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Hydropower Investment Promotion Project (HIPP)

KHUMPRERI HPP

PRE-FEASIBILITY STUDY

UPPER ENGURI RIVER BASIN

JANUARY, 2012

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DELOITTE CONSULTING LLP

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DISCLAIMER REGARDING THIS PRE-FEASIBILITY STUDY

Definition of Abbreviations

atm	atmospheres
CAPEX	Capital Expenditure
EIA	Environmental Impact Assessment
EPCM	Engineering, Procurement, and Construction Management
FDC	Flow Duration Curve
GEL	Georgian Lari
GIS	Geographic Information System
GoG	Government of Georgia
GW	Gigawatt
GWh	Gigawatt-hours
HIPP	Hydropower Investment Promotion Project (USAID-funded)
ha	hectare
HP	Hydropower
HPP	Hydropower Plant/Hydropower Project
IFI	International Financial Institutions
kg/s	kilograms per second
kV	kilovolt
kW	kilowatt (a measure of power)
kWh	kilowatt-hour (a measure of energy)
m^3/s	cubic meters per second
m^3/s-hrs	cubic meters per second x hours
masl	meters above sea level
MENR	Ministry of Energy and Natural Resources of Georgia
MW	Megawatts
MWh	Megawatt-hours
SS	Substation
T	Metric Tonnes
TBM	Tunnel Boring Machine
TL	Turkish Lira
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

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EXECUTIVE SUMMARY

Project Area Social Characteristics

The Khumpreri Project area is located in Mestia Municipality, which is part of the Samegrelo-Upper Svaneti Region Administrative Unit. The Mestia Municipality occupies the upper part of the Enguri River watershed and is located between the elevations of 800 m and 5,070 m above sea level. Mestia Municipality occupies a total area of 3,044.5 km^2. The population for the whole district is about 14,248, giving a population density of 4.7 people/km^2. Of the residents, 99.4% are Georgians. The area is mainly populated by ethnic Svans.

The economy is mainly based on subsistence agriculture. Animal husbandry, grain and hay crop production, vegetable (mainly potato) production, and forestry are developed in the region. The Mestia District is also well-known for its mineral resources.

Mestia is one of the most popular tourist spots in the country, due to rich natural, cultural and historical assets. The Upper Svaneti area is listed among the UNESCO World Heritage Sites. Planned Protected Areas within the Mestia Municipality occupy 46,122 ha. Extensive tourist developments are under construction or planned for the area. These include a world-class skiing and winter sports destination resort.

The Khumpreri Project area lies near the Lakhamuli community. The nearest settlement to the project site is the village of Dizi, which is located at an elevation of 1,080 m above sea level and is 48 km from Mestia. Dizi's population is 105 (population census, 2002). The Lakhamuli community is rich in mineral resources. Marble deposits are found near the village of Dizi, and some small outcrops were noticed during HIPP's reconnaissance trip to the Khumpreri site.

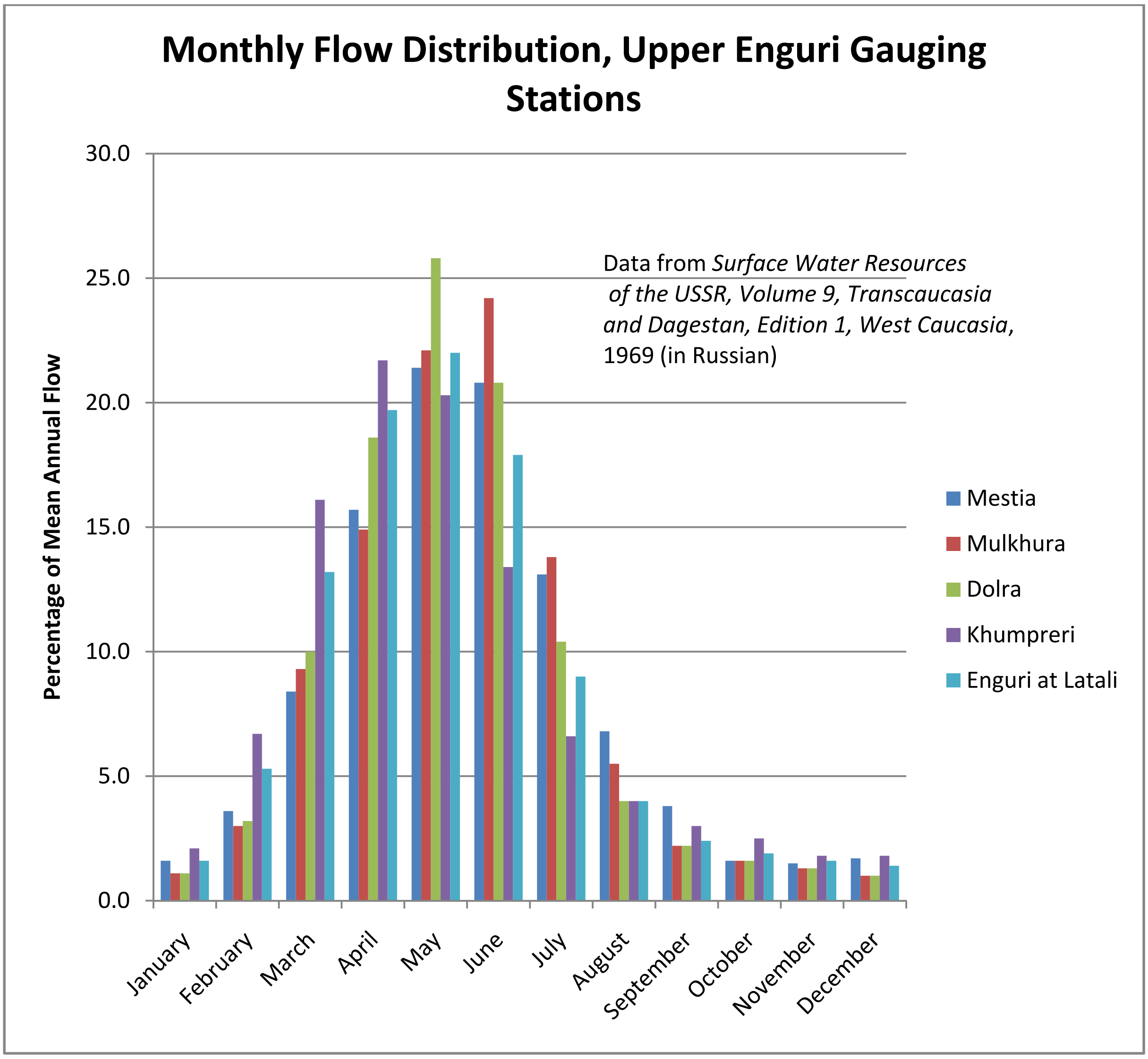
Project Description

The site of the proposed Khumpreri HPP is on the Khumpreri River upstream from its confluence with the Enguri River, in the Mestia District of northern Georgia's Samegrelo - Zemo Svaneti Region. This is one of the sites identified by Gross Energy during their recent work for Winrock/USAID and for the Ministry of Energy and Natural Resources. It is included in the MENR list of available development sites.

There are two scenarios for the development of this HPP—with and without construction of the proposed Khaishi Dam and Reservoir Project on the Enguri River. That potential future project would have a maximum reservoir elevation of 910 masl and encroach on the lower end of the Khumpreri River. Without Khaishi Reservoir, the tailwater elevation will be about 880 masl, gross head will be about 510 m, plant capacity will be 41.7 MW, and annual energy production will be approximately 171 GWh. With Khaishi, the gross head will be about 460 m, plant capacity will be about 37.4 MW, and average annual generation will be about 153 GWh.

The Khumpreri HPP is envisioned to be one of the plants in a possible four-HPP cluster (Khumpreri, Dolra 1, Dolra 2, and Dolra 3 HPPs) on the Dolra and Khumpreri tributaries of the Enguri River. There would be significant construction and operations advantages to a single developer if the decision were made to undertake the study, design, construction and operation of all the HPPs in this cluster.

The river flows in Upper Svaneti are very seasonal. Discharges are low during winter months when most precipitation falls as snow, and are high during spring and summer when melt-water and rain runoff are combined. The variability is demonstrated in the following chart, which shows the seasonality of flow at gauging stations in the upper Enguri River basin:



Sediment loads in the Khumpreri River will vary from day to day, but will be quite high, on average. Control measures will be required.

Two diversion points that seem suitable from topographic and geologic standpoints were identified. This report describes a project with the diversion structure located upstream from the site selected during previous studies. This alternative has a lower flow, but significantly higher head.

The preliminary project layout, based on information available at this time, includes a low diversion dam with sluice, a de-silting facility, a tunnel water conductor, penstock, a surface powerhouse, open cut channel tailrace, substation, and a short transmission line, as shown on the Arrangement Drawing, Figure 1. Two Pelton turbines will probably be used at this high head site.

Project cost and construction schedule

The currently estimated cost of the Khumpreri HPP without Khaishi is US$ 43.1 million, or about US$ 1,034/kW of installed capacity, excluding VAT. 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 assessments 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 each year to take advantage of the seasonal differentials in power prices between Georgia and its neighboring countries.

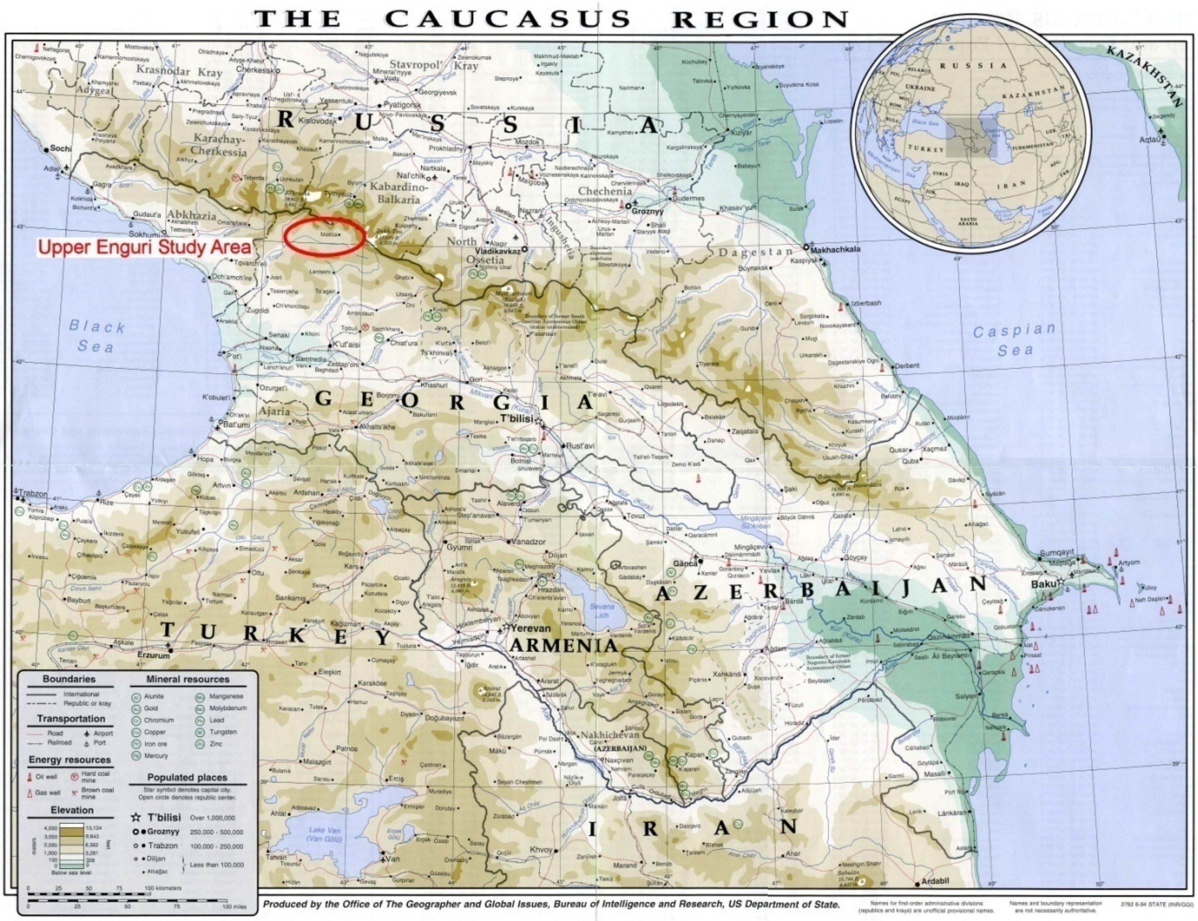
Table 1: Project Significant Data, Option A, without Khaishi Reservoir

General	
Project name	Khumpreri Hydropower Project
Project location (political)	Mestia District of northern Georgia's Samegrelo - Zemo Svaneti Region
Nearest town or city	Dizi village
River name	Khumpreri River
Watershed name	Khumpreri River Watershed
Drainage area at diversion	132.3 km^2
Financial Estimates	
Estimated construction cost, excluding VAT	$43.1 Million
Estimated cost per kW capacity	$1,034/kW

Hydrological Data (Adjusted to Intake Location)	
Stream gauge used	Khumpreri River near the mouth
Years of record	1956-1970
Gauge drainage area	160 km^2
Mean river flow at intake	5.35 m^3/s
Facility design discharge (m^3/s)	10 m^3/s
Preliminary design flood (100 yr return period)	165 m^3/s
Max. recorded flow	110 m^3/s
Mean annual flood	32.2 m^3/s
Diversion Facilities	
Normal operating level	1380 masl
Approximate dam height	10 m
Approximate diversion pond area	2 ha
De-silting structure	required
Sanitary or environmental bypass flow (assumed)	2%-10% of mean monthly flow for each month
Power Tunnel	
Tunnel length	6,380 m
Tunnel section (horseshoe shape)	2.2 m wide, 2.5 m high
Tunnel approximate effective diameter	2.8 m
Penstock	
Penstock length	860 m
Outside diameter	2,000 mm
Powerhouse	
Type	Above-ground
Installed capacity, at generator terminals	41.7 MW
Units and net capacity at high-voltage transformer terminals	2, 20.3 MW, 2-jet horizontal Pelton units, with jet deflectors
Rated speed	500 rpm
Preliminary generator voltage	15 kV or less, based on manufacturer’s recommendation
Rated generator capacity	2, 23.3 MVA at 0.90 Power Factor
Size of powerhouse	14 m x 30 m x 15 m high
Tailrace	
Length	20 m
Width	13 m
Type	Open channel
Normal tailwater elevation, without Khaishi Reservoir	870 masl
Normal maximum tailwater elevation, with Khaishi Reservoir	920 masl

Transmission line	
Interconnection location	New 110 kV or 220 kV line, by others, passing the HPP Substation
Distance to interconnection (km)	1.0 km or less
Voltage	110 or 220 kV
Power & Energy	
Gross head	510 m
Total head loss at rated discharge	17.5 m
Net head at rated discharge	492.5 m
Estimated average annual generation	Approximately 171 GWh
Nominal installed capacity	41.7 MW
Preliminary annual plant factor	47 %
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	Svaneti Planned Protected Areas

Project Location Map



1.0 GENERAL INTRODUCTION TO THE PROJECT

Table 2: Development Area Significant Data

Project Location (Political)	Northern Georgia's Samegrelo-Upper Svaneti (Zemo Svaneti) Region
Political Subdivisions	Mestia District
Area Population	14,248
Nearest Town or City	Dizi
River Name	Khumpreri
Economic Activity in the Area	Primarily agriculture, logging and wood products for construction; previously marble quarrying.
Special Natural Resources	Timber, glaciers, mineral and building stone deposits.
Special Cultural Resources	Churches, monasteries, Svan defensive towers, hot springs, etc.
Critical Environmental Receptors	Svaneti Planned Protected Area

1.1 PROJECT AREA SOCIAL CHARACTERISTICS

The Khumpreri Project area is located in Mestia Municipality, which is part of the Samegrelo-Upper Svaneti Region Administrative Unit. The Mestia Municipality occupies the upper part of the Enguri River watershed and is located between the elevations of 800 m and 5,070 m above sea level. Mestia Municipality occupies a total area of 3,044.5 km^2. The population for the whole district is about 14,248, giving a population density of 4.7 people/km^2. Of the residents, 99.4% are Georgians. The area is mainly populated by ethnic Svans.

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Mestia is one of the most popular tourist spots in the country, due to rich natural, cultural and historical assets. The Upper Svaneti area is listed among the UNESCO World Heritage Sites. Planned Protected Areas within the Mestia Municipality occupy 46,122 ha. Extensive tourist developments are under construction or planned for the area. These include a world-class skiing and winter sports destination resort.

The Khumpreri Project area lies near the Lakhamuli community. The nearest settlement to project site is the village of Dizi, which is located at the elevation of 1,080 m above sea level and is 48 km from Mestia. Dizi population is 105 (population census, 2002). The Lakhamuli community is rich in mineral resources. Marble deposits are found near the village of Dizi, and some small outcrops were noticed during HIPP's reconnaissance trip to the Khumpreri site.

1.2 PROJECT AREA ENVIRONMENTAL CHARACTERISTICS

Flora: The Enguri River watershed in the Upper Svaneti is rich in biological resources. Plants are distributed according to the vertical zoning here. Mixed mountain forests and alpine meadows are common to the area. Sub-nival and nival belts (snow-influenced vegetation belts) range between 3200 m and 3800 meters above sea level. The Enguri River watershed is rich in relict and endemic species. Svaneti flora counts for 1100 species of vascular plants, 264 of which are endemic.

Mountain forests (1200-1900 masl) distributed on the Southern Caucasus and Svaneti ranges along Nenskra, Nakra, Mestiatchala, Mulkhura and other rivers usually have broad-leaf species dominating at the lower altitudes and conifers leading at the upper elevations. Mixed mountain forests are distributed within the project area along the Khumpreri River. High mountain oak, beech, hornbeam, alder, and lime-tree are prominent in deciduous forests; while pine and fir trees with an irregular distribution of spruce are dominant among conifers.

Fauna: The Enguri River watershed area shelters up to 55 species of mammals, 152 of birds, 7 reptile, 3 amphibian and 35 fish species. Brown bear, wolf, jackal, fox, European wild cat, pine marten, roe deer, common otter, and mink are found in mountain forests; while Caucasian shrew, long-clawed vole, and West and East Caucasian tur (goat-antelopes) inhabit subalpine and alpine zones of Svaneti. A diverse population of falcons, eagles, hawks, woodpeckers, owls, pigeons, passerines, and near-passerines is distributed within the Enguri watershed. Common trout, Crimea barbel, Colchic nase, chub, minnow, and gudgeon are among fishes dwelling in the Enguri river and its tributaries.

Some of the resident species are among the “red-list” species of Georgia, including West Caucasian tur (Endangered), East Caucasian tur (Vulnerable), Brown bear (Endangered), Black Grouse (Vulnerable), common trout (Vulnerable), etc.

(Source: Upper Svaneti Protected Areas Management Plan, 2008)

1.3 TRANSMISSION

The existing transmission system includes a 35 kV line from a substation at the Khudoni Dam construction site to Mestia, and lower-voltage lines radiating out from there. The system has been very unreliable and there are low voltage and system stability problems.

A program to remedy these problems has been planned and construction is underway. A new 110 kV line has been completed from Mestia, up along the Mulkhura and Enguri Rivers to Kala. This line will soon be extended over the Svaneti Range to the Tskhenistskali River valley, where it will connect at Jakhunderi to an existing 110 kV line from the Lajanuri HPP substation. The existing system, together with the improvements now under construction, may be adequate to evacuate power from a few of the proposed hydro projects in the upper Enguri River basin. Any significant level of hydro development, however, will require new connections to the 220 kV substation to be constructed for the Nenskra HPP (assuming it is built) or to other substations. These new lines and substations will probably be 220 kV. This situation is being considered in the Georgian State Electrosystem’s (GSE’s) initial planning for future transmission development in the area.

The Khumpreri HPP is located immediately adjacent to the 35 kV Khudoni to Mestia line. However, the capacity of that line will not be adequate to carry the Khumpreri output. GSE is currently planning transmission improvements in the immediate area to accommodate the many new hydro project developments that have been proposed. Their plans are expected to include a new 110 kV and/or 220 kV transmission line passing the Khumpreri power plant, which will be connected to the new line.

1.4 ACCESS TO THE AREA

A new airport recently opened in Mestia, and daily prop-jet flights are available from Tbilisi.

Highway access to the Upper Enguri Basin is much improved over the situation only a year ago. The road from Zugdidi (the Regional Capital) to Mestia has been completely rebuilt and repaved, with new drainage, short tunnels to bypass some dangerous curves, guide rails along steep drop-offs, etc. It is now possible to drive from Tbilisi to Mestia in less than 7 hours. This road is expected to be kept open throughout the winter to accommodate winter sports enthusiasts as well as local residents.

The main roads beyond Mestia and the local roads are unpaved, without exception. They are in fairly good condition and are regularly maintained, but are often passable only by trucks, buses, and 4-wheel-drive vehicles with adequate ground clearance. Some are closed during the winter and all are subject to temporary closure due to snow, avalanches, rockfalls, landslides, floods, etc. Not all minor stream crossings have bridges.

The Roads Department in the Ministry of Regional Development and Infrastructure has recently announced a GEL 50 million project to rehabilitate the main road between Mestia and Ushguli. Tendering for construction is expected to begin by the end of 2011 or early 2012, and work is expected to proceed at an accelerated pace.

Some of the high-elevation intake areas (Khumpreri, Dolra 1 and Mestiatchala 1, for example) are accessible only on foot or horseback at this time. Access will have to be improved or developed for construction and project operation in those areas.

At Khumpreri, there are deteriorated bridges and an abandoned roadway that provided vehicle access up the valley at some time in the past. These could be quickly upgraded to provide temporary access, but construction and operation of the project will require more substantial improvements over a distance of about 8 km.

<table>
<tr><td></td><td></td></tr>
<tr><td>Suspension bridge across the Enguri River, leading to the Khumpreri Valley</td><td>A path, once a road, passes up the Khumpreri Valley</td></tr>
</table>

2.0 BASELINE CONDITIONS

2.1 DATA AVAILABILITY

Maps. Soviet-era topographic maps are available for the entire study area at 1:200,000; 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. The entire area is probably covered at this scale, but funds are not available to purchase scanned copies of the sheets missing from our source's files. 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 1:50,000 and 1:25,000. Information from these maps has been used to prepare the Project Geologic Map, Figure 3.

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.

2.2 HYDROLOGY AND WATER RESOURCES

Table 3: Hydrology Significant Data

Records available	Mean monthly flows for 13 years for the "Khumpreri River near the mouth" gauging station, from publications of the predecessors of the Department of Hydrometeorology. Flood flow peaks for 14 years. Daily records exist, but could not be obtained for this study
Method of analysis	Monthly
Drainage area at gauge	160 km^2
Total drainage area for Khumpreri HPP	132.3 km^2
Adjustment factor	0.827
Maximum plant discharge	10.0 m^3/s
Minimum plant discharge	As low as 0.6 m^3/s
Flood flows	Average Annual Flood (2.33 yr return period) = 32 m^3/s*
Highest recorded flow	110 m^3/s*
Calculated 100 year flood	165 m^3/s*, but based on a short period of record (14 years)
Recommended additional data collection and study recommendations for feasibility and design	Re-establish a stream flow gauging station near the mouth of the river or at another suitable location below the proposed diversion point. This stream gauge location would also be used for monitoring of suspended and bedload sediments, water quality parameters, water temperature, fish, etc.

*These flood flows are based on a simple drainage area ratio adjustment of the Khumpreri 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 4: Khumpreri HPP Intake, Characteristic Discharge Information

Annual average flow (m^3/s)	5.54
Maximum recorded monthly average flow (m^3/s)	23.7
Minimum recorded monthly average flow (m^3/s)	0.72
Average monthly discharge during seasonal runoff period (April through September) (m^3/s)	9.40
Average monthly discharge during winter season (Oct – March) (m^3/s)	1.66
Average discharge during Georgian winter peak electric demand period (Dec-Feb) (m^3/s)	1.31
Assumed river discharge reserved for environmental/sanitary and other beneficial natural channel functions and values*	2-10% of average monthly discharge, for each month

* This percentage range is a conservative average. Examination of the immediate tributary flows into the Khumpreri River between the diversion dam and the powerhouse suggest that for several if not most of the months of the year reserved flows for in-stream environmental and sanitary requirements may not be required. It is recommended that this issue be included as part of detailed feasibility studies in so far as the amount of energy potential to be gained if reserves are not required could be significant (on the order of 5% of average annual generation).

