternating gray and Greenish-gray argillite and gray fine-grained and medium-grained sandstone. .... 7 m

2) Green medium-fragmental tuff. .... 2,2 m

1) Green medium-fragmental tuff (0,5-1 m) interlaid with units (0,2-0,5 m) of thin (1-5 cm) layers of alternating gray and brownish-gray argillite and gray fine-grained and medium-grained sandstone, occasionally gravelite at the bottom of sandstone. ....35 m

Total visible thickness – 1861,2 m (2521,5 m)

Annex 2.3 shows a detailed description of the sediments and effusive covers spread in the area of Rustavi-Sakuneti and studied by field investigations. Samples recovered from the field were used to prepare thin sections (51 specimens) for precise identification of the soil types. Petrography of

the samples was described by Dr. of Sc. (Geology and Mineralogy) E. V. Varsimashvili (see Annex 2.3).

The obtained data and existing geology maps at 1:50000 (Jigauri et al., 1956; Gujabizde et al., 1955) were used to produce a geology map and a structural cross-section at 1:25000, also a structural cross-section at 1:2000 along the proposed tunnel axis.

Photographs of interesting exposures in the study area are enclosed in the annex.

4.1.1. **Intrusive Rock in the area of main HPS Facilities**

Tertiary eruptive rock is not widespread in the studied area and is only exposed in some locations in the form of intrusive bodies.

The magmatic cycle starts with the effusive phase coinciding in time with the geological cycle lithogenesis, and finishes by the intrusive phase that coincides with orogenesis. Of all the magmatic cycles identified by P.D. Gamkrelize (1949), the following are found in the studied area: the Paleocene-Eocene, Upper Eocene, Upper Miocene – Lower Pliocene, Upper Pliocene, Upper Pliocene – Lower Quaternary, and Quaternary.

The intrusive phase of the upper Eocene volcanism is associated with the Pyrenean phase of folding (Gamkrelize, 1949). It includes numerous beds and crossing veins of teschenite, diabase and diabase-porphyrite that are part of medium-grained Upper Eocene sediments of the studied area.

To the west from Sakuneti, in the middle reaches of the small first right tributary of the Mtkvari, there are two small outcrops of a teschenite intrusive body (εN) exposed body in the divide. This full-crystalline rock is of gray and dark-gray color, frequently with black oblong crystals. It has ophite structure and consists of small prismatic laths of fully zeolitized plagioclase, also of numerous grains of green augite, primarily xenomorphous and filling up angular spaces between the plagioclase laths. The augite is frequently substituted by chlorite, and forms porphyrite impregnations together with the plagioclase. There are fine scattered grains of pyrite in the rock.

To the east and west from the village of Kopadze, the Upper Eocene sediments are cut by a dyke-like body of diabase gabbro-porphyrite stretching for 1500 m southwest.

Under microscopy, the main mass of the rock is whole crystals, consisting of short prismatic crystals of fresh plagioclase (labrador) and large quantities of light-green grains of fresh augite. There are a lot of transparent grains of olivine frequently forming phenocrystals, and small quantities of fresh biotitic plates. The latter is found in large quantities as an accessory mineral in this rock group. There are a lot of scattered fine grains of ore mineral and large quantities of apatite needles penetrating through the plagioclase.

In the actual vicinity of the village of Kopadze (in parallel to the diabase bodies), the clays of and sandstone of Upper Eocene are crossed by two small dyke-like teschenite bodies. In the contact line, the bearing rock was very metamorphosed by a hot teschenite stream. The material is rock consisting of whole crystals of gray and dark-gray color, frequently black oblong crystals. It has ophite structure and consists of small prismatic laths of fully zeolitized and strongly pelitized plagioclase, also a lot of green augite grains, primarily xenomorphous and filling up the

angular spaces between the plagioclase laths. The augite is frequently substituted by chlorite, and forms porphyrite impregnations together with the plagioclase. There are scattered fine grains of pyrite in the rock.

Mount Satsernako and the respective range stretching northeast consist of alternating dark-gray andesite (diabase) and gray and light-gray hornstone, with a total visual thickness of 85 m. At the intersection with the Elis-gele gorge, there are only andesite (diabase) outcrops, a thickness of 15-19 m.

Bed intrusion of gabbro-diabase can be seen well on the right bank of the Mtkvari (the proposed reservoir area), to the southwest from Rustavi (vil. Akhasheni), and occupies an area of about 1 sq. km. Along the contact line, there are signs of weak metamorphism of the bearing rock. The vein thickness is 20-30m.

The gabbro-diabase is of gray color, occasionally with rusty spots. The microstructure is porphyrous; finer fully-crystalline mass shows a diabase structure and consists of fine crystals of labrador, monoclinic pyroxene, and magnetite. Spaces between the labrador crystals are filled up with k-feldspar. The porphyry impregnations are formed by labrador and augite.

There are also small outcrops of biotitic-augite camptonite on an area of several hundred square meters. These dyke-like formations cut across the same deposits of Upper Eocene. The main rock is a zeolitized and pelitized mass with contours of prismatic crystals of plagioclase with zeolite matrix. Green augite grains and fresh biotitic plates seem to be ‘submerged’ into the main mass. There are small quantities of scattered apatite prisms and pyrite grains.

4.1.2. **Volcanism of the area of main HPS facilities**

Tertiary eruptive rock is not widespread in the studied area and is only exposed in some locations in the form of intrusive bodies.

The magmatic cycle starts with the effusive phase coinciding in time with the geological cycle lithogenesis, and finishes by the intrusive phase that coincides with orogenesis (Gamkrelize, 1949). The phase includes numerous beds and crossing veins of teschenite, diabase and diabase-porphyrite of the Neogene age with inclusions of medium-grained formations of Upper Eocene.

To the west from Sakuneti, in the middle reaches of the small first right tributary of the Mtkvari, there are two small outcrops of a teschenite intrusive body (εN) exposed on the divide. The material is rock consisting of whole crystals of gray and dark-gray color, frequently with black oblong crystals. It has ophite structure and consists of small prismatic laths of fully zeolitized plagioclase and strongly pelitized plagioclase (the bedrock), also of numerous grains of green titanaugite, primarily xenomorphous and filling up angular spaces between the plagioclase laths, also of hornblende (barkevikite) and analsime. The titanaugite is frequently substituted by chlorite, and forms porphyrite impregnations together with the plagioclase. There are scattered fine grains of ore minerals and pyrite in the rock.

To the east and west from the village of Kopadze, the Upper Eocene sediments are cut by a dyke-like body of diabase gabbro-porphyrite stretching for 1500 m southwest.

Under microscopy, the main mass of the rock is whole crystals with ophite structure, consisting of oblong, almost idiomorphic prismatic crystals of fresh plagioclase (labrador) and large

quantities of light-green grains of fresh augite. There are a lot of transparent grains of augite frequently forming phenocrystals and lamellas, and oblong prismatic crystals of fresh brown hornblende. There are a lot of scattered fine grains of ore mineral.

In the actual vicinity of the village of Kopadze (in parallel to the diabase bodies), the clays of and sandstone of Upper Eocene are crossed by two small dyke-like teschenite bodies. In the contact line, the bearing rock is very metamorphosed by a hot teschenite stream. The material is rock consisting of whole crystals of gray and dark-gray color, frequently with black oblong crystals. It has an ophite structure and consists of prismatic crystals of pyroxene and many grains of hornblende. There are scattered fine grains of pyrite in the rock.

Mount Satsernako and the respective range stretching northeast consist of alternating dark-gray andesite (diabase) and gray and light-gray hornstone (pelite), with a total visual thickness of 85 m. At the intersection with the Elis-gele gorge, there are only andesite (diabase) outcrops, a thickness of 15-19 m.

The diabase consists of whole crystals of rock with ophite structure, including oblong, almost ideomorpohous prismatic crystals of fresh plagioclase (labrador) (occasionally there are also lamellar grains), light-green crystals of augite, and oblong prismatic crystals of brown hornblende and ore minerals.

Bed intrusion of gabbro-diabase can be seen well on the right bank of the Mtkvari, in the small right tributary, to the southwest from Rustavi (to the north from Akhasheni), and occupies an area of about 1 sq. km (the proposed reservoir area). It lies concordantly with tuff stone and clays of Upper Eocene. Along the contact line, there are signs of weak metamorphism of the bearing rock. The vein thickness is 20-30m.

The gabbro-diabase is of gray color, occasionally with rusty spots. The microstructure is porphyrous; finer fully-crystalline mass shows a diabase structure and consists of fine crystals of labrador, monoclinic pyroxene, and magnetite. Spaces between the labrador crystals are filled up with k-feldspar. The porphyry impregnations are formed by labrador and augite.

Mount Satsernako

1. To the west along the tunnel line (an intrusive body, Mount Satsernako) – **ηN**

d. Dark-gray andesite (diabase). .... 15 m

c. Gray hornstone. .... 35 m

b. Dark-gray andesite (diabase). .... 25 m

a. Light-gray hornstone. .... 10 m. Total – 85 m

River Parata-Ulisi

2-1. Southern hill (behind the farm) – **δN**

Black-and-white fine-grained and medium-crystalline intrusive rock (teschenite)..... over 120 m.

A flat between hills (no outcrops!) – about 50 m

2-2. Northern hill (to the west from the farm) – **ηN**

c. Dark-gray andesite cover. .... 22 m

b. Gray medium-crystalline silicified andesite cover. .... 8 m

a. Dark-gray rusty silicified argillite (hornstone) with spherical inclusions (0,3-1,5 cm). .... 4 m; Total 34 m.

A slope to the west from vil. Sakuneti (Tsnisi anticline)

3. A small intrusive body (vein) of teschenite – **εN**

Black-and-white medium-grained coarse-crystalline intrusive rock... 30-40 m

Annex 2.3 includes a detailed description of the intrusive rock spread in the area of Rustavi-Sakuneti studied by field investigations. Samples recovered from the field were used to prepare thin sections (9 specimens) for precise identification of types of the igneous rock. Petrography of the samples was described by Dr. of Sc. (Geology and Mineralogy) E. V. Varsimashvili.

4.1.3. **Tectonics of the Area of Main HPS Facilities**

The studied area is located in the southern part of the Southern subzone of the Adjara-Trialeti folded zone (Gamkrelidze, 1949).

Tectonically the Southern or Akhaltsikhe subzone consists of short, very compressed brachianticlines and wide synclines, inclined to the south. The folds are subject to virgation – substitute each other in echelon, and branch. There are slip planes, compression and squeezing of clayey layers, also thickening of fold arcs, which shows differential movement of thin layers of tuff, tuff-sandstone and argillite.

Structures found from north to south in the studied area is described in detail below:

The Tori-Tadzrisi Syncline. In the area of village Tkemlana, this syncline branches, and the so-called Zikilia syncline has its axis between the villages of Tkemlana and Zikilia covered with terraces of the Quaternary stage. Eastern end of the Tsnisi anticline goes between these two synclines near villages of Sakuneti and Kopadze. In the cross-section, the syncline is wide and almost symmetrical. The fold axis with latitudinal strike goes in the northern part of the proposed powerhouse area (in the close vicinity of the Mtkvari floodplain). Its northern limb is dipping southward at 20-30°, and the southern limb is dipping in the NNE direction at 10°.

The Tsnisi Anticline. The anticline axis is cut by a latitudinal fault dipping northward at 85°, also by current teschenite bodies (30-40 m). Its southern limb is dipping in the SSE direction at 30-35°. It is cut by a fault striking northeast and dipping at 85° to the northwest, with associated current bodies of andesite (diabase) (34-40 m) and teschenite (120 m).

The Zykilia Syncline. This structure goes in the soft terrigenous rock of the Upper Eocene stage and has been identified from separate fragmented outcrops. The axis stretches to the northeast, with its limbs dipping to the north and south at 50°.

The Satsernako anticline and syncline. These structures stretch northeast, and their common limb has recumbent dip of (80°) to the northwest. It is crossed by a steeply dipping (80°) body consisting of dark-gray andesite (diabase) and gray and light-gray hornstone, with a total visual thickness of 85 m. The southern limb of the syncline is dipping gently (40°) to the northwest.

The Orfola anticline and syncline. These narrow (250 m) structures actually cross the gentle northern limb of the Ortatavi-Sabaduri anticline. A recumbent limb connecting these structures strikes to the northeast, dipping at 65-70° to the northwest. The southern limb of the syncline dips at 40-55° to the northeast. In the southwest (outside the studied area) they tie up to the Toba anticline and syncline, positioned similarly.

The Ortatavi-Sabaduri anticline is the biggest tectonic structure not only in the studied area but in the total Adjara-Trialeti folded zone. The anticline strikes northwest, going across mounts Sabaduri and Ortatavi (to the northeast from the studied area), and its length is about 12 km, embracing the divide and being the most elevated. Its arc and limbs are ill by thick massive tuff breccias, different-grained sandstone and andesite covers originating from the Middle and Upper series of the Middle Eocene. Its north limb dips at 30-55° to the northwest, and the southern limb dips at 30-35° to the southeast. The anticline arc is gentle and rather wide, up to 2 km.

The Rustavi syncline. Terraces and deluvial sediments are widespread on the right bank of the Mtkvari in the vicinity of Rustavi, which interferes with geological investigation of the area. Yet we managed to make a lithological/stratigraphic profile in narrow gorges of several right tributaries of the Rustavis-Khevi river in the north and northeast direction. The fold limbs consist of tuff-sandstone and tuff from the middle and upper series of Middle Eocene, and the mould consists of clayey-sandy material of the Upper Eocene. The syncline axis is of the northeast direction. The southern limb of the fold dips northwestward at 25-30°, and the northern limb in inclined southeast at 35°. To the northwest, near the ruins of Tertsikhe, there are several gentle secondary folds over the primary structure (5-35 m).

The Tskhaltbili anticline. There is an anticilinal fold identified to the south of the Rustavi syncline. The arc that is located at the proposed dam consists of outcropping massive layers of gray and greenish-gray different-grained sandstone and the middle series of the Middle Eocene covered by a thick andesite stratum. The fold axis strikes north-north-east, and can be well observed on the right steep bank of the Mtkvari. Its southern limb dips southeast at 25-45°, and the northern limb dips northwest at 15-20°.

The Blordza-Kodiana overthrust goes in the southwest limb f the Tori—Tadzrisi syncline or in the northwest wing of the Ortatavi-Sabadura anticline. It is apparent in the area of the village of Tori (to the east from the studied area), crosses the Kodiana pass, and continues to the west through the village of Blordza. In the studied area, it is represented by an intrusive complex of Mount Satsernako, which seems to be am outcropping fault of magmatic melt. It is of northwest strike, dipping northwest at 80°.

Fault Tectonics

According to the Terms of Reference of the proposed Mtkvari HPS project, we carried out investigations to identify a system of faults in the local rock. The studied area is located on the main Ortatavi-Sabaduri anticline of the Adjara-Trialeti folding zone. The area is built by medium-grained and clayey sand and volcanogenic formations originating from Upper Eocene. These rocks have apparent faults and fissures.

Different types of the rock were investigated for their lithological and physical and mechanical properties in certain locations. A total of 15 spots were identified and 1263 measurements made (see Figures 1 and 2). All the 15 investigated sites were described in detail, showing their coordinates, numbers of photos, a lithological description, geographic position, distribution of the spots on the Volf grid and rose-diagram, a statistical analysis and a list of measurements of separate faults. The data are enclosed in Annex 6.

The data were processed using 2Dmove2.5 software. A detailed structural and statistical enabled even more detailed description of the fault tectonics than those presented in earlier reports (Gujabizde, 1955; Jugauri, 1956).

There are faults of different types within the studied area. Their limbs stretch northeast, with limb dipping at 10-85° respectively to the northwest and southeast.

Based on the general statistical analysis, all faults can be classified as either going parallel to, across or diagonal to the rock layers. There are six primary systems of faults and three main vector components in the area (see Figures 1 and 2), also there are some less spread fault systems (VII-XI).

After the analysis of data obtained from the fault investigation in the area, the following systems of faults were identified:

I. 315-330°∠30-45°

II. 320-340°∠70-85°

III. 150-160°∠30-40°

IV. 175-190°∠25-30°

V. 20-25°∠22-25°

VI. 60-80°∠70-80°

At some sites, smaller fault systems were found:

VII. 40-50°∠65-70°

VIII. 220-240°∠60-80°

IX. 180-190°∠70-80°

X. 120-140°∠80-89°

XI. 100-110°∠65-70°

When processed in 2Dmove, the main vector component showed the average main system of faults going in three directions. Faults of the first system make up 45,19% of all faults (252° ∠5°), faults of the second system - 29,83% (152° ∠63°), and the fault system is 24,98% (344° ∠27°). The main stress tensor (or direction) is NWN-SES (178° ∠52°). All the three fault systems have folds.

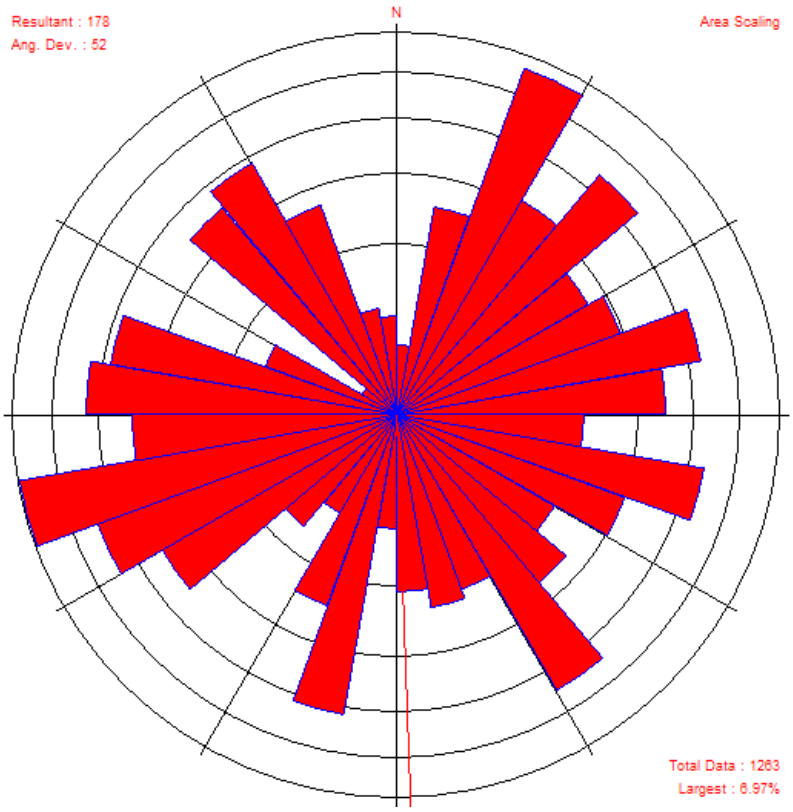

Figure 1. Rose Diagram

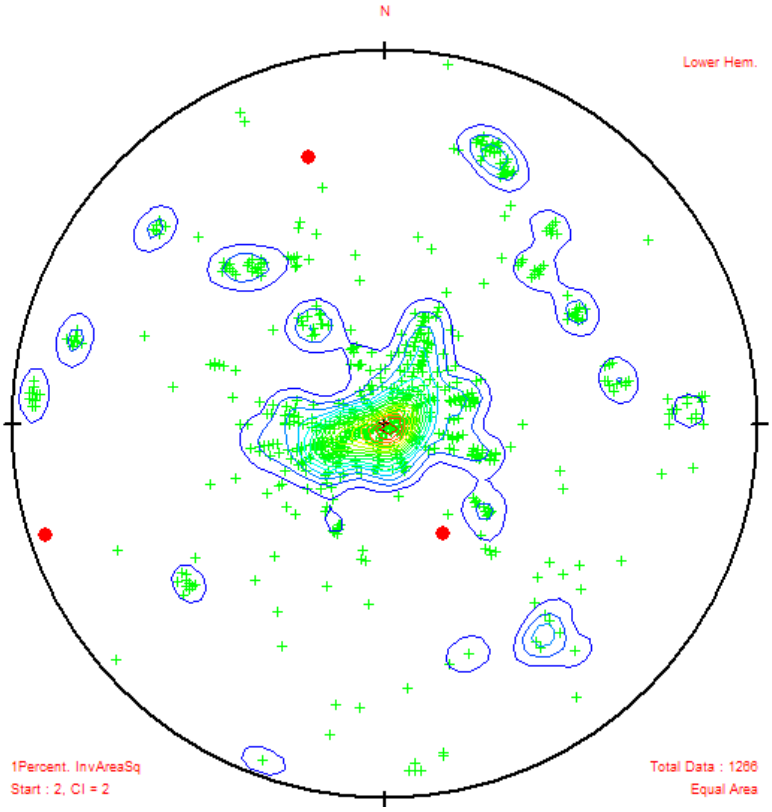

Figure 2. Summary Diagram of Cracks (main red dots show main vectors)

Vector 1 (az.pl):(252° ∠5°), Eigenvalue: 570.81
Vector 2 (az.pl):(152° ∠63°), Eigenvalue: 376.61
Vector 3 (az.pl):(344° ∠27°), Eigenvalue: 315.58

It should be also mentioned that less spread faults inclined in the ESE and SSE direction with oblique angles (65-80°) cross all other existing fault networks, hence, these are younger than the other ones. A similar system of faults mainly originates from compression caused by folding at the late-Alpine stage.

Results of block and cavity identification in the rocks are enclosed in Annex 6.

4.2. Description of Proposed Reservoir Area Geology

From the place where the Mtkvari valley makes a sharp turn and forms a cape protruding to the north, where the Mtkvari HPS dam will be constructed, the area of the proposed reservoir stretches along the ravine for a distance of 5 km to the east.

The geology on both slopes of the Mtkvari ravine was studied and mapped at 1:5000.

As the area is crossed by extensive slopes, we had to study separate small bedrock outcrops and then try to build the entire picture. The studied area is built by gray and greenish-gray microfragmental and medium-fragmental tuff (up to 4 m), light-gray and gray argillite (up to 1.5m), light-gray and gray fine-grained clayey sandstone and geological units (over 25 m) of thin (1-40 cm) alternating layers of gray argillite and gray fine-grained clayey sandstone dating back to Upper Eocene (Pg23).

On the eastern slope of the cape, on the left bank of the Mtkvari, we produced a geological section of the central part of Middle Eocene (**Pg_2^{2b}**) stratum, which assisted in detailed description of the area where the proposed dam will be located. The detailed data with actual thickness of each geological unit are given below:

6. Grayish-green medium-fragmental tuff (>2 m), light-green fine-grained sandstone (2,5 m) and alternation of gray fine-grained sandstone (2-40 cm) and gray argillite (0,5-25 cm) (9m). .... over 19 m

   4) Grayish-green medium-fragmental tuff. .... >2 m

   3) Light-green fine-grained sandstone . .... 2,5 m

   2) Alternation of gray fine-grained sandstone (2-40 cm) and gray argillite (0,5-25 cm). .... 9,0 m

   1) Greenish-gray massive medium-grained sandstone . .... 5,5 m

5. Gray andesite cover. .... 0,5 m

4. Greenish-gray and gray massive medium-grained sandstone with units (2,3-6,5 m) of alternating gray fine-grained sandstone (2-25 cm) and gray argillite (0,5-20 cm). 24,1m

8) Alternation of gray fine-grained sandstone (2-25 cm) and gray argillite (0,5-20 cm). .... 6,5 m

7) Greenish-gray massive medium-grained sandstone . .... 4,5 m

6) Gray silicified argillite. .... 0,7 m

5) Gray massive medium-grained sandstone . .... 5,2 m

4) Alternation of gray fine-grained sandstone and gray argillite (1-10 cm). .... 2,3 m

3) Greenish-gray massive medium-grained sandstone . .... 7,5 m

2) Alternation of thin layers of gray fine-grained sandstone and gray argillite. .... 4,5 m

1) Gray argillite. .... 0,4 m

3. Gray andesite cover. .... 4,85 m

3) Gray andesite cover. .... 3,5 m

2) Gray sandy argillite. .... 1,2 m

1) Gray andesite cover. .... 0,15 m

2. Brown striate argillite (11,0 m), gray massive medium-grained sandstone (1-2,6 m), greenish medium-fragmental tuff (1,0 m) and units (0,4-1 m) of alternating gray fine-grained sandstone and gray argillite. .... 23,1 m

14) Brown silica striate argillite . .... 11,0 m

13) Alternation of thin gray fine-grained sandstone and gray argillite (up to 3 cm). .... 0,7 m

12) Gray massive medium-grained sandstone . .... 2,6 m

11) Alternation of gray fine-grained sandstone and gray argillite. .... 0,4 m

10) Greenish-gray medium-grained sandstone . .... 1,5 m

9) Gray argillite. .... 0,1 m

8) Gray fine-grained sandstone . .... 0,3 m

7) Alternation of gray fine-grained sandstone and gray argillite. .... 0,5 m

6) Gray massive medium-grained sandstone . .... 1,2 m

5) Alternation of thin gray fine-grained sandstone and gray argillite (3-10 cm). .... 0,6 m

4) Greenish-gray medium-grained sandstone, in the lower part, fine cobble conglomerate (0,25 cm). .... 1,0 m

3) Greenish medium-fragmental tuff. .... 1,0 m

2) Greenish-gray medium-grained sandstone . .... 1,2 m

1) Alternation of Greenish-gray fine-grained sandstone (10-40 cm) and gray argillite (2-5 cm). .... 1,0 m

1 Gray andesite cover. .... 74,8 m

3) Gray andesite cover. .... 26,0 m

2) Gray fine-grained sandstone . .... 0,8 m

1) Gray andesite cover. .... 48,0 m (edge of cape).

On the left bank of the Mtkvari, outcrops of Mio-Pliocene Kisatibi series (N_1^2-N_2^1) come very close to the river floodplain, which has an impact on the relief morphology and the composition of colluvial and deluvial formations. It is formed by continental-volcanogenic effusive formations, occasionally gray and dark-gray medium-fragmental tuff with layers of diatomite. Its upper part consists of andesite-dacite and dolerite lavas.

On the right bank of the Mtkvari, at 1349,5 m and 1342,8 m above the sea, there are small remains of Quaternary (QIII) dark-gray massive dolerite lavas that are very damaged and mixed with light-brown and yellow loam (i.e. intermediately plastic clay) and clay of the slopes. Their visual thickness does not exceed 20-25 m.

Within this section of the ravine, the bedrock underlies Quaternary alluvial, proluvial, colluvial, and deluvial loose-fragmental and clayey material. Alluvial formations are more widespread on the bottom of the ravine, within the floodplain and above-floodplain terraces; proluvial formations are mainly found on the slopes, and deluvial and colluvial deposits are found both at the toes and on steep slopes of the ravine, with their thickness decreasing with steepness of the slopes. Quaternary sediments are associated with physical and gravitational processes that transport easily weathered soils - argillite, tuff and weak sandstone – down the slopes. Loose-fragmental (colluvial) accumulations are found at the foot of the steep and gentle slopes built by hard sandstone, diabase of intrusive bodies and dolerites lava sheets, collapsed or brought down by rockslides.

Within the ravine, the thickness of the Quaternary stratum (primarily alluvial sediments) reaches 18 meters. The deluvial-colluvial formations are not so thick, and the underlying bedrock is frequently exposed on the slopes.

Within the proposed reservoir area, the banks of the Mtkvari are built by alluvial-proluvial loose-fragmental soils with sandy or loam (intermediately plastic clay) and loamy sand (low plastic silt) matrix, which causes erosion and land sliding in many locations along the banks of the Mtkvari and some lateral ravines.

Intrusive rock is less spread in the proposed reservoir area. Bedded intrusion of gabbro-diabase is apparent on the right bank of the Mtkvari, to the southeast from the village of Rustavi (to the north from ruins of village Akhalsheni), and occupies an area of about 1 sq. m. It lies concordantly with tuff-sandstone and argillite of the Upper Eocene. There are signs of weak metamorphism along the contact line. The gabbro-diabase is of gray color, in some places with rusty spots. It has a porphyritic microstructure, and main finer-grained crystalline mass has a diabase structure and consists of fine

crystals of labrador, monocline pyroxene, and magnetite. Spaces between the labrador crystals are filled with k-feldspar. Porphyritic inclusions consist of labrador and augite.

The diabase and porphyrite is exposed to the west from Gabisti, showing a thickness of about 50 meters. A small outcrop of intrusive rock of the same composition can be seen farther to the east, on the left bank of the Mtkvari.

Microscopically, the diabase and porphyrite are of dark-gray, Greenish-gray and black color, frequently with inclusions of zeolite and oblong crystals of plagioclases. Microscopy shows porphyritic, more rarely ophitic structure. The main mass consists of chaotically scattered prisms of plagioclases. Angular spaces between them are filled with grains of augite, magnetite, and short-short-columnar minerals.

Structurally, there are three structures exposed in the proposed reservoir area, namely, these are:

The Tskhaltbili anticline. The anticlinal fold is well seen in the proposed dam area. In its arc there are outcrops of different units of gray and greenish-gray massive-layered medium-grained sandstone of the middle series dating back to Middle Eocene, alternating with massive andesite sheets. The fold axis goes north-northeast and apparent on the right steep bank of the Mtkvari. Its southern wind dips to the south-east at 25-45°, and to the northwest at 15-20°.

The Bakuriani-Oshora syncline. According to P.D. Gamkrelidze (1949) the syncline starts close to the village of Bakuriani and stretches to the west, going across the Bakuriani-Tsikhisjvari depression, the Saniso range and farther to the Aspindza district, crossing the Mtkvari to the west from the village of Aspindza, and then can be tracked farther to the west up to the ravine of the Uraveli River. On the right bank of the Mtkvari where outcrops of poorly exposed Upper-Eocene formations are found, this structure is almost symmetrical to the bed elements - north 120-130° ∠35-45°, and south - 275-280° ∠35-40°. The syncline axis stretches from north to east. In some locations it has secondary folds. On a large area of the left bank, as the fold axis is submerged there, the syncline is covered with Mio-Pliocene continental-volcanogenic formations (the Kisatibi series).

The Teleti-Gumbati anticline can be seen on a small area in the Mtkvari ravine, to the northwest from the village of Aspindza where it is built with Upper-Eocene formations. The fold is difficult to track because it is covered with younger slopes. Its axis goes eat-northeast, and can be seen at the road, to the north from the ruins of Alakhsheni, in the mid-turn of the Mtkvari. The southeast wind of the fold has a dip azimuth of 150-160°, at the angles of 30-40°. To the west, the fold is also covered with sediments of the Kisatibi series.

5. Hydrogeological Conditions

Subsoil waters are the main groundwater resources in the study area. The subsoil waters occur in contemporary alluvial sediments in rivers and also in eluvial zones of volcanogenic formations dated back to the Middle Eocene. These are weakly mineralized hydrocarbonate-calcium waters. Weakly mineralized hydrocarbonate-sodium-calcium cold fracture waters occur in thick volcanogenic rocks dated back to the Middle Eocene on the edges of the Akhaltsikhe artesian basin. Thermal waters of similar composition with outlet temperature up to 50^0 are found in the deeply sunken central part of the basin.

Chalk deposits, presumably containing thermal pressure waters, occur at the depth of 3-5 km in the study area.

Natural reserves of subsoil waters in this region are 2.3 m3/sec.

The study area is represented by the following water-bearing and waterproof formations:

5.1. Water-bearing complex of alluvial and alluvial-proluvial quaternary sediments (apQ_{IV})

The aquifer is widely spread in the broadened sections of the rivers Mtkvari, Potskhovi, Kvabliani and others, with floodplain widths ranging from 20-300m to 0,5-1,5 km. The I and II terraces are the most saturated, while the sporadically distributed III and IV terraces are inundated only periodically.

The first floodplain terrace is developed in the Mtkvari valley between the villages of Atskuri-Agara, Giorgitsminda-Mugareti, Tsnisi and Minadze. The terrace is built with shingle with well rounded cobble of andesite, porphyrite, more seldom tuffs, tuff breccias and limestone with gravel and sand fillers, in some locations with loam, loamy sand (low plastic silt) and sand fillers. Clay fillers dominate in the alluvial clayey sediments dated back to the Upper Eocene – Oligocene. Thickness of alluvial sediments of the first terrace ranges between 1-2m and 30 m.

The sediments, covering the floodplain and floodplain terraces, bedded on rocks, are always underlain by less permeable sediments. This causes seeping precipitation to outcrop on the border between alluvial sediments and the rocks either directly into the river or above the water level.

Rivers without underflows, so-called „suspended rivers“, are formed in the locations, where loam and less permeable formations are spread. This is the case with the Mtkvari in the area of Rustavi and Vardzia.

Quaternary sediments are highly permeable, being loose and ungraded. According to data from the pump-out tests, their permeability coefficients range between 0.3 and 20 m/day. Permeability coefficients for alluvial sediments with sandy-clayey Kf are less than 0.2-3 m/day.

Groundwater aeration zone thickness is 0.5-3 m. The groundwaters are generally unconfined and pressureless, yet there is some pressure in locations where waterproof clays are spread.

Fewer springs outcrop on the II terrace, as they occur in the base of the stratum at 40-50m asl and are less affluent (the springs near the Rustavi village).

The diluvial sediments mainly occur in bases of cornices, valleys and ridges.

These formations differ in their composition and nature and depend on lithology of bedrocks, building this part of the region. Thus, in locations where Middle Eocene formations are developed, diluvium has mixed composition and is made of medium-grained fragments of andesite, tuff, sandstone, etc.

In the areas where Upper Eocene formations are spread, diluvium is composed of separate fragments of rocks and plaster. This composition prevents groundwater aquifer forming. Diluvial waters have different chemical composition and mineralization (from 0,1 to 0,1 g/l of hydrocarbonate-sulphate-calcium-magnesium plaster).

Discharges of springs range between 0,8 and 8-12 l/sec.

The subsoil waters are mainly fed by groundwaters occurring at the level of the bedrocks, which cannot seep to the surface through the diluvium layer.

5.2. Water-Bearing Complex of Volcanogenic Continental Deposits of Lower Pliocene – Miocene Age (N_1^2-n_2^1)

This complex is widely spread on the Akhaltsikhe lava upland. It is formed by Kisatibi or Goderdzi series represented by andesite, dacoits, dolerites and their pyroclastolites. The Kisatibi sediments have been found in the southernmost part of the study area, where they build the left slope of the Mtkvari valley within the planned reservoir area.

The Kisatibi series are highly permeable because of their porosity and thick fracturing pattern. The andesite and dacite lavas are more saturated than tuffs, tuff sandstone, tuff lavas and lava breccias that have comparatively low permeability and in some locations serve as a confining bed for the overlying water-bearing lava sheet stratum.

In the upper reaches of the rivers Kvabiani, Uraveli and others, the depth of occurrence of groundwaters, confined to the andesite lava sheet, ranges from 20 to 100 m depending on the degree of terrain dissection. The base of the strata, mainly built with tuffs, coarse-fragmented and lava andesite breccias, is weakly saturated. Discharges of the springs range between 0,01 and 1,0 l/sec. Yet, in the Mtkvari valley, in favorable morphological conditions, springs with higher discharges outcrop. Three such springs have been registered and tested on the left slope of the Mtkvari valley in the planned reservoir area.

Unconfined groundwaters predominate in the Kisatibi series because of the lack of substantial confining beds.

Groundwaters of the water-bearing complex of volcanogenic continental deposits of the Lower Pliocene – Miocene (N_1^2-N_2^1) have low mineralization (0,5 g/l) and hydrocarbonate-calcium or calcium-sodium composition.

The groundwaters have high sulfate content in the contact area with the waterproof sediments dated back to Oligocene – Upper Eocene age.

The complex is mainly fed by precipitation or sometimes by groundwater coming from the lava sheet of the Upper Pliocene – Middle Quaternary period. Recharge and discharge areas frequently coincide. Regimes of springs, occurring in the deep valley, are rather stable.

5.3. Waterproof Lagoonal and Marine Sediments of Lower Miocene – Upper Eocene **(N_1^1-Pg_2^3**

These sediments with the thickness of 300m to 1200m are mainly constituted by gypsiferous clay, clay marl and sandstone with interlayers of conglomerates. The sediments are weakly saturated. Springs, occurring in thin sandy and tuffogenous layers, have discharges of 0,01-0,2 l/sec and mineralization of 1-18 g/l.

No water occurred in the boreholes drilled in this section of complex in the Akhalgori depression.

5.4. Aquifer of Volcanogenic Sediments of Middle Eocene (Pg_2)

Middle Eocene is lithologically divided into three series. Yet, given the likeness of these series in terms of their saturation, it would be more reasonable to unite them into one aquifer when giving their geological description. A majority of volcanogenic formations of this horizon, except for the tuff layers and clays, are permeable. Permeability of some of them, for instance tuff-breccias and tuff-sandstones, is conditioned by the presence of coarse-fragmental materials and rather loose and often coarse cement. Yet, fracturing of the formations plays the main role, while in case of the porphyrite sheet it has a decisive importance.

Separate low-permeable or impermeable strata, interlaying permeable layers, play the role of a confining bed and promote forming of a series of new water-bearing aquifers with limited distribution. This is conditioned by the fact that water-bearing strata, losing the waterproof surface, allow water to seep to the underlayer, thus creating a system of interconnected water-bearing aquifers that actually make up one complex overflow aquifer.

M. Buachidze distinguishes two water-bearing zones in the described horizon, according to their fracturing conditions: upper shallow circulation zone that is the most strongly fractured and involves the weathering zone, and the lower deep circulation zone, where joints are developed most of all. Descending waters with short seepage paths occur in the upper water-bearing zone; both ascending and descending waters are found in the lower zone.

Feeding of the upper water-bearing zone is related with precipitation distribution and discharge area, while the presence of ascending springs in the lower zone indicated that its recharge area is positioned above this location and at a considerable distance from it, so that it does not coincide either with distribution or spreading. Judging from the lithology of the Middle Eocene formations, waters occurring in this aquifer are of fracture-porous and fracture types, which can be proved by the example of springs coming to the surface in the environs of the villages of Andriatsminda, Rustavi (two springs), Orpola, Tskaltbila, Pertsikhe and others. Some springs outcrop in the upper sections of gullies from permeable tuff-breccias close to the line of contact with Upper Eocene.

The non-uniform distribution of springs in this aquifer is also worth mentioning. Thus, there are almost no springs on the Mtkvari slopes in the Minadze-Rustavi section, where the river cuts its way through the tuffogenous rocks dated back to the Middle Eocene, forming a deep narrow valley. The same is in the lower reaches of Mtkvari's tributaries in this section.

The number of springs sharply increases 2-3 km away from the Mtkvari valley. According to Ostakhov V.O., this is conditioned by extremely strong drainage of the slopes by the river and very flat, depression curve of water surface in the tuffogenous strata. The drainage of the slopes in some sections conditions the seepage of springs in depressions, mainly close to the riverbed, where they are covered by alluvial-diluvial sediments, or within the riverbed, where they can be observed only late in autumn or early in winter, during recession of water level in the Mtkvari.

Thus, the seeming low-flow capacity of the tuffogenous aquifer in the Mtkvari valley is caused rather by drainage of these strata then by their waterproofness.

The deep ravines of the Mtkvari's right and left tributaries, cutting through the tuffogenous strata of this horizon, expose water-bearing layers and form a number of springs that outcrop owing to the lack of the cover. Such springs occur in the area of the villages of Toba, Rustavi, Pertsikhe, Indusa and others.

The waters of this aquifer are weakly mineralized (0.4 g/l) and have hydrocarbonate sodium or calcium magnesium composition.

6. Composition, Condition, and Physical and Mechanical Properties of Soils

Geotechnically, the rocks, building the massif in the proposed HPS construction site, can be divided in two classes:

Material with rigid structural links, i.e. rocks;

Material without rigid structural links, i.e. earth (soil).

Rocks

This class involves Quaternary and pre-Quaternary rocks, including:

Upper Quaternary-Q_{III}

Neogene-N;

Upper Eocene -Pg_2^3;

Middle Eocene:

Upper Series - Pg_2^{2c};

Middle Series - Pg_2^{2b};

Based on results of geological surveys, described in Chapter 4, the massif is built with soils (rocks) of the following groups, subgroups and types:

Soil Group	Soil Subgroup	Soil Type (Lithological Unit)
Magmatic	Intrusive	Dark-gray diabase
		Medium crystalline or coarse crystalline teschenite
	Effusive	Dark-gray, dark-brown or dark-green andesite
		Coarse-grained and medium-grained, green, brownish-green or gray tuff
Metamorphic	Contact-metamorphosed	Gray hornstone
Sedimentary consolidated	Coarse-grained	Green, gray, dark-gray andesite breccia
		Medium-grained, gray, green-gray, light-brown sandstone
		Fine-grained, gray, green-gray, brown sandstone
	Powder-like and clayey	Gray, green-gray, brownish-gray, purple or dark-red argillite

Layers and bodies of the mentioned types (lithological units) of rocks are bedded in different combinations with different mass/volume ratios in different parts of the study area. The evaluation of physical and mechanical properties of particular types of soils in this chapter is followed in Chapter 7 by evaluation of soil conditions of the proposed construction site of HPS facilities, based on physical-mechanical values of each soil type and its percentage in separate units. We considered it reasonable to use this approach for evaluating foundation soils of separate facilities as types (lithological units) of soils are identical in different parts of the study area.

Standard and calculated values of physical-mechanical properties of separate kinds of rocks and semi-rock have been determined through statistical processing of test results. Results of laboratory tests of separate soil samples are given in Appendix 2, while a summary table of standard and calculated values of physical-mechanic properties of soils is given in Appendix 3.

Teschenite

#	Soil Parameter	Unit	No. of Tests		Roof-mean-square deviation,, S_{n-1}	Variation Coefficient, V	Coefficient of Excess	Asymmetry Coefficient	Nominal value, A^n	Design Value for confidence probability		
			Initial	Final						□=0.85	□ =0.95	□ =0.99
	Particle density, ρ_s	g/cm^3	8	8	0,09	0,03	-0,71	1,10	2,88	2,85	2,83	2,79
	Bulk Density, ρ	g/cm^3	8	8	0,12	0,04	-0,83	0,97	2,81	2,76	2,73	2,68
	Uniaxial Compression Strength in dry state, R_c	MPa	8	8	92,32	0,61	-1,57	0,19	151,60	115,05	89,59	53,69
	Uniaxial Compression Strength in saturated state, R_c	MPa	8	8	83,72	0,63	-1,53	0,13	132,77	99,62	76,54	43,98
	Softening coefficient, K_{saf}	-	8	8	0,07	0,08	-1,19	0,16	0,88	0,83	0,81	0,79

According to the tabled data, for teschenite:

- Nominal particle density ρ_s=2,88 g/cm ^{3};
- Nominal bulk density ρ=2,81 g/cm ^{3};
- Uniaxial compression strength in dry state R_c=151,6 Mpa;
- According to uniaxial compression strength in saturated state, teschenite is rocky material with high strength (R_c=132,77 MPa)
- According to the softening coefficient, the rock is not softening, K_{saf}=0.88 (K_{saf}>0,75); The rigidity factor is $f_{rigidity}$=13,28

Diabase

#	Soil Parameter	Unit	No. of Tests		Roof-mean-square deviation, S_{n-1}	Variation Coefficient, V	Coefficient of Excess	Asymmetry Coefficient	Nominal value, A^n	Design Value for confidence probability		
			Initial	Final						□ =0.85	□ =0.95	□ =0.99
	Particle density, ρ_s	g/cm^3	7	6	0,02	0,01	-1,50	0,53	2,72	2,71	2,71	2,70
	Bulk Density, ρ	g/cm^3	7	7	0,03	0,01	0,04	0,97	2,68	2,67	2,66	2,64
	Uniaxial Compression Strength in dry state, R_c	MPa	7	7	23,00	0,27	-0,52	-0,03	85,68	75,86	68,81	58,38
	Uniaxial Compression Strength in saturated state, R_c	MPa	7	7	15,62	0,28	0,03	-0,90	55,41	48,74	43,96	36,87
	Softening coefficient, K_{saf}	-	7	7	0,16	0,25	0,38	0,06	0,66	0,59	0,54	0,47

According to the tabled data, for diabase:

- Nominal particle density ρ_s=2,72 g/cm ^{3};

- Nominal bulk density ρ=2,68 g/cm ^{3};
- Compressive strength (UCS) in dry state R_c=85,68 Mpa;
- According to Uniaxial Compression Strength in saturated state, the diabase is rocky material with medium strength (R_c=55,41 MPa)
- According to the softening coefficient, the rock is prone to softening, K_{saf} =0.65 (K_{saf}<0,75);
  The rigidity factor is $f_{rigidity}$=5,54.

Andesite

#	Soil Parameter	Unit	No. of Tests		Roof-mean-square deviation,, S_{n-1}	Variation Coefficient, V	Coefficient of Excess	Asymmetry Coreffficient	Nominal value, A^n	Design Value for confidence probability		
			Initial	Final						□ =0.85	□ =0.95	□ =0.99
	Particle density, ρ_s	g/cm^3	30	30	0,06	0,02	-0,04	-0,34	2,70	2,68	2,68	2,67
	Bulk Density, ρ	g/cm^3	48	47	0,12	0,05	-0,10	-0,10	2,45	2,43	2,42	2,40
	Uniaxial Compression Strength in dry state, R_c	MPa	44	44	30,94	0,57	-0,10	-0,88	54,31	49,41	46,47	43,01
	Uniaxial Compression Strength in saturated state, R_c	MPa	47	47	21,13	0,54	0,12	-0,88	39,13	35,89	33,95	31,66
	Softening coefficient, K_{saf}	-	44	44	0,15	0,19	-0,71	0,30	0,72	0,73	0,71	0,70
	Modulus of Elasticity, E	MPa	9	9	1279	0,32	-0,40	-0,64	3974	3501	3181	2738
	Poisson's ratio, μ	-	9	8	0,01	0,03	-0,67	0,00	0,30	0,29	0,29	0,29

According to the tabled data, for diabase:

- Nominal particle density ρ_s=2,70 g/cm ^{3};
- Nominal bulk density ρ=2,45 g/cm ^{3};
- Compressive strength (UCS) in dry state R_c=54,31 Mpa;
- According to Uniaxial Compression Strength in saturated state, the andesite is a rock with medium strength (R_c=39,13 MPa)
- According to the softening coefficient, the rock is prone to softening, K_{saf} =0.72 (K_{saf}<0,75);

According to data enclosed as Annexes 2 and 3:

- Angle of internal friction φ=33^0;
- Cohesion C= 10,6 MPa;
- Elasticity modulus E=3973МПа;
- Poisson's ratio μ=0,295.
  The rigidity factor is $f_{rigidity}$=3,90.

Hornstone

#	Soil Parameter	Unit	No. of Tests		Roof-mean-square deviation,, S_{n-1}	Variation Coefficient, V	Coefficient of Excess	Asymmetry Corefficient	Nominal value, A^n	Design Value for confidence probability		
			Initial	Final						□ =0.85	□ =0.95	□ =0.99
	Particle density, ρ_s	g/cm^3	6	6	0,05	0,02	-0,71	-0,55	2,67	2,64	2,62	2,59
	Bulk Density, ρ	g/cm^3	6	6	0,10	0,04	-1,22	0,43	2,45	2,40	2,37	2,31
	Uniaxial Compression Strength in dry state, R_c	MPa	6	6	22,82	0,36	-1,50	-0,52	64,02	53,22	45,30	32,72
	Uniaxial Compression Strength in saturated state, R_c	MPa	6	6	5,10	0,13	-0,64	-0,21	40,40	37,98	36,21	33,41
	Softening coefficient, K_{saf}	-	6	6	0,23	0,43	-1,41	-0,60	0,69	0,41	0,34	0,21

According to the tabled data, for hornstone:

- Nominal particle density ρ_s=2,67 g/cm ^{3};
- Nominal bulk density ρ=2,45 g/cm ^{3};
- Compressive strength (UCS) in dry state R_c=64.02 Mpa;
- According to Uniaxial Compression Strength in saturated state, the hornstone is a rocky material with medium strength (R_c=40,40 MPa)
- According to the softening coefficient, the rock is prone to softening, K_{saf} =0.63 (K_{saf}<0,75);
  The rigidity factor is $f_{rigidity}$=4,04.

Tuff

#	Soil Parameter	Unit	No. of Tests		Roof-mean-square deviation,, S_{n-1}	Variation Coefficient, V	Coefficient of Excess	Asymmetry Corefficient	Nominal value, A^n	Design Value for confidence probability		
			Initial	Final						□ =0.85	□ =0.95	□ =0.99
	Particle density, ρ_s	g/cm^3	16	16	0,05	0,02	-1,23	0,40	2,69	2,68	2,67	2,66
	Bulk Density, ρ	g/cm^3	15	15	0,11	0,04	0,09	1,11	2,59	2,56	2,54	2,52
	Uniaxial Compression Strength in dry state, R_c	MPa	16	15	22,43	0,67	-0,36	-1,02	33,25	27,00	23,06	18,08
	Uniaxial Compression Strength in saturated state, R_c	MPa	17	16	13,49	0,64	-0,76	-0,81	21,23	17,62	15,33	12,46
	Softening coefficient, K_{saf}	-	16	16	0,14	0,21	-0,56	-0,33	0,64	0,63	0,61	0,60

According to the tabled data, for tuff:

- Nominal particle density ρ_s=2,69 g/cm^3;
- Nominal bulk density ρ=2,59 g/cm ^{3};
- Compressive strength (UCS) in dry state R_c=33,25 Mpa;

- According to Uniaxial Compression Strength in saturated state, the tuff is a rocky material with medium strength (R_c=21,23 MPa)
- According to the softening coefficient, the rock is prone to softening, K_{saf} =0. 64 (K_{saf}<0,75);

According to data enclosed as Annexes 2 and 3:

- Angle of internal friction $\varphi=31^0$;
- Cohesion C= 5,80 MPa;
- Elasticity modulus E=1736,5 MPa;
- Poisson's ratio μ=0,315.

  The rigidity factor is $f_{rigidity}$=2,12.

Medium-Grained Sandstone

#	Soil Parameter	Unit	No. of Tests		Roof-mean-square deviation,, S_{n-1}	Variation Coefficient, V	Coefficient of Excess	Asymmetry Corefficient	Nominal value, A^n	Design Value for confidence probability		
				Final						□ =0.85	□ =0.95	□ =0.99
	Particle density, ρ_s	g/cm^3	8	8	0,04	0,02	-1,48	0,59	2,65	2,64	2,63	2,61
	Bulk Density, ρ	g/cm^3	10	10	0,07	0,03	0,33	-0,68	2,39	2,37	2,36	2,33
	Uniaxial Compression Strength in dry state, R_c	MPa	9	8	10,43	0,27	-0,85	1,41	38,71	34,58	31,71	27,65
	Uniaxial Compression Strength in saturated state, R_c	MPa	9	8	6,18	0,23	-1,67	0,92	26,96	24,46	22,75	20,35
	Softening coefficient, K_{saf}	-	9	9	0,14	0,19	-1,03	-0,11	0,70	0,67	0,64	0,59

According to the tabled data, for tuff:

- Nominal particle density ρ_s=2,65 g/cm^3;
- Nominal bulk density ρ=2,39 g/cm ^{3};
- Compressive strength (UCS) in dry state R_c=38.71 Mpa;
- According to Uniaxial Compression Strength in saturated state, the medium-grained sandstone is a rocky material with medium strength (R_c=26.96 MPa)
- According to the softening coefficient, the medium-grained sandstone is prone to softening, K_{saf}=0. 70 (K_{saf}<0,75);

According to data enclosed as Annexes 2 and 3:

- Angle of internal friction $\varphi=29^0$;
- Cohesion C= 11,40 MPa;
- Elasticity modulus E=2890,1 MPa;
- Poisson's ratio μ=0,303.

  The rigidity factor is $f_{rigidity}$=2,7.

Fine-Grained Sandstone

#	Soil Parameter	Unit	No. of Tests		Roof-mean-square deviation,, S_{n-1}	Variation Coefficient, V	Coefficient of Excess	Asymmetry Corefficient	Nominal value, A^n	Design Value for confidence probability		
			Initial	Final						□ =0.85	□ =0.95	□ =0.99
	Particle density, ρ_s	g/cm^3	20	20	0,06	0,02	-0,75	0,24	2,63	2,61	2,60	2,59
	Bulk Density, ρ	g/cm^3	13	13	0,08	0,03	-1,07	-0,68	2,34	2,32	2,30	2,28
	Uniaxial Compression Strength in dry state, R_c	MPa	12	12	15,16	0,43	0,76	-1,50	35,41	30,64	27,54	23,51
	Uniaxial Compression Strength in saturated state, R_c	MPa	17	16	9,32	0,40	1,00	-1,25	23,02	20,52	18,94	16,96
	Softening coefficient, K_{saf}	-	12	11	0,06	0,08	-0,86	-0,54	0,81	0,79	0,77	0,76
	Modulus of Elasticity, E	MPa	6	5	533,9	0,23	-1,37	-0,47	2367	2083	1858	1471
	Poisson's ratio, μ	-	6	6	0,01	0,05	-1,65	0,00	0,30	0,29	0,28	0,28

According to the tabled data, for the fine-grained sandstone:

- Nominal particle density ρ_s=2,63 g/cm^3;
- Nominal bulk density ρ=2,34 g/cm^3;
- Compressive strength (UCS) in dry state R_c=35,41 Mpa;
- According to Uniaxial Compression Strength in saturated state, the fine-grained sandstone is a rocky material with medium strength (R_c=23,02 MPa)
- According to the softening coefficient, the fine-grained sandstone is prone to softening, K_{saf}=0. 65 (K_{saf}<0,75);

According to data enclosed as Annexes 2 and 3:

- Angle of internal friction $\varphi=29^0$;
- Cohesion C= 11,40 MPa;
- Elasticity modulus E=2367 MPa;
- Poisson's ratio μ=0, 295.

  The rigidity factor is $f_{rigidity}$=2,30.

Andesite Breccia

#	Soil Parameter	Unit	No. of Tests		Roof-mean-square deviation,, S_{n-1}	Variation Coefficient, V	Coefficient of Excess	Asymmetry Corefficient	Nominal value, A^n	Design Value for confidence probability		
			Initial	Final						□ =0.85	□ =0.95	□ =0.99
	Particle density, ρ_s	g/cm^3	6	6	0,02	0,01	-1,18	-0,29	2,72	2,71	2,71	2,70
	Bulk Density, ρ	g/cm^3	6	6	0,02	0,01	-0,83	-0,58	2,48	2,47	2,47	2,46

According to the tabled data, for the fine-grained the breccia:

- Nominal particle density ρ_s=2,72 g/cm^3;
- Nominal bulk density ρ=2,48 g/cm^3;

- Compressive strength (UCS) in dry state R_c=35,41 MPa;
- The rigidity factor is $f_{rigidity}$=3,90.

