USAID FROM THE AMERICAN PEOPLE

Hydropower Investment Promotion Project (HIPP)

ARAGVI 1 HPP

PRE-FEASIBILITY STUDY

ARAGVI RIVER BASIN

Friday, May 24, 2013

This publication was produced for review by the United States Agency for International Development. It was prepared by Deloitte Consulting.

ARAGVI 1 HPP

PRE-FEASIBILITY STUDY

ARAGVI RIVER BASIN

USAID HYDROPOWER INVESTMENT PROMOTION PROJECT (HIPP)

CONTRACT NUMBER: EEM-I-00-07-00005-0

DELOITTE CONSULTING LLP

USAID/CAUCASUS OFFICE OF ENERGY AND ENVIRONMENT

FRIDAY, MAY 24, 2013

DISCLAIMER:

The author's views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

Date of Draft Publication
May 24, 2013

This document was prepared by:

Author	Organization	Contact Details
Roland Sikharulidze	Deloitte Consulting Overseas Projects	sikharulidzer@yahoo.com
Keti Skhireli	Deloitte Consulting Overseas Projects	kskhireli@dcop-hipp.ge
Gigla Sikharulidze	Deloitte Consulting Overseas Projects	gsikharulidze@dcop-hipp.ge
Guram Rodonaia	Deloitte Consulting Overseas Projects	guram.rodonaia@yahoo.com
Gvantsa Pochkhua	Deloitte Consulting Overseas Projects	gpochkhua@dcop-hipp.ge
Reviewer	**Organization**	**Contact Details**
Jake Delphia	Deloitte Consulting Overseas Projects	jdelphia@deloitte.com
George Chikovani	Deloitte Consulting Overseas Projects	gchikovani@dcop-hipp.com

***Note to Reader**:* This document is based largely on existing information, and information gathered during field visits by a small group of professionals from Deloitte Consulting.

DISCLAIMER REGARDING THIS PREFEASIBILITY STUDY

This Pre-Feasibility Study has been sponsored by USAID and prepared for the use of the Georgian Ministry of Energy and Natural Resources (MENR) and is distributed for information purposes only. This Pre-Feasibility Study does not constitute an offer or invitation for the sale of any assets or shares, or recommendation to form a basis for investment. This Pre-Feasibility Study and the data contained herein shall not form the basis of or in any way constitute any contract or binding offer or agreement.

While the information contained in this Pre-Feasibility Study has been prepared in good faith, it is not and does not purport to be comprehensive or to have been independently verified, and neither the Ministry of Energy and Natural Resources, Georgian Energy Development Fund or any of their officers, employees, advisers or consultants accept any liability or responsibility for the accuracy, reasonableness or completeness of or for any errors, omissions or misstatements, negligent or otherwise, relating to or makes any representation or warranty, express or implied, with respect to the information contained in the Pre-Feasibility Study or on which it is based or with respect to any written or oral information made, or to be made available to any of the recipients or their professional advisers and, so far as permitted by law and except in the case of fraudulent misrepresentation by the party concerned, any liability therefore is hereby expressly disclaimed.

While considering the Pre-Feasibility Study, each recipient/interested party should make its own independent assessment and seek its own professional, financial, legal and tax advice.

The author's views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

Definition of Abbreviations

CAPEX	Capital Expenditure
EIA	Environmental Impact Assessment
EPCM	Engineering, Procurement, and Construction Management
EU	European Union
GEL	Georgian Lari
GSE	Georgian State Electrosystem
GW	Gigawatt
GWh	Gigawatt-hours
ha	Hectare
HEC-SSP	Hydrologic Engineering Center Statistical Software Package
HIPP	Hydropower Investment Promotion Project (USAID-funded)
HPP	Hydropower Plant/Hydropower Project
HV	High Voltage
kV	Kilovolt
kW	Kilowatt (a measure of power)
kWh	Kilowatt-hour (a measure of energy)
LS	Lump Sum
m^3/s	Cubic meters per second
masl	Meters above sea level
MENR	Ministry of Energy and Natural Resources of Georgia
MW	Megawatts
MWh	Megawatt-hours
SS	Substation
UNESCO	United Nations Educational, Scientific and Cultural Organization
US ¢	United States Cent (also USc)
US $	United States Dollar (also USD)
USAID	United States Agency for International Development
VAT	Value Added Tax

TABLE OF CONTENTS

GENERAL INTRODUCTION TO THE PROJECT 5

1.1 PROJECT AREA SOCIAL CHARACTERISTICS 5

1.2 PROJECT AREA ENVIRONMENTAL CHARACTERISTICS 6

1.3 TRANSMISSION 9

1.4 ACCESS TO THE AREA 10

BASELINE CONDITIONS 10

1.5 DATA AVAILABILITY 10

1.6 HYDROLOGY AND WATER RESOURCES 11

1.7 FLOODING AND FLOOD RISK 13

1.8 SEDIMENT 13

GEOLOGY 15

1.9 GEOLOGICAL MAP 15

1.10 SEISMOLOGY 15

1.11 FUTURE GEOLOGICAL INVESTIGATIONS 16

HYDROPOWER PROJECT DESCRIPTION 17

1.12 GENERAL 17

1.13 DIVERSION FACILITIES 17

1.14 WATER CONDUCTORS 17

1.15 POWER PLANT 17

POWER AND ENERGY STUDIES 19

1.16 AVAILABLE FLOW DATA 19

1.17 BYPASS (SANITARY) FLOWS 19

ENVIRONMENTAL AND SOCIAL STUDIES 20

1.18 ENVIRONMENTAL RECEPTOR IMPACTS & MITIGATION PRACTICES ... 20

PROJECT COST ESTIMATE AND CONSTRUCTION SCHEDULE 21

1.19 ASSUMPTIONS 21

1.20 PROJECT COST ESTIMATE 22

LIST OF TABLES

Table 1: Project Significant Data 3

Table 2: Development Area Significant Data 5

Table 3: The Aragvi River Fish Spawning Periods 8

Table 4: Hydrology Significant Data 11

Table 5: Gudauri Village Climate Data 12

Table 6: Tetri Aragvi River at Mleta Gauge Location: Sediment Load Data 14

Table 7: Significant Earthquake Data 15

Table 8: Aragvi 1 HPP Power and Energy Calculations 18

Table 9: Stream Gauges in the Aragvi Watershed 19

Table 10: Aragvi 1 HPP Estimated Capital Expenditure 22

LIST OF APPENDICES

Appendix 1: Location Map

Appendix 2: Watershed Map

Appendix 3: Geology Map

Appendix 4: Geomorphology Map

Appendix 5: Soils Map

Appendix 6: Preliminary Turbine – Generator Characteristics

Appendix 7: Land Cover Map

Appendix 8: Mean Annual Precipitation

Appendix 9: Environmental and Social Impacts, Affected Environment

Appendix 10: Cultural Resources & Recreation Areas

Appendix 11: Listed Cultural Properties in Dusheti Municipality

EXECUTIVE SUMMARY

Project Description

The site of the proposed Aragvi 1 Hydropower Plant Project (HPP) is located in the Dusheti District of Eastern Georgia's Mtskheta-Mtianeti Region. The potential hydropower project involves construction of an approximately 10.2 Megawatt (MW) run-of-river Hydropower Plant (HPP) on the Tetri Aragvi River.

The Aragvi 1 HPP will be the one of the plants in the cluster of the Aragvi River Watershed Area. The Aragvi River is 112 km long and drains an area of 2,724 km^2. At an elevation of 1,040 masl, near the village of Pasanauri, the Tetri (white) and the Shavi (Black) Aragvi merge to form the Aragvi River, which flows through the Zhinvali Reservoir into the Mtkvari River near the town of Mtskheta. The Aragvi River has nearly 716 tributaries with a combined length of 1926 km, the major ones are the Tetri Aragvi (41 km), the Shavi Aragvi (30 km), the Pshavis Aragvi (54km), and the Narekvavi (41km), etc.

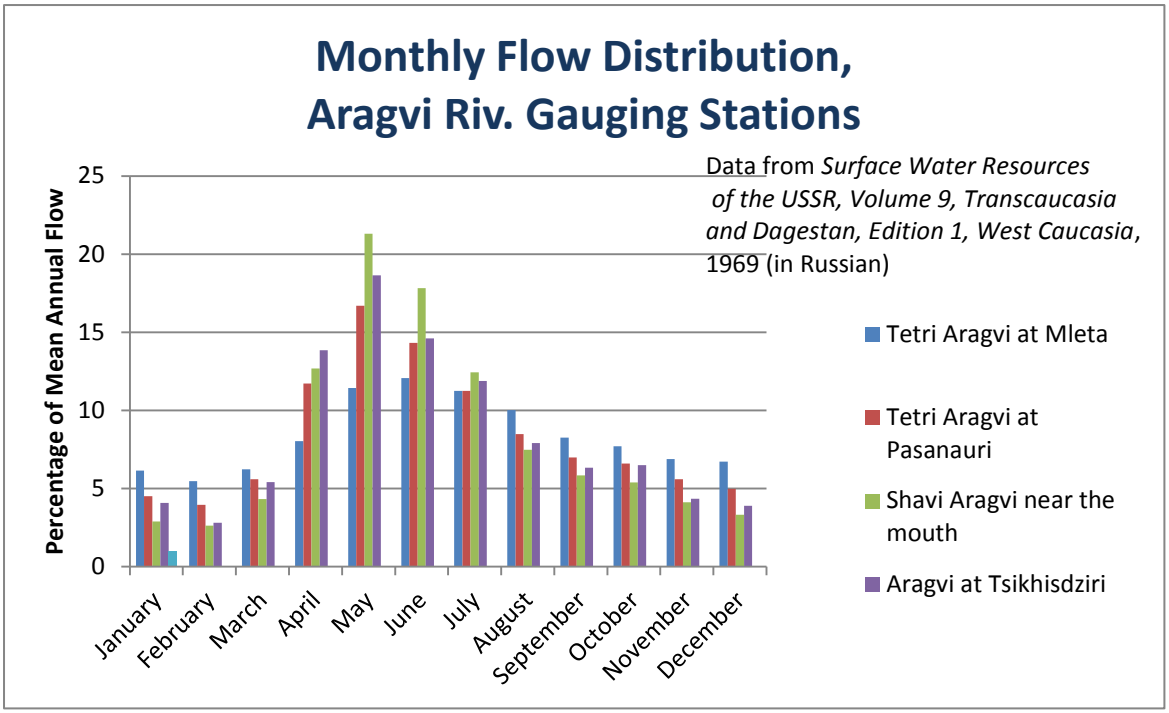
The Aragvi River flows through mountainous terrain and lowlands. Its upper course mainly flows through gorges separated with ridges of the Lomisi range (separating the Tetri Aragvi and Ksani Rivers), the Gudamakri Range (separating the Shavi and Khevsureti Aragvi Rivers) and the Tianeti range (separating the Pshavis Aragvi and Iori Rivers) while the lower course crosses lowlands starting from the Lake Bazaleti.

The Aragvi 1 Hydropower Plant site is located on the left-bank of the Tetri Aragvi River, located about 65 km upstream from the developed area of Dusheti district of Mtskheta-Mtianeti Region. The nearest settlements are Bedoni, Kvesheti and Arakhveti villages about 0.5-1.0 km away from the Aragvi 1 HPP powerhouse (See Appendices 1 and 2 for Location and Watershed maps).

The geologic conditions in the Aragvi Basin are variable. The area enters the southern zone of the Mestia-Tianeti fold system of the Greater Caucasus. Quaternary effusive volcanic rocks, upper Jurassic and lower Cretaceous carbonate flysch sediments dominate in the area. Couple of regional and thrust faults is observed within the watershed area concentrated mainly near the Zhinvali Reservoir and middle reaches of the Shavi Aragvi River. Earthquake probability is also fairly high in the region. Rock ranges from very strong deposits, through metamorphic rock zones to poorly cemented deposits. Sandstones, limestone, clay-slates, argillites, andesite, basalt and schist slates are widely spread in the area. Alluvial-proluvial and deluvial-proluvial sediments in the study area are predominately met along the river-bed and river-valley. Detailed geologic studies and careful orientation and placement of structures will be required to develop a successful project (See Appendices 3, 4 and 5 for Geology, Geomorphology and Soils maps).

The Tetri Aragvi River flow is characterized by high flows in spring and summer from snowmelt in the alpine areas, moderate flows in autumn and relatively stable low flows during the winter. About 61% of the annual discharge occurs in spring and summer, 21% in autumn and 18% in winter.

The hydrological variability is demonstrated in the following chart, which shows the seasonality of flow at gauging stations in the Aragvi River basin:



The diversion point for Aragvi 1 HPP is on the Tetri Aragvi River, about 2.0 km upstream from Zemo (Upper) Mleta village. Moderate flows and high head are available at this location, making an HPP of about 10.2 MW appear attractive. The power plant will be located on the North bank of the Tetri Aragvi River, about 1.0 km upstream from the village of Kvesheti.

The project layout, based on information available at this time, includes a low diversion dam with sluices and intake, de-silting facilities, a pressure tunnel water conductor, penstock, and a surface powerhouse, as shown on the Arrangement Drawing, Figure 1. Two Pelton turbines could be used at this site (Appendix 6 depicts Preliminary Turbine –Generator Characteristics).

Project cost and construction schedule

The estimated cost of the Aragvi 1 HPP is US$ 25.8 million, or about US$ 2,530/kW of installed capacity, including VAT and a 25% contingency. The project is expected to have a 1-year pre-construction period and 3-year construction period. The critical path for the project may be controlled by the tunnel construction or by the procurement, manufacture, delivery and installation of major mechanical and electrical components.

Conclusions

According to preliminary assessment, the plant offers a good potential opportunity to sell modest amounts of energy during three winter months inside Georgia, replacing (displacing) expensive thermal power; and to export energy during the remainder of the year to take advantage of the seasonal differentials in power prices between Georgia and its neighboring countries.

Table 1: Project Significant Data

General	
Project name	Aragvi 1 Hydropower Project
Project location (political)	Dusheti District of Eastern Georgia's Mtskheta-Mtianeti Region
Nearest town or city	Dusheti
River name	Tetri Aragvi River
Watershed name	Aragvi River Watershed
Drainage area at diversion	96.1 km^2
Financial Estimates	
Estimated construction cost, including VAT	$ 25.8 Million
Estimated cost per kW capacity	$2,530/kW
Hydrological Data	
Stream gauge used	Mleta gauging station
Years of record	1935,1937-38,1942,1944-86
Gauge drainage area	107 km^2
Mean river flow at intake	4.71 m^3/s
Facility design discharge	5.8 m^3/s
Preliminary design flood (100 yr. return period) (Adjusted to Intake Location)	51 m^3/s
Max. recorded flow (Mleta gauging station)	68 m^3/s
Mean annual flood (Mleta gauging station)	17.2 m^3/s
Diversion Facilities	
Normal operating level	1550 masl
Approximate dam height	15 m
Approximate diversion pond area	10 ha
De-silting structure	Required
Sanitary or environmental bypass flow (assumed)	10% of mean annual flow
Power Tunnel	
Tunnel length	5,600 m
Tunnel section (diameter)	2.0 m
Penstock	
Penstock length	80 m
Outside diameter	2,020 mm
Powerhouse	
Type	Above-ground
Installed capacity	10.2 MW
Units, turbine output and turbine type	2 x 6.1 MW, 4-jet vertical Pelton units, with jet deflectors
Units and rated generator capacity	2 x 7.6 MVA at 0.80 Power Factor
Preliminary generator voltage	10 kV or 6.3 kV
Rated speed	500 rpm
Units, type and net capacity at high-voltage transformer	2; 110/10-10 MVA or 110/6.3-10 MVA
Tailrace	
Length	40 m
Width	2.0 m
Type	Open channel
Normal tail water elevation	1335 masl
Transmission line	
Interconnection location	Existing 110 kV Mleta substation
Distance to interconnection (km)	1.0 km
Voltage	110 kV
Power & Energy	
Gross head	215 m
Total head loss at rated discharge	7.3 m
Net head at rated discharge	207.7 m

Estimated average annual generation	Approximately 65.4 GWh
Nominal installed capacity	10.2 MW
Preliminary annual plant factor	73 %
Construction Period	
Conceptual design, feasibility studies & EIA	1 year
Engineering, procurement and construction	3 years
Ongoing environmental monitoring	Some studies and data collection will extend throughout construction.
Environmental	
Critical environmental receptors	Kazbegi Protected Area

Project Location Map

GENERAL INTRODUCTION TO THE PROJECT

Table 2: Development Area Significant Data

Project Location (Political)	Eastern Georgia's Mtskheta-Mtianeti Region
Political Subdivisions	Dusheti District (Municipality)
Area Population	33,600
Nearest Settlements	Arakhveti, Bedoni, Zemo (Upper) Mleta, Kvemo (Lower) Mleta and Kvesheti
River Name	Aragvi
Economic Activity in the Area	Agriculture, highway services, ski resort
Special Natural Resources	Water, timber, accessible ski conditions
Special Cultural Resources	Churches, monasteries, castles, etc.
Critical Environmental Receptors	Kazbegi Protected Area

1.1 PROJECT AREA SOCIAL CHARACTERISTICS

The Aragvi 1 Project area is located in Dusheti Municipality, which is part of the Mtskheta-Mtianeti Region Administrative Unit. The Dusheti municipality consists of one town, two townlets and 288 villages. The city of Dusheti is the administrative center of the Dusheti District. According to the 2002 census, the municipality population is about 33,600 people, with a population density of 11.3 people/ km^2. The distance from Tbilisi to the administrative center of Dusheti is about 54 km by road and the Aragvi 1 project is a further 65 km northwest of Dusheti. A military road (Highway 3) goes through the area along the Aragvi gorge. The Dusheti District is bordered by Kazbegi Municipality on the North, Tianeti Municiplity on the East, Akhalgori and Kaspi Municipalities on the West and Mtskheta Municipality on the South.

The Village of Bedoni. Image taken by HIPP team during the field visit

The Military Road going through Pasanauri-Gudauri section. Image taken by HIPP team during the field

The landscape of the Dusheti district is mainly mountainous with alpine and sub-alpine terrains. Area is rich in water resources having one lake, two reservoirs and three rivers of 105 km in total length. The total area of district land equals to 2,981.5 km^2 of which agricultural land amounts 1,390 km^2. The economy heavily relies on animal husbandry and agriculture especially in lowlands. The area is rich in mineral waters, medicinal plants, mineral resources (mainly building stones) and nature monuments. District has several resorts of local importance with touristic bases in Pasanauri, Ananuri and Bazaleti.

There is growing ski resort tourism at Gudauri (Kazbegi Municipality), which is expected to deliver increasing benefits to the surrounding area and villages providing services along the main access highway.

The region is also culturally rich represented by many old churches, monasteries, towers and other cultural relics, such as the Ananuri Castle fortified ensemble dating back to the 17th century A.D. (listed in the UNESCO World Heritigae site tentative list), Bebris Fortress, etc. As for natural treasury, there is no oficially designated natural monuments within the boundaries of the Dusheti municipality, however Kazbegi National Park belonging to the Kazbegi district comes extremely close to northern borders of the Dusheti municipality.

Aragvi 1 HPP lies in the upper reach of the Aragvi River. The nearest settlments to the project area, Arakhveti, Kvesheti, Bedoni, Kvemo (lower) and Zemo (upper) Mleta villages (Kvesheti community), are at 61 km, 65 km, 69 km and 70 km respectively from Dusheti town. The villages are located at 1,300-1,680 m above sea level. According to the last census (2002) Arakhveti counts for 326 people, Bedoni has up to 153 inhabitants, Zemo Mleta (176 people) and Kvemo Mleta (137 people) community together accounts for 313 people and 355 people reside in Kvesheti village. The local community mainly depends on subsistance farming. Main agricultural activities include animal husbandary (sheep breeding is leading, beekipeeng and fishing is also widely spread among local communities) and cultivation of fruits and vegetables. Historic monuments of the Middle Ages are found in the villages, such as Kobt fortress in Kvesheti, Kviratskhoveli Church in Arakhveti, towers in Bedoni and church of the Virgin Mary in Kvemo Mleta.

1.2 PROJECT AREA ENVIRONMENTAL CHARACTERISTICS

Floodplain at the Tetri Aragvi River. Image taken by HIPP team during the field visit

Bridge across the Tetri Aragvi River. Image taken by HIPP team during the field visit

Flora: The Aragvi River watershed is rich in biological resources. Forests occupy almost all of the watershed areas of the territory (See Appendix 7 - Land Cover). Rare and endemic species are found in the area. Many of the species are not only endemic to Georgia but to the Caucasus. Nine plant species are listed in the Red Book of Georgia.