Table 5: Mestia 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
Lowest Air Temperature in °C	-31	-27	-24	-16	-3	-1	1	1	-4	-14	-24	-27		-31
Lowest Average monthly Air Temperature in °C	-10.5	-9.2	-5.6	0.2	5.0	7.5	10.0	9.4	5.9	1.4	-2.5	-7.8	0.3	
Average Monthly Air Temperature in °C	-5.7	-4.0	-0.5	5.6	10.9	13.8	16.6	16.2	12.0	6.8	2.0	-3.5	5.8	
Highest Average Monthly Air Temperature in °C	0.6	2.8	6.4	12.5	18.1	21.3	24.9	24.8	20.6	14.7	8.7	2.2	13.1	
Highest Monthly Air Temperature in °C	11	15	21	27	29	31	38	35	33	27	23	14		38
Average Relative Humidity in %	79	77	74	72	70	70	71	72	77	78	80	82	75	
Average Monthly Precipitation, liquid, in mm	1	2	7	45	82	89	84	89	83	68	29	4		583
Average Monthly Precipitation, solid, in mm	59	46	45	11	1	1	0	0	1	6	20	58		248
Average Monthly Precipitation, mixed, in mm	5	10	21	24	5	1	0	0	2	24	26	16		134
Average Monthly Precipitation, with wetting corrections, in mm	65	58	73	80	88	91	84	89	86	98	75	78		965
Average Monthly Wind Speed in m/s	0.6	0.7	1.0	1.4	1.4	1.2	1.2	1.1	0.9	0.6	0.4	0.4	0.9	

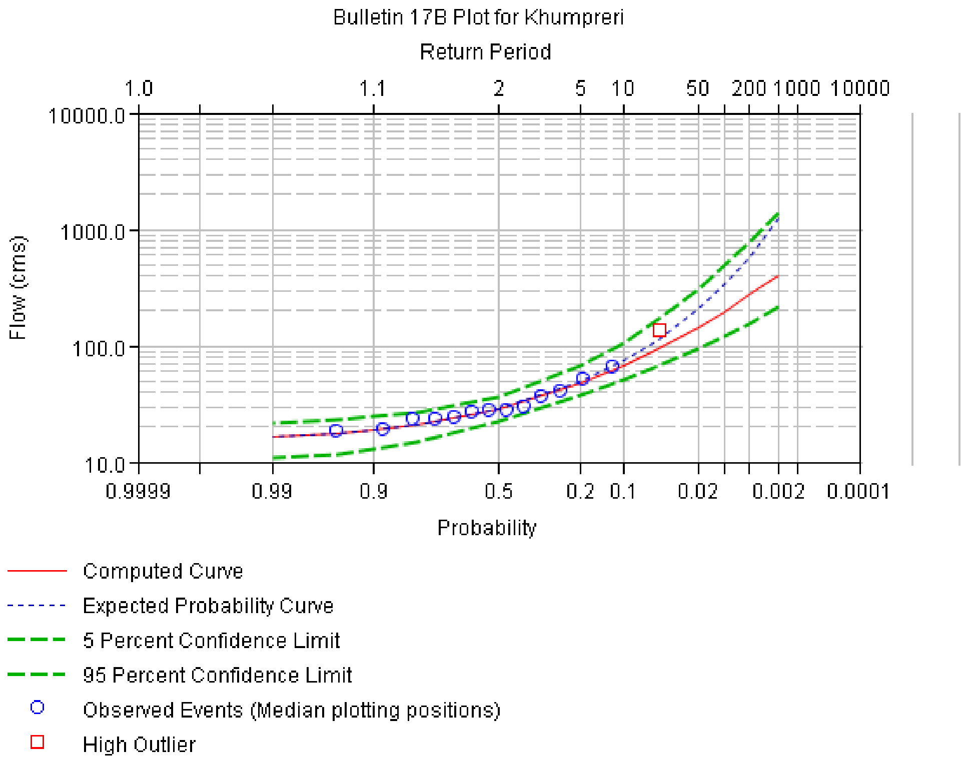
Source: Data on climate and meteorology for Mestia was taken from ***Scientific-Practical Handbook of the Climate of the USSR***, Series 3, Parts 1-6, Issue 14, Soviet Socialist Republic of Georgia, Gidrometeoizdat, Leningrad, 1990 (in Russian).

2.3 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 14 years of peak flood flow data are available for the Khumpreri streamflow 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 are shown on the following plot:



These flood flows were adjusted to the diversion location using a simple drainage basin area ratio.

Because of the very short period of record, the probabilities of only relatively common flood events should be considered reliable. 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.

2.4 SEDIMENT

Sediment content of the Khumpreri River is highly variable, but will be quite high on average. This was apparent during a HIPP field reconnaissance trip to the area during late 2011. On the first day of the visit, the flow in the river was moderate and the water was nearly clear. Several days later, following a series of rainy days including one strong storm, the river flow was much higher and the water was carrying a very heavy suspended sediment load.

It was not possible to obtain historic sediment data for the Khumpreri River gauge during this assessment study, but it is believed that such data were collected by Tbilisi HydroProject, which installed and operated the gauge during the 1950s and 1960s. Every attempt to obtain that data and acquire new sediment data should be made during feasibility studies. Suspended solids, bedload, grain size distribution, and mineralogical data are needed for design of the de-silting structure and to prepare turbine specifications that account for the erosive properties of particles that are not removed.

2.5 GLACIATION AND CLIMATE CHANGE IMPACTS

The headwaters of the Khumpreri River are in the Svaneti Range, with a maximum watershed elevation of about 4009 masl at Mount Lahili. The Laila Glacier extends northwestward down to the Laila River, one of the two major forks of the Khumpreri River. Several smaller glaciers are also located within the upper watershed, at elevations far above the Khumpreri intake.

View of Mt. Lahili and the surrounding glaciers, looking southward.
Image from Google Earth, taken by contributor "caucasica."

During project feasibility studies and design, the possibility of unexpected events in the upper watershed must be considered. These would include formation of lakes on or above glaciers, avalanches or large landslides; short-term increases in sediment and debris discharges; sudden flood releases from lakes (glacial lake outflow floods); sudden flow disruption by avalanches or landslides, etc.

In the long term, a developer must consider whether changes in climate (global warming) might affect the amount and seasonal timing of discharges from the watershed. Since the life of a hydropower plant is typically 100 years or more, changes in operational requirements or the revenue stream could occur during the project lifetime.

3.0 GEOLOGY

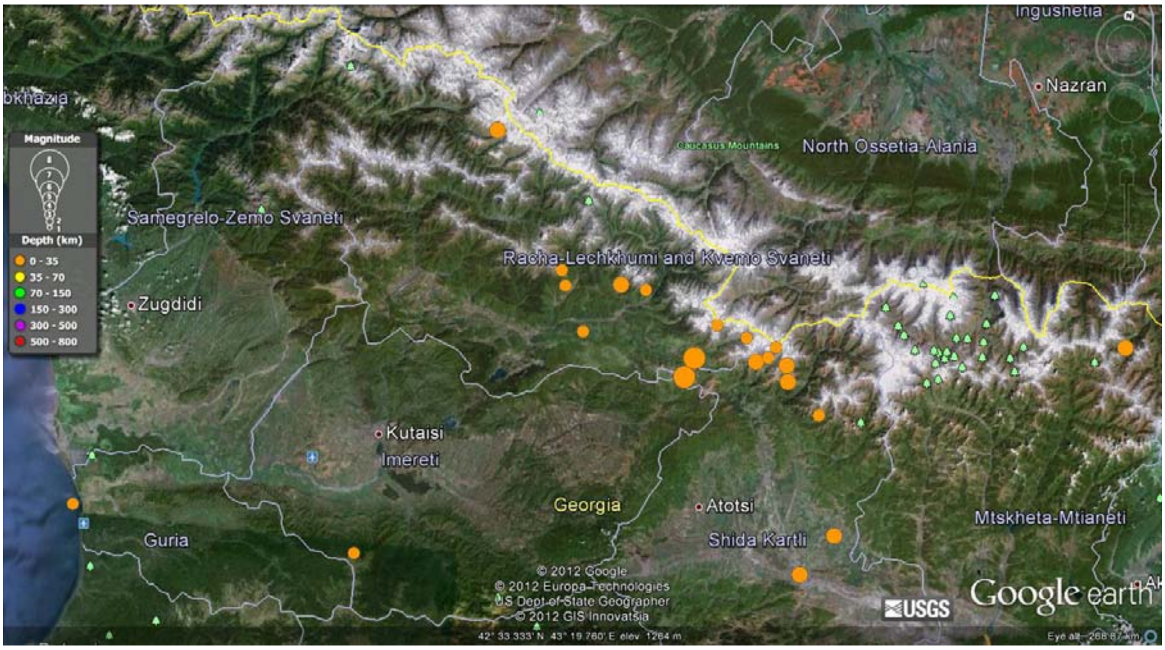
3.1 GEOLOGICAL MAP

The geologic data available at the time of this study included geologic maps at the scales of 1:500,000, 1:50,000, and 1:25,000; and field reconnaissance notes by HIPP's consulting geologist. A geological map of the project area is shown in Figure 2. Interestingly, the maps indicate that there are significant mineral deposits in the general project area. The project water conductor alignment has been revised to avoid a marble deposit that may have some economic value. There is an inactive marble quarry in Dizi, just across the Enguri River from the mouth of the Khumpreri River. There are also rock formations within a few kilometers that may contain metallic minerals such as copper and gold.

3.2 SEISMOLOGY

The project site is within a very active seismic zone. The geology of the project area is within the Fold System of the Greater Caucasus (Gagra-Djava Zone) as defined by I. Gamkrelidze (2000). As a result of its location on the boundary of colliding tectonic plates, according to the current Georgian seismic zoning classification the project is in hazardous zone 9 (the zone with greatest hazard). 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 150 km of Mestia, taken from the United States Geological Survey databases of historic major earthquakes and of recent earthquakes.



Earthquake activity has been more frequent to the east of the Upper Svaneti projects, though the risk of large earthquakes is similar.

Table 6: Significant Earthquake Data

Date	Name	Mag.	MMI	Deaths	Damage	Distance From Mestia
April 14, 1275	Georgia	6.7		100-1000	Severe	155 km
1283		6.3				149 km
1350	Adishi Area	6.5				20 km
1688		5.3				176 km
September 22, 1888		6.1				194 km
December 31, 1899		5.6				167 km
Feb 20, 1920	Gori, Tiflis	6.2		100-1000	Severe	156 km
May 7, 1940		6.0				168 km
May 13, 1986		5.6				194 km
April 29, 1991	Racha: Dzhava, Chiatura, Ambrolauri	7.3	9	270	Extreme	95 km
June 15, 1991	Dzhava, Tskhinvali, Ossetia	6.5	8	8	Severe	116 km
October 23, 1992		6.8				197 km

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

3.3 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. It will be especially important to study the power tunnel crossing of the major fault on the right side of the Khumpreri Valley. Rock testing for tunnel construction planning and support design will also be needed.

4.0 HYDROPOWER PROJECT DESCRIPTION

4.1 GENERAL

The Khumpreri HPP development is expected to include a diversion weir across the Khumpreri River, intake structure, de-silting structure, power tunnel, penstock, and surface powerhouse. A substation will be located near the plant, and a short transmission line will connect to a line, owned by others, along the Khaishi to Mestia Road.

A short, excavated tailrace channel will convey water from the powerhouse to the river.

There are two possible scenarios for tailwater: with and without the Khaishi Dam and Reservoir project development. The natural tailwater without Khaishi Reservoir is about 870 masl. The proposed maximum operating reservoir elevation for Khaishi is 910 masl. Since Pelton turbines will be used for the Khumpreri HPP, the runner centerlines must be at least 3.5 m above the maximum tailwater surface. For energy studies we have assumed a conservative setting of 5 meters above tailwater, or at 875 masl without Khaishi. For the with-Khaishi option, a revised powerhouse location along the Khumpreri River has been selected. It will have a tailwater elevation of about 920 masl, and the runner centerline is assumed to be set at 925 masl.

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 Khumpreri 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).

Overall views of the project arrangements for options with and without the Khaishi Reservoir are shown in Figures 1A and 1B.

4.2 DIVERSION FACILITIES

The diversion for the run-of-river Khumpreri HPP will be located a short distance below the confluence of the two main forks of the river—the Laila River and the Leshkuri River. It will include a concrete overflow spillway section and a large sluice controlled by a radial gate. The power intake will be located immediately adjacent to the sluice, on the right 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 with two parallel low-velocity reinforced concrete channels, each controlled by gates that permit operators to use one or both of the channels. Another open-channel transition will direct the flow into the power tunnel intake.

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.

4.3 WATER CONDUCTORS

The main water conductor will be a low-pressure tunnel from the de-silting structure to the hillside above 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. The alignment shown on the project arrangement drawing has been kept relatively close to the mountain slope, so intermediate adits can be drilled for access, ventilation, and muck removal if a contractor so chooses.

The tunnel alignment for the section closest to the Enguri River has been adjusted to avoid a marble deposit identified on the 1:50,000 geological map of the area. That map shows a boundary that may indicate that a mining concession has been granted. This deposit appears to be related to the Dizi marble deposit, which was mined directly across the Enguri River from the mouth of the Khumpreri. The Dizi deposit was reported to be of excellent quality, and stone from the quarry was used in the construction of the Moscow subway system. The Dizi mine is no longer active.

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. Where the tunnel crosses faults or other areas of weakness, steel supports and reinforced concrete lining will probably be needed. For cost estimating purposes, 80 percent unlined and 20 percent lined has been assumed.

A 2-m-diameter steel penstock, about 860 m long, is proposed to carry the flow from the tunnel portal to the powerhouse below.

4.4 POWER PLANT

The powerhouse is expected to be a surface structure located along the Enguri River, for the without-Khaishi Reservoir option.

Table 7: Turbine Characteristics, Option A, without Khaishi Reservoir

Unit	Speed, rpm	Runner Pitch Diameter, mm	Design Flow, m3/s	Minimum Flow, m3/s	Maximum Turbine Power, MW	Minimum Turbine Power, MW
No. 1	500	1,759	5.0	1.0	21.8	4.1
No. 2	500	1,759	5.0	1.0	21.8	4.1
Plant Total			10.0		43.5*	

*The plant total output is lower than the sum of the two unit outputs, since head losses are greater with both units operating.

This installation will result in a maximum electric power output, at the high-voltage transformer terminals, of about 40.5 MW, as shown in the following table:

Table 8: Khumpreri Output Summary, Option A, without Khaishi Reservoir

Khumpreri Unit Output Summary, Option A, Without Khaishi Reservoir				
Two Equal Pelton Turbines				
Description	**Efficiency**	**Unit 1**	**Unit 2**	**Plant**
Design Flow, m^3/s		5.0	5.0	10.0
Gross Head, m		510.0	510.0	510.0
Runner Centerline to Tailwater Drop, m		5.0	5.0	5.0
Intake and Desilting Facility Losses		1.0	1.0	4.0
Friction Head Losses, m		10.5	10.5	12.5
Total Head Loss		16.5	16.5	21.5
Head Losses, % Gross Head		3.24%	3.24%	4.22%
Net Head at Design Flow, m		494.5	494.5	492.5
Turbine Output, MW	90.00%	21.8	21.8	43.5
Generator Output, MW	96.00%	21.0	21.0	41.7
Generator kVA at 0.90 PF		23.3	23.3	46.4
Transformer Output, High-Voltage Side, MW	97.00%	20.3	20.3	40.5

For the with-Khaishi option, the surface powerhouse would be located along the Khumpreri River, about 800 m south of the confluence with the Enguri. This places the development above the maximum operating level of the reservoir, 910 masl. It will also be south of the marble deposit in the area. The gross head will be 460 m. Turbine characteristics are summarized in the following table:

Table 9: Turbine Characteristics, Option B, with Khaishi Reservoir

Unit	Speed, rpm	Runner Pitch Diameter, mm	Design Flow, m^3/s	Minimum Flow, m^3/s	Maximum Turbine Power, MW	Minimum Turbine Power, MW
No. 1	428.6	1,989	5.0	1.0	19.6	4.1
No. 2	428.6	1,989	5.0	1.0	19.6	4.1
Plant Total			10.0		39.0*	

*The plant total output is lower than the sum of the two unit outputs, since head losses are greater with both units operating.

#

Table 10: Khumpreri Output Summary, Option B, with Khaishi Reservoir

Khumpreri Unit Output Summary, Option B, with Khaishi Reservoir				
Two Equal Pelton Turbines				
Description	**Efficiency**	**Unit 1**	**Unit 2**	**Plant**
Design Flow, m^3/s		5.0	5.0	10.0
Gross Head, m		460.0	460.0	460.0
Runner Centerline to Tailwater Drop, m		5.0	5.0	5.0
Intake and Desilting Facility Losses		1.0	1.0	3.0
Friction Head Losses, m		10.0	10.0	10.0
Total Head Loss		16.0	16.0	18.0
Head Losses, % Gross Head		3.48%	3.48%	3.91%
Net Head at Design Flow, m		444.0	444.0	442.0
Turbine Output, MW	90.00%	19.6	19.6	39.0
Generator Output, MW	96.00%	18.8	18.8	37.5
Generator kVA at 0.90 PF		20.9	20.9	41.6
Transformer Output, High-Voltage Side, MW	97.00%	18.3	18.3	36.3

4.5 ACCESS IMPROVEMENTS

The existing suspension bridge across the Enguri River will be replaced by a new structure with a higher load rating before construction begins. The span will be relatively short, probably about 50 to 60 meters long, if the Khaishi Reservoir is not built; but it would have to be much longer to connect a relocated main road from Enguri Dam to Mestia (assumed to remain on the right bank of a reservoir) and the Khumpreri powerhouse and access road to the intake on the left bank.

Two new bridges across the Khumpreri River will be needed. The spans will probably be in the 10 to 20 m range.

This old log bridge along the Khumpreri intake access route will be replaced to provide safe access for construction, operation, and maintenance.

The existing trail leading up the Khumpreri River valley to the diversion dam and intake, about 8 km long, must be rebuilt into a permanent road for construction and operation and maintenance purposes.

About 1,000 m of new road will be built along the south bank of the Enguri River, to reach the power plant site from the new Enguri bridge, for the without-Khaishi development option.

4.6 TRANSMISSION

The power plant substation will be located adjacent to the powerhouse, and will include two transformers to raise the generator voltage to 110 kV or 220 kV for connection to a new 110 kV or 220 kV line that is expected to be built up through the Enguri River valley. The connecting transmission line will be about 200 m long for the without-Khaishi option, and less than 1,000 m long for the with-reservoir option.

It is assumed that the new 110 kV and 220 kV lines needed to collect the energy generated by projects in the Upper Svaneti area will be built by GSE, and that the costs for the lines will be recovered through transmission (wheeling) tariffs.

5.0 POWER AND ENERGY STUDIES

5.1 AVAILABLE FLOW DATA

Monthly streamflow data were used for this study. Daily data exists, but was not available to be used in the Project Evaluation Studies. The following table lists the gauging station data that is believed to be available, and the current status of data collection:

Table 11: Stream Gauges in the Upper Enguri Watershed

River	Location	Drainage Area, km^2	Period of Record	Gauge Owner	Comments
Enguri	Ipari	362	1967-1980 + ??		have monthly
Enguri	Latali	975	1935-1938; 1955-1965++		have monthly
Enguri	Lakhamula	1,410	1933-1942		short record
Enguri	Tobari Dam Site	1462	1933-1978	HydroProject Institute	no information
Enguri	Dizi	1,760?? 1,620??	1932-1942; 1956-??; Khudoni FS got 1980-1989	HydroMet	have daily 1980-1989. Different areas reported.
Mulkhura	Cholashi	186	1931-1932		very short record
Mulkhura	at mineral spring (Mestia)	197	1962-1980++		have monthly
Mulkhura	Latali	420	1932-1938 or 1933-1937?		very short record
Mestiatchala	Mestia	144	1939, 1940, 1942, 1943; 1946-1980++	HydroMet	have daily flows to 1975, monthly to 1980
Dolra	Becho	146	1930-1933; 1956-1965++	HydroProject Institute	very limited daily data received
Khumpreri	near mouth	160	1956-1965++	HydroProject Institute	very limited daily data received, monthly used

Note: data from the highlighted stations are being used in studies.

Drainage areas for the sub-basins have been computed using a digital terrain model of the upper Enguri River basin, developed from Soviet topography. These numbers have been supplemented and checked using areas measured from Soviet-era topographic maps using AutoCAD. These areas are shown on Figure 4, and are summarized in the spreadsheet file that follows Figure 4.

5.2 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. The minimum sanitary flow requirement is set at 10 percent of the minimum monthly flow ever experienced at the diversion site. This is generally a very low flow.

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 organisms 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. For this assessment study, assumed levels of bypass flow that vary from month to month have been adopted to estimate the flow actually available for power generation. They are shown in the two tables in the following section.

5.3 AVERAGE MONTHLY FLOW ANALYSIS:

Table 12: Khumpreri HPP Power and Energy Calculations, Option A, without Khaishi Reservoir

Khumpreri A HPP															
Hydropower Calculations for Average Monthly Flows												Q_{HPP}=	10	m³/sec	
Months	Mean Monthly River flow Q_v, m³/sec	Bypassed percent of mean monthly flow, %	Bypass (sanitary) Flow Q m³/sec	HPP Flow Q_{HPP}, m³/sec	Diversion water level elevation ▼$_{upstream}$ m	Tailwater elevation, ▼$_{downstream}$ m	Gross head H_{gross}, m	Total head loss Sh, m	Net head, H_{net}, m	Turbine efficiency h_t, %	Turbine total capacity N_t, kW.	Generator efficiency h_g, %	Unit capacity N_i, kW.	Number of hours per month T h.	Generated Energy, GWh.
I	1.12	10	0.112	1.01	1380.00	870.00	510.00	14.840	495.16	0.90	4423	0.96	4,246	744	3.159
II	1.11	10	0.111	1.00	1380.00	870.00	510.00	14.839	495.16	0.90	4360	0.96	4,186	672	2.813
III	1.30	10	0.130	1.17	1380.00	870.00	510.00	14.849	495.15	0.90	5118	0.96	4,914	744	3.656
IV	4.45	3	0.133	4.32	1380.00	870.00	510.00	15.309	494.69	0.90	18847	0.96	18,093	720	13.027
V	10.52	5	0.52	10.00	1380.00	870.00	510.00	17.477	492.52	0.90	43485	0.96	41,745	744	31.059
VI	13.57	26	3.57	10.00	1380.00	870.00	510.00	17.477	492.52	0.90	43485	0.96	41,745	720	30.057
VII	13.01	23	3.01	10.00	1380.00	870.00	510.00	17.477	492.52	0.90	43485	0.96	41,745	744	31.059
VIII	8.75	3	0.263	8.49	1380.00	870.00	510.00	16.733	493.27	0.90	36975	0.96	35,496	744	26.409
IX	4.30	5	0.215	4.09	1380.00	870.00	510.00	15.258	494.74	0.90	17861	0.96	17,146	720	12.345
X	2.60	6	0.156	2.45	1380.00	870.00	510.00	14.972	495.03	0.90	10689	0.96	10,261	744	7.634
XI	1.95	7	0.137	1.81	1380.00	870.00	510.00	14.900	495.10	0.90	7932	0.96	7,615	720	5.483
XII	1.56	10	0.156	1.40	1380.00	870.00	510.00	14.865	495.14	0.90	6129	0.96	5,884	744	4.378
Gross average annual generation excluding losses													**171.078**	GWh	
Estimated energy losses from outages, substation losses 5%													**8.554**	GWh	
Average annual energy for sale													**162.524**	GWh	
HPP operation duration per year													**4098**	h	
Capacity usage ratio/efficiency (plant factor)													**0.47**		

Table 13: Khumpreri HPP Power and Energy Calculations, Option B, with Khaishi Reservoir

Khumpreri B HPP															
Hydropower Calculations for Average Monthly Flows												Q_{HPP}=	10	m^3/sec	
Months	Mean Monthly River flow Q_w, m^3/sec	Bypassed percent of mean monthly flow, %	Bypass (sanitary) 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 Sh, m	Net head, H_{net}, m	Turbine efficiency h_t, %	Turbine total capacity N_t, kW.	Generator efficiency h_g, %	Unit capacity N_i, kW.	Number of hours per month T h.	Generated Energy, GWh.
I	1.12	10	0.112	1.01	1380.00	920.00	460.00	15.686	444.31	0.90	3969	0.96	3,810	744	2.835
II	1.11	10	0.111	1.00	1380.00	920.00	460.00	15.685	444.32	0.90	3912	0.96	3,756	672	2.524
III	1.30	10	0.130	1.17	1380.00	920.00	460.00	15.694	444.31	0.90	4593	0.96	4,409	744	3.280
IV	4.45	3	0.133	4.32	1380.00	920.00	460.00	16.084	443.92	0.90	16913	0.96	16,236	720	11.690
V	10.52	5	0.52	10.00	1380.00	920.00	460.00	17.924	442.08	0.90	39031	0.96	37,470	744	27.877
VI	13.57	26	3.57	10.00	1380.00	920.00	460.00	17.924	442.08	0.90	39031	0.96	37,470	720	26.978
VII	13.01	23	3.01	10.00	1380.00	920.00	460.00	17.924	442.08	0.90	39031	0.96	37,470	744	27.877
VIII	8.75	3	0.263	8.49	1380.00	920.00	460.00	17.293	442.71	0.90	33185	0.96	31,858	744	23.702
IX	4.30	5	0.215	4.09	1380.00	920.00	460.00	16.041	443.96	0.90	16027	0.96	15,386	720	11.078
X	2.60	6	0.156	2.45	1380.00	920.00	460.00	15.798	444.20	0.90	9591	0.96	9,208	744	6.851
XI	1.95	7	0.137	1.81	1380.00	920.00	460.00	15.737	444.26	0.90	7118	0.96	6,833	720	4.920
XII	1.56	10	0.156	1.40	1380.00	920.00	460.00	15.707	444.29	0.90	5500	0.96	5,280	744	3.928
Gross average annual generation excluding losses													153.541	GWh	
Estimated energy losses from outages, substation losses 5%													7.677	GWh	
Average annual energy for sale													145.864	GWh	
HPP operation duration per year													4098	h	
Capacity usage ratio/efficiency (plant factor)													0.47		

6.0 ENVIRONMENTAL AND SOCIAL STUDIES

6.1 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 1 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.