Silicified Argillite

#	Soil Parameter	Unit	No. of Tests		Roof-mean-square deviation,, S_{n-1}	Variation Coefficient, V	Coefficient of Excess	Asymmetry Corefficient	Nominal value, A^n	Design Value for confidence probability		
			Initial	Final						□ =0.85	□ =0.95	□ =0.99
	Particle density, ρ_s	g/cm^3	7	7	0,02	0,01	0,30	1,09	2,67	2,66	2,65	2,65
	Bulk Density, ρ	g/cm^3	7	6	0,07	0,03	-1,16	-0,57	2,39	2,36	2,34	2,30
	Uniaxial Compression Strength in dry state, R_c	MPa	11	11	5,87	0,34	-0,16	0,00	17,07	15,12	13,86	12,18
	Uniaxial Compression Strength in saturated state, R_c	MPa	11	10	6,00	0,53	-0,35	-0,05	11,27	9,18	7,79	5,92
	Softening coefficient, K_{saf}	-	11	11	0,15	0,28	-0,01	0,24	0,66	0,48	0,45	0,41

According to the tabled data, for the argillite:

- Nominal particle density ρ_s=2,67 g/cm^3;
- Nominal bulk density ρ=2,39 g/cm ^{3};
- Compressive strength (UCS) in dry state R_c=17,07 Mpa;
- According to Uniaxial Compression Strength in saturated state, the argillite is a rocky material with low strength (R_c=11,27 MPa)
- According to the softening coefficient, the argillite is prone to softening, K_{saf} =0.66 (K_{saf}<0,75);
- The rigidity factor is $f_{rigidity}$=1,50.

Argillite (samples recovered from BH 14)

#	Soil Parameter	Unit	No. of Tests		Roof-mean-square deviation,, S_{n-1}	Variation Coefficient, V	Coefficient of Excess	Asymmetry Corefficient	Nominal value, A^n	Design Value for confidence probability		
			Initial	Final								
	Particle density, ρ_s	g/cm^3	15	15	0,03	0,01	-1,01	-0,36	2,72	2,72	2,71	2,70
	Bulk Density, ρ	g/cm^3	15	14	0,12	0,06	-0,63	-0,55	2,12	2,09	2,07	2,04
	Uniaxial Compression Strength in natural state, R_c	MPa	18	18	5,35	0,65	-0,64	-0,78	8,27	6,92	6,07	5,03
	Cohesion, C	MPa	9	8	0,83	0,60	-0,89	-0,82	0,14	0,13	0,11	0,10
	Angle of internal friction, φ	degree	8	8	16,04	0,46	-0,81	0,89	35,00	28,65	24,23	17,99

Note: Argillite shear resistance was tested on weakened surfaces (stratification faults (gullets) or tectonic faults), by two methods:

- uniaxial compression;

- direct shear in the shear box.

According to the tabled data, for the argillite:

- Nominal particle density ρ_s=2,72 g/cm^3;
- Nominal bulk density ρ=2,12 g/cm ^{3};
- Compressive strength (UCS) in natural state R_c=8,27 Mpa;
- The rigidity factor is $f_{rigidity}$=1,50.
- Angle of internal friction φ=35^0;
- Cohesion C= 1,37 MPa;

From the lithological soil types described above, argillites are prone to weathering. Unconserved cores of argillites started to disintegrate along numerous hidden fractures of different origin 10-12 hours after removal from the massive. Surfaces of some fractures were smooth, sometimes bright, which suggests tectonic origin of the fractures. In general the massif is dissected by systems of fractures of different spatial orientation. Results of fracture studies are discussed in detail in 4.1.3.

Non-Rocks (Soils)

The class of non-rock includes uncemented soils of the Quaternary age (Q), different origin and composition. Quaternary loose-fragmental and clayey soils overlie rocks, and their thickness in different part of the studied area varied from several centimeters to twenty meters. The greatest thickness of the Quaternary sediments was encountered in BH 4 where it reached 20 meters in the bottom of the Mtkvari gorge (on a floodplain terrace). The sediments of the Quaternary age are most widespread in the reservoir site and main intake area. They were studied in boreholes and test pits; 32 test pits were excavated to the depth of 1.3 to 4 meters in the areas.

The sediments of the Quaternary age encountered in the studied area were subdivided into 7 lithological-stratigraphic (lithostratigraphic) units that differed in composition, condition and properties. Description of the units, their group and subgroup according to GOST-25100-82 is given below:

Soil Group	Soil Subgroup		Lithostratigraphic unit
Artificial	Fill (technogenic – t)		Angular cobble, gravel, and boulders with loamy-loamy sand (low plastic silt) matrix (earth roadbed)
Uncemented sedimentary soils	Coarse-grained (colluvial-c)		Angular cobble, gravel, and boulders, with loamy sand (low plastic silt) matrix (30-40%)
	Pulverescent and clayey	Landslide-dl	Loam and clay, brown, with inclusions of angular gravel, and cobble, angular and rounded boulders
		Colluvial-deluvial - cd	Brown loam, with inclusions of angular gravel, angular and rounded cobble, and boulders
		Deluvial-proluvial - dp	Clay, brown, with inclusions of angular gravel and cobble, boulders
			Loam, brown, with inclusions of angular gravel and cobble, with lenses and interbeds of loamy sand (low plastic silt)
	Coarse-grained (alluvial-a)		Rounded cobbles with sand matrix and inclusions of boulders up to 15-20%, moist and saturated with water

These lithostratigraphic units of non-rock soils (identified with unique numbers, never repeated on the entire studied area) are graphically shown on geotechnical maps (see dwg. GC-0904-MH-2, GC-0904-MH-4, GC-0904-MH-7) and cross-sections (see dwg. GC-0904-MH-5 and GC-0904-MH-8).

A geotechnical description of the lithostratigraphic units (varieties) of nonrock soils is given below, based on the results of field and laboratory studies.

Lithostratigraphic unit 31 – rounded cobbles with sandy matrix and inclusions of boulders (up to 15-20%). The rounded cobble is encountered within the floodplain terrace of the Mtkvari. It is moist down to the groundwater level and water-saturated below. According to grain size distribution tests, the material is cobble with loamy sand (low plastic silt) matrix. The percentage of fractions over 10mm (rounded boulders and cobble) is 57-66% of the soil mass. The material is rather dense. On large areas where alluvial rounded cobble is found it is covered with alluvial-deluvial loamy and loamy-sandy materials, occasionally thicker than 2 meters.

Lithostratigraphic unit 32 – brown loam (i.e. intermediately plastic clay), with inclusions of angular gravel and cobble, with lenses and interbeds of loamy sand. According to laboratory testing of physical parameters, the soil belongs to loams of hard consistency, as its plasticity index is I_p=0,12-0,17 and the liquidity index is I_L=12-17. The voids ratio varies within 0,33 to 0,42. The percentage of fragmental materials (gravel and broken rock) also varied within a wide range (15-30%).

The material has the following physical parameters:

- Cohesion C=45kPa;
- Angle of internal friction $\varphi = 26^0$;
- Deformation modulus E=34 MPa.

According to the tests, the loam is prone to subsidence, as the subsidence index is $\square_{sl}$=0,0199 (i.e.> 0,01) and also prone to slow soaking, as 70% of it mass takes 3 hours for soaking.

Lithostratigraphic unit 33 is brown clay, with inclusions of angular gravel and cobble, boulders. According to laboratory testing of physical parameters, the soil is hard or hard-plastic loam as the plasticity index is I_p=0,23-0,27, and the liquidity index I_L varies from -0,36 to +0,25. The voids ratio varies within 0,39 to 0,52. The percentage of fragmental materials (gravel and broken rock) also varied within a wide range (0,5-50%).

- Cohesion C=88 kPa;
- Angle of internal friction $\varphi = 25{,}6^0$;

According to the above physical parameters, the deformation modulus is E=20 MPa.

According to the tests, the soils are prone to slow soaking, as 75% of its mass takes 1.2 hours for soaking.

Lithostratigraphic unit 34 is brown loam, with inclusions of angular gravel and cobble, rounded cobble and boulders, encountered on a very limited area on the left river bank. There were no

boreholes or test pits in the area, and no laboratory tests were carried out. The material is described based on field observations only.

Lithostratigraphic unit 35 – Brown loam and clay, with inclusions of angular gravel and cobble, angular and rounded boulders. It is a group of soils prone to landsliding, encountered in the eastern part of the studied area. According to laboratory testing, the landslide material is of heterogeneous composition and condition. In some locations the material is loam, in others it is clay. Its consistency also frequently changes from hard to semi-hard. The plasticity index (I_p) varies from -0,15 to 0,29, and the liquidity index I_L changes from -0,65 to +0,13. The voids ratio varies within a wide range between 0,52 and 1,03. The percentage of fragmental materials (gravel and broken rock) also varied within a wide range (0,2 to 30%).

- Cohesion C=50-73 kPa;
- Angle of internal friction $\varphi = 9\text{-}19^0$;

According to the test, the loam is prone to swelling, subsidence, and soaking.

Lithostratigraphic unit 36 is angular cobble and gravel and boulders, with loamy sand (low plastic silt) matrix. The material is also encountered on a limited area, on the right steep bank of the Mtkvari, close to the headworks site. The area was not studied in either boreholes or test pits, nor laboratory tests were carried out. The material is described based on field observations only that suggest that the percentage of coarse-grained material in the soil mass is at least 60-70%. The material is debris collapsed from a steep slope located above the colluvial accumulations.

Lithostratigraphic unit 37 is angular cobble and gravel and boulders, with loamy and loamy sand (low plastic silt) matrix. These are soils of technogenic origin, namely, the roadbed, hence they are spread only within a narrow strip along the road. No testing of physical and mechanical parameters of the material was planned or conducted.

7. Geotechnical Conditions

During the geotechnical investigations, the exact locations of separate facilities (structures) of the Mtkvari HPS was not defined, so the drafted and implemented investigations programs envisaged study of soil conditions on the entire construction area. Accordingly, the text below describes geotechnical conditions of separate geological units and lithostratigraphic units of soils that are representative for the entire study area. Each unit and lithostratigraphic varieties of soils have their own unique numbers that do not repeated on the study area. The same numbers are used in this texts and on geotechnical maps and sections. The numbering is given according to the upward stratigraphic cross-section – from older strata to newer ones.

Geotechnical conditions on the construction area depend on the integrity of several factors, including:

- Local geomorphology;
- geological structure;
- composition, condition and properties of soils;
- hydrogeological conditions;
- geological processes and hazards.

Studies of the above factors are discussed in detail above, together with the obtained data that characterize geotechnical conditions for the future construction.

7.1. Geotechnical Conditions in the Reservoir Area

In the proposed reservoir area, the channel of the Mtkvari is meandering, forming two low capes on both banks. The dam will be constructed at the upstream cape, and the reservoir will occupy the area upstream from the dam to the village of Idumala. The Mtkvari valley from the village of Minadze to the proposed dam is narrow, with steep banks, in some locations precipices. Upstream from the dam, in the reservoir area, the valley is widening, its slopes become gentler, yet in many places there are gullies cut by erosion. The biggest gullies include:

On the right bank : a side gorge of the river Oshora, flowing into the Mtkvari at Idumala; a narrow and shallow gully 2 km downstream from Idumala; two gullies close to each other, with streams running down at the east of Rustavi.

On the left bank : a deep and narrow gully of a small river flowing between the villages of Orgora and Sakudabeli.

In addition to these streams and gullies, there are numerous dry gullies, ravines, and other erosive forms that cut the banks in many places.

By its geological structure discussed in detail in 4.2, the reservoir area is built by rock and semi-rock material, of Middle Eocene (Pg_2^{2b}) and Upper Eocene (Pg_2^{3}): alternating argillite and sandstone, with rare interlayers of medium-fragmental tuff. On the bank, there are occasional

dykes of diabase, and thick doleritic stream of the Neogene age (N_1^2-N_2^1) is exposed in the upper part of the left bank. Fragments of the doleritic stratum are also found in the watershed on the right bank.

Within this section of the valley, the bedrock is everywhere covered with Quaternary formations of different origin: alluvial, proluvial, colluvial, and deluvial loose-fragmental and clayey material. These sediments are the thickest along the foot of the banks and the bottom. There is the Akhaltsikhe-Ninotsminda-Armenia highway going along the right bank over the sediments.

Lithostratigraphic units of soils identified in the reservoir area are shown on the geological map and schematic geotechnical map at 1:25000 (see Drawings, dwg. GC-0904-MH-1 and GC-0904-MH-2). They are also shown on the geotechnical map of a larger scale (1:5000) and respective cross-sections (see dwg. GC-0904-MH-4 and GC-0904-MH-5).

According to the terms of reference, two boreholes were drilled, 29 test pits excavated, and geophysical survey conducted to study the soils forming the reservoir area. Locations of the boreholes/test pits and geophysical survey are also indicated on the geotechnical map at 1:5000.

Field investigations in the rock forming the reservoir zone enabled identifying 11 geological units (no. 1,2,3,4,5,6,7,8,9,23-25, 28), differing from each other by percentage of main lithological soil types: sandstone, argillite, tuff, andesite, etc. By their composition, condition and properties, loose-fragmental sediments of the Quaternary age can be also subdivided into seven lithostratigraphic units, as also shown on the geotechnical maps and cross-sections of the reservoir area.

Obtained data on physical and mechanical properties of the soils discussed in Chapter 6 have been used to evaluate the soil conditions in the reservoir area, in view of percentages of each soil type in the units, and their specific properties.

Geological Unit 1

Gray andesite (74м-99%), interlaid with fine-grained sandstone (1%).

In view of the very low percentage of sandstone in the andesite unit and the fact that both types of soils have medium strength, the following values for andesite can be assumed as averaged meanings of physical and mechanical parameters of the soils in unit 1:

#	Physical and Mechanical Parameters of Unit 1 Soils	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54.31
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39.13
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33

- According to the uniaxial compression strength in saturated state, Geological Unit 1 is rocky material of medium strength (R_c=39,13 MPa).

Geological Unit 2

Brown striate silicified argillite (11,1m – 48,05%), gray massive (1-2,6м) medium-grained sandstone and (7,8m-33,77%), greenish medium-fragmental tuff (1,0м-4,33%) and units (0,4-1,0m) of alternating gray fine-grained sandstone and gray argillite (3,2-13,85%).

Average nominal values of physical and mechanical parameters for soils in unit 2 are shown in the table below:

#	Physical and Mechanical Parameters of Soils in Unit 2	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,25
3	Uniaxial Compression Strength in dry state, R_c	MPa	22,88
4	Uniaxial Compression Strength in saturated state, R_c	MPa	17,21
5	Cohesion, C	MPa	5,65
6	Angle of internal friction, φ	degree	32,38

- According to the uniaxial compression strength in saturated state, Geological Unit 2 is rocky material of medium strength (R_c=17,21 MPa).

Geological Unit 3

Gray andesite cover (3,65м-75,26%) and gray sandy argillite (1,2м-24,74%).

Average nominal values of physical and mechanical parameters for soils in unit 3 are shown in the table below:

#	Physical and Mechanical Parameters of Soils in Unit 3	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,70
2	Bulk Density, ρ	g/cm^3	2,37
3	Uniaxial Compression Strength in dry state, R_c	MPa	42,80
4	Uniaxial Compression Strength in saturated state, R_c	MPa	31,41
5	Cohesion, C	MPa	8,29
6	Angle of internal friction, φ	degree	33,5

– According to the uniaxial compression strength in saturated state, Geological Unit 3 is rocky material of medium strength (Rc=31,41 MPa);

Geological Unit 4

Greenish-gray and gray massive medium-grained sandstone (17,2и-54,43%) and gray argillite (1,1 м – 3,48%), with units of alternating gray fine-grained (2,0-25,0см) sandstone and gray (0,5-20,0см) argillite (13,3-42,09%).

Average nominal values of physical and mechanical parameters for soils in unit 4 are shown in the table below:

#	Physical and Mechanical Parameters of Soils in Unit 4	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,67
2	Bulk Density, ρ	g/cm^3	2,32
3	Uniaxial Compression Strength in dry state, R_c	MPa	31,09
4	Uniaxial Compression Strength in saturated state, R_c	MPa	22,29
5	Cohesion, C	MPa	8,89
6	Angle of internal friction, φ	degree	30,5

– According to the uniaxial compression strength in saturated state, Geological Unit 4 is rocky material of medium strength (R_c=22,29 MPa).

Geological Unit 5

Gray andesite cover (0,5м-100%).

Nominal values of physical and mechanical parameters for soils in unit 5 are shown in the table below:

#	Physical and Mechanical Parameters of Soils in Unit 5	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54,3
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39,13
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33
7	Modulus of elasticity, E	MPa	3973
8	Poisson's ratio, μ	-	0,295

– According to the uniaxial compression strength in saturated state, Geological Unit 5 is rocky material of medium strength (R_c=39,13 MPa).

– According to the softening coefficient, the soil is prone to softening, K_{saf}=0.73 (K_{saf}<0,75).

Geological Unit 6

Grayish-green medium-fragmental tuff (2,0m–10,53%), light-green fine-grained sandstone (8,0m-42,11%) and alternation of gray fine-grained sandstone (2,0-40,0 cm) and gray argillite (0,5-25,0 cm) (9,0-47,36%).

Average nominal values of physical and mechanical parameters for soils in unit 6 are shown in the table below:

#	Physical and Mechanical Parameters of Soils in Unit 6	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,65
2	Bulk Density, ρ	g/cm^3	2,31
3	Uniaxial Compression Strength in dry state, R_c	MPa	29,77
4	Uniaxial Compression Strength in saturated state, R_c	MPa	19,55
5	Cohesion, C	MPa	8,43
6	Angle of internal friction, φ	degree	30,64

- According to the average value of uniaxial compression strength in saturated state, Geological Unit 6 is rock with medium strength (Rc=19,55 MPa).

Geological Unit 7

Dark-gray andesite cover, with spherical singularities in the lower part (10-50см) (13м-100%).

Nominal values of physical and mechanical parameters for soils in unit 7 are shown in the table below:

#	Physical and Mechanical Parameters of Soils in Unit 7	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54,3
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39,13
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33
7	Modulus of elasticity, E	MPa	3973
8	Poisson's ratio, μ	-	0,295

- According to the uniaxial compression strength in saturated state, Geological Unit 7 is rock of medium strength (Rc=39,13 MPa);

Geological Unit 8

Alternation of Greenish-gray medium-grained sandstone (0,25-1-1,5м) and gray argillite (6-25cm) (7m-100%).

Average nominal values of physical and mechanical parameters for soils in unit 8 are shown in the table below:

#	Physical and Mechanical Parameters of Soils in Unit 8	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,68
2	Bulk Density, ρ	g/cm^3	2,55
3	Uniaxial Compression Strength in dry state, R_c	MPa	23,49
4	Uniaxial Compression Strength in saturated state, R_c	MPa	17,62
5	Cohesion, C	MPa	6,38
6	Angle of internal friction, φ	degree	32

- According to the average value of uniaxial compression strength in saturated state, Geological Unit 8 is rock with medium strength (Rc=17,62 MPa).

Geological Unit 9

Dark-gray andesite cover (21-36m-100%).

Nominal values of physical and mechanical parameters for soils in unit p are shown in the table below:

#	Physical and Mechanical Parameters of soils in Unit 9	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54,3
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39,13
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33
7	Modulus of elasticity, E	MPa	3373
8	Poisson's ratio, μ	-	0,295

- According to the average value of uniaxial compression strength in saturated state, Geological Unit 9 is rock with medium strength (Rc=38,49 MPa).

Units 23-25

Gray and greenish-gray microfragmental and medium-fragmental tuff (11%), light-gray argillite (4%), light-gray and gray fine-grained clayey sandstone (3%) and units of alternating thin layers (1-40cm) of gray argillite and gray fine-grained clayey sandstone (82%).

Average nominal values of physical and mechanical parameters for soils in units 23-25 are shown in the table below:

#	Physical and Mechanical Parameters of soils in Unit 23-25	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,67
2	Bulk Density, ρ	g/cm^3	2,27
3	Uniaxial Compression Strength in dry state, R_c	MPa	22,96
4	Uniaxial Compression Strength in saturated state, R_c	MPa	16,18
5	Cohesion, C	MPa	6,26
6	Angle of internal friction, φ	degree	31,9

- According to the average value of uniaxial compression strength in saturated state, Geological Units 23-25 is rock with medium strength (Rc=16,18 MPa).

Unit 28

Dark-gray diabase and gray hornstone

Average nominal values of physical and mechanical parameters for soils in units 28 are shown in the table below:

#	Physical and Mechanical Parameters of soils in Unit 28	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,71
2	Bulk Density, ρ	g/cm^3	2,57
3	Uniaxial Compression Strength in dry state, R_c	MPa	83,17
4	Uniaxial Compression Strength in saturated state, R_c	MPa	42,16

- According to the average value of uniaxial compression strength in saturated state, Geological Unit 28 is rock with medium strength (Rc=42,16 MPa).

– According to the softening coefficient value, the soil is prone to softening, K_{saf} =0.55 (K_{saf}<0,75);

On the left bank of the Mtkvari, outcrops of Mio-Pliocene Kisatibi series (N_1^2-N_2^1) come very close to the floodplain, affecting the bank morphology and the composition of colluvial and deluvial formations. The floodplain is built with continental-volcanogenic effusive formations, in some places dark-gray medium-fragmental tuffs with beds of diatomite. It supper part consist of andesite-dacite and dolerite lavas.

On the right bank of the Mtkvari, at 1349,5 m and 1342,8 m, there are small remains of dark-gray massive dolerite lavas of the Quaternary age (Q_{III}) that are very damaged and mixed with light-brown and yellow loam and clay forming the bank. Their visual thickness does not exceed 20-25 meters.

No hydrostructure is proposed within the area of the Kisatibi series and dolerite lavas.

Lithostratigraphic units of Quaternary non-rock identified in the reservoir area and numbered with unique numbers, are described in detail in Chapter 6, so the description is not repeated here.

Soil samples were recovered from 17 test pits for chemical testing. According to the test data, in different locations the soils have different degree of aggressivity to different concrete grades. Soils of lithostratigraphic units no. 35, 31 and 33 are primarily very aggressive to types of concrete based on Portland cement, sometimes also to concretes on sulfate-resistant cement. Results of the chemical tests and soil aggressivity evaluations are enclosed in Annex 2.2..

As banks of the Mtkvari in the reservoir area consist of alluvial-proluvial loose-fragmental and clayey soils, side erosion and collapse of the banks, also their underflooding are the main geohazards that could potentially cause certain difficulties with geodynamic stability of facilities and the environment. It is especially true about the right bank where the highway is running.

Investigations of the right bank of the Mtkvari identified deformations caused by landsliding, as shown on geotechnical maps at 1:25000 and 1:5000 (dwg. GC-0904-MH-2 and GC-0904-MH-4, respectively) and geotechnical cross-sections (dwg. GC-0904-MH-5).

- There is an old landslide identified by morphological signs at the proposed HPS headworks, upstream from the road. Yet the landslide is now fully stabilized, with no signs of potentially becoming active in future.

- There is an active landslide 4.5 km along the road from the diversion tunnel portal, and the main landslide bench is located in the vicinity of the road. The width of the landslide (parallel to the road and river) is 250 m, and its length along the movement line is 70-75 m. The sliding of the earth mass is caused by erosion at the foot of the bank built by loamy material and strongly weathered argillites. The sliding continues as the bank foot is eroded again, and the earth roadbed could also potentially slide down in future.

- There is a stabilized landslide at a distance of 6.2 km from the tunnel portal, and its main bench is located above the road, with the tongue reaching the river. Thus the road goes over the landslide body, yet there are no signs of movement observed either on the road or elsewhere. The landslide width parallel to the road and river is 200 m, and its length is 150 m.

- There is an active landslide above the road, at a distance of 6.5 km from the tunnel portal, where the road goes in a deep gully. The landslide was caused, on the one hand, by cutting of the bank consisting of rounded cobble of the alluvial terrace and alternating layers of weathered argillite and sandstone, on the other hand, by a steep slope of a deeply cutting in gully. The landslide width is 40-50 m, and its length is 50-60 m. The landslide will not activate after flooding of the reservoir area, as it is located outside the zone.

- Accumulation of several landslides is clearly seen at the distances of 7.0 to 7.5 km from the proposed tunnel portal where erosion of the bank consisting of deluvial-proluvial sediments and weathered argillite caused instability of the slope. As the foot of the slope is eroded, soil masses slide towards the Mtkvari, also affecting the roadbed where cracks and pits have occurred on the surface.

There are also landslides on the left bank, with their toes coming directly to the riverbed. The landsliding continues together with erosion of the landslide toes, and only some landslides are currently stabilized, yet reservoir flooding could activate them as well as strengthen the currently active landslides.

There are landslides in other locations within these sections of the valley, also on steep slopes of side gorges and gullies cutting the banks of the Mtkvari. Yet these landslides cannot seriously affect the construction or operation of the reservoir, as they are located too far from it.

Other geohazards in this area include accumulation of proluvial debris in mouths of some side tributaries that results from periodical prolluvial streams, also accumulation of fragmental material at the foot of high cornices. These geohazards neither can seriously affect the construction or operation of the reservoir.

On some areas of the right bank where edges of eroded terraces are getting closer to the road, cross-profiles were surveyed at 1:500 and geotechnical cross-sections developed with a description of local soils (see Drawings, dwg. GC-0904-MH-5).

In conclusion, natural conditions in the area are generally favorable for construction of the reservoir, would not cause any risk, as a reservoir of such size could not cause any significant change in local environment.

Yet consideration should be given to the fact that flooding of the banks consisting of soils that are not waterproof would trigger the natural process of their transformation and activate landsliding in some areas, resulting in deformations of the road on the right bank. The smaller is the flooded area, the lower is the risk.

Groundwater was encountered in test pits excavated in the floodplain terrace or the first above-floodplain terrace. No groundwater was encountered within the investigated depth on more elevated banks.

A total of 6 water samples were obtained from springs and different small surface streams for chemical testing of groundwater encountered under the Quaternary sediments. According to the data obtained, the groundwater is not aggressive to any type of concrete. Some soils were slightly aggressive to W4 concrete. Results of the chemical testing and groundwater aggressivity evaluations are given in Annex 2.2.

7.2. Geotechnical Conditions of the Main Intake Area

The reservoir dam is located on the floodplain terrace of the river, and the remaining facilities are located at the toe of the right bank of the Mtkvari, on its right bank.

In the dam area, the Mtkvari channel meanders forming to low capes in both banks. The dam will be located at the upstream cape of the left bank where the channel makes a 180-degree turn. At the nose of the cape (i.e. within the turn area), the width of the river floodplain is actually limited by the width of the channel itself, and does not exceed 30-70m, somewhat exceeding the channel width at sides, reaching 70-100 meters. The length of the left bank cape is 480m, and its width varies from 100 to 200 m, the height varying within 10-30m. The cape crest is gentle, inclined at 2-3^0 on its sides and towards the river (NE).

The southern slope of the Trialeti Ridge, upstream from the headworks, is stepped. The lower step is sloping at 45^0, its intermediate step – at 27-30^0, and the slope of the upper step varied from 45 to 75-80^0. Above the steps, starting from 1113 m ASL, the slope first becomes 10-15^0, and then becomes adverse. Relative elevation of the steep slope edge (1113 m ASL) from the river level is 121 meters.

According to the geological structure described in detail in 4.1, the headworks area consists of rock and semi-rock of the middle series of Middle Eocene (Pg22b). The strata mainly consist of andesite, sandstone, argillite, and tuff.

On a large area, the bedrock is covered with Quaternary sediments of different origin: alluvial, proluvial, colluvial and deluvial technogenic fills: loose-fragmental and clayey material. These layer is the thickest at the toe of the slope and in the bottom, In boreholes drilled in the floodplain terrace, the thickness of the alluvial sediments was 16-17m, and the total thickness of the technogenic, deluvial and alluvial sediments reached 20m in BH 4.

Lithostratigraphic units identified in the valley section within the headworks area are shown on the geotechnical map at 1:1000 and respective geotechnical cross-sections (see Drawings, dwg. GC-0904-MH-7 and GC-0904-MH-8).

According to the Terms of reference of the project, 7 boreholes were drilled and geophysical investigations conducted to study the soils at the site. Locations of the boreholes and geophysical testing are also shown on the geotechnical map (see Drawings, dwg. GC-0904-MH-7).

Resulting from the field studies, 36 geological units were identified in the rock and semi-rock strata that differ from each other by percentages of main lithological types of soils: sandstone, argillite, tuff, and andesite. Loose fragmental sediments of the Quaternary age can be also subdivided into different lithostratigraphic units differing in their condition and properties.

Physical and mechanical properties of the soils detailed in Chapter 6 enabled evaluation of soil conditions at the main intake facility area by separate units as given below (see geotechnical map, dwg. GC-0904-MH-7, and geotechnical cross-sections, dwg. GC-0904-MH-8).

Geological Unit 1

Gray andesite (74m-99%) with an interbed of fine-grained sandstone (1%).

In view of the very low percentage of sandstone in the andesite unit and the fact that both types of soils have medium strength, the following values for andesite can be assumed as averaged meanings of physical and mechanical parameters of the soils in unit 1:

#	Physical and Mechanical Properties of Soils in Unit 1	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54.31
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39.13
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33

- According to the average value of uniaxial compression strength in saturated state, Geological Unit 1 is rock with medium strength (R_c=39,13 MPa);

Geological Unit 2

Brown silica striate argillite (11,1m – 48,05%), gray massive (1-2,6м) medium-grained sandstone (7,8м-33,77%), greenish medium-fragmental tuff (1,0m-4,33%) and units (0,4-1,0m) of alternating gray fine-grained sandstone and gray argillite (3,2-13,85%).

Average nominal values of physical and mechanical parameters for soils in unit 2 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 2	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,25
3	Uniaxial Compression Strength in dry state, R_c	MPa	22,88
4	Uniaxial Compression Strength in saturated state, R_c	MPa	17,21
5	Cohesion, C	MPa	5,65
6	Angle of internal friction, φ	degree	32,38

- According to the average value of uniaxial compression strength in saturated state, Geological Unit 2 is rock with medium strength (Rc=17,21 MPa);

Geological Unit 3

Gray andesite cover (3,65m-75,26%) and gray sandy argillite (1,2m-24,74%).

Average nominal values of physical and mechanical parameters for soils in unit 3 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 3	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,70
2	Bulk Density, ρ	g/cm^3	2,37
3	Uniaxial Compression Strength in dry state, R_c	MPa	42,80
4	Uniaxial Compression Strength in saturated state, R_c	MPa	31,41
5	Cohesion, C	MPa	8,29
6	Angle of internal friction, φ	degree	33,5

- According to the average value of uniaxial compression strength in saturated state, Geological Unit 3 is rock with medium strength (Rc=31,41 MPa);

Geological Unit 4

Greenish-gray and gray massive medium-grained sandstone (17,2m-54,43%) and gray argillite (1,1m – 3,48%), with units of alternating gray fine-grained (2,0-25,0cm) sandstone and gray (0,5-20,0cm) argillite (13,3-42,09%).

Average nominal values of physical and mechanical parameters for soils in unit 4 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 4	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,67
2	Bulk Density, ρ	g/cm^3	2,32
3	Uniaxial Compression Strength in dry state, R_c	MPa	31,09
4	Uniaxial Compression Strength in saturated state, R_c	MPa	22,29
5	Cohesion, C	MPa	8,89
6	Angle of internal friction, φ	degree	30,5

- According to the average value of uniaxial compression strength in saturated state, Geological Unit 4 is rock with medium strength (Rc=22,29 MPa);

Geological Unit 5

Gray andesite cover (0,5m-100%).

Average nominal values of physical and mechanical parameters for soils in unit 5 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 5	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54,3
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39,13
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33
7	Elasticity modulus, E	MPa	3973
8	Poisson's ratio, μ	-	0,295

- According to the average value of uniaxial compression strength in saturated state, Geological Unit 5 is rock with medium strength (Rc=39,13 MPa);

Geological Unit 6

Grayish-green medium-fragmental tuff (2,0m–10,53%), light-green fine-grained sandstone (8,0m-42,11%) and alternation of gray fine-grained sandstone (2,0-40,0cm) and gray argillite (0,5-25,0cm) (9,0-47,36%).

Average nominal values of physical and mechanical parameters for soils in unit 6 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 6	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,65
2	Bulk Density, ρ	g/cm^3	2,31
3	Uniaxial Compression Strength in dry state, R_c	MPa	29,77
4	Uniaxial Compression Strength in saturated state, R_c	MPa	19,55
5	Cohesion, C	MPa	8,43
6	Angle of internal friction, φ	degree	30,64

– According to the average value of uniaxial compression strength in saturated state, Geological Unit 6 is rock with medium strength (Rc=19,55 MPa);

Geological Unit 7

Dark-gray andesite cover, with spherical (10-50cm) singularities (13м-100%) in the lower part.

Average nominal values of physical and mechanical parameters for soils in unit 7 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 7	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54,3
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39,13
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33
7	Elasticity modulus, E	MPa	3973
8	Poisson's ratio, μ	-	0,295

– According to the average value of uniaxial compression strength in saturated state, Geological Unit 7 is rock with medium strength (Rc=39,13 MPa);

Geological Unit 8

Alternation Greenish-gray medium-grained sandstone (0,25-1-1,5m) и gray sandy (6-25cm) argillite (7m-100%).

Average nominal values of physical and mechanical parameters for soils in unit 8 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 8	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,68
2	Bulk Density, ρ	g/cm^3	2,55
3	Uniaxial Compression Strength in dry state, R_c	MPa	23,49
4	Uniaxial Compression Strength in saturated state, R_c	MPa	17,62
5	Softening coefficient, K_{saf}	-	
6	Cohesion, C	MPa	6,38
7	Angle of internal friction, φ	degree	32

– According to the average value of uniaxial compression strength in saturated state, Geological Unit 8 is rock with medium strength (Rc=17,62 MPa);

Geological Unit 9

Dark-gray andesite cover (21-36m-100%).

Nominal values of physical and mechanical parameters for soils in unit 9 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 9	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54,3
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39,13
5	Cohesion, C	MPa	10,6

6	Angle of internal friction, φ	degree	33
7	Elasticity modulus, E	MPa	3373
8	Poisson's ratio, μ	-	0,295

– According to the average value of uniaxial compression strength in saturated state, Geological Unit 9 is rock with medium strength (Rc=39,13 MPa).

Geological Unit 23-25

Gray and greenish-gray microfragmental and medium-fragmental tuff (11%), light-gray argillite (4%), light-gray and gray fine-grained clayey sandstone (3%) and units of thin (1-40cm) alternating layers of gray argillite and gray fine-grained clayey sandstone (82%).

Average nominal values of physical and mechanical parameters for soils in unit 23-25 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 1	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,67
2	Bulk Density, ρ	g/cm^3	2,27
3	Uniaxial Compression Strength in dry state, R_c	MPa	22,96
4	Uniaxial Compression Strength in saturated state, R_c	MPa	16,18
5	Cohesion, C	MPa	6,26
6	Angle of internal friction, φ	degree	31,9

– According to the average value of uniaxial compression strength in saturated state, Geological Unit 23-25 is rock with medium strength (Rc=16,18 MPa);

Lithostratigraphic units of non-rock material of the Quaternary age identified in the reservoir area, under their unique numbers, are described in detail in Chapter 6, so the description is not repeated here.

Chemical tests were conducted of water extracts from the non-rock material samples recovered from BH1 and BH4. According to the obtained data, the soils are not aggressive to any grade of concrete.

Geohazards in the main intake facilities area include rock sliding from the steep right banks and insignificant erosion in two locations of the right bank (see geotechnical map, dwg. GC-0904-MH-7). By morphological signs, there is a large old landslide body (dlQ_{IV}) at the toe of the right bank that is currently fully stabilized and no activation is expected.

Geophysical survey conducted in the area included vertical electrical sounding and seismic profiling. The tables above show dynamic parameters of soils determined by seismic tests, whereas data obtained from the geophysical survey were taken into account when generating the geotechnical maps and sections. A comprehensive geophysical survey report is enclosed in Annex 5.

Hydrogeological investigations were also conducted in the headworks area. Groundwater was encountered in all boreholes drilled at the site. Groundwater level stabilized at different depths. In sections of low alluvial terraces in the area close to the river channel (BH5 and BH 15), the groundwater level was recorded at the depth of 2-3 m. In BH 4, near the river channel, at the road, the groundwater was encountered at the depth of 6 meters. Because of direct interconnection between the groundwater and the river, the groundwater depth depended and had a direct influence on the river water level. In other boreholes drilled at higher banks (BH 1, 2, 3,

and 16), the groundwater depth varied from 11 to 39.6m. Elevations of the wellheads and the river water level in respective river sections suggest that the groundwater level there as well depends on the river level, though to a smaller extent. The groundwaters mainly feed from river water, and to some extent by rain and melting snow/ice. Groundwater levels are shown on geotechnical sections of the area (dwg. GC-0904-MH-8).

Groundwater samples were obtained from BH1, BH2, BH3 and BH4 for chemical testing. According to the obtained data, the groundwater are not aggressive to concretes, and only slight aggressivity was identified to W4 grade, also to reinforcement if affected periodically.

Results of the chemical tests and groundwater aggressivity data are shown in Annex 2.2.

Field pumping tests were carried out in the boreholes to determine permeability of the massif. The boreholes for the tests were drilled by core drilling, using 152-93 dia bores, and respective equipment was used for the testing. Results of the pumping tests are shown below.

Pump-in Tests in Boreholes

Aquifers were tested in boreholes by interval pumping for determining the degree of fissuring and permeability of the strata. Results of the pumping were double-checked using flow -pressure diagrams (P) (Qt). With laminar movement of groundwater, the relation is linear, and the curve starts from the coordinate origin.

The water absorption was calculated from the equation:

$$\eta=(60xQ_{np})/(h_m xP_{np})\ l/min$$

where:

η is water absorption in l/min;

Q_{np} is water flow in l/min, under the pressure;

h_m is the thickness of the tested area in meters;

P_{np} is the water pressure during pumping, which equals to the height of the water column above the static groundwater level, in meters.

The field pump-in tests were conducted at different depths in boreholes BH1 and BH2, under three different pressures.

Pump-out Tests

Pump-out tests in boreholes were conducted by double pumping-out, which allowed drawing flow-level curves. The curve allowed finding a calculation formula for determining the permeability coefficient and the well capacity at each decrease of the level.

The pumping-out consisted of 3 stages: 1) well cleaning; 2) pumping out to get the first decrease of the groundwater level; 3) pumping out to get the second decrease of the groundwater level.

Prior to cleaning the well, static groundwater level was measured, and then the water pumped out before a stable flow is obtained. The same is then repeated for the second time. Then the flow-

level graph is drawn that, and the permeability coefficient calculated from the graph using the following equation for pressureless imperfect wells:

$KK=0.73 \times Q\,(lgR-lgr)/(H^2_0 - h^2_0)$ meters per day

where:

Q is flow in the test well, in m^3 per day;

R is the radius affected by the pumping, in meters;

r is the test well radius, in meters;

H_0 is the thickness of the active zone, in meters;

h_0 is the dynamic groundwater level calculated from the start of the active zone in imperfect wells, in meters.

Results of the field tests and respective calculations are enclosed in Annex 4.

The table below shows water absorption (η, l/min) and permeability coefficient (K, m per day) based on the field tests.

Field Pump-in and Pump-out Tests to Determine Soil Water Absorption and Permeability Coefficient

#	Test	BH no.	Tested depth interval, m	Water absorption, η l/min	Permeability coefficient, K m/day
1	Pumping in	1	22.0-27.0	0.088	-
2			27.0-32.0	0.00384	-
3			32.0-37.0	0.0112	-
4		2	7.0-12.0	0.00896	-
5			12.0-17.0	0.0424	-
6			17.0-22.0	0.05184	-
7			22.0-27.0	0.01176	-
1	Pumping out	1	39.6-50.0	-	3.34
2		2	29.0-37.6	-	2.57
3		3	12.1-20.0	-	5.67
4		4	25.0-30.0	-	7.90
5		5	3.1-14.0	-	97.9
6		11	4.55-20.0	-	36.6
7		13	5.05-20.0	-	95.72
Calculation of flow under max. pressure in the reservoir according to data from BH 1 and BH1 (at the reservoir water level at 1025m ASL)					
1	-	data from BH1	Head P=35м. Adjusted flow Q_{adjust} =0.035 l/s	0.0112	
2	-	data from BH2	Head P=35м. Adjusted flow Q_{adjust} =0.15l/s.	0.05184	

7.3. Geotechnical Conditions of the Diversion Tunnel Area

The proposed diversion tunnel does under the western edge of the Trialeti Range, where elevations range within 1200-1430 m above the sea level (ASL) on average, with the main part at 1000-1200 m ASL. Most noteworthy are the mounts of Zegverda (1427,0m) and Satsernako (1225,0m).

The lithology of range-forming sediments and their folding conditioned the local relief. Different denudation resistance of the rock conditioned alternations of hills and depressions. Rocky ridges formed by covers of porphyrite and andesite that are not prone to weathering, are mainly exposed and have steep slopes. Within the tunnel area, such relief can be found on the section from the southern portal to the northern foot of Mount Zegverda (i.e. the northern foot of the Trialeti range).

Certain units of sandstone, tuff breccias and argillite are more prone to weathering and are dissected by a thick network of small streams and dry gorges and ravines that run temporary streams of rainwater and melting water down from the range. The rocks prone to weathering condition local hilly relief with gentle forms. Such relief is found on the tunnel section from the northern foot of Mount Zegverda (environs of the village of Orpola) to the northern portal of the tunnel. Outcrops of more massive sandstone in the relief from certain folding. Denudation resistance of bedded veins and cross-veins present in the Eocene formations also promotes formation of positive relief forms.

By their geological structure described in detail in section 4.1, the diversion tunnel right-of-way is built by rock and semi-rock of Middle Eocene (Pg_2^2) and Upper Eocene (Pg_2^3). Andesite, sandstone, tuff and argillite prevail in the bedrock strata.

On the main part of the area the bedrock is covered by a Quaternary cover of different origin: deluvial, proluvial and colluvial clayey-loamy and fragmental sediments. The thickness of the cover sediments in the tunnel area was tested only in BH14 where it was 0.8m. Judging by some existing indications, their thickness increases in depressions and decreases in hills and elevations. In general, the Quaternary cover does not play a significant part in the construction of the diversion tunnel, except for portal areas where the sediments should be removed from the portal sites.

The identified lithostratigraphic units of rock and semi-rock in the diversion tunnel right-of-way are shown on geological map at 1:25000 and respective geological cross-section (see drawings, dwg. GC-0904-MH-1).

A borehole was drilled to 155 meters in order to detail the geological sections of the northern tunnel section built by rather weak material: argillites. The borehole (BH14) was drilled fully in argillites with rare interbeds of sandstone (Geological Unit 25). The lithological log of the borehole is enclosed in Annex 1 and shown on the geotechnical cross-section of the tunnel at 1:2000 (see drawings, dwg. GC-0904-MH-11).

Samples were recovered from BH14 and from exposed soils on the surface for laboratory testing to determine physical and mechanical properties of the subsurface strata. Locations of the borehole and sample recovery spots are shown on the geological map (see drawings, dwg. GC-0904-MH-1).

Resulting from the field and laboratory studies, 36 geological units were identified in the rock and semi-rock strata that differ from each other by percentages of main lithological types of soils: sandstone, argillite, tuff, andesite, and breccias. The soil units are shown on the geotechnical cross-section of the tunnel (see drawing, dwg. GC-0904-MH-11).

The obtained values of physical and mechanical parameters of separate soil types as discussed in item 6 were used to evaluate soil conditions in the proposed diversion tunnel area by separate geological units forming the strata.

Geological Unit 1

Gray andesite (74m-99%) with interbeds of fine-grained sandstone (1%).

In view of the very low content of sandstone in the andesite unit and the fact that both types of soils are classified as having medium strength, the following values for andesite shown in the table below can be assumed physical and mechanical parameters for soils in unit 1.

#	Physical and Mechanical Properties of Soils in Unit 1	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54.31
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39.13
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33
7	Elasticity modulus, E	MPa	3373.9
8	Poisson's ratio, μ	-	0.3

- According to the uniaxial compression strength in saturated state, Geological Unit 1 is rock of medium strength (R_c=39.13 MPa);

Geological Unit 2

Greenish-gray massive-layered medium-grained sandstone and rare interbeds (2-10 cm) of greenish-gray sandy argillite

Average nominal values of physical and mechanical parameters for soils in unit 2 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 2	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,65
2	Bulk Density, ρ	g/cm^3	2,39
3	Uniaxial Compression Strength in dry state, R_c	MPa	38.71
4	Uniaxial Compression Strength in saturated state, R_c	MPa	26.96
5	Cohesion, C	MPa	11.40
6	Angle of internal friction, φ	degree	29.0
7	Elasticity modulus, E	MPa	2890
8	Poisson's ratio, μ	-	0.303

- According to the uniaxial compression strength in saturated state, Geological Unit 2 is rock of medium strength (Rc=26.96МПа);

Geological Unit 3

Dark-gray andesite cover (100%)

Nominal values of physical and mechanical parameters for soils in unit 3 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 3	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,70
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54.31
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39.13
5	Cohesion, C	MPa	10.60
6	Angle of internal friction, φ	degree	33
7	Elasticity modulus, E	MPa	3373.9
8	Poisson's ratio, μ	-	0.295

- According to the uniaxial compression strength in saturated state, Geological Unit 3 is rock of medium strength (Rc=39.13МПа).

Geological Unit 4

Greenish-gray massive different-grained sandstone (0,3-6,0 м) interlaid with gray and Greenish-gray medium-fragmental tuff (0,15-1,0 m) and gray and brown argillite (0,1-3,5).

Nominal values of physical and mechanical parameters for soils in unit 4 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 4	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,65
2	Bulk Density, ρ	g/cm^3	2,39
3	Uniaxial Compression Strength in dry state, R_c	MPa	38.71
4	Uniaxial Compression Strength in saturated state, R_c	MPa	26.96
6	Cohesion, C	MPa	11.4
7	Angle of internal friction, φ	degree	29.0
8	Elasticity modulus, E	MPa	2890
9	Poisson's ratio, μ	-	0.303

- According to the uniaxial compression strength in saturated state, Geological Unit 4 is rock of medium strength (Rc=26.96МПа).

Geological Unit 5

Dark-gray andesite cover with spherical singularities (100%).

Nominal values of physical and mechanical parameters for soils in unit 5 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 5	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54.3
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39.13
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33
7	Elasticity modulus, E	MPa	3373.9
8	Poisson's ratio, μ	-	0.30

- According to the uniaxial compression strength in saturated state, Geological Unit 5 is rock of medium strength (Rc=39.13МПа);

Geological Unit 6

Greenish-gray medium-grained sandstone (100%)

Nominal values of physical and mechanical parameters for soils in unit 6 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 6	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,65
2	Bulk Density, ρ	g/cm^3	2,39
3	Uniaxial Compression Strength in dry state, R_c	MPa	38.71
4	Uniaxial Compression Strength in saturated state, R_c	MPa	26.96
5	Cohesion, C	MPa	11.40
6	Angle of internal friction, φ	degree	29.0
7	Elasticity modulus, E	MPa	2890.1
8	Poisson's ratio, μ	-	0.303

- According to the uniaxial compression strength in saturated state, Geological Unit 6 is rock of medium strength (Rc=26.96 MPa);

Geological Unit 7

Dark-gray andesite cover, with spherical singularities (10-50см) in the lower part (13m-100%).

Nominal values of physical and mechanical parameters for soils in unit 7 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 7	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54.3
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39.13
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33
7	Elasticity modulus, E	MPa	3973.9
8	Poisson's ratio, μ	-	0.295

- According to the uniaxial compression strength in saturated state, Geological Unit 7 is rock of medium strength (Rc=39.13 MPa);

Geological Unit 8

Alternation of Greenish-gray medium-grained sandstone (0,25-1-1,5m) and gray sandy (6-25cm) argillite (7m-100%).

Average nominal values of physical and mechanical parameters for soils in unit 8 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 8	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,26

3	Uniaxial Compression Strength in dry state, R_c	MPa	23.49
4	Uniaxial Compression Strength in saturated state, R_c	MPa	17.62
5	Cohesion, C	MPa	6,39
6	Angle of internal friction, φ	degree	32
7	Elasticity modulus, E	MPa	2,69
8	Poisson's ratio, μ	-	

- According to the uniaxial compression strength in saturated state, Geological Unit 8 is rock of medium strength (Rc=17.62МПа);

Geological Unit 9

Dark-gray andesite cover (21-36м-100%)

Nominal values of physical and mechanical parameters for soils in unit 9 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 9	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54.3
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39.13
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33
7	Elasticity modulus, E	MPa	3373.9
8	Poisson's ratio, μ	-	0.295

- According to the uniaxial compression strength in saturated state, Geological Unit 9 is rock of medium strength (Rc=39.13МПа);

Geological Unit 10

Alternation (5-60cm) of gray and Greenish-gray argillite and fine-grained sandstone, interlaid with green fine-fragmented tuff (1,2m) and gray and Greenish-gray medium-grained massive-layered (1-3m) sandstone (45m-100%).

Average nominal values of physical and mechanical parameters for soils in unit 10 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 10	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,67
2	Bulk Density, ρ	g/cm^3	2,23
3	Uniaxial Compression Strength in dry state, R_c	MPa	26.34
4	Uniaxial Compression Strength in saturated state, R_c	MPa	18.36

- According to the uniaxial compression strength in saturated state, Geological Unit 10 is rock of medium strength (Rc=18.36 MPa)

Geological Unit 11

Gray andesite cover (41м-100%)

Nominal values of physical and mechanical parameters for soils in unit 11 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 11	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54.3
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39.13
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33
7	Elasticity modulus, E	MPa	3973.9
8	Poisson's ratio, μ	-	0.295

- According to the uniaxial compression strength in saturated state, Geological Unit 11 is rock of medium strength (Rc=39.13 MPa);

Geological Unit 12

Gray and Greenish-gray different-fragmental tuff(31%), interlaid with violet argillite (6%) and units of alternating thick-layered dark-red argillite and light-gray sandstone (13%), with green microfragmental andesite breccia in the lower part (50%).

Average nominal values of physical and mechanical parameters for soils in unit 12 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 6	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,70
2	Bulk Density, ρ	g/cm^3	2,47
3	Uniaxial Compression Strength in dry state, R_c	MPa	42.99
4	Uniaxial Compression Strength in saturated state, R_c	MPa	30.15
5	Cohesion, C	MPa	8,36
6	Angle of internal friction, φ	degree	30,39

- According to the uniaxial compression strength in saturated state, Geological Unit 12 is rock of medium strength (Rc=30.15 MPa);

Geological Unit 13

Dark-gray andesite cover (5м-100%).

Nominal values of physical and mechanical parameters for soils in unit 13 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 13	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54.3
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39.13
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33
7	Elasticity modulus, E	MPa	3973.9
8	Poisson's ratio, μ	-	0.295

- According to the uniaxial compression strength in saturated state, Geological Unit 12 is rock of medium strength (Rc=39.13 MPa).

Geological Unit 14

Alternation of thick-layered brownish-green microfragmental and macrofragmental tuff (58%), light-green and brownish-black silicified argillite (25%) and Greenish-gray fine-grained and medium-grained striate sandstone (17).

Average nominal values of physical and mechanical parameters for soils in unit 14 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 14	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,43
3	Uniaxial Compression Strength in dry state, R_c	MPa	31.15
4	Uniaxial Compression Strength in saturated state, R_c	MPa	19.71
5	Cohesion, C	MPa	5,64
6	Angle of internal friction, φ	degree	31,66

- According to the uniaxial compression strength in saturated state, Geological Unit 14 is rock of medium strength (Rc=19.71MΠa);

Geological Unit 15

Grayish-green, massive medium-grained, occasionally silicified sandstone (100%).

Nominal values of physical and mechanical parameters for soils in unit 15 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 15	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,65
2	Bulk Density, ρ	g/cm^3	2,39
3	Uniaxial Compression Strength in dry state, R_c	MPa	38.71
4	Uniaxial Compression Strength in saturated state, R_c	MPa	26.96
5	Cohesion, C	MPa	11,40
6	Angle of internal friction, φ	degree	29

- According to the uniaxial compression strength in saturated state, Geological Unit 15 is rock of medium strength (Rc=26.96 MPa).

Geological Unit 16

Light-green microfragmental and medium-fragmental tuff (30-100 cm - 70%) interlaid with light-gray different-grained sandstone (2-15cm - 15%) and gray argillite (2-15cm - 15%).

Average nominal values of physical and mechanical parameters for soils in unit 16 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 16	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,68
2	Bulk Density, ρ	g/cm^3	2,48
3	Uniaxial Compression Strength in dry state, R_c	MPa	29.83
4	Uniaxial Compression Strength in saturated state, R_c	MPa	19.55
5	Cohesion, C	MPa	5,97
6	Angle of internal friction, φ	degree	31,30

- According to the uniaxial compression strength in saturated state, Geological Unit 16 is rock of medium strength (Rc=19.55 MPa);

Geological Unit 17

Dark-brown, occasionally dark-green andesite cover with apparent big crystals (100%).

Nominal values of physical and mechanical parameters for soils in unit 17 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 17	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54.3
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39.13
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33
7	Elasticity modulus, E	MPa	3973.9
8	Poisson's ratio, μ	-	0.295

- According to the uniaxial compression strength in saturated state, Geological Unit 17 is rock of medium strength (Rc=39.13 MPa).

Geological Unit 18

Dark-gray andesite cover (30м-100%)

Nominal values of physical and mechanical parameters for soils in unit 18 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 18	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54,3
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39.12
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33
7	Elasticity modulus, E	MPa	3973.9
8	Poisson's ratio, μ	-	0.295

- According to the uniaxial compression strength in saturated state, Geological Unit 18 is rock of medium strength (Rc=39.13 MPa).

Geological Unit 19

In the upper part of the unit, dark-green massive microfragmental and medium-fragmental tuff is interlaid with dark-gray argillite an gray sandstone (1-15 cm, - 17,2 m); in the lower part, light-green microfragmental tuff is interlaid with thin (1-7 cm) alternation of gray and green microfragmental tuff, gray argillite and gray fine-grained sandstone (48,8 m).

Average nominal values of physical and mechanical parameters for soils in unit 19 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 19	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,68
2	Bulk Density, ρ	g/cm^3	2,41
3	Uniaxial Compression Strength in dry state, R_c	MPa	27.77

4	Uniaxial Compression Strength in saturated state, R_c	MPa	18.55
5	Cohesion, C	MPa	6,08
6	Angle of internal friction, φ	degree	31,48

- According to the uniaxial compression strength in saturated state, Geological Unit 19 is rock of medium strength (Rc=18.55 MPa).

Geological Unit 20

Dark-gray andesite cover, with apparent spherical singularities in the lower part (4 m, - 100%).

Nominal values of physical and mechanical parameters for soils in unit 20 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 20	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54.3
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39.13
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33
7	Elasticity modulus, E	MPa	3973.9
8	Poisson's ratio, μ	-	0.295

- According to the uniaxial compression strength in saturated state, Geological Unit 20 is rock of medium strength (Rc=38,49 MPa).

Geological Unit 19-1

Light-green microfragmental and medium-fragmental tuff (0,5-1.5 m, - 70%) interlaid with light-gray or light-brown diffident-grained sandstone (0.1-0.4 m, - 15%) and thin gray argillite (0,05-0,1 m, - 15%).