Vertical zoning is characteristic to the plants of the Aragvi River watershed. At the altitude of 900 m steppe grasses (*Botriochloa ischaemum, Festuca valesiaca, Stipa ssp*.), “Shiblyak” and open woodlands (*Juniperus foetidissima, J. polycarpos, Celtis caucasica*) are dominant. Deciduous forests are spread at 900-1,800 (2,100) m above sea level with leading species of oak, beech and hornbeam. Starting from 1,800 (2,100) m up to 2,500 m above sea level subalpine flora intervenes and is represented by high mountain oaks, birch, maple, rhododendron and subalpine

valleys. Alpine shrubbery and meadows take over at 2,500-2,900 m above sea level. The area of the potential HPP is mainly covered with deciduous forests mixed with lines of conifers in Northern part of the Dusheti district. Pine forests are spread on the left slopes of the Aragvi River between Mleta and Pasanauri villages. Oak (*Quercus iberica, Q. pedunculiflora and Q. caucasica*), beech (*Fagus orientalis*) and hornbeam (*Carpinus orientalis, C. caucasica*) forests dominate along the watershed between Zhinvali and Pasanauri villages. Together with leading species the forest contains: willow (*Salix australior, S. alba, S. caprea*), poplar *(Populus canescens, P. nigra*), salt-cedar (*Tamarix ssp*.), sea-buckthorn (*Hippophae rhamnoides*), alder (*Alnus barbata*), elm (*Ulmus carpinifolia*), maple (*Acer campestre, A. laetum*), ash (*Fraxinus excelsior*), cherry plum (*Prunus divaricata*), cornel (*Cornus mas*), etc. The most common shrubs are: black and common hawthorn (*Crategus monogyna, C. pentagyna*), common medlar (*Mespilus germanica*), blackberry (*Rubus spp*.), dog rose (*Rosa spp*.), wild apple, wild pear, hazel nut, etc. (SEA Small Hydropower Plants Aragvi River Basin, 2010).

Fauna: The Aragvi River watershed harbors great variety of fauna. 18 species of mammals, 8 species of amphibians, 17 species of reptiles, 110 bird species are found in the area. Many of them are rare and endemic to Caucasus and Georgia.

The following mammals have been recorded in the Aragvi watershed area: roe dear (*Capreolus capreoulus)*, chamois (*Rupicapra rupicapra*), brown bear (*Ursus arctos*), grey wolf (*Canis lupus*), red fox (*Vulpes vulpes*), jackal (*Canis aureus*), lynx (*Lynx lynx*), wild cat (*Felis silvestris*), marten (*Martes martes*), weasel (*Mustela nivalis*), European hare (*Lepus europeaus*), different species of voles (*Terricola majori, Microtus arvalis, Chionomus gud*), squirrel (*Sciurus anomalus*), hedgehog (*Erinaceus concolor*), long-clawed mole vole (*Prometheomys schaposchnikowi*), forest dormouse (*Dryomys nitedula*), squirrel (*Sciurus anomalus*), and shrews (*Sorex raddei, S. satunini, S. volnuchini, S. araneus*) (SEA Small Hydropower Plants Aragvi River Basin, 2010).

Following amphibian species are spread in the Aragvi River watershed: Asia minor frog (*Rana macrocnemis*), green toad (*Bufo viridis*), lake frog (*Rana ridibunda*), smooth newt (*Lissotriton vulgaris*), common treefrog (*Hyla arborea*), banded newt (*Ommatotriton vittatus*). Caucasian mud-diver (*Pelodytes caucasicus*) and Caucasian toad (*Bufo verrucosissimus*) are Caucasian endemics.

Variety of reptiles is common to the Aragvi River watershed: snakes (*Vipera kaznakovi, Natrix natrix*, *N. tessellate, Telescopus fallax, Eirenis collaris*), lizards (*Lacerta agilis*, *Darevskia rudis*, *D. parvula*, *D. saxicola, Pseudopus apodus, Lacerta strigata*), turtles (*Emys orbicularis*). Caucasian lizard (*Darevskia caucacisa*) and Artwin lizard (*Darevskia derjugini*) are endemics of the Caucasus region.

The Aragvi watershed is very rich in bird species. They are vertically distributed and are grouped into three categories of lowlands, forest and high-mountain (Subalpine and Alpine) species. The highest diversity is found in the forest areas. The most common forest bird species are: Eurasian jay (*Garrulus glandarius*), tits (*Parus major*, *P. ater*), common blackbird (*Turdus merula*), common redstart (*Phoenicurus phoenicurus*), green warbler (*Phylloscopus trochiloides*), etc. Diversity of falcons, eagles, hawks, woodpeckers, owls, pigeons is spread within the River Aragvi watershed. More than 70 passerine and near passerines are found in the area.

The local fishery is also considered a primary environmental receptor for baseline comparison.

The Aragvi River, its tributaries and Zhinvali Reservoir are populated by following fish species: Brown trout (*Salmo trutta forma fario*), Transcaucasian barb-khramulya (*Capoeta capoeta*), Kura barbell (*Barbus lacerta),* mursa (*Barbus mursa),* chub *(Squalius cephalus),* spirlin *(Alburnoides bipunctatus),* blackbrow bleak (*Acanthalburnus microlepis*), Kura bleak (*Alburnus filippii*), Kura gudgeon (*Romanogobio persus*), Kura stone loach (*Oxynoemacheilus brandtii*), goldside loach (*Sabanejewia aurata*), round goby (*Neogobius melanostomus*), vimba (*Vimba vimba*), Kura nase (*Chondrostoma cyri)* and Bulatmai barbell (*Barbus capito capito*) (Ninua. N, Japoshvili B, Checklist of fishes of Georgia, Proceedings of the Institute of Zoology, vol XXIII, 2008). Spawning periods for major fish species found in the river are noted in table below.

Table 3: The Aragvi River Fish Spawning Periods

Fish	Spawning Period
Brown trout	September-February
Khramulya	May-August
Musra	May-June
Chub	May-August
Spirlin	May-August
Kura bleak	May-August
Kura gudgeon	May-June
Kura stone loach	May-July
Round goby	May-June
Kura nase	May-August

The Aragvi River fish distribution depends highly on vertical zoning. More favorable conditions for fish are found in mountain forest zone and foothill zone of the river basin. The alpine zone of the Aragvi River, due to harsh conditions, is not rich in fish species.

Some of the species in the Aragvi River are rare or endemic. E.g. Trout is listed as a vulnerable species in the Red List of Georgia (Red list of Georgia, 2006); Mursa, black-brow bleak, Kura bleak and Kura stone loach are endemic species of the Caucasian region.

Literature on fish composition in the Aragvi River dates back several decades. Since then no monitoring on fish species has been conducted. Therefore, it's hard to know whether all of these species still inhabit the study area or not. The sampling of fish species should be included as part of the feasibility study and environmental assessment.

1.3 TRANSMISSION

The current transmission and high-voltage distribution system in the Aragvi 1 HPP area is 110 kV. For this pre-feasibility study, it is assumed that the output of the Aragvi 1 HPPs will be 110 kV. The network interconnection for the Aragvi 1 HPPs could be directly to the Energo-Pro 110 kV Mleta substation near the military road (Highway 3) going along the Tetri Aragvi River.

The distribution lines and all of the 110 kV lines in the area are owned and operated by Energo-Pro, the licensed distribution utility serving most of Georgia outside Tbilisi.

A single-circuit 220 kV line, property of the government-owned Georgian State Electrosystem (GSE), connects the Zhinvali HPP Substation to the Ksani 500 kV substation west of Mtskheta.

Ananuri 110 kV line running through Dusheti-Pasanauri. Image taken by HIPP team

Gudauri 110 kV substation. Image taken by HIPP team

The Aragvi 1 power plant will be located 1.0 km upstream from Kvesheti village. About 1.0 km of new 110 kV line will be needed to evacuate the power from the Aragvi 1 SS to the existing Mleta 110 kV SS, which in turn is connected to the Dusheti 110 kV substation via Pasanauri SS.

1.4 ACCESS TO THE AREA

Infrastructure of the region is developed. The highway and road connections are good and it is possible to drive from Tbilisi to Dusheti in less than one hour. A military road (Highway 3) goes through the area along the Aragvi gorge. During recent period rehabilitation of roads has been implemented by the Government of Georgia within the region. The road maintenance is regular over the whole year. The road to surrounding villages is kept open during wintertime.

Access to the power house, diversion and intake site is good. The locations of both the powerhouse and diversion weir sites are adjacent to Highway 3, which serves as a year round access to the Gudauri Ski Area and also trans-shipping between Russia and Armenia. To reach the Aragvi 1 HPP headwork site only about 300 m of new road needs to be built.

Power house location at the Tetri Aragvi River. Image taken by HIPP team during the field visit

Head-structure location at the Tetri Aragvi River. Image taken by HIPP team during the field visit

BASELINE CONDITIONS

1.5 DATA AVAILABILITY

Maps. Soviet-era topographic maps are available for the entire study area at 1:250,000; 1:100,000; and 1:50,000. Most of the area is covered by 1:25,000 topography that has been available to HIPP at no cost. This Soviet mapping has been used to prepare the Project Arrangement Drawing, Figure 1, and the River Profile, Figure 2.

Geologic mapping is available for the entire area at scales of 1:250,000, 1:50,000 and 1:25,000. Information from these maps has been used to prepare the Project Geologic Map, Figure 3 and Appendices 3 and 4.

Aerial and Satellite Imagery*.* Part of the area is covered by Google Earth imagery that shows useful detail, but the Google service has only low-resolution satellite imagery for most of the area. The local firm GeoGraphic has high-resolution, aerial color imagery, taken in 2010, for the entire area but funds are not available to purchase the material at this time.

1.6 HYDROLOGY AND WATER RESOURCES

Table 4: Hydrology Significant Data

Method of analysis	Monthly
Drainage area at gauge	107 km^2
Total drainage area for Aragvi 1 HPP	96.1 km^2
Adjustment factor	0.898
Maximum plant discharge	6.75 m^3/s
Minimum plant discharge	As low as 0.14 m^3/s
Flood flows	Average Annual Flood 15.4 m^3/s*
Highest recorded flow	68 m^3/s
Calculated 100 year flood	51 m^3/s*, based on 42 year period of record
Records available	Mean monthly flows of the Tetri Aragvi River at Mleta gauging station for 44 years, from publications of the Hydromet.
Recommended additional data collection and study recommendations for feasibility and design	Install the new gauging station at Aragvi 1 HPP's headworks. It would also be used for monitoring of suspended and bed load sediments, water quality parameters, water temperature, fish, etc.

**These flood flows are based on a simple drainage area ratio adjustment of the Mleta gauge data. They are probably slight underestimations of flood flows at the diversion. That is due to the smaller drainage basins and steeper tributary areas, which results in shorter times of concentration.*

Table 5: Gudauri Village Climate Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	
Data Type	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**mean**	**Annual Totals**
Average Monthly Air Temperature in °C	-7.7	-7.7	-4.6	0.4	5.5	9.1	12.3	12.3	8.3	4.0	-1.2	-5.3	2.1	
Lowest Average monthly Air Temperature in °C	-11.2	-11.4	-8.9	-3.0	2.1	5.5	8.2	8.2	4.6	0.5	-4.6	-8.5	-1.5	
Lowest Recorded Air Temperature in °C	-33	-31	-27	-16	-10	-5	-1	-2	-12	-17	-22	-29		-33
Highest Average Monthly Air Temperature in °C	-3.3	-2.3	0.3	4.8	10.0	13.7	16.6	17.1	12.9	8.6	3.0	-1.2	6.6	
Highest Recorded Monthly Air Temperature in °C	9	12	17	20	22	26	27	27	27	23	18	13	27	
Average Relative Humidity in %	72	73	75	74	76	76	76	74	78	75	72	68	74	
Average Monthly Precipitation in mm	79	95	116	142	192	171	139	118	106	105	99	90	121	1,452
Average Monthly Wind Speed in meters/sec.	2.0	2.4	1.8	1.9	1.9	1.6	1.6	1.8	1.6	1.6	2.2	2.2	1.9	

Source: *Meteorological Station Located in Gudauri village in Dusheti District. Data on climate and meteorology was provided by the Department of Hydrometeorology of Georgia.*

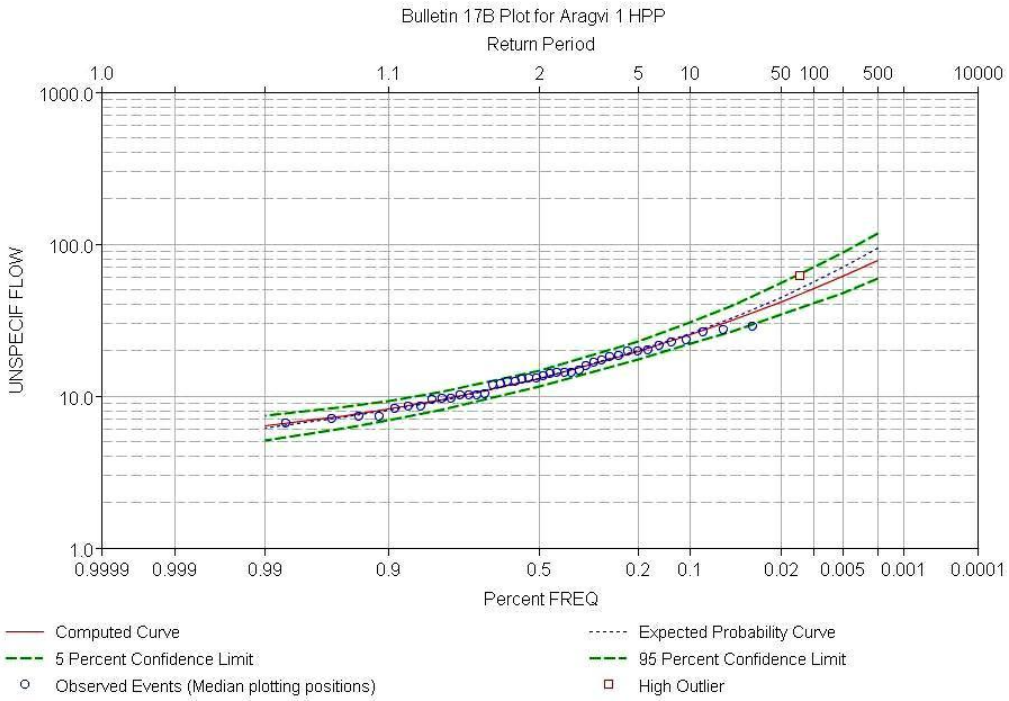
Also see Appendix 8 for the Map of the Mean Annual Precipitations.

1.7 FLOODING AND FLOOD RISK

Flooding occurs frequently in the project watershed and in the project vicinity. Steep slopes, deep gorges, significant areas of exposed rock and impervious surfaces, snowmelt runoff enhanced by warm temperatures and intense precipitation all contribute to major flooding risk for the project and the local environment.

Only 42 years of peak flood flow data are available for the Mleta stream-flow gauge. These data points were analyzed using the U.S. Army Corps of Engineers Hydrologic Engineering Center - Statistical Software Package (HEC-SSP) computer program, Version 2.0. See: http://www.hec.usace.army.mil/

A Log-Pearson III analysis was prepared, following the procedures in United States Water Resources Council Bulletin 17B, *Guidelines for Determining Flood Flow Frequency:* http://water.usgs.gov/osw/bulletin17b/bulletin_17B.html. The results for the Aragvi 1 HPP are shown on the following plot:



Flood flows of Mleta gauge were adjusted to the diversion location using a simple drainage basin area ratio.

The divergence of the green 5 and 95 percent confidence limit lines shows the greater uncertainties in floods larger than about the 10-year event. Further flood hydrology studies should be conducted during the feasibility phase of development to improve the understanding of rarer flood events.

1.8 SEDIMENT

Upstream of the Aragvi 1 HPP intake location, the river carries a very low concentration of suspended sediment and bedload sediment. Although the watershed is steep-sloped generating a high-velocity surface runoff and river velocities, the measurements of sediment at the Mleta gage report very low sediment. Table 6 presents monthly and annual sediment discharge in the Tetri Aragvi River at the Mleta gauge.

Table 6: Tetri Aragvi River at Mleta Gauge Location: Sediment Load Data

Record years	Average Monthly Discharge of Sediment in kg/sec												Average Annual Sediment Discharge in kg/s	Annual Sediment Discharge in Tonnes x1000	Assumed Daily Maximum kg/s
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**			
1976	0.046	0.027	0.058	0.590	1.300	0.820	2.300	0.049	0.050	0.027	0.023	0.009	0.442	14.0	27 (20/VII)
1977	0.015	0.023	0.072	0.250	1.800	6.400	2.100	0.470	0.400	0.069	0.004	0.019	0.969	31.0	56 (11/VI)
1978	0.024	0.036	0.059	0.170	0.710	0.460	0.850	3.600	1.700	0.160	0.020	0.012	0.650	21.0	46 (23/VIII)
1979	0.023	0.027	0.023	0.180	0.320	1.000	3.000	0.160	0.005	0.027	0.023	0.024	0.401	13.0	13 (19/VII)
1980	0.023	0.031	0.031	0.250	1.200	0.160	0.520	0.710	0.097	0.062	0.018	0.012	0.260	8.2	12 (26/V)
Monthly Average	0.040	0.033	0.044	0.390	1.400	1.800	1.500	1.300	0.500	0.210	0.220	0.074	0.630	20.0	N/A
Monthly Maximum	0.340	0.210	0.190	2.900	6.100	8.800	5.400	11.000	2.900	2.600	3.200	0.660	1.800	57.0	140 (31/V/1948)
Monthly Minimum	0.003	0.004	0.002	0.020	0.096	0.059	0.056	0.030	0.005	0.010	0.004	0.002	0.044	1.4	0.97 31/VII/1957)

Note: This data is published by the Hydromet (The National Environmental Agency, Dept. of Hydrometeorology, Government of Georgia) and was collected and provided by a consultant to the project team.

GEOLOGY

1.9 GEOLOGICAL MAP

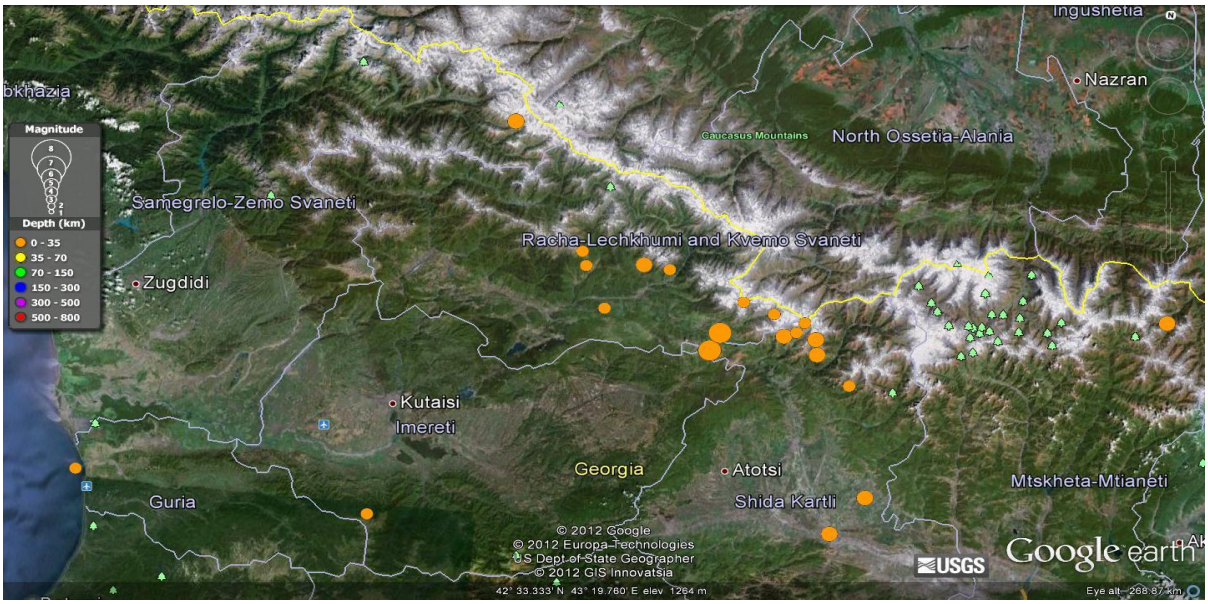
The geologic data available at the time of this study included geologic maps at the scales of 1:250,000, 1:50,000, and 1:25,000; and field reconnaissance notes by HIPP's consulting geologist. The Aragvi 1 HPP area has diverse geo-morphological structure, largely consisting of semi-rock and rock masses suitable for construction and operation of medium-sized HPPs. The study area is mainly built of consolidated rocks mixed with semi-consolidated masses. The headwork and the derivation tunnel lay in the area of Lower Cretaceous flysch formations. The rocks are formed from the rhythmical alternation of limestone, clay or sandy limestones, carbonate sandstones, marls, marly shales, clay shales and rarely sandstones. Interlayers of andesite and basalts are observed within the flysch formations. No major faults or landslide zones are observed within the project area. Geological drillings need to be carried out during further geological studies before construction begins. A geological map of the project area is shown in Figure 3.

1.10 SEISMOLOGY

The Aragvi River watershed is located in the southern part of the Fold System of Greater Caucasus (Mestia-Tianeti Zone), which is an ongoing collision of tectonic plates. This inevitably creates an earthquake hazard zone along both sides of the mountain range. According to the current Georgian seismic zoning classification the project is in hazard zone 9. The design criteria for earthquake loads and resistance of structures must be defined in accordance with applicable standards and regulations.

The following Google Earth image shows the locations of earthquakes with a Magnitude of 5 and above, within different regions of Georgia, taken from the United States Geological Survey databases of historic major earthquakes and of recent earthquakes.

Table 7: Significant Earthquake Data



Date	Name	Mag.	MMI	Deaths	Damage
April 14, 1275	Georgia	6.7		100-1000	Severe
1283	Samtskhe-Dzhavakheti	6.3			
1350	Adishi Area	6.5			
1688		5.3			
September 22, 1888		6.1			
December 31, 1899		5.6			
Feb 20, 1920	Gori, Tiflis	6.2		100-1000	Severe
May 7, 1940		6.0			
May 13, 1986		5.6			
April 29, 1991	Racha: Dzhava, Chiatura, Ambrolauri	7.3	9	270	Extreme
June 15, 1991	Dzhava, Tskhinvali, Ossetia	6.5	8	8	Severe
October 23, 1992	Khevsureti	6.3			

Data are from the United States Geological Survey, National Earthquake Information Center, on-line Earthquake Database: http://earthquake.usgs.gov/earthquakes/eqarchives/epic/

1.11 FUTURE GEOLOGICAL INVESTIGATIONS

A site-specific geologic investigation will be required during the feasibility and design stages of project development. This will probably include core drilling, geophysical investigations, and detailed field mapping of the area. Rock testing for tunnel construction planning and support design will also be needed.