Affected Environment Assessment: The Khumpreri 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 facility this is a short term impact period of approximately 3 years. It includes all phases of construction from initial land and water resource disturbance to startup of plant operations.
>
> Operations: 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 Khumpreri HPP) are expected to be Low, based on information that is available at this time.

One impact category that will be very important for most of the hydro project developments in the upper Enguri River basin is the protection and preservation of historic and cultural monuments and artifacts. Appendix 2 is a list of the ***many*** areas and specific sites in Upper Svaneti 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 Khumpreri HPP, there are no listed or known cultural or archeological sites within or near the development area.

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

7.0 PROJECT COST ESTIMATE AND CONSTRUCTION SCHEDULE

7.1 ASSUMPTIONS

These cost estimates do not include any customs duties or Georgian Value Added Tax that may be the responsibility of the contractors and/or the project owner.

The price level is February 2012. All costs were developed in US$ or were converted to US$ at exchange rates effective in February 2012.

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 twelve pre-feasibility studies completed by HIPP, the Mtkvari HPP Feasibility Report prepared by Verkis, and the contracted prices for the Bakhvi Project construction work (underway as of this writing), 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.

7.2 OPTION "A" ESTIMATE – WITHOUT KHAISHI

Table 14: Khumpreri HPP Estimated Capital Expenditure, Option A, Without Khaishi Reservoir

	Units	Amt	Unit Cost	Total US$
Land purchase	ha	5	$12,000	$60,000
Preparatory & infrastructure works	LS			$800,000
New Bridge above Riv. Enguri	m	50-60		$600,000
New Bridge above Riv. Khumpreri (Qty 2 bridges)	m	2x25		$800,000
New access road (8 m wide gravel)	m	4,700	$130	$611,000
Improvement of existing access road	m	9,000	$20	$180,000
Stream diversion and cofferdams	LS			$350,000
Main Dam & Intake Structure	LS			$1,500,000
De-silting Structure	m	45		$320,000
Covered Canal (2.2x2.5m)	m	85	$450	$38,250
Tunnel including rock bolts & shotcrete	m	5,840	$950	$5,548,000
Adits	m	300	$800	$240,000
Pressure Tank	LS			$520,000
Steel Penstock (D=2m)	m	860	$1,750	$1,505,000
Above ground power house	LS			$1,200,000
Tailrace canal	m	20	$450	$9,000
Switchyard	MW	41.7	$7,750	$323,175
Electric and mechanical parts (turn-key) *	MW	41.7	350,000	$14,595,000
Grid connection transmission line @ 110 kV	km	1	150,000	$150,000
Subtotal of Schedule Items				**$29,349,425**

Geology (investigation field, lab and office) @ 1.5%	LS			$440,000
Feasibility study @ 1%	LS			$293,000
EIA @ 1%	LS			$293,000
EPCM @ 14%	LS			$4,109,000
Contingencies @ 25%	LS			$8,621,106
Total, excluding VAT				**$43,105,531**
MW Capacity	**41.70**	**CAPEX/kW**		**$1,034**

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

OPTION "B" ESTIMATE – WITH KHAISHI RESERVOIR

Table 15: Khumpreri HPP Estimated Capital Expenditure, Option B, with Khaishi Reservoir

	Units	Amt	Unit Cost	Total US$
Land purchase	ha	5	$12,000	$60,000
Preparatory & infrastructure works	LS			$800,000
New Bridge above Riv. Enguri	m	120		$1,800,000
New Bridge above Riv. Khumpreri (Qty 2 bridges)	m	2x25		$800,000
New access road (8 m wide gravel)	m	4,300	$130	$559,000
Improvement of existing access road	m	8,350	$20	$167,000
Stream diversion and cofferdams	LS			$350,000
Main Dam & Intake Structure	LS			$1,500,000
De-silting Structure	m	45		$320,000
Covered Canal (2.2x2.5m)	m	85	$450	$38,250
Tunnel including rock bolts & shotcrete	m	6,180	$950	$5,871,000
Adits	m	200	$800	$160,000
Pressure Tank	LS			$520,000
Steel Penstock (D=2m)	m	730	$1,750	$1,277,500
Above ground power house	LS			$1,200,000
Tailrace canal	m	20	$450	$9,000
Switchyard	MW	37.5	$7,750	$290,625
Electric and mechanical parts (turn-key) *	MW	37.5	350,000	$13,125,000
Grid connection transmission line @ 110 kV	km	1	150,000	$150,000
Subtotal of Schedule Items				**$28,997,375**
Geology (investigation field, lab and office) @ 1.5%	LS			$435,000
Feasibility study @ 1%	LS			$290,000
EIA @ 1%	LS			$290,000
EPCM @ 14%	LS			$4,060,000
Contingencies (Assumptions Variable) @ 25%	LS			$8,518,094
Total, excluding VAT				**$42,590,469**
MW Capacity	**37.50**	**CAPEX/kW**		**$1,136**

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

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3C	Geologic Legend, Sheet A
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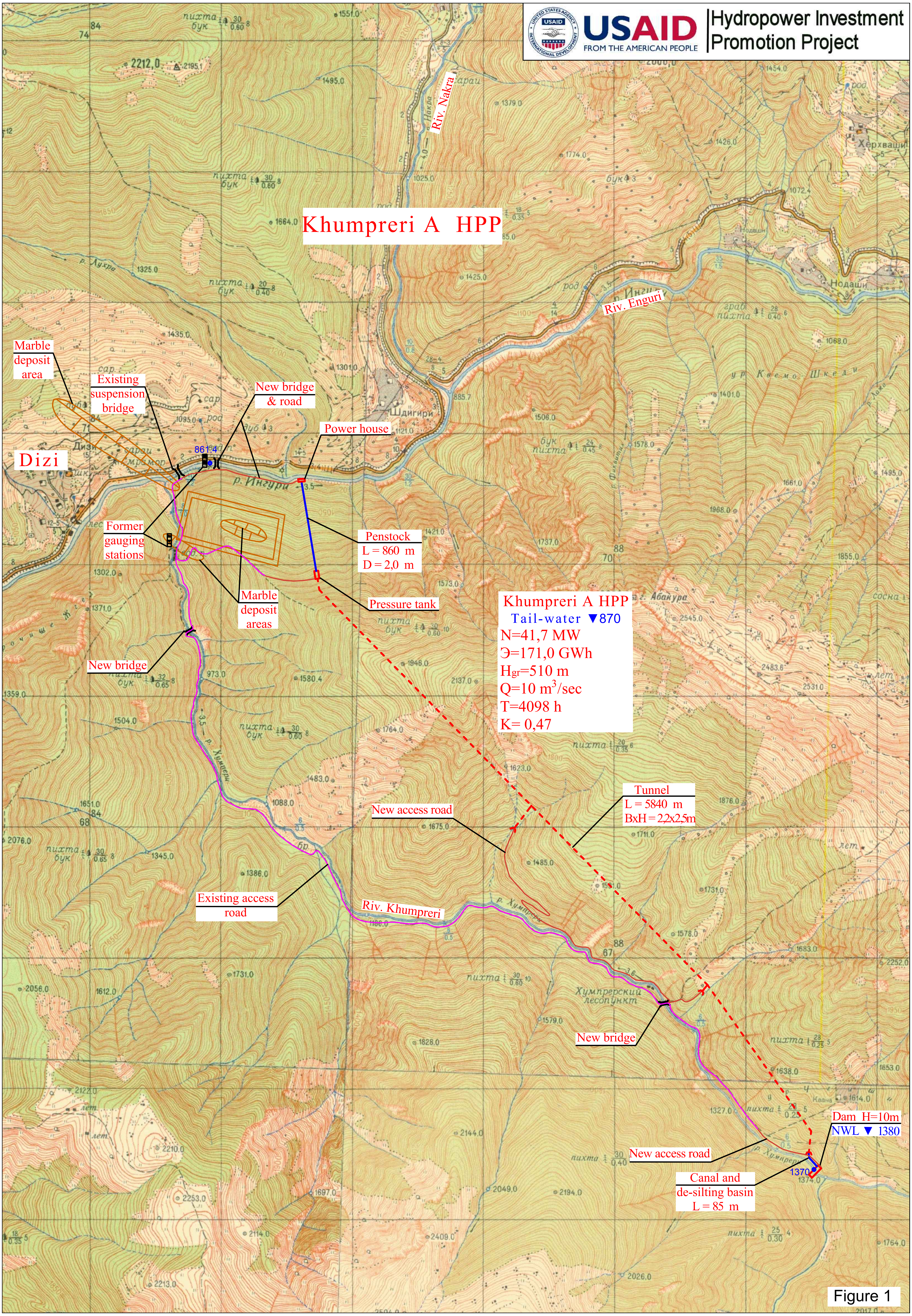
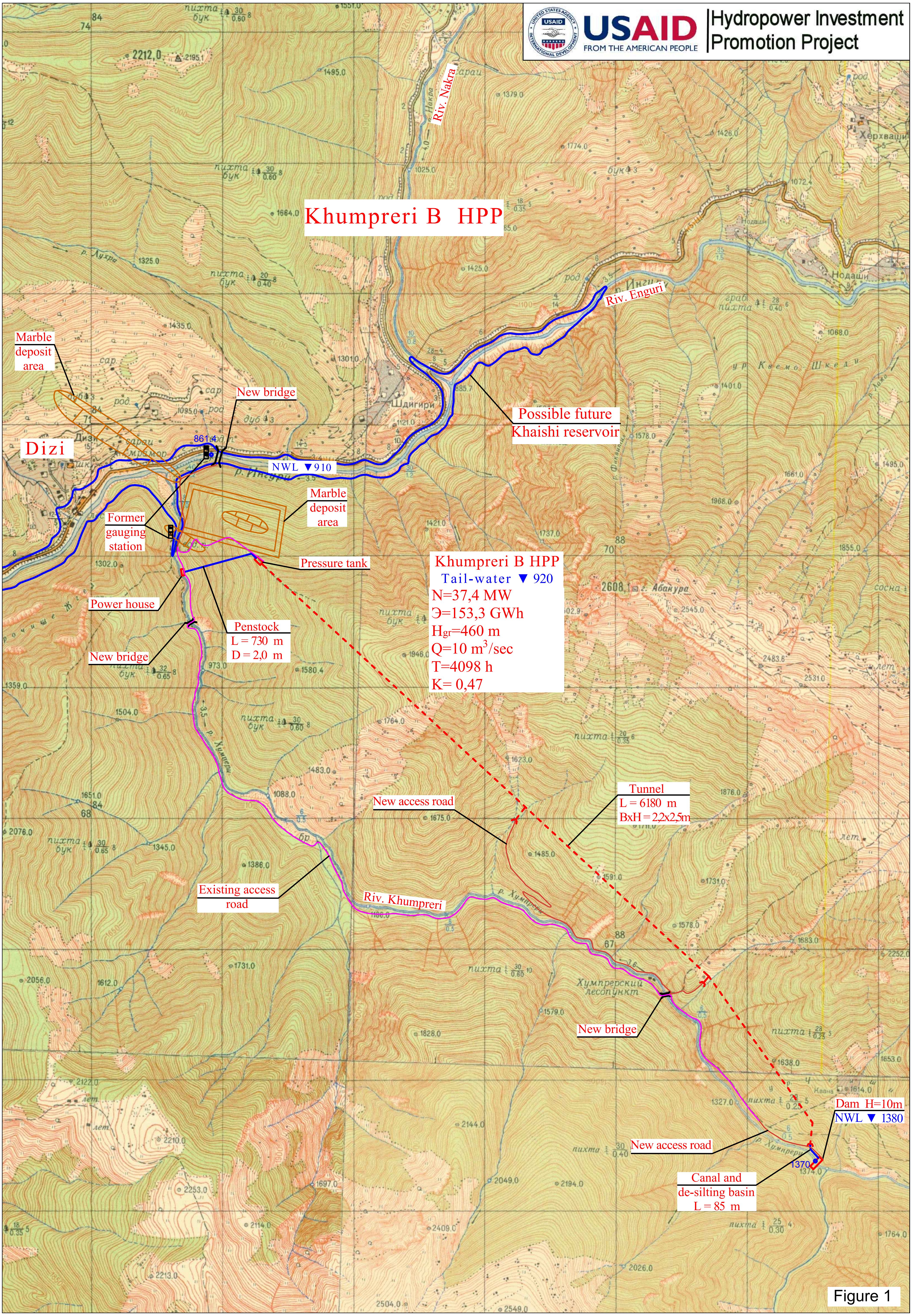
4	Svaneti Protected Areas
5	Upper Enguri Drainage Basin Area Map



USAID
FROM THE AMERICAN PEOPLE
Hydropower Investment
Promotion Project
Khumpreri A HPP
Riv. Nakra
Riv. Enguri
Marble
deposit
area
Existing
suspension
bridge
New bridge
& road
Power house
Dizi
861.4
Former
gauging
stations
Penstock
L = 860 m
D = 2,0 m
Pressure tank
Marble
deposit
areas
New bridge
Khumpreri A HPP
Tail-water ▼870
N=41,7 MW
Э=171,0 GWh
H_{gr}=510 m
Q=10 m^3/sec
T=4098 h
K= 0,47
Tunnel
L = 5840 m
BxH = 2,2x2,5m
New access road
Existing access
road
Riv. Khumpreri
New bridge
Dam H=10m
NWL ▼ 1380
New access road
1370
Canal and
de-silting basin
L = 85 m

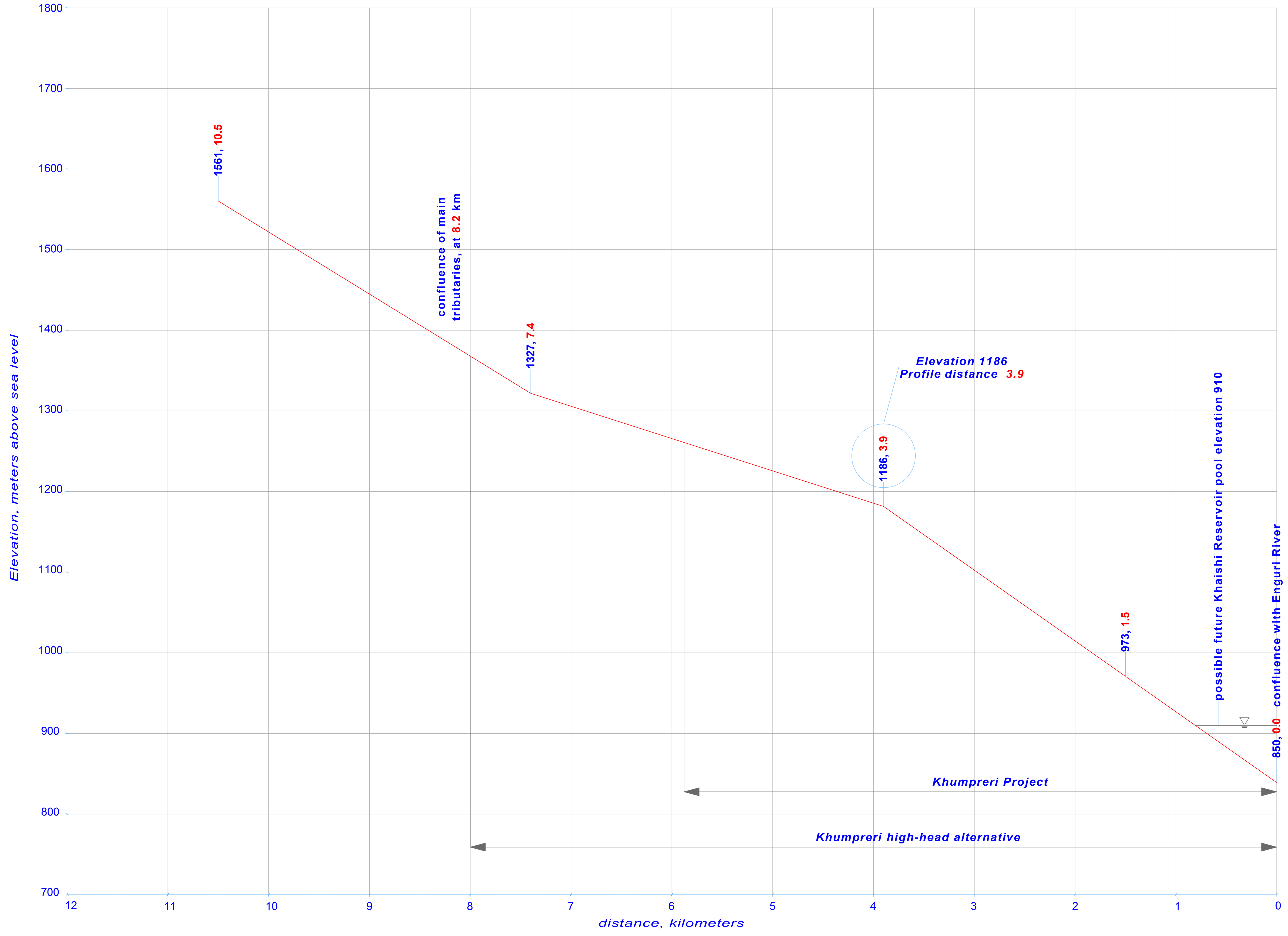
Figure 1



USAID
FROM THE AMERICAN PEOPLE
Hydropower Investment Promotion Project
Khumpreri B HPP
Riv. Nakra
Riv. Enguri
Marble deposit area
New bridge
Dizi
861.4
NWL ▼910
Possible future Khaishi reservoir
Marble deposit area
Former gauging station
Pressure tank
Power house
Khumpreri B HPP
Tail-water ▼ 920
N=37,4 MW
Э=153,3 GWh
Hgr=460 m
Q=10 m3/sec
T=4098 h
K= 0,47
Penstock
L = 730 m
D = 2,0 m
New bridge
New access road
Tunnel
L = 6180 m
BxH = 2,2x2,5m
Existing access road
Riv. Khumpreri
New bridge
Dam H=10m
NWL ▼ 1380
New access road
1370
Canal and de-silting basin
L = 85 m

Figure 1

Figure 2



BLACK & VEATCH
Building a world of difference.

Upper Enguri River Basin
Run-of-River Hydro Sites

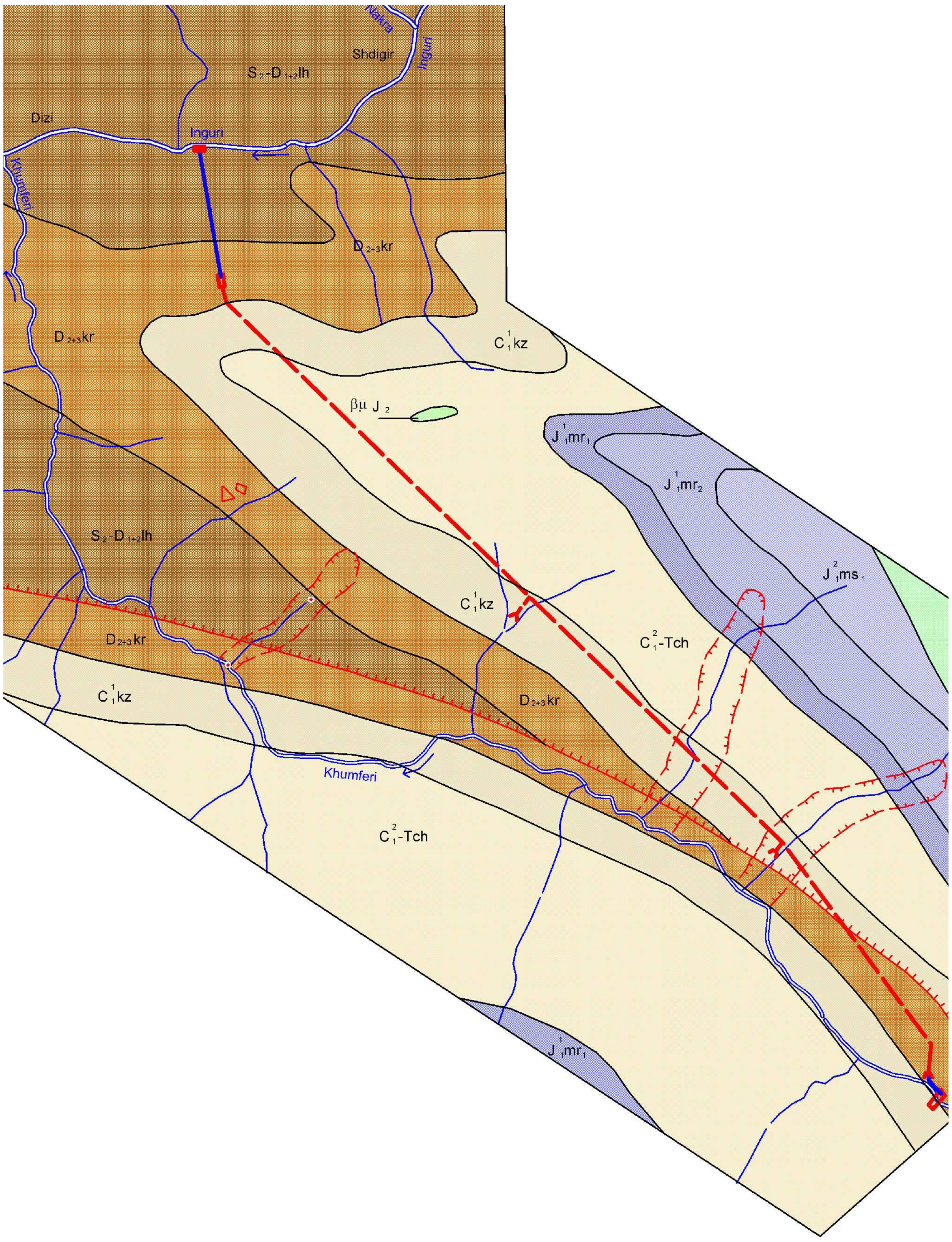
Khumpreri River Profile

September 2011

Khumpreri A HPP

Geological map

Scale 1:30 000



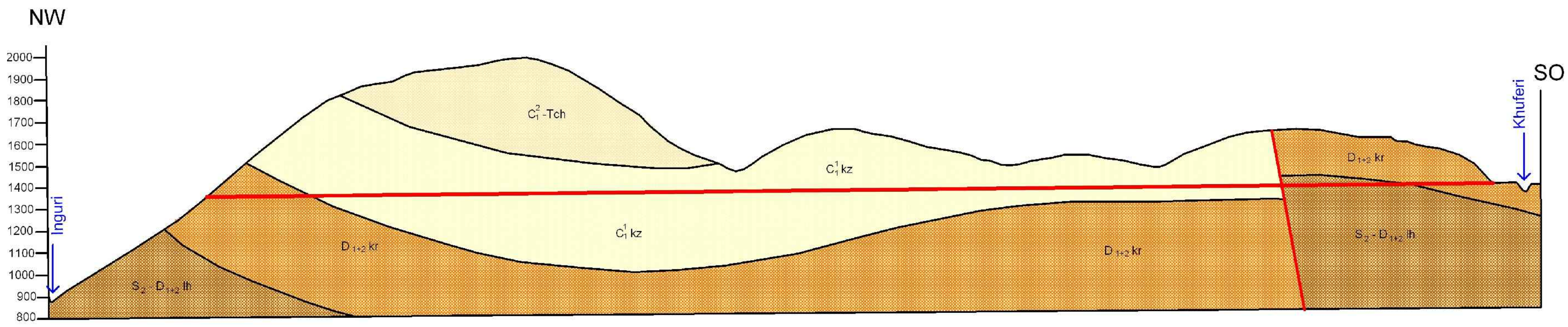


Figure 3

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Khumpreri B HPP
Geological map
Scale 1:30 000