Average nominal values of physical and mechanical parameters for soils in unit 19-1 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 19-1	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,68
2	Bulk Density, ρ	g/cm^3	2,48
3	Uniaxial Compression Strength in dry state, R_c	MPa	30.32
4	Uniaxial Compression Strength in saturated state, R_c	MPa	20.15
6	Cohesion, C	MPa	5,97
7	Angle of internal friction, φ	degree	31,30

- According to the average uniaxial compression strength in saturated state, Geological Unit 19-1 is rock of medium strength (Rc=20.15 MPa).

Geological Unit 19-2

Green massive medium-fragmental tuff (38%) interlaid with alternations of gray and dark-gray, occasionally silicified argillite (41%) and gray and light-brown fine-grained sandstone (21%).

Average nominal values of physical and mechanical parameters for soils in unit 19-2 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 19-2	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,34
3	Uniaxial Compression Strength in dry state, R_c	MPa	27.07
4	Uniaxial Compression Strength in saturated state, R_c	MPa	17.52
5	Cohesion, C	MPa	5,16
6	Angle of internal friction, φ	degree	32,22

- According to the average uniaxial compression strength in saturated state, Geological Unit 19-2 is rock of medium strength (Rc=17,52МПа).

Geological Unit 20

Dark-gray andesite cover (20м,-100%).

Nominal values of physical and mechanical parameters for soils in unit 20 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 20	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54.3
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39.13
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33
7	Elasticity modulus, E	MPa	3973.9
8	Poisson's ratio, μ	-	0.295

- According to the average uniaxial compression strength in saturated state, Geological Unit 20 is rock of medium strength (Rc=39.13 MPa).

Geological Unit 21-1

Dark-gray silicified and weakly silicified argillite (0,15-0,25 м, - 90%). In the lower part, light-brown fine-grained sandstone (2 m, - 10%).

Average nominal values of physical and mechanical parameters for soils in unit 21-1 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 21-1	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,66
2	Bulk Density, ρ	g/cm^3	2,39
3	Uniaxial Compression Strength in dry state, R_c	MPa	18.90
4	Uniaxial Compression Strength in saturated state, R_c	MPa	12.44

- According to the average uniaxial compression strength in saturated state, Geological Unit 21-1 is rock of medium strength (Rc=12.44 MPa).

Geological Unit 22-25

Green microfragmental and medium-fragmental tuff (0,5-2,0 м) interlaid with light-gray or light-brown sandstone (0.1-0,25-0,4 м), occasionally with thin (up to 10 cm) and massive (up to 3 m) interlayers of gray argillite.

Average nominal values of physical and mechanical parameters for soils in unit 22-25 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 22-25	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,68
2	Bulk Density, ρ	g/cm^3	2,56
3	Uniaxial Compression Strength in dry state, R_c	MPa	32.56
4	Uniaxial Compression Strength in saturated state, R_c	MPa	21.16
5	Cohesion, C	MPa	6.36
6	Angle of internal friction, φ	degree	30.80

- According to the average uniaxial compression strength in saturated state, Geological Unit 22-25 is rock of medium strength (Rc=21.16 MPa).

Geological Unit 21

Alternation of gray and green medium-fragmental tuff (0,5-1,5 m, - 32%), medium-grained sandstone (3-5-7 cm, - 33%) and dark-gray silicified argillite (1-3 cm, - 32%); Greenish-gray medium-grained sandstone (2 m, - 3%) in the lower part.

Average nominal values of physical and mechanical parameters for soils in unit 21 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 21	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,67
2	Bulk Density, ρ	g/cm^3	2,35
3	Uniaxial Compression Strength in dry state, R_c	MPa	28.83
4	Uniaxial Compression Strength in saturated state, R_c	MPa	18.66
5	Cohesion, C	MPa	6,34
6	Angle of internal friction, φ	degree	31,58

- According to the average uniaxial compression strength in saturated state, Geological Unit 21 is rock of medium strength (Rc=18.66 MPa).

Geological Unit 22

Greenish-gray medium-grained massive sandstone (78%) interlaid with greenish medium-fragmental tuff (11%) and gray argillite (11%).

Average nominal values of physical and mechanical parameters for soils in unit 22 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 22	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,64
2	Bulk Density, ρ	g/cm^3	2,34
3	Uniaxial Compression Strength in dry state, R_c	MPa	34.76
4	Uniaxial Compression Strength in saturated state, R_c	MPa	24.27
5	Cohesion, C	MPa	9,68
6	Angle of internal friction, φ	degree	29,88

- According to the average uniaxial compression strength in saturated state, Geological Unit 22 is rock of medium strength (Rc=24.27 MPa);

Geological Unit 23

Gray and Greenish-gray fine-grained and medium-grained massive (0,4-1,3 м) sandstone (85%), interlaid with units (0,2-0,3m) of thin layers of gray argillite, gray fine-grained sandstone and light-green microfragmental tuff (15%).

Average nominal values of physical and mechanical parameters for soils in unit 23 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 23	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,64
2	Bulk Density, ρ	g/cm^3	2,31
3	Uniaxial Compression Strength in dry state, R_c	MPa	31.82
4	Uniaxial Compression Strength in saturated state, R_c	MPa	21.72
5	Cohesion, C	MPa	9,90
6	Angle of internal friction, φ	degree	29,90

- According to the average uniaxial compression strength in saturated state, Geological Unit 23 is rock of medium strength (Rc=21.72 MPa).

Geological Unit 24

Light-green microfragmental and medium-fragmental tuff (0,5-1,2 м, - 85%), with interbeds (0,05-0,2-0,7 м) of gray and light-gray fine-grained and medium-grained sandstone.

Average nominal values of physical and mechanical parameters for soils in unit 24 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 24	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,68
2	Bulk Density, ρ	g/cm^3	2,55
3	Uniaxial Compression Strength in dry state, R_c	MPa	33.57
4	Uniaxial Compression Strength in saturated state, R_c	MPa	21.50
5	Cohesion, C	MPa	6,64
6	Angle of internal friction, φ	degree	30,70

- According to the average uniaxial compression strength in saturated state, Geological Unit 24 is rock of medium strength (Rc=21.50 MPa).

Geological Unit 25

Alternation of dark-gray argillite (50,9%) and light-brown and gray fine-grained sandstone (49,1%), occasionally light-green microfragmental and medium-fragmental tuff.

Average nominal values of physical and mechanical parameters for soils in unit 25 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 25	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,75
2	Bulk Density, ρ	g/cm^3	2,30
3	Uniaxial Compression Strength in dry state, R_c	MPa	22,11
4	Uniaxial Compression Strength in saturated state, R_c	MPa	15.79
5	Cohesion, C	MPa	6,83
6	Angle of internal friction, φ	degree	32,81

- According to the average uniaxial compression strength in saturated state, Geological Unit 25 is rock of medium strength (Rc=15.79 MPa).

Geological Unit 27

Medium-crystalline teschenite (100%)

Nominal values of physical and mechanical parameters for soils in unit 27 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 27	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,88
2	Bulk Density, ρ	g/cm^3	2,81
3	Uniaxial Compression Strength in dry state, R_c	MPa	151,60
4	Uniaxial Compression Strength in saturated state, R_c	MPa	132,70

- According to the average uniaxial compression strength in saturated state, Geological Unit 27 is rock of medium strength (Rc=132,78 MPa).

Geological Unit 28

Dark-gray diabase and gray hornstone

Average nominal values of physical and mechanical parameters for soils in unit 28 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 28	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,71
2	Bulk Density, ρ	g/cm^3	2,57
3	Uniaxial Compression Strength in dry state, R_c	MPa	83.17
4	Uniaxial Compression Strength in saturated state, R_c	MPa	42.16

- According to the average uniaxial compression strength in saturated state, Geological Unit 28 is rock of medium strength (Rc=42.16 MPa).

Geological Unit 0-1

Green massive medium-fragmental and macrofragmental tuff (77%), with inclusions and lenses of light-gray and gray fine-grained sandstone and units (0,1-2 m, - 13%) of thin (1-15cm) layers of gray and brown-gray argillite an gray fine-grained and medium-grained sandstone (10%).

Average nominal values of physical and mechanical parameters for soils in unit 0-1 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 0-1	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,59
3	Uniaxial Compression Strength in dry state, R_c	MPa	33,25
4	Uniaxial Compression Strength in saturated state, R_c	MPa	21,23
5	Cohesion, C	MPa	5,80
6	Angle of internal friction, φ	degree	31,00

- According to the average uniaxial compression strength in saturated state, Geological Unit 0-1 is rock of medium strength (Rc=21,23 MPa);

Geological Unit 0-2

Dark-gray andesite cover (16m, - 41%) and gray and dark-gray coarse-fragmental andesite breccia (25m, - 59%).

Average nominal values of physical and mechanical parameters for soils in unit 0-2 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 0-2	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,70
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54.3
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39.12
5	Cohesion, C	MPa	10,60
6	Angle of internal friction, φ	degree	33,00
7	Elasticity modulus, E	MPa	3373.9
8	Poisson's ratio, μ	-	0.295

- According to the average uniaxial compression strength in saturated state, Geological Unit 0-2 is rock of medium strength (Rc=39.12 MPa).

Geological Unit 0-3

Green microfragmental and medium-fragmental tuff (0,5-2,0 m, - 70%), with interbeds of light-gray or light-brown sandstone (0.1-0,25-0,5m, - 15%), with thin (up to 8cm) interbeds of gray argillite (15%).

Average nominal values of physical and mechanical parameters for soils in unit 0-3 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 0-3	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,68
2	Bulk Density, ρ	g/cm^3	2,48
3	Uniaxial Compression Strength in dry state, R_c	MPa	30.12
4	Uniaxial Compression Strength in saturated state, R_c	MPa	20.15
5	Cohesion, C	MPa	5,98
6	Angle of internal friction, φ	degree	31,30

- According to the average uniaxial compression strength in saturated state, Geological Unit 0-3 is rock of medium strength (Rc=20.15 MPa).

Geological Unit 0-4

Dark-gray andesite cover (30м,-100%).

Average nominal values of physical and mechanical parameters for soils in unit 0-4 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 0-4	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54.3
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39.12
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33
7	Elasticity modulus, E	MPa	3373.5
8	Poisson's ratio, μ	-	0.295

- According to the average uniaxial compression strength in saturated state, Geological Unit 0-4 is rock of medium strength (Rc=39.12 MPa).

Soil samples were recovered for chemical testing from BH 14 (from the depth of 107, 140 and 150 m). According to the obtained data, soils from unit №25 are not aggressive to any grade of concrete. Results of the chemical tests and soil aggressivity testing are enclosed in Annex 2.2.

Lithostratigraphic units of Quaternary non-rock soils identified in the reservoir area are described in detailed in item 6, so the description is no longer necessary here.

There are no active geological processes and hazards within the diversion tunnel right-of-way. Note should be taken of rock slides from the right steep bank of the Mtkvari, upstream from southern portal, and insignificant erosion on the right bank in front of the portal site (see Geotechnical Map of the site, dwg. GC-0904-MH-7). Prior to construction of the headworks, including the southern tunnel portal, the right bank over the portal should be cleaned of hanging or unstable stones, some of which are of large sizes.

Geological processes within the tunnel could be conditioned by the tectonics and lithological composition of the massif, also to some extent by the technology of the tunnel excavation and strengthening.

A positive factor along the entire tunnel is the angle between the tunnel axis and the bed strike ranging primarily between 45^0 and 65^0, in some cases reaching 90^0.

Natural factors that could have a certain negative impact on the tunnel construction are the large quantity of fractures and low strength of some soil types, especially argillite. On some tunnel sections that go through strata where prevailing argillite, in addition to individual collapsing boulders and inrush, soil heaving could be expected from unsupported sides and the bottom.

The inrush volumes depend on the nature and degree of fracturing, the fracture thickness, length and type of intersections. Inrushes from the tunnel roof should be expected on the sections where fault intersect and the width of the weakened soil area with increased degree of fracturing is about 10-12 meters. Inrushes may also be due to incorrect or unobserved excavation technologies, large amounts of explosives or lagging in time and distance between excavation and supporting. In case of time lag in very fractured soils and especially in argillite that are also very prone to weathering, the soils are softened and collapsing more and more with time. The mass of the collapsed soils may increase proportionally to the length of the unsupported tunnel side. Therefore the design should also envisage an optimum tunnel excavation and supporting technology that should be complied with during the construction.

In addition, underground excavations may lead to heaving, rock pressure, bounce, bursts, inrush of groundwater and quicksand, inflows of adverse natural gas. At the western edge of the Trialeti range in the diversion tunnel it is from three sides open and surrounded by an arc-shaped section of the Mtkvari, suggesting that the once existing tectonic stress in the depth of the massive, at the tunnel depth, is now abating, so no overburden pressure, shooting, rock bursts caused by massive tension should occur. Some overburden pressure and respective insignificant massif deformations should be expected from the impact of gravity forced on the roof rock, also in argillites that may sharply change their condition and properties during tunneling, potentially also causing heaving and respective deformation of the tunnel bottom. Therefore the tunnel

should be supported on its entire girth. Tunnel support (lining) resistance to overburden pressure increases when the tunnel has a circular cross-section.

In our opinion, there are no reasons to expect large amounts of groundwaters and quick sand during tunnel construction, as the massif is exposed from three sides and dissected by fissures of different direction, which favors discharge of groundwater to the Mtkvari river, which decreases chances for accumulation of large water volumes and formation of quick sands.

Hydrogeological conditions of the diversion tunnel area are described in detail in 5.4. It should be noted that within the tunnel area groundwater was encountered at the depth of 6 meters in BH14. The water occurred during dry drilling without flushing.

The water was sampled from the depth of 5.8m in BH 14 for chemical testing. The tests showed that the water was aggressive to all grades of concrete based on Portland cement (State Standard GOST 10178-76) with sulfate component (see Annex 2.2). In addition, samples were recovered from almost all surface watercourses (springs, streams, rivers) in the vicinity of the proposed tunnel. According to the tests, the water is almost not aggressive to either concrete grade. Only in a small river at the village of Tsnisi (sample #7) the water was aggressive to all concrete grades based on Portland cement (GOST 10178-76) for sulfate component.

Results of the chemical tests and aggressivity testing are enclosed in Annex 2.2.

Adverse natural gas monitoring was also done during drilling in BH 14 as well as later on in sealed piezometer well installed in the cleaned borehole to the depth of 110m. No explosive or adverse gas was identifying by air testing in the borehole. Yet there might be some adverse natural gas in other parts of the tunnel area that have not been examined so far, so the monitoring should continue at later survey stages.

Temperature differences at different depths are also important for tunnel construction (e.g. temperature calculations for the Saint-Gotard tunnel in Swiss Alps, temperature models for the Zhinvali, Arkhoti, and Tari tunnels in the Greater Caucasus). This issue is of particular importance for the Lesser Caucasus as an area with increased heat flows. The central part of the Adjara-Trialeti is the area of maximum registered heat flows in Georgia (≈8.4-8.6•10-2W/m2).

In order to specify the geothermal gradient in the proposed tunnel area, temperature measurements were made in BH 14 (KP 69+04), and temperatures were 11,520C and 12,960C at the depths of 10 and 110 meters respectively. Hence the temperature gradient is calculated as follows:

$$gradT=(12.96-11.52)/100=1.44*10^{-2}$$

The maximum expected temperature in the proposed tunnel was calculated from the equation:

$$T=T_{110}+\Delta H \bullet gradT$$

Temperature calculations for different tunnel depths are given below:

KP	Altitude, m ASL	Design Tunnel Elevation	Tunnel Depth	ΔH	T, degree
38+89	1407,59	989,01	418,58	308,58	17,40
28+95	1288,86	991,00	297,86	187,86	15,67
55+74	1124,73	982,00	142,73	32,73	13,43
76+89	1116,02	981,41	134,61	24,61	13,31
1+89	1129,39	996,36	133,03	23,03	13,29

Tunneling and respective technical issues are shown on the Geotechnical Long-Section at 1:2000 (see drawings, dwg. № GC-0904-MH-11).

Geotechnical Conditions on the Equalizing Reservoir and the Powerhouse Area

The equalizing reservoir and the powerhouse will be located at the northern foot of Trialeti Range, on the right bank of the Mtkvari, near Sakuneti. Geomorphologically, the area is located in the eastern part of the Akhaltsikhe depression. The terrain in a slope inclined to the north, with average slope of 10-11^0. The slope surface is hilly, with erosion gullies and undulations. The deepest gully is in the central part of the area, and in the middle the gully slopes sharply go down to the depth of 25-30 meters. In the upper part the gully is shallow and adjoins the overall slope of the area. Another eroded gully, a smaller one, only 200m long, is located in the northeast part of the area.

There is an old debris cone in the middle at the foot of the slope. The cone consists of proluvial sediments accumulated in the period of active erosion in the above gullies. The cone surface is gentling sloping northward, towards the river. The cone foot adjoins the river floodplain terrace. The cone width along the river is 220-230 m, and the cone length (upslope) is 60-80 meters.

In the remaining part of the slope, to the east and west from the gully and the cone, the terrain is undulated, with rather plat locations and different depths of gullying.

According to geological structure described in 4.1, the equalizing reservoir and powerhouse area is built by rock and semi-rock of the middle series of Middle Eocene (Pg_2^{2b}), primarily by tuff (77%), sandstone (10%), argillite (10%), and andesite (3%).

On a large area the bedrock is covered with Quaternary sediments: alluvial, deluvial and proluvial loam, loamy sand (low plastic silt), sand and gravel and cobble. The thickness of the Quaternary sediments varied from several centimeters to 2,5-3 meters, reaching 9 meters in boreholes drilled at the foot of the slope, along the riverbank.

The identified lithostratigraphic units of rock and semirock strata within the reservoir and powerhouse area are shown on geological map at 1:25000 and respective geological-structural cross-section (see drawings, dwg. GC-0904-MH-1), also on the geotechnical map of the area at 1:1000 (see dwg. GC-0904-MH-9) and respective geotechnical sections (dwg. GC-0904-MH-10).

For detailed investigation of soils in the powerhouse area, at the right bank of the Mtkvari, three boreholes were drilled to 20 meters in the middle of the debris cone (BH 11, 12, and 13). Soil samples were recovered for testing physical and mechanical parameters. Borehole locations, soil sampling points as well as groundwater and surface water sampling points and geophysical tests are shown on the geological map (see drawings, dwg. GC-0904-MH-1 and GC-0904-MH-10).

Four units of rocks were identified in the area resulting from field and laboratory testing data. The units are shown on the geotechnical map and cross-sections (see dwg. GC-0904-MH-9 and dwg. GC-0904-MH-10).

The obtained data on physical and mechanical properties of soils types described in Chapter 6 were used to evaluate soil conditions at the equalizing reservoirs and powerhouse area according to individual lithostratigraphic units forming the strata.

Geological Unit 0-1

Green massive medium-fragmental and macrofragmental tuff (77%), with inclusions and lenses of light-gray and gray fine-grained sandstone and units (0,1-2 м, - 13%) of thin (1-15см) alternation of gray and brown-gray argillite and gray fine-grained and medium-grained sandstone (10%).

Average nominal values of physical and mechanical parameters for soils in unit 0-1 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 0-1	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,59
3	Uniaxial Compression Strength in dry state, R_c	MPa	33,25
4	Uniaxial Compression Strength in saturated state, R_c	MPa	21,23
5	Cohesion, C	MPa	5,80
6	Angle of internal friction, φ	degree	31,00

- According to the average uniaxial compression strength in saturated state, Geological Unit 0-1 is rock of medium strength (R_c=21,23 MPa).

Geological Unit 0-2

Dark-gray andesite cover (16м, - 41%) and gray and dark-gray coarse-fragmented andesite breccias (25м, - 59%).

Average nominal values of physical and mechanical parameters for soils in unit 0-2 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 0-2	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,70
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	Value
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39,13
5	Cohesion, C	MPa	10,60
6	Angle of internal friction, φ	degree	33,00
7	Elasticity modulus, E	MPa	3373
8	Poisson's ratio, μ	-	0,295

- According to the average uniaxial compression strength in saturated state, Geological Unit 0-2 is rock of medium strength (Rc=39,13 MPa);

Geological Unit 0-3

Green microfragmental and medium-fragmental tuff (0,5-2,0 m, - 70%), interlaid with light-gray or light-brown sandstone (0.1-0,25-0,5m, - 15%), thin (up to 8cm) interbeds of gray argillite (15%).

Average nominal values of physical and mechanical parameters for soils in unit 0-3 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 0-3	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,68
2	Bulk Density, ρ	g/cm^3	2,48
3	Uniaxial Compression Strength in dry state, R_c	MPa	30,32
4	Uniaxial Compression Strength in saturated state, R_c	MPa	20,15

5	Cohesion, C	MPa	5,98
6	Angle of internal friction, φ	degree	31,30

- According to the average uniaxial compression strength in saturated state, Geological Unit 0-3 is rock of medium strength (Rc=20,15 MPa);

Geological Unit 0-4

Dark-gray andesite cover (30m,-100%).

Nominal values of physical and mechanical parameters for soils in unit 0-4 are shown in the table below:

#	Physical and Mechanical Properties of Soils in Unit 0-4	Unit	Value
1	Particle Density, ρ_s	g/cm^3	2,69
2	Bulk Density, ρ	g/cm^3	2,45
3	Uniaxial Compression Strength in dry state, R_c	MPa	54,3
4	Uniaxial Compression Strength in saturated state, R_c	MPa	39,13
5	Cohesion, C	MPa	10,6
6	Angle of internal friction, φ	degree	33
7	Elasticity modulus, E	MPa	3373
8	Poisson's ratio, μ	-	0,295

- According to the average uniaxial compression strength in saturated state, Geological Unit 0-4 is rock of medium strength (Rc=38,49 MPa).

Lithostratigraphic units of Quaternary non-rock soils identified in the proposed reservoir area, identified with unique numbers, are discussed in detail in Chapter 6, so the discussion is not repeated here.

Chemical tests were done of water extracts from non-rock soil samples recovered from BH11 and BH13 from the reservoir and powerhouse area. According to the obtained data, the soils are not aggressive to any grade of concrete.

There are small proluvial debris in the upper part of the debris cone. The proluvial debris is brought by temporary surface flows running down from the above-described gullies after rains or snow melting. Also, there is side erosion in some locations on the right bank. The banks are eroded during floods when the river floods the floodplain terrace reaching up to the foot of the debris cone and eroding it.

Protruding rock in the upstream and downstream ends of the area protect the right bank there from the side erosion. Yet the Mtkvari could pose a serious risk to buildings and facilities located close to the bank in case the hydraulic regime of the river changed and the river started actively eroding the right bank consisting of loose-fragmental and clayey soils of the alluvial terrace and the debris cone.

Groundwater was encountered in all the 3 boreholes. Stabilized groundwater levels were identified at the river level, which confirms hydraulic interconnection between the groundwater and the river through sand-gravel and cobble alluvial sediments. High permeability of the sediments conditions the fluctuation of the groundwater level in the bank area synchronously with the fluctuation of the river water level.

No springs and other surface sources of groundwater were identified in the area. So presumably the groundwater occurs at the level similar to the river water level.

According to chemical tests of water samples recovered from BH13, the groundwater is not aggressive to any concrete grade. Results of the sample tests are enclose din Annex 2.2.

8. Local Building Materials

According to data available from literature and the Internet, there are deposits and exposures of the following building materials around the planned construction site: inert materials (gravel and sand), light concrete aggregates (scoria), building stone (tuff, tuff-breccias, basalt, dolerite, and teschenite), facing stone and rubble (basalt, dolerite, and teschenite), bentonitic clay and brick clay. A schematic map of nonmetallic deposits and exposures at 1:50000 (see Drawings, dwg. GC-0904-MH-3) is attached to this report. The table below shows all deposits and exposures with indication of their numbers, names, reserves of materials, extent of exploitation and exploration. A thorough examination of particular inert and building materials is necessary to determine usability of relevant deposits.

List of Nonmetallic Deposits and Exposures along the Mtkvari Valley in Akhaltsikhe and Aspindza Districts

#	Deposit/exposure no. on the map	Names and Locations of Deposits and Exposures	Mineral	Range of Application	Material Reserves (thousand m^3)	Exploitation and Prospects	Notes
1	-	Vale-1 deposit; 3 km to the west of Akhaltsikhe, the Potskhovi floodplain	Gravel and sand	Inert materials	B+C 7800	Licensed exploitation of separate sections	Studied in detail in 1964 (outside the map)
2	1,2,3	Akhaltsikhe-Tsnisi and Minadze deposit, at the juncture of the Mtkvari and Potskhovi	Gravel and sand	Inert materials	Probable P-2000	Licensed exploitation (80ha) by Meskheti-XXII, License № S/G-010	Studied during exploration
3	4	Atskuri exposure; 2,5 km SW, the Mtkvari floodplain	Gravel and sand	Inert materials	900	Licensed exploitation (32 ha) by Meskheti-XXII, License № 539	Studied during exploration and evaluation survey
4	7	Idumali exposure, the Mtkvari Valley, between the villages of Idumala and Rustavi, 4 sections	Gravel and sand	Inert materials	P-200	Licensed exploitation by Shoreti Ltd. License № 00061	Not studied
5	12	Mugareti exposure, the Mtkvari floodplain, 1 km to the south of the village of Mugareti	Gravel and sand	Inert materials	P-37	License holder Armazi Ltd (1,24ha), License № 00907	Not studied
6	13	Tsnisi exposure, 1km NE of the village of Tsnisi, the Mtkvari floodplain	Gravel and sand	Inert materials	P-25	License holder Otskhe Ltd. (0,95ha), License № 00155	Not studied
7	15	Rustavi exposure; 0,8 km NW of the village of Rustavi (synonym 'Kornebis Bode')	Presumably, volcanogenic materials	Inert materials	P-50	License holder Mshenebeli-2 (2,0ha), License № 00623	Not studied
8	8	Orgoro exposure; 0.7 km to the west of Orgoro village	Scoria	Light concrete aggregate	P-20	License holder Omo Ltd. (1,76 ha), License № 00256	Studied during exploration
9	9	Chobareti exposure; 5 km NW of Chobareti village	Tuff	Building stone	P-30	License holder Omo Ltd. (1,47 ha), License № 00257	Not studied
10	5	Gurkeli exposure; 1 km to the north of Gurkeli village, 1st section	Tuff-breccias	Building stone	P-10	License holder Saukmsheni (0,76 ha), License № 100157	Not studied
11	14	Gurkeli exposure; 2nd section	Tuff-breccias	Building stone	P-10	License holder Arali Ltd.	Not studied

#	Deposit/exposure no. on the map	Names and Locations of Deposits and Exposures	Mineral	Range of Application	Material Reserves (thousand m^3)	Exploitation and Prospects	Notes
12	10	Indusa exposure, 2 km to the south of Indusa village	Basalt (Dolerite)	Building stone	P-10	License holder (1,83ha) Akhaltsikhis Gvinis Karkhana, License № 00270	Not studied
13	11	Saukuneti exposure, 3 km SW of Saukuneti village	Teschenite	Building and facing stone	P-25	License holder Arali Ltd. (1,4ha) License № 00258	Found during exploration. Not studied
14	6	Gabieti and Kaliani exposures, 5-7 km NE of Dzveli village, 3 sections	Basalt (accumulations of blocks)	Building and facing stone, rubble	P-27	License holder Peritsikhe Ltd. License № S/DK-019	Registered during exploration. Not studied
15	-	Khizabavra deposit, 8-10 km SE of Aspindza, in Khizabavra village environs	Dolerite	Facing stone and rubble	$A+B+C_1$ – 14200 C_2-13900	Was under development; Present state unknown	Studied in detail in 1984 (outside the map)
16	-	Arali deposit	Bentonitic clay	Chemical industry.	$A+B+C_1$ – 8795	Unknown	Studied in detail
17	-	Churchuto-Chikheli deposit	Bentonitic clay	Chemical industry	$A+B+C_1$ – 16600	Unknown	Studied in detail
18	-	Akhaltsikhe (Tsintskaro) exposure	Brick clays	Ceramics	Not calculated	Not exploited	No estimated
19	-	Clay exposures in the environs of Idumala and Rustavi villages	Brick clays	Ceramics	Not calculated	Not exploited (unfit for making bricks)	Studied during exploration

9. Conclusions

9.1 The proposed construction site of the Mtkvari HPS and its environs are positioned in the moderately humid subtropical zone with typical climate of submountain steppe, cold winter with small amount of snow and long warm summer. Average yearly air temperature is 9-10^0, absolute minimum air temperature is -32^0, absolute maximum - +39^0;

9.2 Morphologically the largest part of the study area is positioned in the centre of the Trialeti upland and only a small northern part is located in the Akhaltsikhe depression. The reservoir and the headworks will be situated in the bottom of the valley, near the village of Rustavi; the diversion tunnel will cross the Trialeti ridge from its western edge, while the HPS will be located on the right bank of the Mtkvari, close to the village of Sakuneti;

9.3 The Mtkvari River is the main watercourse in the proposed construction site area. There are four minor tributaries within the planned construction site. Two of them are flowing down the Trialeti ridge close to the village of Rustavi, while two other tributaries are streaming down from the northern slope of same ridge close to the village of Sakuneti;

9.4 Medium-grained volcanogenic and sedimentary soils dated back to the Middle Eocene are spread in the study area. The sediments are represented by tuff-breccias and layered tuffogenic series. Upper Eocene is represented by clayey and sandy facies. Lithologically the series are mainly composed of sandstone, tuff, argillite, andesite and andesite breccias. Tuff, breccia and andesite form thicker layers, sandstones form intermediate layers, while argillite layers range from thin to thick; some lithologic elements form massive layers. In some locations the sediments have inclusions of intrusive hornstone and diabase bodies;

9.5 Hydrogeologically the alluvial shingle in the bottom of the Mtkvari valley, where the reservoir and the dam are planned to be constructed, is the most water-saturated formation. The river is the main feeding source for groundwater there. The rocks under the shingle are also water-saturated, while the rocks building the Trialeti ridge along the tunnel route are weakly saturated. The fracture waters of the massif are fed by precipitation. Groundwaters discharge through the fractures at the Mtkvari level (i.e. at the local base level). Layers and units of andesite, sandstones, tuff and breccias are characterized by rather high permeability, while argillites have low permeability. While constructing the tunnel, drips and spurts may occur in the sections cut in highly permeable rocks, within the bottoms of surface streams and in highly fissured zones of tectonic fractures. Strong dripping should be expected in the tunnel section under the crest of the ridge, built with highly permeable rocks, where the tunnel passes close to the surface. Some dripping may occur in the tunnel sections close to the surface, cut in low-permeability formations, namely argillites. The total length of such sections makes up the major part of the tunnel;

9.6 With regard to geodynamic conditions, landslides occur on both banks of the Mtkvari in the proposed reservoir site. The landslides are formed in clayey-detrital diluvial-proluvial surface sediments. The reservoir construction is unlikely to cause any complications or environmental changes there, although landslides may become more active until they become relatively stabilized in the newly created conditions. Intensification of landslides on the right bank may lead to further deformation of the roadbed in the sections, where it has already been deformed by landslides. New deformation, caused by landslides, may occur in some sections of the road close to the cornices subject to washing. Minor proluvial events in the mouths of small side ravines should be mentioned among physical geological events occurring in the planned reservoir site, which will not have any adverse impact on the construction, though. Other noteworthy events are: the rockfalls in the planned headworks are on the right steep rocky slope and the signs of washing of the right bank and minor proluvial debris in the gullies on the slope in the power house area;

9.7 Rocks differ from each other by their conditions and properties. Lithologically, teschenite and diabase are relatively weakly-fractured and with high strength, but not spread widely. Andesite, tuff, andesite breccias and hornstones are also weakly fractured and with medium strength. Sandstones have medium strength and medium fracture; argillites are highly fractured, with low strength. According to their strength values, all these varieties should be referred to rocks, except for the argillites that are semi-rock. An important favorable factor for the diversion tunnel construction is that the angle between the tunnel axis and the course of the beds ranges from 45^0 to 65^0 and in some locations makes 90^0. Such a natural factor as the presence of highly fractured rocks with low strength, especially the argillites, will have a certain negative impact on the tunnel construction. Separate blocks and soil may fall in the tunnel sections cut in the argillite

layer. Volumes of falling blocks and soils will depend on type and degree of fracturing, density of fractures, their length and intercrossing;

9.8 According to data obtained by drilling BH14 along the diversion tunnel axis on the Trialeti ridge, soil temperature in different sections of the tunnel will range between 12^0 and 17^0C. No natural gases, explosive or harmful for human health, have been revealed in the borehole.

9.9 Full information on seismic conditions in the planned area of main HPS facilities is available in the special report in Appendix 5.

10. Recommendations

10.1 As it was mentioned above, submerging of landslide-prone slopes in the reservoir area may cause activity of existing and new landslides and lead to deformation of the roadbed as it has already happened in several sections. Adverse impact on the road stability may be reduced by shrinking the submerged zone;

10.2 Since the floodplain terrace of the Mtkvari in the dam area is built with highly permeable alluvial shingle (98m/day), the dam should be based on the rocks underlying the shingle. Although the underlying andesite bedrock is less permeable than the shingle (according to results of the permeability tests, bedrocks range from weakly permeable to highly permeable), special measures should be carried out to diminish their permeability;

10.3 Prior to constructing the southern tunnel portal and other facilities within the proposed area, special measures should be taken to prevent stones or blocks from falling from the steep, precipitous slope above the construction site. One of possible measures is removal of unstable stones from the slope. The portal site at the base of the slope should be cleaned from fallen stones and earth in order to establish the portal on the rock after removing its weathered surface.

10.4 Separate blocks and soil may fall in the tunnel section passing through the weathering-prone argillites. If the tunnel lining (support) comes off the mass of fallen soil and blocks may increase proportionally to the length of the unlined section. This is why the project should involve development of an optimal tunnel lining technology that should be observed during the tunnel construction;

10.5 In the tunnel sections built with argillites with changeable conditions and properties, soil heaving may cause deformations, namely, swelling of tunnel floor. This is why the tunnel should be supported with lining along its cross-section. Tunnel lining resistance to external pressure is higher with circular cross-section.

10.6 To ensure safety of the HPS to be positioned near the right bank of the Mtkvari, close to the village of Sakuneti, the construction site should be selected considering that the central part of the area, built with proluvial clayey detrital soils, will be subject to side erosion and washing. The HPS should be built in an area built with rocks (in the upper or lower sections of the proposed construction site). The power house should be also protected from the surface waters flowing down the slope.

10.7 The surveys that have been conducted at this stage do not provide information sufficient for estimating conditions along the entire length of the diversion tunnel, including information on condition of soils at the tunnel depth, massif watering, occurrence of explosive or harmful natural gases, etc. Specification of these and other issues should be envisaged at the following stages of the project.

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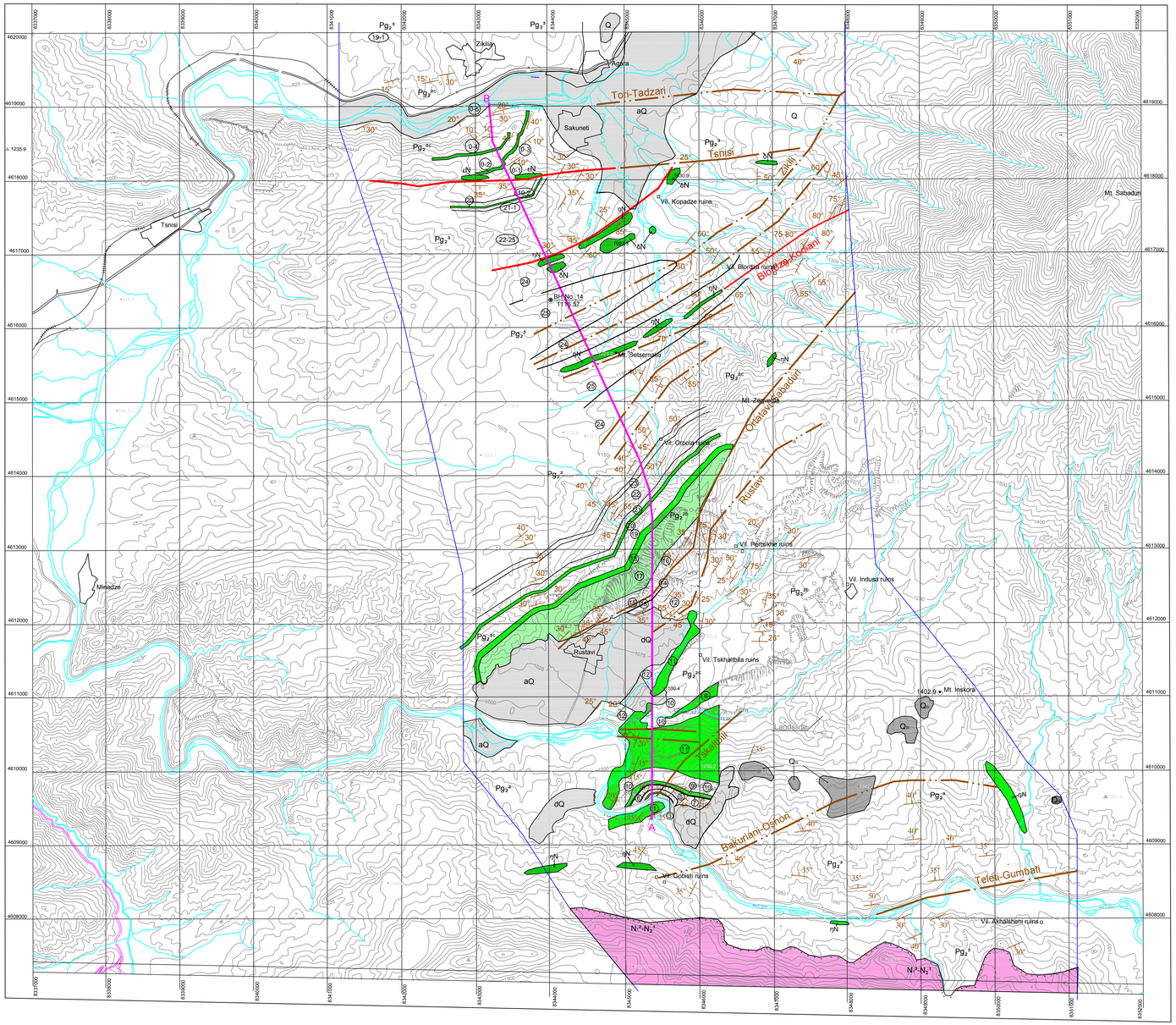
Lithologic-stratigraphical Column

Sub-level	Index	Member No.		Thickness	Stratum Description
Quarternary	Q				Terrace, alluvium, proluvium, deluvium
	Q_{III}			>20	Doleritic stream
Upper Miocene Lower Pliocene	N_1^2-N_2^1			300-1100	***Kisatib formation.*** Doleritic and andesite lavas and their pyroclastics with diatomite layers in places at the upper part.
Upper Eocene	Pg_2^3	25		>250	Alternation of dark grey argillites and light brown and grey fine-grained sandstones, at times light green fine and medium-grained tuffs.
		24		>310	Light green fine and medium-grained tuffs (0.5-1.2m) with grey and light grey fine and medium-grained sandstones interlayers (0.05-0.2-0.7m)
		23		65	Grey and greenish-grey fine and medium-grained massive sandstones (0.4-1.3m) with interbedded members of grey argillites thin alternation, grey fine-grained sandstones and light green fine-grained tuffs
Middle Eocene (upper formation)	Pg_2^{2c}	22		138	Greenish-grey medium-grained massive sandstones with greenish medium-grained tuff interlayers and grey argillites.
		21		62	Alternation of grey and green medium-fragmental tuffs (0.5-1.5m), medium-grained sandstones (3-5-7cm) and dark grey silicified argillites (1-3cm). Greenish-grey medium-grained sandstone at the lower part (2m).
Middle Eocene (middle formation)	Pg_2^{2b-c}-Pg_2^3	22-25		>200	Green micro and medium-fragmental tuffs (0.5-2.0m) with light grey and light brown sandstone interlayers (0.1-0.25-0.4m), in places thin (up to 10cm) and massive (up to 3m) interlayers of grey argillites.
		21-1		20	Dark grey silicified and slightly silicified argillites (0.15-0.25m). Light brown fine-grained sandstone (2m) at the lower part.
		20		20	Dark grey andesite cover (flow breccia).
		19-2		50.5	Green massive medium-fragmental tuffs with interlayers of interbedded members of grey and dark grey silicified argillites in places and grey and light brown fine-grained sandstones.
		19-1		>150	Light green micro and medium-fragmental tuffs (0.5-1.5m) with interlayers of light grey or light brown consertal sandstones (0.1-0.4m) and grey thin (0.05-0.1m) argillites.
	Pg_2^{2b}	20		23	Dark grey andesite cover (flow breccia) with strongly marked spheroidal jointings (4m) at the lower part.
		19		66	At the upper part: dark green massive fine and medium-grained tuffs with dark grey argillites and grey sandstone interlayers (1-15cm) - 17.2m. At the lower part: light green microfragmental tuffs with interlayers of thinly (1-7cm) interbedded members of grey and green fine-grained tuffs, grey argillites and grey fine-grained sandstones - 48.8m.
		18		30	Dark grey andesite cover (flow breccia).
		17		270	Dark brown, in places dark green, andesite cover (flow breccia) with well-marked coarse-grained crystals.
		16		140	Light green micro and medium-fragmental tuffs (0.3-1.0m) with interlayers of light grey consertal sandstones and grey argillites (2-15cm).
		15		12	Greyish-green massive medium-grained, in places interstratified, sandstones
		14		30.7	Alternation of thickly bedded brownish-green micro and macrofragmental tuffs, light green and brownish-black silicified argillites and greenish-grey fine and medium-grained banded sandstones.
		13		5	Dark grey andesite cover (flow breccia).
		12		146	Grey and greenish-grey various fragmental tuffs with interlayers of purple argillites and interbedded members of thinly bedded dark red argillites and light grey sandstones, with added green microfragmental breccias of andesite content at the lower half .
		11		41	Dark grey andesite cover (flow breccia).
		10		45	Alternation (5-60cm) of grey and greenish-grey argillites and fine-grained sandstones with interlayers of green microfragmental tuff (1.2m) and grey and greenish-grey medium-grained massive bedded (1-3m) sandstones. At the lower part: interbedded (5-40cm) member (2.2m) of dark grey silicified argillites and grey fine-grained sandstones.
		9		21-36	Dark grey andesite cover (flow breccia).
		8		7	Alternation of greenish-grey medium-grained sandstones (0.25-1-1.5m) and grey sandy argillites (6-25cm) .
		7		13	Dark grey andesite cover (flow breccia) with spheroidal jointings (10-50cm) at the lower part.
		6		25	Greenish-grey medium-grained sandstone.
		5		6	Dark grey andesite cover (flow breccia) with spheroidal jointings.
		4		27	Greenish-grey massive consertal sandstones (0.3-0.6m) with interlayers of grey and greenish-grey medium-fragmental tuffs (0.15-1.0m) and grey and brown argillites (0.1-3.5m).
		3		15	Dark grey andesite cover (flow breccia).
		2		25	Greenish-grey massive bedded medium-grained sandstones with rare interlayers (2-10cm) greenish-grey sandy argillites.
		1		>72	Grey andesite cover (flow breccia).
		0-5		48.8	Alternation of green fine and medium bedded tuffs (0.4-4.5m) with interbedded members (0.2-5.3m) of grey and purple argillites (0.05-0.1m) and grey and greenish-grey fine and medium-grained sandstones (0.01-0.1m) and light green fine-grained tuffs (0.02-0.05m).
		0-4		30	Dark grey andesite cover (flow breccia).
		0-3		25	Green micro and medium-fragmental tuffs (0.5-2.0m) with interlayers of light grey and light brown sandstones (0.1-0.25-0.5m), in places grey argillite thin interlayers (up to 8cm).
		0-2		41	Dark grey andesite cover (flow breccia) of 16m and grey and dark grey macrofragmental breccia of andesite content (25m).
		0-1		>75	Green massive medium and macrofragmental tuffs with light grey and grey fine-grained sandstone inclusions and lens and thin interbedded (1-15cm) members (0.1-2m) of grey and brownish-grey argillites and grey fine and medium-grained sandstones.

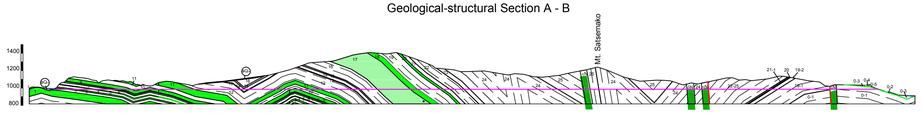
Intrusive rocks

- ηN — Dark grey diabase and grey hornfels
- εN — Macrocrystalline teschenite
- δN — Medium-grained Teschenite

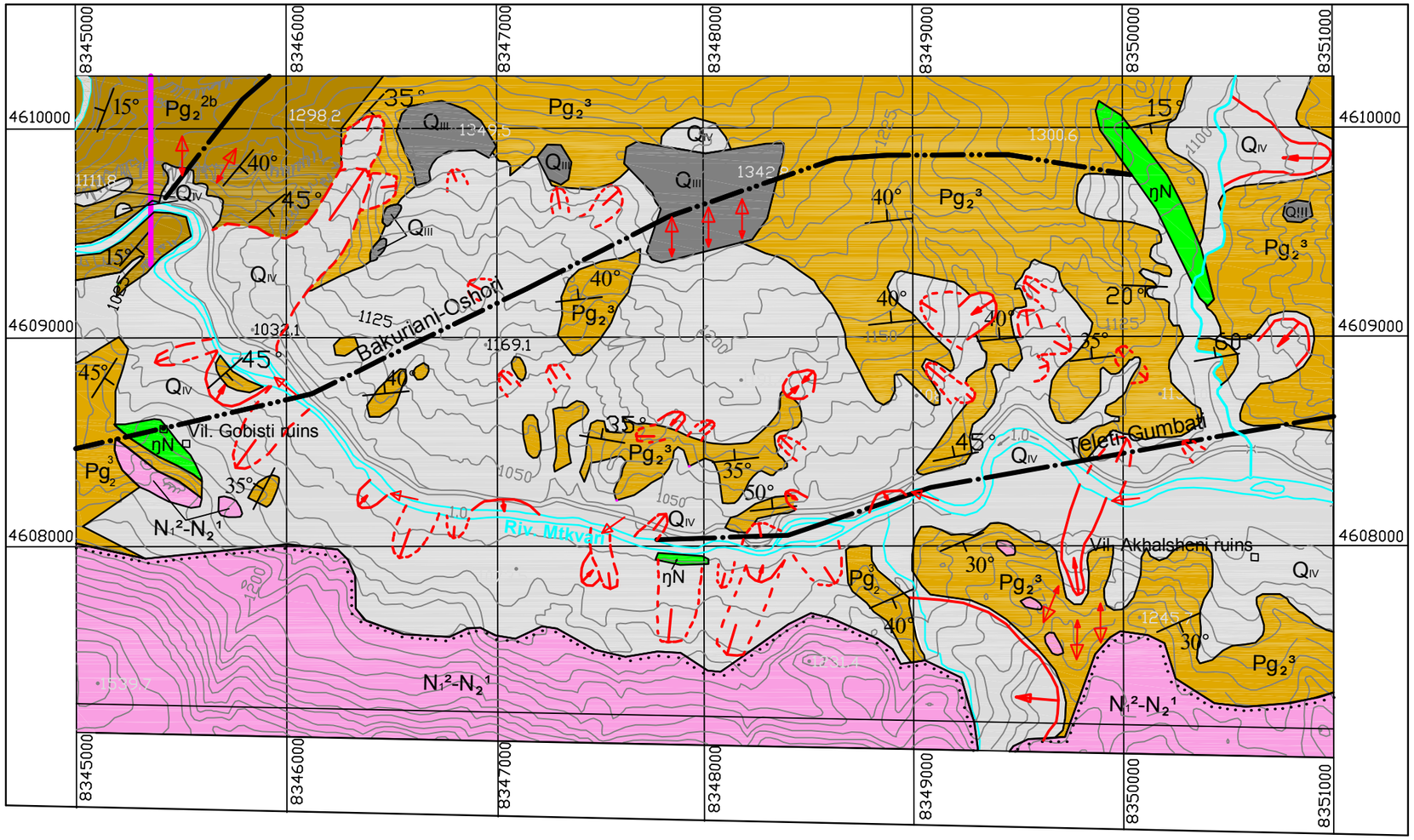
- borders of lithologic-stratigraphical units
- (12) - serial number of lithologic-stratigraphical units
- fault
- section line
- anticlinal axis (anticlinal name, e.g. Ortatavi-Sabaduri, is given along the appropriate axis line type)
- synclinal axis (synclinal name, e.g. Bakuriani-Oshori, is given along the appropriate axis line type)
- 30° - bedding elements



Geological-structural Section A - B



GeoEngineering Ltd. Civil Engineering - Survey, Design, Construction, Consulting	**Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia**
	Geotechnical Investigation
	Geological Map and Geological-structural Section — GC-0904-MH-1
	Sheet 1 / 1
	Scale 1:25000 — Date: 2-May-2009



LEGEND:

Q_{IV}	Modern alluvial, diluvial-proluvial, colluvial-diluvial, landslide and colluvial deposits
Q_{III}	Upper Quarternary Doleritic cover
N_1^2-N_2^1	Upper Miocene - lower Pliocene. Kisatib formation. Doleretic and andesite lavas and their piroclastics with diatomite layers in places at the upper part
ηN	Dark grey diabase and grey hornfels
Pg_2^3	Upper Eocene. Tuffs, argillites, sandstones, interbedded members of argillites and argillaceous sandstones
Pg_2^{2b}	Middle Eocene (middle formation). Sandstones, argillites, tuffs and andesite covers

Borders of lithologic-stratigraphical units

Unconformability

15° — Strike, inclination and inclination angle of seam

- synclinal axis (synclinal name, e.g. Teleti-Gumbati, is given along the appropriate axis line type)

- anticlinal axis (anticlinal name, e.g. Bakuriani-Oshori, is given along the appropriate axis line type)

Underwashing and erosion of river banks (lateral erosion)

Active landslide

Stabilized landslide

Talus

Tunnel line

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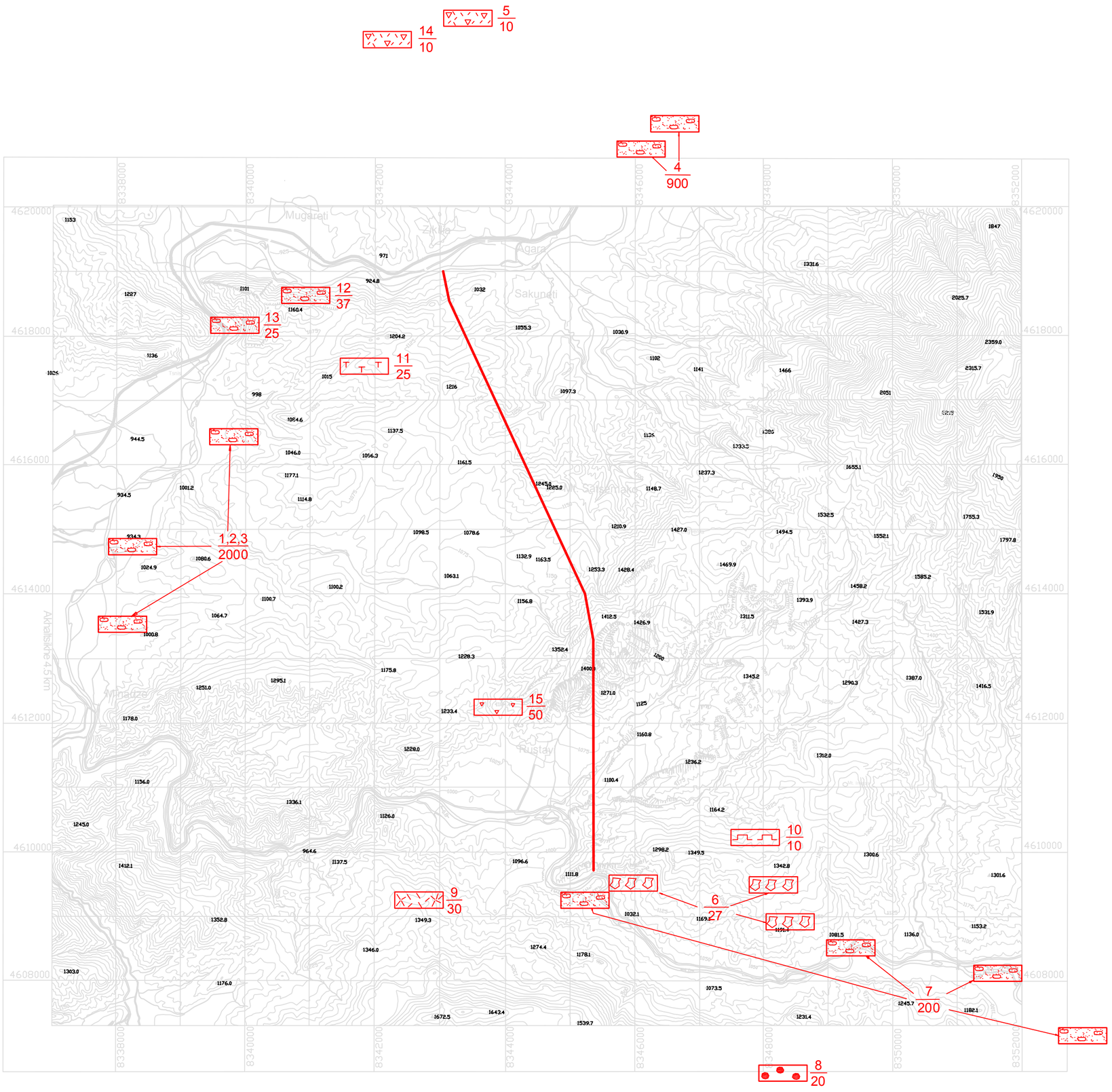
Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

Schematic Engineering-geological Map of Water Reservoir Site	GC-0904-MH-2
	Sheet 1 / 1
Scale 1:25000	Date: 12-May-2009



LEGEND:

15/50 — Number of Deposit and Occurrence on the Map (1)
Reserve of stuff, thousand m³ (50.0)

— Gravel and sand

— Detritus

— Scoria

— Tuff

— Tuff breccia

— Basalt

— Teschenite

— Basalt (blocky accumulation)

— Dolerite

— Bentonite

— Brick clay

GEOENGINEERING LTD. Civil Engineering - Survey, Design, Construction, Consulting	**Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia** **Geotechnical Investigation**	
	Schematic Map of Deposit and Occurrence of Non-metallic Minerals	GC-0904-MH-3 Sheet 1 / 1
	Scale 1:50000	Date: 6-May-2009

Hydroelectric Power Station (HPS) at the River Mtkvari in Georgia.