HYDROPOWER PROJECT DESCRIPTION

1.12 GENERAL

The Aragvi 1 HPP development is expected to include a diversion weir across the Tetri Aragvi River, intake structure, de-silting structure, canal, pressure tunnel, penstock and surface powerhouse. A substation will be located near the plant. A 110 kV transmission line will directly connect Aragvi 1 SS to the existing Mleta 110 kV SS, which is connected to the Dusheti 110 kV substation via Pasanauri SS. A short tailrace channel will convey water from the powerhouse to the Tetri Aragvi River. The power plant may be called on to work in island mode as well as in synchronization with the national power grid, allowing both direct and grid-connected supplies to consumers. To allow continuous operation of the Aragvi 1 plant, sufficient auxiliary backup power (probably a diesel generator) will be provided to allow black-starts when this plant is isolated from the national transmission network (island mode).

1.13 DIVERSION FACILITIES

The diversion for the run-of-river Aragvi 1 HPP will be located on the Tetri Aragvi River. It will include rockfill dam, sluice gates and a short concrete overflow spillway section. The intake structure will be located on the left side of the dam. It will include bar racks to stop large debris, a bulkhead gate for maintenance purposes, and a hydraulically operated wheel gate to provide the normal shutoff capacity.

The flow from the intake will enter a transition section leading to a de-silting structure controlled by gates. The de-silting structure will direct the flow into the pressure tunnel. It will be important to design the diversion facilities so that an ice cover will develop over the entire pond during the winter. That will minimize the likelihood of problems with frazil ice clogging the waterways. Gates should probably be insulated where exposed on the downstream sides, and heating the gates and gate seals may be needed to provide reliable operation during very cold periods.

1.14 WATER CONDUCTORS

The main water conductor will be a pressure tunnel from the intake structure to the proposed powerhouse. It may be excavated using drill and blast methods or a tunnel boring machine, and the finished tunnel cross-section will depend on the method selected.

Based on the limited information available from existing geologic mapping and from field visits to the project location, it appears that most of the tunnel length can be supported during construction and long-term operation using rock bolts, steel mesh, and shotcrete.

A 2.0 m-diameter steel penstock, about 80 m long, is proposed to carry the flow from the pressure tunnel to the powerhouse below.

1.15 POWER PLANT

The powerhouse is expected to be a surface structure located along the Tetri Aragvi River.

This installation will result in a maximum electric power output, at the high-voltage transformer terminals, of about 10.2 MW, as shown in the following table:

Table 8: Aragvi 1 HPP Power and Energy Calculations

Calculations for Average Monthly Flows												
Tetri Aragvi riv. Streamflow gauge Mleta					F=	107	km^2	1935,1937-38,1942,1944-86				
I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Average**
3.80	3.74	3.84	5.13	7.05	7.69	6.94	6.19	5.27	4.75	4.39	4.15	5.24
Tetri Aragvi riv. ▼1430					F=	96.10	km^2	K=96.1/107=0.898				
3.41	3.36	3.45	4.60	6.33	6.91	6.23	5.56	4.73	4.27	3.94	3.73	4.71

Aragvi 1 HPP

Hydropower Calculations for Average Monthly Flows — Q_{HPP}= **5.8** m^3/sec

Months	Mean Monthly River flow Q_{riv}, m^3/sec	Percent of mean monthly flow, %	Bypassed Flow Q, m^3/sec	Extra Flow Q, m^3/sec	HPP Flow Q_{HPP}, m^3/sec	Diversion water level elevation ▼upstream m	Tailwater elevation, ▼downstream m	Gross head H_{gross}, m	Total head loss ∑h, m	Net head, H_{net}, m	Turbine efficiency h_t, %	Turbine total capacity N_t, kW.	Generator efficiency h_g, %	Unit capacity N_u, kW.	Number of hours per month T h.	Generated Energy, GWh.
I	**3.41**	14	0.47	_	**2.94**	1,550	1,335	215	1.88	213.12	0.90	5,534	0.96	5,313	744	3.953
II	**3.36**	14	0.47	_	**2.89**	1,550	1,335	215	1.82	213.18	0.90	5,445	0.96	5,227	672	3.513
III	**3.45**	14	0.47	_	**2.98**	1,550	1,335	215	1.93	213.07	0.90	5,608	0.96	5,384	744	4.005
IV	**4.60**	10	0.47	_	**4.13**	1,550	1,335	215	3.71	211.29	0.90	7,714	0.96	7,405	720	5.332
V	**6.33**	8	0.47	0.06	**5.80**	1,550	1,335	215	7.30	207.70	0.90	10,636	0.96	10,211	744	7.597
VI	**6.91**	7	0.47	0.64	**5.80**	1,550	1,335	215	7.30	207.70	0.90	10,636	0.96	10,211	720	7.352
VII	**6.23**	8	0.47	_	**5.76**	1,550	1,335	215	7.19	207.81	0.90	10,566	0.96	10,144	744	7.547
VIII	**5.56**	8	0.47	_	**5.09**	1,550	1,335	215	5.61	209.39	0.90	9,405	0.96	9,029	744	6.718
IX	**4.73**	10	0.47	_	**4.26**	1,550	1,335	215	3.94	211.06	0.90	7,940	0.96	7,622	720	5.488
X	**4.27**	11	0.47	_	**3.80**	1,550	1,335	215	3.12	211.88	0.90	7,099	0.96	6,815	744	5.071
XI	**3.94**	12	0.47	_	**3.47**	1,550	1,335	215	2.61	212.39	0.90	6,508	0.96	6,247	720	4.498
XII	**3.73**	13	0.47	_	**3.26**	1,550	1,335	215	2.30	212.70	0.90	6,117	0.96	5,872	744	4.369

Gross average annual generation including losses	**65.441**	GWh
Estimated energy losses from outages, substation losses 5%	**3.272**	GWh
Average annual energy for sale	**62.169**	GWh
HPP operation duration per year	**6,409**	h
Capacity usage ratio/efficiency (plant factor)	**0.73**	

POWER AND ENERGY STUDIES

1.16 AVAILABLE FLOW DATA

Monthly streamflow data were used for this study. Daily data exists, but only part of it was available to us. The following table lists the gauging station data that is believed to be available, and the current status of data collection:

Table 9: Stream Gauges in the Aragvi Watershed

River	Location	Drainage Area, km^2	Period of Record	Gauge Owner	Comments
Tetri Aragvi	Mleta	107.0	1935,1937-38,1942,1944-86	HydroMet	have monthly, partly daily
Tetri Aragvi	Pasanauri	335.0	1937-86	HydroMet	have monthly, partly daily
Shavi Aragvi	Near Mouth	235.0	1939-86	HydroMet	have monthly
Aragvi	Tsikhisdziri	760.0	1973-86	HydroMet	1973-80 have monthly
Aragvi	Chinti	1900	1976-86	HydroMet	1973-80 have monthly

Note: data from the shaded station are being used in this study.

Drainage areas for the sub-basins have been computed using a digital terrain model of the Aragvi River basin, developed from Soviet topography. These numbers have been supplemented and checked using areas measured from Soviet-era topographic maps using AutoCAD.

1.17 BYPASS (SANITARY) FLOWS

Georgian regulations require a part of the total flow in a stream to remain in that stream when water is diverted for hydroelectric power generation, irrigation, water supply, or other use. This bypass flow is often referred to as a “sanitary” flow, since a major purpose of the rule is to ensure that human and other waste products entering the stream bypass reach are diluted. In practice, sanitary flow is set as a 10 percent of the mean annual flow for the majority of studies in Georgia.

Modern hydroelectric practice considers biological habitat needs (and, sometimes, aesthetic and recreational concerns) when determining bypass flow. In-stream flow requirements to maintain healthy conditions for fish and other inhabitants are generally higher than the sanitary flows. They must generally be determined by environmental studies conducted during the feasibility or design stages of project development. In this study, assumed levels of bypass flow that vary from month to month have been adopted to estimate the flow actually available for the power generation. Sanitary flow for this study is set as a 10% of the mean annual flow, as is shown in Table 8. In practice, sanitary flow would probably be higher between the intake structure and the powerhouse due to the added inflow from the tributaries. However, it is recommended to carry out further detailed study of the bypass flow during the Feasibility Study.

ENVIRONMENTAL AND SOCIAL STUDIES

1.18 ENVIRONMENTAL RECEPTOR IMPACTS & MITIGATION PRACTICES

General Categories for Environmental Receptors:

Surface Water Resources (Quantity, Water Quality, Flood Risk)
Land Cover
Air Quality
Geology and Soils
Cultural Heritage and Recreational Resources
Biodiversity (flora, fauna, etc.)
Community and Socio-Economic

Appendix 9 contains a detailed series of tables that have been created to help development team members identify and evaluate the environmental, social, cultural, and other impact categories that are likely to be important when considering a small- to medium-size, run-of-river development in Georgia.

This material is necessarily preliminary, since detailed studies of the project and the affected environment have not been started yet, but can provide general guidance when developing a study program. As noted in the Appendix, the material is based on procedures adopted by the European Union (EU).

***Affected Environment Assessment**:* The Aragvi 1 HPP has two hydropower development activity periods that will impact environmental receptors, over different time horizons, and at different risk or impact levels. The following are the activity periods of interest:

Construction: Compared to the lifecycle of the all phases of construction from initial land and water resource disturbance facility this is a short term impact period of approximately 3 years. It includes to startup of plant operations.

Operations: The time horizon for full operational lifecycle before major component replacement is 30 to 40 years.

Risks to an environmental receptor from the activities (development and operation of the Aragvi 1 HPP) are expected to be relatively low, based on information that is available at this time. The entirety of the Aragvi 1 HPP lies 1 km away from the boundaries of the Kazbegi National Park (see map of the Cultural Resources and Recreation Areas in the Appendix 10).

Kviratskhoveli Church of Zemo Mleta village.

Lomisi St. George's Church in Kvemo Mleta village.

One impact category that will be very important for most of the hydro project developments in the Aragvi River basin is the protection and preservation of historic and cultural monuments and artifacts. Appendix 11 is a list of the many areas and specific sites in Dusheti District that have been officially recognized by the National Agency for Cultural Heritage Preservation of Georgia, in the Ministry of Culture. The area also includes many other un-listed resources.

In the specific case of the Aragvi 1 HPP, there are no listed or known cultural or archeological sites within or near the development area. However, during the construction period unknown archeological sites could be revealed due to the cultural and archeological diversity of the region.

From an affected natural environmental perspective, the Aragvi 1 HPP can be developed so that the project overall minimizes its construction and operations impacts on the local and watershed environment.

PROJECT COST ESTIMATE AND CONSTRUCTION SCHEDULE

1.19 ASSUMPTIONS

Our cost estimates do not include any customs duties that may be the responsibility of the contractors and/or the project owner.

The price level is May 2013. All costs were developed in US$ or were converted to US$ at exchange rates effective in May 2013.

Prices in this estimate are not based on detailed layouts or designs for project structures. Quantity takeoffs were not possible for most items. Overall costs for major works were estimated using figures from projects now under construction in Georgia and from pre-feasibility and feasibility reports recently prepared for projects that are under development at this time, adjusted to account for differences in project head, design flow, river conditions, geology, inflation, etc. Sources have included the thirty eight pre-feasibility studies completed by HIPP, the Mtkvari HPP Feasibility Report prepared by Verkis, and the contracted prices for the Bakhvi Project construction work, among others.

Electrical and mechanical equipment prices are based on single-source procurement for supply and installation of turbines, generators, governors, inlet valves, plant protection, control, and communication systems, station AC service, station DC system, air, fire protection, cooling water, potable water, and other auxiliaries; and main power transformers, breakers, arrestors, and other substation equipment. The contracted supplier is assumed to be one of the larger, more-capable Chinese hydro equipment companies. This assumption is based solely on the lower cost usually available from China. European and American equipment will probably be more expensive, based on recent experience. It will be a developer's responsibility to select the right balance of cost versus efficiency, reliability, and support when selecting an equipment supplier.

1.20 PROJECT COST ESTIMATE

Table 10: Aragvi 1 HPP Estimated Capital Expenditure

Aragvi 1 HPP CAPEX				
	Units	**Amt**	**Unit Cost**	**Total US$**
Land purchase	ha	2	$12,000	$24,000
Preparatory & infrastructure works	LS			$180,000
New access road (8 m wide gravel)	m	300	$91	$27,300
Stream diversion and cofferdams	LS			$180,000
Main Dam & Intake Structure	LS			$1,850,000
De-silting Structure	m	65		$530,000
Canal	m	20	$620	$12,400
Tunnel including rock bolts & shotcrete	m	5,600	$1,500	$8,400,000
Steel Penstock (D=2.0m)	m	80	$1,420	$113,600
Above ground power house	LS			$560,000
Tailrace canal	m	40	$750	$30,000
Turbines, Generators, Governors, Auxiliaries, etc. *	MW	10.2	$200,000	$2,040,000
Transformers and Switchyard equipment *	MW	10.2	$82,000	$836,400
Grid connection transmission line @ 110 kV	km	1	$110,000	$110,000
Subtotal of Schedule Items				**$14,893,700**
Geology (investigation field, lab and office) @ 1.5%	LS			$223,000
Feasibility study @ 1%	LS			$149,000
EIA @ 1%	LS			$149,000
EPCM @ 14%	LS			$2,085,000
Contingencies (Assumptions Variable) @ 25%	LS			$4,374,925
Subtotal				**$21,874,625**
VAT 18%				**$3,933,113**
Total				**$25,807,738**
MW Capacity	**10.20**	**CAPEX/kW**		**$2,530**

**Equipment pricing is based on supply and installation by one of the better-quality Chinese companies.*

List of Figures

Figure Number	Title
1	Aragvi 1 HPP Arrangement
2	Aragvi River Profile
3	Aragvi 1 HPP Geological Map
3A	Geologic Legend

USAID FROM THE AMERICAN PEOPLE

Hydropower Investment Promotion Project (HIPP)

Aragvi 1 HPP

Aragvi 1 HPP
Tail-water ▼ 1335
N=10,2 MW
Э=65,4 mln. kwh
H_{gr}=215 m
Q=5,8 m^3/sec
T=6409 h
K= 0,73

Tetri Aragvi Riv.

Power house of the on going Aragvi HPP

Dam H=15m
NWL ▼ 1550
V_{res}=0,6 mln m^3

Canal and de-silting basin
L = 80 m

Tunnel
L = 5600 m
D = 2,0 m

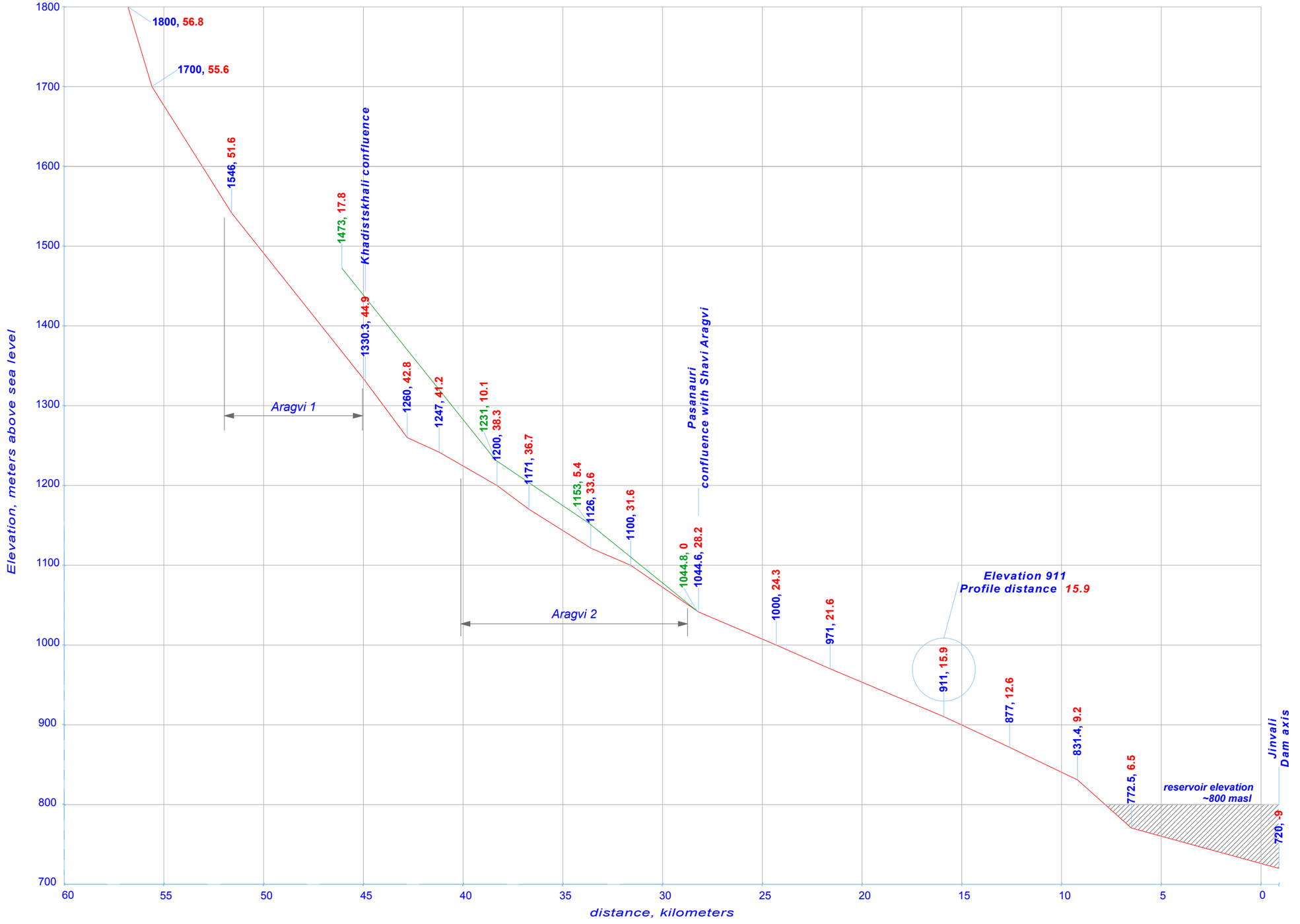
Khadistskali Riv.