Figure 3

Figure 3A

LEGEND

Quaternary System		Q_{IV}	Recent Sediments - Glacial and water-glacial sediments: boulders, pebbles, cobbles, proluvial - deluvial sediments (unconsolidated and semi-consolidated rocks)
		Q_{III}	Glacial and water-glacial sediments - boulders, pebbles, cobbles; II Upper-grove (Chaliszeda) terrace sediments: proluvial-deluvial sediments. (Unconsolidated and semi-consolidated rocks).
		Q_{II}	Mid-Quaternary sediments. Glacial and water-glacial sediments: boulders, pebbles, cobbles; III Upper-grove (Chaliszeda) terrace sediments: cobbles, sands. (Unconsolidated and semi-consolidated rocks).
		Q_{I}	Lower-Quaternary sediments. Glacial and water-glacial sediments: boulders, pebbles, cobbles. Lake sediments: sandy clays, clays, deluvial sediments. (Unconsolidated and semi-consolidated rocks).
		K_1pr	Cretaceous System. Porkhishuli Suite - limestones, sandy and marly limestones, carbonate and micaceous shales, marls (rock mass).
Jurassic System	Upper	J_3nc	Notsarauli Suite: limestones, marls, carbonate sandstones, carbonate shales, rarely micro-conglomerates (rock mass)
		J_3cv	Chveshuri Suite: marls, carbonate shales, limestones, carbonate sandstones, sandstones, micro-conglomerates (Semi - rock and rock mass)
	Middle	J_2tl_2	Bathian stage; Upper-talakhiani Sub-suite: sandstones, sandy shales. (semi-rock mass)
		J_2tl_1	Bajocian stage; Lower-talakhiani Sub-suite: clay-sandy shales, arcosee sandstones, tuffogenic sandstones, tuffs, diabase cover layers. (Semi - rock and rock mass)
		J_2S_2	Aalenian stage; Upper Sori Suite: sandstones and clay-shales (semi-rocky mass)
	Lower	$J_1^3S_1$	Toarcian stage; Lower Sori Suite: clay-shales, sandstones (semi-rock mass)
		$J_1^2ms_2$	Muashi Suite. Upper sub-suite: clayshales, aspid shales, quarts sandstones (semi-rock and rock mass)
		$J_1^2ms_1$	Muashi Suite. Lower sub-suite: aspid shales, clayshales, quarts sandstones, argillites, diabase layered veins (rock and rock-free mass)
		$J_1^2ms_1^2$	Muashi Suite. Lower sub-suite upper packs: sandy-clayey and aspide shales, quarts sandstones, argillites, tuffbreccias, porphyrites, quartzites, tuff-sandstones (semi-rock and rock mass)
		$J_1^2ms_1^1$	Muashi Suite. Lower sub-suite lower packs: conglomerates, gravelites, arcose sandstones, clayshales (rock and semi-rock mass)
		$J_1^1mr_2$	Morgouli Suite upper sub-suite: clayshales, sandstones, diabases layered veins (semi-rock and rock mass)
		C_3Kv_1	Carbon System, Kvishi Suite, Upper Sub-Suite - Aleurolites, sandstones (Semi Rock Mass)
		C_1^2Tch	Carbon System, Tskhenistskali Suite - Clay and phyllite shales, sandstones, gravelites, conglomerates (Rock and Semi-rock Mass)
		C_1^1KZ	Carbon System, Kazakhstvibi Suite - Phyllite shales, sandstones, marbleized limestones (Rock Mass)
		$D_{2+3}Kr$	Devonian System, Kirari Suite - Phyllite shales, gravelites, lenses of conglomerates and marbleized limestones (Rock Mass)
		$S_2\text{-}D_{1\text{-}2}lh$	Silurian System - Devonian System, Lukhri Suite - Phyllite shales, phyllites, sandstones, porphyrites, albitophyres, marbleized limestones (Rock Mass)
		$O\text{-}S_1dl$	Ordovician System - Silurian System: Dolri Suite: crystal shales, amphibolites, migmatites (rock mass)
		ΦN	Neogene intrusive: albitophyre - bodies, dykes and veins (rock mass)

პირობითი ნიშნები

მეოთხეული სისტემა		Q_{IV}	თანამედროვე ნალექები - მყინვარეული და წყალმყინვარეული ნალექები: ლოდები, კაჭარი, კენჭნარი, პროლივიურ-დელუვიური ნალექები (შეუკავშირებელი და ნახევრადშეკავშირებული ქანები)
		Q_{III}	მყინვარეული და წყალმყინვარეული ნალექები - ლოდები, კაჭარი, კენჭნარი; II ჭალისზედა ტერასის ნალექები: პროლუვიურ-დელუვიური ნალექები. (შეუკავშირებელი და ნახევრადშეკავშირებელი ქანები)
		Q_{II}	შუამეოთხეული ნალექები - მყინვარეული და წყალმყინვარეული ნალექები: ლოდები, კაჭარი, კენჭნარი; III ჭალისზედა ტერასის ნალექები: კენჭნარი, ქვიშები. (შეუკავშირებელი და ნახევრადშეკავშირებელი ქანები)
		Q_{I}	ქვედამეოთხეული ნალექები - მყინვარეული და წყალმყინვარეული ნალექები: ლოდები, კაჭრები, კენჭნარი; ტბიური ნალექები: ქვიშიანი თიხები, თიხები, დელუვიური ნალექები. (შეუკავშირებელი და ნახევრადშეკავშირებელი ქანები)
		K_1pr	ცარცული სისტემა - პორხიშულის წყება: კირქვები, ქვიშიანი და მერგელოვანი კირქვები, კარბონატული და ქარსიანი ფიქლები, მერგელები (კლდოვანი ქანები)
იურული სისტემა	ზედა	J_3nc	ნოცარაულის წყება - კირქვები, მერგელები, კარბონატული ქვიშაქვები, კარბონატული ფიქლები, იშვიათად მიკროკონგლომერატები (კლდოვანი ქანები)
		J_3cv	ქვეშურის წყება - მერგელები, კარბონატული ფიქლები, კირქვები, კარბონატული ქვიშაქვები, ქვიშაქვები, მიკროკონგლომერატები (ნახევრად კლდოვანი და კლდოვანი ქანები)
	შუა	J_2tl_2	ბათის იარუსი - ზედატალახიანის ქვეწყება: ქვიშაქვები, ქვიშიანი ფიქლები. (ნახევრადკლდოვანი ქანები)
		J_2tl_1	ბაიოსის იარუსი - ქვედატალახიანის ქვეწყება: თიხაქვიშიანი ფიქლები, არკოფული ქვიშაქვები, ტუფოგენური ქვიშაქვები, ტუფები, დიაბაზის განფენები. (ნახევრადკლდოვანი და კლდოვანი ქანები)
		J_2S_2	აალენის იარუსი - ზედა სორის წყება: ქვიშაქვები და თიხაფიქლები (ნახევრადკლდოვანი ქანები)
	ქვედა	$J_1^3S_1$	ტოარის იარუსი - ქვედა სორის წყება: თიხაფიქლები, ქვიშაქვები (ნახევრადკლდოვანი ქანები)
		$J_1^2ms_2$	ზედა ქვეწყება - თიხაფიქლები, ასპიდური ფიქლები, კვარცული ქვიშაქვები (ნახევრადკლდოვანი და კლდოვანი ქანები)
		$J_1^2ms_1$	ქვედა ქვეწყება: ასპიდური ფიქლები, თიხაფიქლები, კვარცული ქვიშაქვები, არგილიტები, დიაბაზების ფენებრივი ძარღვები (კლდოვანი და არაკლდოვანი ქანები)
		$J_1^2ms_1^2$	ქვედა ქვეწყების ზედა დასტა: ქვიშა-თიხური და ასპიდური ფიქლები, კვარცული ქვიშაქვები, არგილიტები, ტუფბრექჩიები, პორფირიტები, კვარციტები, ტუფოქვიშაქვები (ნახევრადკლდოვანი და კლდოვანი ქანები)
		$J_1^2ms_1^1$	ქვედა ქვეწყების ქვედა დასტა: კონგლომერატები, გრაველიტები, არკოზული ქვიშაქვები, თიხაფიქლები (კლდოვანი და ნახევრადკლდოვანი ქანები)
		$J_1^1mr_2$	მორგოულის წყების ზედა ქვეწყება: თიხაფიქლები, ქვიშაქვები, დიაბაზების ფენებრივი ძარღვები (ნახევრადკლდოვანი და კლდოვანი ქანები)
		C_3Kv_1	კარბონული სისტემა: ქვიშის წყება, ზედა ქვეწყება - ალევროლიტები, ქვიშაქვები (ნახევრადკლდოვანი ქანები)
		C_1^2Tch	კარბონული სისტემა: ცხენისწყალის წყება - თიხა და ფილიტიზებული ფიქლები, ქვიშაქვები, გრაველიტები, კონგლომერატები (კლდოვანი და ნახევრადკლდოვანი ქანები)
		C_1^1KZ	კარბონული სისტემა: კაზახტვიბის წყება - ფილიტიზებული ფიქლები, ქვიშაქვები, გამარმარილოებული კირქვები (კლდოვანი ქანები)
		$D_{2+3}Kr$	დევონური სისტემა: კირარის წყება - ფილიტიზებული ფიქლები, გრაველიტები, კონგლომერატების და გამარმარილოებული კირქვების ლინზები (კლდოვანი ქანები)
		$S_2\text{-}D_{1\text{-}2}lh$	სილურული სისტემა - დევონური სისტემა: ლუხრის წყება, ფილიტიზებული ფიქლები, ფილიტები, ქვიშაქვები, პორფირიტები, ალბიტოფირები, გამარმარილოებული კირქვები. (კლდოვანი ქანები)
		$O\text{-}S_1dl$	ორდოვიკული სისტემა - სილურული სისტემა; დოლრის წყება:კრისტალური ფიქლები, ამფიბოლიტები, მიგმატიტები (კლდოვანი ქანები)
		ΦN	ნეოგენური ინტრუზივები: ალბიტოფირები - სხეულები, დაიკები და ძარღვები (კლდოვანი ქანები)

Figure 3B

	Recent exogenic geological processes
	Active landslide in surface sediments
	Complex active landslide
	Mudflow source area
	Avalanche risky zone
	Side erosion
	Landslide spreading area

	თანამედროვე ეკზოგენური გეოლოგიური პროცესები
	აქტიური მეწყერი ზედაპირულ ნალექებში
	რთული აქტიური მეწყერი
	ღვარცოფული კერა
	ზვავსაშიში, ნამქერსაშიში უბანი
	გვერდითი ეროზია
	მეწყრების გავრცელების უბანი

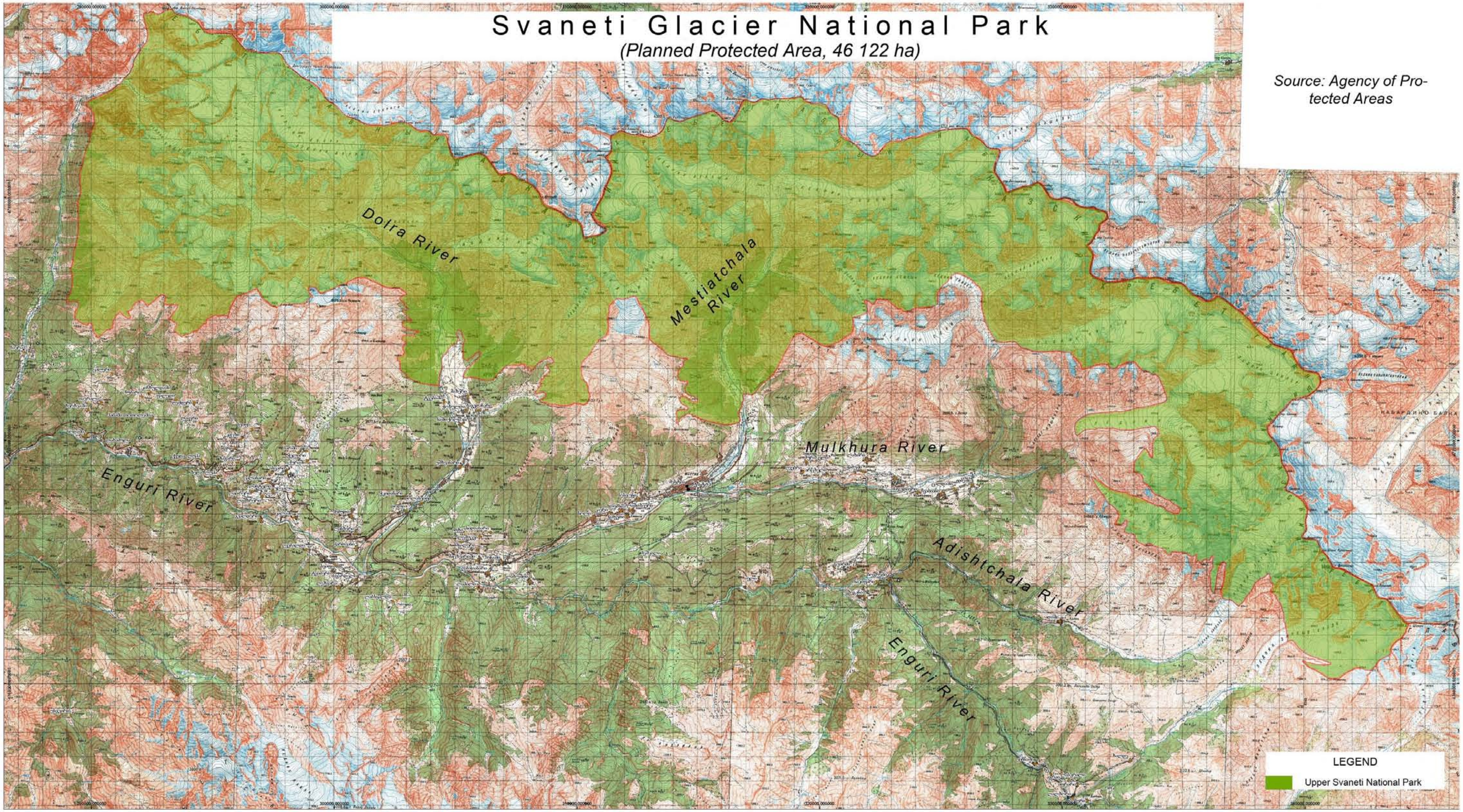
BmJ_2	Mid-Jurassic intrusive - diabase porphyrites (rock mass)
$rD_3\text{-}C_1^1$	Latedevonian - Earlycarbonate intrusive: grano-diorites - gneisses (rock mass)
	Tectonic contacts
(40)	Thickness of quaternary system sediments in meter

BmJ_2	შუაიურული ინტრუზივები - დიაბაზური პორფირიტები (კლდოვანი ქანები)
$rD_3\text{-}C_1^1$	გვიანდევონური - ადრეკარბონული ინტრუზივი: გრანოდიორიტ-გნეისები (კლდოვანი ქანები)
	ტექტონიკური კონტაქტები
(40)	მეოთხეული სისტემის ნალექების სიმძლავრე მეტრებში

	Base rocks weathering degree
□ □ □	Boulder-bed
□ △ □	Boulder-debris
△ ◇	Debris - crushed
◇ = ◇	Crushed-clayey
= ◇ =	Clayey-crushed

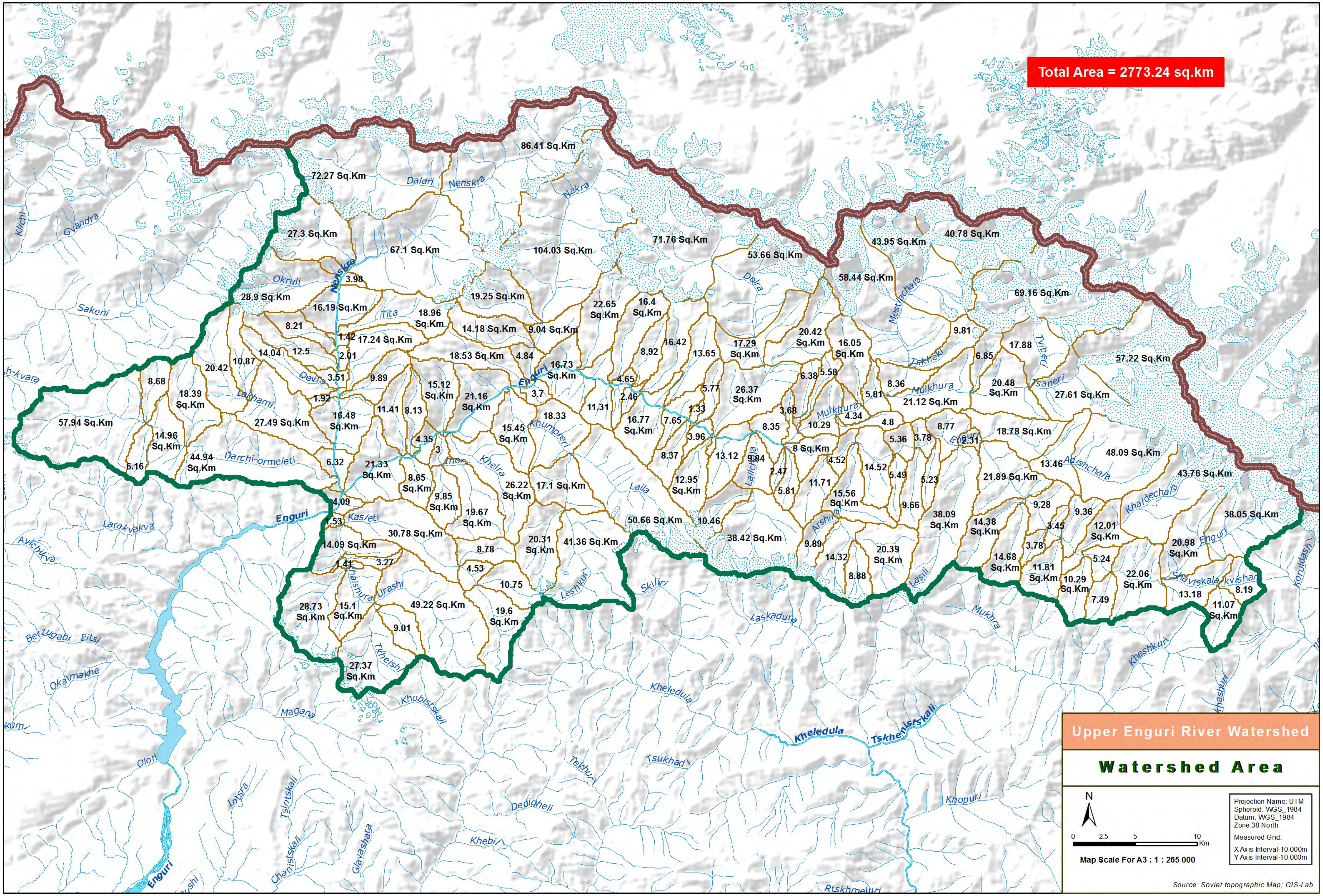
	ძირითადი ქანების გამოფიტვის ხასიათი
□ □ □	ლოდნარი
□ △ □	ლოდნარ - ნატეხოვანი
△ ◇	ნატეხოვან - ღორღიანი
◇ = ◇	ღორღიან - თიხიანი
= ◇ =	თიხიან - ღორღიანი

Figure 4



Svaneti Glacier National Park
(Planned Protected Area, 46 122 ha)
Source: Agency of Protected Areas
Dolra River
Mestiatchala River
Mulkhura River
Enguri River
Adishtchala River
Enguri River
LEGEND
Upper Svaneti National Park

Figure 5



Total Area = 2773.24 sq.km
Upper Enguri River Watershed
Watershed Area
N
0 2.5 5 10 Km
Map Scale For A3 : 1 : 265 000
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.
Enguri
Nenskra
Nakra
Dalari
Tita
Devra
Lakhami
Khumpreri
Khelra
Laila
Dolra
Mestiachala
Tskheki
Mulkhura
Tviberi
Tsaneri
Adishchala
Khaldechala
Shavtskala
Kasleti
Urashi
Tkheishi
Leshkuri
Skiliri
Laskadura
Lasili
Mukhra
Kheshkuri
Kheledula
Tskhenistskali
Khobistskali
Magana
Darchi-ormeleti
Larakvakva
Sakeni
Okruli
Gvandra
Klichi
Avichikva
Berzugabi
Eitsi
Okalmakhe
Olon
Tekhuri
Tsukhadi
Dedigheli
Khebi
Khopuri
Intsra
Tsintskali
Chanistskali
Glavashala
Rtskhmeluri
Korulddashi
Khashuri
Total Area = 2773.24 sq.km
86.41 Sq.Km
72.27 Sq.Km
104.03 Sq.Km
71.76 Sq.Km
67.1 Sq.Km
57.94 Sq.Km
57.22 Sq.Km
58.44 Sq.Km

Upper Enguri Basin Drainage Areas

Using sub-areas from the GIS-Lab 1:265,000 drainage basin map, except as noted

Description	Area, km^2	Partial Areas, km^2	Comments
Enguri Above Ushguli			
	38.05	38.05	Diversion point, Enguri 1
	20.98	59.03	
Shavtskala-Kvishara Above Ushguli			
	11.07		
	8.19	19.26	Diversion point, Enguri 1
	13.18	32.44	check ds boundary
Subtotal, Shavtskala-Kvishara	32.44	**57.31**	**Total DA, Enguri 1**
Subtotal, Below Confluence at Ushguli	**91.47**		Enguri part of Drainage Area for Enguri 2
Intervening			
	22.06		
	7.49		
	5.24		
	10.29		
	1.10		
			very small missing area?
Subtotal, Enguri Above Khaldechala River	**137.65**		
Khaldechala River			
	43.76		Khaldechala part of Enguri 2 DA
	11.90		
Subtotal, Khaldechala	**55.66**	**135.23**	**Total Enguri 2 Drainage Area**
Subtotal Below Confluence	**193.31**		**Total Enguri 3 Drainage Area**
Intervening			
	9.36		
	11.81		
	3.45		
	3.78		
	9.28		
	14.68		
	14.38		
Subtotal for Enguri 4 Diversion	**260.05**		**Total Enguri 4 Drainage Area**
Intervening	21.89		
Subtotal above Adishchala	**281.94**		
Adishchala			
	48.09	48.09	D.A. for high-head alternative
	13.46	61.55	D. A. for original layout
	18.78	80.33	
Subtotal, Adishchala	**80.33**		
Subtotal below confluence	**362.27**		Enguri is 362 in Ipari records