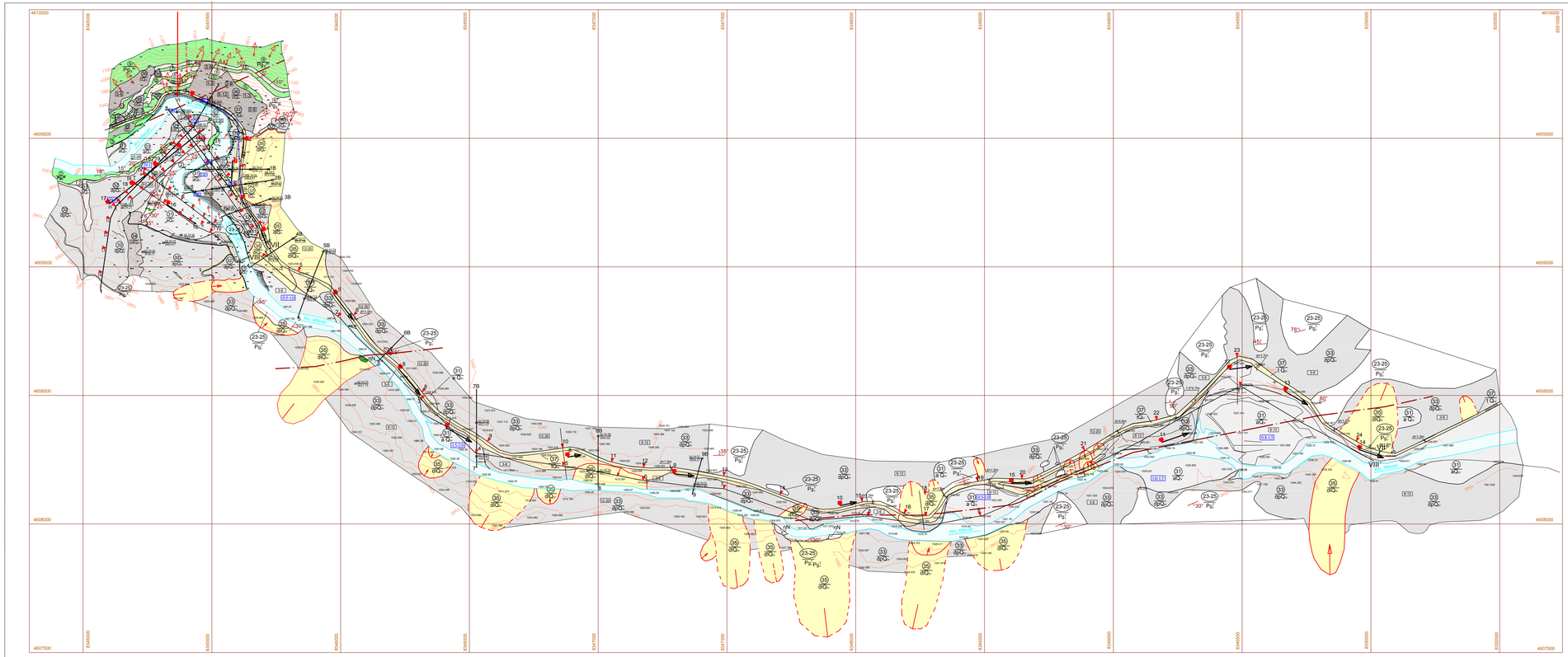
Local Construction Materials

According to the existing library materials and data obtained from the Internet, deposition and occurrence of construction materials, in particular inert materials (gravel and sand), light concrete aggregates (scoria), building stone (tuff, tuff breccia, basalt, dolerite, teschenite), facing and quarry stone (basalt, dolerite, teschenite), bentonite and brick clay. Schematic Map (scale 1:50000) of Deposit and Occurrence of Non-metallic Minerals is attached to this Report. Also, below you can find tables listing all deposits and occurrences indicating their number, name, reserve of stuff, performance and status of their study. In order to obtain more precise information on usability of one or another deposit or occurrence, it will be necessary to study appropriate inert and construction materials in detail.

List of deposits and occurrence of non-metallic minerals located along the river Kura (Mtkvari) ravine in Akhaltsikhe and Aspindza regions

No.	No. of deposits and occurrence on the Map	Deposit or occurrence name and location	Mineral deposits	Field of application	Reserve of stuff, thousand m^3	Exploitation and possibilities	Comments
1	-	Vale-1, deposit; In 3 km westward of Akaltsikhe in the riv. Potskhovi flood-plane	Gravel and Sand	Inert materials	B+C 7800	Was used; licensed by separate areas	Studied in detail in 1964 (located beyond the map borders)
2	1,2,3	Akhaltsikhe-Tsnisi and Minadze, near confluence of the riv. Kura and the riv. Potskhovi	Gravel and Sand	Inert materials	Hypothetical P-2000	Licensed (80ha), Currently used by "Mesketi-XXP", License No. S/DJ-010	Studied at exploration stage
3	4	Atskuri occurrence; in 2.5 km S-Westward, in the riv. Kura flood-plane	Gravel and Sand	Inert materials	900	Licensed (32ha), "Mesketi-XXP", License No. 539	Studied at exploration stage of evaluation works
4	7	Idumala occurrence; in the riv. Kura ravine from Idumala village to Rustavi vallage, 4 areas	Gravel and Sand	Inert materials	P-200	Were licensed (license No. 00061), was used by Shoreti Ltd	Not studied
5	12	Mugareti occurrence in the riv. Kura flood-plane, in 1 km southward of Mugareti vallage	Gravel and Sand	Inert materials	P-37	Licensed by Armazi Ltd (1.24ha), License No. 00907	Not studied
6	13	Tsinisi occurrence; in 1 km N-Eastward of Tsnisi village, Akhaltsikhe in the riv. Kura flood-plane	Gravel and Sand	Inert materials	P-25	Licensed by Otskhe Ltd (0.95ha), License No. 00155	Not studied
7	15	Rustavi occurrence; in 0.8 km N-Westward of Rustavi village ("Kornebis bude")	Possibly volcanic fragmental material	Inert materials	P-50	Licensed by Mshenebeli-2 Ltd (2.0ha), License No. 00623	Not studied
8	8	Orgoro occurrence; in 0.7 km Westward of Orgoro village.	Scoria	Light concrete aggregate	P-20	Licensed by Omo Ltd (1.76ha), License No. 00256	Studied at exploration stage
9	9	Chobareti occurrence; in 5 km N-Westward of Chobareti village.	Tuff	Building stone	P-30	Licensed by Omo Ltd (1.47ha), License No. 00257	Not studied

No.	No. of deposits and occurrence on the Map	Deposit or occurrence name and location	Mineral deposits	Field of application	Reserve of stuff, thousand m^3	Exploitation and possibilities	Comments
10	5	Gurkeli occurrence; in 1 km Northward of Gurkeli village, 1st area	Tuff breccia	Building stone	P-10	Licensed by Saukmsheni Ltd (0.76ha), License No. 100157	Not studied
11	14	Gurkeli occurrence; 2nd area	Tuff breccia	Building stone	P-10	Licensed by Arali Ltd	Not studied
12	10	Indusi occurrence; in 2 km southward of Indusa village	Basalt (Dolerite)	Building stone	P-10	Licensed by Akhaltsikhis Gvinis Karkhana Ltd (1.83ha) License No. 00270	Not studied
13	11	Sakuneti occurrence; in 3 km S-Westward of Sakuneti village.	Teschenite	Building and facing stone	P-25	Licensed by Arali Ltd (1.4ha) License No. 00258	Registered during exploration. Not studied
14	6	Gabieti and Kakliani occurrences; in 5-7 km N-Eastward of Dzveli village (3 areas)	Basalt (blocks accumulation)	Building, quarry and facing stone	P-27	Licensed by Peritsikhe Ltd License No. S/DK-019	Registered during exploration. Not studied
15	-	Khizabavra occurrence; in 8-10 km S-Eastward of Aspindza Regional Center in precinct of Khizabavra village	Dolerite	Facing and quarry stone	$A+B+C_1$ – 14200 C_2-13900	Was mined. Current status is unknown	Studied in detail in 1984 (located beyond the map borders)
16	-	Arali deposit	Bentonite (clay)	Chemical industry	$A+B+C_1$ – 8795	Unknown	Studied in detail
17	-	Churchuto-Chikheli deposit	Bentonite (clay)	Chemical industry	$A+B+C_1$ – 16600	Unknown	Studied in detail
18	-	Akhaltsikhe (Tsintskaro) occurrence	Brick clay	Ceramic branch	Not calculated	Not used	Not evaluated
19	-	Occurrence of clay in precinct of Idumala and Rustavi villages	Brick clay	Ceramic branch	Not calculated	Not used (unusable for brickmaking)	Studied at exploration stage



LEGEND:

1. Engineering-geological Description of Soils

A. ROCKS

Group	Subgroup	Variety by Strength	Symbol and Geological Index	Number of lithologic-stratigraphical unit (member, formation, intrusive or effusive formations)	Description
Magmatic and metamorphic	Intrusive and contact metamorphic	Moderately strong	$\gamma\delta N_1$	28	Dark grey diabase and grey hornfels
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-46 % Moderately strong-50%	Pg_2^1	23-25	Grey and greenish-grey micro and medium-fragmental tuff (11%), light grey argillite (4%), light grey and grey fine-grained clayey sandstones (3%) and thin (1-40cm) interbedded members of light grey and grey fine-grained clayey sand-stones (82%)
Magmatic	Effusive	Moderately strong	Pg_2^{2b}	9	Dark grey andesite cover (flow breccia) (21-36m-100%)
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-50 % Moderately strong-50%	Pg_2^{2a}	8	Alternation of greenish-grey medium-grained sandstones (0.25-1.1-5m) and grey sandy (6-25cm) argillites (7m-100%)
Magmatic	Effusive	Moderately strong	Pg_2^{2b}	7	Dark grey andesite cover (flow breccia) with spheroidal jointings (10-50cm) at the lower part (13m-100%)
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-24 % Moderately strong-76%	Pg_2^{2a}	6	Greenish-grey medium-fragmental tuff (2.2m-10.53%),light green fine-grained sandstone (8.0m-42.11%) and alternation of grey fine-grained (2.0-40.0cm) sandstones and grey (0.5-25.0cm) argillites (9.0m-47.36%)
Magmatic	Effusive	Moderately strong	Pg_2^{2b}	5	Grey andesite cover (flow breccia) (0.5m-100%)
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-26 % Moderately strong-75%	Pg_2^{2a}	4	Greenish-grey and grey massive medium-grained sandstones (17.2m-54.43%) and grey argillite (1.1m-3.48%) with interbedded members of grey fine-grained (2.0-25.0cm) sandstones and grey (0.5-20.0cm) argillites (13.3m-42.09%)
Magmatic and sedimentary cemented	Effusive and silty-clayed (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	3	3.65m-75.26% grey andesite cover (flow breccia) and grey sandy argillite (1.2m-24.74%)
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-55 % Moderately strong-45%	Pg_2^{2a}	2	Brown banded siliceous argillites (11.1m-48.05%), grey massive (1-2.8m) medium-grained sandstones (7.8m-33.77%), greenish-medium-fragmental tuffs (1.0m-4.33%) and interbedded members (0.4-1.0m) of grey fine-grained sandstones and grey argillites (3.2m-13.85%)
Magmatic	Effusive (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	1	Grey andesite cover (flow breccia) (74m-99%) and grey fine-grained sandstone (0.8m-1%)

B. SOILS

Group	Subgroup		Symbol and Geological Index	Number of lithologic-stratigraphical unit	Description
Artificial	Fill (road bed)		tQ_{IV}	37	Crushed-stone, angular gravel and boulders with intermediately plastic clay and low plastic silt clay matrix (road bed fill)
Sedimentary incoherent	Macrofragmental (colluvial)		cQ_{IV}	36	Angular cobbles and gravel, angular boulders with low plastic silt matrix (30-40%)
	Silty and clayed	Landslide	dlQ_{IV}	35	Brown, intermediately plastic clay with angular gravel and cobbles, angular and rounded boulders inclusions
		Colluvial-diluvial	cdQ_{IV}	34	Brown, intermediately plastic clay with angular gravel, rounded and angular cobbles and rounded boulders inclusions
		Diluvial-proluvial	dpQ_{IV}	33	Brown, intermediately and highly plastic clay with angular gravel and cobbles, and angular boulders inclusions
				32	Brown, intermediately plastic clay with angular gravel and cobbles, with low plastic silt lens and interlayers
	Macrofragmental (alluvial floodplain and sub-floodplain terraces)		aQ_{IV}	31	Rounded cobbles with sand matrix and rounded boulders inclusions (15-20%)

Tunnel line

Strike, inclination and inclination angle of seam

Synclinal axis

Anticlinal axis

Tectonic faults:
1. observable
2. Supposittious

Large tectonic fractures

Cliffs

Occurrence depth of groundwater in separate places

Underwashing and erosion of river banks (lateral erosion)

Active landslide

Stabilized landslide

Talus

III N1 996.50 — Trial Pit with water, its number (40) and top elevation (105.0)

III N2 996.47 — Trial Pit without water

OKB N11 993.21 — Borehole without water, its number and top elevation (1000.0)

OKB N15 995.42 — Borehole with water, its number and top elevation (1000.0)

Borders of lithologic-stratigraphical units

Index (serial number) of lithologic-stratigraphical units

Index of lithologic-stratigraphical units / Geological index

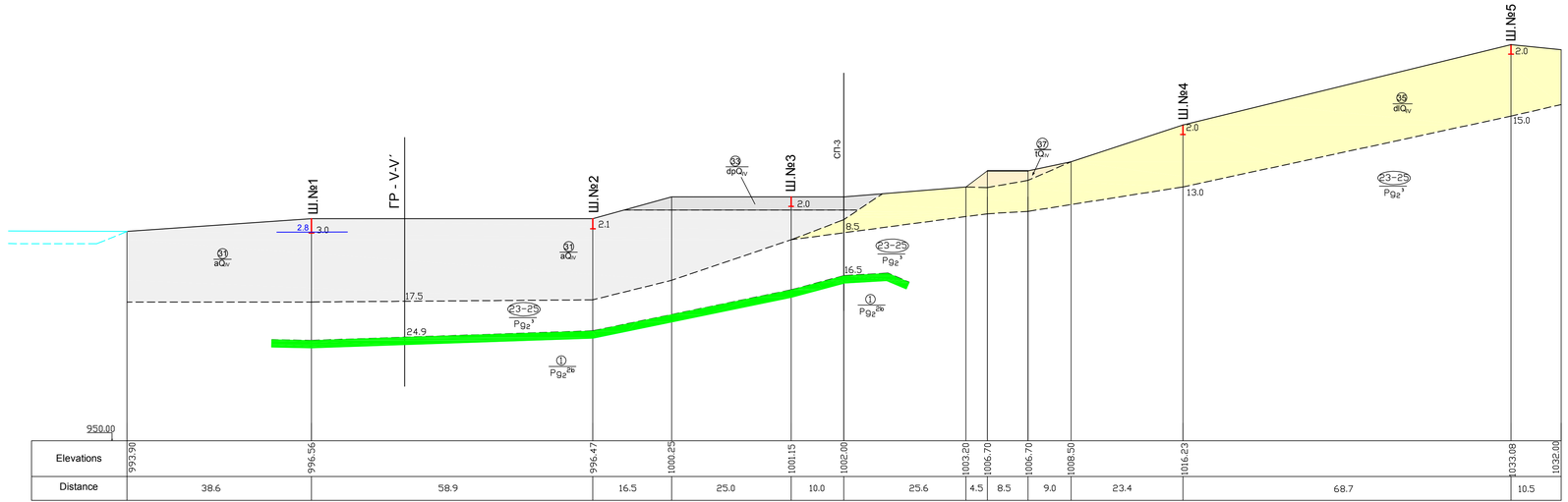
1 — 1' — Enginnering-geological section line and number (1-1)

1 — 1 — Seismic profile line and number (1)

V — V' — Geoelectric section line and number (V-V')

6 — Vertical Electrical Sounding (VES) point and number (6)

GEOENGINEERING LTD. Civil Engineering - Survey, Design, Construction, Consulting	Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia	
	Geotechnical Investigation	
	Engineering-geological M ap of Water Reservoir Site	GC-0904-MH-4
		Sheet 1 / 1
	Scale 1:5000	Date: 14-May-2009



LEGEND:

1. Engineering-geological Description of Soils

A. ROCKS

Group	Subgroup	Variety by Strength	Symbol and Geological Index	Number of lithologic-stratigraphical unit (member, formation, intrusive or effusive formations)	Description
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Magmatic	Effusive (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	1	Grey andesite cover (flow breccia) (74m-99%) and grey fine-grained sandstone (0.8m-1%)

B. SOILS

Group	Subgroup		Symbol and Geological Index	Number of lithologic-stratigraphical unit	Description
Artificial	Fill (road bed)		tQ_{IV}	37	Crushed-stone, angular gravel and boulders with intermediately plastic clay and low plastic silt clay matrix (road bed fill)
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				32	Brown, intermediately plastic clay with angular gravel and cobbles, with low plastic silt lens and interlayers
	Macrofragmental (alluvial floodplain and sub-floodplain terraces)		aQ_{IV}	31	Rounded cobbles with sand matrix and rounded boulders inclusions (15-20%)

Trial Pit: number (1) and depth (2,0)

Borehole without water, its number and top elevation (1000.0)

Borders of lithologic-stratigraphical units

Index of lithologic-stratigraphical units / Geological index

СП-1 — Seismic profile and number (1)

ГР-V-V' — Geoelectric section and number (V-V')

1.6 — Groundwater level

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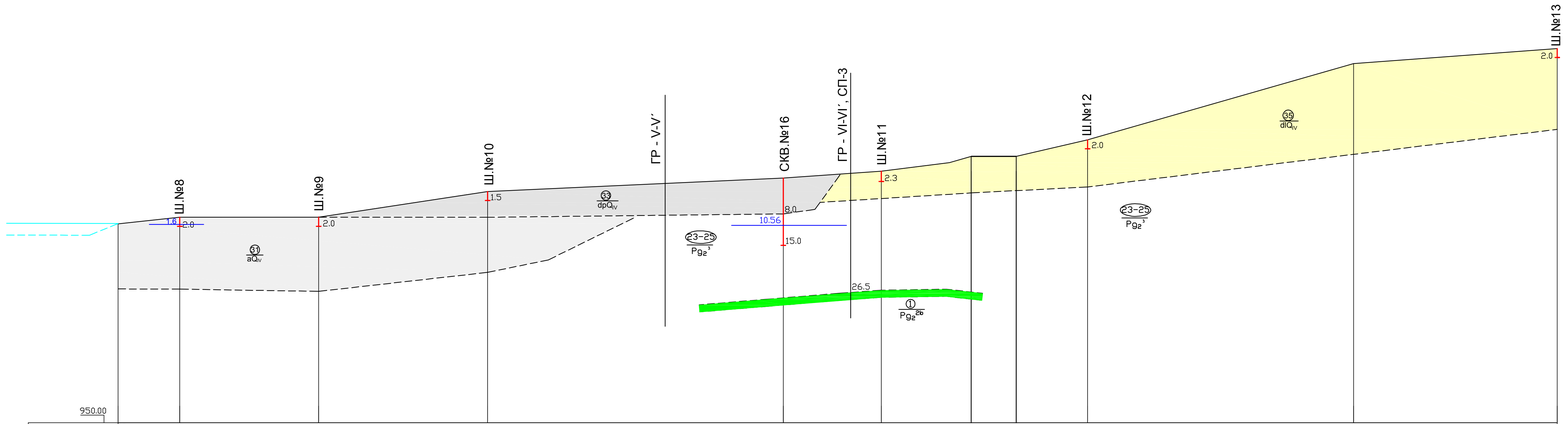
Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

Engineering-geological cross-sections of Water Reservoir Site	GC-0904-MH-5
Cross-section 1 - 1B	Sheet 1 / 9
Scale 1:500	Date: 12-May-2009



LEGEND:

1. Engineering-geological Description of Soils

A. ROCKS

Group	Subgroup	Variety by Strength	Symbol and Geological Index	Number of lithologic-stratigraphical unit (member, formation, intrusive or effusive formations)	Description
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Magmatic	Effusive (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	1	Grey andesite cover (flow breccia) (74m-99%) and grey fine-grained sandstone (0.8m-1%)

B. SOILS

Group		Subgroup	Symbol and Geological Index	Number of lithologic-stratigraphical unit	Description
Artificial		Fill (road bed)	tQ_{IV}	37	Crushed-stone, angular gravel and boulders with intermediately plastic clay and low plastic silt clay matrix (road bed fill)
Sedimentary incoherent		Macrofragmental (colluvial)	cQ_{IV}	36	Angular cobbles and gravel, angular boulders with low plastic silt matrix (30-40%)
	Silty and clayed	Landslide	dlQ_{IV}	35	Brown, intermediately plastic clay with angular gravel and cobbles, angular and rounded boulders inclusions
		Colluvial-diluvial	cdQ_{IV}	34	Brown, intermediately plastic clay with angular gravel, rounded and angular cobbles and rounded boulders inclusions
		Diluvial-proluvial	dpQ_{IV}	33	Brown, intermediately and highly plastic clay with angular gravel and cobbles, and angular boulders inclusions
				32	Brown, intermediately plastic clay with angular gravel and cobbles, with low plastic silt lens and interlayers
		Macrofragmental (alluvial floodplain and sub-floodplain terraces)	aQ_{IV}	31	Rounded cobbles with sand matrix and rounded boulders inclusions (15-20%)

Trial Pit: number (1) and depth (2.0)

Borehole without water, its number and top elevation (1000.0)

Borders of lithologic-stratigraphical units

Index of lithologic-stratigraphical units Geological index

СП-1 — Seismic profile and number (1)

ГР-V-V' — Geoelectric section and number (V-V')

1.6 — Groundwater level

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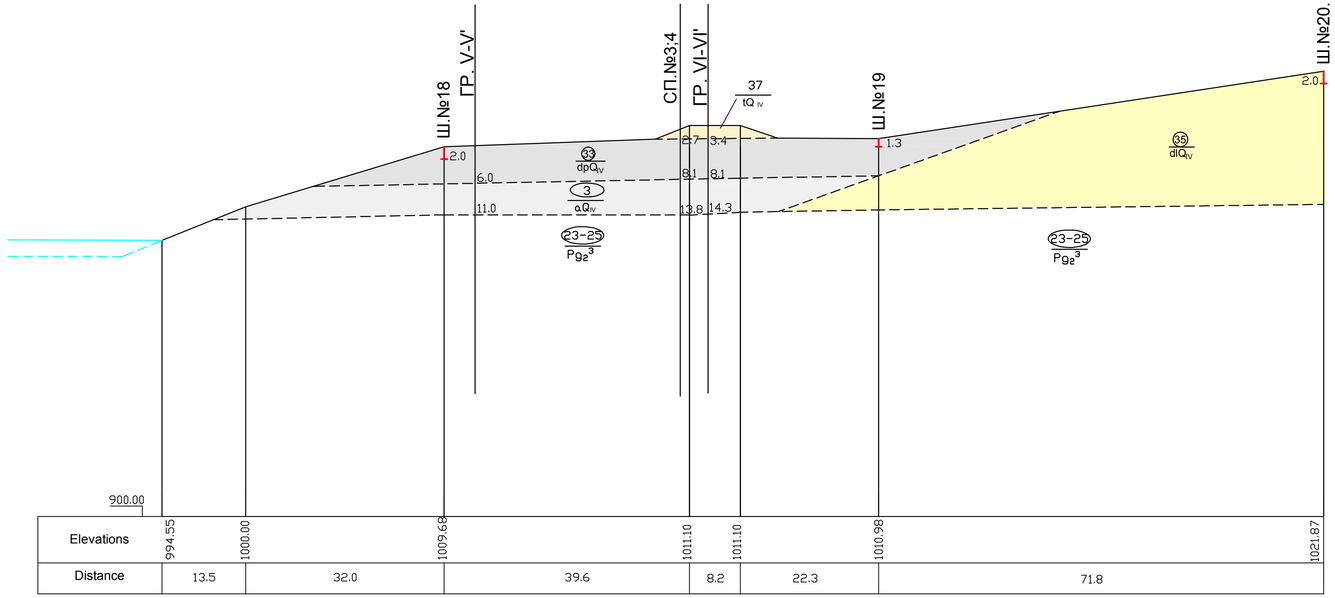
Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

Engineering-geological cross-sections of Water Reservoir Site	GC-0904-MH-5
Cross-section 2 - 2B	Sheet 2 / 9
Scale 1:500	Date: 12-May-2009



LEGEND:

1. Engineering-geological Description of Soils

A. ROCKS

Group	Subgroup	Variety by Strength	Symbol and Geological Index	Number of lithologic-stratigraphical unit (member, formation, intrusive or effusive formations)	Description
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Magmatic	Effusive (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	1	Grey andesite cover (flow breccia) (74m-99%) and grey fine-grained sandstone (0.8m-1%)

B. SOILS

Group	Subgroup		Symbol and Geological Index	Number of lithologic-stratigraphical unit	Description
Artificial	Fill (road bed)		tQ_{IV}	37	Crushed-stone, angular gravel and boulders with intermediately plastic clay and low plastic silt clay matrix (road bed fill)
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	Macrofragmental (alluvial floodplain and sub-floodplain terraces)		aQ_{IV}	31	Rounded cobbles with sand matrix and rounded boulders inclusions (15-20%)

ШП№1 / 2.0	Trial Pit: number (1) and depth (2,0)
СКВN№6 / 30.0	Borehole without water, its number and top elevation (1000.0)
	Borders of lithologic-stratigraphical units
5 / aQ_{IV}	Index of lithologic-stratigraphical units Geological index
СП-1	Seismic profile and number (1)
ГР-V-V´	Geoelectric section and number (V-V´)
1.6	Groundwater level

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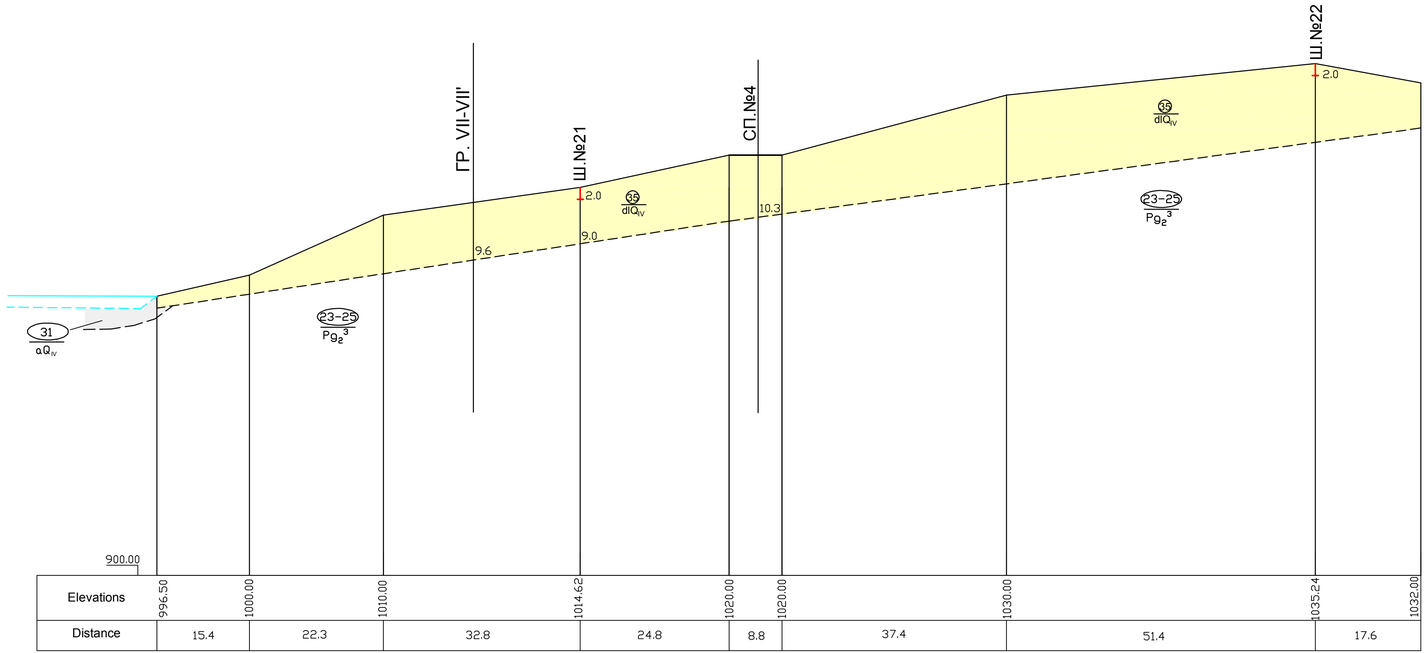
Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

Engineering-geological cross-sections of Water Reservoir Site	GC-0904-MH-5
Cross-section 3 - 3B	Sheet 3 / 9
Scale 1:500	Date: 12-May-2009



LEGEND:

1. Engineering-geological Description of Soils

A. ROCKS

Group	Subgroup	Variety by Strength	Symbol and Geological Index	Number of lithologic-stratigraphical unit (member, formation, intrusive or effusive formations)	Description
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Magmatic	Effusive (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	1	Grey andesite cover (flow breccia) (74m-99%) and grey fine-grained sandstone (0.8m-1%)

B. SOILS

Group	Subgroup		Symbol and Geological Index	Number of lithologic-stratigraphical unit	Description
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	Macrofragmental (alluvial floodplain and sub-floodplain terraces)		aQ_{IV}	31	Rounded cobbles with sand matrix and rounded boulders inclusions (15-20%)

ШN11 / 2.0	Trial Pit: number (1) and depth (2,0)
СВN16 / 30.0	Borehole without water, its number and top elevation (1000.0)
	Borders of lithologic-stratigraphical units
5 / aQIV	Index of lithologic-stratigraphical units Geological index
СП-1	Seismic profile and number (1)
ГР-V-V'	Geoelectric section and number (V-V')
1.6	Groundwater level

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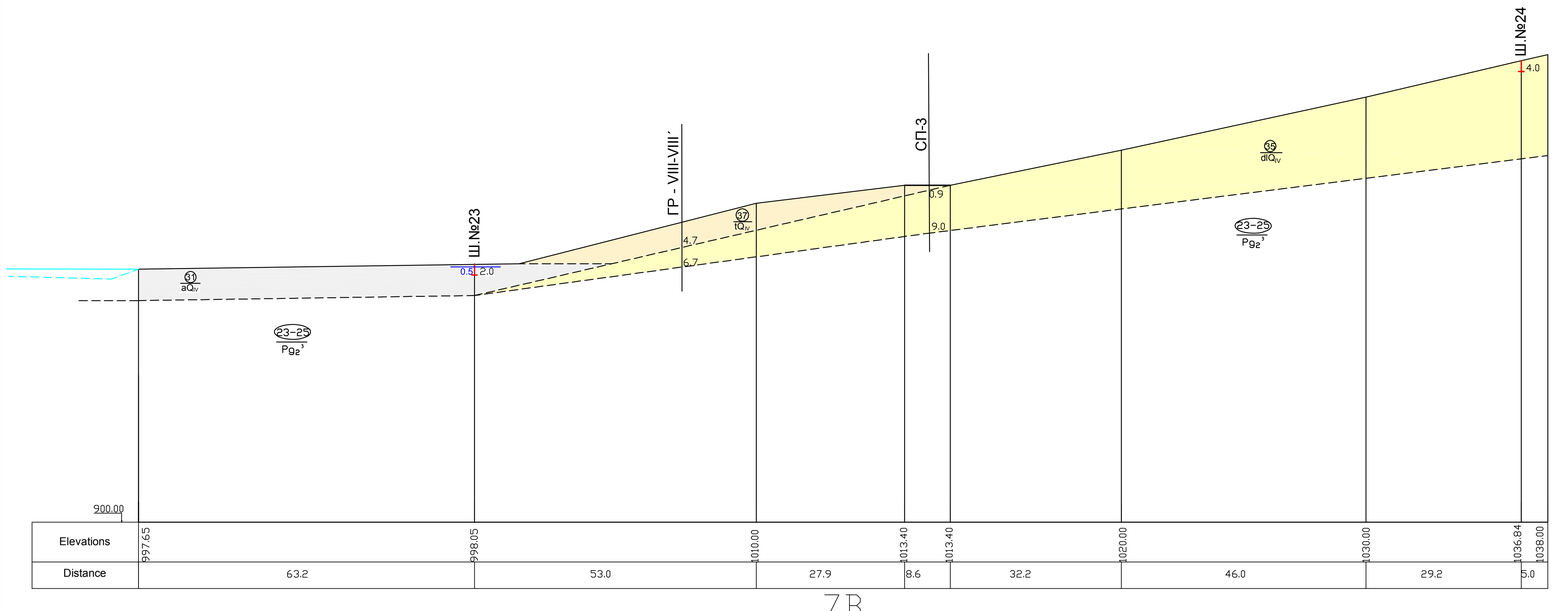
Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

Engineering-geological cross-sections of Water Reservoir Site	GC-0904-MH-5
Cross-section 4 - 4B	Sheet 4 / 9
Scale 1:500	Date: 12-May-2009



LEGEND:

1. Engineering-geological Description of Soils

A. ROCKS

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Magmatic	Effusive (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	1	Grey andesite cover (flow breccia) (74m-99%) and grey fine-grained sandstone (0.8m-1%)

B. SOILS

Group	Subgroup		Symbol and Geological Index	Number of lithologic-stratigraphical unit	Description
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Trial Pit: number (1) and depth (2.0)

Borehole without water, its number and top elevation (1000.0)

Borders of lithologic-stratigraphical units

Index of lithologic-stratigraphical units / Geological index

СП-1 — Seismic profile and number (1)

ГР-V-V´ — Geoelectric section and number (V-V´)

1.6 — Groundwater level

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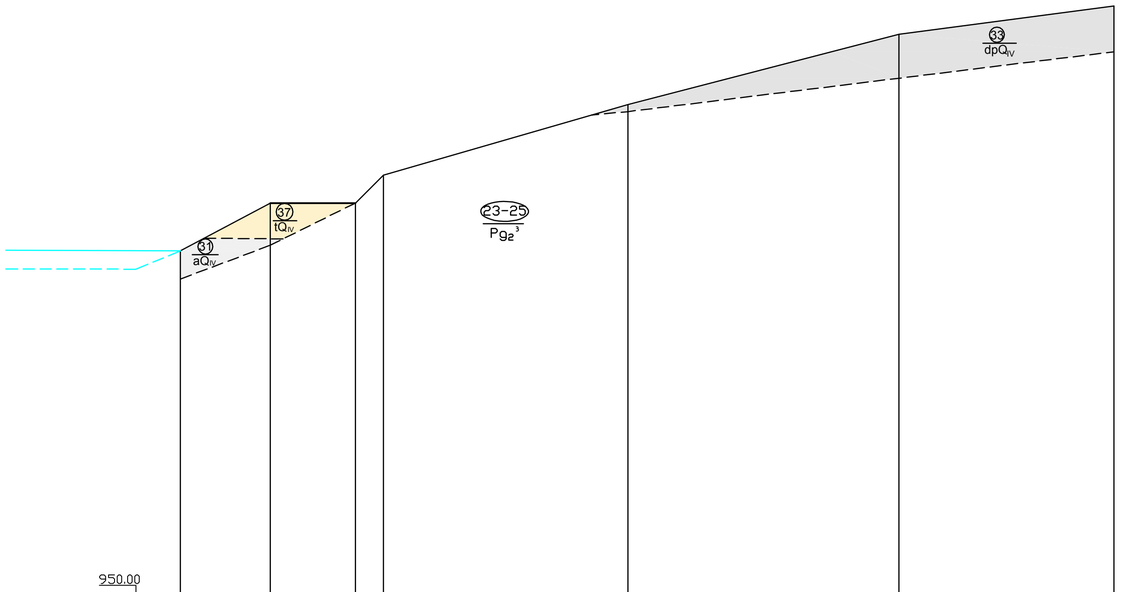
Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

Engineering-geological cross-sections of Water Reservoir Site	GC-0904-MH-5
Cross-section 5 - 5B	Sheet 5 / 9
Scale 1:500	Date: 12-May-2009



LEGEND:

1. Engineering-geological Description of Soils

A. ROCKS

Group	Subgroup	Variety by Strength	Symbol and Geological Index	Number of lithologic-stratigraphical unit (member, formation, intrusive or effusive formations)	Description
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Magmatic	Effusive (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	1	Grey andesite cover (flow breccia) (74m-99%) and grey fine-grained sandstone (0.8m-1%)

B. SOILS

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	Macrofragmental (alluvial floodplain and sub-floodplain terraces)		aQ_{IV}	31	Rounded cobbles with sand matrix and rounded boulders inclusions (15-20%)

ШN1 / 2,0	Trial Pit: number (1) and depth (2,0)
СКВN№6 / 30,0	Borehole without water, its number and top elevation (1000.0)
— — —	Borders of lithologic-stratigraphical units
5 / aQ_{IV}	Index of lithologic-stratigraphical units / Geological index
СП-1	Seismic profile and number (1)
ГР-V-V′	Geoelectric section and number (V-V′)
1.6	Groundwater level

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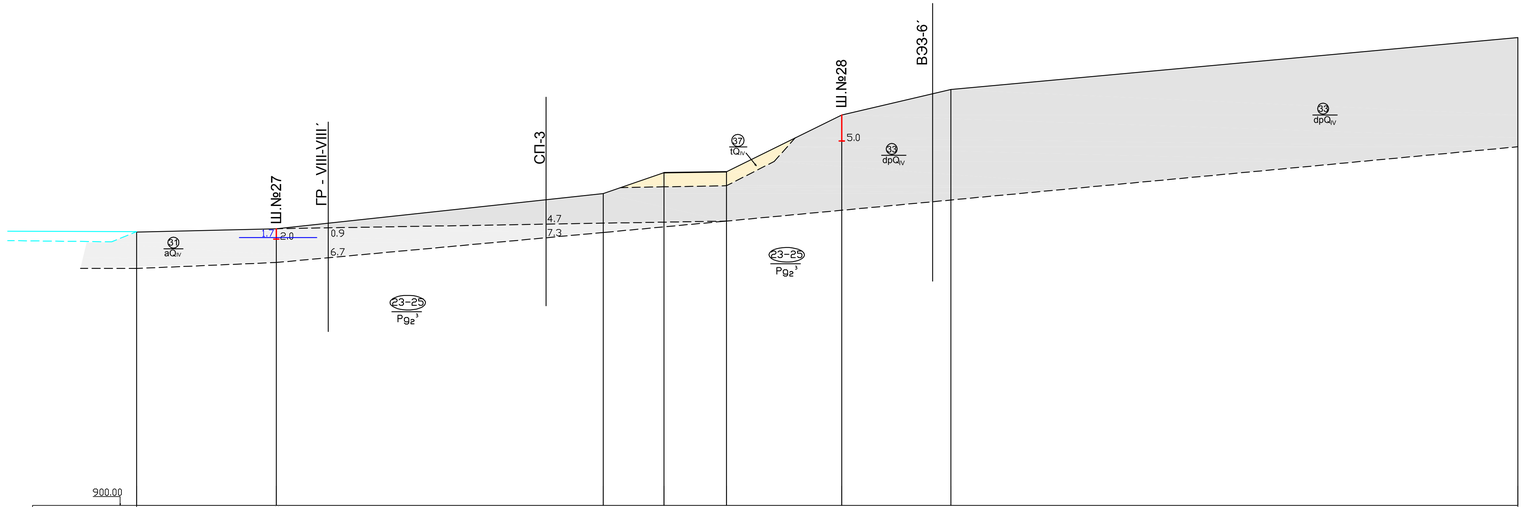
Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

Engineering-geological cross-sections of Water Reservoir Site	GC-0904-MH-5
Cross-section 6 - 6B	Sheet 6 / 9
Scale 1:500	Date: 12-May-2009



Elevations	1002.69	1003.23	1010.00	1014.20	1014.20	1025.12	1030.00	1040.00
Distance	26.9	62.9	11.7	12.0	22.2	21.0	109.1	

LEGEND:

1. Engineering-geological Description of Soils

A. ROCKS

Group	Subgroup	Variety by Strength	Symbol and Geological Index	Number of lithologic-stratigraphical unit (member, formation, intrusive or effusive formations)	Description
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-45 % Moderately strong-55%	Pg_2^3	23-25	Grey and greenish-grey micro and medium-fragmental tuff (11%), light grey argillite (4%), light grey and grey fine-grained clayey sandstones (3%) and thin (1-40cm) interbedded members of grey argillites and grey fine-grained clayey sand-stones (82%)
Magmatic	Effusive (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	1	Grey andesite cover (flow breccia) (74m-99%) and grey fine-grained sandstone (0.8m-1%)

B. SOILS

Group	Subgroup		Symbol and Geological Index	Number of lithologic-stratigraphical unit	Description
Artificial	Fill (road bed)		tQ_{IV}	37	Crushed-stone, angular gravel and boulders with intermediately plastic clay and low plastic silt clay matrix (road bed fill)
Sedimentary incoherent	Macrofragmental (colluvial)		cQ_{IV}	36	Angular cobbles and gravel, angular boulders with low plastic silt matrix (30-40%)
	Silty and clayed	Landslide	dlQ_{IV}	35	Brown, intermediately plastic clay with angular gravel and cobbles, angular and rounded boulders inclusions
		Colluvial-diluvial	cdQ_{IV}	34	Brown, intermediately plastic clay with angular gravel, rounded and angular cobbles and rounded boulders inclusions
		Diluvial-proluvial	dpQ_{IV}	33	Brown, intermediately and highly plastic clay with angular gravel and cobbles, and angular boulders inclusions
				32	Brown, intermediately plastic clay with angular gravel and cobbles, with low plastic silt lens and interlayers
	Macrofragmental (alluvial floodplain and sub-floodplain terraces)		aQ_{IV}	31	Rounded cobbles with sand matrix and rounded boulders inclusions (15-20%)

Ш.№1 / 2.0 — Trial Pit: number (1) and depth (2.0)

Borehole without water, its number and top elevation (1000.0)

Borders of lithologic-stratigraphical units

5 / aQ_{IV} — Index of lithologic-stratigraphical units / Geological index

СП-1 — Seismic profile and number (1)

ГР-V-V´ — Geoelectric section and number (V-V´)

1.6 — Groundwater level

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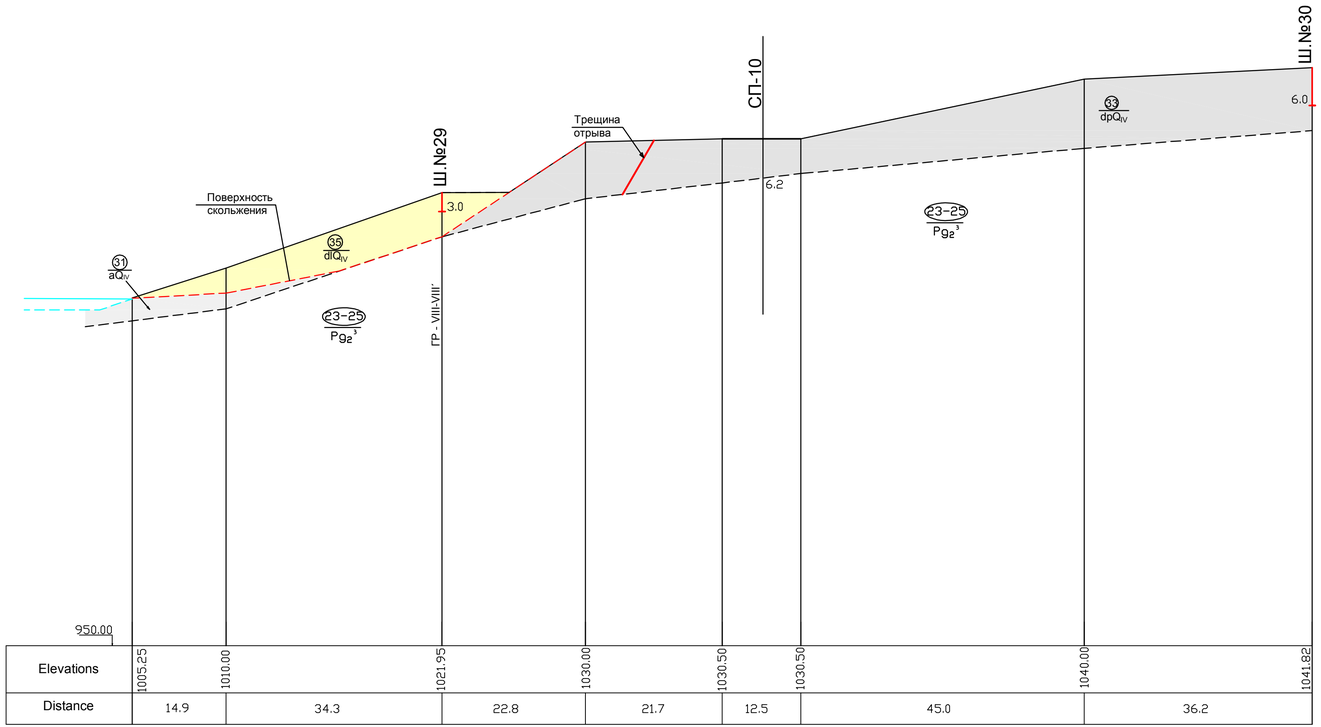
Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

Engineering-geological cross-sections of Water Reservoir Site	GC-0904-MH-5
Cross-section 7 - 7B	Sheet 7 / 9
Scale 1:500	Date: 12-May-2009



LEGEND:

1. Engineering-geological Description of Soils

A. ROCKS

Group	Subgroup	Variety by Strength	Symbol and Geological Index	Number of lithologic-stratigraphical unit (member, formation, intrusive or effusive formations)	Description
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-45 % Moderately strong-55%	Pg_2^3	23-25	Grey and greenish-grey micro and medium-fragmental tuff (11%), light grey argillite (4%), light grey and grey fine-grained clayey sandstones (3%) and thin (1-40cm) interbedded members of grey argillites and grey fine-grained clayey sandstones (82%)
Magmatic	Effusive (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	1	Grey andesite cover (flow breccia) (74m-99%) and grey fine-grained sandstone (0.8m-1%)

B. SOILS

Group	Subgroup		Symbol and Geological Index	Number of lithologic-stratigraphical unit	Description
Artificial	Fill (road bed)		tQ_{IV}	37	Crushed-stone, angular gravel and boulders with intermediately plastic clay and low plastic silt clay matrix (road bed fill)
Sedimentary incoherent	Macrofragmental (colluvial)		cQ_{IV}	36	Angular cobbles and gravel, angular boulders with low plastic silt matrix (30-40%)
	Silty and clayed	Landslide	dlQ_{IV}	35	Brown, intermediately plastic clay with angular gravel and cobbles, angular and rounded boulders inclusions
		Colluvial-diluvial	cdQ_{IV}	34	Brown, intermediately plastic clay with angular gravel, rounded and angular cobbles and rounded boulders inclusions
		Diluvial-proluvial	dpQ_{IV}	33	Brown, intermediately and highly plastic clay with angular gravel and cobbles, and angular boulders inclusions
				32	Brown, intermediately plastic clay with angular gravel and cobbles, with low plastic silt lens and interlayers
	Macrofragmental (alluvial floodplain and sub-floodplain terraces)		aQ_{IV}	31	Rounded cobbles with sand matrix and rounded boulders inclusions (15-20%)

ШN°1 2.0 — Trial Pit: number (1) and depth (2,0)

СВN°6 30.0 — Borehole without water, its number and top elevation (1000.0)

Borders of lithologic-stratigraphical units

5 / aQ_{IV} — Index of lithologic-stratigraphical units / Geological index

СП-1 — Seismic profile and number (1)

ГР-V-V' — Geoelectric section and number (V-V')

1.6 — Groundwater level

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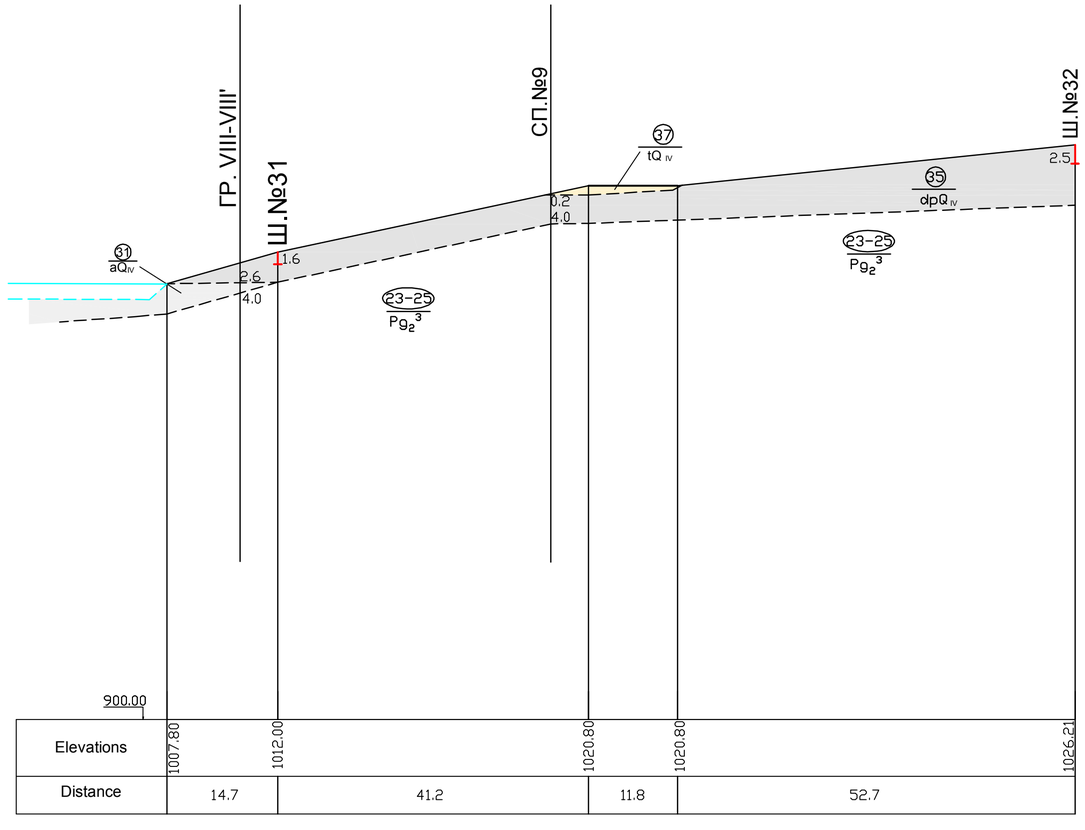
Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

Engineering-geological cross-sections of Water Reservoir Site	GC-0904-MH-5
Cross-section 8 - 8B	Sheet 8 / 9
Scale 1:500	Date: 12-May-2009



LEGEND:

1. Engineering-geological Description of Soils

A. ROCKS

Group	Subgroup	Variety by Strength	Symbol and Geological Index	Number of lithologic-stratigraphical unit (member, formation, intrusive or effusive formations)	Description
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-45 % Moderately strong-55%	Pg_2^3	23-25	Grey and greenish-grey micro and medium-fragmental tuff (11%), light grey argillite (4%), light grey and grey fine-grained clayey sandstones (3%) and thin (1-40cm) interbedded members of grey argillites and grey fine-grained clayey sand-stones (82%)
Magmatic	Effusive (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	1	Grey andesite cover (flow breccia) (74m-99%) and grey fine-grained sandstone (0.8m-1%)

B. SOILS

Group	Subgroup		Symbol and Geological Index	Number of lithologic-stratigraphical unit	Description
Artificial	Fill (road bed)		tQ_{IV}	37	Crushed-stone, angular gravel and boulders with intermediately plastic clay and low plastic silt clay matrix (road bed fill)
Sedimentary incoherent	Macrofragmental (colluvial)		cQ_{IV}	36	Angular cobbles and gravel, angular boulders with low plastic silt matrix (30-40%)
	Silty and clayed	Landslide	dlQ_{IV}	35	Brown, intermediately plastic clay with angular gravel and cobbles, angular and rounded boulders inclusions
		Colluvial-diluvial	cdQ_{IV}	34	Brown, intermediately plastic clay with angular gravel, rounded and angular cobbles and rounded boulders inclusions
		Diluvial-proluvial	dpQ_{IV}	33	Brown, intermediately and highly plastic clay with angular gravel and cobbles, and angular boulders inclusions
				32	Brown, intermediately plastic clay with angular gravel and cobbles, with low plastic silt lens and interlayers
	Macrofragmental (alluvial floodplain and sub-floodplain terraces)		aQ_{IV}	31	Rounded cobbles with sand matrix and rounded boulders inclusions (15-20%)

ШN1 — 2.0 — Trial Pit: number (1) and depth (2,0)

СКВN16 — 30.0 — Borehole without water, its number and top elevation (1000.0)

Borders of lithologic-stratigraphical units

5 / aQ_{IV} — Index of lithologic-stratigraphical units / Geological index

СП-1 — Seismic profile and number (1)

ГР-V-V′ — Geoelectric section and number (V-V′)

1.6 — Groundwater level

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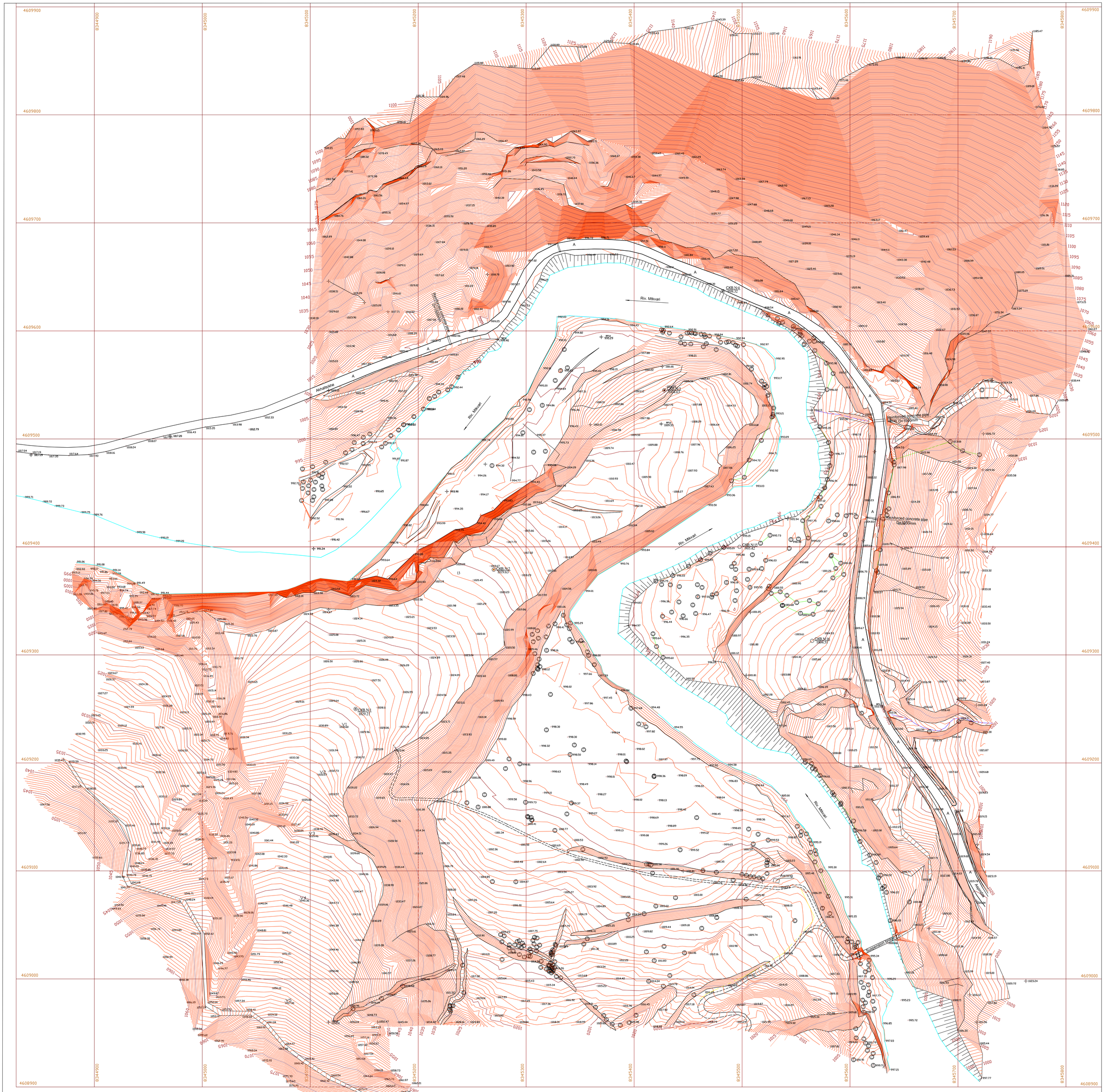
Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