Penstock
L = 80 m
D = 2,0 m

Power house

Existing Mleta 110kV Substation

Figure 1



USAID FROM THE AMERICAN PEOPLE | Hydropower Investment Promotion Project (HIPP)

Aragvi River Basin
Pre-Feasibility Study

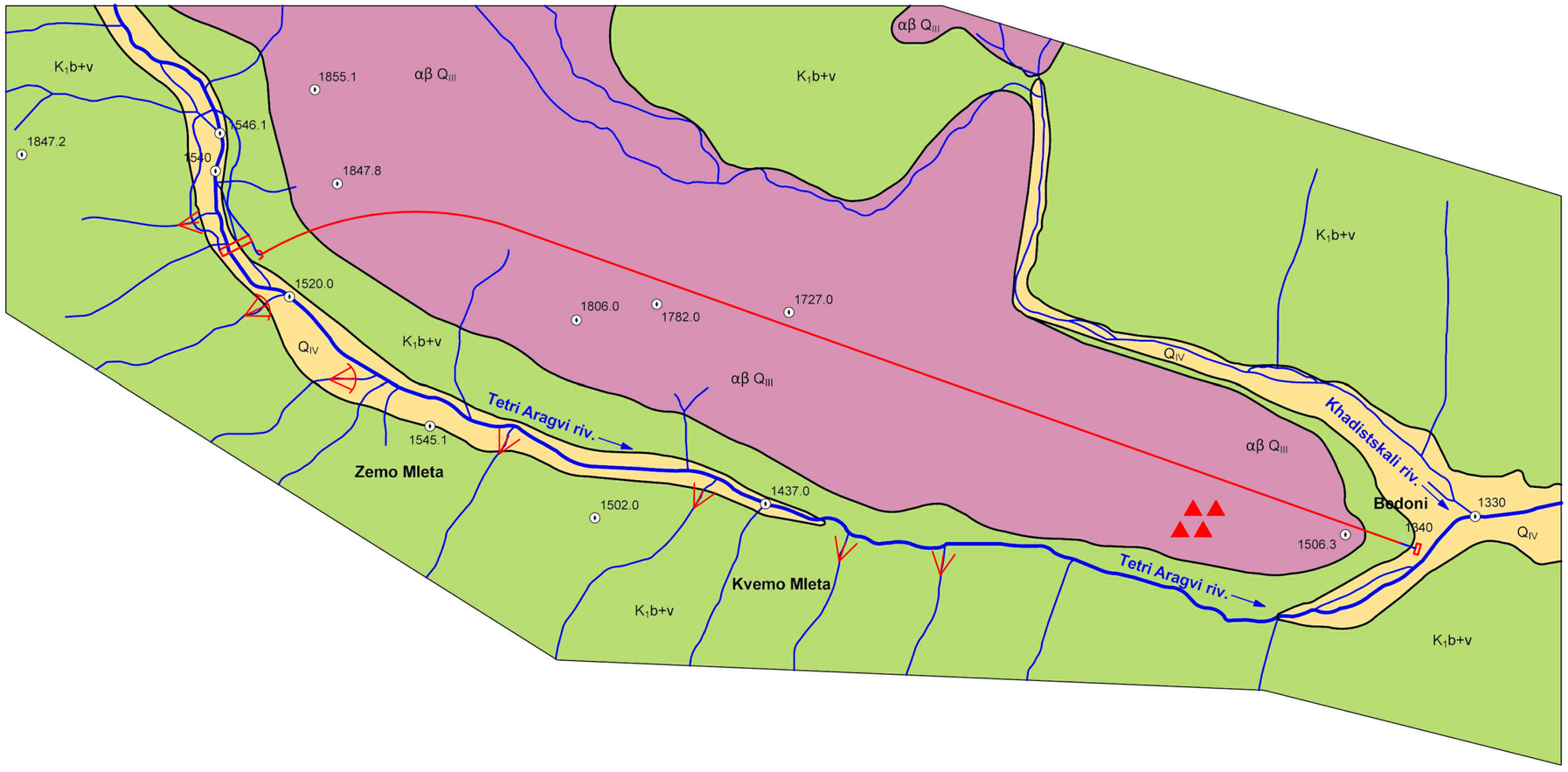
Aragvi River Profile

April 2013

Aragvi 1 HPP

Geological map

Scale 1:25 000



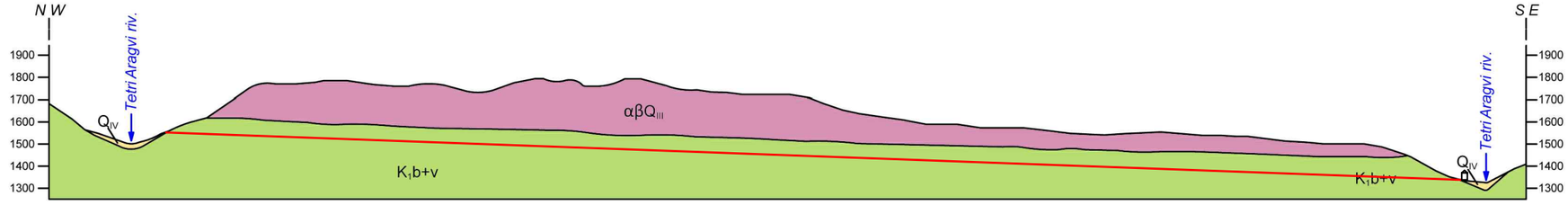


Figure 3

Figure 3A

LEGEND

Quaternary Period	Modern deposits	Q_{IV}	Alluvial and alluvial-proluvial sediments:pebbles, cobbles, sands, gravel and crushed stone mixed with clay.
		Q_{IV}	Diluvial and diluvial-colluvial sediments:crushed stone cemented with clay and sandy clay material.
		$\alpha\beta Q_{III}$	Effusive rocks: Andesite-basalts.
Cretaceous Period	Lower Cretaceous	K_1a	Aptian stage:Clayshales and sandstones with interlayers of marls (Dghnali suite).
		$K_1h_{3+}br$	Hauterivian stage (upper layer) and Barremian Stage:Quartz sandstones, marls, clayshales, marly shales (Pasanauri suite).
		K_1h_{1+2}	Hauterivian stage (upper and middle layer):marls, marly shales, clayshales, sandstones and sandy limestones. In upper part clayshales and marly shales with interlayers of sandstones.
		K_1v	Valanginian stage:sandy and marly limestones with interlayers of marls, sandstones, or clayshales (Edisi suite).
		K_1b	Berriasian stage:marls, calyshales, carbonate sandsotnes, sandy limestones.
Jurassic Period	Upper Jurassic	J_3t	Tithoniam stage:poorly consolidated sandy limestones, marls and clay limestones.
		J_3o_2+km	Oxfordian stage -Upper layer and Kimmeridgian stage:pseudo-oolitic limestone with interlayers of conglomerates and marls (Dumartskho suite).
		J_3o_1	Oxfordian stage -Lower layer:marls, clayshales, sandy limestones and carbonate sandsotnes (Kasari suite).
		J_3k	Callovian stage:marly clayshales with interlayers of limestones. In the lower part-sandy limestones (Narvani suite).

	Rock slides
	Alluvial fan of mudflow
	Alluvial fan of stream flow
	Inrerrupted fault
	Tectonic fault
	Landslide zone

პირობითი ნიშნები

მეოთხეული სისტემა	თანამედროვე ნალექები	Q_{IV}	ალუვიური და ალუვიურ-პროლუვიური ნალექები:კაჭარ-კენჭნარი, ქვიშახრეში,ქვიშნარი, ღორღი თიხის მინარევით.
		Q_{IV}	დელუვიური და დელუვიურ-კოლუვიური ნალექები:სხვადასხვა ზომისა და ქანების უხეშნატეხოვანი ღორღი, შეცემენტებული თიხისა და ქვიშიანი თიხის მასალით.
		$\alpha\beta Q_{III}$	ეფუზიური წარმონაძნები:ანდეზიტ-ბაზალტები.
ცარცული სისტემა	ქვედა განყოფილება	K_1a	აატის იარუს:თიხაფიძლებისა და ქვიშაქვების მორიგეობა, მერგელოვანი ფიქლების შუაშრეები (დღნალის წყება).
		$K_1h_{3+}br$	ჰოტერივული იარუსის ზედა ქვეიარუსი და ბარემის იარუს:კვარცული ქვიშაქვები, მერგელები, თიხაფიქალი, მერგელოვანი ფიქალი (ფასანაურის წყება).
		K_1h_{1+2}	ჰოტერივული იარუსი (ქვედა და შუა იარუს):მერგელები, მერგელოვანი ფიქლები, ოქვიათად თიხაფიძლები, ქვიშაქვები და ქვიშიანი კირქვები. ზედა ნაწილში თიხაფიძლები და მერგელოვანი ფიქლები ქვიშაქვების შუაშრეები.
		K_1v	ვალანჟინის იარუს:ქვიშიანი და მერგელოვანი კირქვები მერგელებისა და ქვიშაქვების შუაშრეებით, ოქვიათად თიხაფიძლები (ედისის წყება).
		K_1b	ბერიასის იარუს:ფიქლოვანი მერგელები, თიხაფიძლები, კარბონატული ქვიშაქვები, ქვიშიანი კირქვები.
ურული სისტემა	ზედა განყოფილება	J_3t	ტიტონის იარუს:ხუსტადქვიშიანი კირქვები, ოქვიათად მერგელები და თიხიანი კირქვები.
		J_3o_2+km	ოქსფორდის იარუსის ზედა ქვეიარუსი და კიმერიჯული იარუს:ფსევდოოოლითური და ნატეხოვანი კირქვები კონგლომერატების და მერგელების შუაშრეებით (დუმაცხოს წყება).
		J_3o_1	ოქსფორდის იარუსის ქვედა ქვეიარუს:საშუალო და სქელშრეებრივი დაფიქლებული მერგელები, ნაკლებად თიხაფიქლები ქვიშიანი კირქვებისა და კარბონატული ქვიშაქვებით (კასარის წყება).
		J_3k	კელოვიური იარუს:მერგელოვანი თიხაფიძლები კირქვების შუაშრეებით, ქვედა ნაწილში-ქვიშიანი კირქვები (ნარვანის წყება).

	კლდეზვავი
	ღვარცოფული ნაკადის გამოტანის კონუსი
	წყლის ნაკადის გამოტანის კონუსი
	წყვეტითი რღვევები დეშიფრირებული აეროფოტოსურათებიდან
	ტექტონიკური რღვევა-შეცოცება
	მეწყერული ზონა

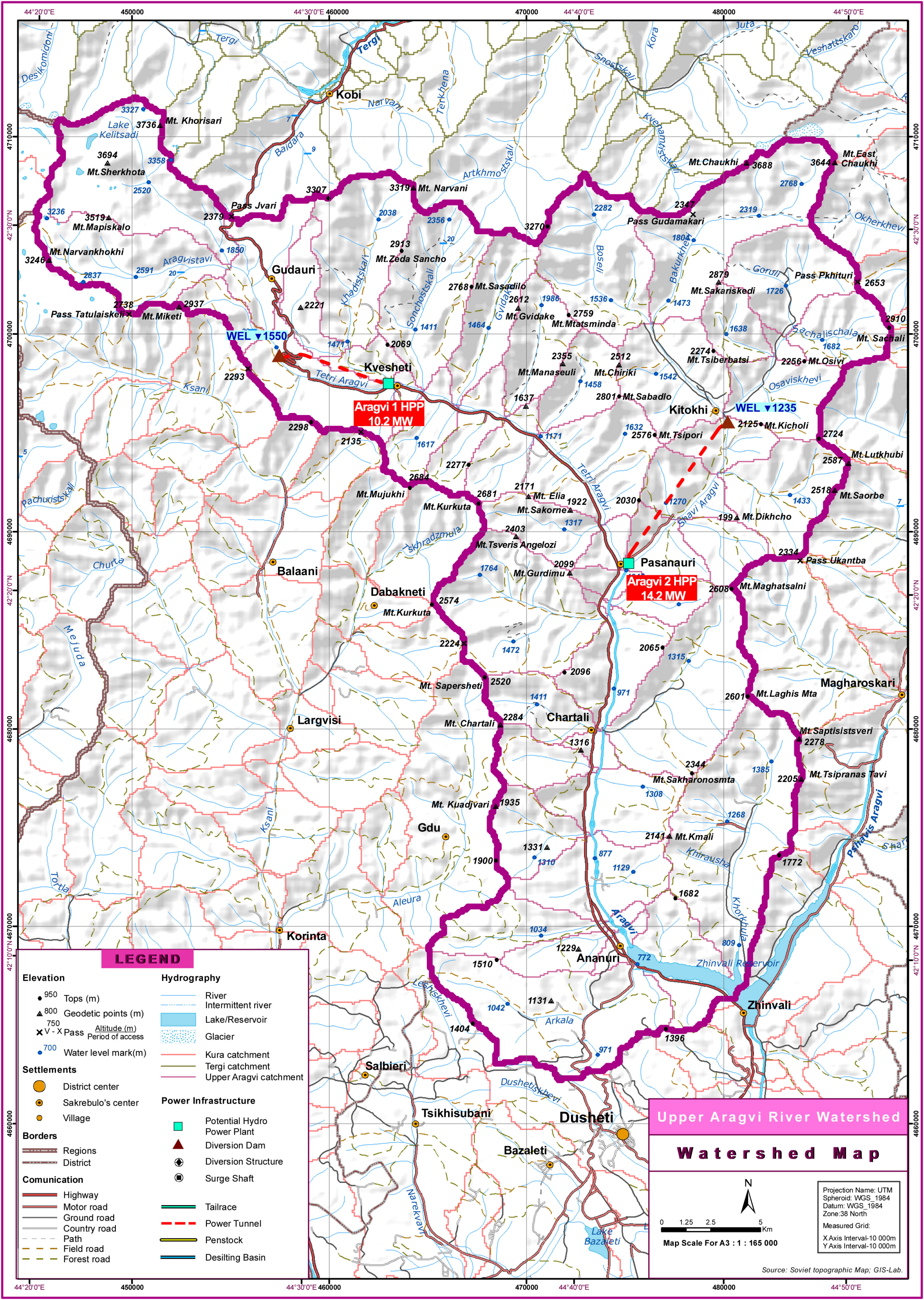
APPENDIX 1

Location Map

Upper Aragvi River Watershed
Location Map
Map Scale For A3 : 1 : 165 000
0 1.25 2.5 5 Km
N
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m
Source: Soviet topographic Map; The Shuttle Radar Topography Mission (SRTM); GIS-Lab.
Aragvi 1 HPP
10.2 MW
Aragvi 2 HPP
14.2 MW
WEL ▼1550
WEL ▼1235
Other Symbols
Bridges
Solitary tree
Deciduous
Coniferous
Shrubs
Young forest
Bush belt
Deforestated area
Wind breaker
Wineyards
Orchard
Spring
Waterfall
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Diversion Structure
Surge Shaft
Tailrace
Power Tunnel
Penstock
Desilting Basin
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Village
Borders
State
Regions
Roads
Highway
Motor road
Ground road
Country road
Field road
Forest road
Path
Relief/Relief forms
Cliff
Stone
Caves
1200 Contour line
Erosion
Roadside flats
Earth embankment
Linear ravine
Ravine
Hydrography
River
Intermittent river
Lake/Reservoir
Glacier
Vegetation
Bush
Forest
Protected area
44°20'0"E
44°30'0"E
44°40'0"E
44°50'0"E
450000
460000
470000
480000
4710000
4700000
4690000
4680000
4670000
4660000
42°30'0"N
42°20'0"N
42°10'0"N
Kobi
Gudauri
Kvesheti
Kitokhi
Pasanauri
Dabakneti
Chartali
Largvisi
Magharoskari
Gdu
Korinta
Ananuri
Zhinvali
Salbieri
Tsikhisubani
Dusheti
Bazaleti
Kvavili
Okrokana
Zemo Okrokana
Shevardeni
Nogkau
Almasiani
Ukhati
Kanobi
Koseli
Akhaltsikhe
Karkucha
Juta
Artkhmo
Ereto
Palagkau
Tskere
Mughure
Benian-begoni
Korogho
Iukho
Soncho
Sharmiani
Sviana-rostiani
Seturni
Kumlistsikhe
Kaishaurni
Zakatkan
Tsikhiani
Zhozhoni
Usharni
Lakatkhevi
Gvidake
Zemo Mleta
Kvemo Mleta
Arakhveti
Bedoni
Sepe
Kvelani
Gognauri
Salajuri
Nadibani
Kharkheti
Chiriki
Manaseuri
Chokhelni
Jaghmiani
Chikani
Zemo Amirni
Chadistsikhe
Tsinkobani
Tsipori
Khevsha
Zhizhoni
Bakhani
Dikhcho
Torelaani
Tsinamkhari
Lutkhubi
Boseli
Dumatskho
Chokhi
Atnokhi
Chobalaurni
Gamsi
Didebani
Kavtaraani
Zanduki
Pakhviji
Sakerpo
Bakurkhevi
Totiaurni
Sijanani
Sachalischala
Ukanakho
Katsalkhevi
Migriaulta
Arbachkhani
Gometsari
Khiliana
Kuchecha
Kanatia
Tsiprani
Gudrukhi
Tvalivi
Khartisho
Pudznari
Bodavi
Dolosha
Vartsla
Chinti
Aranisi
Pridonaantkari
Mgliani
Iori
Mchedliantkari
Chigoiani
Navikhevi
Eloiani
Okhiri
Pavliani
Tinikaani
Kareltkari
Tsiptauri
Kara
Velisa
Sabarkleti
Mujukhi
Ukanaubani
Daviturni
Ukanamkhari
Bibiliani
Veshagurni
Tsinamkhari
Bantsuri
Sodeve
Mejilaurni
Sakere
Makhiareti
Tokhta
Zodekhi
Shaliantkari
Khudaliani
Tsikhisopeli
Buchaani
Jughisi
Vashlobi
Muguda
Chalisopeli
Chitaurebi
Dolaskedi
Zenubani
Sonda
Mamulaani
Boselta
Meneso
Kodijvari
KvemoKhorkhi
Zemo Khorkhi
Ubani
Khirausha
Dgnali
Chandari
Pavleuri
Sondisvela
Stsropavi
Nedzikhi
Bzikurtkari
Lausha
Avenisi
Tsikhisdziri
Kadoeti
Monasteri
Ardisi
Doretkari
Mochaleti
Mshvelieti
Roro
Garueti
Khramistskaro
Tskhavati
Koloti
Nakhidi
Gezevreti
Sadzeguri Pirveli
Zemo Ghru
Kvemo Ghru
Iketi
Kvitkiri
Kurta
Kharkelani
Shua Alevi
Kvemo Alevi
Kochiani
Gudatsveri
Zemo Tsolda
Zemo Zakhori
Armazi
Bidzinani
Jvarisubani
Bantsurtkari
Zotikiantkari
Shalikiantkari
Pkhundavi
Vedzatkhevi
Okruaani
Karaulebi
Naniani
Dudaurebi
Arghuni
Veltaurtkari
Kerana
Kvemo Ashi
Javakhiantkari
Taniantkari
Tandilaantkari
Delkani
Toncha
Arboeti
Tkhilovani
Tsigriantkari
Kedeloba
Chontili
Varsimaani
Pirmisaani
Undilaantkari
Karsimaantkari
Chanadirtkari
Chirdileliantkari
Grigolaantkari
Chilurti
Ebnisi
Chubiniantkari
Tsitsamura
Kvemo Shuakhevi
Zemo Shuakhevi
Chasha
Kvitkiristskaro
Bakakurebi
Nagomevi
Karkushaani
Mikeliani
Petriani
Dzveli Burghuli
Akhali Burghuli
Chorchani
Lake Kelitsadi
Lake Bazaleti
Zhinvali Reservoir
Tergi
Narvani
Baidara
Aragvistavi
Tetri Aragvi
Shavi Aragvi
Pshavis Aragvi
Aragvi
Ksani
Tortla
Aleura
Arkala
Dushetiskhevi
Khirausha
Korkhula
Okherkhevi
Goruli
Sachalischala
Osaviskhevi
Veshattskari
Juta
Kora
Boseli
Bakurkhevi
Gvidake
Artkhmostskali
Kvenamtistskali
Pachuristskali
Skhradzmula
Narekvavi
Mt. Khorisari
Mt. Khirguma
Mt. Sherkhota
Mt. Mapiskalo
Mt. Narvankhokhi
Mt. Miketi
Mt. Suti
Mt. Kabarjini
Mt. Narvani
Mt. Zeda Sancho
Mt. Sasadilo
Mt. Tseri
Mt. Chaukhi
Mt. L. Asatiani
Mt. Poshkakhorkhi
Mt. Saghveliasgori
Mt. Sakariskedi
Mt. Mtatsminda
Mt. Sabadlo
Mt. Tsipori
Mt. Sachali
Mt. Osivi
Mt. Mujukhi
Mt. Kurkuta
Mt. Eltsesi
Mt. Tsaratskaro
Mt. Sapersheti
Mt. Maghatsalni
Mt. Laghis Mta
Mt. Biliuneti
Mt. Sakharonosmta
Mt. Zemakuri
Mt. Alevi Tskala
Mt. Mariam Tsminda
Mt. Bodavi
Jvari Pass
Pass Gudamakari
Pass Chaukhi
Pass Ighlisghele
Pass Ukantba
Chaukhi Ridge
Sakori Ridge
Tsiteli Ridge
Laktkhevi Ridge
Gvidake Ridge
Sabziko Ridge
Gurdimi Ridge
Ksniskeli Ridge
Kurkuta Ridge
Tsikhisi Ridge
Mtiulet' Gudamakari Ridge