Upper Enguri Basin Drainage Areas

Using sub-areas from the GIS-Lab 1:265,000 drainage basin map, except as noted

Description	Area, km^2	Partial Areas, km^2	Comments
Intervening			
	2.31		
Lasili River	38.09		
Subtotal for Enguri 5 Intake	**402.67**		**Total Enguri 5 Drainage Area**
Intervening	8.77		
	5.23		
	3.78		
	9.66		
	5.36		
	5.49		
	14.52		need breakdown to get exact number for Enguri 1 Intake
Subtotal for Enguri 6 Intake	**455.48**		**Total Enguri 6 Drainage Area**
Arshira, Southern Trib			
	20.39		
	8.88		
	14.32		
	9.89		
	15.56		
Subtotal, Arshira	**69.04**		
Intervening			
	4.52		
	11.71		
	8.00		
	5.81		
	2.47		
Subtotal, Enguri above Mulkhura	**557.03**		
Mulkhura Basin			
Tviberi River, Upper North			
	69.16		DA for Tviberi Diversion
	17.88		
Subtotal, Tviberi	**87.04**		
Tsaneri River, Upper South			
	57.22		DA for Tsaneri Diversion
	27.61		
		126.38	**Total Drainage Area for Mulakhi HPP**
Subtotal, Tsaneri	**84.83**		
Intervening			
	20.48		
	6.85		
	21.12		

Upper Enguri Basin Drainage Areas

Using sub-areas from the GIS-Lab 1:265,000 drainage basin map, except as noted

Description	Area, km^2	Partial Areas, km^2	Comments
Subtotal Mulkhura above Mestiachala	**220.32**		Gauge records say 197 at mineral spring, this may be where the 20 km^2 difference appears
Mestiachala			
	40.78	40.78	
	43.95	84.73	**Total Mestiatchala 1 Drainage Area (AutoCAD)→**
	58.44	143.17	**Total Mestiatchala 2 Drainage Area (AutoCAD)→**
	9.81	152.98	
	8.36	161.34	sub-basins do not match diversion locations
Subtotal Mestiachala	**161.34**		
Subtotal, Mulkhura below Mestiachala	**381.66**		**Mulkhura Project Drainage Area**
Intervening			
	5.81		
	16.05		
	4.34		
	4.80		
	10.29		
	5.58		
	6.38		
	0.00		
	3.68		
Subtotal. Mulkhura at Enguri	**438.59**		Mulkhura is 420 km^2 in gauging records, at Latali
			↓↑ We have about 20 km^2 more area at these points
Subtotal, Enguri below Mulkhura Confluence	**995.62**		At Latali gauging station ±. Records say 975 km^2
Intervening			
	8.35		
Lailchala	38.42		
Lailchala	10.36		
Lailchala	9.84	58.62	Lailchala DA
	13.12		
Subtotal, Enguri above Dolra	**1,075.71**		
Dolra River			
	71.76	71.76	**71.34 from AutoCAD, Dolra 1 Drainage Area**
	53.66	125.42	**104.0 from AutoCAD, Dolra 2 Drainage Area**
	17.29	142.71	
	20.42	163.13	**168.2 from AutoCAD, Dolra 3 Drainage Area**
	26.37	189.50	
Subtotal Dolra	**189.50**		**Dolra is 146 km^2 in gauging records, but gauge is not near mouth**
Subtotal, Enguri below Dolra Confluence	**1,265.21**		
Intervening			
	3.96		
	5.77		

Upper Enguri Basin Drainage Areas

Using sub-areas from the GIS-Lab 1:265,000 drainage basin map, except as noted

Description	Area, km^2	Partial Areas, km^2	Comments
	1.33		
	8.37		
	7.65		
	13.65		
	16.77		
	16.42		
	2.46		
	8.92		
	4.65		
	16.40		
	11.31		
	22.65		
	16.73		
Subtotal, Enguri above Nakra	**1,422.25**		
Nakra River			
	104.03		
	19.25		
	9.04		
	14.18		
	4.84		
Subtotal Nakra	**151.34**		
Subtotal, Enguri below Nakra	**1,573.59**		
Intervening			
	3.70		
	17.77		
	0.76		
Subtotal, Enguri above Khumpreri	**1,595.82**		**Dizi gauge DA is 1,620 km^2 in some records, after 1970, matching the ±20 km^2 extra that we calculated above. This would be at the gauge location shown on Soviet topo maps**
Khumpreri River			
	41.36		
	20.31		
	17.10		
	50.66	**129.43**	**Upper diversion drainage area, 132.3 from AutoCAD**
	18.33	147.76	Gross Energy diversion area; 145.4 at Roland's lower diversion point
	15.45		
Subtotal, Khumpreri	**163.21**		**Khumpreri is 160 km^2 in gauging records, gauge was a bit above mouth**
Subtotal, Enguri below Khumpreri	**1,759.03**		**Dizi gauge is 1,760 km^2 in some records, up to 1970. Error or location change??**

Appendix 1

Environmental and Social Impacts and Affected Environment

Appendix 1
Environmental and Social Impacts and Affected Environment

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 project assessment 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 heath 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, None) and Value (H, L)	**IMPACT (Description of effect)**	**Duration (occurs during construction, operation or decommissioning phase and LG/MD/SH/VSH term) and frequency**	**Risk Level (VL, L, M, H, and Irreversible/ reversible; temporary/ permanent**	**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 L/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	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

 ------------------------- M/L	from Dam and intake structure --- **Operation Phase:** • effects on surface water resources during facility operations	 ---------------------------- LG	 ------------------------------------ L/R/T	during construction. --- 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 ------------------------ M/L	**Construction Phase (HPP and Transmission Facility):** • Increase to flood discharge from failure of dam during construction **---** **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 ------------------------------ VSH	VL/R/T ------------------------------------- L/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. --- 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				
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**
Soils, Geology, Landscape **(Vulnerability (H, M, L, None) and Value (H, L)** M/H ---------------------------- M/H	**Seismic Risk** **Construction Phase (HPP and Transmission Facility)**: Impacts on infrastructure and public due to seismic activity -- **Operation Phase**: Impacts on infrastructure and public due to seismic activity that causes HPP to fail	VSH -------------------------------- VSH	L/R/T -------------------------------------- L/R/T	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. --- 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	M/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	L/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	M/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	M/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**	**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	SH	M/R/T	Wildlife management plan should be developed. Noise management plan. Proper scheduling of construction activities; Monitoring of vibration and blasting activities from construction equipment

------------------------- L/H	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	------------------------- LG	------------------------- VL/R/P	------------------------- 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	L/R/T ------------------------- L/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	L/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	VL/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	L/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	VL/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	N/A	N/A	N/A

	considerable nuisance.			
Recreation (Vulnerability (H, M, L, None) and Value (H, L) L/H ---------------------------- 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 -- **Operation Phase:** New reservoir and new infrastructure (e.g. better roads) may positively impact on recreational activities	SH -------------------------------- LG	L/R/T -------------------------------------- M/IR/P	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. --- 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 ---------------------------- 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 -- **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.	SH -------------------------------- LG	L/R/T -------------------------------------- VL/R/P	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. --- 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,**	**Construction Phase (HPP and Transmission Facility)**:	SH	VL/R/T	Health and safety plan should be in line with national and international standards. Occupational

L, None) and Value (H, L) L/H ----------------------------- L/H	Construction activities might cause health impact to the workers (e.g. construction related accidents). Also see Air Quality, Population Receptors --- **Operation Phase:** Operational activities might cause health impact to the workers and/or local population.	 --------------------------------- LG	 --------------------------------------- L/R/P	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) -- Ensure compliance with health and safety plan

Appendix 2

Listed Cultural Properties in Svaneti

APPENDIX 2

Historical, Cultural and Archeological Resources in the Mestia District

#	Name	Location	Dated
1	Original rural settlement pattern	Mestia, district Laghami	Medieval
2	Church "Macxvar"	Mestia, district Laghami, centre	XIII-XVI A.D.
3	Khodge Khoreliani Residential Complex 1. "Machubi" (ground floor hall) 2. Tower	Mestia, district Laghami	Medieval
4	Jua Phaliani Residential Complex 1. "Machubi" (ground floor hall) 2. Tower	Mestia, district Laghami	Medieval
5	Khergiani's Tower	Mestia, district Laghami	Medieval
6	Irodi Khoreliani Residential Complex 1. "Machubi" (ground floor hall) 2. Tower	Mestia, district Laghami	Medieval
7	Jarakhmat Phaliani Residential Complex 1. "Machubi" (ground floor hall) 2. Tower	Mestia, district Laghami	Medieval
8	Ioseliani's Tower	Mestia, district Laghami	Medieval
9	Germane Khodgeliania's Tower	Mestia, district Laghami	Medieval
10	Germane Khodgeliani's Residential Complex "Gubandi-Gvemi"	Mestia, district Laghami	Medieval
11	Nodar Gvarliani's Tower	Mestia, district Laghami	Medieval
12	Bidzina Barliani's Residential Complex 1."Machubi" (ground floor hall) 2. Tower	Mestia, district Laghami	Medieval
13	Mikheil Khergiani's House-Museum 1."Machubi" (ground floor hall) 2. Tower	Mestia, district Laghami	Medieval
14	District development pattern	Mestia, district Lanchvali	Medieval
15	Church Taringzeli (Church of Archangel)	Mestia, district Lanchvali	Medieval

#	Name	Location	Dated
16	Phaliani's Tower	Mestia, district Lanchvali	Medieval
17	Phalian Phaliani's Residential Complex 1.“Machubi” (ground floor hall) 2.Tower	Mestia, district Lanchvali	Medieval
18	Bijo Ratiani's Residential Complex 1.“Machubi” – Ground floor hall 2.Tower	Mestia, district Lanchvali	Medieval
19	Grigol Ratiani's Tower	Mestia, district Lanchvali	Medieval
20	Alexander Ratiani's Tower	Mestia, district Lanchvali	Medieval
21	Khergianis' Residential Complex 1. “Machubi” (ground floor hall) 2. Tower	Mestia, district Lanchvali	Medieval
22	Shota Niguriani's Residential Complex 1.“Machubi” (ground floor hall) 2. Tower	Mestia, district Lanchvali	Medieval
23	Qeleshb Niguriani's Residential Complex 1. “Machubi” (ground floor hall) 2. Tower	Mestia, district Lanchvali	Medieval
24	Sozar Niguriani's Residential Complex 1. “Machubi” (ground floor hall) 2. Tower	Mestia, district Lanchvali	Medieval
25	Ardevan Nakani's Residential Complex 1. “Machubi” (ground floor hall) 2. Tower	Mestia, district Lanchvali	Medieval
26	District development pattern	Mestia, district Lekhtagi	Medieval
27	St. Mary Church “ Lamaria”	Mestia, district Lekhtagi	Medieval
28	Khergianis' Residential Complex: 1. Tower 2. “Gubandi” (the corridor) 3. “Marchubi” (ground floor hall)	Mestia, district Lekhtagi	Medieval
29	District development pattern	Mestia, district Seti	Medieval
30	Church Taringzeli (Church of Archangel)	Mestia, district Seti	Medieval.
31	Church “Phusd”	Mestia, district Seti	Medieval
32	St. George's Church “Jgrag”	Mestia, district Seti	XIX A.D.

#	Name	Location	Dated
33	Nugzar Nakani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Mestia, district Seti	Medieval
34	Gogi Mushkudiani's Tower	Mestia, district Seti	Medieval
35	Iason Mushkudiani's Tower	Mestia, district Seti	Medieval
36	Valeri Phaliani's Tower	Mestia, district Seti	Medieval
37	Tower	Mestia, district Seti	Medieval
38	Abi Devdariani's Tower	Mestia, district Seti	Medieval
39	Alexi Japaridze's Tower	Mestia, district Seti	Medieval
40	Japaridzes' Tower	Mestia, district Seti	Medieval
41	Tower	Mestia, district Seti, Tourist base "Ushba"	Medieval
42	Tower	Mestia, district Seti, Cemetery	Medieval
43	Original rural settlement pattern	Village Agrai	Medieval
44	Sergo Khardziani's Residential Complex	Village Agrai	Medieval
45	Original rural settlement pattern	Village Adishi	Medieval
46	St. George's Church "Jgrag"	Village Adishi, 3 km east	Medieval
47	Architectural Complex: 1. Church "Matskhovari" (Church of the Redeemer) 2. Tower	Village Adishi, 1 km east	Medieval
48	Church "Taringzeli" (Church of Archangel)	Village Adishi, 1 km east	Medieval
49	Church "Taringzeli" (Church of Archangel)	Village Adishi, district Zagrali	Medieval
50	Church "Matskhovari" (Church of the Redeemer)	Village Adishi, Northern part, Cemetary	XI A.D.
51	St. George's Church	Village Adishi, Southern part	Medieval
52	Amiran Avaliani's Tower	Village Adishi	Medieval

#	Name	Location	Dated
53	Baju Avaliani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Adishi	Medieval
54	Bodgho Qaldani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Adishi	Medieval
55	Agraphina Avaliani's Residential Complex: 1. "Machubi (ground floor hall) 2. Tower	Village Adishi	Medieval
56	Aster Avaliani's Tower	Village Adishi	Medieval
57	Ghenter Avaliani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Adishi	Medieval
58	Ramzia Avaliani's Residential Complex: 1. "Machubi" – Ground floor Hall 2. Tower	Village Adishi	Medieval
59	Ramzia Avaliani's Tower	Village Adishi	Medieval
60	Aprasion Avaliani's Tower	Village Adishi	Medieval
61	Amiran Avaliani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Adishi	Medieval
62	Bavri Qaldani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Adishi	Medieval
63	Baju Qaldiani's Tower	Village Adishi	Medieval
64	Mushni Avaliani's Tower	Village Adishi	Medieval
65	Germane Qaldani's Tower	Village Adishi	Medieval
66	Tatash Avaliani Tower	Village Adishi	Medieval
67	Alexandre Avaliani's " Machubi" (ground floor hall)	Village Adishi	Medieval
68	Original rural settlement pattern	Village Artskheli	Medieval

#	Name	Location	Dated
69	Goji Jorjoliani's Tower	Village Artskheli	Medieval
70	Kote Jorjoliani's Tower	Village Artskheli	Medieval
71	St. Gabriel's Church	Village Bagvdanari, Riv. Gulichala gorge	Medieval
72	St. George's Church "Jgrag"	Village Bagvdanari	Medieval
73	Church "Sviphi"	Village Bagvdanari (Ghvibrasheni)	Medieval
74	Residential-Defensive Complex of Buildings	Village Bari, 0.5 km North-West	Medieval
75	Dadeshqelianis' Residential Complex: 1. Tower 2. Defensive wall 3. Ruins of other buildings	Village Bari	Medieval
76	Church "Jagragle-Koeleshi"	Chorokhi settlement	Medieval
77	Ilmaz Gurchiani's "Tchar-svaniri"	Village Bari	Medieval
78	Original rural settlement pattern	Village Bogreshi	Medieval
79	St. Mary Church " Lamaria"	Village Bogreshi	Medieval
80	Tower in the Enguri watercourse area	Village Bogreshi, 1 km South-East	Medieval
81	Ivane Kordzaia's Residential Complex: 1. "Machubi (ground floor hall) 2. Tower	Village Bogreshi	Medieval
82	Solomon Gulbani's Tower	Village Bogreshi	Medieval
83	Margveliani Family Tower	Village Davberi	Medieval
84	Tower-Chapel "Lamaria"	Village Davberi	Medieval
85	Church "Phusdi"	Village Doli, Mount Meziri	Medieval
86	Church "Phusdali"	Village Doli	Medieval
87	Tower	Village Doli	Medieval
88	St. George's Church "Jgrag"	Village Doli, 0.5 km North	Medieval
89	Guram Phiphani's Tower	Village Etseri	Medieval

#	Name	Location	Dated
90	Original rural settlement pattern	Village Vichnashi	Medieval
91	Mirza Kharziani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Vichnashi	Medieval
92	Original rural settlement pattern	Village Zardlashi	Medieval
93	Church "Tarigzeli" (Church of Archangel)	Village Zardlashi	Medieval
94	Changaz Dadvani's Tower	Village Zardlashi	Medieval
95	Valo Dadvani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Zardlashi	Medieval
96	Otar Gabliani's Complex of the Residential House	Village Zardlashi	Medieval
97	Original rural settlement pattern	Village Zegani, district Leqvaubani	Medieval
98	St. Mary Church " Lamaria"	Village Zegani, district Leqvaubani, Cemetery	Medieval
99	Emzar Khvistani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Zegani, district Leqvaubani	Medieval
100	Mikheil Khvistani's Residential Complex: 1. "Machubi(ground floor hall) 2. Tower	Village Zegani, district Leqvaubani	Medieval
101	Original rural settlement pattern	Village Zegani, district Lejaubani	Medieval
102	Andria Gulbani's Residential Complex: 1. "Machubi" (ground floor hall)) 2. Tower	Village Zegani, district Lejaubani	Medieval
103	Original rural settlement pattern	Village Zegani, district Krshi and Lesulani	Medieval
104	Shalva Pirveli's Tower	Village Zegani, district Krshi	Medieval
105	Nugzar Gulbani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Upper Luha	Medieval
106	Mosel Tsalani's Tower	Village Upper Luha	Medieval

#	Name	Location	Dated
107	Valo Tsulkani's Tower	Village Upper Luha	Medieval
108	Jora Tsulkani's Tower	Village Upper Luha	Medieval
109	Ruzgen Tsalani's Tower	Village Upper Luha	Medieval
110	St. George's Church "Jgrag"	Village Tavrali, Western mountain hill	Medieval
111	Original rural settlement pattern	Village Tavrali, 1 km North-West, village remnant Patara Tavrali	Medieval
112	Two Towers	Village Tavrali, 1 km South-West	Medieval
113	Church "Matskhovari" (Church of the Redeemer)	Village Tavrali, cemetery	Medieval
114	Tsindeliani's Tower	Village Ieli, district Askarti	Medieval
115	Original rural settlement pattern	Village Ieli, district Askarti, cemetery	Medieval
116	Ioane Makharobeli (St. John's) Church	Village Ieli, district Askarti	Medieval
117	St. George's Church "Jgrag"	Village Ieli, district Askarti	Medieval
118	Iano Samsiani's Tower	Village Ieli, district Askarti	Medieval
119	Mose Samsiani's Tower	Village Ieli, district Askarti	Medieval
120	Original rural settlement pattern	Village Ieli, district Nesgaubani, Northern part	Medieval
121	Ioane Natlismcemeli's (St. John's) Church	Village Ieli, district Nesgaubani, Northern part	Medieval
122	Ioane Makharobeli (St. John's) Church	Village Ieli, district Nesgaubani, western part	Medieval
123	St. Mary Church " Lamaria"	Village Ieli, district Nesgaubani, South-Western part	Medieval
124	Grigol Khvibliani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Ieli, district Nesgaubani	Medieval
125	Avtandil Khvibliani's Tower	Village Ieli, district Nesgaubani, western part	Medieval

#	Name	Location	Dated
126	Soso Phangani's Residential Complex:: 1. "Machubi" (ground floor hall) 2. Tower	Village Ieli, district Nesgaubani, western part	Medieval
127	Church "Tarigzeli" (Church of the Archangel)	Village Ieli, district Atsa, South-East	Medieval
128	Original rural settlement pattern	Village Ieli, district Atsa	Medieval
129	St. Mary Church " Lamaria"	Village Ieli, district Atsa, East	Medieval
130	Pimen Khvibliani's Tower	Village Ieli, district Atsa	Medieval
131	Jobe Khorguani's Residential Complex: 1. Machubi" (ground floor hall) 2. Tower	Village Ieli, district Atsa	Medieval
132	Semlar Khvibliani's Tower	Village Ieli, district Atsa	Medieval
133	Mane Kvebliani's Tower	Village Ieli, district Atsa	Medieval
134	Original rural settlement pattern	Village Ienashi	Medieval
135	Ioane Tsinascarmetkveli "Ian" (St. John's) Church	Village Ienashi	Medieval
136	Givi Darjani's Tower	Village Ienashi	Medieval
137	Misdon Darjani's Tower	Village Ienashi	Medieval
138	Boris Darjani's Tower	Village Ienashi	Medieval
139	Anton Gvichiani's Tower	Village Ienashi	Medieval
140	Bekhai Tserediani's Tower	Village Ienashi	Medieval
141	Tseredianis' Tower	Village Ienashi	Medieval
142	Ninia Tserediani's Tower	Village Ienashi	Medieval
143	Baru Parjiani's Tower	Village Ienashi, district Leshgvani	Medieval
144	Beqai Parjiani Tower	Village Ienashi, district Leshgvani	Medieval
145	Parjianis' Tower	Village Ienashi, district Leshgvani	Medieval
146	Parjianis' Tower	-	Medieval

#	Name	Location	Dated
147	Gubaz Pirveli's Tower	Village Ipari	Medieval
148	Murtaz Pirveli's Tower	Village Ipari	Medieval
149	Guram Philphani's Tower	Village Iprari	Medieval
150	Original rural settlement pattern	Village Iprari	Medieval
151	Church "Taringzeli" (Church of the Archangel)	Village Iprari, Cemetery	XI A.D.
152	Margvlianis' Tower "Besilusha"	Village Iprari	Medieval
153	Original rural settlement pattern	Village Ipkhi	Medieval
154	St. George's Church "Jgrag"	Village Ipkhi, 0.3 km South-East	Medieval
155	Togo Gvichiani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Ipkhi	Medieval
156	Bidzina Gvichiani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Ipkhi	Medieval
157	Bito Gvichiani's Residential 1. "Machubi" (ground floor hall) 2. Tower	Village Ipkhi	Medieval
158	Varden Nanskani Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Ipkhi	Medieval
159	Vladymer Melani's Tower	Village Kaeri	Medieval
160	Church "Matskhovari" (Church of the Redeemer)	Village Kalashi, 0.5km South-West	Medieval
161	Murghvlianis' Tower	Village Kalashi	Medieval
162	Murghvlianis' Tower	Village Kalashi	Medieval
163	Murghvlianis' Tower	Village Kalashi	Medieval
164	Charkviani Family Tower	Village Kvanchianari	Medieval
165	Tower " Khatis Tskhoveli"	Village Kvanchianari	Medieval

#	Name	Location	Dated
166	St. George's Church "Jgrag Jhibreshi"	Village Kirchkhuldashi	Medieval
167	Valiko Jachvliani's "Svaniri"	Village Kirchkhuldashi	Medieval
168	Church "Tarigzeli" (Church of the Archangel)	Village Labskhaldi	Medieval
169	Original rural settlement pattern	Village Lalkhorali	Medieval
170	Gelovani Family Tower	Village Lalkhorali	Medieval
171	Mikho Katshani's Tower	Village Lanteli	Medieval
172	Original rural settlement pattern	Village Lashtkhveri	Medieval
173	Ioane Makharobeli (St. John's) Church	Village Lashtkhveri, South-East	Medieval
174	Church "Matskhovari" (Church of the Redeemer)	Village Lashtkhveri, North-East	Medieval
175	Ilarion Guledani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Lashtkhveri	Medieval
176	Gramiton Jachvliani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Lashtkhveri	Medieval
177	Valiko Jachvliani"s Tower	Village Lashtkhveri	Medieval
178	Guram Jachvliani"s Tower	Village Lashtkhveri	Medieval
179	Piribe Jachvliani"s Tower	Village Lashtkhveri	Medieval
180	Mushni Udesiani's Tower	Village Lashtkhveri	Medieval
181	Amiran Udesiani's Tower	Village Lashtkhveri	Medieval
182	Baju Udesiani's "Gubandi" (corridor)	Village Lashtkhveri	Medieval
183	Nugzar Ildiani's Tower	Village Lashtkhveri	Medieval
184	Indiko Arghvliani's	Village Lashtkhveri	Medieval
185	Church Complex: St. George Church " Jgrag Lakhmash"	Village Lakhami	Medieval