Engineering-geological cross-sections of Water Reservoir Site	GC-0904-MH-5
Cross-section 9 - 9B	Sheet 9 / 9
Scale 1:500	Date: 12-May-2009



LEGEND:

CKB №1	Borehole without water, its number and top elevation (1000.0)
CKB №15 995.42	Borehole with water, its number and top elevation (1000.0)

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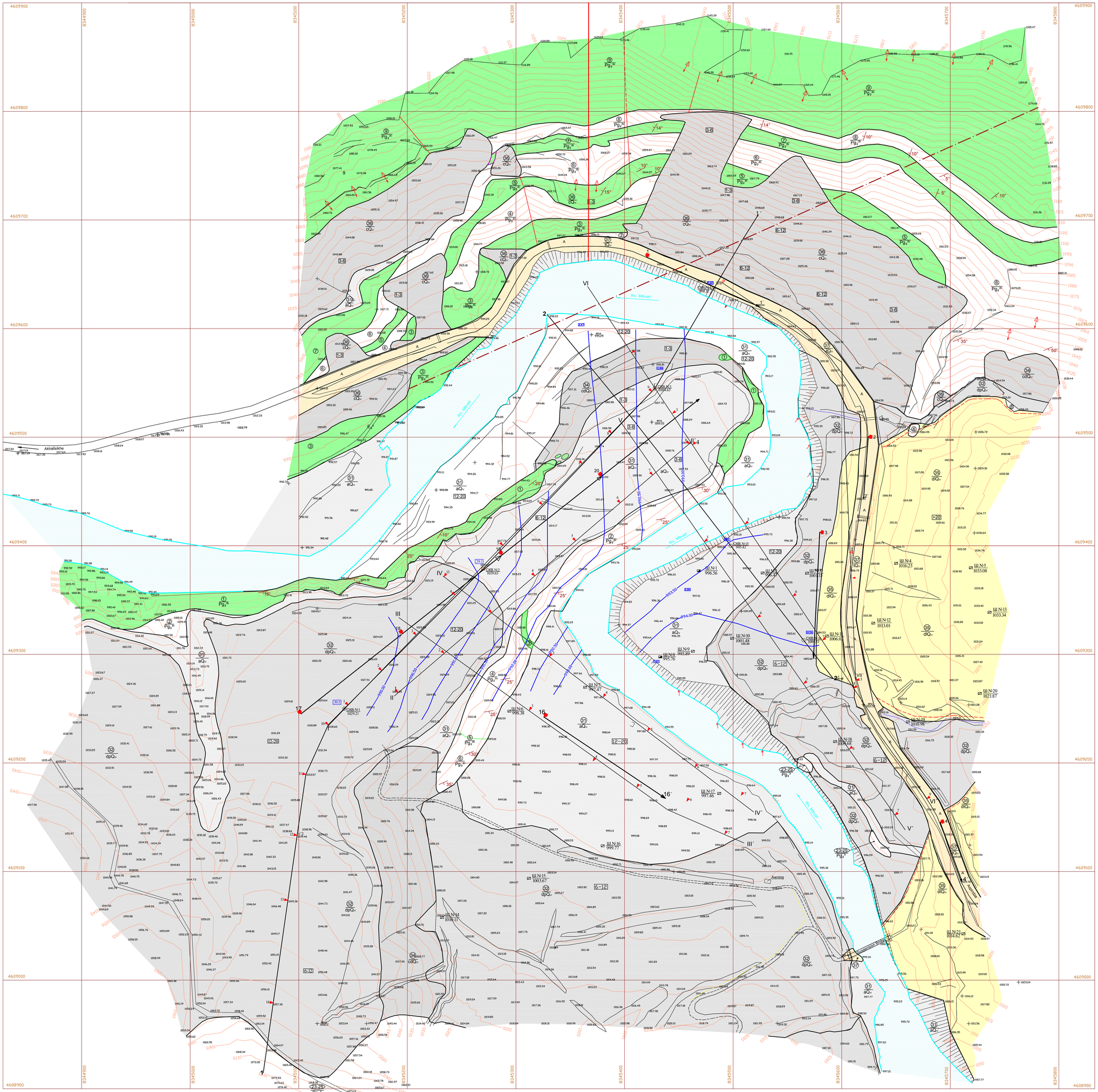
Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

Topographical Map of Dam Construction Site	GC-0904-MH-6
	Sheet 1 / 1
Scale 1:1000	Date: 12-May-2009



LEGEND:

1. Engineering-geological Description of Soils

Group	Subgroup	Variety by Strength	Symbol and Geological Index	Number of lithologic-stratigraphical unit (member, formation, intrusive or effusive formations)	Description
Magmatic	Effusive	Moderately strong	Q_{III}	30	Doleritic cover
			N_1^2–N_2^1	29	Doleritic and andesite covers and their pyroclastics with diatomite layers in places at the upper part -300-1100m
Magmatic and metamorphic	Intrusive and contact metamorphic	Moderately strong	ηN	28	Dark grey diabase and grey hornfels
Magmatic	Intrusive	Very strong	δN		Medium-grained crystalline Teschenite
			εN	26	Macrocrystalline Teschenite
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-45 % Moderately strong-55%	Pg_2^3	23–25	Grey and greenish-grey micro and medium-fragmental tuff (11%), light grey argillite (4%), light grey and grey fine-grained clayey sandstones (3%) and thin (1-40cm) interbedded members of grey argillites and grey fine-grained clayey sandstones (82%)
Magmatic	Effusive	Moderately strong	Pg_2^{2b}	11	Dark grey andesite cover (flow breccia) (41m-100%)
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-45 % Moderately strong-55%	Pg_2^{2b}	10	Alternation (5-60cm) of grey and greenish-grey argillites and fine-grained sandstones with green microfragmental tuff interlayers (1.2m) and grey and greenish-grey medium-grained massive (1-3m) sandstones (45m-100%)
Magmatic	Effusive	Moderately strong	Pg_2^{2b}	9	Dark grey andesite cover (flow breccia) (21-36m-100%)
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-50 % Moderately strong-50%	Pg_2^{2b}	8	Alternation of greenish-grey medium-grained sandstones (0.25-1.5m) and grey sandy (6-25cm) argillites (7m-100%)
Magmatic	Effusive	Moderately strong	Pg_2^{2b}	7	Dark grey andesite cover (flow breccia) with spheroidal jointings (10-50cm) at the lower part (13m-100%)
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-24 % Moderately strong-76%	Pg_2^{2b}	6	Greenish-grey medium-fragmental tuff (2.0m-10.53%),light green fine-grained sandstone (8.0m-42.11%) and alternation of grey fine-grained (2.0-40.0cm) sandstones and grey (0.5-25.0cm) argillites (9.0m-47.36%)
Magmatic	Effusive	Moderately strong	Pg_2^{2b}	5	Grey andesite cover (flow breccia) (0.5m-100%)
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-25 % Moderately strong-75%	Pg_2^{2b}	4	Greenish-grey and grey massive medium-grained sandstones (17.2m-54.43%) and grey argillite (1.1m-3.48%) with interbedded members of grey fine-grained (2.0-25.0cm) sandstones and grey (0.5-20.0cm) argillites (13.3m-42.09%)
Magmatic and sedimentary cemented	Effusive and silty-clayed (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	3	3.65m-75.26% grey andesite cover (flow breccia) and grey sandy argillite (1.2m-24.74%)
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-55 % Moderately strong-45%	Pg_2^{2b}	2	Brown banded siliceous argillites (11.1m-48.05%), grey massive (1-2.6m) medium-grained sandstones (7.8m-33.77%), greenish medium-fragmental tuffs (1.0m-4.33%) and interbedded members (0.4-1.0m) of grey fine-grained sandstones and grey argillites (3.2m-13.85%)
Magmatic	Effusive (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	1	Grey andesite cover (flow breccia) (74m-99%) and grey fine-grained sandstone (0.8m-1%)

B. SOILS

Group	Subgroup	Symbol and Geological Index	Number of lithologic-stratigraphical unit	Description
Artificial	Fill (road bed)	tQ_{IV}	37	Crushed-stone, angular gravel and boulders with intermediately plastic clay and low plastic silt clay matrix (road bed fill)
Sedimentary incoherent	Macrofragmental (colluvial)	cQ_{IV}	36	Angular cobbles and gravel, angular boulders with low plastic silt matrix (30-40%)
	Silty and clayed: Landslide	dlQ_{IV}	35	Brown, intermediately plastic clay with angular gravel and cobbles, angular and rounded boulders inclusions
	Silty and clayed: Colluvial-diluvial	cdQ_{IV}	34	Brown, intermediately plastic clay with angular gravel, rounded and angular cobbles and rounded boulders inclusions
	Silty and clayed: Diluvial-proluvial	dpQ_{IV}	33	Brown, intermediately and highly plastic clay with angular gravel and cobbles, and angular boulders inclusions
			32	Brown, intermediately plastic clay with angular gravel and cobbles, with low plastic silt lens and interlayers
	Macrofragmental (alluvial floodplain and sub-floodplain terraces)	aQ_{IV}	31	Rounded cobbles with sand matrix and rounded boulders inclusions (15-20%)

- Tunnel line
- Strike, inclination and inclination angle of seam
- Synclinal axis
- Anticlinal axis
- Tectonic faults: 1. observable 2. Supposititous
- Large tectonic fractures
- Hydroisohypses
- Occurrence depth of groundwater in separate places
- Underwashing and erosion of river banks (lateral erosion)
- Active landslide
- Stabilized landslide
- Talus
- Trial Pit with water, its number (40) and top elevation (105.0)
- Trial Pit without water
- Borehole without water, its number and top elevation (1000.0)
- Borehole with water, its number and top elevation (1000.0)
- Borders of lithologic-stratigraphical units
- Index (serial number) of lithologic-stratigraphical units
- Index of lithologic-stratigraphical units / Geological index
- Enginnering-geological section line and number (1-1')
- Seismic profile line and number (1)
- Geoelectric section line and number (V-V')
- Vertical Electrical Sounding (B3/3) point and number (6)
- Thickness of covering deposits

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Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

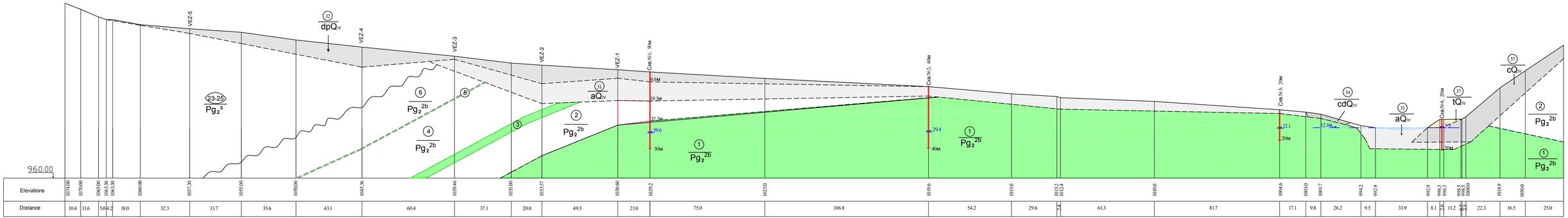
Engineering-geological Map of Dam Construction Site

GC-0904-MH-7

Sheet 1 / 1

Scale 1:1000

Date: 12-May-2009



1. Engineering-geological Description of Soils, A. ROCKS

Group	Subgroup	Variety by Strength	Symbol and Geological Index	Number of lithologic-stratigraphical unit (member, formation, intrusive or effusive formations)	Description
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-45% Moderately strong-55%	Pg_2^3	23-25	Grey and greenish-grey micro and medium-fragmental tuff (11%), light grey argillite (4%), light grey and grey fine-grained clayey sandstones(3%) and thin (1-40cm) interbedded members of grey argillites and grey fine-grained clayey sand-stones (82%)
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-24 % Moderately strong-76%	Pg_2^{2b}	6	Greenish-grey medium-fragmental tuff (2.0m-10.53%),light green fine-grained sandstone (8.0m-42.11%) and alternation of grey fine-grained (2.0-40.0cm) sandstones and grey (0.5-25.0cm) argillites (9.0m-47.36%)
Magmatic	Effusive	Moderately strong	Pg_2^{2b}	5	Grey andesite cover (flow breccia), (0.5m-100%)
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-25 % Moderately strong-75%	Pg_2^{2b}	4	Greenish-grey and grey massive medium-grained sandstones (17.2m-54.43%) and grey argillite (1.1m-3.48%) with interbedded members of grey fine-grained (2.0-25.0cm) sandstones and grey (0.5-20.0cm) argillites (13.3m-42.09%)
Magmatic and sedimentary cemented	Effusive and silty-clayed (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	3	3.65m-75.26% grey andesite cover (flow breccia) and grey sandy argillite (1.2m-24.74%)
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-55 % Moderately strong-45%	Pg_2^{2b}	2	Brown banded siliceous argillites (11.1m-48.05%), grey massive (1-2.6m) medium -grained sandstones (7.8m-33.77%), greenish medium-fragmental tuffs (1.0m-4.33%) and interbedded members (0.4-1.0m) of grey fine-grained sandstones and grey argillites (3.2m-13.85%)
Magmatic	Effusive (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	1	Grey andesite cover (flow breccia), (74m-99%) and grey fine-grained sandstone (0.8m-1%)

LEGEND:

B. SOILS

Group	Subgroup		Symbol and Geological Index	Number of lithologic-stratigraphical unit	Description
Artificial	Fill (road bed)		tQ_{IV}	37	Crushed-stone, angular gravel and boulders with intermediately plastic clay and low plastic silt clay matrix (road bed fill)
Sedimentary incoherent	Macrofragmental (colluvial)		cQ_{IV}	36	Angular cobbles and gravel, angular boulders with low plastic silt matrix (30-40%)
	Silty and clayed	Landslide	dlQ_{IV}	35	Brown, intermediately plastic clay with angular gravel and cobbles, angular and rounded boulders inclusions
		Colluvial-diluvial	cdQ_{IV}	34	Brown, intermediately plastic clay with angular gravel, rounded and angular cobbles and rounded boulders inclusions
		Diluvial-proluvial	dpQ_{IV}	33	Brown, intermediately and highly plastic clay with angular gravel and cobbles, and angular boulders inclusions
				32	Brown, intermediately plastic clay with angular gravel and cobbles, with low plastic silt lens and interlayers
	Macrofragmental (alluvial floodplain and sub-floodplain terraces)		aQ_{IV}	31	Rounded cobbles with sand matrix and rounded boulders inclusions (15-20%)

Borehole, its number and depth

Borders of lithologic-stratigraphical units

Index of lithologic-stratigraphical units
Geological index

Groundwater level

VEZ - Vertical Electrical Sounding

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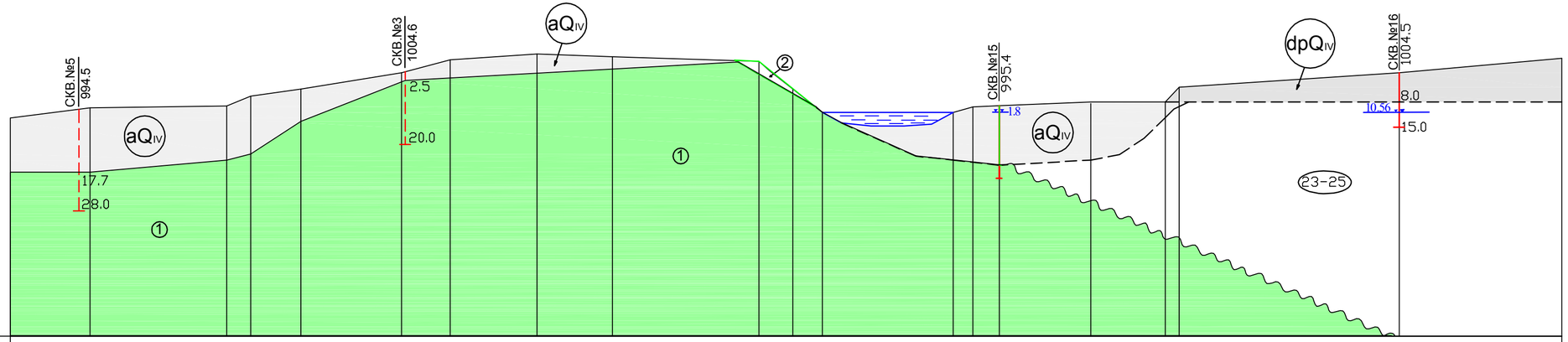
Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

Dam and Headgate Unit Site	GC-0904-MH-8
Geological Section 1 - 1'	Sheet 1 / 2
Scale 1:1000	Date: 12-May-2009



Elevations	992.0	994.8	995.3	998.0	1000.0	1004.5	1008.0	1009.6	1008.9	1007.6	1000.0	993.5	993.5	995.1	995.4	996.0	996.5	1000.5	1004.5	1008.4
Distance	21.9	37.6	6.6	13.8	27.7	13.4	≈23.9	20.7	40.3	9.3	8.2	35.9	5.5	7.2	25.2	20.5	3.8	60.5	44.7	

LEGEND:

1. Engineering-geological Description of Soils

A. ROCKS

Group	Subgroup	Variety by Strength	Symbol and Geological Index	Number of lithologic-stratigraphical unit (member, formation, intrusive or effusive formations)	Description
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-45 % Moderately strong-55%	Pg_2^3	23-25	Grey and greenish-grey micro and medium-fragmental tuff (11%), light grey argillite (4%), light grey and grey fine-grained clayey sandstones (3%) and thin (1-40cm) interbedded members of grey argillites and grey fine-grained clayey sand-stones (82%)
Magmatic	Effusive (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	1	Grey andesite cover (flow breccia) (74m-99%) and grey fine-grained sandstone (0.8m-1%)

B. SOILS

Group	Subgroup		Symbol and Geological Index	Number of lithologic-stratigraphical unit	Description
Artificial	Fill (road bed)		tQ_{IV}	37	Crushed-stone, angular gravel and boulders with intermediately plastic clay and low plastic silt clay matrix (road bed fill)
Sedimentary incoherent	Macrofragmental (colluvial)		cQ_{IV}	36	Angular cobbles and gravel, angular boulders with low plastic silt matrix (30-40%)
	Silty and clayed	Landslide	dlQ_{IV}	35	Brown, intermediately plastic clay with angular gravel and cobbles, angular and rounded boulders inclusions
		Colluvial-diluvial	cdQ_{IV}	34	Brown, intermediately plastic clay with angular gravel, rounded and angular cobbles and rounded boulders inclusions
		Diluvial-proluvial	dpQ_{IV}	33	Brown, intermediately and highly plastic clay with angular gravel and cobbles, and angular boulders inclusions
				32	Brown, intermediately plastic clay with angular gravel and cobbles, with low plastic silt lens and interlayers
	Macrofragmental (alluvial floodplain and sub-floodplain terraces)		aQ_{IV}	31	Rounded cobbles with sand matrix and rounded boulders inclusions (15-20%)

CKB.№16 1004.5 15.0 — Borehole, its number, depth and top elevation (1000.0)

1.6 — Groundwater level

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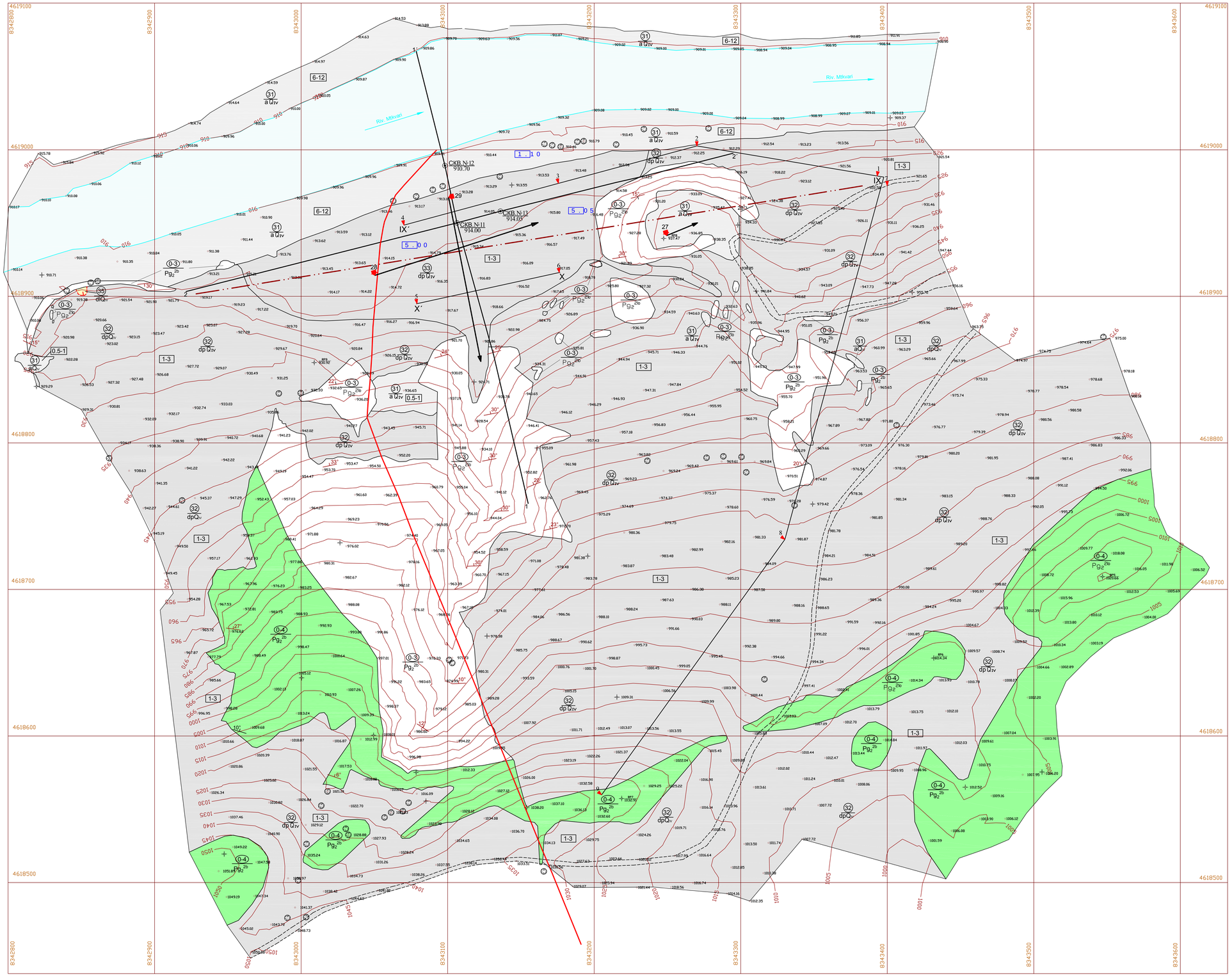
Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

Dam and Headgate Unit Site	GC-0904-MH-8
Geological Section 2 - 2'	Sheet 2 / 2
Scale 1:1000	Date: 12-May-2009



LEGEND:

1. Engineering-geological Description of Soils

A. ROCKS

Group	Subgroup	Variety by Strength	Symbol and Geological Index	Number of lithologic-stratigraphical unit (member, formation, intrusive or effusive formations)	Description
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-45 % Moderately strong-55%	Pg_2^{2b}	0–3	Green micro and medium-fragmental tuff (0.5-2.0m) with light grey and light brown sandstone interlayers (0.1-0.25-0.5m), with thin (up to 8cm) grey argillite interlayers in places
Magmatic	Effusive (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	0–4	Dark-grey andesite cover (flow breccia),(16m) and dark-grey macrofragmental breccia of andesite content (25m)

B. SOILS

Group	Subgroup		Symbol and Geological Index	Number of lithologic-stratigraphical unit	Description
Sedimentary incoherent	Silty and clayed	Landslide	dlQ_{IV}	35	Brown, intermediately plastic clay with angular gravel and cobbles, angular and rounded boulders inclusions
		Diluvial-proluvial	dpQ_{IV}	33	Brown, intermediately and highly plastic clay with angular gravel and cobbles, and angular boulders inclusions
				32	Brown, intermediately plastic clay with angular gravel and cobbles, with low plastic silt lens and interlayers
	Macrofragmental (alluvial floodplain and sub-floodplain terraces)		aQ_{IV}	31	Rounded cobbles with sand matrix and rounded boulders inclusions (15-20%)

- Tunnel line
- 10° — Strike, inclination and inclination angle of seam
- Synclinal axis
- 2 . . 8 0 — Occurrence depth of groundwater in separate places
- Stabilized landslide
- CKB №15 995.42 — Borehole with water, its number and top elevation (1000.0)
- Borders of lithologic-stratigraphical units
- 5 / aQ_{IV} — Index of lithologic-stratigraphical units / Geological index
- 1——1' — Enginnering-geological section line and number (1-1')
- 1 — Seismic profile line and number (1)
- V——V' — Geoelectric section line and number (V-V')
- 6 — Vertical Electrical Sounding (BЗЗ) point and number (6)
- 1-3 — Thickness of covering deposits

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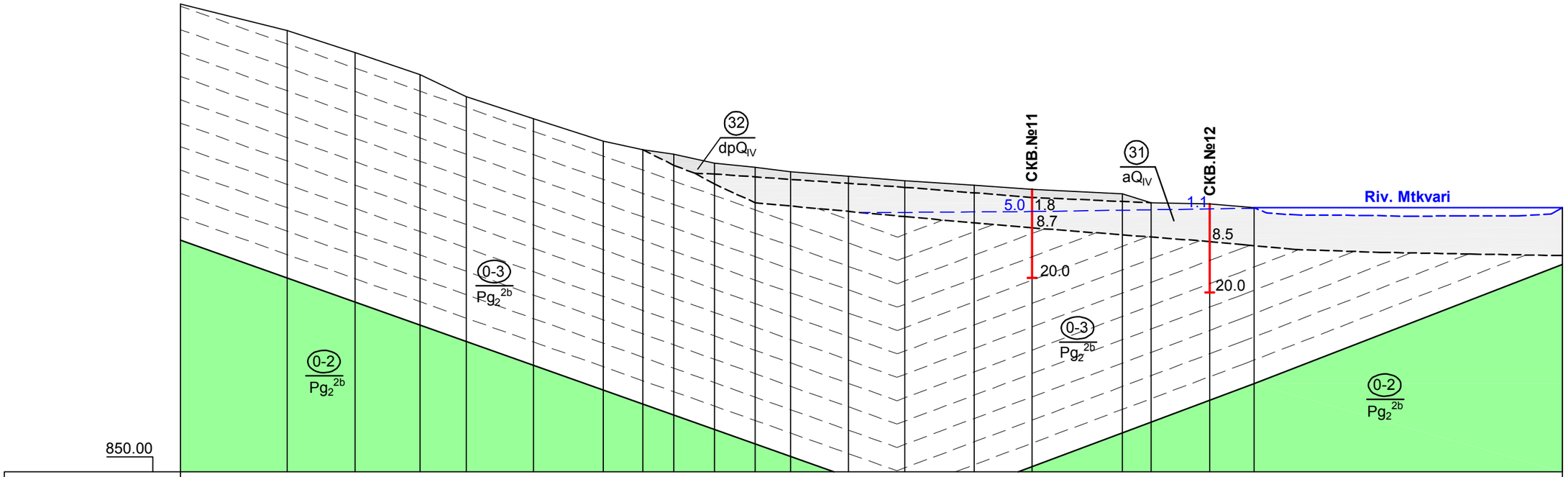
Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

Engineering-geological Map of HPS Building Site	GC-0904-MH-9
	Sheet 1 / 1
Scale 1:1000	Date: 14-May-2009



Elevations	956.00	950.00	945.00	940.00	935.00	930.00	925.00	923.00	922.00	920.00	919.00	918.00	917.00	916.00	915.00	914.00	913.00	911.00	910.70	909.91	909.88
Distance	24.2	15.4	14.7	10.5	15.3	15.8	9.0	7.0	9.2	9.3	8.0	13.1	12.8	15.8	13.1	20.5	6.5	13.3	10.1	69.7	

LEGEND:

1. Engineering-geological Description of Soils

A. ROCKS

Group	Subgroup	Variety by Strength	Symbol and Geological Index	Number of lithologic-stratigraphical unit (member, formation, intrusive or effusive formations)	Description
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-45 % Moderately strong-55%	Pg_2^{2b}	0-3	Green micro and medium-fragmental tuff (0.5-2.0m) with light grey and light brown sandstone interlayers (0.1-0.25-0.5m), with thin (up to 8cm) grey argillite interlayers in places
Magmatic	Effusive (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	0-2	Dark-grey andesite cover (flow breccia), (16m) and grey and dark-grey macrofragmental breccia of andesite content (25m)

B. SOILS

Group	Subgroup		Symbol and Geological Index	Number of lithologic-stratigraphical unit	Description
Sedimentary incoherent	Silty and clayed	Diluvial-proluvial	dpQ_{IV}	33	Brown, intermediately and highly plastic clay with angular gravel and cobbles, and angular boulders inclusions
				32	Brown, intermediately plastic clay with angular gravel and cobbles, with low plastic silt lens and interlayers
	Macrofragmental (alluvial floodplain and sub-floodplain terraces)		aQ_{IV}	31	Rounded cobbles with sand matrix and rounded boulders inclusions (15-20%)

CKB.№6 30.0 — Borehole, its number and depth

Borders of lithologic-stratigraphical units

31 / aQ_{IV} — Index of lithologic-stratigraphical units
Geological index

5.0 — Groundwater level

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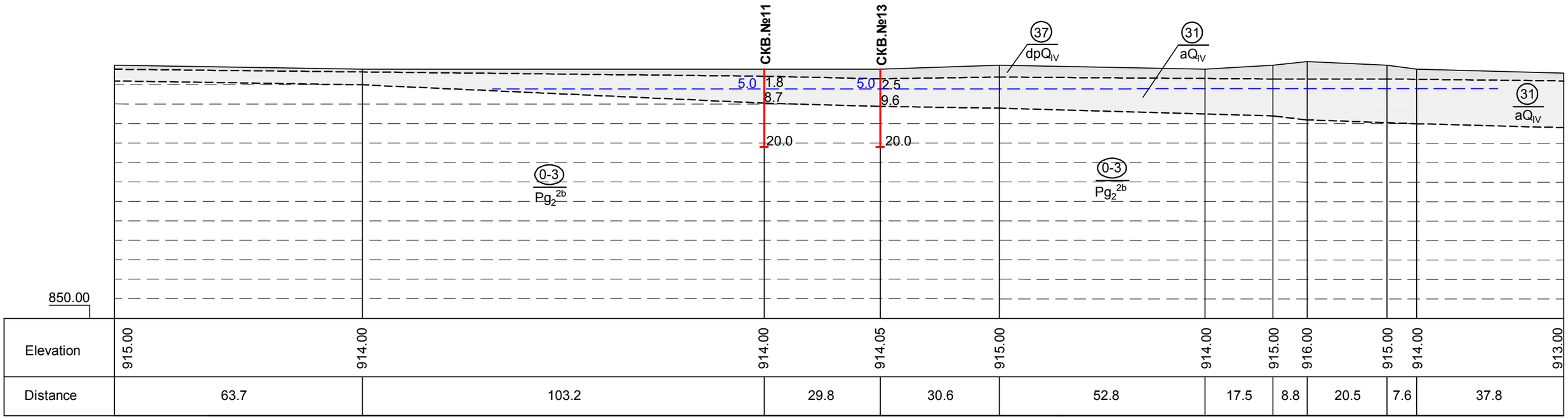
Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

Engineering-geological Sections of HPS Building Site	GC-0904-MH-10
Section 1 - 1'	Sheet 1 / 2
Scale 1:1000	Date: 12-May-2009



LEGEND:

1. Engineering-geological Description of Soils

A. ROCKS

Group	Subgroup	Variety by Strength	Symbol and Geological Index	Number of lithologic-stratigraphical unit (member, formation, intrusive or effusive formations)	Description
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-45 % Moderately strong-55%	Pg_2^{2b}	0-3	Green micro and medium-fragmental tuff (0.5-2.0m) with light grey and light brown sandstone interlayers (0.1-0.25-0.5m), with thin (up to 8cm) grey argillite interlayers in places
Magmatic	Effusive (igneous-sedimentary)	Moderately strong	Pg_2^{2b}	0-2	Dark-grey andesite cover (flow breccia), (16m) and grey and dark-grey macrofragmental breccia of andesite content (25m)

B. SOILS

Group	Subgroup		Symbol and Geological Index	Number of lithologic-stratigraphical unit	Description
Sedimentary incoherent	Silty and clayed	Diluvial-proluvial	dpQ_{IV}	33	Brown, intermediately and highly plastic clay with angular gravel and cobbles, and angular boulders inclusions
				32	Brown, intermediately plastic clay with angular gravel and cobbles, with low plastic silt lens and interlayers
	Macrofragmental (alluvial floodplain and sub-floodplain terraces)		aQ_{IV}	31	Rounded cobbles with sand matrix and rounded boulders inclusions (15-20%)

СКВ.№16 30.0 — Borehole, its number and depth

Borders of lithologic-stratigraphical units

31 / aQ_{IV} — Index of lithologic-stratigraphical units / Geological index

5.0 — Groundwater level

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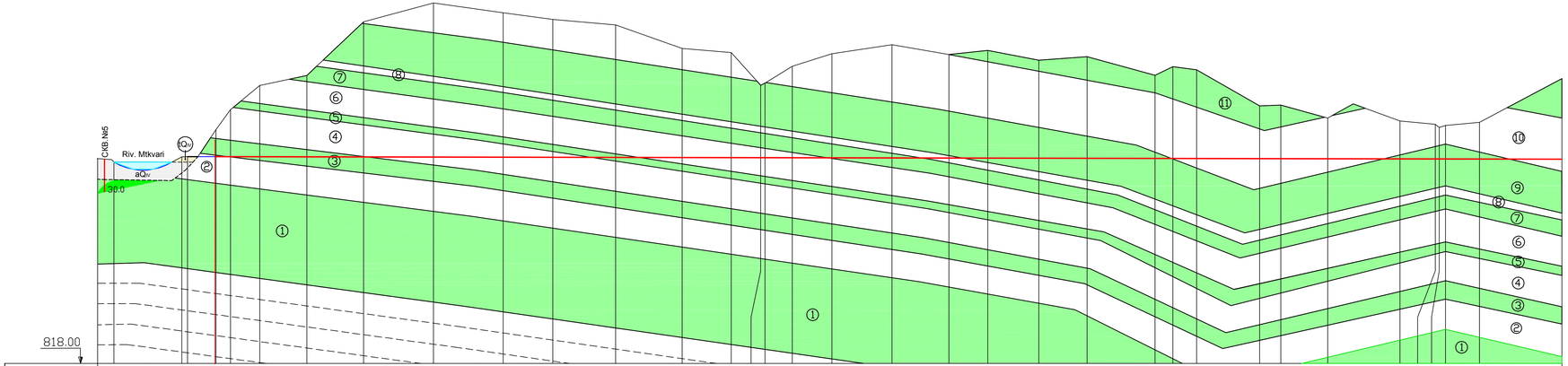
Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

Engineering-geological Sections of HPS Building Site	GC-0904-MH-10
Section 2 - 2'	Sheet 2 / 2
Scale 1:1000	Date: 12-May-2009



Structural and tectonic description	Axis anticline (90°); North limb of Tskaltbili anticline; Dip azimuth 300° ∠15°; Flexure-bend; Dip azimuth 305° ∠15°; Flexure-bend; Dip azimuth 305°∠20°; Flexure-bend; Dip azimuth 300°∠20°; Axis syncline (90°); Dip azimuth 220°∠20°; Axis anticline (90°); Dip azimuth 310°∠20°
Lithological description of soils	2. Grey, greenish-grey massive bedded (1.5-5m), in places interstratified medium-grained sandstones with rare interlayers (2-10cm) greenish-grey sandy argillites.
	3. Dark grey andesite cover (flow breccia)
	4. Greenish-grey medium-grained sandstone. At the upper part interbedded member (0.5m) of thin (1-5cm) sandy argillites and fine-grained sandstones.
	5. Dark grey and grey andesite cover (flow breccia) with spheroidal jointings.
	6. Greenish-grey medium-grained sandstone
	7.Dark grey andesite cover (flow breccia) with spheroidal jointings (10-50cm) at the lower part.
	8. Alternation of greenish-grey medium-grained sandstones (0.25-1.5m) and grey sandy argillites (0.25 cm)
	9. Dark grey andesite cover (flow breccia).
	10. Alternation (5-60cm) of grey and greenish-grey argillites and fine-grained sandstones with interlayers of green microfragmental tuff (1.2m) and grey and greenish-grey medium-grained massive bedded (1-3m) sandstones. At the lower part: interbedded (5-40cm) member (2.2m) of dark grey silicified argillites and grey fine-grained sandstones.
	9. Dark grey andesite cover (flow breccia).
Physical-mechanical properties of soils (average weighted values)	ρs=2.65gm/cm³; ρ=2.39gm/cm³; Rc=38.71MPa; Rcw=26.96MPa; C=11.40MPa; φ=29.0°; E=2890MPa;μ=0.303.
	ρs=2.70gm/cm³; ρ=2.45gm/cm³; Rc=54.31MPa; Rcw=39.13MPa; C=10.60MPa; φ=33.0°; E=3373.9MPa;μ=0.295.
	ρs=2.65gm/cm³; ρ=2.39gm/cm³; Rc=38.71MPa; Rcw=26.96MPa; C=11.40MPa; φ=29.0°; E=2890MPa;μ=0.303.
	ρs=2.70gm/cm³; ρ=2.45gm/cm³; Rc=54.31MPa; Rcw=39.13MPa; C=10.60MPa; φ=33.0°; E=3373.9MPa;μ=0.295.
	ρs=2.65gm/cm³; ρ=2.39gm/cm³; Rc=38.71MPa; Rcw=26.96MPa; C=11.40MPa; φ=29.0°; E=2890MPa;μ=0.303.
	ρs=2.70gm/cm³; ρ=2.45gm/cm³; Rc=54.31MPa; Rcw=39.13MPa; C=10.60MPa; φ=33.0°; E=3373.9MPa;μ=0.295.
	ρs=2.69gm/cm³; ρ=2.26gm/cm³; Rc=23.49MPa; Rcw=17.62MPa; C=6.39MPa; φ=32.0°.
	ρs=2.70gm/cm³; ρ=2.45gm/cm³; Rc=54.31MPa; Rcw=39.13MPa; C=10.60MPa; φ=33.0°; E=3373.9MPa;μ=0.295.
	ρs=2.67gm/cm³; ρ=2.23gm/cm³; Rc=26.34MPa; Rcw=18.36MPa;
	ρs=2.70gm/cm³; ρ=2.45gm/cm³; Rc=54.31MPa; Rcw=39.13MPa; C=10.60MPa; φ=33.0°; E=3373.9MPa;μ=0.295.
Hardness coefficient	f=1.6-2.0
	f=3.5-3.9
	f=2.4-2.7
	f=3.5-3.9
	f=2.4-2.7
	f=3.5-3.9
	f=2.1
	f=3.5-3.9
	f=2.0
	f=2.7-3.5
Soil stability degree	Weak and medium stability; Medium stability; Medium stability; Medium stability
Type of water ingress	Heavy downpour Expected inflow Q=0.5-1.0m³/h; Slight downpour Expected inflow in shaft Q=0.01-0.50m³/h; Heavy downpour. Expected inflow Q=0.5-1.0m³/h; Slight downpour Expected inflow in shaft Q=0.01-0.50m³/h; Heavy downpour. Expected inflow Q=0.5-1.0m³/h; Downpour with interrupted flow Q=1.0-5.0m³/h
Temperature conditions	13.29°; 12.52°; 12.06°
Gas-bearing of soils	Appearance of explosive and hazardous natural gases is not expected during tunnel driving. Possible appearance of CO_2 in places.
Expected engineering-geological phenomena	Fall and delamination of separate blocks and boulders; Fall of separate blocks and boulders; Fall of separate blocks and boulders; Fall of separate blocks and boulders
Ground elevation	995.00; 992.12; 992.03; 992.23; 995.53; 996.71; 1020.00; 1037.30; 1058.20; 1066.83; 1113.15; 1129.39; 1120.98; 1115.18; 1110.49; 1090.24; 1086.60; 1058.33; 1060.13; 1074.79; 1085.55; 1093.37; 1084.92; 1088.52; 1080.03; 1083.02; 1066.97; 1074.34; 1071.77; 1040.62; 1041.17; 1030.04; 1042.30; 1027.49; 1024.55; 1021.90; 1023.53; 1026.28; 1064.00
Distance	14.1; 50.0; 0.4; 2.6; 5.0; 15.5; 12.6; 25.2; 40.6; 49.0; 60.3; 60.0; 42.9; 54.2; 57.3; 42.4; 25.5; 3.7; 23.4; 34.3; 51.9; 49.0; 33.5; 44.0; 41.8; 58.6; 15.4; 20.5; 54.3; 18.2; 40.5; 22.0; 40.4; 30.5; 3.3; 5.3; 29.4; 71.2
Chainage	0; 1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 11
Kilometers	0; 1

Standard values of physical-mechanical properties of rocks

Lithological type of rocks	Indexes: Particle density, ρs gm/cm³	Bulk density, ρ, gm/cm³	Ultimate Uniaxial Compression Strength, Rc, MPa	Ultimate Uniaxial Compression Strength in saturated condition, R_{cw}, MPa	Softening coefficient, K_{sof}	Specific cohesion, C, MPa	Internal friction angle, φ°	Elasticity modulus E, MPa	Poisson's ratio, μ	Strength factor, f (Protodyakonov)
Fine-grained sandstone	2.63	2.34	35.41	23.02	0.65	11.40	29.00	2366.68	0.295	2.30
Medium-grained sandstone	2.65	2.39	38.71	26.96	0.70	11.40	29.00	2890.10	0.303	2.70
Silicified argillite	2.67	2.39	17.07	11.27	0.66	–	–	–	–	1.50
Argillite	2.72	2.12	8.27	–	–	0.14	35.00	–	–	1.50
Tuff	2.69	2.59	33.25	21.23	0.64	5.80	31.00	1736.50	0.315	2.12
Andesite	2.70	2.45	54.31	39.13	0.72	10.60	33.00	3373.90	0.295	3.90
Breccia of andesite content	2.72	2.48	–	–	–	–	–	–	–	3.90
Teschenite	2.88	2.81	151.60	132.77	0.88	–	–	–	–	13.28
Hornfels	2.670	2.450	64.02	40.40	0.630	–	–	–	–	4.04
Diabase	2.720	2.680	85.680	55.410	0.650	–	–	–	–	5.54

LEGEND:

- Tunnel line
- Borders of lithologic-stratigraphical units
- ⑤ aQIV — Index of lithologic-stratigraphical units / Geological index
- CKB.№5 30.0 — Borehole, its number and depth

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Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

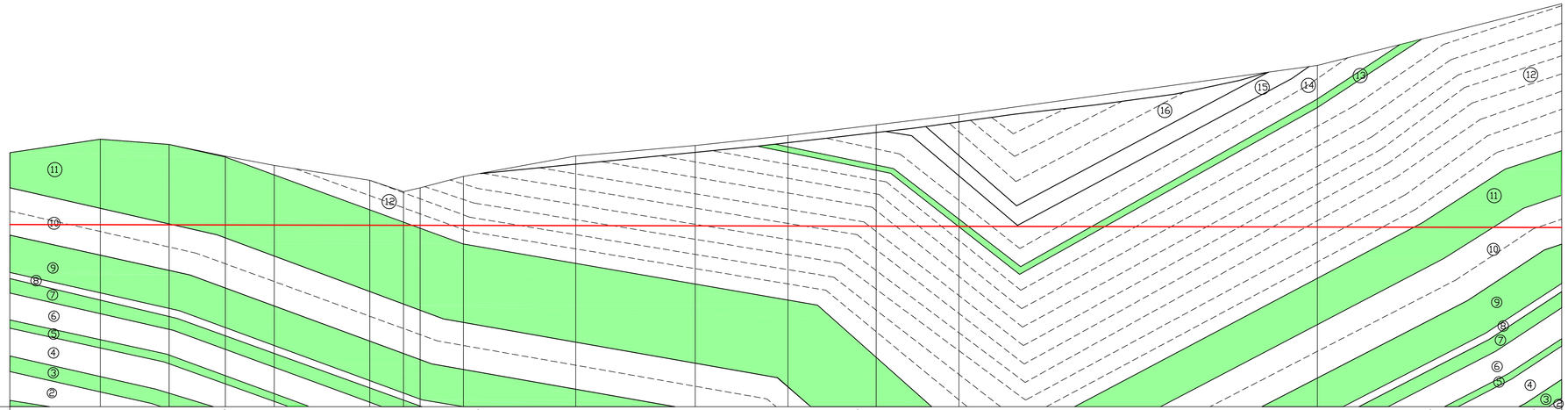
Engineering-geological Section along Diversion Tunnel Axis

GC-0904-MH-11

Sheet 1 / 8

Scale 1:2000

Date: 14-May-2009



Structural and tectonic description	Dip azimuth 310°∠20°	Fauxe-bend	Dip azimuth 330°∠45°	Fauxe-bend	Dip azimuth 305°∠30°	Fauxe-bend	Dip azimuth 330°∠45°	Axis of plane symmetry	Dip azimuth 140°∠30°	Fauxe-bend	Dip azimuth 120°∠35°	Fauxe-bend	Dip azimuth 110°∠35											
Lithological description of soils	10. Alternation (5-60cm) of grey and greenish-grey argillites and fine-grained sandstones with interlayers of green microfragmental tuff (1.2m) and grey and greenish-grey medium-grained massive bedded (1-3m) sandstones. At the lower part: interbedded (5-40cm) member (2.2m) of dark grey silicified argillites and grey fine-grained sandstones.	11. Dark grey andesite cover (flow breccia)	12. Grey and greenish-grey various fragmental tuffs with interlayers of purple argillites and interbedded members of thinly bedded dark red argillites and light grey sandstones, with added green microfragmental breccias of andesite content at the lower half				13.Dark grey andesite cover (flow breccia)	14. Alternation of thickly bedded brownish-green micro and macrofragmental tuffs, light green and brownish-black silicified argillites and greenish-grey fine and medium-grained banded sandstones.	13.Dark grey andesite cover (flow breccia)	12. Grey and greenish-grey various fragmental tuffs with interlayers of purple argillites and interbedded members of thinly bedded dark red argillites and light grey sandstones, with added green microfragmental breccias of andesite content at the lower half			11. Dark grey andesite cover (flow breccia)	10. Alternation (5-60cm) of grey and greenish-grey argillites and fine-grained sandstones with interlayers of green microfragmental tuff (1.2m) and grey and greenish-grey, medium-grained massive bedded (1-3m) sandstones. At the lower part: interbedded (5-40cm) member (2.2m) of dark grey silicified argillites and grey fine-grained sandstones.			
Physical-mechanical properties of soils (average weighted values)	ρs=2.67gm/cm³; ρ=2.23gm/cm³; Rc=26.34MPa; Rcw=18.36MPa;	ρs=2.70gm/cm³; ρ=2.45gm/cm³; Rc=54.31MPa; Rcw=39.13MPa; C=10.60MPa; φ=33.0°; E=3373.9MPa;μ=0.295;	ρs=2.70gm/cm³; ρ=2.47gm/cm³; Rc=42.99MPa; Rcw=30.15MPa;				ρs=2.70gm/cm³; ρ=2.45gm/cm³; Rc=54.31MPa; Rcw=39.13MPa; C=10.60MPa; φ=33.0°; E=3373.9MPa;μ=0.295;	ρs=2.69gm/cm³; ρ=2.43gm/cm³; Rc=31.15MPa; Rcw=19.71MPa; C=5.64MPa; φ=31.6°;	ρs=2.70gm/cm³; ρ=2.45gm/cm³; Rc=54.31MPa; Rcw=39.13MPa; C=10.60MPa; φ=33.0°; E=3373.9MPa;μ=0.295;	ρs=2.70gm/cm³; ρ=2.47gm/cm³; Rc=42.99MPa; Rcw=30.15MPa;			ρs=2.70gm/cm³; ρ=2.45gm/cm³; Rc=54.31MPa; Rcw=39.13MPa; C=10.60MPa; φ=33.0°; E=3373.9MPa;μ=0.295;	ρs=2.67gm/cm³; ρ=2.23gm/cm³; Rc=26.34MPa; Rcw=18.36MPa;		
Hardness coefficient	f=2.0	f=3.5-3.9	f=2.8-3.1				f=3.5-3.9	f=2.1-2.4	f=3.5-3.9		f=2.8-3.1		f=3.5-3.9	f=2.0										
Soil stability degree	Medium stability		Medium stability										Medium stability											
Type of water ingress	Slight downpour Expected inflow in shaft Q=0.01-0.50m³/h		Downpour with interrupted flow Q=1.0-6.0m³/h	Slight downpour Expected inflow in shaft Q=0.01-0.50m³/h				Heavy downpour Expected inflow Q=0.5-1.0m³/h		Slight downpour Expected inflow in shaft Q=0.01-0.50m³/h			Heavy downpour Expected inflow Q=0.5-1.0m³/h											
Temperature conditions	12.00°			12.79°							13.63°													
Gas-bearing of soils	Appearance of explosive and hazardous natural gases is not expected during tunnel driving. Possible appearance of CO_2 in places.																							
Expected engineering-geological phenomena	Fall of separate blocks and boulders			Fall of separate blocks and boulders							Fall of separate blocks and boulders													
Ground elevation	1064.00	1077.07	1071.98	1069.65	1051.71		1037.32	1026.16	1030.00	1040.90		1060.70		1071.00		1080.59	1090.93	1100.71				1149.53		1208.20
Distance	87.8	66.6	54.6	47.3	92.8		32.7	16.0	42.0	108.9		115.8		89.9		85.6	80.3	347.4				237.0		
Chainage	12	13		14		15				16		17		18		19	20	21		22		23	24	25	26
Kilometers																	2							

Standard values of physical-mechanical properties of rocks

Lithological type of rocks	Indexes									
	Particle density, ρ_s, gr/cm³	Bulk density, ρ_d, gr/cm³	Ultimate Unaxial Compression Strength, Rc, MPa	Ultimate Unaxial Compression Strength in saturated condition, R_{cw}, MPa	Softening coefficient, K_{soft}	Specific cohesion, C, MPa	Internal friction angle, φ°	Elasticity modulus, E, MPa	Poisson's ratio, μ	Strength factor, f (Protodyakonov)
Fine-grained sandstone	**2.63**	**2.34**	**35.41**	**23.02**	**0.65**	**11.40**	**29.00**	**2366.68**	**0.295**	**2.30**
Medium-grained sandstone	**2.65**	**2.39**	**38.71**	**26.96**	**0.70**	**11.40**	**29.00**	**2890.10**	**0.303**	**2.70**
Silicified argillite	**2.67**	**2.39**	**17.07**	**11.27**	**0.66**	**–**	**–**	**–**	**–**	**1.50**
Argillite	**2.72**	**2.12**	**8.27**	**–**	**–**	**0.14**	**35.00**	**–**	**–**	**1.50**
Tuff	**2.69**	**2.59**	**33.25**	**21.23**	**0.64**	**5.80**	**31.00**	**1736.50**	**0.315**	**2.12**
Andesite	**2.70**	**2.45**	**54.31**	**39.13**	**0.72**	**10.60**	**33.00**	**3373.90**	**0.295**	**3.90**
Breccia of andesite content	**2.72**	**2.48**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**3.90**
Teschenite	**2.88**	**2.81**	**151.60**	**132.77**	**0.88**	**–**	**–**	**–**	**–**	**13.28**
Hornfels	**2.670**	**2.450**	**64.02**	**40.40**	**0.630**	**–**	**–**	**–**	**–**	**4.04**
Diabase	**2.720**	**2.680**	**85.680**	**55.410**	**0.650**	**–**	**–**	**–**	**–**	**5.54**

LEGEND:

Tunnel line

Borders of lithologic-stratigraphical units

5 / aQ_{IV} — Index of lithologic-stratigraphical units; Geological index

BH-3 / 30.0 — Borehole, its number and depth

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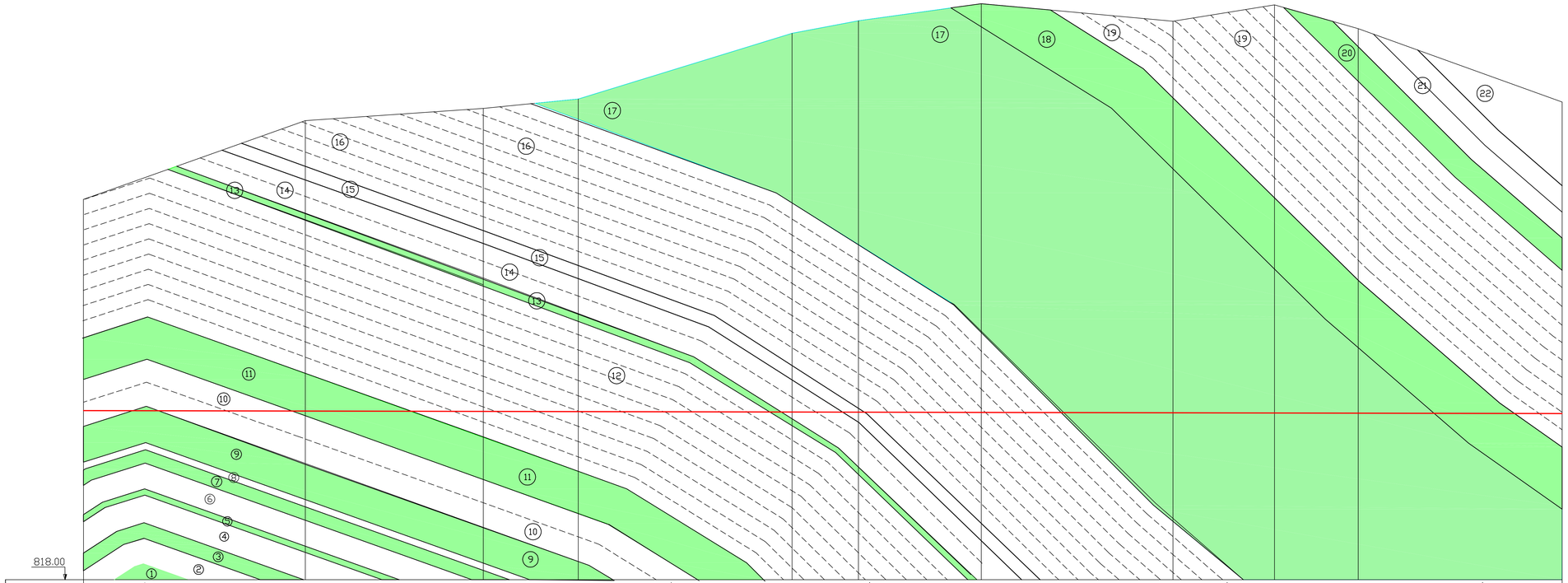
Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