APPENDIX 2

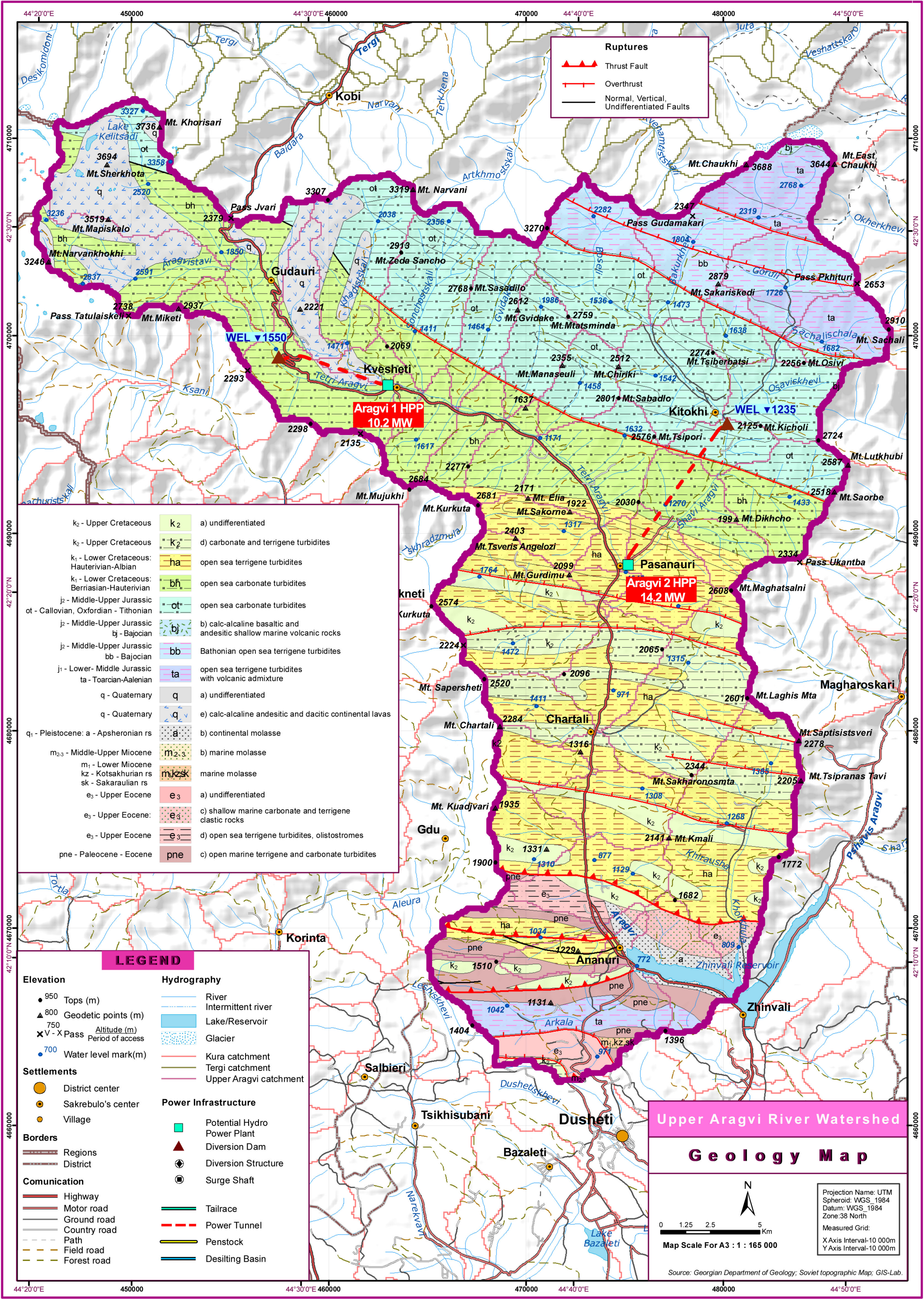
Watershed Map



Upper Aragvi River Watershed
Watershed Map
LEGEND
Elevation
Tops (m)
Geodetic points (m)
Pass
Altitude (m)
Period of access
Water level mark(m)
Settlements
District center
Sakrebulo's center
Village
Borders
Regions
District
Comunication
Highway
Motor road
Ground road
Country road
Path
Field road
Forest road
Hydrography
River
Intermittent river
Lake/Reservoir
Glacier
Kura catchment
Tergi catchment
Upper Aragvi catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Diversion Structure
Surge Shaft
Tailrace
Power Tunnel
Penstock
Desilting Basin
Aragvi 1 HPP 10.2 MW
Aragvi 2 HPP 14.2 MW
WEL ▼1550
WEL ▼1235
Kobi
Gudauri
Kvesheti
Kitokhi
Pasanauri
Balaani
Dabakneti
Chartali
Magharoskari
Largvisi
Gdu
Korinta
Ananuri
Zhinvali
Salbieri
Tsikhisubani
Dusheti
Bazaleti
Mt. Khorisari
Mt. Sherkhota
Mt. Mapiskalo
Mt. Narvankhokhi
Pass Tatulaiskeli
Mt. Miketi
Pass Jvari
Mt. Narvani
Mt. Zeda Sancho
Mt. Sasadilo
Mt. Gvidake
Mt. Mtatsminda
Mt. Chaukhi
Mt. East Chaukhi
Pass Gudamakari
Mt. Sakariskedi
Pass Pkhituri
Mt. Sachali
Mt. Tsiberbatsi
Mt. Osivi
Mt. Manaseuli
Mt. Chiriki
Mt. Sabadlo
Mt. Kicholi
Mt. Tsipori
Mt. Lutkhubi
Mt. Saorbe
Mt. Dikhcho
Mt. Mujukhi
Mt. Kurkuta
Mt. Elia
Mt. Sakorne
Mt. Tsveris Angelozi
Mt. Gurdimu
Pass Ukantba
Mt. Maghatsalni
Mt. Laghis Mta
Mt. Sapersheti
Mt. Chartali
Mt. Saptisistsveri
Mt. Sakharonosmta
Mt. Tsipranas Tavi
Mt. Kuadjvari
Mt. Kmali
Tetri Aragvi
Aragvi
Shavi Aragvi
Pshavis Aragvi
Zhinvali Reservoir
Lake Kelitsadi
Tergi
Narvani
Baidara
Aragvistavi
Ksani
Khadistskali
Sonchostskali
Gvidakhevi
Boseli
Bakurkhevi
Goruli
Sachalischala
Osaviskhevi
Okherkhevi
Snostskali
Kvenamtistskali
Kora
Juta
Veshattskaro
Terkhena
Artkhmostskali
Pachuristskali
Churta
Mejuda
Tortla
Aleura
Skhradzmula
Khirausha
Khorkhula
Arkala
Leshiskhevi
Dushetiskhevi
Narekvavi
Lake Bazaleti
Desikomidoni
44°20'0"E
450000
44°30'0"E
460000
470000
44°40'0"E
480000
44°50'0"E
4710000
4700000
4690000
4680000
4670000
4660000
42°30'0"N
42°20'0"N
42°10'0"N
N
0 1.25 2.5 5 Km
Map Scale For A3 : 1 : 165 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m
Source: Soviet topographic Map; GIS-Lab.

APPENDIX 3

Geology Map


Ruptures
Thrust Fault
Overthrust
Normal, Vertical, Undifferentiated Faults
Kobi
Gudauri
Kvesheti
Kitokhi
Pasanauri
Chartali
Magharoskari
Gdu
Korinta
Ananuri
Zhinvali
Salbieri
Tsikhisubani
Dusheti
Bazaleti
Mt. Khorisari
Mt.Sherkhota
Mt.Mapiskalo
Mt.Narvankhokhi
Mt. Narvani
Mt.Zeda Sancho
Mt.Sasadilo
Mt.Gvidake
Mt.Mtatsminda
Mt.Manaseuli
Mt.Chiriki
Mt.Sabadlo
Mt.Tsiberbatsi
Mt.Osivi
Mt.Sakariskedi
Mt.Chaukhi
Mt.East Chaukhi
Mt.Miketi
Mt.Mujukhi
Mt.Kurkuta
Mt.Elia
Mt.Sakorne
Mt.Gurdimu
Mt.Tsveris Angelozi
Mt.Kicholi
Mt.Tsipori
Mt.Lutkhubi
Mt.Saorbe
Mt.Dikhcho
Mt.Maghatsalni
Mt.Laghis Mta
Mt.Saptisistsveri
Mt.Tsipranas Tavi
Mt.Sachali
Mt.Kmali
Mt. Kvadjvari
Mt. Sapersheti
Pass Jvari
Pass Gudamakari
Pass Pkhituri
Pass Ukantba
Pass Tatulaiskeli
WEL ▼1550
WEL ▼1235
Aragvi 1 HPP
10.2 MW
Aragvi 2 HPP
14.2 MW
Lake Kelitsadi
Lake Bazaleti
Zhinvali Reservoir
Tergi
Baidara
Narvani
Terkhena
Artkhmostskali
Bochorgostskali
Khadistskali
Gvidakhevi
Bakurkhevi
Gorula
Okherkhevi
Osavickhevi
Sachalischala
Aragvistavi
Tetri Aragvi
Shavi Aragvi
Ksani
Tskhradzmula
Leshniskhevi
Dushetiskhevi
Narekvavi
Arkala
Khirausha
Aleura
Tortla
Pshavis Aragvi
Desikomidoni
Juta
Veshattskaro
Venamtistskali
LEGEND
Elevation
Tops (m)
Geodetic points (m)
Pass
Altitude (m)
Period of access
Water level mark(m)
Settlements
District center
Sakrebulo's center
Village
Borders
Regions
District
Comunication
Highway
Motor road
Ground road
Country road
Path
Field road
Forest road
Hydrography
River
Intermittent river
Lake/Reservoir
Glacier
Kura catchment
Tergi catchment
Upper Aragvi catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Diversion Structure
Surge Shaft
Tailrace
Power Tunnel
Penstock
Desilting Basin
k2 - Upper Cretaceous
a) undifferentiated
d) carbonate and terrigene turbidites
k1 - Lower Cretaceous: Hauterivian-Albian
open sea terrigene turbidites
k1 - Lower Cretaceous: Berriasian-Hauterivian
open sea carbonate turbidites
j2 - Middle-Upper Jurassic ot - Callovian, Oxfordian - Tithonian
j2 - Middle-Upper Jurassic bj - Bajocian
b) calc-alcaline basaltic and andesitic shallow marine volcanic rocks
j2 - Middle-Upper Jurassic bb - Bajocian
Bathonian open sea terrigene turbidites
j1 - Lower- Middle Jurassic ta - Toarcian-Aalenian
open sea terrigene turbidites with volcanic admixture
q - Quaternary
a) undifferentiated
q - Quaternary
e) calc-alcaline andesitic and dacitic continental lavas
q1 - Pleistocene: a - Apsheronian rs
b) continental molasse
m2-3 - Middle-Upper Miocene
b) marine molasse
m1 - Lower Miocene kz - Kotsakhurian rs sk - Sakaraulian rs
marine molasse
e3 - Upper Eocene
a) undifferentiated
e3 - Upper Eocene:
c) shallow marine carbonate and terrigene clastic rocks
e3 - Upper Eocene
d) open sea terrigene turbidites, olistostromes
pne - Paleocene - Eocene
c) open marine terrigene and carbonate turbidites
Upper Aragvi River Watershed
Geology Map
N
0 1.25 2.5 5 Km
Map Scale For A3 : 1 : 165 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m
Source: Georgian Department of Geology; Soviet topographic Map; GIS-Lab.
44°20'0"E
450000
44°30'0"E
460000
470000
44°40'0"E
480000
44°50'0"E
4710000
4700000
4690000
4680000
4670000
4660000
42°30'0"N
42°20'0"N
42°10'0"N

APPENDIX 4

Geomorphology Map

Upper Aragvi River Watershed

Geomorphology Map

Exogenous geological processes

- Complex Landslide
- Landslide in Covering Layers
- Landslides in Bedrocks
- Avalanche
- Sheet Flood
- Mudflow Occurrence
- Screes
- Cryogravimetry procces area
- Dynamic Equilibrium
- Thrust Fault
- Overthrust
- Pediment
- Normal, Vertical, Undifferentiated Faults
- Subsidence over the territory of the underground mine workings
- Tectoseismogenic landslides

LEGEND

Elevation

- 950 Tops (m)
- 800 Geodetic points (m)
- 750 V - X Pass — Altitude (m) / Period of access
- 700 Water level mark(m)

Settlements

- District center
- Sakrebulo's center
- Village

Borders

- Regions
- District

Comunication

- Highway
- Motor road
- Ground road
- Country road
- Path
- Field road
- Forest road

Hydrography

- River
- Intermittent river
- Lake/Reservoir
- Glacier
- Kura catchment
- Tergi catchment
- Upper Aragvi catchment

Power Infrastructure

- Potential Hydro Power Plant
- Diversion Dam
- Diversion Structure
- Surge Shaft
- Tailrace
- Power Tunnel
- Penstock
- Desilting Basin

Aragvi 1 HPP 10.2 MW

Aragvi 2 HPP 14.2 MW

WEL ▼1550

WEL ▼1235

Kobi, Gudauri, Kvesheti, Kitokhi, Pasanauri, Balaani, Dabakneti, Chartali, Largvisi, Gdu, Korinta, Ananuri, Zhinvali, Salbieri, Tsikhisubani, Dusheti, Bazaleti, Magharoskari

Mt. Khorisari 3736, Mt.Sherkhota 3694, Mt.Mapiskalo 3519, Mt.Narvankhokhi 3246, Mt. Narvani 3319, Mt.Zeda Sancho 2913, Mt.Sasadilo 2768, Mt.Gvidake 2612, Mt.Mtatsminda 2759, Mt.Miketi 2937, Mt.Chaukhi 3688, Mt.East Chaukhi 3644, Mt.Sakariskedi 2879, Mt.Tsiberbatsi 2274, Mt.Osivi 2256, Mt. Sachali 2910, Mt.Manaseuli 2355, Mt.Chiriki 2512, Mt.Sabadlo 2801, Mt.Kicholi 2125, Mt.Tsipori 2576, Mt.Lutkhubi 2724, Mt.Saorbe 2587, Mt.Dikhcho 199, Mt.Mujukhi 2684, Mt.Kurkuta 2681, Mt. Elia 2171, Mt.Sakorne 1922, Mt.Tsveris Angelozi 2403, Mt.Gurdimu 2099, Mt.Maghatsalni 2608, Mt. Sapersheti 2520, Mt. Chartali 2284, Mt.Laghis Mta 2601, Mt.Saptisistsveri 2278, Mt.Tsipranas Tavi 2205, Mt.Sakharonosmta 2344, Mt. Kuadjvari 1935, Mt.Kmali 2141, Mt.Lagodekhi 1772, Mt.Ukantba 2334

Pass Jvari 2379, Pass Tatulaiskeli 2738, Pass Gudamakari 2347, Pass Pkhituri 2653, Pass Ukantba 2334

Tergi, Kelitsadi, Baidara, Narvani, Terkhena, Snostskali, Kora, Juta, Veshattskaro, Artkhmostskali, Kvenamtistskali, Okherkhevi, Aragvistavi, Khadistskali, Sonchostskali, Gvidakali, Bosei, Bakurkhevi, Goruli, Sachamschala, Ksani, Tetri Aragvi, Osaviskhevi, Shavi Aragvi, Pachuristskali, Tskhradzmula, Leshiskhevi, Arkala, Dushetiskhevi, Narekvavi, Tortla, Aleura, Khirausha, Khobistskali, Pshavis Aragvi, Zhinvali Reservoir, Lake Bazaleti

Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m

N

0 1.5 3 6 Km

Map Scale For A3 : 1 : 165 000

Source: MOE; Soviet topographic Map; GIS-Lab.ltd

44°20'0"E 450000 44°30'0"E 460000 470000 44°40'0"E 480000 44°50'0"E

4710000 4700000 4690000 4680000 4670000 4660000

42°30'0"N 42°20'0"N 42°10'0"N

APPENDIX 5

Soils Map

Upper Aragvi River Watershed
Soils Map
0 No data
1 Primitive mountain meadow, fragmentary between rocks and stone embankments.
4 Mountain meadow soddy, mainly loam and skeletal, developed on debris of weathering products of splashed out and sedimentary rocks.
6 Brown forest, shallow, skeletal, heavy loam and clayey, here and there weakly developed and strongly eroded, developed on weathering products of splashed out and sedimentary rocks.
7 Brown forest typical, of medium and high thickness, developed on weathering products of splashed out and sedimentary rocks.
8 Brown forest light, podzolized, loam and clayey, often skeletal, developed on weathering products of splashed out and sedimentary rocks.
9 Cinnamonic forest, weakly developed, shallow, skeletal, here and there strongly eroded, developed on loessial loams and on weathering products of conglomerates and sandstones.
10 Cinnamonic forest typical, of medium and high thickness, heavy and medium loam, developed on loessial loams and on weathering products of conglomerates and sand stones.
13 Meadow-cinnamonic, intergrade, of medium and high thickness, heavy loam and clayey, mainly irrigated, developed on loessial rocks, alluvial and deluvial layers.
15 Humus calcareous, of medium thickness, heavy loam and clayey, here and there weakly developed and eroded, developed on limestones and limy conglomerates.
16 Humus calcareous, of medium thickness, heavy loam and clayey, here and there weakly developed and eroded, developed on limestones and limy conglomerates.
52 Alluvial meadow (meadow cinnamonic), calcareous, heavy loam, mainly irrigated.
68 Meadow-field, medium saline (solonchak), heavy loam and clayey, developed on saline loessial and clayey layers.
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) / Period of access
700 Water level mark(m)
Settlements
District center
Sakrebulo's center
Village
Borders
Regions
District
Comunication
Highway
Motor road
Ground road
Country road
Path
Field road
Forest road
Hydrography
River
Intermittent river
Lake/Reservoir
Glacier
Kura catchment
Tergi catchment
Upper Aragvi catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Diversion Structure
Surge Shaft
Tailrace
Power Tunnel
Penstock
Desilting Basin
Aragvi 1 HPP 10.2 MW
Aragvi 2 HPP 14.2 MW
WEL ▼1550
WEL ▼1235
Kobi
Gudauri
Kvesheti
Kitokhi
Pasanauri
Dabakneti
Chartali
Gdu
Korinta
Magharoskari
Ananuri
Zhinvali
Salbieri
Tsikhisubani
Dusheti
Bazaleti
Mt. Khorisari
Mt.Sherkhota
Mt.Mapiskalo
Mt.Narvankhokhi
Mt.Miketi
Pass Tatulaiskeli
Pass Jvari
Mt. Narvani
Mt.Zeda Sancho
Mt.Sasadilo
Mt.Gvidake
Mt.Mtatsminda
Mt.Manaseuli
Mt.Chiriki
Mt.Sabadlo
Mt.Tsipori
Mt.Chaukhi
Mt.East Chaukhi
Pass Gudamakari
Mt.Sakariskedi
Pass Pkhituri
Mt. Sachali
Mt.Tsiberbatsi
Mt.Osivi
Mt.Kicholi
Mt.Lutkhubi
Mt.Saorbe
Mt.Dikhcho
Pass Ukantba
Mt.Maghatsalni
Mt.Mujukhi
Mt.Kurkuta
Mt. Elia
Mt.Sakorne
Mt.Tsveris Angelozi
Mt.Gurdimu
Mt. Sapersheti
Mt. Chartali
Mt. Kuadjvari
Mt.Sakharonosmta
Mt.Kmali
Mt.Laghis Mta
Mt.Saptisistsveri
Mt.Tsipranas Tavi
Lake Kelitsadi
Tergi
Narvani
Baidara
Terkhena
Artkhmostskali
Snostskali
Kvenamtistskali
Kora
Juta
Veshattskaro
Okherkhevi
Desikomidoni
Aragvistavi
Khadistskali
Sonchostskali
Gvidaki
Boseli
Bakurkhevi
Goruli
Sachalischala
Osaviskhevi
Tetri Aragvi
Shavi Aragvi
Ksani
Pachuristskali
Skhradzmula
Tortla
Aleura
Khirausha
Khorkhula
Aragvi
Pshavis Aragvi
Zhinvali Reservoir
Leshiskhevi
Arkala
Dushetiskhevi
Narekvavi
Lake Bazaleti
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m
0 1.25 2.5 5 Km
Map Scale For A3 : 1 : 165 000
Source: Georgian Land Use Institute; Soviet topographic Map; GIS-Lab.
44°20'0"E
44°30'0"E
44°40'0"E
44°50'0"E
42°30'0"N
42°20'0"N
42°10'0"N
450000
460000
470000
480000
4710000
4700000
4690000
4680000
4670000
4660000

APPENDIX 6

Preliminary Turbine – Generator Characteristics

TURBNPRO Version 3 - PELTON TURBINE SOLUTION SUMMARY

Solution File Name: d:₩projects₩database₩turbin~1₩ar1-4xp

TURBINE SIZING CRITERIA

Rated Discharge:	102.4	cfs	/	2.90 m3/s
Net Head at Rated Discharge:	681.4	feet	/	207.7 meters
Gross Head:	705.4	feet	/	215.0 meters
Efficiency Priority:			5	
System Frequency:			50 Hz	
Minimum Net Head:	681.4	feet	/	207.7 meters
Maximum Net Head:	695.8	feet	/	212.1 meters

PELTON TURBINE SOLUTION DATA

Arrangement:	VERTICAL WITH RUNNER ON TURBINE SHAFT			
Intake Type:	4 - JET			
Runner Pitch Diameter:	45.5	inches	/	1157 mm
Unit Speed:	500.0	rpm		
Multiplier Efficiency Modifier:	1.000			
Flow Squared Efficiency Modifier:	0.0000			

Specific Speed at Rated Net Head (turbine) -	(US Cust.)	(SI Units)
At 100% Turbine Output:	12.1	46.0
At Peak Efficiency Condition:	11.0	42.1

Specific Speed at Rated Net Head (per jet) -	(US Cust.)	(SI Units)
At 100% Turbine Output:	6.0	23.0
At Peak Efficiency Condition:	5.5	21.0

SOLUTION PERFORMANCE DATA

At Rated Net Head of: 681.4 feet / 207.7 meters

% of Rated Discharge	Output (KW)	Efficiency (%)	cfs	m3/s
** 116.7	6113	88.6	119.5	3.38
100	5269	89.2	102.4	2.90
* 83.3	4398	89.3	85.3	2.42
75	3951	89.2	76.8	2.18
50	2603	88.1	51.2	1.45
25	1278	86.5	25.6	0.73

** - Overcapacity

* - Peak Efficiency Condition

At Maximum Net Head of: 695.8 feet / 212.1 meters

Max. Output (KW)	Efficiency (%)	cfs	m3/s
6297	88.5	120.7	3.42

At Minimum Net Head of: 681.4 feet / 207.7 meters

Max. Output (KW)	Efficiency (%)	cfs	m3/s
6109	88.6	119.5	3.38

Solution File Name: d:₩projects₩database₩turbin~1₩ar1-4xp

MISCELLANEOUS DATA

Maximum Runaway Speed (at Max. Net Head): 879 rpm

D/B Ratio (Runner Pitch Dia./Bucket Width): 2.79

Maximum Hydraulic Thrust (at Max. Net Head):	7814 lbs	/	3552 kg
Hydraulic Thrust per Jet (at Max. Net Head):	5527 lbs	/	2512 kg
Estimated Axial Thrust:	7285 lbs	/	3311 kg

Approximate Runner and Shaft Weight: 6425 lbs / 2921 kg

DIMENSIONAL DATA

Intake Type: 4 - JET

	inches	/	mm
Inlet Diameter:	27.3		694
Nozzle Diameter:	16.2		411
Jet Orifice Diameter:	5.2		131
Needle Stroke:	4.9		125
Inlet Piping Spiral Radius:	104.1		2643
Jet to Jet Included Angle:	90 Degrees		

Housing/Discharge Geometry:

	inches	/	mm
Centerline to Housing Top:	32.4		824
Housing Diameter:	155.3		3945
Discharge Width:	116.5		2958
Tailwater Depth:	25.7		653
Discharge Ceiling to T.W.:	27.3		694
Centerline to Tailwater:	76.3		1937