#	Name	Location	Dated
186	Emzar Davitiani's Tower	Village Lakhamula	Medieval
187	Nazi Torias Tower	Village Lakhamula	Medieval
188	Original rural settlement pattern	Village Lakhiri	Medieval
189	Ioane Makharobeli (St. John's) Church	Village Lakhiri, East, cemetery	Medieval
190	Amiran Gvidiani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Lakhiri	Medieval
191	Lazare Gvidani's Tower	Village Lakhiri	Medieval
192	Jano Ioseliani's Tower	Village Lakhiri	Medieval
193	Grisha Ioseliani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Lakhiri	Medieval
194	Agtion Ioseliani's Tower	Village Lakhiri	Medieval
195	Gela Zurebiani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Lakhiri	Medieval
196	Pasiko Zurebiani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Lakhiri	Medieval
197	Zaur Margiani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Lakhiri	Medieval
198	Edison Zurebiani's Tower	Village Lakhiri	Medieval
199	Ivane Margiani's Tower	Village Lakhiri	Medieval
200	Orshag Margiani's Tower	Village Lakhiri	Medieval
201	Emzar Gvidiani's Tower	Village Lakhiri	Medieval
202	Alexandre Gvidiani's Tower	Village Lakhiri	Medieval
203	Qemlat Ioseliani's Tower	Village Lakhiri	Medieval
204	Davit Tevzadze's Tower	Village Lakhiri	Medieval

#	Name	Location	Dated
205	Davit Zurabiani's Tower	Village Lakhiri	Medieval
206	Islam Gvidani's Tower	Village Lakhiri	Medieval
207	Jimsher Gvidani's Tower	Village Lakhiri	Medieval
208	Jokola Ioseliani's Tower	Village Lakhiri	Medieval
209	Kamo Margiani's Tower	Village Lakhiri	Medieval
210	Marlen Zhorzholiani's Tower	Village Lakhiri	Medieval
211	Shakro Ioseliani's Tower	Village Lakhiri	Medieval
212	Sozar Gvidani's Tpwer	Village Lakhiri	Medieval
213	Teimuraz Mitiani's Tower	Village Lakhiri	Medieval
214	Valeri Margiani's Tower	Village Lakhiri	Medieval
215	Vasiko Ioseliani's Tower	Village Lakhiri	Medieval
216	Original rural settlement pattern	Village Lakhushdi	Medieval
217	Church "Tanghi-Taringzeli" (Church of the Archangel)	Village Lakhushdi, 1.5 km North-East, pass	Medieval
218	Church "Matskhovari" (Church of the Redeemer)	Village Lakhushdi, Village center, cemetery	XIX A.D.
219	Taisav Chagulani's Tower	Village Lakhushdi	Medieval
220	Davit Asumbiani's Tower	Village Lakhushdi	Medieval
221	Givi Pirtskhelani's Tower	Village Lakhushdi	Medieval
222	Pridon Kvanchiani's Tower	Village Lakhushdi	Medieval
223	Durkhan Kvanshiani's Tower	Village Lakhushdi	Medieval
224	Zaur Pirtskhelani's Residential Complex 1. "Machubi" (ground floor hall) 2. Tower	Village Lakhushdi	Medieval
225	St. George's Church	Village Lahili, 4 km south "Ushba view"	Medieval
226	St. Elia Church "Ieli"	Village Lahili, 1.5 km South-West	Medieval

#	Name	Location	Dated
227	St. Mary Church “ Lamaria”	Village Lahili, 0.3 km South-East	Medieval
228	Church “Matskhvar” (Church of the Redeemer)	Village Lahili, Village Sguburi remnants	Medieval
229	Original rural settlement pattern	Village Lahili	Medieval
230	St. George’s Church “Mkheis Jgrag”	Village Lahili, South	Medieval
231	Church “Matskhvar” (Church of the Redeemer)	Village Lahili, North	Medieval
232	Tower	Village Lezgara, Southern part	Medieval
233	Church “Matskhvar” (Church of the Redeemer)	Village Lemsia	Medieval
234	Mizdon Shukvani’s Tower	Village Lemsia	Medieval
235	Soso Skukvani’s Tower	Village Lemsia	Medieval
236	Soso Merlani’s Tower	Village Lemsia	Medieval
237	Bichi Ildyani Tower	Village Lenjeri	Medieval
238	David Jajviani’s Tower	Village Lenjeri	Medieval
239	Evgeny Udesiani’s Tower	Village Lenjeri	Medieval
240	Gocha Guledani’s Tower	Village Lenjeri	Medieval
241	Gogia Maghedani’s Tower	Village Lenjeri	Medieval
242	Levan Jajvani’s Tower	Village Lenjeri	Medieval
243	Original rural settlement pattern	Village Leshukvi	Medieval
244	Ivechiani’s Dynasty Tower	Village Leshukvi	Medieval
245	Murad Ivechiani’s Tower	Village Mazeri, 1.5km North	Medieval
246	St. George’s Church “Shkhraigrag”	Village Mazeri	Medieval
247	Dadeshqeliani’s Family Tower	Village Mazeri	Medieval
248	Dadeshqeliani’s Family Tower	Village Matskhvarishi	Medieval
249	Original rural settlement pattern	Village Matskhvarishi	Medieval

#	Name	Location	Dated
250	Church "Matskhvar" (Church of the Redeemer)	Village Matskhvarishi	X-XI
251	Church "Taringzeli" (Church of the Archangel)	Village Matskhvarishi	Medieval
252	Nestor Girgvliani's Residential Complex	Village Matskhvarishi	Medieval
253	Original rural settlement pattern	Village Murkhmeli	Medieval
254	Church "Matskhvar" (Church of the Redeemer)	Village Murkhmeli, cemetery	Medieval
255	St. Barbale Church "Barbal"	Village Murkhmeli, outskirts, west	Medieval
256	Giorgi Charqseliani's Tower	Village Murkhmeli	Medieval
257	Varden Ghvachliani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Murkhmeli	Medieval
258	Church "Matskhvar" (Church of the Redeemer)	Village Murkhmeli	Medieval
259	Oldymar Kakriashvili's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Murkhmeli	Medieval
260	Baju Kakriashvili's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Murkhmeli	Medieval
261	Bikenti Charqseliani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Murkhmeli	Medieval
262	Bejan Ghvachlianis Residential Complex 1. "Machubi" (ground floor hall) 2. Tower	Village Murkhmeli	Medieval
263	Vaso Tsindeliani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Murkhmeli	Medieval
264	Qishvardi Tserediani's Tower	Village Nashtqoli	Medieval

#	Name	Location	Dated
265	Kola (Aslamaz) Tsindeliani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Nashtqoli	Medieval
266	Kola (Aslamaz) Tsindeliani's Tower	Village Nashtqoli	Medieval
267	Dadeshqelianebi's castle "Namurkvami"	Village Nashtqoli	Medieval
268	Original rural settlement pattern	Village Nashtqoli	Medieval
269	Original rural settlement pattern	Village Nesguni	Medieval
270	St. Elias Church "Ieli"	Village Nesguni, 0.3km North-west	Medieval
271	Church "Matskhovari" (Church of the Redeemer)	Village Nesguni	Medieval
272	St. George's Church "Jgrag"	Village Nesguni	Medieval
273	Church "Matskhovari" (Church of the Redeemer)	Village Nesguni, South-West	Medieval
274	Minada Guledani's Tower	Village Nesguni	Medieval
275	Gipho Maledani's Tower	Village Nesguni	Medieval
276	Anzor Guledani's Twer	Village Nesguni	Medieval
277	Chichiko Geladni's Tower	Village Nesguni	Medieval
278	Zurab Guledani's Tower	Village Nesguni	Medieval
279	Zhivler Guledani's Tower	Village Nesguni	Medieval
280	Original rural settlement pattern	Village Zhabeshi	Medieval
281	St. Mary Church " Lamaria"	Village Zhabeshi, 3 km North-East	Medieval
282	Defensive-watching Tower	Village Zhabeshi, North-East, on the other side of the Riv. Mulkhura	Medieval
283	Church "Matskhovari" (Church of the Redeemer)	Village Zhabeshi	Medieval
284	Raphiel Naveriani's Tower	Village Zhabeshi	Medieval

#	Name	Location	Dated
285	Avtandil Qichqanis Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Zhabeshi	Medieval
286	Radion Naveriani's Residential Complex:: 1. "Machubi" (ground floor hall) 2. Tower	Village Zhabeshi	Medieval
287	Tengiz Gujedjiani's Tower	Village Zhabeshi	Medieval
288	Jumber Kakhiani's Residential Complex	Village Zhabeshi	Medieval
289	Abo Zurebiani's Tower	Village Zhabeshi	Medieval
290	Sophrom Gujejiani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Zhabeshi	Medieval
291	Alexander Japaridze's Tower	Village Zhabeshi	Medieval
292	Original rural settlement pattern	Village Zhamushi	Medieval
293	Church "Matskhovari" (Church of the Redeemer)	Village Zhamushi	XI A.D.
294	Giorgi Naveriani's Tower	Village Zhamushi	Medieval
295	Shaliko Naveriani's Tower	Village Zhamushi	Medieval
296	Ardevan Naveriani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Zhamushi	Medieval
297	Platon Naveriani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Zhamushi	Medieval
298	Lado Naveriani's Tower	Village Zhamushi	Medieval
299	Razhden Qaldani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Zhamushi	Medieval
300	Biqtor Qaldani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Zhamushi	Medieval
301	Original rural settlement pattern	Village Zhibiani	Medieval

#	Name	Location	Dated
302	Lamaria Complex: 1. St. Mary Church "Lamaria" 2. Residential Complex	Village Zhibiani, North-East	1. XI-XII A.D. 2. Medieval 3. Medieval
303	St. George's Church "Jgrag"	Village Zhibiani, Northern part	Medieval
304	Church "Phusd"	Village Zhibiani, Southern part	Medieval
305	Onisime Nizharadze's Residential Complex	Village Zhibiani	Medieval
306	Shura Nizharadze's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Zhibiani	Medieval
307	Varden Ratiani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Zhibiani	Medieval
308	David Khachvani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Zhibiani	Medieval
309	Guram Nizharadze's Residential Complex: 1. "Machubi" – Ground floor hall 2. Tower	Village Zhibiani	Medieval
310	Pimen Chelidze's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Zhibiani	Medieval
311	Jemal Khachvanis Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Zhibiani	Medieval
312	Domna Nizharadze's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Zhibiani	Medieval
313	Odishar Ratiani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Zhibiani	Medieval
314	Mate Ratiani's Residential Complex: 1. "Machubi" (ground floor hall) Tower	Village Zhibiani	Medieval
	Varden Ratiani's Tower	Village Zhibiani	Medieval

#	Name	Location	Dated
315	St. George's Church "Jgrag"	Village Sviphi	X A.D.
316	Roza Arghvliani's Residential Complex: 1. "Machubi" (ground floor hall) Tower	Village Sviphi	Medieval
317	Church "Guhlis Taringzeli" (Church of the Archangel	Village Sidianari, 1 km East	Medieval
318	Original rural settlement pattern	Village Sidianari	Medieval
319	Jobe Sidiani's Tower	Village Sidianari	Medieval
320	Original rural settlement pattern	Village Soli	Medieval
321	St. George's Church "Jgrag"	Village Soli, cemetery	Medieval
322	Ioane Natlismtsemeli (St. John's) Church	Village Soli, Village Center	Medieval
323	Tevdore Shukvani's Tower	Village Soli	Medieval
324	Shaliko Khaphtani's Tower	Village Soli	Medieval
325	Mushni Khaphtani's Tower	Village Soli	Medieval
326	Boris Khaphtani's Tower	Village Soli	Medieval
327	Valeri Guledani's Tower	Village Soli	Medieval
328	Beqa Khorguani's Tower	Village Soli	Medieval
329	Toriebi Family Tower	Village Soli	Medieval
330	Miron Udesiani's Tower"	Village Soli	Medieval
331	St. George's Church "Jgrag"	Village Ughvali	Medieval
332	St. Mary Church "Lamaria"	Village Ushkhvanari, cemetery	XIX A.D.
333	Grigol Kvitsiani's Tower	Village Ushkhvanari	Medieval
334	Vakhtang Shamphriani's "Machubi" (ground floor hall)	Village Ushkhvanari	Medieval
335	Teimuraz Nizharaze's Tower	Ushguli Community	Late Medieval
336	Church "Taringzeli" (Church of the Archangel)	Village Pkhutreri	Medieval
337	Original rural settlement pattern	Village Qashveti	Medieval
338	St. George's Church "Jgrag"	Village Qashveti	Medieval
339	Mikheil Philphani's Tower	Village Qashveti	Medieval
340	Vaso Philphani's Tower	Village Qashveti	Medieval
341	Babu Phiphani's&Salareb Tsiphiani's Tower	Village Qashveti	Medieval

#	Name	Location	Dated
342	St. George's Church "Jgrag Laka"	Village Qveda Luha	Medieval
343	St. George's Church "Jgrag"	Village Qurashi	Medieval
344	Church "Kaishi Taringzeli" (Church of the Archangel)	Village Gheshderi	Medieval
345	Rozan Geldiani's Tower	Village Ghvebaldi	Medieval
346	Original rural settlement pattern	Village Ghvebra	Medieval
347	Bato Marghiani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Ghvebra	Medieval
348	Germane Tsiphiani's Tower	Village Ghvebra	Medieval
349	Original rural settlement pattern	Village Chazhashi	Medieval
350	Tamari's Fortress "Lenkveri"	Village Chazhashi	Medieval
351	Complex of the Lower Fortress: 1. Church "Lashq-Duir"; Forge 2. Towers	Village Chazhashi	Medieval
352	Church "Matskhovari" (Church of the Redeemer)	Village Chazhashi	Medieval
353	Ilo Nizharadze's Tower	Village Chazhashi	Medieval
354	Ilia Nizharadze's Tower	Village Chazhashi	Medieval
355	Tower of three residents	Village Chazhashi	Medieval
356	Merab Nizharadze's Tower	Village Chazhashi	Medieval
357	Dami Nizharadze's Tower	Village Chazhashi	Medieval
358	Ephrem Nizharaze's Tower	Village Chazhashi	Medieval
359	Nikoloz Davituliani's I Tower	Village Chazhashi	Medieval
360	Nikoloz Davituliani's II Tower	Village Chazhashi	Medieval
361	Konstantine Nizharaze's Tower	Village Chazhashi	Medieval
362	Kalo Nizharadze's Tower	Village Chazhashi	Medieval
363	Datiko Nizharadze's Tower	Village Chazhashi	Medieval
364	Leonti Nizharadze's Tower	Village Chazhashi	Medieval
365	Zurab Nizharadze's I Tower	Village Chazhashi	Medieval
366	Zurab Nizharadze's II Tower	Village Chazhashi	Medieval
367	Nameless Tower	Village Chazhashi	Medieval
368	David Davituliani's Tower	Village Chazhashi	Medieval

#	Name	Location	Dated
369	Original rural settlement pattern	Village Chvabiani	Medieval
370	Church "Matskhovari" (Church of the Redeemer)	Village Chvabiani	Medieval
371	Church "Taringzeli" (Church of the Archangel	Village Chvabiani, west, cemetery	Medieval
372	Jokola Gujedjiani's Tower	Village Chvabiani	Medieval
373	Datiko Gujejiani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Chvabiani	Medieval
374	Mushni Gulbani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Chvabiani	Medieval
375	Bukhuti Gigani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Chvabiani	Medieval
376	Omar Margani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Chvabiani	Medieval
377	Irodi Gigani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Chvabiani	Medieval
378	Semlar Gigani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Chvabiani	Medieval
379	Valeri Gigani's Residential Complex: 1. "Machubi" – Ground floor hall 2. Tower	Village Chvabiani	Medieval
380	Masho Gigani's Residentail Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Chvabiani	Medieval
381	Lado Gigani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Chvabiani	Medieval

#	Name	Location	Dated
382	Shaliko Gigani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Chvabiani	Medieval
383	Temur Gigani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Chvabiani	Medieval
384	Baju Chekhani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Chvabiani	Medieval
385	Avto Gigani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Chvabiani	Medieval
386	Original rural settlement pattern	Village Chvabiani	Medieval
387	Church of "Mama Uphali" (God Father)	Village Chvabiani	Medieval
388	Ivane Charqseliani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Chvabiani	Medieval
389	Ilia Charqseliani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Chvabiani	Medieval
390	Tevdore Chelidze's Tower	Village Chvabiani	Medieval
391	Baju Charkviani's Tower	Village Chvabiani	Medieval
392	"Bapre-Qor" – House of the priests	Village Chvabiani	Medieval
393	Church "Jgrag-chani"	Village Chvabiani	Medieval
394	Original rural settlement pattern	Village Tsaldashi	Medieval
395	Givi Zurebiani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Tsaldashi	Medieval
396	Gogi Naveriani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Tsaldashi	Medieval
397	Church "Phusd"	Village Tsaleri	Medieval
398	Shaliko Vibliani's "Svaniri"	Village Tsvirmi, district Zagari	Medieval

#	Name	Location	Dated
399	Original rural settlement pattern	Village Tsvirmi, district Zagari	Medieval
400	Church "Taringzeli" (Church of the Archangel)	Village Tsvirmi, district Zagari	Medieval
401	Jorji Korzaia's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Tsvirmi, district Zagari	Medieval
402	Gogi Kipiani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Tsvirmi, district Zagari	Medieval
403	Original rural settlement pattern	Village Tsvirmi, district Sviphi	Medieval
404	Church "Matskhovari" (Church of the Redeemer)	Village Tsvirmi, district Kvemo Chobani	Medieval
405	Ismail Kipiani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Tsvirmi, district Kvemo Chobani	Medieval
406	Original rural settlement pattern	Village Tsvirmi, district Kvemo Chobani	Medieval
407	Church "Naka Taringzeli" (Church of the Archangel)	Village Tsvirmi, district Kvemo Chobani	Medieval
408	Amiran Tamliani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Tsvirmi, district Kvemo Chobani	Medieval
409	Tamliani Family Tower	Village Tsvirmi, district Kvemo Chobani	Medieval
410	Original rural settlement pattern	Village Tsvirmi, district Zemo Chobani	Medieval
411	St. George's Church "Jgrag"	Village Tsvirmi, district Zemo Chobani	Medieval
412	Giorgi Pirtskheliani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Tsvirmi, district Zemo Chobani, cemetery	Medieval
413	Chichiko Tamliani's Tower	Village Tsvirmi, district Zemo Chobani	Medieval
414	Original rural settlement pattern	Village Tsvirmi	Medieval
415	St. Barbale Church	Village Tsvirmi, district Lamuldi	Medieval
416	Anzor Phirtskhelani's Tower	Village Tsvirmi, district Lamuldi	Medieval

#	Name	Location	Dated
417	Raphiel Giglemiani's Tower	Village Tsvirmi, district Lamuldi	Medieval
418	Original rural settlement pattern	Village Tsvirmi, district Tuberi	Medieval
419	Vladymer Phangani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Tsvirmi, district Tuberi	Medieval
420	St. Mary Church "Lamaria"	Village Tsvirmi, district Pekhi	1881
421	Original rural settlement pattern	Village Tcholashi	Medieval
422	St. George's Church "Jgrag"	Village Tcholashi	XIX-XX A.D.
423	Qvito Devdariani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Tcholashi	Medieval
424	Tatash Jachvliani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Tcholashi	Medieval
425	Giorgi Qochqani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Tcholashi	Medieval
426	Sasha Shervashidze's Tower	Village Tcholashi	Medieval
427	Giorgi Pirtskheliani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Tcholashi	Medieval
428	Vati Gujejiani's Tower	Village Tcholashi	Medieval
429	Mirdon Gujejiani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Tcholashi	Medieval
430	Gelakhsan Devdariani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Tcholashi	Medieval
431	Givi Gujejiani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Tcholashi	Medieval
432	Gela Jorjoliani's Residential Complex: 1. "Machubi" (ground floor hall) 2. Tower	Village Tcholashi	Medieval

#	Name	Location	Dated
433	Church “Matskhovari” (Church of the Redeemer)	Village Tchokhuldi	XI A.D.
434	Kvitsiani Family Tower	Village Tchokhuldi	Medieval
435	Church “Taringzeli” (Church of the Archangel)	Village Khaishi, Dakari	Medieval
436	Original rural settlement pattern	Village Khalde	Medieval
437	Church “Matskhovari” (Church of the Redeemer)	Village Khalde, cemetery	XIX A.D.
438	Original rural settlement pattern	Village Khe	Medieval
439	Complex of the Church: 1. St. Kvirike and Ivlita Church “Lagvirka” 2. Defensive fence 3. Other buildings	Village Khe, South-West, “Mtis Kontskhi”	XI-XII A.D.
440	St. Barbale Church	Village Khe, Center of the village, cemetery	XI A.D.
441	Ilia Gulbani’s Tower	Village Khe	Medieval
442	Grigol Ansiani’s Tower	Village Kherkhvashi	Medieval
443	Church “Matskhovari” (Church of the Redeemer)	Village Hebuti	Medieval

Source: Ministry of Culture of Georgia: Ministerial Orders #3/133 and #3/110(2006 and 2011)

English-Language Translation: USAID Hydropower Investment Promotion Project (HIPP), January 2012.