Engineering-geological Section along Diversion Tunnel Axis	GC-0904-MH-11
	Sheet 2 / 8
Scale 1:2000	Date: 14-May-2009



Structural and tectonic description	Dip azimuth 120°∠35°; Axis anticline (188.88°); Fissure-bend; Dip azimuth 300°∠35°; Fissure-bend; Dip azimuth 305°∠35°; Fissure-bend; Dip azimuth 310°∠45°; Fissure-bend; Dip azimuth 300°∠50°; Fissure-bend; Dip azimuth 305°∠45°
Lithological description of soils	9.Dark grey andesite cover (flow breccia); 10. Alternation (5-60cm) of grey and greenish-grey argillites and fine-grained sandstones with interlayers of green microfragmental tuff (1.2m) and grey and greenish-grey medium-grained massive bedded (1-3m) sandstones. At the lower part: interbedded (5-40cm) member (2.2m) of dark grey silicified argillites and grey fine-grained sandstones.; 11. Dark grey andesite cover (flow breccia); 12. Grey and greenish-grey various fragmental tuffs with interlayers of purple argillites and interbedded members of thinly bedded dark red argillites and light grey sandstones, with added green microfragmental breccias of andesite content at the lower half; 13. Light grey massive sandstones; 14. Alternation of thickly bedded (1-3m) sandstones with green microfragmental tuffs, light green and brownish-black silicified argillites and greenish-grey fine and medium-grained bended sandstones.; 15. Grayish green massive medium-grained, in places mineralized sandstones; 16. Light green micro and medium-fragmental tuffs (0.3-1.0m) with interlayers of light grey consertal sandstones and grey argillites (2-15cm).; 17. Dark brown, in places dark green, andesite cover (flow breccia) with well-marked coarse-grained crystals.; 18. Dark grey andesite cover (flow breccia).
Physical-mechanical properties of soils (average weighted values)	ρs=2.67gm/cm³; ρ=2.23gm/cm³; Rc=26.34MPa; Rc₁=18.36MPa; ρs=2.70gm/cm³; ρ=2.45gm/cm³; Rc=64.31MPa; Rc₁=39.13MPa; C=10.60MPa; φ=33.0°; E=3373.9MPa; μ=0.295; ρs=2.67gm/cm³; ρ=2.23gm/cm³; Rc=26.34MPa; Rc₁=18.36MPa; ρs=2.70gm/cm³; ρ=2.45gm/cm³; Rc=64.31MPa; Rc₁=39.13MPa; C=10.60MPa; φ=33.0°; E=3373.9MPa; μ=0.295; ρs=2.70gm/cm³; ρ=2.47gm/cm³; Rc=42.99MPa; Rc₁=30.15MPa; ρs=2.70gm/cm³; ρ=2.45gm/cm³; Rc=64.31MPa; Rc₁=39.13MPa; C=10.60MPa; φ=33.0°; E=3373.9MPa; μ=0.295; ρs=2.69gm/cm³; ρ=2.43gm/cm³; Rc=31.15MPa; Rc₁=19.71MPa; C=5.64MPa; φ=31.6°; ρs=2.65gm/cm³; ρ=2.39gm/cm³; Rc=38.71MPa; Rc₁=26.96MPa; C=11.40MPa; φ=29.0°; E=2890MPa; μ=0.303; ρs=2.68gm/cm³; ρ=2.48gm/cm³; Rc=29.83MPa; Rc₁=19.55MPa; C=5.97MPa; φ=31.3°; ρs=2.70gm/cm³; ρ=2.45gm/cm³; Rc=64.31MPa; Rc₁=39.13MPa; C=10.60MPa; φ=33.0°; E=3373.9MPa; μ=0.295; ρs=2.70gm/cm³; ρ=2.45gm/cm³; Rc=64.31MPa; Rc₁=39.13MPa; C=10.60MPa; φ=33.0°; E=3373.9MPa; μ=0.295.
Hardness coefficient	f=2.0; f=2.7-3.5; f=2.0; f=3.5-3.9; f=2.8-3.1; f=3.5-3.9; f=2.1; f=2.4-2.7; f=2.1; f=3.5-3.9; f=3.5-3.9
Soil stability degree	Medium stability; Medium stability; Medium stability
Type of water ingress	Heavy downpour Expected inflow Q=0.5-1.0m³/h; Slight downpour; Expected inflow in shaft Q=0.01-0.50m³/h; Heavy downpour Expected inflow Q=0.5-1.0m³/h
Temperature conditions	15.85°; 17.16°; 17.40°; 17.06°
Gas-bearing of soils	Appearance of explosive and hazardous natural gases is not expected during tunnel driving. Possible appearance of CO_2 in places.
Expected engineering-geological phenomena	Fall of separate blocks and boulders; Fall of separate blocks and boulders; Fall of separate blocks and boulders
Ground elevation	1288.20; 1288.86; 1301.48; 1311.05; 1378.57; 1391.36; 1408.80; 1390.81; 1407.59; 1383.27; 1308.06
Distance	227.5; 182.5; 97.5; 219.2; 68.0; 126.1; 196.6; 104.1; 85.9; 209.2
Chainage	27; 28; 29; 30; 31; 32; 33; 34; 35; 36; 37; 38; 39; 40; 41
Kilometers	3; 4

Standard values of physical-mechanical properties of rocks

Lithological type of rocks	Indexes									
	Particle density, ρ_s, g/cm³	Bulk density, ρ, g/cm³	Ultimate Uniaxial Compressive Strength, Rc, MPa	Ultimate Uniaxial Compressive Strength in saturated condition, $Rc_{(1)}$, MPa	Softening coefficient, K_{soft}	Specific cohesion, C, MPa	Internal friction angle, φ°	Elasticity modulus E, MPa	Poisson's ratio, μ	Strength factor, f (Protodyakonov)
Fine-grained sandstone	2.63	2.34	35.41	23.02	0.65	11.40	29.00	2366.68	0.295	2.30
Medium-grained sandstone	2.65	2.39	38.71	26.96	0.70	11.40	29.00	2890.10	0.303	2.70
Silicified argillite	2.67	2.39	17.07	11.27	0.66	–	–	–	–	1.50
Argillite	2.72	2.12	8.27	–	–	0.14	35.00	–	–	1.50
Tuff	2.69	2.59	33.25	21.23	0.64	5.80	31.00	1736.50	0.315	2.12
Andesite	2.70	2.45	54.31	39.13	0.72	10.60	33.00	3373.90	0.295	3.90
Breccia of andesite content	2.72	2.48	–	–	–	–	–	–	–	3.90
Teschenite	2.88	2.81	151.60	132.77	0.88	–	–	–	–	13.28
Hornfels	2.670	2.450	64.02	40.40	0.630	–	–	–	–	4.04
Diabase	2.720	2.680	85.680	55.410	0.650	–	–	–	–	5.54

LEGEND:

- Tunnel line
- Borders of lithologic-stratigraphical units
- ⑤ aQ₄ — Index of lithologic-stratigraphical units; Geological index
- DBN5 30.0 — Borehole, its number and depth

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Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

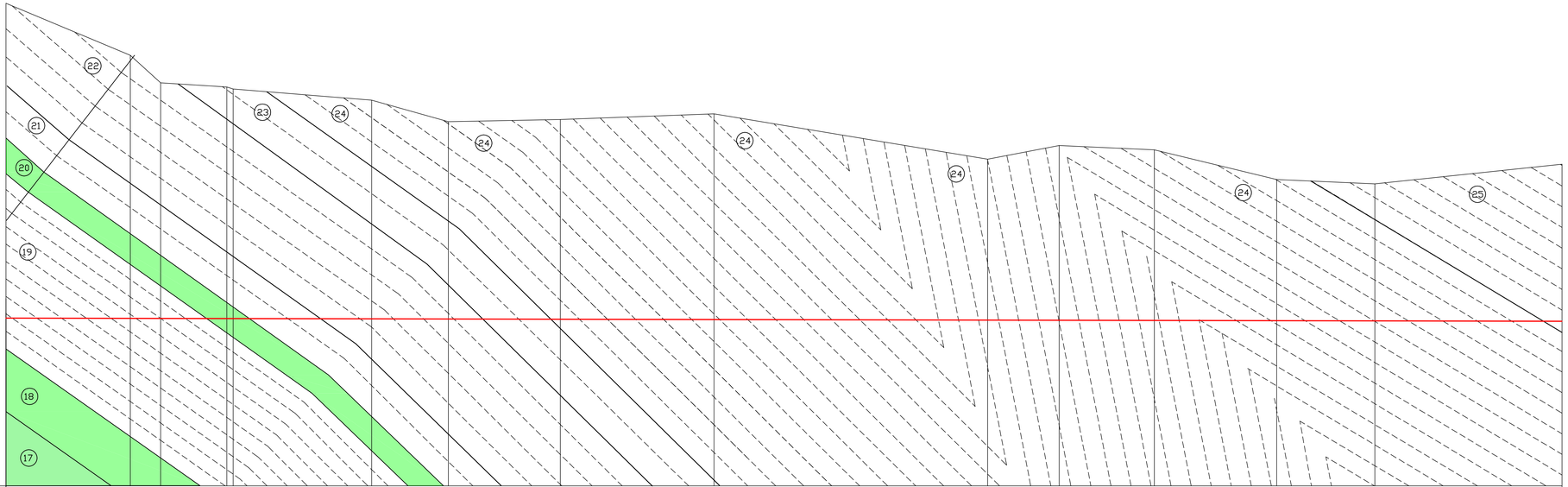
Engineering-geological Section along Diversion Tunnel Axis

GC-0904-MH-11

Sheet 3 / 8

Scale 1:2000

Date: 14-May-2009



Structural and tectonic description	Dip azimuth 305°/40°; Fissure-band; Dip azimuth 305°/50°; Axis syncline (∠67°NW); Dip azimuth 305°/70°; Axis anticline (∠48°NW); Dip azimuth 295°/40°
Lithological description of soils	19. At the upper part: dark green massive fine and medium-fragmental tuffs with dark grey argillites and grey sandstone interlayers (1-15cm). At the lower part: light green microfragmental tuffs with interlayers of thinly (1-7cm) interbedded members of grey and green microfragmental tuffs, grey argillites and grey fine-grained sandstones; 20. Dark grey andesite cover (flow breccia) with strongly marked spheroidal jointings (4m) at the lower part; 21. Alternation of grey and green medium-fragmental tuffs (0.5-1.0m), medium-grained sandstones (3-5-7cm) and dark grey silicified argillites (1-3cm). Greenish-grey medium-grained sandstone at the lower part; 22. Greenish-grey medium-grained massive sandstones with greenish medium-fragmental tuff interlayers and grey argillites; 23. Grey and greenish-grey fine and medium-grained massive sandstones (0.4-1.3m) with interbedded members (0.2-0.3m) of grey argillites thin (1-3cm) and thin (5-7cm) grey sandstones and light green microfragmental tuffs; 24. Light green fine and medium-fragmental tuffs (0.5-1.2m) with grey and light grey fine and medium-grained sandstones interlayers (0.05-0.2-0.7m)
Physical-mechanical properties of soils (average weighted values)	ρs=2.68gm/cm³; ρ=2.41gm/cm³; Rc=27.77MPa; Rc.w=18.55MPa; C=6.08MPa; φ=31.4°; ρs=2.67gm/cm³; ρ=2.35gm/cm³; Rc=26.83MPa; Rc.w=18.66MPa; C=6.34MPa; φ=31.6°; ρs=2.64gm/cm³; ρ=2.34gm/cm³; Rc=34.76MPa; Rc.w=24.27MPa; C=9.68MPa; φ=29.8°; ρs=2.64gm/cm³; ρ=2.31gm/cm³; Rc=31.82MPa; Rc.w=21.72MPa; C=9.90MPa; φ=29.9°; ρs=2.68gm/cm³; ρ=2.55gm/cm³; Rc=33.57MPa; Rc.w=21.50MPa; C=6.64MPa; φ=30.7°;
Hardness coefficient	f=2.0; f=3.5-3.9; f=2.1; f=2.5; f=2.4; f=2.2
Soil stability degree	Medium stability; Medium stability; Medium stability
Type of water ingress	Slight downpour; Expected inflow in shaft Q=0.01-0.50m³/h; Slight downpour; Expected inflow in shaft Q=0.01-0.50m³/h
Temperature conditions	14.64°; 14.15°; 13.42°; 13.43°
Gas-bearing of soils	Appearance of explosive and hazardous natural gases is not expected during tunnel driving. Possible appearance of CO_2 in places.
Expected engineering-geological phenomena	Fall of separate blocks and boulders; Fall of separate blocks and boulders; Fall of separate blocks and boulders

Ground elevation	Distance	Chainage	Kilometers
1318.06		42	
1255.18	126.3	43	
1227.19	30.7		
1223.10	67.3	44	
1226.93	6.4		
1209.70	140.8	45	
1187.73	77.8	46	
1189.98	113.9	47	
1195.80	156.1	48	
1149.65	278.1	49	
1163.64	72.6	50	0
1159.14	96.8	51	
1129.03	124.2	52	
1124.73	99.7	53	
1144.61	190.2	54	
		55	
		56	
		57	

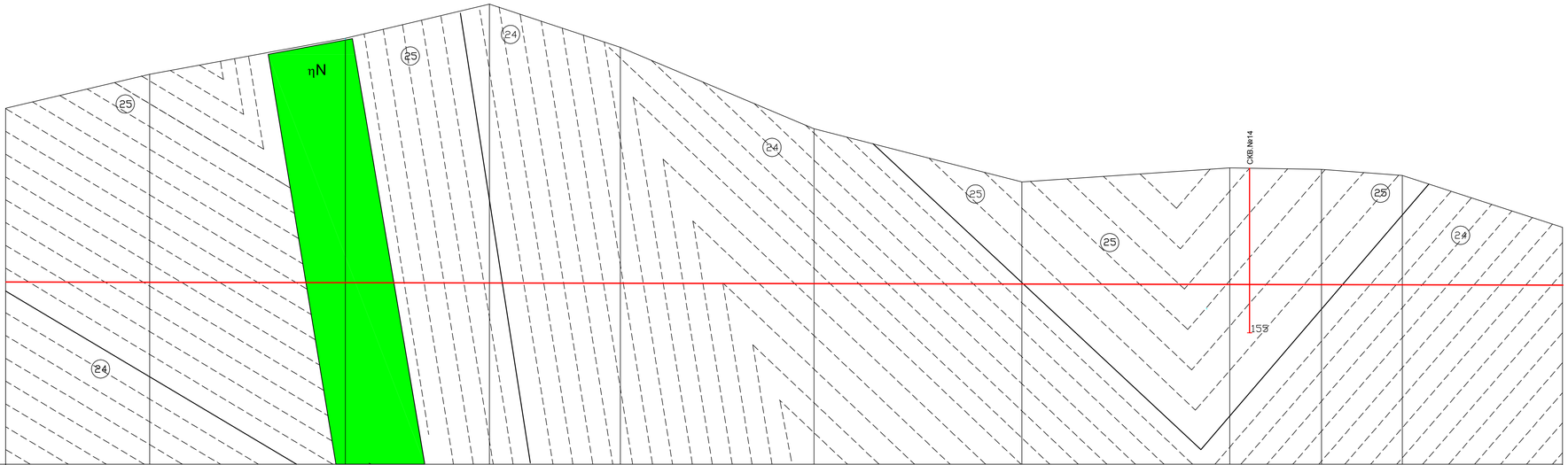
Standard values of physical-mechanical properties of rocks

Lithological type of rocks	Particle density, ρ_s gr/cm³	Bulk density, ρ_1 gr/cm³	Ultimate Uniaxial Compression Strength, Rc_w MPa	Ultimate Uniaxial Compression Strength of saturated rocks, Rc_{sat}, MPa	Softening coefficient, K_{sof}	Specific cohesion, C, MPa	Internal friction angle, φ°	Elasticity modulus E, MPa	Poisson's ratio, μ	Strength index f (Protodyakonov)
Fine-grained sandstone	2.63	2.34	35.41	23.02	0.65	11.40	29.00	2366.68	0.295	2.30
Medium-grained sandstone	2.65	2.39	38.71	26.96	0.70	11.40	29.00	2890.10	0.303	2.70
Silicified argillite	2.67	2.39	17.07	11.27	0.66	–	–	–	–	1.50
Argillite	2.72	2.12	8.27	–	–	0.14	35.00	–	–	1.50
Tuff	2.69	2.59	33.25	21.23	0.64	5.80	31.00	1736.50	0.315	2.12
Andesite	2.70	2.45	54.31	39.13	0.72	10.60	33.00	3373.90	0.295	3.90
Breccia of andesite content	2.72	2.48	–	–	–	–	–	–	–	3.90
Teschenite	2.88	2.81	151.60	132.77	0.88	–	–	–	–	13.28
Hornfels	2.670	2.450	64.02	40.40	0.630	–	–	–	–	4.04
Diabase	2.720	2.680	85.680	55.410	0.650	–	–	–	–	5.54

LEGEND:

- Tunnel line
- Borders of lithologic-stratigraphical units
- 5 / aQ_{IV} — Index of lithologic-stratigraphical units; Geological index
- GeBH5 / 30.0 — Borehole, its number and depth

GEOENGINEERING LTD. Civil Engineering - Survey, Design, Construction, Consulting	**Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia** **Geotechnical Investigation**
Engineering-geological Section along Diversion Tunnel Axis	GC-0904-MH-11; Sheet 4 / 8
Scale 1:2000	Date: 14-May-2009



Structural and tectonic description	Dip azimuth 295°∠40°	Axis azimuth 170°(NW)	Dip azimuth 340°∠80°	Axis azimuth (∠55°NW)	Dip azimuth 300°∠50°	Axis azimuth (∠85°NW)	Dip azimuth 130°∠50°
Lithological description of soils	25. Alternation of dark grey argillites and light brown and grey fine-grained sandstones, at times light green fine and medium-fragmental tuffs.	Dark grey diabase and grey hornfels	25. Alternation of dark grey argillites and light brown and grey fine-grained sandstones, at times light green fine and medium-fragmental tuffs.	24. Light green fine and medium-fragmental tuffs (0.5-1.2m) with grey and light grey fine and medium-grained sandstones interlayers (0.05-0.2-0.7m)	25. Alternation of dark grey argillites and light brown and grey fine-grained sandstones, at times light green fine and medium-fragmental tuffs.	24. Light green fine and medium-fragmental tuffs (0.5-1.2m) with grey and light grey fine and medium-grained sandstones interlayers (0.05-0.2-0.7m)
Physical-mechanical properties of soils (average weighted values)	ρs=2.75gm/cm³; ρ=2.30gm/cm³; Rc=22.11MPa; Rcw=15.79MPa; C=6.83MPa; φ=32.8°;	ρs=2.71gm/cm³; ρ=2.57gm/cm³; Rc=63.17MPa; Rcw=42.16MPa;	ρs=2.75gm/cm³; ρ=2.30gm/cm³; Rc=22.11MPa; Rcw=15.79MPa; C=6.83MPa; φ=32.8°;	ρs=2.68gm/cm³; ρ=2.55gm/cm³; Rc=43.57MPa; Rcw=21.50MPa; C=6.64MPa; φ=30.7°;	ρs=2.75gm/cm³; ρ=2.30gm/cm³; Rc=22.11MPa; Rcw=15.79MPa; C=6.83MPa; φ=32.8°;	ρs=2.68gm/cm³; ρ=2.55gm/cm³; Rc=43.57MPa; Rcw=21.50MPa; C=6.64MPa; φ=30.7°;
Hardness coefficient	f=1.9-2.0	f=4.3-4.8	f=1.9-2.0	f=2.2	f=1.9-2.0	f=2.2
Soil stability degree	Weak stability	Medium stability	Weak stability	Medium stability	Weak stability	Medium stability
Type of water ingress	Slight downpour Expected inflow in shaft Q=0.01-0.50m³/h	Heavy downpour. Expeded inflow Q=0.5-1.0m³/h	Slight downpour Expected inflow in shaft Q=0.01-0.50m³/h			
Temperature conditions	14.40°		13.42°		12.86°	
Gas-bearing of soils	Appearance of explosive and hazardous natural gases is not expected during tunnel driving. Possible appearance of CO_2 in places.					
Expected engineering-geological phenomena	Delamination and fall of separate blocks. Possible rock heaving at tunnel unsupported sides and bottom.	Fall of separate blocks and boulders	Delamination and fall of separate blocks. Possible rock heaving at tunnel unsupported sides and bottom.	Fall of separate blocks and boulders	Delamination and fall of separate blocks. Possible rock heaving at tunnel unsupported sides and bottom.	Fall of separate blocks and boulders

Ground elevation	1144.61	1175.73	1208.78	1240.19	1200.53	1125.87	1076.96	1089.96	1088.46	1082.92	1035.41		
Distance	131.9	179.2	131.9	119.8	177.5	190.3	190.3	84.0	74.0	146.6			
Chainage	58	59	60	61	62	63	64	65	66	67	68	69	70	71
Kilometers	6							7					

Standard values of physical-mechanical properties of rocks

Lithological type of rocks	Indexes									
	Particle density, ρs, gr/cm³	Bulk density, ρ, gr/cm³	Ultimate Uniaxial Compression Strength, Rc, MPa	Ultimate Uniaxial Compression Strength in saturated condition, R_{cw}, MPa	Softening coefficient, K_{sof}	Specific cohesion, C, MPa	Internal friction angle, φ°	Elasticity modulus E, MPa	Poisson's ratio, μ	Strength factor, f (Protodyakonov)
Fine-grained sandstone	2.63	2.34	35.41	23.02	0.65	11.40	29.00	2366.68	0.295	2.30
Medium-grained sandstone	2.65	2.39	38.71	26.96	0.70	11.40	29.00	2890.10	0.303	2.70
Silicified argillite	2.67	2.39	17.07	11.27	0.66	–	–	–	–	1.50
Argillite	2.72	2.12	8.27	–	–	0.14	35.00	–	–	1.50
Tuff	2.69	2.59	33.25	21.23	0.64	5.80	31.00	1736.50	0.315	2.12
Andesite	2.70	2.45	54.31	39.13	0.72	10.60	33.00	3373.90	0.295	3.90
Breccia of andesite content	2.72	2.48	–	–	–	–	–	–	–	3.90
Teschenite	2.88	2.81	151.60	132.77	0.88	–	–	–	–	13.28
Hornfels	2.670	2.450	64.02	40.40	0.630	–	–	–	–	4.04
Diabase	2.720	2.680	85.680	55.410	0.650	–	–	–	–	5.54

LEGEND:

- Tunnel line
- Borders of lithologic-stratigraphical units
- ⑤ / aQIV — Index of lithologic-stratigraphical units / Geological index
- CYB№5 / 30.0 — Borehole, its number and depth

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Mtkvari Hydroelectric Power Station (HPS) on the River Mtkvari in Georgia

Geotechnical Investigation

Engineering-geological Section along Diversion Tunnel Axis	GC-0904-MH-11
	Sheet 5 / 8
Scale 1:2000	Date: 14-May-2009

Structural and tectonic description: Dip azimuth 130°∠50° | Intrusive | Dip azimuth 345°∠85° | Dip azimuth 345°∠85° | Intrusive | Dip azimuth 345°∠85° | Fault | Dip azimuth 180°∠50° | Flexure bend | Dip azimuth 180°∠50° | Flexure bend

Lithological description of soils:
- Medium-grained crystalline Teschenite
- 24. Light green fine and medium-fragmental tuffs (0.5-1.2m) with grey and light grey fine and medium-grained sandstones interlayers (0.05-0.2-0.7m)
- Dark grey diabase and grey hornfels
- 22-25. Green micro and medium-fragmental tuffs (0.5-2.0m) with light grey and light brown sandstone interlayers (0.1-0.25-0.4m), in places thin (up to 10cm) and massive (up to 3m) interlayers of grey argillites.
- 21-1. Dark grey silicified and slightly silicified argillites (0.15-0.25m). Light brown fine-grained sandstone (2m) at the lower part.
- 20. Dark grey andesite cover (flow breccia)
- 19-2. Green massive medium-fragmental tuffs with interlayers of interbedded members of grey and dark grey silicified argillites in places and grey and light brown fine-grained sandstones.
- 19-1. Light green micro and medium-fragmental tuffs (0.5-1.5m) with interlayers of light grey or light brown consertal sandstones (0.1-0.4m) and grey thin (0.05-0.1m) argillites.

Physical-mechanical properties of soils (average weighted values):
- ρs=2.88gm/cm³; ρ=2.81gm/cm³; Rc=158.60MPa; Rc(s)=132.70MPa; Ksaf=0.86
- ρs=2.68gm/cm³; ρ=2.55gm/cm³; Rc=33.57MPa; Rc(s)=21.50MPa; C=6.64MPa; φ=30.7°;
- ρs=2.71gm/cm³; ρ=2.57gm/cm³; Rc=83.17MPa; Rc(s)=42.16MPa;
- ρs=2.68gm/cm³; ρ=2.56gm/cm³; Rc=32.65MPa; Rc(s)=21.16MPa; C=6.36MPa; φ=30.8°; E=1736MPa; μ=0.315.
- ρs=2.66gm/cm³; ρ=2.39gm/cm³; Rc=18.90MPa; Rc(s)=12.44MPa;
- ρs=2.70gm/cm³; ρ=2.45gm/cm³; Rc=54.31MPa; Rc(s)=39.13MPa; C=10.60MPa; φ=33.0°; E=3373.9MPa; μ=0.295
- ρs=2.69gm/cm³; ρ=2.34gm/cm³; Rc=27.07MPa; Rc(s)=17.52MPa; C=5.16MPa; φ=32.2°;
- ρs=2.68gm/cm³; ρ=2.48gm/cm³; Rc=30.32MPa; Rc(s)=20.15MPa; C=5.97MPa; φ=31.3°;

Hardness coefficient: f=2.2 | f=12.4-13.8 | f=2.2 | f=5.36 | f=1.0-1.5 | f=2.1 | f=1.58 | f=3.5-3.9 | f=1.9 | f=2.1

Soil stability degree: Medium stability | Stable | Medium stability | Stable | Weak stability | Medium stability | Weak stability | Medium stability | Weak stability | Medium stability

Type of water ingress: Slight downpour Q=0.01-0.50m³/h | Heavy downpour Expected inflow Q=0.5-1.0m³/h | Slight downpour Expected inflow in shaft Q=0.01-0.50m³/h | Slight downpour Expected inflow in shaft Q=0.01-0.50m³/h

Temperature conditions: 12.74° | 13.31° | 12.88° | 13.21°

Gas-bearing of soils: Appearance of explosive and hazardous natural gases is not expected during tunnel driving. Possible appearance of CO_2 in places.

Expected engineering-geological phenomena: Fall of separate blocks and boulders | Fall of separate blocks and boulders | Fall of separate blocks and boulders | Fall of separate blocks and boulders | Fall of separate blocks and boulders

Ground elevation: 1035.41 | 1057.67 | 1046.99 | 1116.02 | 1117.97 | 1089.63 | 1096.39 | 1084.49 | 1104.74 | 1136.25 | 1132.70 | 1084.56

Distance: 93.9 | 73.6 | 331.3 | 66.5 | 81.0 | 66.7 | 70.8 | 189.9 | 129.1 | 66.6 | 265.0

Chainage: 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86

Kilometers: 8

Standard values of physical-mechanical properties of rocks

Lithological type of rocks	Indexes: Particle density, ρ_s, gr/cm³	Bulk density, ρ, gr/cm³	Ultimate Uniaxial Compression Strength, Rc, MPa	Ultimate Uniaxial Compression Strength in saturated condition, $Rc_{(s)}$, MPa	Softening coefficient, K_{saf}	Specific cohesion, C, MPa	Internal friction angle, φ°	Elasticity modulus E, MPa	Poisson's ratio, μ	Strength factor, f (Protodyakonov)
Fine-grained sandstone	2.63	2.34	35.41	23.02	0.65	11.40	29.00	2366.68	0.295	2.30
Medium-grained sandstone	2.65	2.39	38.71	26.96	0.70	11.40	29.00	2890.10	0.303	2.70
Silicified argillite	2.67	2.39	17.07	11.27	0.66	–	–	–	–	1.50
Argillite	2.72	2.12	8.27	–	–	0.14	35.00	–	–	1.50
Tuff	2.69	2.59	33.25	21.23	0.64	5.80	31.00	1736.50	0.315	2.12
Andesite	2.70	2.45	54.31	39.13	0.72	10.60	33.00	3373.90	0.295	3.90
Breccia of andesite content	2.72	2.48	–	–	–	–	–	–	–	3.90
Teschenite	2.88	2.81	151.60	132.77	0.88	–	–	–	–	13.28
Hornfels	2.670	2.450	64.02	40.40	0.630	–	–	–	–	4.04
Diabase	2.720	2.680	85.680	55.410	0.650	–	–	–	–	5.54

LEGEND:

- Tunnel line
- Borders of lithologic-stratigraphical units
- ⑤ / aQ_{IV} — Index of lithologic-stratigraphical units / Geological index
- CKBN5 30.0 — Borehole, its number and depth

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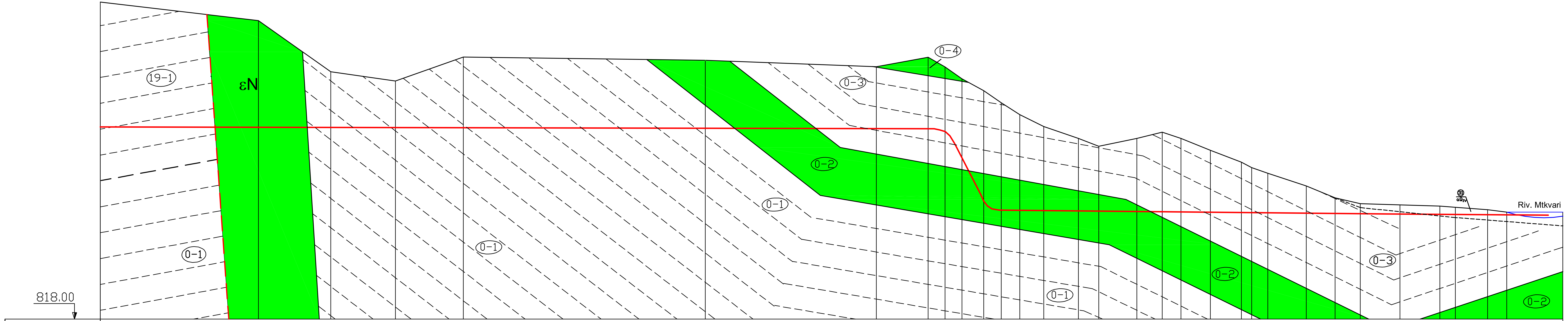
Geotechnical Investigation

Engineering-geological Section along Diversion Tunnel Axis	GC-0904-MH-11
	Sheet 6 / 8
Scale 1:2000	Date: 14-May-2009



Structural and tectonic description	Fault / Dip azimuth 300°∠37° / Flexure bend / Dip azimuth 0°∠10° / Flexure bend / South limb of Tori-Tadziri anticline; Dip azimuth 355°∠30° / Axis syncline (∠85°NW) / North limb of Tori-Tadziri syncline, Dip azimuth 165°∠20°
Lithological description of soils	19-1. Light green micro and medium-fragmental tuffs (0.5-1.5m) with interlayers of light grey or light brown consertal sandstones (0.1-0.4m) and grey thin (0.05-0.1m) argillites. / Macrocrystalline teschenite / 0-1. Green massive medium and macrofragmental tuffs with light grey and grey fine-grained sandstones inclusions and lens and members / 0-2. Dark grey andesite cover (flow breccia) of 16m and grey and dark grey macrofragmental breccia of andesite content (25m) / 0-3. Green micro and medium-fragmental tuffs (0.5-2.0m) with interlayers of light grey and light brown sandstones (0.1-0.25-0.5m), in places grey argillite thin interlayers (up to 8cm). / 0-2. Dark grey andesite cover (flow breccia) of 16m and grey and dark grey macrofragmental breccia of andesite content (25m) / 0-3. Green micro and medium-fragmental tuffs (0.5-2.0m) with interlayers of light grey and light brown sandstones (0.1-0.25-0.5m), in places grey argillite thin interlayers (up to 8cm).
Physical-mechanical properties of soils (average weighted values)	ρs=2.68gm/cm³; ρ=2.48gm/cm³; Rc=30.32MPa; $Rc_{(s)}$=20.15MPa; C=5.97MPa; φ=31.3°; / ρs=2.88gm/cm³; ρ=2.81gm/cm³; Rc=151.60MPa; $Rc_{(s)}$=132.70MPa; K_{saf}=0.86 / ρs=2.69gm/cm³; ρ=2.59gm/cm³; Rc=33.25MPa; $Rc_{(s)}$=21.23MPa; C=5.80MPa; φ=31.0°; E=1736.5MPa; μ=0.315; K_{saf}=0.69 / ρs=2.70gm/cm³; ρ=2.45gm/cm³; Rc=54.34MPa; $Rc_{(s)}$=39.13MPa; C=10.60MPa; φ=33.0°; E=3373.9MPa; μ=0.295 / ρs=2.68gm/cm³; ρ=2.48gm/cm³; Rc=30.32MPa; $Rc_{(s)}$=20.15MPa; C=5.98MPa; φ=31.3°; / ρs=2.70gm/cm³; ρ=2.45gm/cm³; Rc=54.34MPa; $Rc_{(s)}$=39.13MPa; C=10.60MPa; φ=33.0°; E=3373.9MPa; μ=0.295 / ρs=2.68gm/cm³; ρ=2.48gm/cm³; Rc=30.32MPa; $Rc_{(s)}$=20.15MPa; C=5.98MPa; φ=31.3°;
Hardness coefficient	f=2.1 / f=1.0-1.5 / f=11.9-13.7 / f=2.1 / f=3.5-3.9 / f=2.1 / f=3.5-3.9 / f=2.1
Soil stability degree	Medium stability / Weak stability / Stable / Medium stability / Medium stability
Type of water ingress	Slight downpour, Expected inflow in shaft Q=0.01-0.50m³/h / Heavy downpour, Expected inflow Q=0.5-1.0m³/h / Slight downpour, Expected inflow in shaft Q=0.01-0.50m³/h
Temperature conditions	12.22° / 12.19°
Gas-bearing of soils	Appearance of explosive and hazardous natural gases is not expected during tunnel driving. Possible appearance of CO_2 in places.
Expected engineering-geological phenomena	Fall of separate blocks and boulders / Fall of separate blocks and boulders / Fall of separate blocks and boulders
Ground elevation	1084.56, 1069.01, 1026.04, 1018.26, 1038.33, 1035.63, 1030.27, 1038.20, 1030.00, 1020.00, 1010.00, 1000.00, 990.00, 980.00, 970.00, 963.40, 970.00, 975.10, 970.00, 960.00, 950.00, 945.40, 940.60, 930.00, 920.00, 915.00, 914.00, 913.00, 912.00, 910.00, 908.00
Distance	132.9, 60.7, 54.4, 57.2, 203.2, 143.9, 43.5, 14.3, 14.1, 18.3, 14.8, 15.6, 20.1, 29.1, 17.1, 32.0, 21.4, 15.8, 24.6, 26.1, 8.7, 13.6, 32.3, 24.1, 21.3, 33.3, 33.6, 13.0, 27.0, 16.2
Chainage	87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 98+95
Kilometers	9, 10

Standard values of physical-mechanical properties of rocks

Lithological type of rocks	Indexes: Particle density, ρ_s, gr/cm³	Bulk density, ρ, gr/cm³	Ultimate Uniaxial Compression Strength, Rc, MPa	Ultimate Uniaxial Compression Strength in saturated condition, $Rc_{(s)}$, MPa	Softening coefficient, K_{saf}	Specific cohesion, C, MPa	Internal friction angle, φ°	Elasticity modulus E, MPa	Poisson's ratio, μ	Strength factor, f (Protodyakonov)
Fine-grained sandstone	2.63	2.34	35.41	23.02	0.65	11.40	29.00	2366.68	0.295	2.30
Medium-grained sandstone	2.65	2.39	38.71	26.96	0.70	11.40	29.00	2890.10	0.303	2.70
Silicified argillite	2.67	2.39	17.07	11.27	0.66	–	–	–	–	1.50
Argillite	2.72	2.12	8.27	–	–	0.14	35.00	–	–	1.50
Tuff	2.69	2.59	33.25	21.23	0.64	5.80	31.00	1736.50	0.315	2.12
Andesite	2.70	2.45	54.31	39.13	0.72	10.60	33.00	3373.90	0.295	3.90
Breccia of andesite content	2.72	2.48	–	–	–	–	–	–	–	3.90
Teschenite	2.88	2.81	151.60	132.77	0.88	–	–	–	–	13.28
Hornfels	2.670	2.450	64.02	40.40	0.630	–	–	–	–	4.04
Diabase	2.720	2.680	85.680	55.410	0.650	–	–	–	–	5.54

LEGEND:

- Tunnel line
- Borders of lithologic-stratigraphical units
- ⑤ / aQ_{IV} — Index of lithologic-stratigraphical units / Geological index
- CKB№5, 30.0 — Borehole, its number and depth

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Engineering-geological Section along Diversion Tunnel Axis	GC-0904-MH-11
	Sheet 7 / 8
Scale 1:2000	Date: 14-May-2009

A. ROCKS

Group	Subgroup	Variety by Strength	Symbol and Geological Index	Number of lithologic-stratigraphical unit (member, formation, intrusive or effusive formations)	Description
Magmatic and metamorphic	Intrusive and contact metamorphic	Strong-88 % Moderately strong-12%	ηN	28	Dark grey diabase and grey hornfels
Magmatic and metamorphic	Intrusive	Very strong-100%	δN	27	Medium-grained crystalline teschenite
		Very strong-100%	εN	26	Macrocrystalline teschenite
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-51 % Moderately strong -49%	Pg_2^3	25	Alternation of dark grey argillites and light brown and grey fine-grained sandstones, at times light green fine and medium-fragmental tuffs.
		Moderately strong-100%	Pg_2^3	24	Light green fine and medium-fragmental tuffs (0.5-1.2m) with grey and light grey fine and medium-grained sandstones interlayers (0.05-0.2-0.7m)
		Moderately weak and weak-85 % Moderately strong -15%	Pg_2^3	23	Grey and greenish-grey fine and medium-grained massive sandstones (0.4-1.3m) with interbedded members (0.2-0.3m) of grey argillites thin alternation, grey fine-grained sandstones and light green microfragmental tuffs
		Moderately strong -89% Moderately weak and weak-11 %	Pg_2^{2c}	22	Greenish-grey medium-grained massive sandstones with greenish medium-fragmental tuff interlayers and grey argillites.
		Moderately strong -68% Moderately weak and weak-32 %	Pg_2^{2c}	21	Alternation of grey and green medium-fragmental tuffs (0.5-1.5m), medium-grained sandstones (3-5-7cm) and dark grey silicified argillites (1-3cm). Greenish-grey medium-grained sandstone at the lower part (2m).
		Moderately strong -95% Moderately weak and weak-5 %	Pg_2^{2b-c}-Pg_2^3	22-25	Green micro and medium-fragmental tuffs (0.5-2.0m) with light grey and light brown sandstone interlayers (0.1-0.25-0.4m), in places thin (up to 10cm) and massive (up to 3m) interlayers of grey argillites.
		Moderately strong -10% Moderately weak and weak-90 %		21-1	Dark grey silicified and slightly silicified argillites (0.15-0.25m). Light brown fine-grained sandstone (2m) at the lower part.
Magmatic	Effusive	Moderately strong -100%		20	Dark grey andesite cover (flow breccia).
Sedimentary cemented	Microfragmental and silty-clayed	Moderately strong -59% Moderately weak and weak-41 %		19-2	Green massive medium-fragmental tuffs with interlayers of interbedded members of grey and dark grey silicified argillites in places and grey and light brown fine-grained sandstones.
		Moderately strong -85% Moderately weak and weak-15 %		19-1	Light green micro and medium-fragmental tuffs (0.5-1.5m) with interlayers of light grey or light brown consertal sandstones (0.1-0.4m) and grey thin (0.05-0.1m) argillites.
Magmatic	Effusive	Moderately strong -100%	Pg_2^{2b}	20	Dark grey andesite cover (flow breccia) with strongly marked spheroidal jointings (4m) at the lower part.
Sedimentary cemented	Microfragmental and silty-clayed	Moderately strong -76% Moderately weak and weak-24 %	Pg_2^{2b}	19	At the upper part: dark green massive fine and medium-fragmental tuffs with dark grey argillites and grey sandstone interlayers (1-15cm) - 17.2m. At the lower part: light green microfragmental tuffs with interlayers of thinly (1-7cm) interbedded members of grey and green microfragmental tuffs, grey argillites and grey fine-grained sandstones - 48.8m.
Magmatic	Effusive	Moderately strong -100%	Pg_2^{2b}	18	Dark grey andesite cover (flow breccia).
		Moderately strong -100%	Pg_2^{2b}	17	Dark brown, in places dark green, andesite cover (flow breccia) with well-marked coarse-grained crystals.
Sedimentary cemented	Microfragmental and silty-clayed	Moderately strong -85% Moderately weak and weak-15 %	Pg_2^{2b}	16	Light green micro and medium-fragmental tuffs (0.3-1.0m) with interlayers of light grey consertal sandstones and grey argillites (2-15cm).
		Moderately strong -100%	Pg_2^{2b}	15	Greyish-green massive medium-grained, in places interstratified, sandstones.
		Moderately strong -75% Moderately weak and weak-25 %	Pg_2^{2b}	14	Alternation of thickly bedded brownish-green micro and macrofragmental tuffs, light green and brownish-black silicified argillites and greenish-grey fine and medium-grained banded sandstones.
Magmatic	Effusive	Moderately strong -100%	Pg_2^{2b}	13	Dark grey andesite cover (flow breccia).
Sedimentary cemented	Microfragmental and silty-clayed	Moderately strong -94% Moderately weak and weak-6 %	Pg_2^{2b}	12	Grey and greenish-grey various fragmental tuffs with interlayers of purple argillites and interbedded members of thinly bedded dark red argillites and light grey sandstones, with added green microfragmental breccias of andesite content at the lower half .
Magmatic	Effusive	Moderately strong -100%	Pg_2^{2b}	11	Dark grey andesite cover (flow breccia).
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-38 % Moderately strong -62%	Pg_2^{2b}	10	Alternation (5-60cm) of grey and greenish-grey argillites and fine-grained sandstones with interlayers of green microfragmental tuff (1.2m) and grey and greenish-grey medium-grained massive bedded (1-3m) sandstones. At the lower part: interbedded (5-40cm) member (2.2m) of dark grey silicified argillites and grey fine-grained sandstones.
Magmatic	Effusive	Moderately strong -100%	Pg_2^{2b}	9	Dark grey andesite cover (flow breccia).
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-50 % Moderately strong -50%	Pg_2^{2b}	8	Alternation of greenish-grey medium-grained sandstones (0.25-1-1.5m) and grey sandy argillites (6-25cm) .
Magmatic	Effusive	Moderately strong -100%	Pg_2^{2b}	7	Dark grey andesite cover (flow breccia) with spheroidal jointings (10-50cm) at the lower part.
Sedimentary cemented	Microfragmental and silty-clayed	Moderately strong -100%	Pg_2^{2b}	6	Greenish-grey medium-grained sandstone.
Magmatic	Effusive	Moderately strong -100%	Pg_2^{2b}	5	Dark grey andesite cover (flow breccia) with spheroidal jointings.
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-1.5 % Moderately strong -98.5%	Pg_2^{2b}	4	Greenish-grey massive consertal sandstones (0.3-0.6m) with interlayers of grey and greenish-grey medium-fragmental tuffs (0.15-1.0m) and grey and brown argillites (0.1-3.5m).
Magmatic	Effusive	Moderately strong -100%	Pg_2^{2b}	3	Dark grey andesite cover (flow breccia).
Sedimentary cemented	Microfragmental and silty-clayed	Moderately strong -100%	Pg_2^{2b}	2	Greenish-grey massive bedded medium-grained sandstones with rare interlayers (2-10cm) greenish-grey sandy argillites.
Magmatic	Effusive	Moderately strong -100%	Pg_2^{2b}	1	Grey andesite cover (flow breccia).
Magmatic	Effusive	Moderately strong -100%	Pg_2^{2b}	0-4	Dark grey andesite cover (flow breccia).
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-85 % Moderately strong -15%	Pg_2^{2b}	0-3	Green micro and medium-fragmental tuffs (0.5-2.0m) with interlayers of light grey and light brown sandstones (0.1-0.25-0.5m), in places grey argillite thin interlayers (up to 8cm).
Magmatic	Effusive	Moderately strong -100%	Pg_2^{2b}	0-2	Dark grey andesite cover (flow breccia) of 16m and grey and dark grey macrofragmental breccia of andesite content (25m).
Sedimentary cemented	Microfragmental and silty-clayed	Moderately weak and weak-90 % Moderately strong -10%	Pg_2^{2b}	0-1	Green massive medium and macrofragmental tuffs with light grey and grey fine-grained sandstone inclusions and lens and thin interbedded (1-15cm) members (0.1-2m) of grey and brownish-grey argillites and grey fine and medium-grained sandstones.

B. SOILS

Group	Subgroup		Symbol and Geological Index	Number of lithologic-stratigraphical unit	Description
Artificial	Fill (road bed)		tQ_{IV}	37	Crushed-stone, angular gravel and boulders with intermediately plastic clay and low plastic silt clay matrix (road bed fill)
Sedimentary incoherent	Macrofragmental (colluvial)		cQ_{IV}	36	Angular cobbles and gravel, angular boulders with low plastic silt matrix (30-40%)
	Silty and clayed	Landslide	dlQ_{IV}	35	Brown, intermediately plastic clay with angular gravel and cobbles, angular and rounded boulders inclusions
		Colluvial-diluvial	cdQ_{IV}	34	Brown, intermediately plastic clay with angular gravel, rounded and angular cobbles and rounded boulders inclusions
		Diluvial-proluvial	dpQ_{IV}	33	Brown, intermediately and highly plastic clay with angular gravel and cobbles, and angular boulders inclusions
				32	Brown, intermediately plastic clay with angular gravel and cobbles, with low plastic silt lens and interlayers
	Macrofragmental (alluvial floodplain and sub-floodplain terraces)		aQ_{IV}	31	Rounded cobbles with sand matrix and rounded boulders inclusions (15-20%)

Standard values of physical-mechanical properties of rocks

Lithological type of rocks	Indexes									
	Particle density, ρ_s, gr/cm³	Bulk density, ρ, gr/cm³	Ultimate Uniaxial Compression Strength, Rc, MPa	Ultimate Uniaxial Compression Strength in saturated condition, $Rc_{(s)}$, MPa	Softening coefficient, K_{soft}	Specific cohesion, C, MPa	Internal friction angle, φ°	Elasticity modulus E, MPa	Poisson's ratio, μ	Strength factor, f (Protodyakonov)
Fine-grained sandstone	2.63	2.34	35.41	23.02	0.65	11.40	29.00	2366.68	0.295	2.30
Medium-grained sandstone	2.65	2.39	38.71	26.96	0.70	11.40	29.00	2890.10	0.303	2.70
Silicified argillite	2.67	2.39	17.07	11.27	0.66	–	–	–	–	1.50
Argillite	2.72	2.12	8.27	–	–	0.14	35.00	–	–	1.50
Tuff	2.69	2.59	33.25	21.23	0.64	5.80	31.00	1736.50	0.315	2.12
Andesite	2.70	2.45	54.31	39.13	0.72	10.60	33.00	3373.90	0.295	3.90
Breccia of andesite content	2.72	2.48	–	–	–	–	–	–	–	3.90
Teschenite	2.88	2.81	151.60	132.77	0.88	–	–	–	–	13.28
Hornfels	2.670	2.450	64.02	40.40	0.630	–	–	–	–	4.04
Diabase	2.720	2.680	85.680	55.410	0.650	–	–	–	–	5.54

LEGEND:

Tunnel line

Borders of lithologic-stratigraphical units

5 / aQ_{IV} — Index of lithologic-stratigraphical units; Geological index

CKBN5 / 30.0 — Borehole, its number and depth

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Geotechnical Investigation

Engineering-geological Section along Diversion Tunnel Axis	GC-0904-MH-11
	Sheet 8 / 8
Geotechnical Description of Soils	Date: 14-May-2009

APPENDIX 4

PUBLIC CONSULTATION AND DISCLOSURE PLAN

APPENDIX 4. PUBLIC CONSULTATION AND DISCLOSURE PLAN

4.1 Introduction

Mtkvari HPP Project will be realized on the river Mtkvari, which originates in Turkey, as Kura River, and flows into Georgia. The project area is located in southeast of Georgia, on River Mtkvari, near the city of Akhaltsikhe. The installed capacity of the HPP is 43 MW. The type of the HPP is run-off-the-river with the headworks located at a distance of 3 km from village Rustavi and powerhouse at a distance of 1 km from village Sakuneti.

The planned Mtkvari Project will be structured in a way that it meets the required Georgian national criteria and Requiremetns of IFIs. In this regard public consultation and disclosure issues will be given importance throughout the project implementation. This plan is a part of the final ESIA report and aims to ensure that all stakeholder interests are incorporated into project planning and implementation.

This Public Consultation and Disclosure Plan, prepared in accordance with the requirements of IFIs and Georgian Legislation, reflects the following main issues:

- Description of the public, who may be affected by the project.
- How communication among relevant stakeholders works throughout the ESIA process.
- What information will be disclosed and by what means.

As a part of the ESIA Report, this plan is open to review and comment by the stakeholders. The aim of this plan is to define the relevant stakeholders, to develop an engagement strategy covering both the construction and operation phases of the Project, and to provide a grievance mechanism for the public. This plan includes the records of the information disclosure and consultation activities conducted as a part of the ESIA study, and the main environmental and social issues raised by the stakeholders.

4.2. Regulations and Requirements

4.2.1. Georgian Regulations/Requirements

The governing laws on environmental impact assessment in Georgia are the “Law on Environmental Protection” and the “Law on Licenses and Permits”. Within this scope, the project owner (in this case JSC Caucasus Energy and Infrastructure) is responsible for the preparation of the ESIA for submission to the Ministry of Environment Protection and Natural Resources (Ministry). In addition, the environmental and social impact assessment process includes a public notice and participation meeting to be implemented. After submission of the ESIA to the Ministry, the report will be publicised and announcements will be made on the regional and national newspapers. The public has 45 days after the date of publication for submitting objections to the ESIA. Between 45-60 days after the announcement in the newspaper; the local municipality, the Ministry and other interested organizations are invited to the public hearing meeting, where all comments and recommendations can be expressed. Following the public hearing organization, the project developer (JSC CEI) shall be responsible for preparation of the public hearing protocol including all comments and recommendations received and expressed during the meeting. Despite the fact that the received comments and recommendations are taken into account depending on the project developer’s will, the project developer is responsible for providing a written reply for the comments/recommendations regarding the project to the complainant/commenter. After completion of the process regarding the public hearing, the developer shall apply for an environmental permit to the Ministry. Then the Ministry has 20 days to carry out an State Ecological Examination (SEE) and issue a permit. In the context of Georgian Law, no additional consultation or public engagement activities is obligatory after the ESIA is approved and permits are taken.

4.2.2. International Requirements

In addition to the Georgian requirements, a PCDP is also requested by IFIs (EBRD, IFC etc.) since this Project is categorised as a "Category A" Project, which has the potential to have adverse environmental and social impacts.

EBRD Requirements: The requirements of EBRD are regulated by the Environmental and Social Policy (2008). Within this scope, 10 performance requirements are established which are listed below:

PR 1: Environmental and Social Appraisal and Management
PR 2: Labour and Working Conditions
PR 3: Pollution Prevention and Abatement
PR 4: Community Health, Safety and Security
PR 5: Land Acquisition, Involuntary Resettlement and Economic displacement
PR 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
PR 7: Indigenous Peoples
PR 8: Cultural Heritage
PR 9: Financial Intermediaries
PR 10: Information Disclosure and Stakeholder Engagement

PR10, namely Information Disclosure and Stakeholder Engagement is directly related to this disclosure plan. In this context, the issue of consultation as given in the Environmental and Social Policy (2008) can be summarized as follows. "The ultimate aim of meaningful consultation is to consult the people that are potentially affected by the Project and provide equal opportunity to express their concerns and views about the Project including design, location, technological choice and timing. The properties of meaningful consultation include the followings:

- It should be based on the disclosure of relevant and adequate information including, where appropriate and relevant, draft documents and plans, prior to decisions being taken when options are still open.
- It should begin early in the environmental and social appraisal process.

- It will focus on the social and environmental risks and adverse impacts, and the proposed measures and actions to address these.
- It will be carried out on an ongoing basis as the nature of issues, impacts and opportunities evolves."

International Finance Corporation (IFC) Performance Standards: IFC adopted 8 Performance Standards on Social and Environmental Sustainability in order to manage social and environmental risks and impacts and to enhance development opportunities in its private sector financing in its member countries eligible for financing. Clients shall meet the Performance Standards throughout the life of an investment. These Performance Standards are as follows:

Performance Standard 1: Social and Environmental Assessment and Management System
Performance Standard 2: Labor and Working Conditions
Performance Standard 3: Pollution Prevention and Abatement
Performance Standard 4: Community Health, Safety and Security
Performance Standard 5: Land Acquisition and Involuntary Resettlement
Performance Standard 6: Biodiversity Conservation and Sustainable Natural Resource Management
Performance Standard 7: Indigenous Peoples
Performance Standard 8: Cultural Heritage

An important aspect of Performance Standard 1 - Social and Environmental Assessment and Management System is stated as follows: "*establishing importance of effective community engagement through disclosure of project-related information and consultation with local communities on matters that directly affect them*".

Community engagement covers the disclosure of information by the client and public consultation if there are communities affected by the impacts of the project. The purpose, nature, scale of the project, duration of the proposed project activities and any risks and potential impacts will be disclosed by the client. Consultation should:

- be continuous
- based on the disclosure
- begin early in the social and environmental assessment process
- focus on impacts, risks, measures and actions

According to Performance Standard 1, grievance mechanism should be established by the client as well, in order to receive affected communities' concerns and grievance and facilitate resolutions if adverse impacts and risks are anticipated.