Shafting Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT

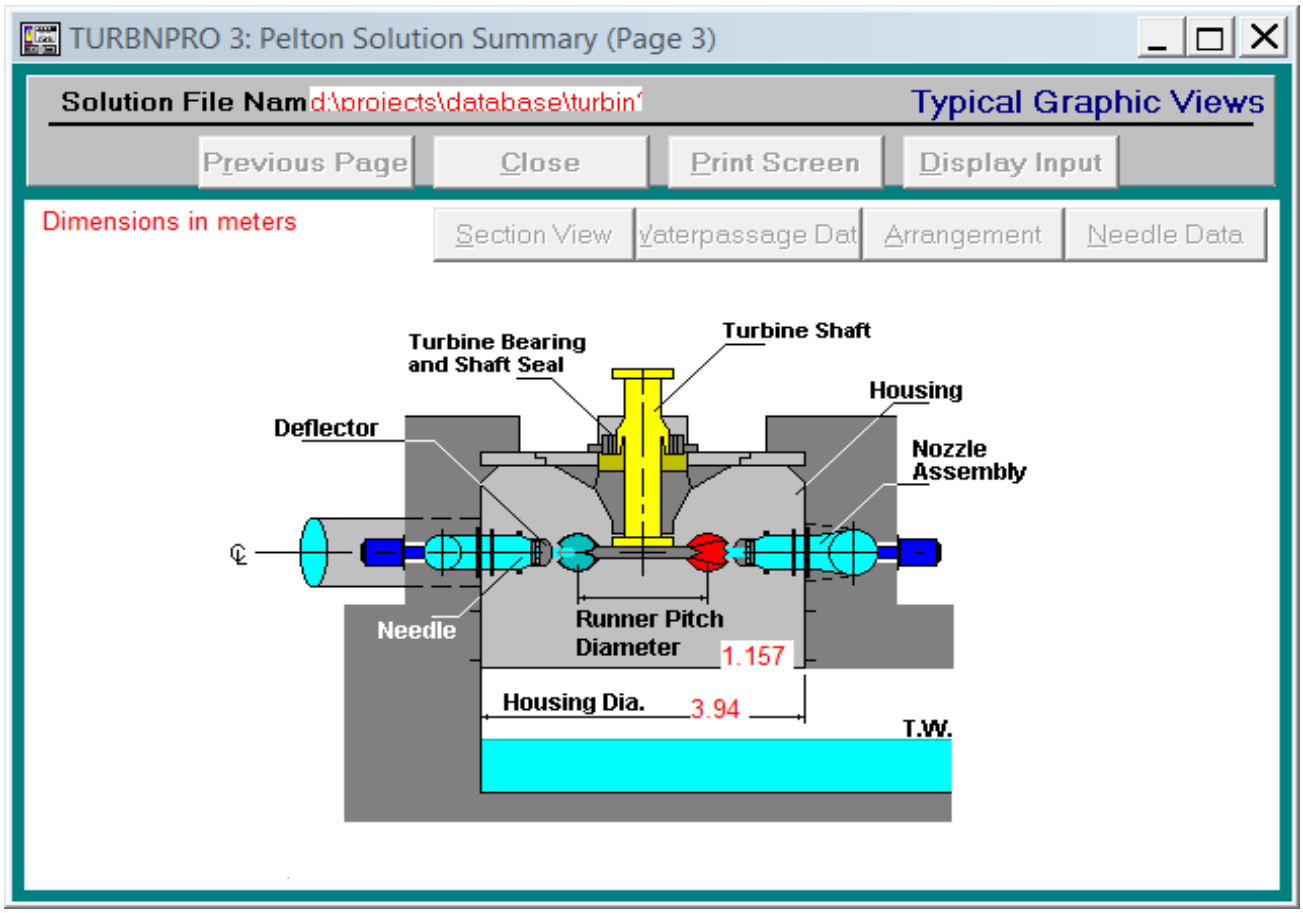
	inches	/	mm
Centerline to Shaft Coupling:	80.4		2043
Turbine Shaft Diameter:	11.0		279

Miscellaneous:

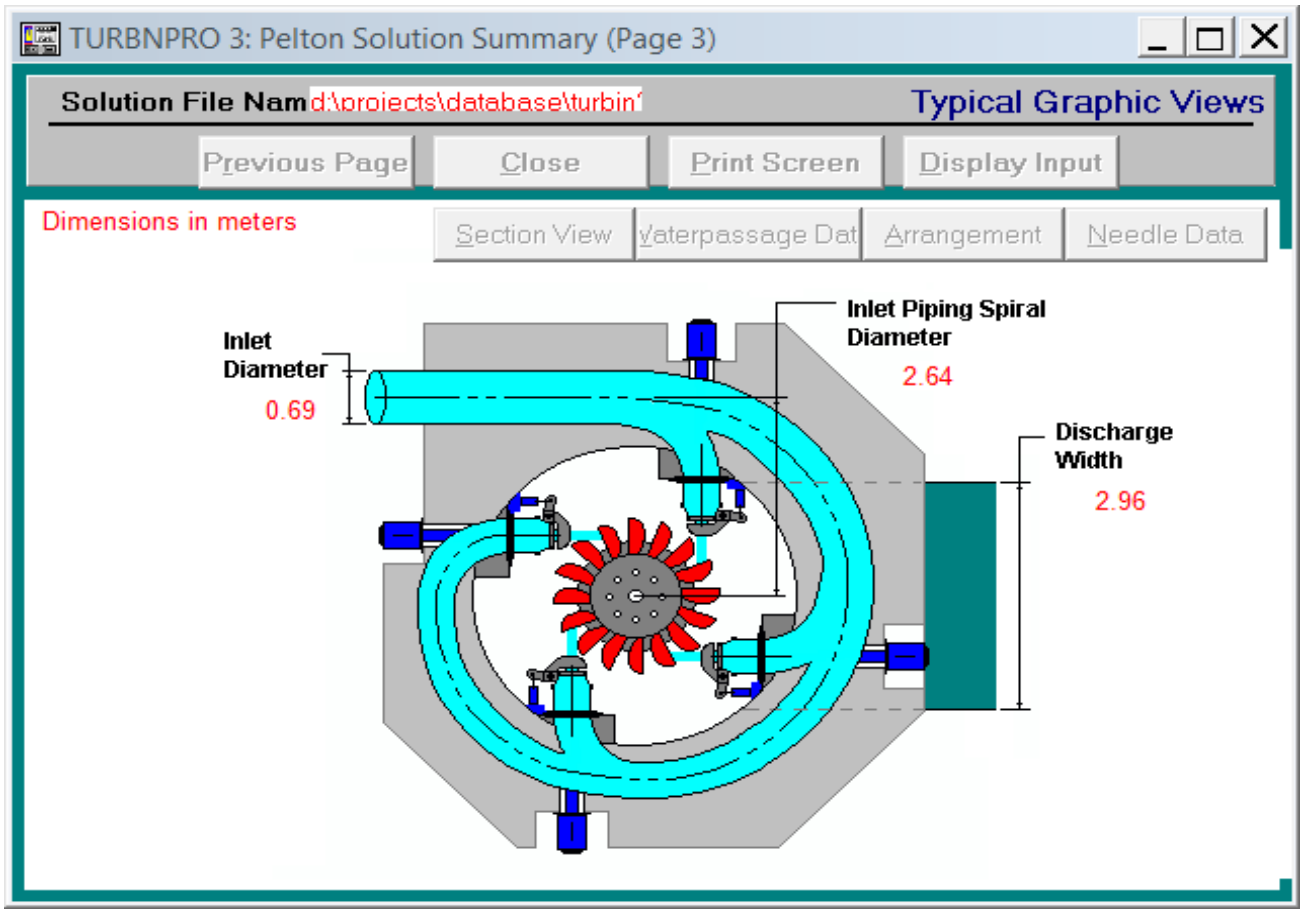
	inches	/	mm
Runner Outside Diameter:	61.9		1571
Runner Bucket Width:	16.3		414

**** All information listed above is typical only. Detailed characteristics will vary based on turbine manufacturer's actual designs.

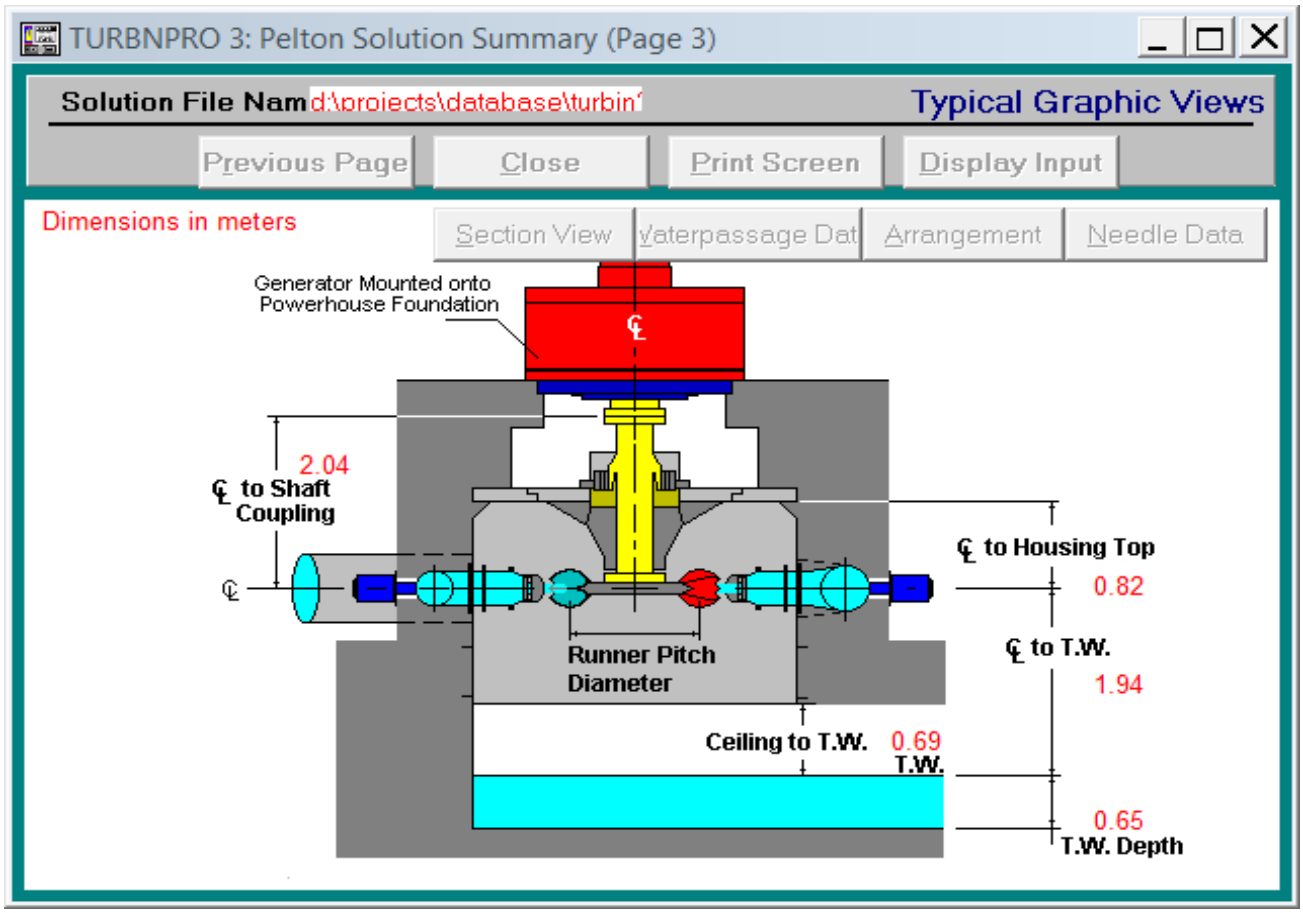
Solution File Name: d:¥projects¥database¥turbin~1¥ar1-4xp
Intake Type: 4 - JET
Runner Diameter: 1157 mm
Net Head at Rated Discharge: 207.70 meters
Unit Speed: 500.0 rpm



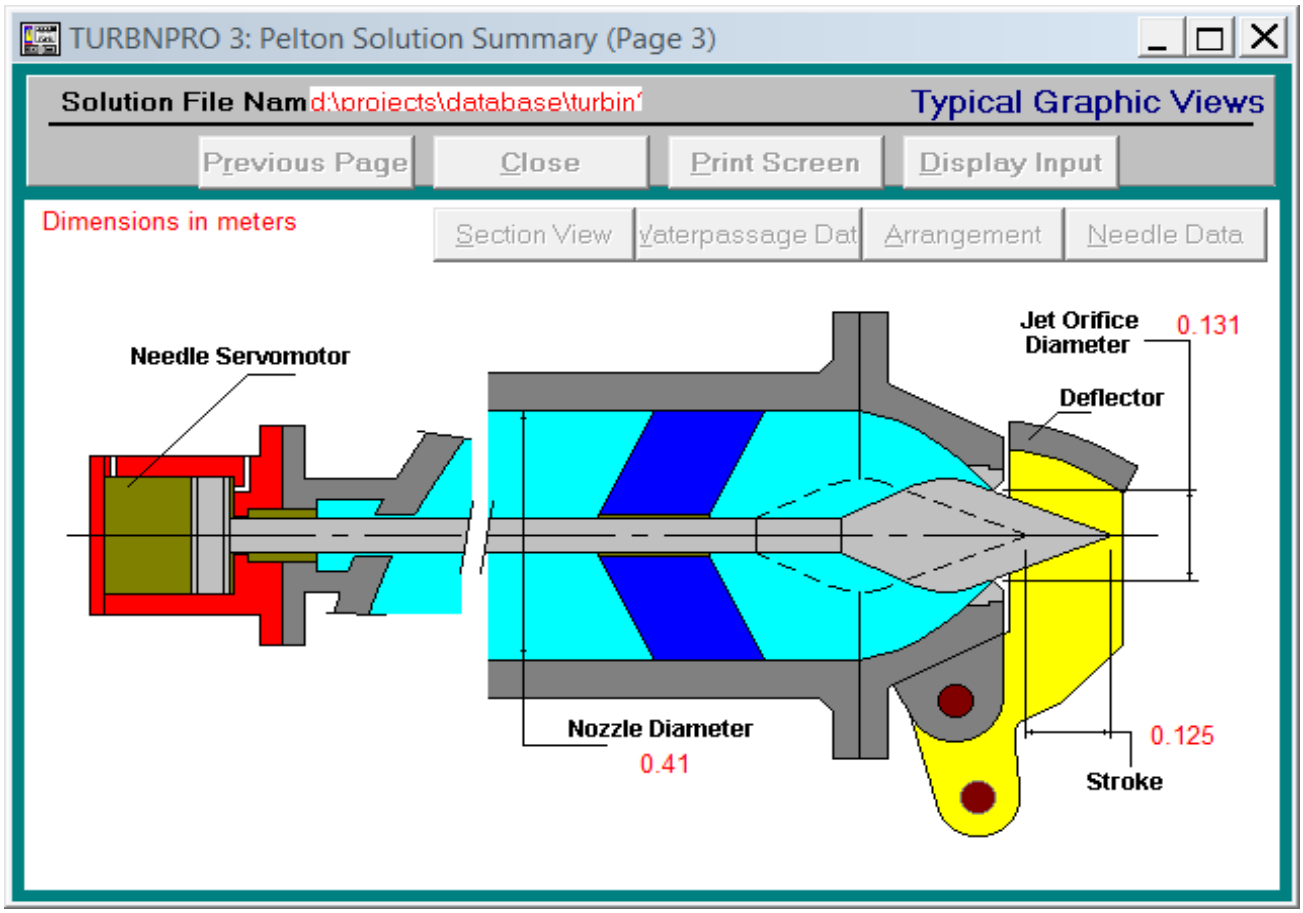
Solution File Name: d:¥projects¥database¥turbin~1¥ar1-4xp
Intake Type: 4 - JET
Runner Diameter: 1157 mm
Net Head at Rated Discharge: 207.70 meters
Unit Speed: 500.0 rpm



Solution File Name: d:¥projects¥database¥turbin~1¥ar1-4xp
Intake Type: 4 - JET
Runner Diameter: 1157 mm
Net Head at Rated Discharge: 207.70 meters
Unit Speed: 500.0 rpm

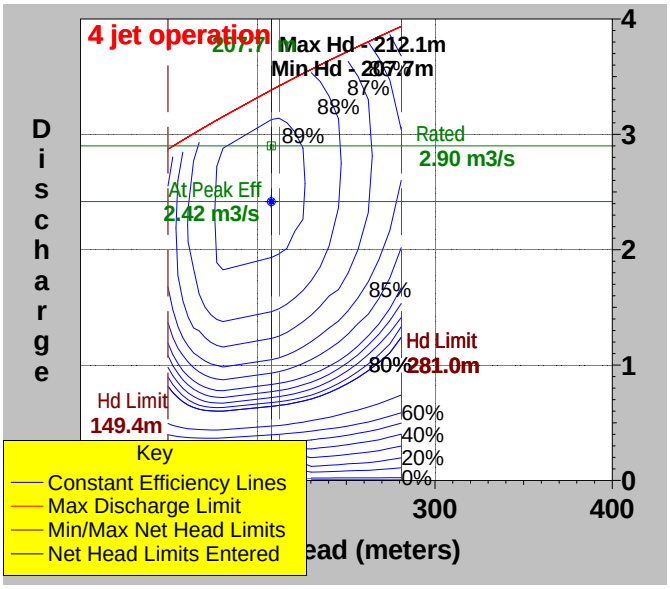


Solution File Name: d:¥projects¥database¥turbin~1¥ar1-4xp
Intake Type: 4 - JET
Runner Diameter: 1157 mm
Net Head at Rated Discharge: 207.70 meters
Unit Speed: 500.0 rpm



Solution File Name: d:₩projects₩database₩turbin~1₩ar1-4xp

Intake Type:	4 - JET
Runner Pitch Diameter:	1157 mm
Net Head at Rated Discharge:	207.70 meters
Unit Speed:	500.0 rpm
Peak Efficiency:	89.3 %
Multiplier Efficiency Modifier:	1.000
Flow Squared Efficiency Modifier:	0.0000



NOTE: Discharge is in cubic meters per second

TURBNPRO Version 3 - PELTON TURBINE HILL CURVE

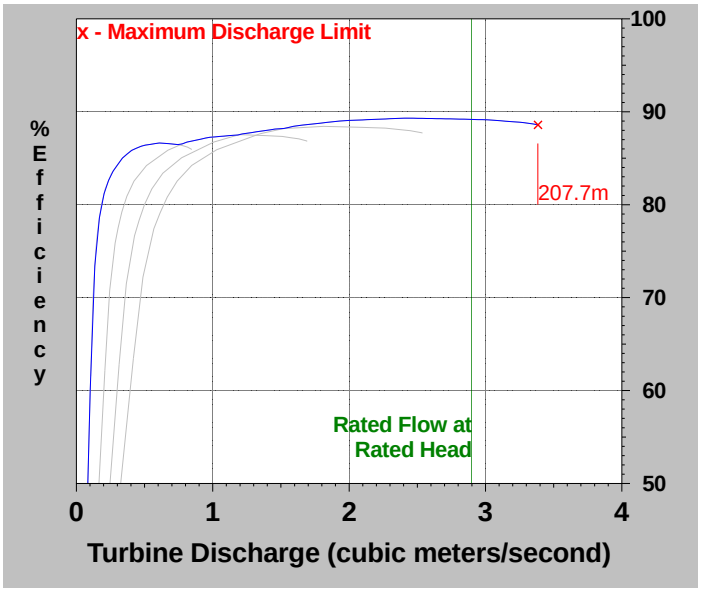
Solution File Name: d:₩projects₩database₩turbin~1₩ar1-4xp
Intake Type: 4 - JET
Runner Pitch Diameter: 1157 mm
Net Head at Rated Discharge: 207.70 meters
Unit Speed: 500.0 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

Performance Data Shown is for a Net Head of: 207.7000

Power (KW)	Efficiency (%)	Discharge (m3/s)	Operating Jets	Notes
6109	88.58	3.38	4	Max Discharge Limit
5998	88.74	3.32	4	Additional Output Capability
5883	88.86	3.25	4	Additional Output Capability
5766	88.94	3.18	4	Additional Output Capability
5648	89.02	3.11	4	Additional Output Capability
5530	89.09	3.05	4	Additional Output Capability
5409	89.14	2.98	4	Additional Output Capability
5288	89.16	2.91	4	Additional Output Capability
5269	89.17	2.90	4	Rated Flow/Head Condition
5167	89.19	2.84	4	-
5045	89.21	2.78	4	-
4923	89.23	2.71	4	-
4801	89.25	2.64	4	-
4679	89.27	2.57	4	-
4557	89.29	2.50	4	-
4434	89.31	2.44	4	-
4399	89.31	2.42	4	Best Efficiency at Net Head
4310	89.28	2.37	4	-
4185	89.24	2.30	4	-
4060	89.20	2.23	4	-
3935	89.16	2.17	4	-
3810	89.12	2.10	4	-
3686	89.07	2.03	4	-
3561	89.03	1.96	4	-
3435	88.94	1.90	4	-
3308	88.83	1.83	4	-
3267	88.42	1.81	3	Best Efficiency for 3 Jet Operation
3181	88.72	1.76	4	-
3055	88.61	1.69	4	-
2929	88.50	1.62	4	-
2801	88.30	1.56	4	-
2675	88.16	1.49	3	-
2550	88.05	1.42	3	-
2425	87.90	1.35	3	-
2300	87.76	1.29	3	-
2175	87.61	1.22	3	-
2156	87.53	1.21	2	Best Efficiency for 2 Jet Operation
2051	87.46	1.15	2	-
1928	87.37	1.08	2	-
1806	87.29	1.02	2	-
1683	87.16	0.95	2	-
1559	86.94	0.88	2	-
1435	86.73	0.81	2	-
1312	86.46	0.74	1	-
1194	86.56	0.68	1	-
1075	86.63	0.61	1	-
1067	86.63	0.60	1	Best Efficiency for 1 Jet Operation
954	86.48	0.54	1	-
833	86.27	0.47	1	-
710	85.84	0.41	1	-
586	85.02	0.34	1	-
461	83.62	0.27	1	-
336	81.17	0.20	1	-