Appendix 3

Preliminary Turbine – Generator Unit Characteristics

TURBNPRO Version 3 - PELTON TURBINE SOLUTION SUMMARY

Solution File Name: c:\georgi~1\hipphy~1\enguri~1\khumpr~1\khu-2xlp.dat

TURBINE SIZING CRITERIA

Rated Discharge:	176.6	cfs	/	5.00	m3/s
Net Head at Rated Discharge:	1460.0	feet	/	445.0	meters
Gross Head:	1542.0	feet	/	470.0	meters
Efficiency Priority:			5		
System Frequency:			50 Hz		
Minimum Net Head:	1460.0	feet	/	445.0	meters
Maximum Net Head:	1520.4	feet	/	463.4	meters

PELTON TURBINE SOLUTION DATA

Arrangement: HORIZONTAL WITH RUNNER ON TURBINE SHAFT
Intake Type: 2 - JET
Runner Pitch Diameter: 78.3 inches / 1989 mm
Unit Speed: 428.6 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:	7.7	29.4
At Peak Efficiency Condition:	7.0	26.8

Specific Speed at Rated Net Head (per jet) -	(US Cust.)	(SI Units)
At 100% Turbine Output:	5.4	20.8
At Peak Efficiency Condition:	5.0	19.0

SOLUTION PERFORMANCE DATA

At Rated Net Head of: 1460.0 feet / 445.0 meters

% of Rated Discharge	Output (KW)	Efficiency (%)	cfs	m3/s
** 116.7	22720	89.2	206.0	5.83
100	19602	89.8	176.6	5.00
* 83.3	16366	90.0	147.1	4.17
75	14708	89.8	132.4	3.75
50	9703	88.9	88.3	2.50
25	4795	87.9	44.1	1.25

** - Overcapacity
* - Peak Efficiency Condition

At Maximum Net Head of: 1520.4 feet / 463.4 meters

Max. Output (KW)	Efficiency (%)	cfs	m3/s
24110	89.1	210.2	5.95

At Minimum Net Head of: 1460.0 feet / 445.0 meters

Max. Output (KW)	Efficiency (%)	cfs	m3/s
22716	89.2	206.0	5.83

Solution File Name: c:\georgi~1\hipphy~1\enguri~1\khumpr~1\khu-2xlp.dat

MISCELLANEOUS DATA

Maximum Runaway Speed (at Max. Net Head):	761 rpm
D/B Ratio (Runner Pitch Dia./Bucket Width):	2.96
Maximum Hydraulic Thrust (at Max. Net Head):	48648 lbs / 22113 kg
Hydraulic Thrust per Jet (at Max. Net Head):	28449 lbs / 12932 kg
Estimated Axial Hydraulic Thrust:	5351 lbs / 2432 kg
Approximate Runner and Shaft Weight:	33190 lbs / 15086 kg

DIMENSIONAL DATA

Intake Type: 2 - JET

	inches	mm
Inlet Diameter:	29.7	754
Nozzle Diameter:	24.8	630
Jet Orifice Diameter:	7.9	201
Needle Stroke:	7.5	191
Centerline to Inlet:	336.7	8553
Jet to Jet Included Angle:	70 to 90 Degrees	

Housing/Discharge Geometry:

	inches	mm
Centerline to Housing Top:	58.3	1480
Housing Width:	108.5	2755
Discharge Width:	108.5	2755
Tailwater Depth:	47.6	1210
Discharge Ceiling to T.W.:	47.0	1193
Centerline to Tailwater:	152.3	3868
Downstream Length:	125.3	3182

Shafting Arrangement: HORIZONTAL WITH RUNNER ON TURBINE SHAFT

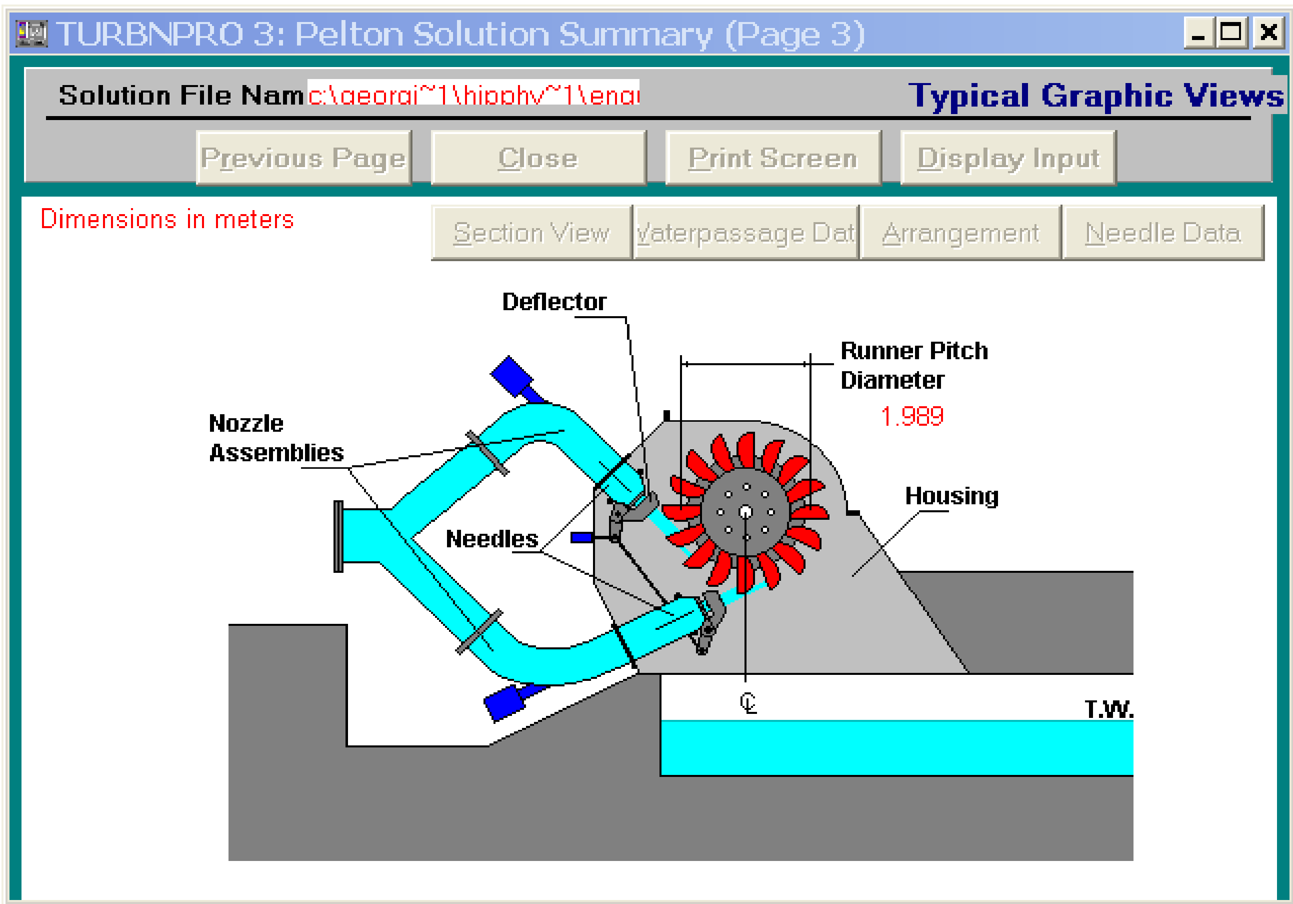
	inches	mm
Overall Shaft Length:	193.9	4925
Turbine Shaft Diameter:	18.0	456

Miscellaneous:

	inches	mm
Runner Outside Diameter:	104.8	2661
Runner Bucket Width:	26.5	672

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

Solution File Name: c:\georgi~1\hipphy~1\enguri~1\khumpr~1\khu-2xlp.dat
Intake Type: 2 - JET
Runner Diameter: 1989 mm
Net Head at Rated Discharge: 445.00 meters
Unit Speed: 428.6 rpm



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Intake Type:                     2 - JET
Runner Diameter:                 1989  mm
Net Head at Rated Discharge:     445.00  meters
Unit Speed:                      428.6  rpm
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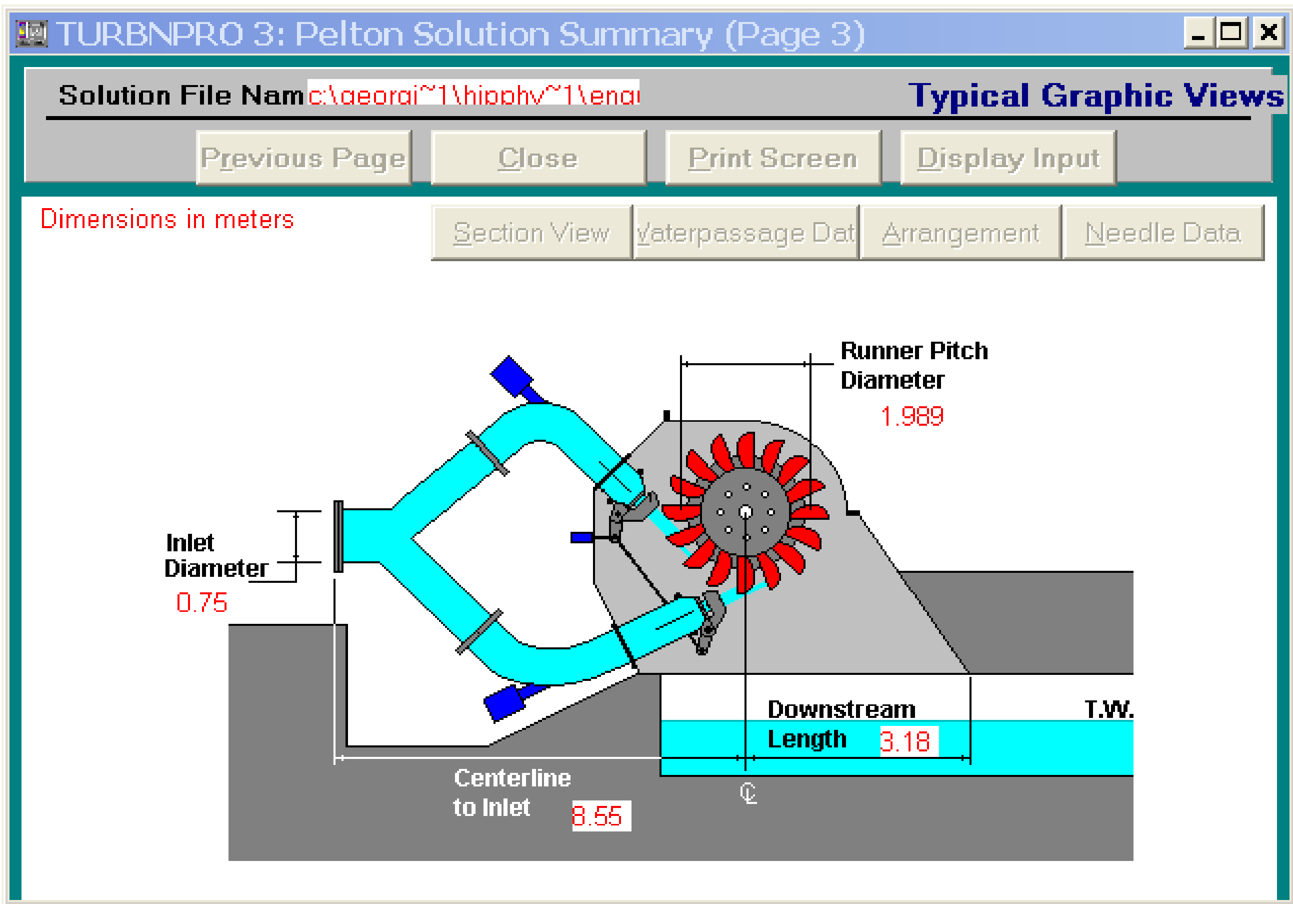

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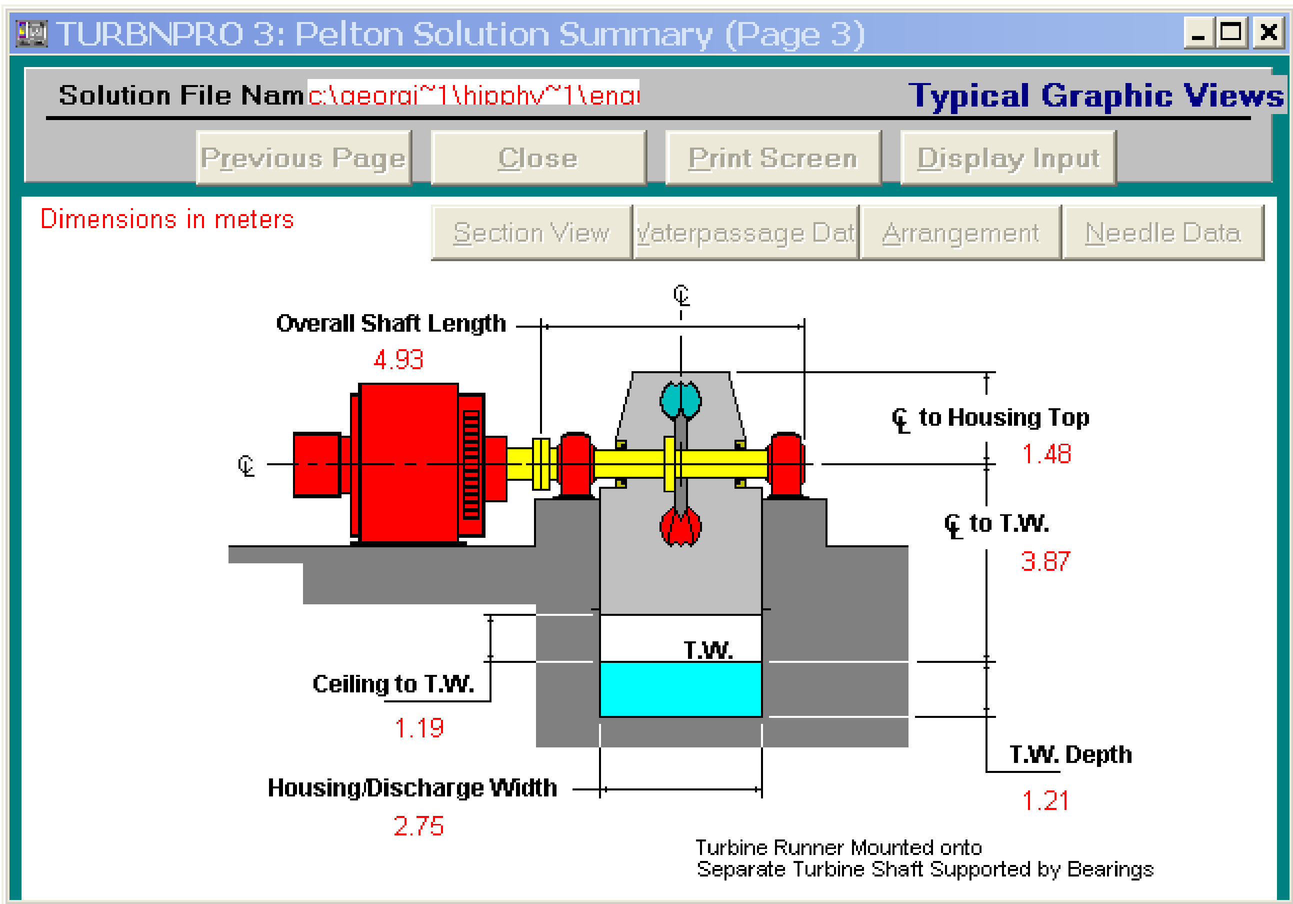
Intake Type: 2 - JET
Runner Diameter: 1989 mm
Net Head at Rated Discharge: 445.00 meters
Unit Speed: 428.6 rpm



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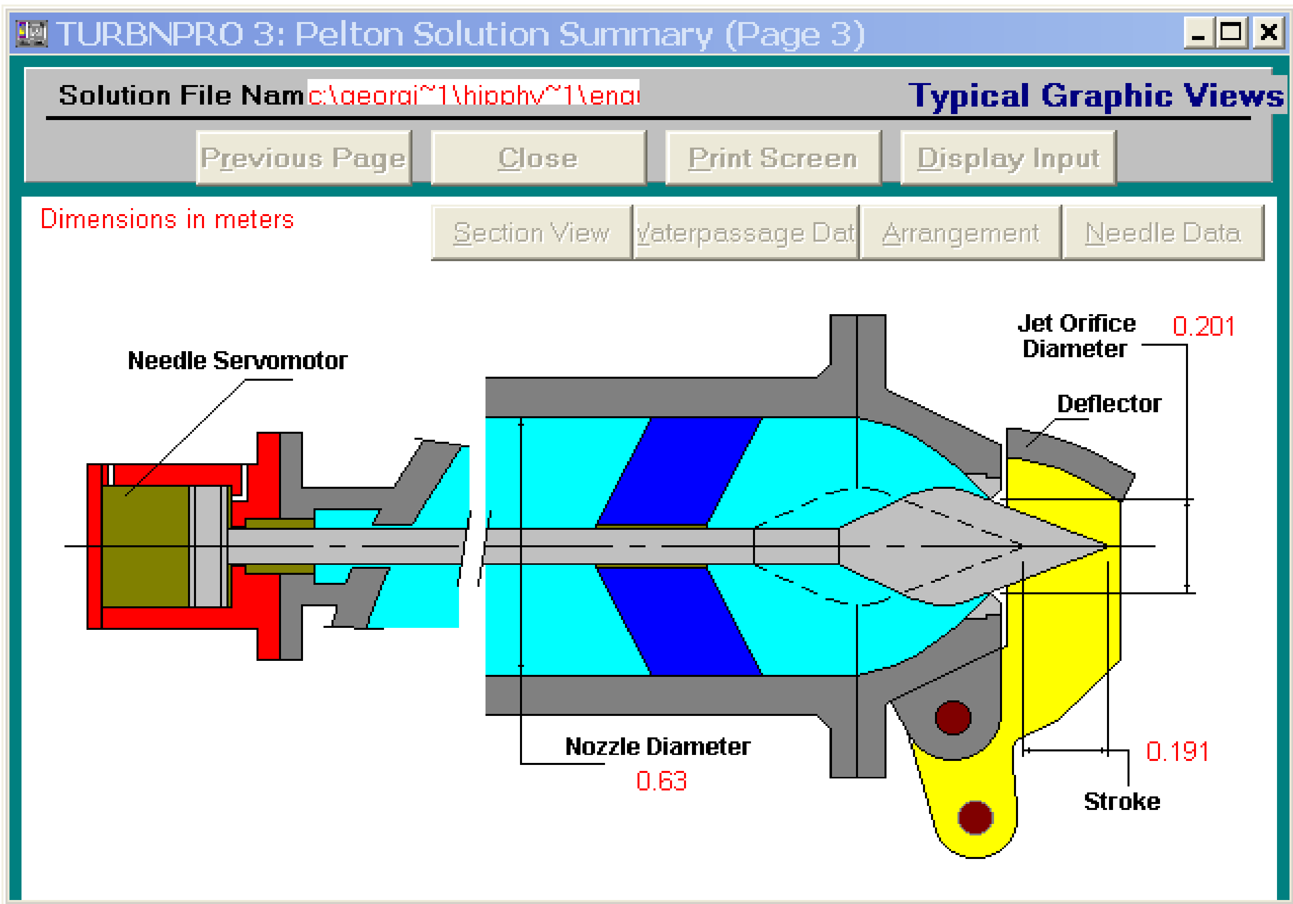
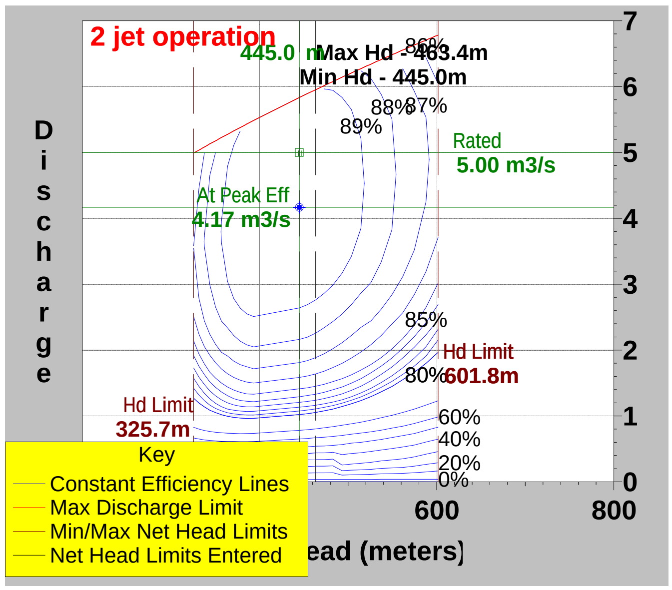
Intake Type: 2 - JET
Runner Diameter: 1989 mm
Net Head at Rated Discharge: 445.00 meters
Unit Speed: 428.6 rpm



Solution File Name: c:\georgi~1\hipphy~1\enguri~1\khumpr~1\khu-2xlp.dat

Intake Type:	2 - JET
Runner Pitch Diameter:	1989 mm
Net Head at Rated Discharge:	445.00 meters
Unit Speed:	428.6 rpm
Peak Efficiency:	90.0 %
Multiplier Efficiency Modifier:	1.000
Flow Squared Efficiency Modifier:	0.0000



NOTE: Discharge is in cubic meters per second

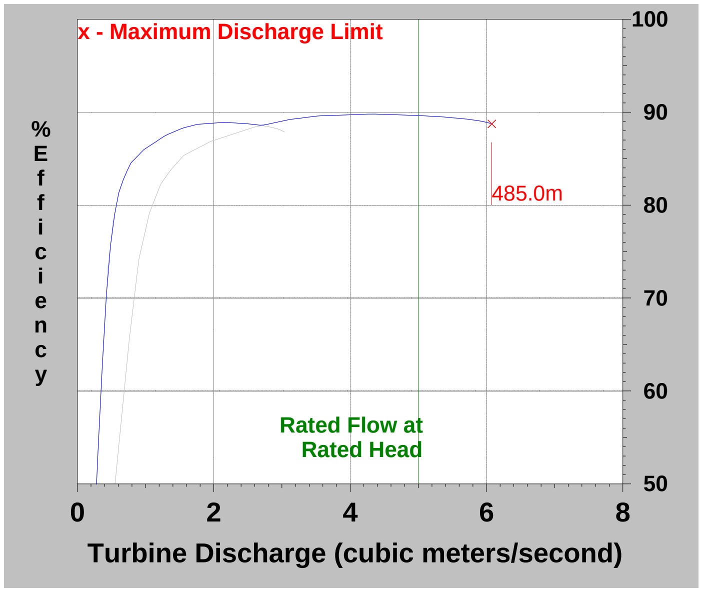
TURBNPRO Version 3 - PELTON TURBINE HILL CURVE

Solution File Name: c:\georgi~1\hipphy~1\enguri~1\khumpr~1\khu-2xlp.dat
Intake Type: 2 - JET
Runner Pitch Diameter: 1989 mm
Net Head at Rated Discharge: 445.00 meters
Unit Speed: 428.6 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

Performance Data Shown is for a Net Head of: 485

Power (KW)	Efficiency (%)	Discharge (m3/s)	Operating Jets	Notes
25659	88.75	6.08	2	Max Discharge Limit
25212	88.98	5.96	2	-
24737	89.12	5.83	2	-
24255	89.24	5.71	2	-
23761	89.33	5.59	2	-
23266	89.41	5.47	2	-
22769	89.49	5.35	2	-
22264	89.54	5.23	2	-
21759	89.59	5.10	2	-
21252	89.64	4.98	2	-
20740	89.67	4.86	2	-
20229	89.70	4.74	2	-
19716	89.73	4.62	2	-
19204	89.76	4.50	2	-
18691	89.79	4.38	2	-
18545	89.79	4.34	2	Best Efficiency at Net Head
18169	89.77	4.25	2	-
17644	89.74	4.13	2	-
17119	89.71	4.01	2	-
16595	89.68	3.89	2	-
16070	89.65	3.77	2	-
15547	89.62	3.65	2	-
15023	89.58	3.52	2	-
14486	89.47	3.40	2	-
13951	89.35	3.28	2	-
13417	89.24	3.16	2	-
12878	89.08	3.04	2	-
12337	88.89	2.92	2	-
11797	88.70	2.80	2	-
11271	88.59	2.67	1	-
10771	88.70	2.55	1	-
10266	88.77	2.43	1	-
9760	88.83	2.31	1	-
9252	88.89	2.19	1	-
9180	88.90	2.17	1	Best Efficiency for 1 Jet Operation
8734	88.84	2.07	1	-
8214	88.78	1.94	1	-
7696	88.72	1.82	1	-
7171	88.57	1.70	1	-
6641	88.35	1.58	1	-
6107	88.00	1.46	1	-
5574	87.63	1.34	1	-
5037	87.11	1.22	1	-
4503	86.53	1.09	1	-
3976	85.94	0.97	1	-
3441	85.02	0.85	1	-
2902	83.65	0.73	1	-
2350	81.27	0.61	1	-
1749	75.62	0.49	1	-
1083	62.45	0.36	1	-
502	43.40	0.24	1	Low efficiency; not used in energy calculation
116	20.03	0.12	1	Low efficiency; not used in energy calculation

TURBNPRO Version 3 - PELTON TURBINE HILL CURVE



TURBNPRO Version 3 - PELTON TURBINE SOLUTION SUMMARY

Solution File Name: c:\georgi~1\hipphy~1\enguri~1\khumpr~1\turbin~1\khu

TURBINE SIZING CRITERIA

Rated Discharge:	176.6	cfs	/	5.00	m3/s
Net Head at Rated Discharge:	1574.8	feet	/	480.0	meters
Gross Head:	1640.4	feet	/	500.0	meters
Efficiency Priority:			5		
System Frequency:			50 Hz		
Minimum Net Head:	1574.8	feet	/	480.0	meters
Maximum Net Head:	1639.1	feet	/	499.6	meters

PELTON TURBINE SOLUTION DATA

Arrangement: HORIZONTAL WITH RUNNER ON TURBINE SHAFT
Intake Type: 2 - JET
Runner Pitch Diameter: 69.3 inches / 1759 mm
Unit Speed: 500.0 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

	(US Cust.)	(SI Units)
Specific Speed at Rated Net Head (turbine) -		
At 100% Turbine Output:	8.5	32.3
At Peak Efficiency Condition:	7.7	29.5
Specific Speed at Rated Net Head (per jet) -		
At 100% Turbine Output:	6.0	22.8
At Peak Efficiency Condition:	5.5	20.8

SOLUTION PERFORMANCE DATA

At Rated Net Head of: 1574.8 feet / 480.0 meters

% of Rated Discharge	Output (KW)	Efficiency (%)	cfs	m3/s
** 116.6	24336	88.7	205.9	5.83
100	21015	89.3	176.6	5.00
* 83.3	17544	89.4	147.1	4.17
75	15766	89.3	132.4	3.75
50	10402	88.4	88.3	2.50
25	5138	87.3	44.1	1.25