Within the scope of Mtkvari HPP Project, consultation involves development of an information sharing process in the early stages of the Project regarding the Project characteristics, its impacts and relevant mitigation measures in an ongoing basis.

When ESIA disclosure is of concern, the priority is to make the ESIA report publicly available at and near the project site in order to allow people to comment on the document. In this context, executive summary will be made available in both English and Georgian. Additionally, the draft and final reports and all other relevant documents (i.e. leaflets etc.) will be available in both Georgian and English at the web site of the project owner.

Furthermore, the project developer is responsible for development of a grievance mechanism that will be addressing the concerns of stakeholders throughout the project lifetime. The grievance mechanism shall be based on evaluation of environmental and social performance of the project by relevant stakeholders.

4.3. Summary of Already Conducted Public Consultation Activities

Public consultation activities of Mtkvari HPP were initiated by the start of the ESIA process. In the site visits conducted by the experts from ENCON Environmental Consultancy Co. preparing the ESIA, a social survey and consultation with locals were carried out in addition to the environmental survey. The initial activities for

incorporating the public into the project was implemented at the site visit conducted in February 2009 (see Photograph 4.1 and Photograph 4.2).

Photograph 4.1. Interview with the Locals during the First Site Visit (February 2009)

Photograph 4.2. Villagers in Sakuneti Village

During these consultations, available preliminary information about the project was provided and the questions of the public were answered openly based on the status of the studies. In this context, the headmen of Sakuneti and Rustavi Villages were also contacted and the key informant questionnaire was performed with the headmen. During these interviews information about the project was given and information about the properties of the local community and their thoughts about the project were taken. During these activities, the questions and comments of the locals showed that the local community is generally positive about the project and supports its implementation as it is expected that the implementation of the project will create employment opportunities.

The second round of information disclosure and public consultations were conducted in June 2009 (see Photograph 4.3). In the scope of these activities an information leaflet was prepared including major information about the project and the environmental/social impacts and delivered to the relevant stakeholders and public. The leaflet was prepared in both English and Georgian languages. The leaflet was also publicly available on the web site of CEI. The leaflet includes a

summary project description, potential environmental and social impacts and preliminary information about the ESIA process. This leaflet is presented in Annex 1 of this plan.

Additionally, an interim report, including further details about the environmental and social baseline of the project and impact area and impacts of Mtkvari HPP Project, was prepared and made public. This report was not only published on the web site of CEI but also distributed in the public consultation meeting held with the relevant stakeholders in both English and Georgian languages.

Within the scope of ESIA studies, public hearing and participation meetings have been organized in accordance with the Georgian Legislation and IFIs requirements. The formal public participation meeting concerning the proposed Mtkvari HPP Project was held in Akhaltsikhe District in the Municipality Hall on June 12, 2009.

The purpose of the meeting was to provide information and get the opinions of the locals related to the project. The date, place and the scope of this meeting were announced in the newspaper on June 2, 2009. Also by contacting to the related headmen, municipalities and districts, it was secured that the maximum participation to the meeting was obtained. Representatives from potentially affected villages were also invited to join the meeting, which took place at the district. The information of the place and time of the meeting was announced to relevant audience by not only the newspapers but also announcements made through the web site of JSC Caucasus Energy and Infrastructure (CEI).

The meeting held in the Akhaltsikhe Municipality Hall on June 12, 2009, was run by the CEO of CEI, Archil Mamatelashvili with an opening speech. The number of attendants in the meeting was 23. In addition to providing information regarding the details of the project and the scope of the ESIA, discussions were held in order to answer the questions about the project and possible environmental and social impacts of the project. In this context, after introductory information regarding the project, the interim report was discussed with the participants. During the meeting, the positive approach of the participants to the project was observed. A few

questions regarding the water pumps on the left bank of the River and the unregistered sites that are considered as private property were raised. During the meetings the questions of the participants were answered in a way that they can understand. It is observed that after the meeting most of the concerns of the participants were settled when compared with before the meeting. All the relevant activities (i.e. participation list, photographs from the meeting, minutes of meeting and relevant documentation about the announcements made for the project) regarding this public consultation round and the meeting have been recorded and presented in Photograph 4.4 and in Annex 2 of this plan.

Photograph 4.3. A Photograph from Consultation with Public in Sakuneti Village

Photograph 4.4. A Photograph from the Public Hearing in Akhaltsikhe on June 12, 2009

Within the scope of ESIA studies, a second public hearing and participation meeting was held in Akhaltsikhe in order to inform the public regarding the results of the ESIA studies conducted and take their opinion regarding the impacts of the project. Information regarding the date and location of the meeting were provided in the newspaper and on the web site of JSC Caucasus Energy and Infrastructure. Before the meeting, the draft ESIA report was made publicly available on the web site of JSC CEI for review.

The second public participation meeting was held in Akhaltsikhe District in the Municipality Hall on October 21, 2009. The purpose of the meeting was to provide information regarding the results of the ESIA studies and get the opinions of the locals related to the impacts of the project. The date, place and the scope of this meeting were announced in the newspaper on September 2, 2009. The information of the place and time of the meeting was announced to relevant audience by not only the newspapers but also announcements made through the web site of JSC Caucasus Energy and Infrastructure (CEI).

The meeting held in the Akhaltsikhe Municipality Hall on October 21, 2009, was run by the CEO of CEI, Archil Mamatelashvili with an opening speech. The number of attendants in the meeting was 16. In addition to providing information regarding the details of the project and the results of the ESIA, discussions were held in order to answer the questions about the environmental and social impacts of the project. During the meeting, the positive approach of the participants to the project was observed. A few questions regarding the expropriation activities were raised. Furthermore, it was asked if any reforestation and recultivation activities would be held after closure of the project. During the meeting the questions of the participants were answered in a way that they can understand. It is observed that after the meeting most of the concerns of the participants were settled when compared with before the meeting. All the relevant activities (i.e. participation list, photographs from the meeting, minutes of meeting and relevant documentation about the announcements made for the project) regarding this public consultation round and the meeting have been recorded and presented in Annex 2 of this plan.

4.4. Identification of Relevant Stakeholders and Potentially Affected Groups

The relevant stakeholders and potentially affected groups and their contributions and relevance to the project can be listed as follows:

Affected public in Rustavi (headworks) and Sakuneti (powerhouse): The interests of affected public are environmental and social impacts of the project during construction and operation period. Those environmental and social impacts might cover temporary health impacts and noise, dust emissions, and loss of cultivated land in addition to potential opportunities for temporary or permanent employment during construction and operation phases.

Governmental Bodies: The governmental bodies that are expected to have an interest related to the project are; Ministry of Environment Protection and Natural Resources, Ministry of Energy, Ministry of Economic Development, Ministry of Health and Social Welfare, Ministry of Culture, Authorities in Administrative Regions. The governmental bodies are interested in not only environmental and

social issues of the project, but also successful implementation of the project (costs, benefits), social welfare of the public and impacts on the energy production and increased tax revenues.

Project Owner: JSC Caucasus Energy and Infrastructure implements the project and hence will affect the procedures in the planning, construction and operation phases of the project.

NGOs: Local and international NGOs are expected to have an interest on the natural protection of the project area. Those organizations might be: REC Caucasus, WWF and all other relevant local NGOs.

IFIs: As a project financer, IFIs will have an impact on the safeguards and procedures for the project planning and implementation, and the relevant activities/measures to be taken during construction and operation phases.

Akhaltsikhe and Aspindza Municipalities: The interests of the municipal bodies include any impact on the public health and environmental resources, and the benefits of the project to the region. Local municipal bodies will collect tax annually, on fixed assets which is 1% of average net book value of fixed assets.

4.5. Disclosure of Information

The objective of public consultation and disclosure plan (PCDP)/stakeholder engagement plan (SEP) is to incorporate stakeholders of the project into the project planning (including the preparation of the ESIA) and implementation activities. In this context, transparency is of priority during ESIA process, which implies that all relevant information regarding the project including the impacts and mitigation measures, project alternatives etc. shall be made publicly available.

Furthermore, relevant information, such as significant milestones of construction and operation phases, shall be made available to stakeholders by various means (e.g. leaflets, factsheets through regional office of the Ministry, and the media including the website of CEI, newspapers etc.).

In this respect, key information regarding the project and its environmental and social impacts will be provided to the public via following means:

1. Informal meetings with the project affected persons, i.e. local villagers to provide them with opportunity to express any concerns.

2. Making inquiries to ensure effective two-way, face-to-face communications in informal meetings.

3. Providing news releases to television stations, radio stations, and newspapers.

4. Conducting periodical project status quarterly briefings for community groups and concerned residents.

5. Formalized presentations and meetings for local and provincial governmental organizations to periodically inform state and local officials regarding developments over the course of the project.

6. Project document repository to maintain en easily accessible repository through which concerned stakeholders may review relevant issues of concern including cited positive and negative opinions, criticisms, etc.

7. Website of JSC Caucasus Energy and Infrastructure (http://www.cei.ge) to provide timely, current information on the project. Additionally, any inquiry can be directed to JSC CEI via the e-mail to cei@cei.ge.

8. Preparing fact sheets to summarize major activities about the project in clear and understandable language. Fact sheets will be mailed to interested stakeholders.

Within the scope of the disclosure activities, a second public participation shall be held upon submission of the draft ESIA Report to the Ministry. The purpose of this second meeting is to inform the public and other relevant stakeholders about the details of the project and assessed environmental and social impacts of the project as well as the mitigation measures developed for the significant impacts. Presentations including the findings of the ESIA and relevant discussion shall be held in the second meeting. As it was in the first public participation meeting, all the relevant activities (i.e. participation list, photographs from the meeting, minutes of meeting and relevant documentation about the announcements made for the project) held in the meeting will be recorded.

Finally, the final ESIA Report will be publicized at the web site of JSC Caucasus Energy and Infrastructure and a hard copy of the report shall be available in Akhaltsikhe and Aspindza Municipalities in addition to the regional office of Ministry of Environmental Protection and Natural Resources in Samtskhe Javakheti Region.

4.6. Timetable

Table 1.4 summarizes a tentative schedule for the information disclosure and public consultation activities to be held for the Mtkvari HPP Project both during the planning and the construction and operation phases. The planning phase activities are more detailed since they will be conducted in short term, where further activities, including the grievance activities, will continue throughout the project economic life and will be scheduled accordingly.

Table 4.1. Timetable for Information Disclosure and Public Consultation Activities

Activity	Schedule
Meeting with Stakeholders and Local People	Whenever necessary, with short notice
Consultation with the Ministry of Environment Protection and Natural Resources and Relevant Governmental Bodies	Continuing as necessary, Fall 2009 for consultations with regard to ESIA report
Public Hearing (Scoping) Meeting (in Akhaltsikhe)	June 2009 (already completed)

Public Disclosure of Interim Report	June 2009 (already completed)
Public Disclosure of Scoping Leaflet	June 2009 (already completed)
Second Public Participation Meeting	Fall 2009
Public Disclosure of Final ESIA	Fall 2009
Grievance management	Throughout project lifetime

4.7. Resources and Responsibilities

The responsible body for implementation of this public consultation and disclosure plan is JSC Caucasus Energy and Infrastructure as the project developer. In this context, the company shall assign a person/team to organize relevant public consultation activities, including meetings, and enhance the participation of relevant stakeholders throughout the project implementation. The municipalities of Akhaltsikhe and Aspindza Districts are also involved in the process as the hosting bodies for public hearing meetings through support for attendance of locals and NGOs. During the ESIA studies the CEI employed consultants in addition to the company staff to enhance and effectively implement the information disclosure and stakeholder consultation activities. If needed, such an approach can be followed during the construction and operation phases of the project.

4.8. Grievance Mechanism

Grievance mechanism is an important component to be considered in the scope of stakeholder engagement/relation activities, since it is a way to communicate and address the comments and complaints of the public regarding the project. As indicated, the ultimate aim is to minimize the complaints and problems of the public related to the project via implementation of impact mitigation measures. The grievance mechanism will be made available to the public with the ESIA report and will be implemented in the construction and operation phases of the project.

The main authority/responsible party that will implement the grievance mechanism is the project owner, which is JSC Caucasus Energy and Infrastructure. Therefore, implementation of the relevant activities under the grievance mechanism will be the responsibility of the project owner. In this context, a sample grievance form

and sample grievance closeout form are presented in Annex 3 of this plan. For the moment, grievances may be submitted/communicated to JSC Caucasus Energy and Infrastructure at the following postal address and phone number:

JSC Caucasus Energy and Infrastructure
Address: 44 Al. Kazbegi Ave., Tbilisi, 0177, Georgia
Tel: (995 32) 393256

The project owner will receive the complaints within the scope of the grievance mechanism via the filled out forms or in written form reaching to the relevant project offices, or in oral form reaching to the relevant telephone numbers. All the grievances will be recorded and answered. Once the grievance is received by the project owner, the relevance will be assessed, and if found irrelevant a written reply will be provided to the person who complained about the project activities. If the relevance of the complaint is validated, the Project owner will implement investigations on the activities that are questioned in order to assess whether there has been any non-conformity. If so, the project owner will take necessary actions in order to resolve the problem satisfactorily for the stakeholders.

4.9. Reporting

The details regarding disclosure of draft ESIA report and results of consultation on the draft ESIA and how comments shall be taken into account are provided in Section 4.2 of this plan. In accordance with the relevant rules defined in the Project, JCS Caucasus Energy and Infrastructure will publish the final ESIA documents. Furthermore, executive summary of final ESIA will also be published on the web site of JSC CEI and will be available at the project offices and the closeby municipalities. In addition, Ministry of Environment Protection and Natural Resources and the Samtskhe Javakheti Regional office shall keep a copy of the ESIA report.

ANNEX 1

Informative Leaflet (distributed to the stakeholders and public during the first round of public consultation activities):

Key Facts about the Project

- HPP Type: Derivational
- Location: South of Georgia, on the river **Mtkvari**, near city **Akhaltsikhe**. The **headworks of HPP** will be located at a distance of **3 km from the village Rustavi**, while the **HPP building** at a distance of **1 km from the village Sakuneti.**
- Main Knots:
  - Headworks
  - Diversion Tunnel – length: 9.5 km, Diameter: 5m;
  - Levelling Tank;
  - HPP building with two units;
  - Outlet channel with length up to 40 m;
  - Voltage build-up substation;
  - 110 kv transmission line with length 13 km.
- Capacity: 42-43 MW

Milestones

- ✓ Completion of feasibility studies: June 2009
- ✓ Start of construction: September 2009
- ✓ Completion of construction: October 2012

Expected Impacts of the Project

Impact	Measure
Construction Period	
Dust emissions, exhaust gases and noise emissions due to construction activities	Watering, maintenance of construction equipment, monitoring of exhaust gases
Hazardous wastes such as dyes, waste oil etc.	Regular collection and transportation to relevant facilities
Wastewater produced from crushing-sieving works and domestic purposes	Appropriate disposal in accordance with local and international legislations
Solid wastes (concrete, scraps, metals, plastics etc.) due to construction activities	Appropriate disposal in accordance with local and international legislations
Visual impacts	Construction of HPP building suitable with the current land use
Operation Period	
Habitat and vegetation loss because of catchment area	Minimum impact due to minimum land use
Change in the downstream flow rate due to regulation of river flow rate	Flow regulation by optimum operation conditions
Possible variations in the quality of water released in terms of temperature and dissolved oxygen	Flow regulation by optimum operation conditions and monitoring continuously

Public Participation

Public Participation Meeting will be organized for Mtkvari HPP, so that the public can express their opinions and be informed about the project, within the scope of the ESIA Study being conducted in line with the Georgian Legislations. Location, date and time of this meeting will be announced later.

Contact Details
Caucasus Energy and Infrastructure
44 Al. Kazbegi Ave., Tbilisi, 0177, Georgia,
Tel: (995 32) 393256 e-mail: cei@cei.ge

MTKVARI

HYDROELECTRIC PROJECT

Republic of GEORGIA

Akhaltsikhe

Informative Leaflet

April 2009

JSC Caucasus Energy and Infrastructure (CEI)

ENCON Environmental Consultancy Co.

VERKİS

MTKVARI HYDROELECTRIC PROJECT

What is hydropower?

Hydropower, hydraulic power or water power is power that is derived from the force or energy of moving water, which may be harnessed for useful purposes. It is one of the oldest methods of producing power. Today, hydropower is mostly used for electricity production. However, water power had been used for irrigation and operation of various machines (i.e. watermills, textile machines, dock cranes and domestic lifts.)

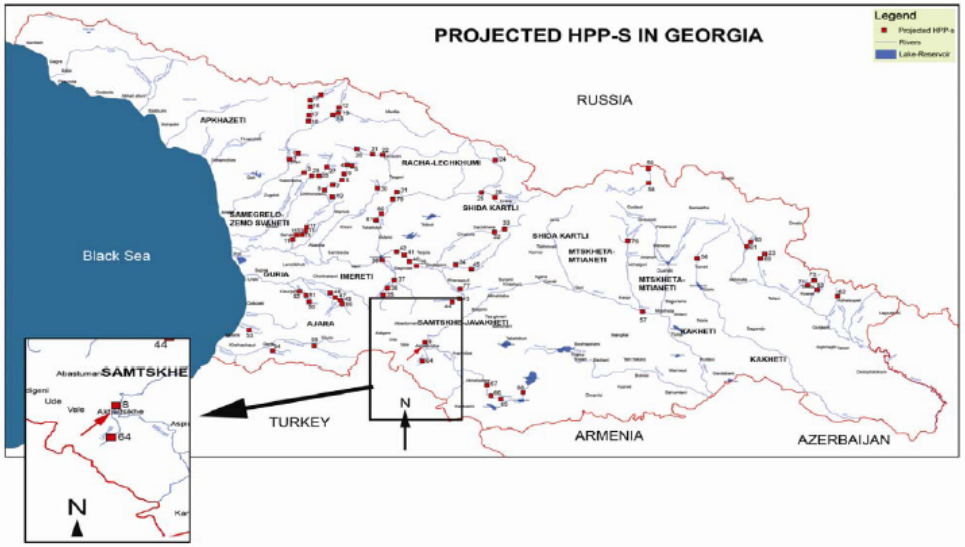
Currently, hydroelectric power meets 13.3% of world electricity demand. The rest of electricity is produced by mainly burning fossil fuels and nuclear power stations which are more expensive than hydropower. Moreover, hydropower is a very weak contributor to the global warming, by emission of CO_2 and other harmful gases in contrast to fossil fuels. Additional advantages of hydropower can be listed as follows:

- Water to run the power plant is provided free by nature
- Operation and maintenance costs are relatively lower
- The technology is reliable and proven over time
- Hydropower is a renewable energy source

Despite valuable advantages of hydropower, some disadvantages are of concern:

- High investment costs
- Hydrology dependency (precipitation)
- In some cases, inundation of land
- In some cases, modification of fish habitat
- In some cases, changes in stream water quality

energy sources in Georgia is only 25-30% of its hydro power potential. Therefore, the sector has the potential to be developed for the production of energy and ensuring energy security, increasing total exports and employment in the country. As a consequence, hydropower is obviously one of the major energy sources in order to meet the



What is the role of hydropower in Georgia?

Hydropower comprises the major energy resources in Georgia as it is one of the richest countries in the world in terms of hydropower resources. Currently, 78% of electricity demand has been met by hydropower plants in Georgia. The hydroelectric potential is estimated as 40-50 billion kWh from which 10-15 billion kWh/year is economically feasible. Whereas, the utilization of water power

increasing electricity demand of Georgia due to the economic development. From this point of view, Mtkvari is considered to be one of the potential dams to be constructed in order to produce electrical energy by the Ministry of Energy. In this context, the purpose of the project is to construct Mtkvari Dam on River Mtkvari to contribute to the development of electricity sector further in order to reduce import and increase sustainable production of energy.

ANNEX 2

Public Hearing Notice of JSC Caucasus Energy and Infrastructure:

JSC Caucasus Energy & Infrastructure

Announcement

Public Hearing of ESIA for
Hydropower Plant Mtkvari Construction Project

JSC Caucasus Energy and Infrastructure announces that the Public Hearing of ESIA for Mtkvari HPP construction project is scheduled to be held on 12 June 2009, at 1 p.m. at the following address: 18 Kostava Str., Akhaltsikhe.

Mtkvari HPP construction project envisages the construction of a 42 MW Hydropower Plant on Riv. Mtkvari, in Samckxe-Javakheti region.

Any member of the public will be able to familiarize himself with the brief Informative Leaflet of ESIA on Mtkvari HPP Project at the following address: 44 Al. Kazgebi Ave., Tbilisi, Georgia or on the following web site: www.cei.ge.

The management of JSC Caucasus Energy and Infrastructure will be able to discuss any suggestions and answer any questions from the members of the public, if they are submitted in a written form until 10 June 2009 at the above address.

The hearing will be open for the attendance of any member of the public, including CEI shareholders.

JSC Caucasus Energy and Infrastructure
2 June 2009

JSC Caucasus Energy & Infrastructure (CEI) : 44 Al. Kazbegi Ave., Tbilisi, 0177, Georgia; Tel: (995 32) 393 256; E-mail: cei@cei.ge

Newspaper Announcement Regarding the Public Hearing Meeting:

ზაზა ფანასკერტელის სახელობის სახელმწიფო სამედიცინო კოლეჯი მდებარეობს საქართველოს ომის ვეტერანთა კლინიკური პოსპიტლის შენობის I და II სართულებზე, რაც მნიშვნელოვნად უწყობს ხელს პრაქტიკული მეცადინეობების წარმატებით ჩატარებას ადგილზევე, ანუ

ომის ვეტერანთა კლინიკური პოსპიტლის შენობამდე).

ტელეფონები: 35-63-61 და 8(99)97-40-84.

მერცია სახელაშვილი

განცხადება

ჰიდროელექტროსადგური მტკვარი-ს მშენებლობის პროექტის გარემოზე ზემოქმედების შეფასების საჯარო განხილვის შესახებ

სს „კაუკაზუს ენერჯი ენდ ინფრასთრაქჩა" აცხადებს ჰიდროელექტროსადგური მტკვარი-ს მშენებლობის პროექტის გარემოზე ზემოქმედების შეფასების საჯარო განხილვას, რომელიც გაიმართება 2009 წლის 12 ივნისს, 13 საათზე, მისამართზე: ქ. ახალციხე, კოსტავას ქ. №18 (გამგეობის შენობა).

ჰიდროელექტროსადგური მტკვარი-ს მშენებლობის პროექტი ითვალისწინებს სამცხე-ჯავახეთში, მდ. მტკვარზე 36-43 მეტ-იანი ჰიდროელექტროსადგურის მშენებლობას.

საზოგადოების ნებისმიერ წარმომადგენელს შეუძლია გაეცნოს პროექტთან დაკავშირებულ დოკუმენტს (პროექტის გარემოზე ზემოქმედების შეფასების მოკლე საინფორმაციო ბროშურას) შემდეგ მისამართზე: ალ. ყაზბეგის გამზირი 44, 0177 თბილისი, საქართველო ან ელექ-ტრონულ მისამართზე: www.cei.ge.

სს „კაუკაზუს ენერჯი ენდ ინფრასთრაქჩა" მზადაა მიიღოს და განიხილოს საზოგადოების წარმომადგენლების შენიშვნები და მოსაზრებები, თუ ისინი 2009 წლის 10 ივნისამდე წერილობითი სახით იქნება წარმოდგენილი ზემოაღნიშნულ მისამართზე.

ჰიდროელექტროსადგური მტკვარი-ს მშენებლობის პროექტის საჯარო განხილვაზე, რომელიც გაიმართება 2009 წლის 12 ივნისს, 11 საათზე, ქ. ახალციხეში, მისამართზე: ქ. ახალციხე, კოსტავას ქ. №18 (გამგეობის შენობა), დასწრების უფლება აქვს საზოგადოების ნებისმიერ წარმომადგენელს.

სს „კაუკაზუს ენერჯი ენდ ინფრასთრაქჩა"
2009 წლის 2 ივნისი

რეკლამა *კოსტავას 12*
„საქართველოს რესპუბლიკაში"
98-65-87; 899 32-85-76.

შპს „ნაბელლავი" (ს/ნ 215 103064) აცხადებს ლიკვიდაციას. დაინტერესებულ პირებს, გთხოვთ, მოგვმართოთ მისამართზე: ფოთი, მშვიდობის ქ. №4. ტელ: 899 350169.

ნუგზარ ქავთარაძე ოჯახით მწუხარებით იუწყება
გურამ ხმალაძის
გარდაცვალებას და თანაუგრძნობს განსვენებულის ოჯახს.

მამიდაშვილები ნათელა და შოთა გამყრელიძეები, შვილებით აკაკი, მარინა და ხათუნა ოჯახებით ღრმა მწუხარებით იუწყებიან, რომ გარდაიცვალა
ირაკლი გიორგის ძე ნიძაბაძე
და სამძიმარს უცხადებენ განსვენებულის ოჯახს.

მიხეილ ქავთარია, გივი სანაძე, რიჩა გაგუა, ლევან დოლმაზაშვილი, ბესიკ ვეშაპიძე, თეიმურაზ დოიაშვილი, თენგიზ მდივანი, ჯენეტო ჭანტურაია, ტარიელ ლოლაძე, გუგულა ჯიმშელაძე, ნოდარ მიხაილოვი ოჯახებით იუწყებიან, რომ გარდაიცვალა
მამუკა ლუკას ძე ხუნდაძე
და თანაგრძნობას უცხადებენ განსვენებულის ოჯახს.

მეუღლე ანზორ ჭლიკაძე, შვილები ანი ჭლიკაძე, ეკა იოსელიანი, სიძე ლევან ზერაკიძე, შვილიშვილები რუსუდან, დაჩი ზერაკიძეები ღრმა მწუხარებით იუწყებიან, რომ გარდაიცვალა
მანანა ყურაშვილი
პანაშვიდი 2, 3 VI, 17 სთ. დაკრძალვა 4 VI, 15 სთ. მისამართი: არაყიშვილის ქ. №9.

ინფორმაცია

ოსეთში ტერაქტი აღკვეთეს

ოს სეპარატისტთა ლიდერი ედუარდ კოკოითი აცხადებს, რომ სამხრეთ ოსეთის სამართალდამცავებმა რესპუბლიკაში არჩევნების ჩაშლისკენ მიმართული ორი ტერორისტული აქტი აღკვეთეს.

კოკოითის თქმით, აფეთქება ცხინვალის ცენტრში მდებარე ერთ ერთ სახოვრებელ სახლში არჩევნების დღეს უნდა მომხდარიყო. მისივე ინფორმაციით, სამართალდამცავების მიერ ჩატარებული ღონისძიებების გამო ორივე აფეთქების თავიდან აცილება და დროული აღკვეთა მოხერხდა.

ХО-306-060

Participation List of Public Hearing (Participation Meeting):

Public Participation Meeting of ESIA

The meeting was attended by:

1. S. Bakhturidze
2. B. Bejuashvili
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]
8. [illegible]
9. [illegible]
10. [illegible]
11. [illegible]
12. [illegible]
13. [illegible]
14. [illegible]
15. [illegible]
16. [illegible]
17. [illegible]
18. Daiva Rasutis – student
19. Eralp ÜGÖZ – Encon Environmental Con. – Hydrogeological Engineer
20. A. Merve KOCABAŞ – ENCON Environmental Consultancy Co. – Environmental Engineer
21. [illegible]
22. M. Gogishvili – [illegible]

Participation List of Public Hearing (Participation Meeting):

Public Participation Meeting of ESIA

The Public Participation Meeting of ESIA was attended by the following persons:

1. Simon Bakhturidze - Chief Engineer of Mtkvari HPP LLC;
2. Bidzina Bejuashvili - Chairman of Supervisory Board;
3. Ruben Karapetian - Deputy Head of Akhaltsikhe Municipality;
4. Vasil Beridze - Chairman of Council of Akhaltsikhe Municipality;
5. Konstantine Buckhrikidze – Head of Aspindza Municipality;
6. Mindia Devnosadze – Deputy Governor of Samtskhe-Javakheti;
7. Alika Melikadze – Head of Aspindza Council;
8. Edisher Ghvaladze – Head of financial-budgetary commission of Akhaltsikhe Municipality;
9. Malkhaz Aspanidze – Deputy Chairman of Council of Akhaltsikhe Municipality;
10. Tamaz Kurdadze – Member of the Council of Akhaltsikhe Municipality;
11. Malkhaz Induashvili – Head of Agara Territorial Body;
12. Irakli Bezhuashvili – CFO of Mtkvari HPP LLC;
13. Ioseb Khatiashvili – Engineer;
14. Marita Arabidze – Representative of the Ministry of Energy of Georgia;
15. Givi Kiknadze - Representative of the Ministry of Energy of Georgia;
16. Marina Gachechiladze – Head of Regional Development Department of Governor;
17. David Kviriashvili – El. Engineer of Mtkvari HPP LLC;
18. Diana Rasutis – Student;
19. Eralp Ucoz – Encon Environmental Consultancy Co. - Hydrological Engineer;
20. A. Merve Kocabas - Encon Environmental Consultacy Co. - Environmental Engineer;
21. Nodar Shubitidze – Head of Administrative Service;
22. Mariam Gogishvili – Office Manager of Mtkvari HPP LLC;
23. Archil Mamatelashvili – CEO of Mtkvari HPP LLC;

Minutes of Meeting of the Public Hearing (Participation Meeting):

LIMITED LIABILITY COMPANY **MTKVARI HESI**

AND **ENCON ENVIRONMENTAL CONSULTANCE CO.**

PUBLIC DISCUSSION OF MTKVARI HYDROPOWER STATION CONSTRUCTION PROJECT
AND
ITS ENVIRONMENTAL AND SOCIAL IMPACT

MINUTES

Public discussion concerning evaluation of environmental and social impact of the Project of JSC Caucasus Energy and Infrastructure (hereinafter - "Company") - Construction of Mtkvari Hydropower Station - was held on 12 June 2009 at the following address: 18 Kostava Street, town Akaltsikhe. The meeting started at 1:00 PM

The following individuals were present at the meeting:

a) Director General of the Company: Archil Mamatelashvili

b) Financial Director of the Company: Irakli Bezhuashvili

c) Chairman of the Supervisory Board of the Company: Bidzina Bezhuashvili

d) Chief Engineer of the Limited Liability Company Mtkvari Hesi: Simon Bakhturidze

e) Electrical Engineer of the Limited Liability Company Mtkvari Hesi: David Kviriashvili

f) Office Manager of the Limited Liability Company Mtkvari Hesi: Mariam Gogishvili

g) Engineer of the Limited Liability Company Mtkvari Hesi: Ioseb Khatiashvili

h) Environmental Engineer of Encon Environmental Co.: A. Merve Kocabas

i) Engineer Hydrologist of Encon Environmental Co.: E. Ugoz

j) Chairman of Sakrebulo (local self-governance body) of Akhaltsikhe Municipality: Vasil Beridze

k) Gamgebeli (head) of Aspindza Municipality: Konstantine Butskhrikidze

l) Deputy Governor of Samtskhe-Javakheti Province: Mindia Devnosadze

m) Chairman of Aspindza Sakrebulo: Alika Melikadze

n) Chairman of Financial-Budget Commission of Akahltsikhe Municipality: Edisher Ghvaladze

o) Deputy Chairman of Sakrebulo of Akhaltsikhe Municipality: Malkhaz Aspanadze

p) Member of Sakrebulo of Akhaltsikhe Municipality: Tamaz Kurdadze

p) Authorized Representative of Agara Territorial Body: Malkhaz Induashvili

q) Deputy Head (Gamgebeli) of Akahltsikhe Municipality: Ruben Karapetian

r) Representative of the Ministry of Energetics of Georgia: Marita Arabidze

s) Representative of the Ministry of Energetics of Georgia: Givi Kiknadze

t) Head of the Governor's Regional Development Service: Marina Gachechiladze

u) Chief of Administration Service: Nodar Shubitidze

v) Student of Michigan University: D. Rasutis

Director General of the Company and Chairman of the Meeting Archil Mamatelashvili opened the Public discussion at the Meeting. He stated that information concerning public evaluation of the Project of Mtkvari Hydropower Station Construction and Environmental and Social Impact of the Project, including the date of current meeting, was published in the press in advance. Accordingly, any interested individuals had a possibility to be present at the current meeting or get information in writing about the issues of their interest.

Chairman of the Meeting familiarized the present public with the purpose of the Meeting.

Principal and essential part of the Meeting started with presentation of information about Mtkvari Hydropower Station Construction Project. Mr. Mamatelashvili familiarized the present public with preliminary report concerning environmental and social impact of the Project, which was prepared by Turkish Company Encon Environmental Co., in details and asked to put questions to him and the representatives of the mentioned Turkish Company about preliminary report and to provide their considerations on the mentioned Project.

Much time was given to the consideration of importance of the evaluation of environmental and social impact for the above project. Participants of the Meeting actively participated in the above.

Opinions were provided by:

Major participants expressed their opinions about the above Project. In answer to the questions about the possible negative impact to the environment, Mr. Mamatelashvili responded that on the grounds of preliminary report, there was not any danger of negative effect to flora and that species of flora and fauna included in the Red Book were not registered at the construction territory of hydro power station.

Participants of the Meeting asked if the existing hydro power station at the River Mtkvari near the village Rustavi would interfere with the implementation of the Project. Mr. Mamatelashvili stated in answer that they carry on negotiations with the owner of the station. At the same time, the volume of water released into the natural river-bed from Mtkvari Hydro Power Station water-retaining structure is absolutely

sufficient for full capacity activation of Rustavi Hydro Power Station, if the latter will be activated and starts operation.

The issue of water pumping station in the village Chacharaki providing drinking water to the village was raised as well at the meeting.

The employees of the Company had not information about the mentioned water pumping station. As was revealed at the meeting, the water pumping station due to its location would not be exposed to any damage during implementation of the Project, though Mr. Mamatelashvili and representatives of the Turkish Company have promised to the participants that would study in details location of the River Chacharaki and the probability of existing risks. The Final Report On Environmental and Social Impact which will be prepared in August by Encon Environmental Co. will contain detailed comments on the above.

Question about employment of local population during implementation of the mentioned Project was raised at the Meeting. Mr. Mamatelashvili's answer was positive.

The issue concerning purchase of land plots on the territory of construction of the hydro power station was raised as well. 80% of lands are in state property, while 20% belong to private owners. Part of private owners have not been established as yet, since they have not registered their property, though Mr. Mamatelashvili stated that every owner will be identified by all means and relevant negotiations will be carried on with them.

Mr. Mamatelashvili talked also about advantages of hydro power station, its capacity and output.

Since there were not any other issues to be considered and questions on the behalf of public present at the Meeting, at _____ o'clock the Chairman declared the Meeting finished.

Chairman of the Meeting

_____

Archil Mamatelashvili

Representative of Encon Environmental Co.

_____

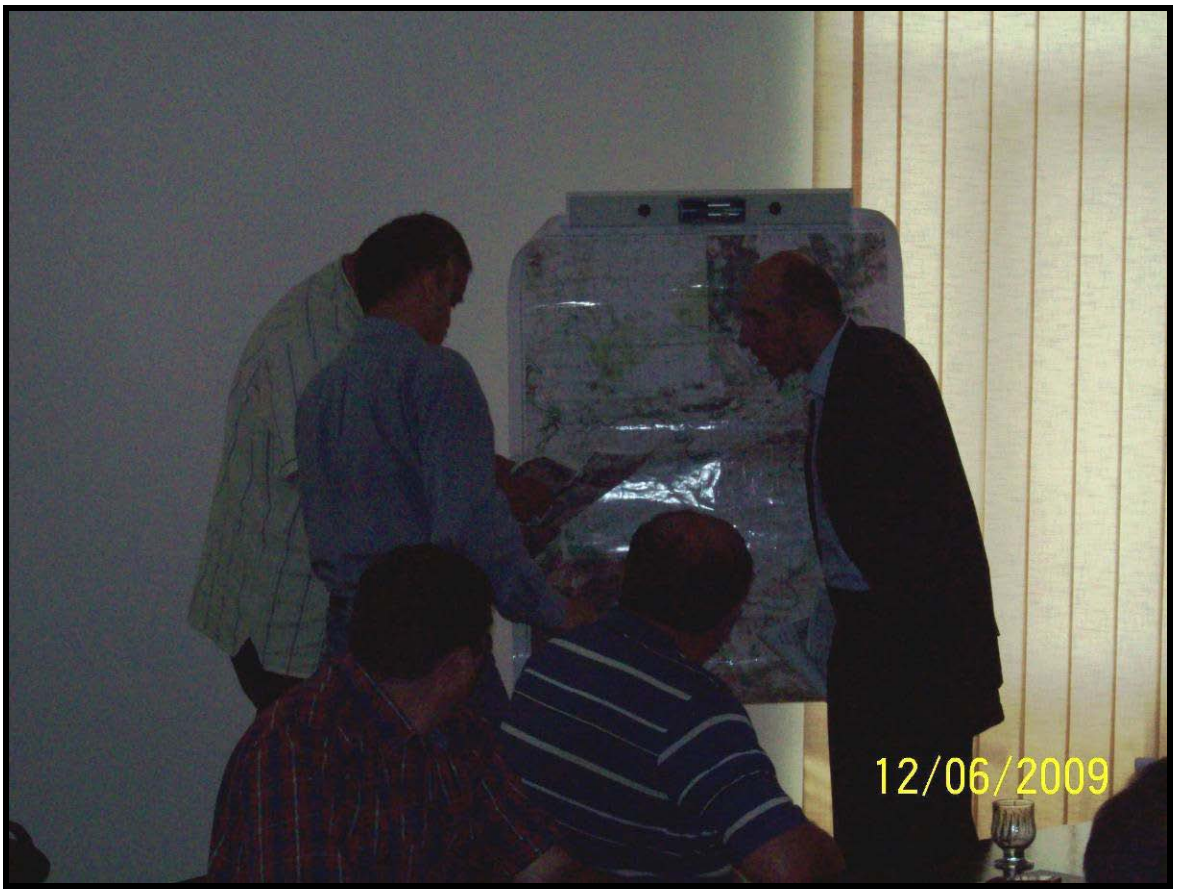
Photographs from the Public Hearing (Participation) Meeting

Photograph 1.5. Start of the Meeting with the Opening Speech of CEO of CEI

Photograph 1.6. Presentation of Introductory Information regarding the Project (1)

Photograph 1.7. Presentation of introductory Information regarding the Project (2)

Photograph 1.8. Presentation of Introductory Information regarding the Project (3)



Photograph 1.9. Discussion of the Potential Impacts and relevant Mitigation Measures to be taken

Photograph 1.10. Discussion of the Potential Impacts and relevant Mitigation Measures to be taken (2)

Photograph 1.11. Discussion of the Potential Impacts and relevant Mitigation Measures to be taken (3)

Photograph 1.12. Discussion of the Potential Impacts and relevant Mitigation Measures to be taken (4)

Second Public Hearing Notice of JSC Caucasus Energy and Infrastructure:

Announcement

Public Hearing of ESIA for Mtkvari Hydropower Plant Construction Project

Mtkvari HPP LLC, a hundred percent subsidiary of JSC Caucasus Energy and Infrastructure, announces that the Public Hearing of ESIA for Mtkvari hydropower plant construction project is scheduled to be held on 15 October 2009, at 1 p.m. on the following address: 18 Kostava Str., Akhaltsikhe.

Mtkvari HPP, Samtskhe-Javakheti Region

Mtkvari HPP construction project envisages the construction of a 38-42 MW Hydropower Plant on river Mtkvari, in Samtskhe-Javakheti region, south of Georgia. The HPP is scheduled to be constructed near the city Akhaltsikhe. The Headworks of HPP will be located 1.5 km from the village Rustavi, while the HPP building will be 0.6 km from the village Sakuneti.

Any member of the public will be able familiarize himself with the corresponding Report on ESIA of Mtkvari HPP Project at the following address: 44 Al. Kazgebi Ave; Tbilisi, Georgia or on the following link: http://dug.ge/MTKVARI_ESIA_REPORT.pdf

Representatives from Mtkvari HPP LLC will be able to discuss any suggestions and answer any questions from the members of the public, if they are submitted in a written form until 15 October 2009.

The hearing at 18 Kostava Street in Akhaltsike will be open for the attendance of any member of the public, including the CEI shareholders.

Mtkvari HPP LLC
September 2, 2009

Amendment of the Announcement on ESIA Public Hearing of Mtkvari HPP

The following amendment will be made in the announcement of public hearing on ESIA for Mtkvari HPP construction project, announced by the subsidiary of JSC Caucasus Energy and Infrastructure, Mtkvari HPP LLC, on 2 September 2009:

The public hearing on ESIA for Mtkvari HPP construction project will be held on 21 October 2009, instead of 15 October 2009 as announced earlier.

Newspaper Announcement Regarding the Second Public Hearing Meeting:

24 საათი 2 სექტემბერი, ოთხშაბათი, 2009 წელი. №190 ტენდერი C7

განცხადება

„ჰიდროელექტროსადგური მტკვარის" პროექტის გარემოზე ზემოქმედების შეფასების ანგარიშის საჯარო განხილვის შესახებ

შპს "მტკვარი ჰესი" აცხადებს „ჰიდროელექტროსადგური მტკვარის" პროექტის გარემოზე ზემოქმედების შეფასების ანგარიშის საჯარო განხილვას, რომელიც გაიმართება 2009 წლის 15 ოქტომბერს 13:00 სთ-ზე, მისამართზე: ქ. ახალციხე, კოსტავას ქ. N18 (გამგეობის შენობა).

მტკვარი ჰესი, სამცხე-ჯავახეთის რეგიონი

შპს მტკვარი ჰესი გეგმავს 38-42 მგტ. სიმძლავრის ჰიდროელექტროსადგურის მშენებლობას სამხრეთ საქართველოში, სამცხე-ჯავახეთის რეგიონში. კერძოდ, ჰესის აშენება გათვალისწინებულია მდ. მტკვარზე, ქალაქ ახალციხის მახლობლად. ჰესის სათავე ნაგებობა განთავსდება სოფ. რუსთავთან - 1.5 კმ-ის მოშორებით, ხოლო ჰესის შენობა სოფ. საყუნეთთან - 0,6 კმ-ის მოშორებით.

საზოგადოების ნებისმიერ წარმომადგენელს შეუძლია გაეცნოს პროექტთან დაკავშირებულ გარემოზე ზემოქმედების შეფასების ანგარიშს, შემდეგ მისამართზე: ყაზბეგის გამზირი 44, III სართული, 0177 თბილისი, საქართველო ან შემდეგ ვებ-გვერდზე: www.cei.ge.

შპს „მტკვარი ჰესი" მზადაა მიიღოს და განიხილოს საზოგადოების წარმომადგენლების შენიშვნები და მოსაზრებები თუ ისინი 2009 წლის 15 ოქტომბრამდე წერილობითი სახით იქნება წარმოდგენილი ზემოაღნიშნულ მისამართზე.

„ჰიდროელექტროსადგური მტკვარის" პროექტის საჯარო განხილვაზე, რომელიც გაიმართება 2009 წლის 15 ოქტომბერს ქ. ახალციხეში, მისამართზე: კოსტავას ქ. N18 (გამგეობის შენობა) დასწრების უფლება აქვს საზოგადოების ნებისმიერ წარმომადგენელს.

შპს „მტკვარი ჰესი"
2009 წლის 2 სექტემბერი

Announcement of Change of the Second Public Participation Meeting Day:

ცვლილება განაცხადში
"ჰიდროელექტროსადგური მტკვარის" პროექტის
გარემოზე ზემოქმედების შეფასების
ანგარიშის საჯარო განხილვის შესახებ

შპს მტკვარი ჰესის მიერ ამა წლის 2 სექტემბერს, გაზეთ "24 საათში" გამოქვეყნებულ განაცხადში „ჰიდროელექტროსადგური მტკვარის" პროექტის გარემოზე ზემოქმედების შეფასების ანგარიშის საჯარო განხილვის შესახებ, შეტანილ იქნეს შემდეგი ცვლილება: "ჰიდროელექტროსადგური მტკვარის" პროექტის გარემოზე ზემოქმედების შეფასების ანგარიშის საჯარო განხილვა, ნაცვლად 20009 წლის 15 ოქტომბრისა, გაიმართება 2009 წლის 21 ოქტომბერს.

შპს "მტკვარი ჰესი"
2009 წლის 8 სექტემბერი

Participation List of Second Public Hearing (Participation Meeting):

Mtkvari HPP LLC 21.10.09

Public Hearing of ESIA Report

List of Participants

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]
8. [illegible]
9. [illegible]
10. Ayşe Merve KOCABAŞ – ENCON Environmental Consultancy Co. – Environmental Engineer
11. Mariam Gogishvili – Mtkvari HPP LLC – office manager
12. [illegible]
13. [illegible]
14. [illegible]
15. [illegible]

Minutes of Meeting of the Public Hearing (Participation Meeting):

LIMITED LIABILITY COMPANY **MTKVARI HPP**

AND **ENCON ENVIRONMENTAL CONSULTANCE CO.**

PUBLIC HEARING OF MTKVARI HYDROPOWER PLANT
CONSTRUCTION PROJECT
AND
ITS ENVIRONMENTAL AND SOCIAL IMPACT

MINUTES

Public Hearing of Environmental and Social Impact Assessment of the Project of Mtkvari HPP LLC (hereinafter - "Company") - Construction of Mtkvari Hydropower Station - was held on October 21, 2009 at the following address: 18 Kostava Street, town Akaltsikhe. The meeting started at 1:00 PM

The following individuals were present at the meeting:

a) Chief executive Officer of the Company: Archil Mamatelashvili

b) Chief Engineer of the Limited Liability Company Mtkvari HPP: Simon Bakhturidz

c) Electrical Engineer of the Limited Liability Company Mtkvari HPP: David Kviriashvili

d) Office Manager of the Limited Liability Company Mtkvari HPP: Mariam Gogishvili

e) Environmental Engineer of Encon Environmental Co.: A. Merve Kocabas

f) Chairman of Sakrebulo (local self-governance body) of Akhaltsikhe Municipality: Vasil Beridze

g) Head of Aspindza Municipality: Konstantine Butskhrikidze

h) Representative of the Ministry of Energetics of Georgia: Marita Arabidze

i) Head of the Governor's Regional Development Service: Marina Gachechiladze

j) Head of Financial Department of South Administration: Gocha Beridze

k) Head of Akhaltscikhe Mnicipality: David Atunashvili

l) "Rustavhesi" LTD, representative: Revaz Sandroshvili

m) Lawyer of Regional Department of Environmental Protection and National Resources: Sofio Gelazarishvili

n) Senior Specialist of Regional Department of Environmental Protection and National Resources: Amian Lazarishvili

o) Deputy Chief of Regional Department of Environmental Protection and National Resources: Zurab Kurtanidze

p) Journalist of Local TV Company "Channel 9": Rusudan Gvaramadze

Director General of the Company and Chairman of the Meeting Archil Mamatelashvili opened the Public discussion at the Meeting. He stated that information concerning public hearing of the Project of Mtkvari Hydropower Plant Construction and Environmental and Social Impact Assessment Report of the Project, including the date of current meeting, was published in the press in advance. Accordingly, any interested individuals had a possibility to be present at the current meeting or get information in writing about the issues of their interest.

Chairman of the Meeting familiarized the present public with the purpose of the Meeting.

Principal and essential part of the Meeting started with presentation of information about Mtkvari Hydropower Plant Construction Project. Mr. Mamatelashvili familiarized the present public with ESIA report concerning environmental and social impact of the Project, which was prepared by Turkish Company: Encon Environmental Co., in details and asked to put questions to him and the representatives of the mentioned Turkish Company about preliminary report and to provide their considerations on the mentioned Project.

Much time was given to the consideration of importance of the assessment of environmental and social impact for the above project. Participants of the Meeting actively participated in the above.

Opinions were provided by:

Major participants expressed their opinions about the above Project. No significant notices were made from the public concerning those negative impacts, which may influence the environment as a result of Mtkvari Hydropower Plant Project. The ESIA report gives the obvious picture of all those measures, which will be taken for minimization of possible negative environmental impact during implementation of Mtkvair hydropower plant construction project.

Question regarding land purchase at Mtkvari HPP project area was raised during the meeting. Mr. Mamatelashvili explained that the company has finished the purchase of all necessary lands as from the government so from private owners.

Question about employment of local population during implementation of the mentioned Project was raised at the meeting. Mr. Mamatelashvili highlighted that during construction works, the local population will surely be employed. The appropriate works are already in process. The company has started to obtain data about local manpower, all the received data will be discussed and consequently the population will be employed. The additional meeting was planned with local population, this time the meeting will be attended by the representatives from local government and the question about employment of local population will be thoroughly discussed

The questions arise on the meeting regarding the water pumping station near village Rustavi, which is not operating during many years. The representative of "Rustavi HPP" asked the project developers to do a favor for Rustavi villagers and repair the abovementioned station. The rehabilitation of this pump station will be very useful and productive to Rustavi villagers. Mr. Mamatelashvili said that this question will be discussed.

Also the question regarding "Rustavi HPP" that is located near the village Rustavi arose. It was explained that according the letter from GNERC (Georgian National Energy Regulation Commission), where the full capacity and other parameters of the HPP is given, the volume of water released into the natural river-bed from Mtkvari Hydro Power Station water-retaining structure is absolutely sufficient for full capacity activation of Rustavi Hydro Power Station, if the latter will be activated and starts operation (The copies of letters from GNERC and GSE are enclosed to this minutes).

The regional representative of the Ministry of Environment and National Resources asked about the usage of fruitful layer of soil, and its recultivation. According to ESIA report it will necessarily be recultivated.

Mr. Mamatelashvili talked also about advantages of hydro power station, its capacity and output.

Since there were not any other issues to be considered and questions on the behalf of public present at the Meeting, at 15:40 o'clock the Chairman declared the Meeting finished.

Chairman of the Meeting

_____

Archil Mamatelashvili

Representative of Encon Environmental Co.

_____

Photographs from the Public Hearing (Participation) Meeting

Photograph 1.13. Start of the Meeting with the Opening Speech of CEO of CEI

Photograph 1.14. Presentation of Introductory Information regarding the Project (1)

Photograph 1.15. Presentation of introductory Information regarding the Project (2)

Photograph 1.16. Discussion of the Impacts and relevant Mitigation Measures to be taken

Photograph 1.17. Discussion of the Impacts and relevant Mitigation Measures to be taken (2)

Photograph 1.18. Discussion of the Impacts and relevant Mitigation Measures to be taken (3)

Photograph 1.19. Discussion of the Impacts and relevant Mitigation Measures to be taken (4)

ANNEX 3

Sample Grievance Form:

GRIEVANCE FORM	
Name of the Recorder	
District/Settlement	
Record No and Date	
INFORMATION ABOUT GRIEVANCE	
Define The Grievance:	

INFORMATION ABOUT THE COMPLAINANT		***Forms of Receive***
Name-Surname		□ *Phone Line* □ *Community/Information Meetings* □ *Mail* □ *Informal* □ *Other*
Telephone Number		
Address		
Village / Settlement		
District / Province		
Signature of Complainant		

DETAILS OF GRIEVANCE				
1. Access to Land and Resources *a) Fishing grounds* *b) Lands* *c) Pasturelands* *d) House* *e) Commercial site* *f) Other (specify)*	***2. Damage to*** *a) House* *b) Land* *c) Livestock* *d) Means of livelihood* *e) Other (specify)*	***3. Damage to Infrastructure or Community Assets*** *a) Roads/Railways* *b) Bridge/Passageways* *c) Power/telephone lines* *d) Water sources, canals and water infrastructure for irrigation and animals* *e) Drinking water* *f) Sewerage* *g) Other (specify)*	***4. Decrease or Loss of Livelihood*** *a) Agriculture* *b) Animal husbandry* *c) Small scale trade* *d) Other (specify)*	***5. Traffic Accident*** *a) Injury* *b) Damage to property* *c) Damage to livestock* *d) Other (specify)*
6. Incidents Regarding Expropriation/Compensation (Specify)	***7. Employment and Recruitment (Specify)***	***8. Construction Camp and Community Relations*** *a) Nuisance from dust* *b) Nuisance from noise* *c) Misconduct of the project personnel* *d)Complaint follow up* *e) Other (specify)*		***9. Other (Specify)***

Sample Grievance Closeout Form:

GRIEVANCE CLOSEOUT FORM		
Record no and date		
Define immediate action required:		
Define long term action required (if necessary):		
Compensation Required:	***□ YES***	***□ NO***
VERIFICATION OF CORRECTIVE ACTION AND SIGN OFF		
Corrective Action Steps to Carry Out Corrective Action		***Due Date***
1		
2		
3		
4		
5		
6		
7		
Responsible Party		
COMPENSATION ACTION AND SIGN OFF		
This part will be filled in and signed by the complainant when he/she receives the compensation or file is closed-out. ***Notes:*** *Date: …./…../…..* *Complainant* *Name-Surname and Signature* *Representative of Responsible Party* *Title-Name-Surname and Signature*		

APPENDIX 5

EFFECTS ON MTKVARI HPP PROJECT ON AIR QUALITY

APPENDIX 5. EFFECTS OF MTKVARI HPP PROJECT ON AIR QUALITY

In this appendix, detailed investigation of particulate matter and gas emissions originating from construction activities of Mtkvari HPP Project is presented. Since there will be no process that will create dust or gaseous emission during operation phase, no modelling study was conducted for this phase. In order to determine cumulative impact, particulate matter generating processes and pollutants released from vehicle exhausts were investigated together.

5.1. Legal Framework

Law on Protection of Ambient Air

International Finance Corporation (IFC) Environmental, Health, and Safety Guidelines- Air Emissions and Ambient Air Quality:

The guideline applies to facility or project that generates emissions to air at any stage of the project lifecycle. This guideline provides an approach to the management of significant sources of emissions, including guidance for assessment and monitoring of impacts.

According to the guideline, at facility level, impacts should be estimated through qualitative or quantitative assessment by the use of baseline air quality assessments and atmospheric dispersion models to assess potential ground level concentrations. Emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards, or in their absence, the current World Health Organization (WHO) Air Quality Guidelines (see Table 5.1) or other internationally recognized sources.

Table 5.1. WHO Ambient Air Quality Guidelines

Pollutants	Averaging Period	Guideline Value in (µg/m^3)
Sulfur dioxide (SO_2)	24 hour	125 (Interim target-1) 50 (Interim target-2) 20 (Guideline)
	10 minute	500 (Guideline)
Nitrogen dioxide (NO_2)	1 year	40 (Guideline)
	1 hour	200 (Guideline)
Particulate Matter (PM_{10})	1 year	70 (Interim target-1) 50 (Interim target-2) 30 (Interim target-3) 20 (Guideline)
	24 hour	150 (Interim target-1) 100 (Interim target-2) 75 (Interim target-3) 50 (Guideline)
Particulate Matter ($PM_{2.5}$)	1 year	35 (Interim target-1) 25 (Interim target-2) 15 (Interim target-3) 10 (Guideline)
	24 hour	75 (Interim target-1) 50 (Interim target-2) 37.5 (Interim target-3) 25 (Guideline)

Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 – on ambient air quality and cleaner air for Europe:

In order to protect human health and the environment as a whole, it is particularly important to combat emissions of pollutants at source and to identify and implement the most effective emissions reduction measures at local, national and community level. Therefore, emissions of harmful air pollutants should be avoided, prevented or reduced and appropriate objectives set for ambient air quality taking into account relevant WHO standards, guidelines and programmes. Table 5.2 lists the annual and daily limit values given in Council Directive 2008/50/EC for different pollutants in the ambient air.