TURBNPRO Version 3 - PELTON TURBINE HILL CURVE

Power (KW)	Efficiency (%)	Discharge (m3/s)	Operating Jets	Notes
202	73.40	0.14	1	-
56	40.32	0.07	1	Low efficiency; not used in energy calculation



APPENDIX 7

Land Cover Map

Upper Aragvi River Watershed

Land Cover Map

Aragvi 1 HPP
10.2 MW

Aragvi 2 HPP
14.2 MW

WEL ▼1550

WEL ▼1235

Kvesheti
Kitokhi
Pasanauri
Ananuri
Zhinvali
Kobi
Gudauri
Balaani
Dabakneti
Largvisi
Chartali
Gdu
Korinta
Salbieri
Tsikhisubani
Dusheti
Bazaleti
Magharoskari

Zhinvali Reservoir

Lake Kelitsadi
Lake Bazaleti

Pass Jvari
Pass Tatulaiskeli
Pass Gudamakari
Pass Ukantba
Pass Pkhituri

Mt. Khorisari
Mt.Sherkhota
Mt.Mapiskalo
Mt.Narvankhokhi
Mt.Miketi
Mt. Narvani
Mt.Zeda Sancho
Mt.Sasadilo
Mt.Gvidake
Mt.Mtatsminda
Mt.Chaukhi
Mt.East Chaukhi
Mt.Sakariskedi
Mt.Tsiberbatsi
Mt.Osivi
Mt. Sachali
Mt.Manaseuli
Mt.Chiriki
Mt.Sabadlo
Mt.Kicholi
Mt.Tsipori
Mt.Lutkhubi
Mt.Saorbe
Mt.Dikhcho
Mt.Maghatsalni
Mt.Tsveris Angelozi
Mt.Gurdimu
Mt.Mujukhi
Mt.Kurkuta
Mt. Elia
Mt.Sakorne
Mt. Sapersheti
Mt. Chartali
Mt.Laghis Mta
Mt.Saptisistsveri
Mt.Tsipranas Tavi
Mt.Sakharonosmta
Mt. Kvadjvari
Mt.Kmali

Kura
Aragvi
Tergi
Narvani
Baidara
Terkhena
Snostskali
Kora
Juta
Veshattskaro
Artkhmostskali
Kvenamtistskali
Okherkhevi
Bakurkhevi
Gvidakhevi
Goruli
Sachalischala
Osaviskhevi
Tetri Aragvi
Shavi Aragvi
Ksani
Tskhradzmula
Pachuri
Desikomidoni
Aragvistavi
Khidistskali
Sorchaktskali
Tortla
Aleura
Leshiskhevi
Arkala
Dushetiskhevi
Narekvavi
Pshavis Aragvi
Khrausha
Khokhula

LEGEND

Elevation
- 950 Tops (m)
- 800 Geodetic points (m)
- 750 V - X Pass — Altitude (m) / Period of access
- 700 Water level mark(m)

Settlements
- District center
- Sakrebulo's center
- Village

Borders
- Regions
- District

Comunication
- Highway
- Motor road
- Ground road
- Country road
- Path
- Field road
- Forest road

Hydrography
- River
- Intermittent river
- Lake/Reservoir
- Glacier
- Kura catchment
- Tergi catchment
- Upper Aragvi catchment

Power Infrastructure
- Potential Hydro Power Plant
- Diversion Dam
- Diversion Structure
- Surge Shaft
- Tailrace
- Power Tunnel
- Penstock
- Desilting Basin

Water
Urban Area
Snow
Rock
Natural Grassland
Deciduous Forest
Coniferous Forest
Bare Soils

N

0 1.25 2.5 5 Km

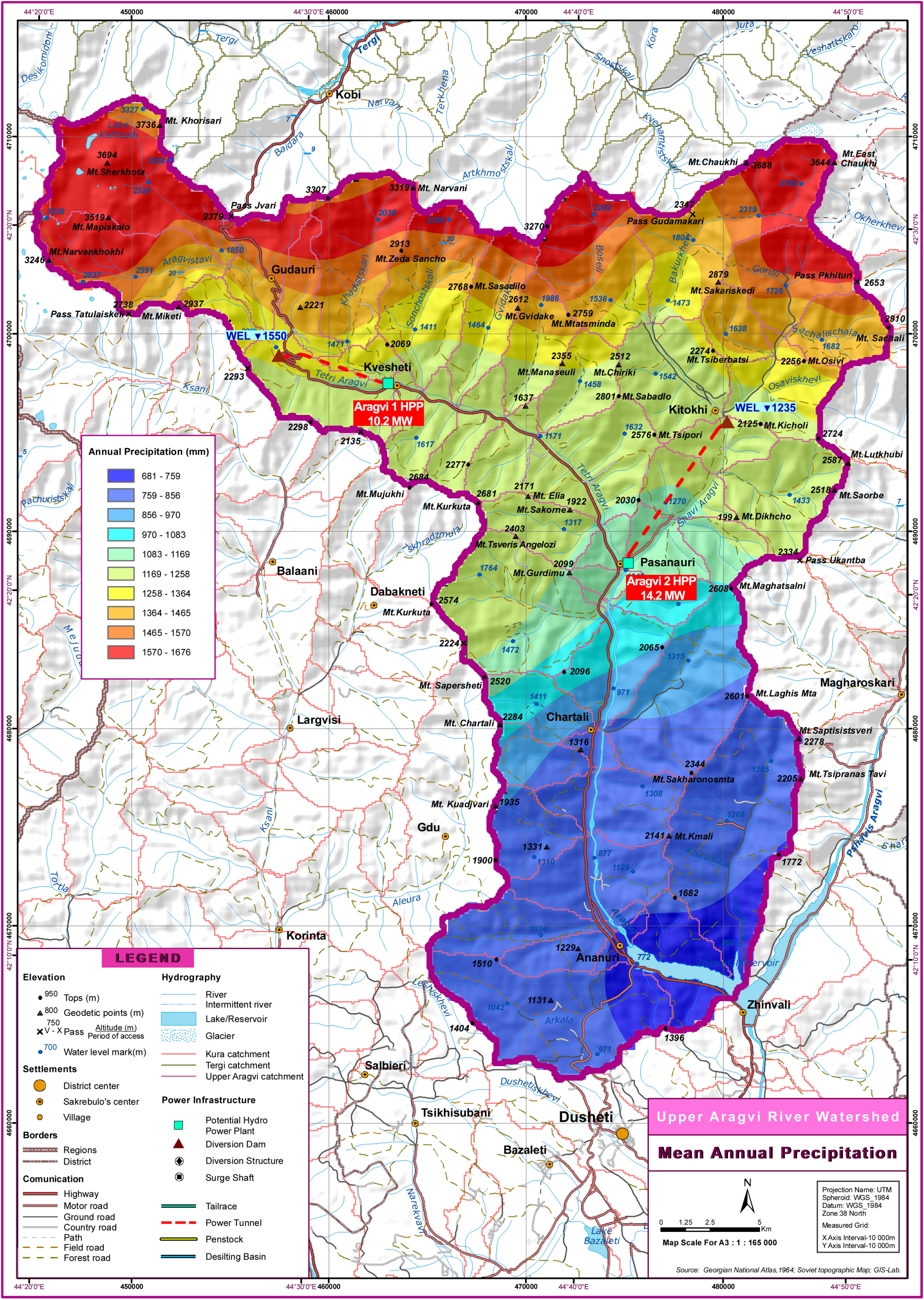
Map Scale For A3 : 1 : 165 000

Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m

Source: Terra ASTER; Soviet topographic Map, GIS-Lab.

APPENDIX 8

Mean Annual Precipitation



Upper Aragvi River Watershed
Mean Annual Precipitation
Annual Precipitation (mm)
681 - 759
759 - 856
856 - 970
970 - 1083
1083 - 1169
1169 - 1258
1258 - 1364
1364 - 1465
1465 - 1570
1570 - 1676
LEGEND
Elevation
Tops (m)
Geodetic points (m)
Pass
Altitude (m)
Period of access
Water level mark(m)
Settlements
District center
Sakrebulo's center
Village
Borders
Regions
District
Comunication
Highway
Motor road
Ground road
Country road
Path
Field road
Forest road
Hydrography
River
Intermittent river
Lake/Reservoir
Glacier
Kura catchment
Tergi catchment
Upper Aragvi catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Diversion Structure
Surge Shaft
Tailrace
Power Tunnel
Penstock
Desilting Basin
Kobi
Gudauri
Kvesheti
Kitokhi
Pasanauri
Balaani
Dabakneti
Largvisi
Chartali
Magharoskari
Gdu
Korinta
Ananuri
Zhinvali
Salbieri
Tsikhisubani
Dusheti
Bazaleti
Aragvi 1 HPP
10.2 MW
Aragvi 2 HPP
14.2 MW
WEL ▼1550
WEL ▼1235
Tergi
Tetri Aragvi
Shavi Aragvi
Pshavis Aragvi
Zhinvali Reservoir
Lake Bazaleti
Mt. Khorisari
Mt. Sherkhota
Mt. Mapiskalo
Mt. Narvankhokhi
Pass Jvari
Mt. Narvani
Mt. Zeda Sancho
Mt. Sasadilo
Mt. Gvidake
Mt. Mtatsminda
Mt. Chaukhi
Mt. East Chaukhi
Pass Gudamakari
Mt. Sakariskedi
Pass Pkhituri
Mt. Sachali
Mt. Osivi
Mt. Tsiberbatsi
Mt. Manaseuli
Mt. Chiriki
Mt. Sabadlo
Mt. Kicholi
Mt. Tsipori
Mt. Lutkhubi
Mt. Saorbe
Mt. Dikhcho
Pass Ukantba
Mt. Maghatsalni
Mt. Mujukhi
Mt. Kurkuta
Mt. Elia
Mt. Sakorne
Mt. Tsveris Angelozi
Mt. Gurdimu
Mt. Sapersheti
Mt. Chartali
Mt. Laghis Mta
Mt. Saptisistsveri
Mt. Sakharonosmta
Mt. Tsipranas Tavi
Mt. Kuadjvari
Mt. Kmali
Mt. Miketi
Pass Tatulaiskeli
Lake Kelitsadi
Desikomidoni
Tergi
Narvani
Baidara
Terkhena
Artkhmostskali
Snostskali
Kora
Juta
Veshattskaro
Okherkhevi
Aragvistavi
Khadistskali
Sonchostskali
Gvidakhi
Boseli
Bakurkhevi
Goruli
Sachalischala
Osaviskhevi
Ksani
Pachuristskali
Tskhradzmula
Mejuda
Tortla
Aleura
Leshiskhevi
Arkala
Dushetiskhevi
Narekvavi
Khirausha
Kvenamtistskali
Kvenamtistskali
Tetri Aragvi
Shavi Aragvi
Pshavis Aragvi
Zhinvali Reservoir
Lake Bazaleti
N
0 1.25 2.5 5 Km
Map Scale For A3 : 1 : 165 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m
Source: Georgian National Atlas,1964; Soviet topographic Map; GIS-Lab.
44°20'0"E
450000
44°30'0"E
460000
470000
44°40'0"E
480000
44°50'0"E
4710000
4700000
4690000
4680000
4670000
4660000
42°30'0"N
42°20'0"N
42°10'0"N

APPENDIX 9

Environmental and Social Impacts, Affected Environment

Appendix 1: Description of Tables

This appendix presents a tabular summary of potential environmental and social receptor impacts from the development of a hydropower project. These tables are based on the "EU Strategic Environmental Assessment Principles" that uses a subset of categories developed that best fits this level of analysis (Ref: http://ec.europa.eu/environment/eia/home.htm). Sections 2 and 3 and Section 6 of this document present a description of environmental and social baseline conditions. Section 6.2 presents environmental and social impacts and mitigation practices for each impacted receptor. The tables include a range of qualitative values for impacts and recommendations for mitigation practices that are considered standards of practice today. This prefeasibility report does not go into any detail with respect to recommended mitigation practices and should be used as a guideline with respect to the types of practice to be incorporated during a feasibility study for the different phases of the project (construction or operations. Decommissioning has not been included at this time).

The table column
Headers are described as follows:

Column 1: Receptors

Receptors are the environmental and social category that an impact is evaluated for. For this prefeasibility report these include:

- Water Resources
    - Surface Water Resources
    - Surface Water Quality
    - Flood Risk
- Soils, Geology, and Landscape
- Air Quality
- Biodiversity
    - Terrestrial Flora
    - Terrestrial Fauna
    - Fisheries
- Community, Socio-Economic, and Public Health
    - Cultural and Historic Assets
    - Population
    - Recreation
    - Public Health

Receptors are evaluated with a Sensitivity level that is defined as follows:

Sensitivity of receptors, based on Value and Vulnerability

Classification	Sensitivity Level			
Vulnerability	**High (H)** *e.g.* potential pathways exist for environmental change in receptors as a result of project, receptor is in a declining condition, and/or dependent on a narrow range of environmental conditions	**Medium (M)** *e.g.* few pathways exist for environmental change in receptors as a result of project, receptor is only expected to recover from disturbance over a prolonged period of time, if at all, or impact potential is high but duration is short	**Low (L)** *e.g.* limited or no pathways exist for environmental change in receptors as a result of project, receptor is in stable or favorable condition &/ or dependent on wide range of environmental conditions	**None (N)** *e.g.* no pathways exist between environmental changes and receptors, receptor is insensitive to disturbance
Value	**High (H)** – receptor is rare, important for social or economic reasons, legally protected, of international or national designation	**Low (L)** – receptor is common, of local or regional designation		

Column 2: Impact

This column is a description of the effect on the receptors during each of the project phases, construction followed by operations.

Column 3: Duration

Duration is the expectation for the length of time an impact will occur to a given receptor. The following table displays the rating values for duration:

Guidelines for determining the period of the project lifecycle

	Duration of effect			
Classification	**Long Term (LG)**	**Medium Term (MD)**	**Short Term (SH)**	**Very Short Term (VSH)**
Guideline	10+ years	3-10 years	1-3 years	<12 months
Project phase	Operation	Operation	Construction (or part thereof)	Part of construction period

Column 4: Risk Level

Risk Level qualitatively addresses the exposure and vulnerability a receptor will have from the project or in some cases how specific risks could cause the project to increase exposure and vulnerability to the receptor. An example of this is Seismic Risk as it pertains to Soils, Geology, and Landscape during each project phase. Risk level also includes whether the impact is Irreversible or Reversible and temporary or Permanent. The following displays the rating values for Risk Level:

Risk Level Rankings Definitions and Description

Risk Level	Description
Very Low (VL)	Rarely occurs, and/or of very low magnitude, and/or rarely causes significant loss or life or property damage
Low (L)	Can occur during the life of the project, and/or can be of modest magnitude, and/or rarely causes loss of life but can cause property some damage
Medium (M)	Occurs several or more times during the life of a project, and/or of significant magnitude, and/or can cause some loss of life and significant property damage
High (H)	Occurs often or on a regular basis and/or of a very high magnitude, and/or causes large loss of life and major property damage
Irreversible	Impact causes irreversible change to the receptor
Reversible	Impact causes reversible changes to the receptor
Temporary	Impact is of a temporary nature and receptor will return to original conditions after activity concludes
Permanent	Impact from activity is permanent changing the original receptor conditions to a new state.

Column 5: Mitigation Practices

Mitigation practices are guidelines and recommendations for a type of prevention activity that will reduce impacts to a receptor, provide necessary data and information for decisions during a project phase, provide health and safety guidelines, and environmental prevention practices to minimize impacts to the receptors.

Table-1 Affected Environmental Impacts and Proposed Mitigation Measures Environmental Receptor Category: Water Resources

Water Resources				
Receptors Vulnerability (H, M, L, N) Value (H, L)	**IMPACT (Description of effect)**	**Duration (construction, operation or decommissioning LG/MD/SH/VSH term) and frequency**	**Risk Level (VL, L, M, H) Irrev./ rev.; Temp./ per**	**Mitigation Practices**
Surface Water Resources (quantity) M/L	**Construction Phase (HPP and Transmission Facility)**: • Altered surface runoff contribution to water courses and ditches, etc. as a result of land disturbance • Temporary Diversion of River away from Dam and intake structure • Large construction/tunnel volume debris disposal • Construction of the dam will create a small permanent reservoir changing natural river conditions.	SH SH SH LG	VL/R/T VL/R/T VL/R/T VL/IR/P	Very high sediment and bed load transport by upper river. Assume site preparation include in-water, bank side, and/or adjacent property. River flow and river channel may be temporarily redirected for site construction. Well understood process. Few if any uncertainties, assume runoff controls and spill prevention plans and monitoring are included in construction. Locate area for construction debris that can contribute to generation of usable land in the future.
M/L	**Operation Phase:** Effects on surface water resources during facility operations	LG	L/R/P	Run of river hydropower operations returns all diverted flow used for generation to the receptor river. Long penstock facilities must meet appropriate receptor guidelines for bypass flows as required.

Surface Water Quality M/L	**Construction Phase(HPP and Transmission Facility)**: • Altered surface runoff water quality to water courses and ditches, etc. as a result of land disturbance • Temporary Diversion of River away from Dam and intake structure	SH SH	VL/R/T VL/R/T	Very high sediment and bed load transport by upper river. Assume site preparation can include in-water, bank side, and/or adjacent property. River flow and river channel may be temporarily redirected for site construction. Well understood process. Few if any uncertainties, assume runoff controls and spill prevention plans and monitoring are included during construction.
M/L	**Operation Phase:** • effects on surface water resources during facility operations	LG	VL/R/T	Run of river hydropower operations returns all diverted flow used for generation to the receptor river. Long penstock facilities must meet appropriate receptor guidelines for bypass flows as required.
Flooding Risk M/L	**Construction Phase (HPP and Transmission Facility):** • Increase to flood discharge from failure of dam during construction	VSH	VL/R/T	• Construction to adhere to all design requirements. • Dispose of large volumes of construction debris in locations that will not increase flood levels, or impact floodplain negatively • Design to address appropriate levels of Flood Risk in planning construction phase. • Monitoring of river discharge upstream on main stem and significant tributaries (flash flood warning) • Emergency Evacuation Plan developed • Emergency site shut down plan to be developed.
M/L	**Operations Phase:** Prevent failure of dam and other project components in the event of a flood that would severely increase the impact from the flooding event	VSH	L/R/T	Insure all facilities are operating correctly including, spillway gates, trash racks, and shut off gates (tunnel and powerhouse), etc. Monitor Dam for seepage, leaks, and structural integrity. Monitor Tunnel for leaks and structural integrity Prepare Emergency operations plan that includes flooding events Prepare Emergency shut down and evacuation plan.

Table-2 Affected Environmental Impacts and Proposed Mitigation Measures Environmental Receptor Category: Soils, Geology, and Landscape

Soils, Geology and Land Use				
Receptors	**IMPACT (Description of effect)**	**Duration LG/MD/SH/VSH term)**	**Risk Level (VL, L, M, H, and Irreversible/ reversible; temporary/ permanent**	**Mitigation Practices**
Soils, Geology, Landscape **(Vulnerability (H, M, L, None) and Value (H, L)** M/H	**Seismic Risk Construction Phase (HPP and Transmission Facility)**: Impacts on infrastructure and public due to seismic activity	VSH	H/R and IR/T and P depending on seismic characteristics	Well understood process. The project structures to be built in the area have to have appropriate design specifications which are in line with the national and international standards. Severe activity can lead to failure, flooding, property damage and loss of human life. Emergency site shut down and Evacuation plans should be included in construction management planning.
M/H	**Operation Phase**: Impacts on infrastructure and public due to seismic activity that causes HPP to fail	VSH	H/R and IR/T and P depending on seismic characteristics	Well understood process but magnitude is unknown. Severe seismic activity can lead to failure, flooding, property damage and loss of human life downstream of HPP. Emergency site shut down and Evacuation plans downstream should be included in HPP Operations Plan
Soils, Geology, and Landscape **(Vulnerability (H, M, L, None) and Value (H, L)** M/H	**Landslides and Mudslides Construction Phase (HPP and Transmission Facility)**: Improper stockpiling of materials, poor sitting, of storage and lay down areas, blasting activities and/or destruction of vegetation cover could increase receptor impacts if land slide or mud slide occurs at HPP site or upstream.	VSH	L/R/T	Erosion and sediment control plan (includes issues like: proper site sitting and engineering design based on best management practices, accumulated sediment disposal plan, grading and smoothing steep slopes, re-vegetation activities etc.) at national and international standards should be developed. Emergency shut down and Evacuation plans should be developed to protect receptors, property, and human life. Early Warning Monitoring to include Weather and watershed and upslope areas from HPP site and known land slide and mud slide locations Proper scheduling of construction activities Monitoring of vibration from construction equipment (and blasting activities)
M/H	**Operation Phase:** Minimize increasing the impacts from this natural occurrence from HPP operations	SH	VL/R/T	Monitoring site conditions on a regular basis; implementation of pre-prepared emergency shut down and Evacuation plans ; Monitoring of Early Warning system

Soils, Geology, and landscape **(Vulnerability (H, M, L, None) and Value (H, L)** M/H	**Visual impact on landscape Construction Phase (HPP and Transmission Facility)**: Visual impact is important in this mountainous setting and impacts to this receptor are significant. Construction activities may cause visual disturbance of landscape (new project units (e.g. dam, powerhouse) will be constructed. Construction activities may cause removal of vegetation cover, changes in land use pattern. Waste generation due to construction activities may create visual impact on landscape as well as impact on land. Management and disposal of construction debris	SH	VL/R/T	Proper storage and utilization of topsoil and excavation materials. Restoration of soil cover, re-vegetation and reforestation activities to national and international standards Proper scheduling of construction activities. Develop construction management plan. Development appropriate waste management plan which includes management of solid, liquid, hazardous waste material and are in line with national and international environmental regulations. Construction debris should be disposed of according to current accepted practice, local and national laws. Where possible use construction in a sustainable manner that provides opportunities for agriculture, local industry, and does not impact local floodplain
M/H	**Operation Phase:** No more additional alterations of landscape are expected during the operation phase. Water body such as impoundment may be considered to create pleasant scenery.	SH	VL/IR/P	Monitoring the landscape restoration activities.