** - Overcapacity
* - Peak Efficiency Condition

At Maximum Net Head of: 1639.1 feet / 499.6 meters

Max. Output (KW)	Efficiency (%)	cfs	m3/s
25825	88.6	210.1	5.95

At Minimum Net Head of: 1574.8 feet / 480.0 meters

Max. Output (KW)	Efficiency (%)	cfs	m3/s
24349	88.7	205.9	5.83

TURBNPRO Version 3 - PELTON TURBINE SOLUTION SUMMARY

Solution File Name: c:\georgi~1\hipphy~1\enguri~1\khumpr~1\turbin~1\khu

MISCELLANEOUS DATA

Maximum Runaway Speed (at Max. Net Head):	888 rpm			
D/B Ratio (Runner Pitch Dia./Bucket Width):	2.80			
Maximum Hydraulic Thrust (at Max. Net Head):	50489 lbs	/	22949 kg	
Hydraulic Thrust per Jet (at Max. Net Head):	29525 lbs	/	13421 kg	
Estimated Axial Hydraulic Thrust:	5554 lbs	/	2524 kg	
Approximate Runner and Shaft Weight:	27004 lbs	/	12275 kg	

DIMENSIONAL DATA

Intake Type: 2 - JET

	inches	/	mm
Inlet Diameter:	29.1		739
Nozzle Diameter:	24.4		619
Jet Orifice Diameter:	7.8		198
Needle Stroke:	7.4		188
Centerline to Inlet:	297.8		7564
Jet to Jet Included Angle:		70 to 90	Degrees

Housing/Discharge Geometry:

	inches	/	mm
Centerline to Housing Top:	52.9		1343
Housing Width:	101.3		2574
Discharge Width:	101.3		2574
Tailwater Depth:	51.0		1295
Discharge Ceiling to T.W.:	41.6		1055
Centerline to Tailwater:	138.0		3504
Downstream Length:	110.8		2814

Shafting Arrangement: HORIZONTAL WITH RUNNER ON TURBINE SHAFT

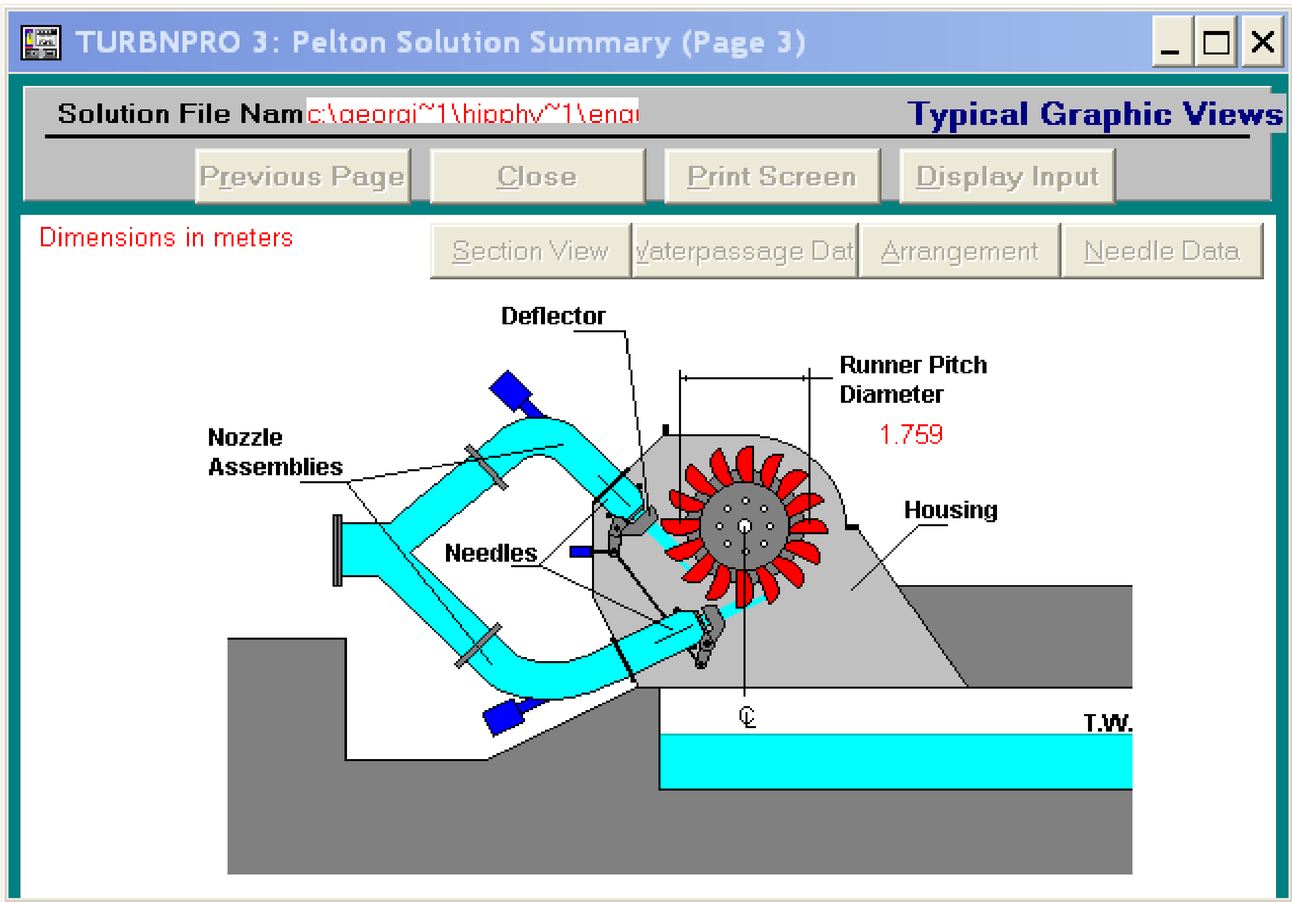
	inches	/	mm
Overall Shaft Length:	184.6		4689
Turbine Shaft Diameter:	17.5		444

Miscellaneous:

	inches	/	mm
Runner Outside Diameter:	94.0		2387
Runner Bucket Width:	24.7		628

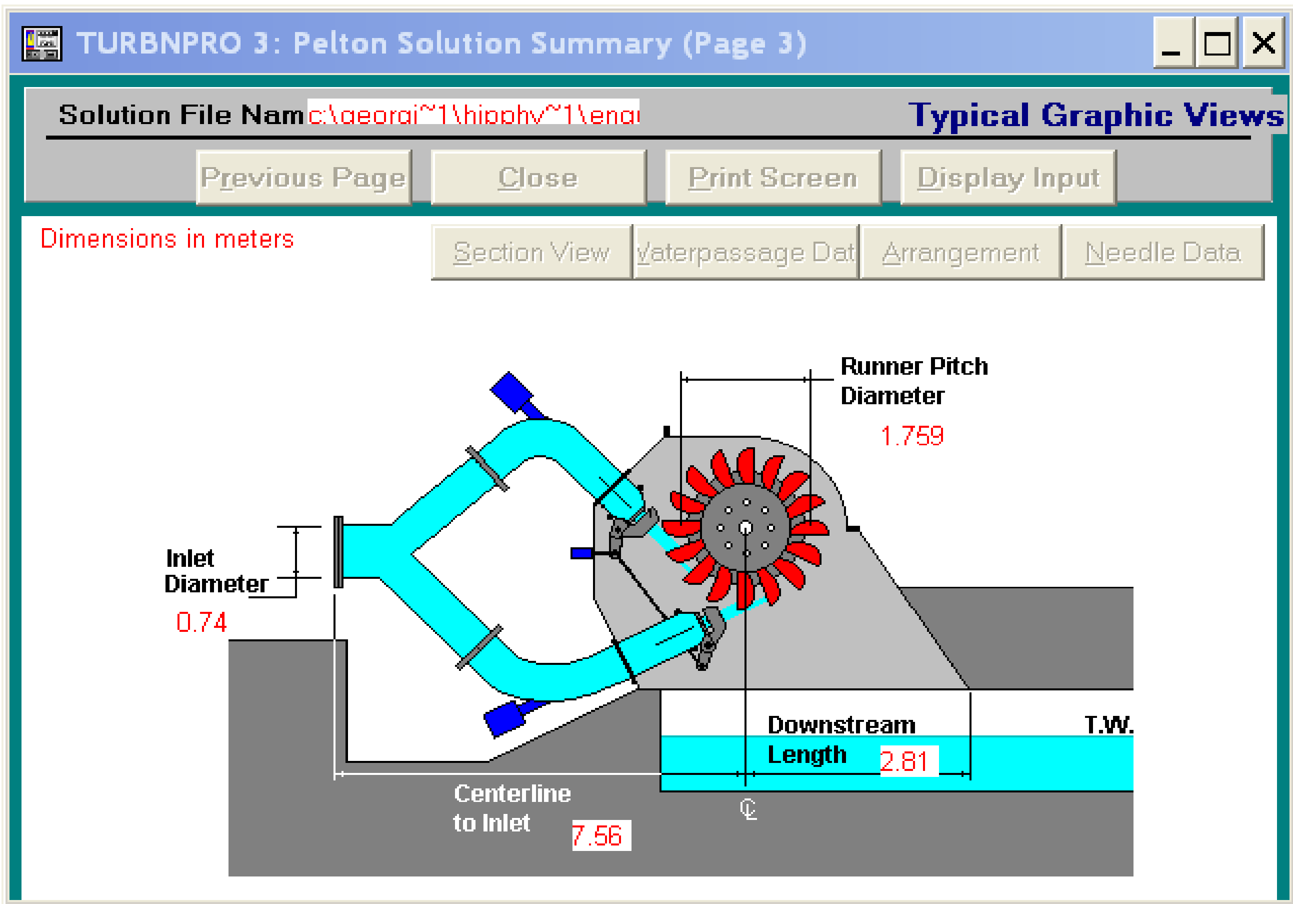
**** All information listed above is typical only. Detailed characteristics will vary based on turbine manufacturer's actual designs.

Solution File Name: c:\georgi~1\hipphy~1\enguri~1\khumpr~1\turbin~1\khum-2p5.dat
Intake Type: 2 - JET
Runner Diameter: 1759 mm
Net Head at Rated Discharge: 480.00 meters
Unit Speed: 500.0 rpm

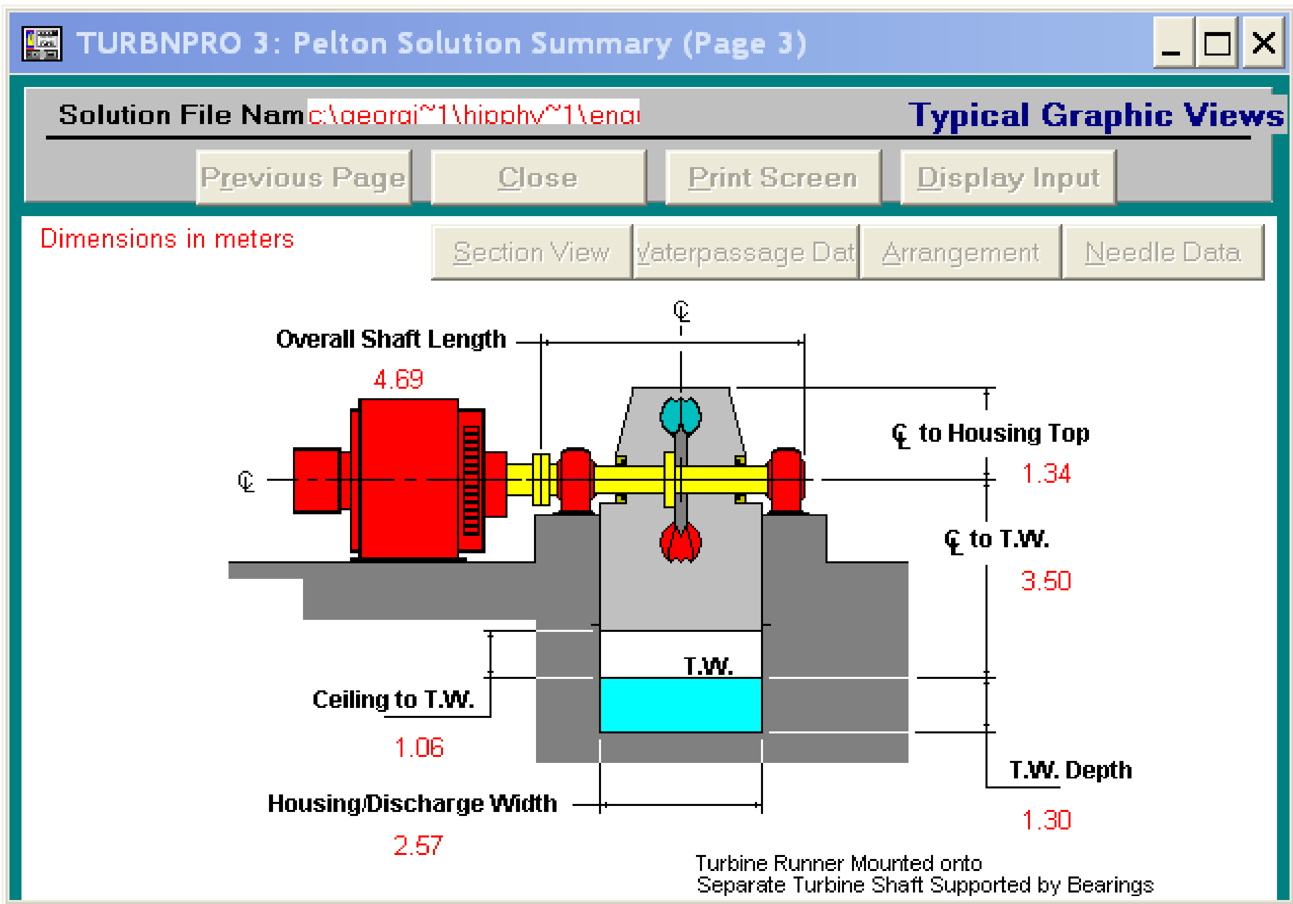


TURBNPRO Version 3.0 - PELTON TURBINE SOLUTION GRAPHICS

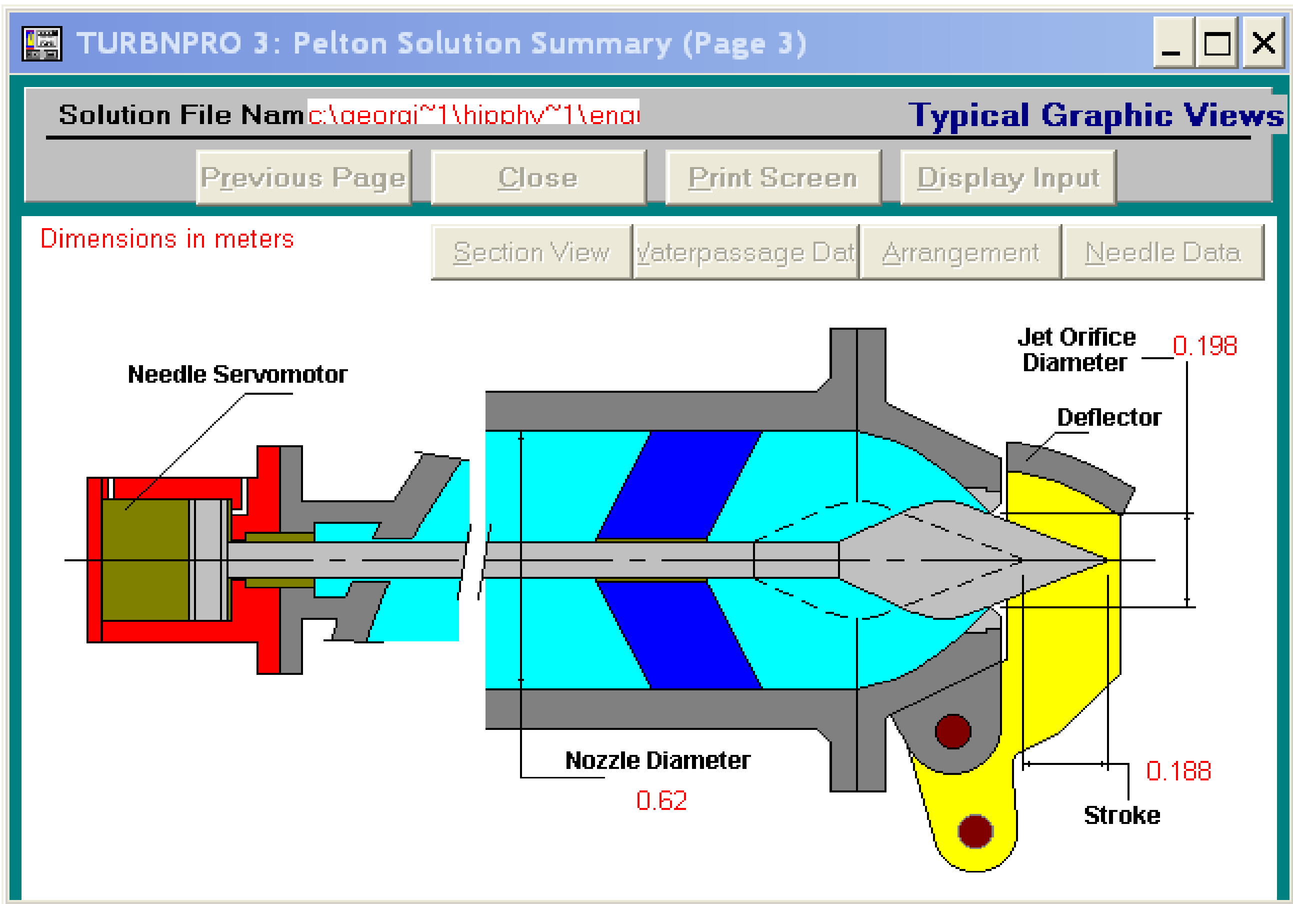
Solution File Name: c:\georgi~1\hipphy~1\enguri~1\khumpr~1\turbin~1\khum-2p5.dat
Intake Type: 2 - JET
Runner Diameter: 1759 mm
Net Head at Rated Discharge: 480.00 meters
Unit Speed: 500.0 rpm



Solution File Name: c:\georgi~1\hipphy~1\enguri~1\khumpr~1\turbin~1\khum-2p5.dat
Intake Type: 2 - JET
Runner Diameter: 1759 mm
Net Head at Rated Discharge: 480.00 meters
Unit Speed: 500.0 rpm

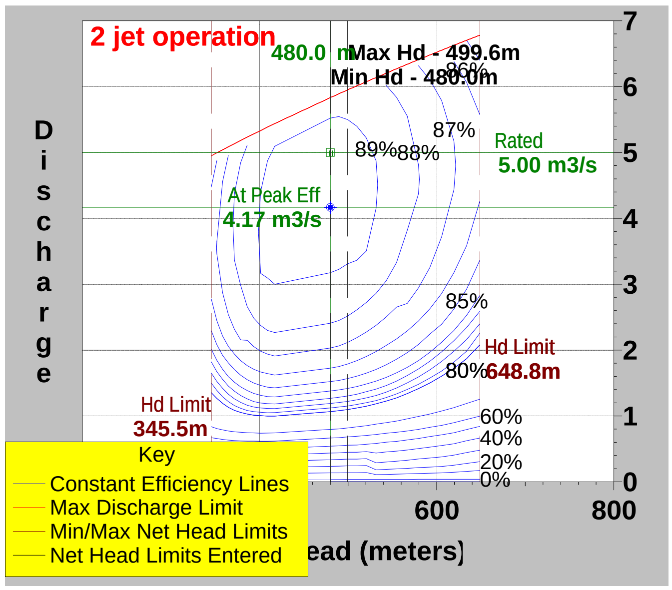


Solution File Name: c:\georgi~1\hipphy~1\enguri~1\khumpr~1\turbin~1\khum-2p5.dat
Intake Type: 2 - JET
Runner Diameter: 1759 mm
Net Head at Rated Discharge: 480.00 meters
Unit Speed: 500.0 rpm



Solution File Name: c:\georgi~1\hipphy~1\enguri~1\khumpr~1\turbin~1\khum-2p5.dat

Intake Type:	2 - JET
Runner Pitch Diameter:	1759 mm
Net Head at Rated Discharge:	480.00 meters
Unit Speed:	500.0 rpm
Peak Efficiency:	89.4 %
Multiplier Efficiency Modifier:	1.000
Flow Squared Efficiency Modifier:	0.0000



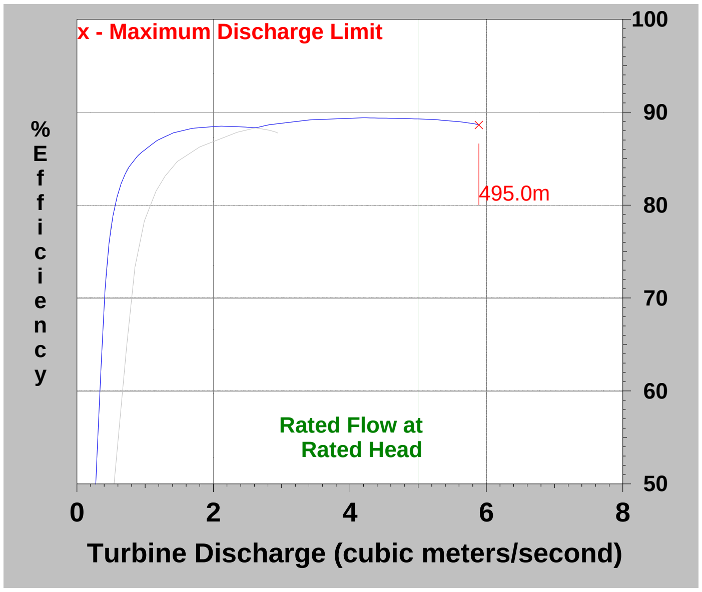
NOTE: Discharge is in cubic meters per second

TURBNPRO Version 3 - PELTON TURBINE HILL CURVE

Solution File Name: c:\georgi~1\hipphy~1\enguri~1\khumpr~1\turbin~1\khum-2p5.dat
Intake Type: 2 - JET
Runner Pitch Diameter: 1759 mm
Net Head at Rated Discharge: 480.00 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: 495

Power (KW)	Efficiency (%)	Discharge (m3/s)	Operating Jets	Notes
25350	88.62	5.89	2	Max Discharge Limit
24893	88.79	5.77	2	-
24421	88.92	5.66	2	-
23934	89.00	5.54	2	-
23445	89.08	5.42	2	-
22954	89.15	5.30	2	-
22460	89.22	5.18	2	-
21956	89.24	5.07	2	-
21452	89.27	4.95	2	-
20948	89.30	4.83	2	-
20442	89.32	4.71	2	-
19934	89.34	4.60	2	-
19426	89.35	4.48	2	-
18918	89.37	4.36	2	-
18410	89.38	4.24	2	-
18265	89.39	4.21	2	Best Efficiency at Net Head
17895	89.36	4.12	2	-
17377	89.33	4.01	2	-
16860	89.30	3.89	2	-
16343	89.26	3.77	2	-
15826	89.23	3.65	2	-
15310	89.20	3.53	2	-
14794	89.16	3.42	2	-
14268	89.07	3.30	2	-
13743	88.96	3.18	2	-
13218	88.86	3.06	2	-
12695	88.75	2.95	2	-
12173	88.65	2.83	2	-
11640	88.45	2.71	2	-
11117	88.32	2.59	1	-
10619	88.38	2.47	1	-
10119	88.43	2.36	1	-
9616	88.46	2.24	1	-
9113	88.49	2.12	1	-
9041	88.49	2.10	1	Best Efficiency for 1 Jet Operation
8602	88.44	2.00	1	-
8090	88.37	1.89	1	-
7578	88.30	1.77	1	-
7063	88.17	1.65	1	-
6543	87.97	1.53	1	-
6026	87.76	1.41	1	-
5499	87.37	1.30	1	-
4976	86.96	1.18	1	-
4444	86.30	1.06	1	-
3919	85.62	0.94	1	-
3391	84.67	0.82	1	-
2861	83.33	0.71	1	-
2314	80.89	0.59	1	-
1736	75.86	0.47	1	-
1071	62.40	0.35	1	-
489	42.77	0.24	1	Low efficiency; not used in energy calculation
113	19.74	0.12	1	Low efficiency; not used in energy calculation


x - Maximum Discharge Limit
495.0m
Rated Flow at
Rated Head
% Efficiency
100
90
80
70
60
50
0
2
4
6
8
Turbine Discharge (cubic meters/second)

USAID Hydropower Investment Promotion Project (USAID-HIPP)

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