Table 5.2. Limit Values Specified for Various Pollutants in Council Directive 2008/50/EC

Pollutants	Averaging Period	Limit Value
SO_2	One hour	350 µg/m^3, not to be exceeded more than 24 times a calendar year
	One day	125 µg/m^3, not to be exceeded more than 3 times a calendar year
NO_2	One hour	200 µg/m^3, not to be exceeded more than 18 times a calendar year
	Calendar year	40 µg/m^3
CO	Maximum daily eight hour mean	10,000 µg/m^3
PM_{10}	One day	50 µg/m^3, not to be exceeded more than 35 times a calendar year
	Calendar year	40 µg/m^3 PM10
Lead	Calendar year	0.5 µg/m^3

5.2. Methodology

ISCST3 Model

The potential impacts of the emissions on air quality are estimated with the help of the ISCST3 (Industrial Source Complex - Short Term 3) model, developed by United States Environmental Protection Agency (USEPA).

ISCST3 as one of the most widely used computer models provides estimates of hourly, daily and annual ground level concentrations and depositions based on the source emission data. The model deals with different types of sources, such as point, volume, area and open pit, as well as taking aerodynamic waves, turbulence and deposition into account.

ISCST3 model works in a network system defined by the user, calculations are done for corner points of each receptor element which forms network system. Network system used in ISCST3 model can be defined as polar or Cartesian. Besides, remote receptors outside the network can be determined and more detailed calculations can be made for those points. In addition to ground level concentrations, calculations also can be done for certain heights of the atmosphere.

Method Used in Modeling

Calculations of emission values and dispersions with model were only performed for construction phase of the project. Since there will not be any operation which cause emission during the operation phase, no emission will occur in that phase. In the construction phase of the project, the expected sources of emissions are:

- The excavation-filling activities performed in the construction of the dam axis, HEPP structure, transmission tunnel etc,
- Loading the excavated material to the trucks,
- The emissions due to the exhausts of the construction equipment,
- The activities performed at the concrete batch plants,

During air quality modelling studies, mass flows of dust and gaseous emissions sourced from above-mentioned sources was calculated first in terms of kg/hour. After that, spread of above-mentioned pollutants under the topographical and meteorological conditions of the region, and potential ground level concentrations as a result of this spread calculated by the help of the model.

Model takes the meteorological data of the area from user with help of a file in certain format. This meteorological data set is formed in hourly format and this file contains information about the flow vector, wind speed, ambient temperature, stability class, rural mixing height, urban mixing height, wind profile exponent, vertical potential temperature gradient, friction velocity, Monin-Obukhov length, surface roughness length, precipitation code and precipitation rate.

For modelling, a working area of 5 km long in east-west direction and 7 km long in north-south direction was selected to include planned units and roads to be used. 1/25,000 topographical maps were digitized and coordinates and heights of 102 points were obtained. Among these 102 points, important ones for impact assessment on air quality (the points close to the project area and settlements) were selected and used in the calculations. The map that shows the locations of planned facilities and transportation roads is given in Figure III.2.

5.3. Emission Amounts

The excavation and filling amounts those will be performed during the construction phase is given Table 5.3.

Table 5.3. Excavation and Filling Amounts

Plant	Excavation Amount (m^3)	Filling Amount (m^3)
Diversion Canal	28,200	6,000
Cofferdam	-	55,000
Spillway	32,000	-
Dam	8,000	142,000
Roads	-	100,000
Headrace Tunnel	8,600	-
Surge Shaft	9,000	-
Powerhouse	13,900	-
Tailrace	10,800	-
Total	**110,500**	**303,000**

As a result of the movements of the vehicles on the roads for the excavation-filling processes and the loading material to the trucks, dust will be generated. While calculating the uncontrolled emission amounts, are those expected during the construction works, the emissions factors given below are used.

Excavation emission factor : 0.025 kg/ton
Loading emission factor : 0.01 kg/ton
Unloading emission factor : 0.01 kg/ton

Particulate matter emissions due to construction activities that will be performed at the same time are assessed cumulatively. As excavation and filling activities cannot be performed at the same time, the highest emissions in excavation and filling activities are used in calculations in order to assess the emissions in worst case scenario. As tunnel excavation activities will be conducted indoors, PM emissions only at the entrances of the adits are included in the calculations. Excess excavated material obtained from headrace tunnel will be stored at appropriate storage areas close to the adits. On the other hand, excess excavated material from powerhouse area and headworks area will be used for the rehabilitation of the river and construction of new roads, respectively. As the

storage areas are in the close vicinity of the construction areas, no PM emissions due to transportation of excavation materials is expected. In light of abovementioned information, the results of PM emission calculations are presented in Table 5.4.

Table 5.4. Emission Values due to Construction Activities

Plant	Hourly excavation amounts (ton/h)	Emissions (kg/h)			
		Demolition	Loading	Unloading	Total
Diversion Canal	8.36	0.21	0.08	-	0.29
Cofferdam	16.30	-	-	0.16	0.16
Spillway	9.48	0.24	0.09	-	0.33
Dam	42.07	-	-	0.42	0.42
Roads	59.26	-	-	0.59	0.59
Headrace Tunnel	0.04	0.001	0.0004	-	0.001
Surge Shaft	2.67	0.07	0.03	-	0.09
Powerhouse	4.12	0.10	0.04	-	0.14
Tailrace	3.20	0.08	0.03	-	0.11
			TOTAL		**2.13**

Construction Equipment

Exhaust gas emissions of vehicles are mainly NO_2, CO, HC, SO_2, PM and lead in PM. Emission characteristics are dependent on parameters such as vehicle age, motor speed, working temperature, ambient temperature, pressure, fuel type and quality. In Table 5.5, emissions of lead petrol and diesel fuel pollutants measured for an average vehicle in 1977 in USA are listed. The reason for not using the emission values obtained in more recent years is to increase the safety factor in calculations.

Table 5.5. Emissions Sourced from Vehicles (USEPA, 1977)

Pollutants	Emissions (g/km/vehicle)	
	Lead Gasoline	**Diesel Fuel**
Nitrogen Oxides (NO_x)	1.2	9.0
Carbonmonoxide (CO)	39.0	15.0
Sulfur Dioxide (SO_2)	0.08	1.5
Hydrocarbons (HC)	2.6	2.9
Particulate Matter (PM)	0.4	0.8
Lead (Pb) [1]	0.064	--

[1] *Diesel fuel does not contain lead*

List of equipments that will be used during construction period is given in Table IV.2 of Chapter IV. Accordingly, total emission values originating from the exhaust gases of construction equipments are listed in Table 5.6.

Table 5.6. Total Emission Values sourced from Construction Equipment's Exhausts

Emission Amount (kg/hour)					
Construction Sites					
NO_X	**CO**	**SO_2**	**HC**	**PM**	**Pb**
0.22	0.36	0.04	0.07	0.02	0.00

5.4. ISCST3 Model Results

At AP 72 Section 11.19.1 that was prepared by Environmental Protection Agency (EPA) it is stated "the dust emissions can be reduced at a rate of 70-95% by watering" (EPA, AP42). Therefore, in order to develop the worst case scenario, it is assumed that the emissions can be reduced 70% by watering while calculating the controlled dust emissions. ISCST3 model was run with the abovementioned assumptions. The results of ISCST3 model regarding PM and other gas emissions and comparison of the results with relevant limit values are presented in Table 5.7.

The distribution of PM and gas emissions with iso-concentration curves are presented in Figures 5.1-5.4.

Table 5.7. Comparison of Model Results for Construction Phase with relevant Limit Values

Parameter (Maximum)	**Concentration** ($\mu g/m^3$)	**WHO** ($\mu g/m^3$)	**2008/50/EC** ($\mu g/m^3$)
Daily (NO_x)	2.58	200	200
Yearly (NO_x)	0.53	40	40
Daily (CO)	4.28	-	10,000
Yearly (CO)	0.88	-	-
Daily (SO_x)	0.43	125	125
Yearly (SO_x)	0.09	-	-
Daily (HC)	0.83	-	-
Yearly (HC)	0.17	-	-
Daily (PM_{10})	90.20	150	50
Yearly (PM_{10})	8.16	70	40

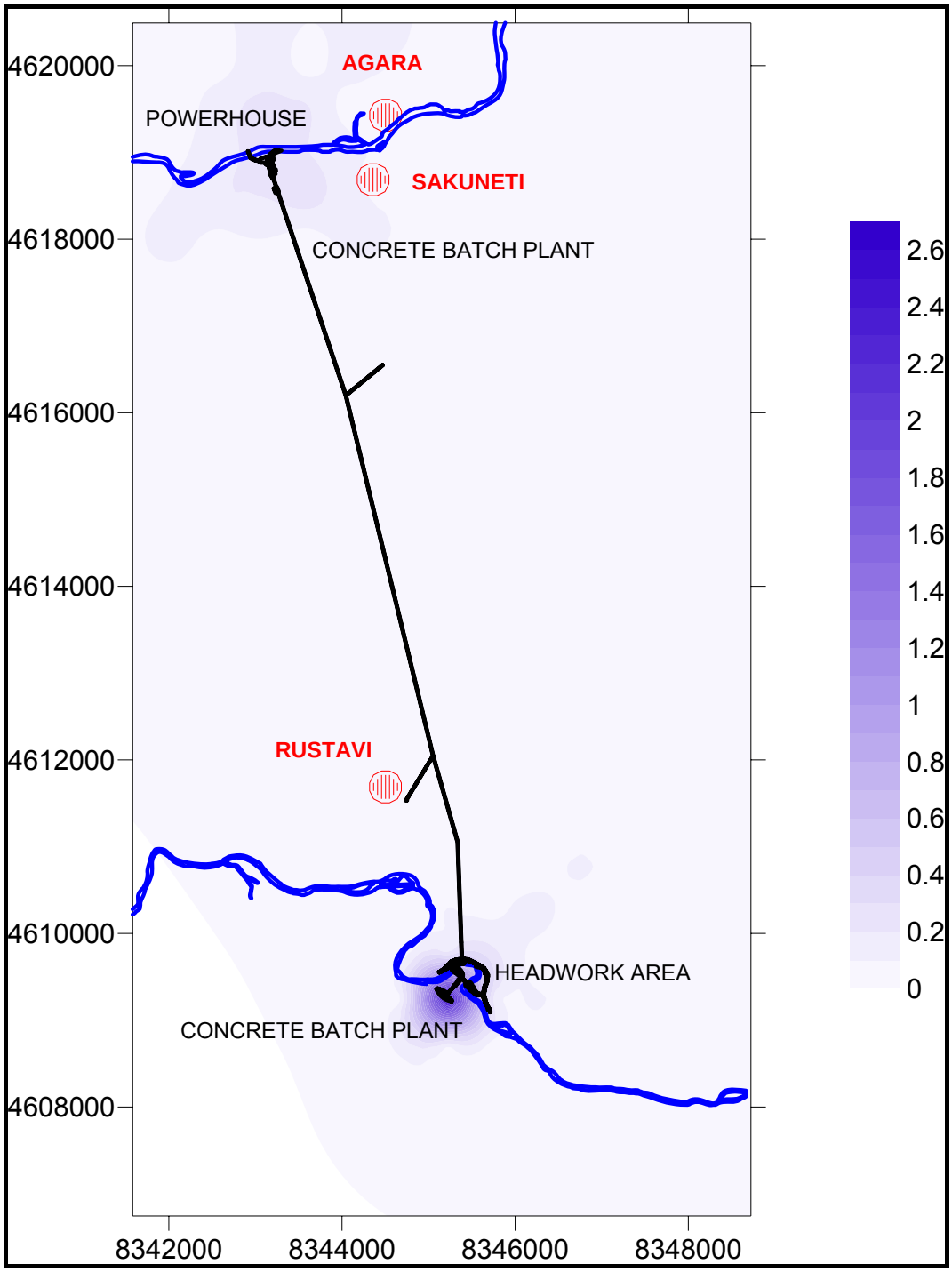


Figure V.1. Equivalent NO_x Concentration Curves for Project Construction Phase ($\mu g/m^3$)

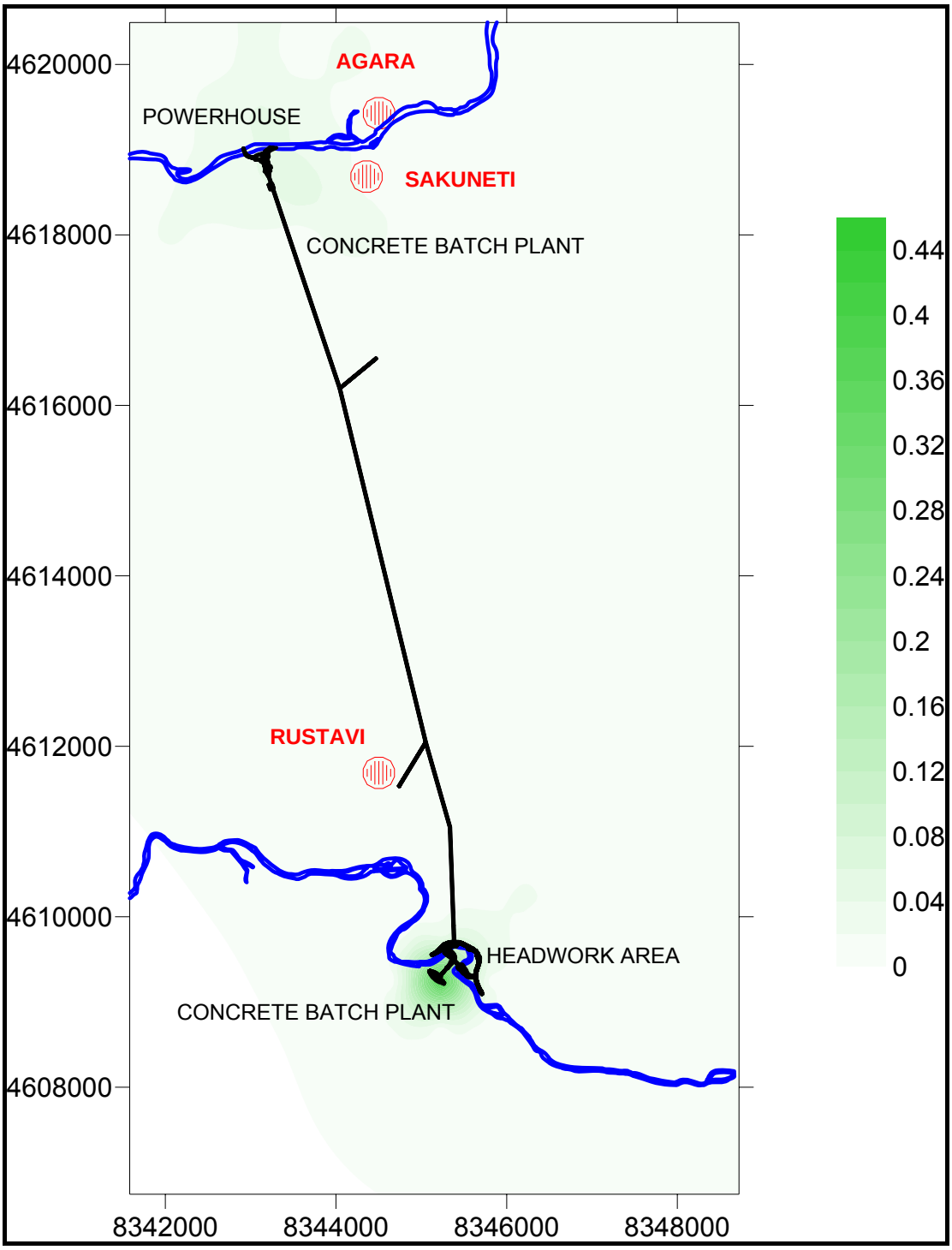


Figure 5.2. Equivalent SO_X Concentration Curves for Project Construction Phase (µg/m^3)

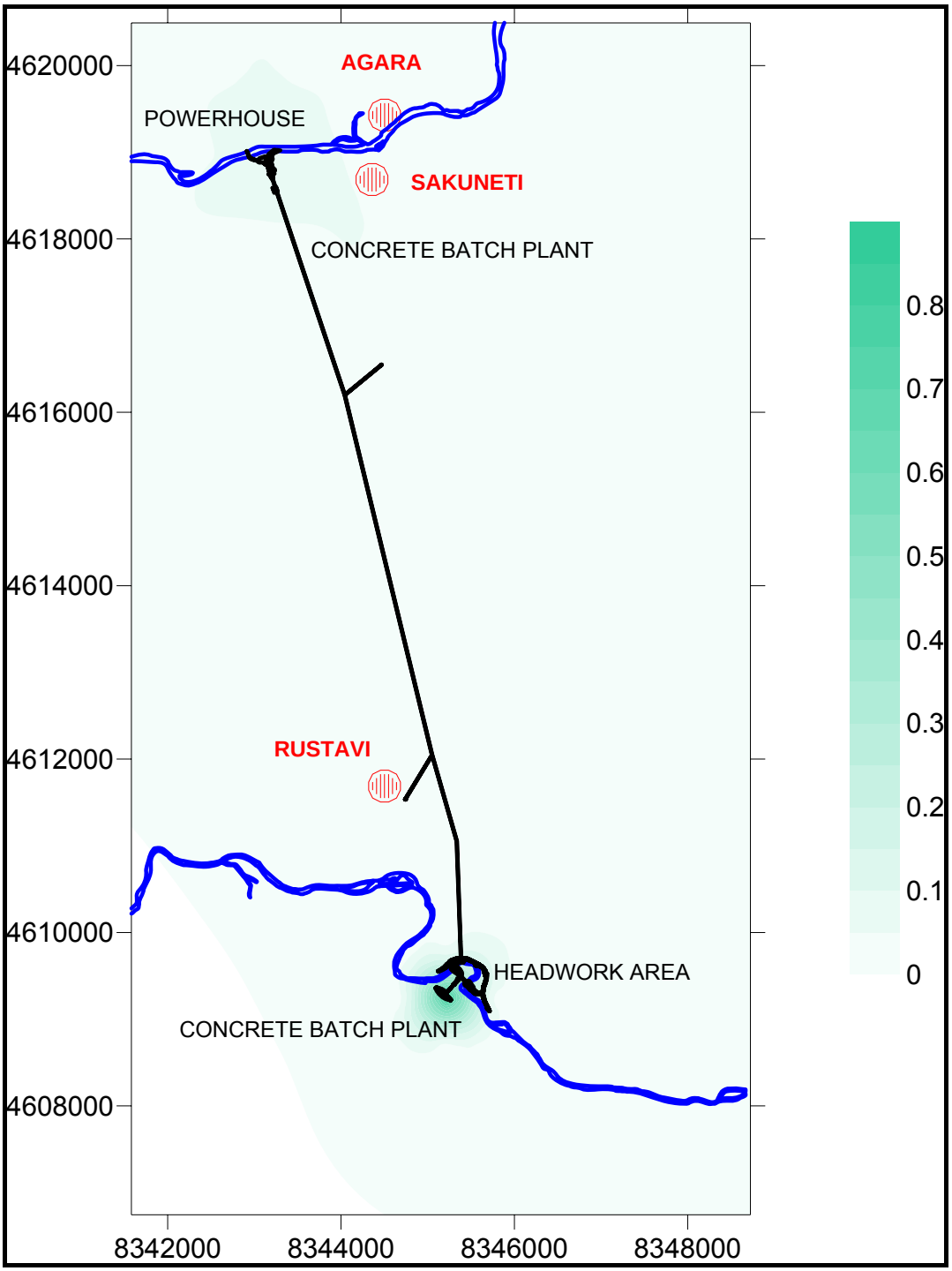


Figure 5.3. Equivalent HC Concentration Curves for Project Construction Phase (μg/m^3)

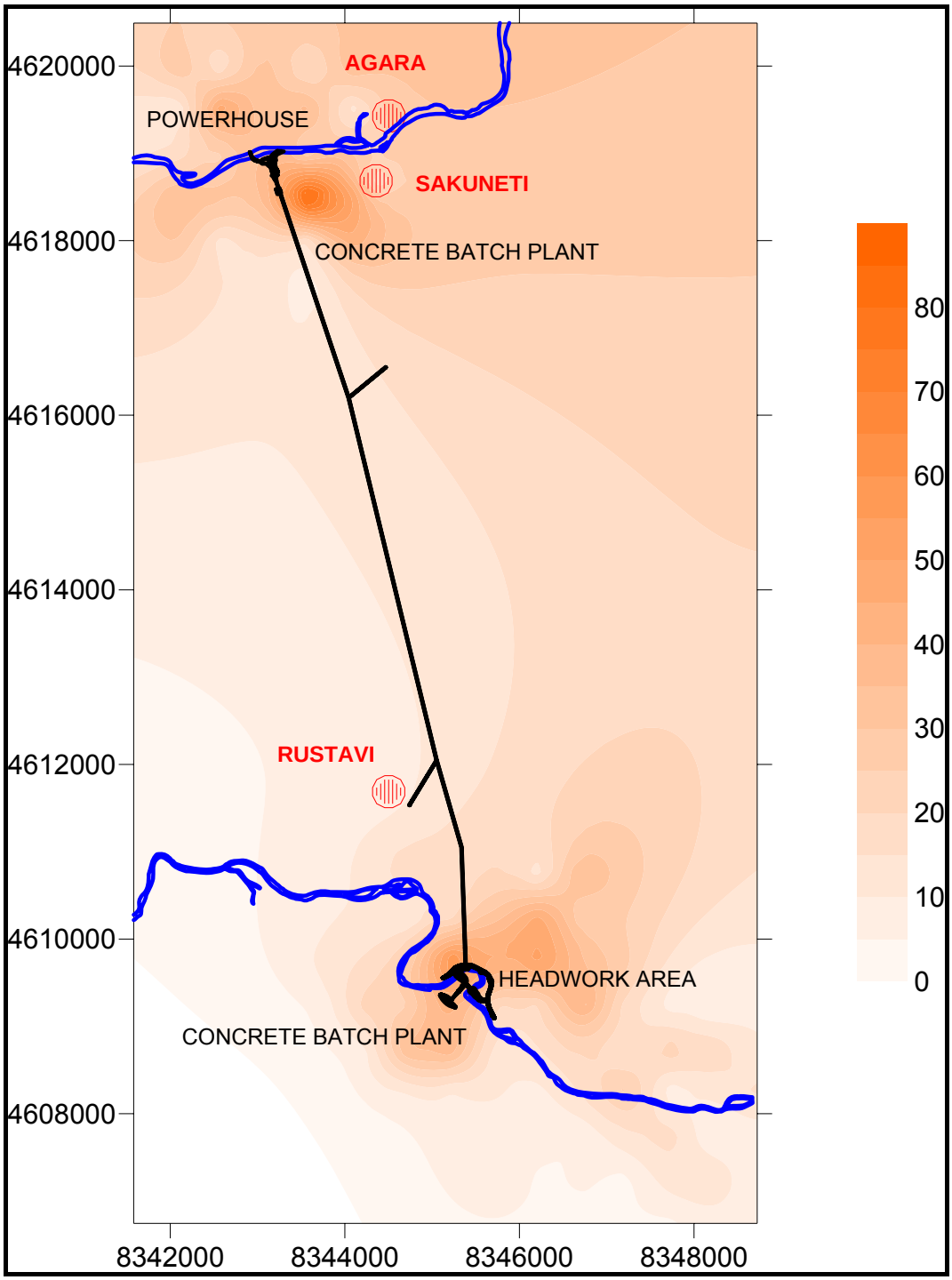


Figure 5.4. Equivalent PM Concentration Curves for Project Construction Phase (μg/m^3)

Settlements

Daily and yearly maximum particulate matter and gas concentrations, which will be expected to occur in the construction phase at the closest settlements around project site, Agara, Sakuneti and Rustavi, are given in Table 5.8.

Table 5.8. Maximum Particulate Matter and Gas Concentrations Expected to Occur on the Closest Settlements (μg/m^3)

Parameters (Maximum)	**Agara** (μg/m^3)	**Sakuneti** (μg/m^3)	**Rustavi** (μg/m^3)	**WHO**	**2008/50/EC**
Daily (NO_X)	0.03	0.05	0.03	200	200
Yearly (NO_X)	0.003	0.002	0.002	40	40
Daily (CO)	0.08	0.10	0.05	-	10,000
Yearly (CO)	0.006	0.006	0.002	-	-
Daily (SO_X)	0.01	0.01	0.01	125	125
Yearly (SO_X)	0.001	0.001	<0.001	-	-
Daily (HC)	0.02	0.02	0.01	-	-
Yearly (HC)	0.001	0.001	<0.001	-	-
Daily (PM_{10})	9.54	15.96	7.31	150	50
Yearly (PM_{10})	0.66	0.41	0.35	70	40

4.5. General Evaluation

The emissions caused by construction activities and the impacts of these emissions to the local air quality were estimated using ISCST3 model. Ground level concentrations of air pollutants such as NO_x, CO, HC, SO_x and PM were calculated and compared with the limits given in the WHO Ambient Air Quality Guidelines and Directive 2008/50/EC.

Particulate matter can cause abrasion on exterior surfaces of the plants. Particulate matter, when covers plant leaves, adversely affects some physiological properties (such as photosynthesis, evapo-transpiration, opening of stoma and leaf temperature). The effects will be more considerable if the size of particulate matter particles is smaller. There is direct relation between the size of particulate

matter and the effect of particulate matter to human health. Particulate matters smaller than 10 µm diameters (PM_{10}) have the most serious impact. These small particles could reach to the respiration organs, and even flow into bloodstream. Therefore, in particulate matter calculations the total particulate matter was used. The concentration calculations were done considering the PM_{10} values which compose 99.4 % of the total particulate matter.

Nitrogen dioxide and sulphur dioxides are reactive in air and produce acids. Produced acids reach to the ground with any form of precipitation (rain, snow, fog) and dry deposition. Acid rain has been shown to have adverse impacts on forests, freshwaters and soils as well as causing damage to buildings and having impacts on human health. In addition, HCs have a potential to produce acid with the effect of moisture, temperature etc. and affect soil and water sources similar to other pollutants released from vehicle exhausts. The adverse impacts on soil and water could have an effect on whole living creatures in an ecosystem through food chain and air.

Carbonmonoxide is a highly toxic gas. Exposures to carbonmonoxide can lead to significant toxicity of the central nervous system and heart. It decreases the ability to carry oxygen to the body organs and tissues. Early symptoms of carbonmonoxide poisoning are headaches, nausea, and fatigue. Prolonged exposure can lead to brain damage and even death.

The effects of the above mentioned pollutants depend on the concentration and exposure time. There are limit values similar to WHO Ambient Air Quality Guidelines and Directive 2008/50/EC in many local and national regulations for above mentioned and other pollutants.

Concentrations of all pollutants calculated from the model are well below the limits of WHO Ambient Air Quality Guidelines. Moreover, these emission values were calculated considering the worst case scenario. Accordingly, the distributed gas concentrations of Mtkvari HPP in construction phase will be much lower. Besides, in order to control the air pollutants, some precautions are suggested.

In order to evaluate the PM emission concentrations, local PM concentrations are compared with the Directive of 2008/50/EC. In accordance with that, daily PM_{10} concentration is above the limit values indicated. On the other hand, it should be noted that daily PM_{10} concentration is much lower in near settlements.

According to the AP 42 (Section 11.19.1) prepared by EPA “watering can reduce the particulate matter emissions by 70–95%” (USEPA AP42, Section11.19.1, 1995). To prepare the worst case scenario of Mtkvari HPP Project, it is assumed that watering can only reduce 70% of particulate matter emissions.

In construction phase, particulate matter emissions will be reduced during excavation and filling operations by watering and similar activities. The topsoil and excavated material produced during excavation will be pressed and watered together with whole area (pressing of topsoil will be performed gently not to damage its structure). Loading-unloading operations will be performed without spreading in addition to setting speed limit for trucks. Additionally, vehicles to be used will be new and in well condition as much as possible, and personnel that will work in construction works will use masks against particulate matter.

Furthermore, in order to achieve compliance with air quality standards, the following precautions should be taken.

- Wind breaker panels will be put or trees will be planted in the area.
- Loading-unloading will be performed without hurling.
- Material will be covered with nylon cloth or with materials having particle size greater than 10 mm.
- Upper layers will be kept with moisture content of 10%. To provide this condition, necessary systems will be set up.

APPENDIX 6

EMERGENCY ACTION PLAN

APPENDIX 6. EMERGENCY ACTION PLAN

A draft emergency preparedness/action plan has been prepared for the emergency situations that could occur in both construction and operation phases within the scope of Mtkvari HPP Project. According to the following plan, Coordinator of Emergency Action Plan identified missions and responsibilities of every individual, and the procedures that should be implemented in emergency situations via forming an Emergency Action Team. This Draft Emergency Action Plan will be improved during construction and operation phases by the Coordinator and Emergency Action Team as necessary.

6.1. Purpose

The purpose of this Emergency Action Plan (EAP) is to protect lives that would be affected from emergency events that are not foreseen during construction and operation phases of the project, natural disasters (fire, earthquake, lightning etc.), hold up, communication loss, incidents in facility, wrong operation, disordered maintenance, and reduce the potential impact on dam and nearby settlements.

In order to implement this plan, an Emergency Action Plan Coordinator and team will be assigned by the project owner/sponsor/developer. These persons will be trained and their mission will be clearly specified. Thus, it will be ensured that each staff would know his/her own responsibility in a potential emergency situation.

6.2. Mission and Responsibility

Project Owner/Developer

All the activities that are performed during the construction and operation phases of the project are under the responsibility of the project owner (his representative). The missions and responsibilities of the project owner in the context of Emergency Action Plan are summarized below:

- Selection of the Emergency Action Plan Coordinator and approval of Emergency Action Team
- Attending the annual review meetings related to EAP and approval of the recent version of the EAP
- Approval of the activities that are not included in EAP during emergency situation
- Analyzing the reports prepared after any emergency situation

Emergency Action Plan Coordinator (EAPC)

In general implementation of the activities developed and specified in the Emergency Action Plan, and improving this plan are the main responsibilities of the Emergency Action Plan Coordinator. More detailed responsibilities of EAPC can be summarized as follows:

- Establishment of the Emergency Action Team (EAT)
- Training the EAT and the project staff for emergency situations
- Making the division of responsibilities between EAT members
- Reviewing and improving, if necessary, the EAP with the EAT annually
- Controlling functionality and practicality of the EAP by performing maneuvers in specified intervals
- According to type of emergency situation, determination of the people that will be contacted during emergency action, and keeping contact information of these people in written form in a place that everybody in the EAT can reach
- Keeping the contact information of the EAT and people that will be contacted in emergency situations updated
- In emergency situations, coordinating the EAT in order to successfully implement the EAP
- Implementation of the necessary measures, which are not specified in the EAP, in an emergency situation after the approval of the project owner and after the end of emergency revising the EAP accordingly

- After the end of emergency, reviewing the situation with the EAT and reporting to the project owner

Emergency Action Team (EAT)

Emergency Action Team will be established from the project staff according to their abilities. The responsibilities of the EAT can be summarized as follows:

- Attending the training sections and maneuvers for implementing the EAP
- Reviewing and improving, if necessary, the EAP annually together with the EAPC
- Informing EAPC when an emergency situation occurs
- According to type of emergency situation, implementing the necessary measures in accordance with the EAP
- Notifying the relevant contact people as required in the EAP
- Reviewing the situation with the EAPC after the emergency situation, and preparation of the report

6.3. Possible Emergency Situations

6.3.1. Accidents

Potential accidents during construction and operation may cause injuries and even death. In such situations, the first aid will be provided by the EAT team and for further action assistance will be sought from the closest village clinic and/or the closest hospital. In any injury encountered in the construction sites or the plant first aid will be the responsibility of the EAT team members and/or the medical doctor available at the camp facilities. In the meantime, to prevent any further damage other EAT members will ensure environmental safety, investigate any fire possibility, and clean any spilled materials.

As a result of some accidents, fuel, oil, or other hazardous liquids may reach the surface waters. When fuel or other hazardous materials are seen floating in the surface waters, first EAT will intervene, and, if necessary, the closest fire department will be contacted to get assistance. Fuel, oil, and other floating materials will be separated from water via skimming. These skimmed materials will be collected in sealed tanks and disposed in accordance with relevant Regulations.

Mission and responsibilities of the EAT in accidents are as follows:

1. All of the team members should know the type of injury risk in each work area.

2. In emergency situations, team members will check for the persons that might be injured in their area of responsibility.

3. The EAT member who identifies a person with injury will provide first aid as proper. If he/she decides that the injury is beyond his/her ability for first aid than a more capable, or authorized, person (such as a doctor) will be waited. Any attempt that may worsen the situation of the injured person should be prevented.

4. Depending on the type and extent of injury an ambulance may be required. In such a case, a member of the EAT will wait in the road junction (or such) to direct the ambulance to the incident location.

5. After the arrival of the ambulance the responsibility passes to the medical personnel that arrived with the ambulance, but EAT member(s) will help first aid activities if needed.

6. During the first aid activities, EAT prevents the entrance of irrelevant people to the incident area.

7. After the completion of the necessary actions and/or injured person is sent to the hospital, the incident record is prepared.

8. If there is no injured person in an accident, EAT secures the incident area and reports to the EAPC.

6.3.2. Fire

Fire possibilities will be minimized in the construction sites and camp facilities by taking necessary preventive measures. In addition, in working areas fire-extinguishing equipments shall be kept at proper places for emergency action. Furthermore, no fires are allowed in the forest areas and all precautions shall be taken in the construction sites to prevent fire. Mission and responsibilities of the EAT in case of fire are as follows:

1. All of the team members should know the fire risk in each work area. They have to know how to extinguish different types of fires as well.

2. In emergency situations, team members shall check for any fire in their area of responsibility.

3. If any fire is determined or emergency situation is a fire, EAT takes the necessary actions for extinguishing without panic under the control of the team leader.

4. Depending on the type and extent of fire a fire engine may be required. In such a case, a member of the EAT will wait in the road junction (or such) to direct the fire engine to the incident location.

5. After fire engine arrives, team members help extinguishing activities if needed.

6. During the fire fighting, EAT prevents the entrance of irrelevant people to the area.

7. If any fire is not determined after emergency situation, team members are counted, and present under the head of team leader collectively.

6.3.3. Earthquake

Trainings will be provided to all workers related to actions to be taken during an earthquake for their safety. If an earthquake greater with a scale of more than 5 on Richter scale is determined in the area, and workers on duty feel earth tremor or are exposed to specified earthquake consequences (feeling of the earthquake by everybody, moving/falling of objects in the shelves, moving/falling down of furniture, fracturing of some plasters and walls, quaking of trees and shrubs), the steps given below will be followed and implemented:

1. After the incident, general visual control of dam shall be done.

2. After audits and controls are completed, relevant authority shall be notified regarding the results.

3. If dam collapses or a serious damage is of concern, settlements located in the downstream, and other dams shall be informed immediately. Furthermore, water level in reservoir shall be reduced under control.

4. If a serious damage on the embankment of the dam is determined, water level in the reservoir shall be reduced under control. Water releasing shall continue until dam embankment is controlled by an authorized engineer or dam owner.

5. If a minor damage on the dam is of concern, monitoring of relevant elements of the environment shall be initiated immediately and collapse risk

of dam shall be assessed. Afterwards, instructions shall be applied via contacting with local and national institutions.

6.3.4. Flood Risk

The water level in the reservoir may increase rather quickly due to high intensity of precipitation and increased flows in the tributaries and surface runoff. In such situations, steps given below shall be followed in order to prevent any adverse impacts on dam embankment, reservoir area and its surrounding, settlements located in the downstream:

1. Local emergency units shall be contacted. Information related to below subjects shall be given.

    - Existing reservoir height and free board (safety portion/height) height
    - Reservoir rising velocity
    - Weather conditions (past-momentary-future)
    - Discharge/drainage conditions of downstream of river
    - Leakage velocity from canals

2. If it is possible, discharge amounts at gates and spillways shall be increased incrementally.

3. Public living at the downstream will be warned and discharge amount shall be increased incrementally in order not to affect them adversely.

4. Depending on the change in water level, increased or decreased leakage shall be controlled.

5. Areas close to dam foundation or crest shall be controlled against leakage, decadence, collapse, slide and other dangerous situations. If such

situations exist, settlements located at the downstream and relevant authorities shall be informed immediately.

6.3.5. Leakage-Spill

Road or Soil Contamination

Oil, fuel, dye etc. may spill on the construction sites and/or roads that are used for transportation. The activities that shall be performed in 30 minutes following these spills are important in terms of prevention of contamination. The actions to be taken in case of leakage and/or spill after an accident are as follows:

1. Leakage source will be determined and if possible, leakage will be stopped.

2. In order to prevent spreading of leakage sandbags shall be placed around the leakage source.

3. In case of big leakages, depending on the slope of the land, a small canal will be opened in the downstream part of the leakage, and this canal shall be filled with absorbent material to collect leakage in this canal and prevent mixing with groundwater.

4. Pollutants, polluted absorbent material and soil shall be put into bags that have proper size and durability, and these bags will be labeled properly.

5. In case of a big leakage and/or spill, the incident shall be reported to the construction supervisor immediately.

6. Trucks, construction equipment etc. that had an accident on the roads shall be brought into their normal position, as fast as possible, and by this way more leakage and/or spill will be prevented.

Leakages to Water Resources

In case of leakage of oil, fuel or other chemicals to water resources, absorbent barges will be used to prevent the dispersion of the spill and to keep the surface area of the spill as small as possible. Inner part of the absorbent barges will be filled with absorbent fibrous material. When required, based on the extent of leakage and flow of water, more than one barge can be used. Following these actions the water quality will be monitored in the downstream and upstream of the leakage point.

Equipment and Materials for Pollution Prevention in case of Spills and Leakages

- Sand: Sand is a good material that absorbs pollutants on roads and soil, and prevents pollutant dispersion, but sand to be used for these purposes should be dry.
- Sawdust: Sawdust is one of the materials used to prevent dispersion of liquid material spilled to the roads and soil.
- In the leakages originating from damaged tins, barrel or such, the material in these packages will be transferred safe packages immediately.
- Absorbent barges.
- Absorbent bolster.
- Plastic gloves, special clothes and personal protective equipment.
- Vacuum pump.
- Barrels resistant to chemical material.
- Firm plastic bags.

6.4. End of the Emergency Situation and Further Actions

When the emergency conditions end at the construction area and EAPC approves the safety of the project area, relevant units and authorities are informed related to the incidence. EAT makes a general assessment together with the EAPC and

prepares the report regarding the emergency incidence. The activities taken during the emergency shall be assessed and any necessary adjustments and/or improvements shall be made in the EAP. If the emergency incidence is an unforeseen case, the precaution measures to prevent this type of emergency incidences and the action plan for such emergencies will be developed and integrated into the EAP.

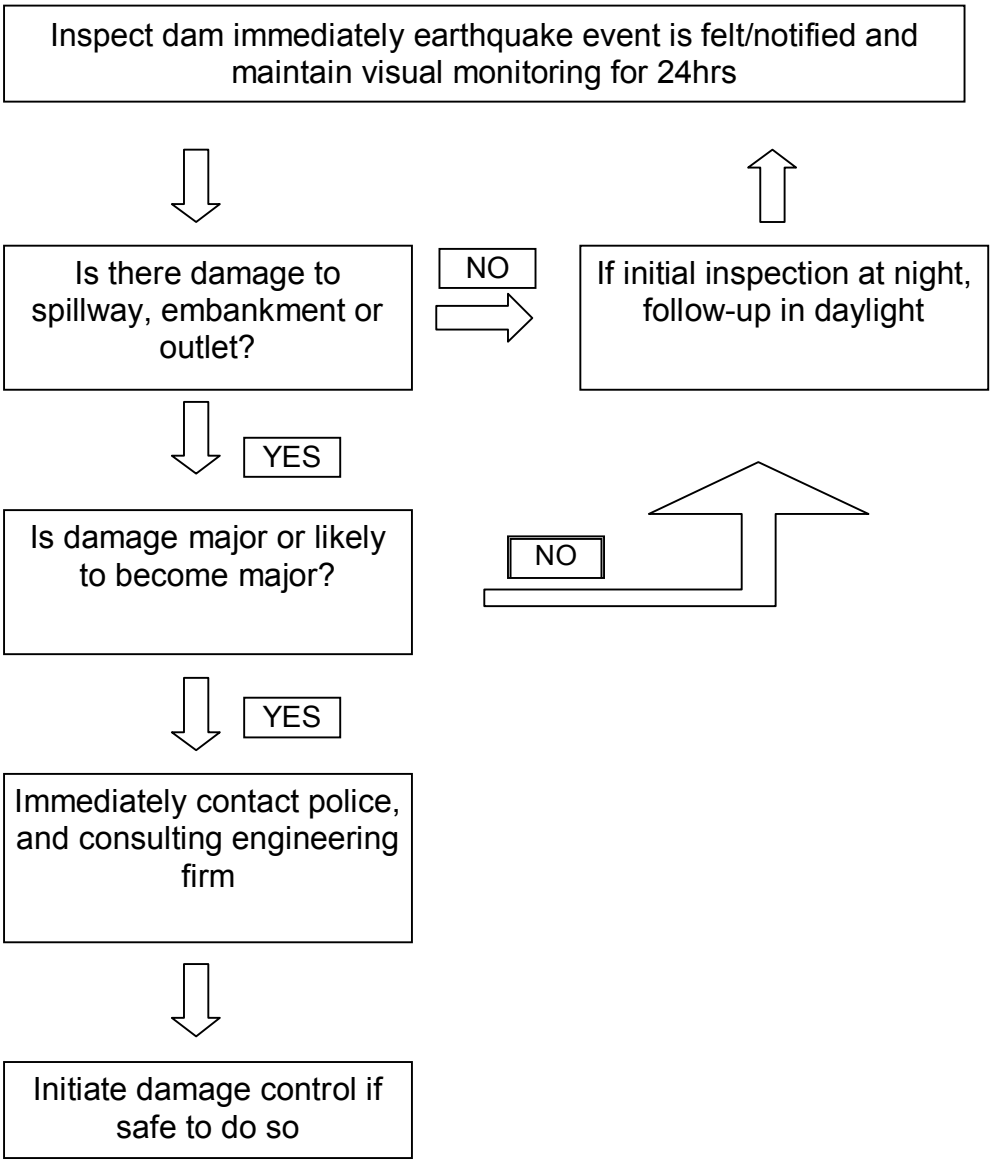
6.5. Contact List for Emergency Situations

Name of the Institution	Name of the person to be contacted	Contact Number	
Akhaltsikhe Police Department	Hot Line	(+995 265) 417206	Office Out of Office
Samtskhe-Javakheti Governorship	Governor of Samtskhe-Javakheti Region Mr. Lasha Chkadua	(+995 95) 775555	Office Out of Office
Rustavi Village Headman	Mr. Beka Bekauri	(+995 91) 918951	Office Out of Office
Agara Village Headman	Mr. Malkhaz Indoshvili	(+995 91) 918814	Office Out of Office
Fire Brigade	Hot Line	(+995 265) 20101	Office Out of Office
Samtskhe - Javakheti Regional Office of Ministry of Environment Protection and Natural Resources	Mr. Zviad Jachvliani	(+995 99) 971260	Office Out of Office

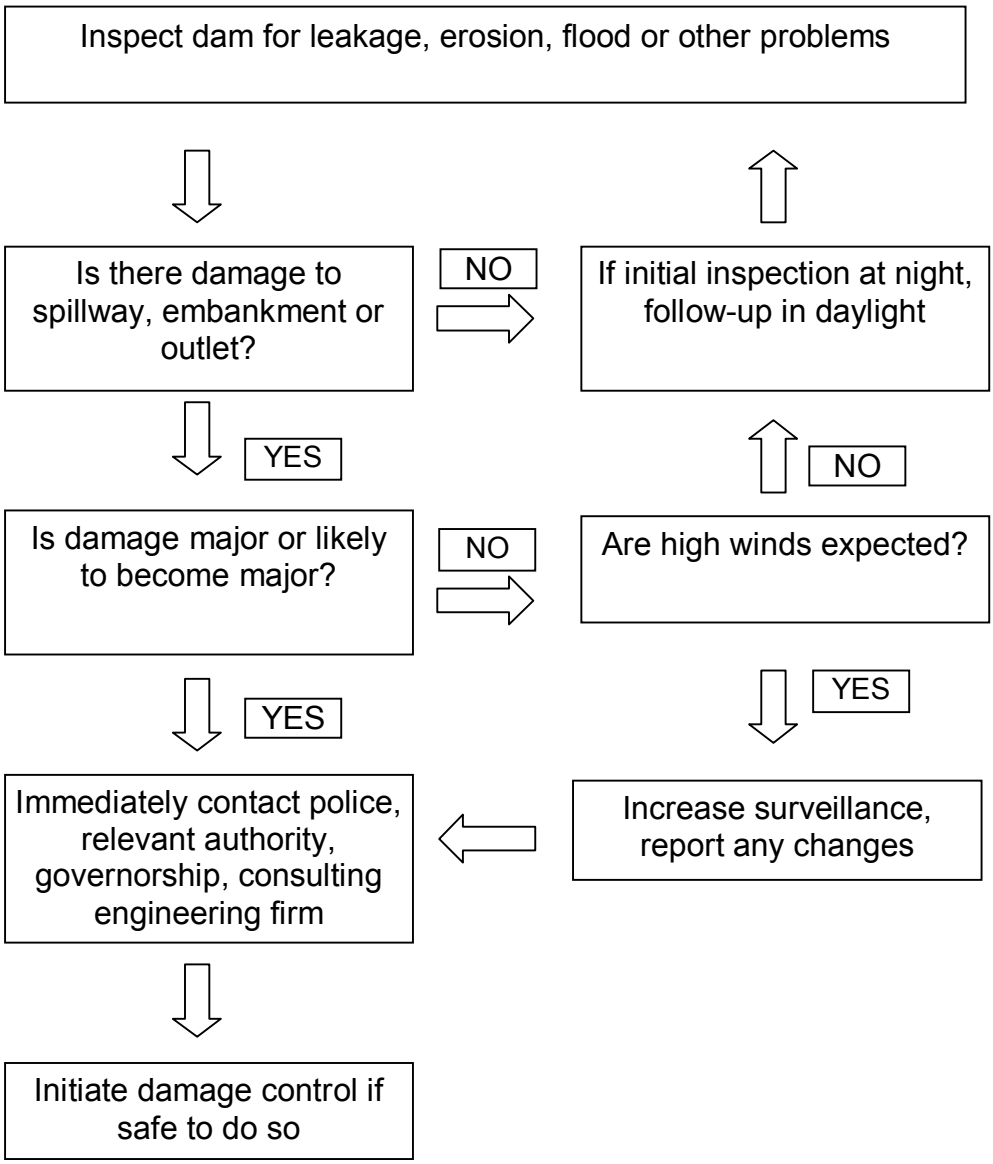
Name of the Institution	Name of the person to be contacted	Contact Number	
JSC ñAkhaltsikhe Regional Hospitalò		(+995 265) 21291	Office Out of Office
Consultant Engineering Firm	Company Limited ñUKRHYDROPROJECTò Chief Engineer of Mtkvari HPP Project Mr, Vasili Romashko	(+38 057) 7175705	Office Out of Office

6.6. Some Emergency Action Flow-Charts

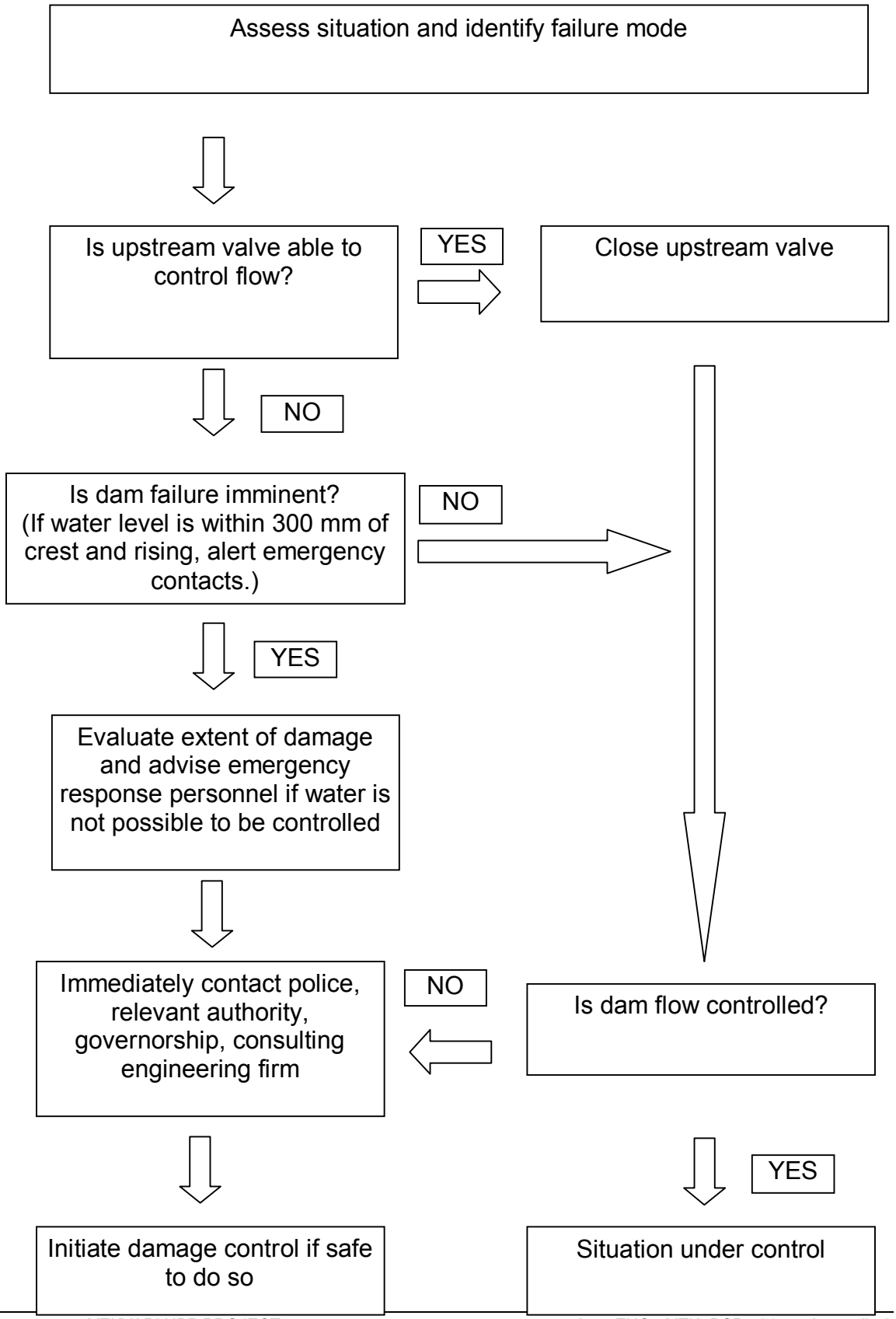
Earthquake:



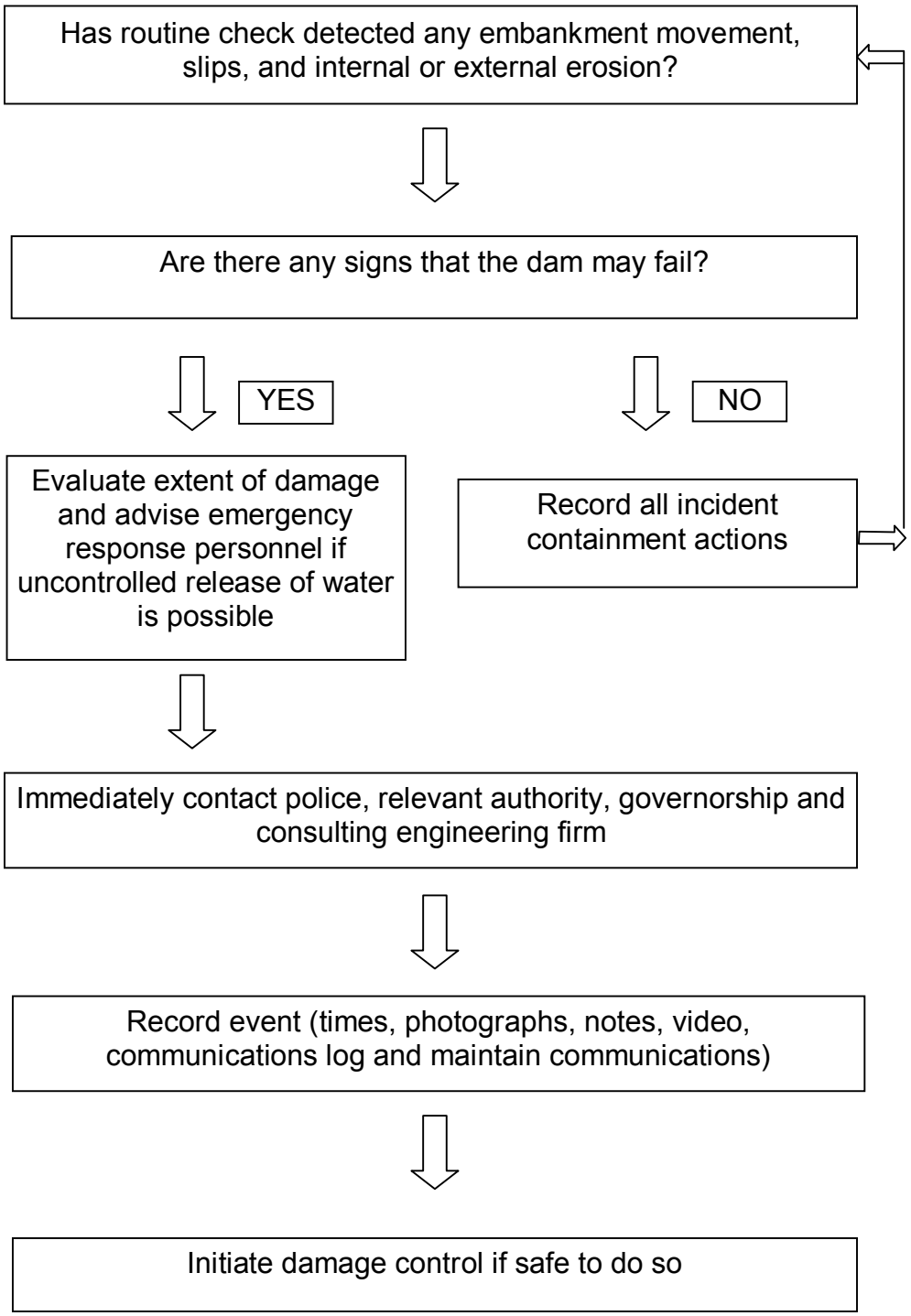
Extreme flood/ flow:



Outlet Works Failure:



Major Structural Failure:



APPENDIX 7

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