Table-3 Affected Environmental Impacts and Proposed Mitigation Measures Environmental Receptor Category: Air Quality

Air Quality				
Receptor s	**IMPACT (Description of effect)**	**Duration LG/MD/SH/VSH term)**	**Risk Level (VL, L, M, H, and Irreversible/ reversible; temporary/ permanent**	**Mitigation Practices**
Air Quality **(Vulnerability (H, M, L, None) and Value (H, L)** **L/H**	**Construction Phase (HPP and Transmission Facility)**: Construction activities may increase the level of emission in the air and dust, especially under windy conditions.	SH	L/R/T	Well understood process. Air management plan should be developed, which includes activities like construction machinery maintenance scheduling, Exhaust gas quality, water spray on construction site to minimize dust, checking construction equipment and/or benzene quality etc.
L/H	**Operation Phase:** During operation there would not be any significant emission level.	VSH	VL/R/T	Ensuring compliance with air management plan, emergency generator exhaust controls.

Table -4 Affected Environmental Impacts and Proposed Mitigation Measures Environmental Receptor Category: Biodiversity

Biodiversity				
Receptor s	**IMPACT (Description of effect)**	**Duration LG/MD/SH/VSH term)**	**Risk Level (VL, L, M, H, and Irreversible/ reversible; temporary/ permanent**	**Mitigation Practices**
Terrestrial flora **(Vulnerability (H, M, L, None) and Value (H, L)** **L/H**	**Construction Phase (HPP and Transmission Facility)**: Project might have following primary and secondary impacts on the terrestrial flora: • Construction of HPP, new roads and/or Transmission lines may cause removal of vegetation (forests, topsoil); • Alien species invading the existing ecosystem;	SH	L/R/T	Well understood process. Restoration and reinstatement of soil cover; re-vegetation and/or reforestation activities.
L/H	**Operation Phase:** There would be minor or no impact on flora during the operation phase	MD	VL/R/P	Monitoring restoration activities.

Terrestrial fauna **(Vulnerability (H, M, L, None) and Value (H, L)** **L/H** **L/H**	**Construction Phase (HPP and Transmission Facility)**: Project might have following primary and secondary impacts on the terrestrial fauna: • Disruption of sites of breeding and sheltering; • Animal mortality due to construction activities (e.g. accidents and/or mortality of birds due to Transmission lines) • Alien species invading the existing ecosystem; number of equipments and/or possible blasting activities may cause the increase the noise/vibration level during the construction process, which may disturb wildlife (affect species behaviour) **Operation Phase:** Impacts affecting fauna elements during operation are: • Ecological barrier effect (movement is disabled or hindered • Mortality of animals on roads; • Mortality of birds on power lines	SH LG	L/R/T VL/R/P	Wildlife management plan should be developed. Noise management plan. Proper scheduling of construction activities; Monitoring of vibration and blasting activities from construction equipment Implementing and monitoring the wildlife management plan.
Fishery **(Vulnerability (H, M, L, None) and Value (H, L)** **L/H** **L/H**	**Construction Phase HPP**: Impact on fish species due to construction in the riverbed and altering the river flow through temporary diversion channel, and blasting activities. **Operation Phase:** Impacts on fish species due to diverting river flow to the powerhouse (mortality fish species in the turbines/generators). Exposure of bypass section of river to very low to no flow.	MD MD	M/R/T M/R/T	Installing fish protecting/screening facilities at the entrance of the HPP feeding tunnels/channels. Scheduling of construction activities. Avoiding the stock piling in the riverbed. Proper scheduling of construction activities; Monitoring of vibration and blasting activities from construction equipment Well understood process. Permanent monitoring of sanitary water flow; compliance with environmental and in-stream flow requirements with monitoring.

Table-5 Affected Environmental Impacts and Proposed Mitigation Measures Environmental Receptor Category: Cultural Resources

Cultural Resources and Recreation				
Receptor s	**IMPACT (Description of effect)**	**Duration LG/MD/SH/VSH term)**	**Risk Level (VL, L, M, H, and Irreversible/ reversible; temporary/ permanent**	**Mitigation Practices**
Cultural and historic assets **(Vulnerability (H, M, L, None) and Value (H, L)** L/H	**Construction Phase HPP and Transmission Facility)**: There are no archaeological and/or cultural heritage sites in the vicinity of the projects. However, during construction works they might occur. Archaeological objects should be protected from damage.	VSH	VL/R/T	Identifying historical and cultural assets. Development of noise and construction management plan. Proper scheduling of construction activities Monitoring of vibration from construction equipment and blasting activities.
L/H	**Operation Phase:** No damage on archaeological/cultural resources is expected from operational phase. Small reservoir behind dam may provide new opportunities for recreational activities	VSH	VL/R/P	N/A

Table-6 Affected Environmental Impacts and Proposed Mitigation Measures Environmental Receptor Category: Community, Socio-Economic and Public Health

Community, Socio-Economic and Public Health				
Receptor s	**IMPACT (Description of effect)**	**Duration (LG/MD/SH/VSH term)**	**Risk Level (VL, L, M, H, and Irreversible/ reversible; temporary/ permanent**	**Mitigation Practices**
Agricultural Land **(Vulnerability (H, M, L, None) and Value (H, L)** L/H	**Construction Phase (HPP and Transmission Facility)**: Impact associated with land acquisition and thereby loss of agricultural land, which may cause loss of income earning means; disposal of debris; limit access to agricultural property	SH	L/R/T	Develop compensation mechanism for occupied agricultural land.; coordinate construction activities to minimize impacts to agricultural properties, appropriate selection of disposal areas, materials storage areas; Monitoring the implementation of compensation scheme

L/H	**Operation Phase:** New infrastructure (e.g. access roads) may positively impact on local population, provide better access to markets for agricultural products	LG	VL/R/P	N/A
Population **(Vulnerability (H, M, L, None) and Value (H, L)** N/H	**Construction Phase (HPP and Transmission Facility)**: Machinery and/or possible blasting activities may cause the increase the noise/vibration level during the construction process; Construction activities cause traffic delays, which affect local population within the vicinity of project. New job opportunities and economic benefits to community	SH	L/R/T	Well understood process. Noise management plan Blast warning plan for construction crews and local residents. Proper scheduling of construction activities Monitoring of vibration from construction equipment (and blasting activities)
N/H	**Operation Phase**: The noise/vibration source during the operation will be generators and turbines located in the powerhouse. Since they are located in the closed building, it will have not any considerable nuisance.	N/A	N/A	N/A
Recreation (Vulnerability (H, M, L, None) and Value (H, L) L/H	**Construction Phase (HPP and Transmission Facility)**: Visual impact due to construction; activities may impact recreation in the region. Waste generation due to construction activities may create visual impact. Delay or prevent access to recreational locations	SH	VL/R/T	Proper scheduling of construction activities. Develop construction management plan. Development appropriate waste management plan which includes management of solid, liquid, hazardous waste management and are in line with national and international environmental regulations. Provide construction schedules and coordinate with recreational locations to minimize access issues for visitors.
L/H	**Operation Phase:** New reservoir and new infrastructure (e.g. better roads) may positively impact on recreational activities	LG	L/IR/P	Operations practice should coordinate with recreational activities so as to assure safe access (fishing), adequate water in bypass channels to support in-stream activities, and provide access to river for such activities if project limits access.

Roads, Infrastructure, and Communities **(Vulnerability (H, M, L, None) and Value (H, L)** L/H	**Construction Phase (HPP and Transmission Facility)**: It is expected that during construction new access roads will be built. Loads on the existing roads will increase due to construction machinery. Traffic increase will affect Noise, Air Quality, community safety, and Public Health Receptors. Construction provides jobs and economic benefits to community	SH	VL/R/T	Develop construction management plan that addresses materials delivery, storage, noise, and air quality issues that are sensitive to local communities and meet all Georgian environmental and legal requirements. Include job training for local population where appropriate.
L/H	**Operation Phase:** It is expected that during operational phase vehicular movement will be increased for maintenance, etc. purposes. Consider community health, safety and security issues, as well as Noise and Air Quality Receptors.	LG	VL/R/P	Develop traffic management plan with limited vehicular movement during operational phase. Ensure compliance with local and regional laws that effect the community
Public Health **(Vulnerability (H, M, L, None) and Value (H, L)** L/H	**Construction Phase (HPP and Transmission Facility)**: Construction activities might cause health impact to the workers (e.g. construction related accidents). Also see Air Quality, Population Receptors	SH	VL/R/T	Health and safety plan should be in line with national and international standards. Occupational health and safety measures should be identified and implemented. Necessary precautionary measures should be implemented in order to avoid and minimize risk of accidents (e.g. fire, flooding etc.)
L/H	**Operation Phase:** Operational activities might cause health impact to the workers and/or local population.	LG	VL/R/P	Ensure compliance with health and safety plan

APPENDIX 10

Cultural Resource & Recreation Areas

Upper Aragvi River Watershed

Cultural Resources and Recreation Areas

Symbols

- Church
- Ruins
- Cave
- School
- Mineral Water
- Waterfall
- Protected Area

LEGEND

Elevation
- Tops (m)
- Geodetic points (m)
- Pass (V - X) Altitude (m) / Period of access
- Water level mark(m)

Settlements
- District center
- Sakrebulo's center
- Village

Borders
- Regions
- District

Comunication
- Highway
- Motor road
- Ground road
- Country road
- Path
- Field road
- Forest road

Hydrography
- River
- Intermittent river
- Lake/Reservoir
- Glacier
- Kura catchment
- Tergi catchment
- Upper Aragvi catchment

Power Infrastructure
- Potential Hydro Power Plant
- Diversion Dam
- Diversion Structure
- Surge Shaft
- Tailrace
- Power Tunnel
- Penstock
- Desilting Basin

N

0 1.25 2.5 5 Km

Map Scale For A3 : 1 : 165 000

Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North

Measured Grid:

X Axis Interval-10 000m
Y Axis Interval-10 000m

Source: Georgian National Tourism Agency; Soviet topographic Map; GIS-Lab.

APPENDIX 11

Listed Cultural Properties in Dusheti Municipality

Historical, cultural and archeological resources of the Dusheti Municipality

#	Name	Location	Dated
1	Church of the St. John the Baptist and Small Church	Village Akhatani	Late Medieval
2	Kharat Fortress, Tower	Village Akhieli	Late Medieval
3	Ananuri Fortified Ensemble (listed in UNESCO World Heritage sites): • Church of Virgin Mary • Minor church of "Gvtaeba" • Single-nave church "Mkurnali" • Bell-tower, etc.	Village Ananuri	1689 XVI-XVII A.D. XVI A.D. XVII A.D.
4	"Andriant" House	Village Ananuri	XIX A.D.
5	Bebristsikhe (Bebris fortress)	Village Ananuri	Medieval
6	Church of Virgin Mary	Village Ananuri	1850
7	Monastery of St. Kvirike	Village Ananuri	IX-X A.D.
8	Namgalauris' Residential House	Village Ananuri	XIX A.D.
9	"Nadiraan" Residential complex	Village Arakhveti	Late Medieval
10	"Tetraant" Tower	Village Aranisi	Late Medieval
11	Zviadauri's Tower	Village Arbachkhani	Late Medieval
12	P. Gogochuri's Residential House	Village Atabe	XIX A.D.
13	Complex of St. George's Church	Village Avenisi	Medieval
14	Church of Virgin Mary	Village Bazaleti	Late Medieval
15	"Tinibegaurt" Tower	Village Batsaligo	Late Medieval
16	Church of Kvelatsminda	Village Bedoni	IX-X A.D.
17	Church of Mtavarmotsame	Village Begotkari	1908
18	Defensive Residential House	Village Begotkari	Late Medieval
19	Church of Virgin Mary	Village Bodorna	1717-XVI A.D. Renovated in 1912
20	Mere Fortress	Village Buchaani	Late Medieval
21	Church	Village Buchaani	X A.D.
22	Mzetsveri St. George's church complex	Village Buchaani	IX -X A.D.
23	Chirdili Church	Village Buchaani	Medieval
24	Mtavarta Complex	Village Buchaani	Late Medieval
25	Vaja-Pshavela Museum	Village Chargali	1831-1890
26	Rocky Towers	Village Chinti	XVIII A.D.
27	Davati St. Mary Church Complex	Village Davati, surroundings	VIII-IX A.D.
28	Mtavarmotsame Fortress Complex	Village Daviturni	Late Medieval
29	Mindia Arabuli's Residential House	Village Davtisi	XX A.D.
30	Fortified complex of Chilashvili Dynasty	Dusheti	XVII-XIX A.D.
31	Residential House	Dusheti	XVIII-XIX A.D.
32	Residential House	Dusheti	XIX A.D.
33	Residential House	Dusheti	XIX A.D.
34	Residential House	Dusheti	XIX A.D.
35	Simagreuli Fortress	Village Gometsari	Medieval
36	Church of "Kviratskhoveli"	Village Grigolaantkari	XVII-XVIII A.D.
37	Mindia Chincharauli's Residential House	Village Gudani	XIX A.D.
38	Church of Virgin Mary	Village Gudrukhi	X A.D.
39	Church of "Kviratskhoveli"	Village Iltoza	XVII A.D.
40	Iriaulis' Tower	Village Iukho	IX-X A.D.
41	Tower	Village Jaghmiani	XVI-XVII A.D.
42	"Dedatsikhe"	Village Jinvali	XI-XIV A.D.
43	"Khertvisi" Complex	Village Jinavali	Medieval

44	“Keli” Fortress, “Tamari” Fortress	Village Jinvali	XII-XIII A.D.
45	St. George Sharao Church Complex	Village Jugisi	Medieval
46	Church	Village Kaishaurni	1899
47	Church of Virgin Mary	Village Kaishaurni	Late Medieval
48	Kudo St. George’s Church	Village Kanatia	VIII-IX A.D.
49	Fortress-House	Village Khakhabo	Late Medieval
50	“Perault” Fortress	Village Khakhmati	Late Medieval
51	Kistani - Fortress Village	Village Kistani	Medieval
52	“Abuletaurt” Fortress	Village Kistani	Late Medieval
53	“Avdilaant” Fortress	Village Kistani	Late Medieval
54	“Kobt” Fortress	Village Kvesheti	XVII A.D.
55	Fortress House	Village Kvesheti	Medieval
56	“Lomisi” St. George’s Church	Village Kvemo (Lower) Mleta	IX-X A.D.
57	Tower	Village Kvemo (Lower) Mleta	XVI-XVII A.D.
58	Towers	Village Lakatkhevi	Late Medieval
59	“Baghiaantkari” Church	Village Laphanaantkari	VI A.D.
60	Kavti St. George’s Church	Village Laphanaantkari	Late Medieval
61	“Salagostsveri” Church	Village Maqarta	VIII-IX A.D.
62	St. George’s Church, “Kharanault” Church	Village Maqarta	XIX A.D.
63	Church	Village Meneso	Medieval
64	St. George’s Church Complex	Village Muguda	Medieval
65	Church of Kviradtskhoveli	Village Muguda	Medieval
66	Church of Kvelatsminda	Village Muguda	Medieval
67	Mutso, Fortress Village	Village Mutso	Medieval
68	“Torghvai” Tower	Village Mutso	Late Medieval
69	“Torghvai” House-Fortress	Village Mutso	Late Medieval
70	“Broliskalo” Icon of St. George	Village Mutso	Late Medieval
71	“Cholookaant” Tower	Village Mutso	Late Medieval
72	Complex of Church of Archangel: • Church • Fortress-Fortification • Bell Tower	Village Mchadijvari	1668 1746 XIX A.D.
73	Tsetskhlisjvari Architectural Ensemble • Church of Virgin Mary • Navy Church	Village Nadibani	IX-X A.D. VIII-IX A.D.
74	Church	Village Naghvarevi	Late Medieval
75	“Bzianis” Complex • St. George’s Church • Hall Church • Defensive Walls • Various Buildings	Village Nedzikhi	VII-VIII A.D. X A.D. Medieval
76	St. George’s Church	Village Noja	IX-X A.D.
77	G. Eristavi’s Castle	Village Odzisi	XIX A.D.
78	R. Eristavi’s Castle	Village Odzisi	XIX A.D.
79	Church of Virgin Mary Complex	Village Odzisi	Late Medieval
80	St. Marina’s Church	Village Odzisi	Late Medieval
81	Remnants of St. George’s Church	Village Pavleuri	Late Medieval
82	The Remnants of the Settlement “Jortpiri”	Village Pavleuri	Late Medieval
83	Church of Virgin Mary	Village Phudznari	XIII A.D.
84	Church of Virgin Mary Complex	Village Qorogho	X-XI A.D. – Late Medieval
85	“Midelauris’” Fortress, Tower	Village Qorogho	X-XI A.D.
86	St. George’s Church and Tower	Village Qvitkiristsako	Late Medieval

87	Church	Village Sakramulo	XVII-XVIII A.D.
88	Tower	Village Sashaburo	XVIII A.D.
89	St. Marina's Church	Village Sephe	XVI-XVIII A.D.
90	Necropolis of Anatori • Tombs • Church of Virgin Mary	Village Shatili	XI-XV A.D. IX-X A.D.
91	"Qachu" Fortress	Village Shatili	Late Medieval
92	"Guro" Fortress	Village Shatili	XVII-XVIII A.D.
93	Cross of the Archangel • The Hall • The Hall's Entrance Door • Bell Tower	Village Shatili	-
94	Church of "Kviratskhoveli" and Bell Tower	Village Sijaniani	Late Medieval
95	Complex of Church of Trinity	Village Sodeve	IX-X A.D.
96	Church Complex	Village Sonda	Late Medieval
97	"Sakvirali" St. George's Church Complex • St. George's Church • The Hall Church • Various Buildings	Village Stsrophavi	VIII-IX A.D. - Medieval
98	"Svianadzes" Residential Complex	Village Sviana-Rostiani	Late Medieval
99	"Bauraki" Church	Village Tchalisopheli	IX-X A.D.
100	St. George's Church	Village Tchikani	IX-X A.D.
101	Church of Matskhovari (Church of the Redeemer)	Village Tchilurti	XIX
102	Complex of Church of St. George	Village Toncha	Late Medieval
103	St. George's Esoje Church Complex	Village Tsikhisdziri	Medieval
104	St. Barbara Church	Village Tsikhisdziri	Late Medieval
105	Tower Gandza St. George	Village Tsikhisdziri	Late Medieval
106	Tkhilobistchala Burial Mound	Village Tsikhisdziri	Late Medieval
107	Burial Mound	Village Tsikhisdziri	XVI
108	Church and Tower	Village Tsikhisubani	XVIII-XIX A.D.
109	"Adzivni" Church	Village Tsinamkhari	XIII-XIV A.D.
110	Church of the Archangel and Tower	Village Tsinamkhari	IX-X A.D.
111	St. George's Church and Tower	Village Tsinkobani	Late Medieval
112	Tavlaghi Church Complex	Village Tsiteli Klde	Late Medieval
113	Zaqaidze's Fortress, Tower	Village Tskere	XVII A.D.
114	Naraidze's Fortress, Tower	Village Tskere	XVII A.D.
115	St. George Church Complex	Village Tvalivi	VIII-IX A.D. renovated in XVI
116	St. George's Church	Village Varsimaani	Late Medieval
117	Tower	Village Zaqatkari	Early Medieval
118	"Achaqveli" Fortress Complex	Village Zemo (Upper) Khorkhi	Medieval
119	Church of Virgin Mary Complex	Village Zemo (Upper) Khorkhi	X A.D.
120	Complex of the Castle 1. Castle 2. Tower 3. Church	Village Zemo (Upper) Kodistskaro	XVI A.D.
121	Church of Virgin Mary	Village Zemo (Upper) Mleta	Medieval
122	Nazghat (Mleta) Fortress	Village Zemo (Upper) Mleta	XVII A.D.
123	Church of Kviratskhoveli	Village Zemo (Upper) Mleta	VIII-IX A.D.
124	Church of Holy Trinity	Village Zeneburi	VIII-IX A.D.

Source: *Ministry of Culture of Georgia: Ministerial Orders #3/133 and #3/110(2006 and 2011)*
SEA Small Hydropower Plants Aragvi River Basin (2010)

USAID Hydropower Investment Promotion Project (USAID-HIPP)

Deloitte Consulting Overseas Projects - HIPP
Tiflis Business Centre, 13th Floor
11 Apakidze Street
Tbilisi 0171, Georgia