Hydropower Investment Promotion Project (HIPP)

TSABLARI 2 HPP PRE-FEASIBILITY STUDY REPORT

This publication was produced for review by the United States Agency for International Development. It was prepared by Deloitte Consulting in collaboration with Black & Veatch and Pierce Atwood Attorneys LLC.

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USAID HYDROPOWER INVESTMENT PROMOTION PROJECT (HIPP)

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

DELOITTE CONSULTING LLP

IN COLLABORATION WITH BLACK & VEATCH AND PIERCE ATWOOD ATTORNEYS LLC.

USAID/CAUCASUS OFFICE OF ENERGY AND ENVIRONMENT

Definition of Technical Abbreviations

atm	Atmospheres
CAPEX	Capital Expenditure
EIA	Environmental Impact Assessment
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
MW	Megawatts
MWh	Megawatt-hours
SS	Substation
T	Metric Tonnes
TBM	Tunnel Boring Machine
US ¢	United States Cent (also USc)
US$	United States Dollar (also USD)
USAID	United States Agency for International Development

1 OFFERING PARTY

1.1GEORGIA

Georgia is situated at the juncture of Eastern Europe and Western Asia between the Black Sea, Russia, Armenia, Azerbaijan, and Turkey. The country covers a territory of approximately 69,700 km^2. Its population is more than 4.4 million.

The country is rapidly developing as a gateway from the Black Sea to the Caucasus and the larger Caspian region. Georgia’s natural resources include forests, manganese deposits, iron ore, copper, gold, minor coal and oil deposits, and abundant hydro resources.

1.2 GOVERNMENT

Georgia's constitution reflects a representative democracy, organized as a unitary, semi-presidential republic. It is currently a member of the United Nations, the Council of Europe, the World Trade Organization, the Organization of the Black Sea Economic Cooperation, the Organization for Security and Cooperation in Europe, the Community of Democratic Choice, the GUAM Organization for Democracy and Economic Development, and the Asian Development Bank. The country aspires to join NATO and the European Union.

1.3.1 Investment in Project Development

GEDF will create special purpose vehicles (SPV) for each project. The preferred legal status of each SPV will be a joint stock company listed on the Georgian Stock Exchange. In case of interest from foreign portfolio investors, GEDF can issue GDRs during the IPO.

GEDF shall make initial equity investment in the range of 5-10% of total project cost with the objective of selling each renewable energy project at the initial stage of construction. GEDF may be required to inject more funds in a particular SPV if a project could not be sold or if its IPO is postponed for any other reason.

SPVs shall carry out all initial development work on a project, namely conceptual design, topographical and geological studies, hydrological calculations, environmental and social impact assessments, land acquisition for construction and impoundment areas for HPP projects, begin detailed project engineering and design, implement infrastructure development (access roads, grid connection, low voltage power supply lines, etc.), obtain all required licenses and permits, begin site construction, submit the Project Design Document (“PDD”) for validation, place orders for hydro-mechanical and electrical equipment, enter into Power Purchase Agreement (“PPA”) with local or foreign counterparty, and other project development activities.

An SPV should be able to obtain loans from IFIs and private financial institutions to leverage a project. The preferred approach is project financing. Completion of debt financing will occur once sufficient equity investment is acquired. The debt to asset ratio can be in the range of 50-70%.

Upon successful completion of the above, the government can announce an IPO of all or part of its shares in the SPV.

1 OFFERING

Part 2 of this Information Memorandum presents an approved offering by the Government of Georgia. The prefeasibility study contained herein is intended to present an overview of the offering and capture relevant data an investor may wish to explore further in conducting their own due diligence.

2 INVESTORS

Interested investors are encouraged to contact the Ministry of Energy and Natural Resources of Georgia to obtain additional information about the project and the MoU process, before undertaking their own due diligence and/or registering an expression of interest.

3 CONSIDERATIONS

While considering any investment, each recipient/interested party should make its own independent assessment and seek its own professional, financial, legal and tax advice.

Each recipient/interested party is encouraged to take into consideration a wide range of factors, among other things the Georgian transmission tariff methodology, the Georgian distribution wheeling tariff methodology, transmission transfer capability with Turkey in non-winter months, transmission capacity allocation, Georgian transmission capacity congestion management, harmonization of legislation and regulations relating to cross border power trading, Georgian market rules, Turkish transmission capacity allocation, Turkish transmission congestion management, and other considerations not referenced herein.

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Project Description

The site of the proposed Tsablari 2 HPP is located about 5 km upstream from the confluence of the Tsablari River with the Khanistskali River near the village of Tskaltashua in the Baghdati District of western Georgia's Imereti Region. The plant capacity will be 16.7 MW with annual generation production of approximately 73.0 GWh.

The Tsablari 2 HPP is envisioned to be the upper plant in a possible 2-HPP cascade (Tsablari 2, and Tsablari 3 HPPs) on the Tsablari 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 both the Tsablari HPPs.

The Tsablari 2 HPP site offers moderately seasonally variable mean annual generation of approximately 73.0 GWh. There will be an intake structure, de-silting channels, power tunnel, surge shaft, pressure tunnel, under-ground (cavern) powerhouse, tailrace, transformer substation, and transmission line connection. The intake captures flow from the Tsablari River about 10 km from its confluence with the Khanistskali. The pressurized power tunnel and pressure tunnel (penstock) minimizes head loss in the conduit thereby maximizing the energy output of the available water.

Access to the site is good. The locations of both the powerhouse and diversion weir site are adjacent to public asphalt paved road. This public road will be heavily used for access to a resort area on the upper Tsablari River. A 35 kV transmission line runs parallel to the public road and will allow easy connection of the Tsablari 2 HPP to the transmission network

The Tsablari 2 HPP development is expected to include a single diversion weir intake unit. The intake will include a relatively low (5 m) concrete diversion weir with 14 m spillway, which ensures maximum water capture, reinforced concrete lined intake channel with de-silting basins with sluice. The power tunnel would be 6.3 km long and 2.25 m in diameter, with a 550 m steel lined pressure tunnel to the powerhouse. A surge shaft will be located at the downstream end of the tunnel. The tailrace would be a tunnel discharge 200 m long.

Project cost and construction schedule

The currently estimated cost of the Tsablari 2 HPP is USD 15.7 million or about USD 940/kW of installed capacity. The project is expected to have a 1 year pre-construction period and 2-3 year construction period. The critical path of the project will be the construction of the 6.3 km power tunnel and pressure tunnel.

Financial analysis

The project is expected to sell power during 3 months of the year within Georgia (for the first ten years of the plant's operating life) and the remaining time into the Turkish competitive power market. Based on preliminary assessment, the Tsablari 2 HPP Project provides an excellent opportunity for investment and should be further investigated by potential developers. The expected simple payback period is approximately 3.75 years based on parameters as shown in Section 8.0.

Conclusions/recommendations

According to preliminary assessments the plant offers a good potential opportunity to sell energy during three winter months inside Georgia, replacing (displacing) expensive thermal power, and 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

General	
Project name	Tsablari 2 Hydropower Project
Project location (political)	Baghdati District of Western Georgia's Imereti Region
Nearest town or city	Sairme Resort
River name	Tsablari River
Total drainage area	182.6 km^2
Financial Estimates	
Estimated Construction Cost	$15.7 Million
Estimated Cost per kW capacity	$940 /kW
Simple Pay Back Period	3.75 years
Hydrological Data (Adjusted to Intake Location)	
Annual mean river flow at intake	4.35 m^3/s
Facility design discharge (m^3/s)	7.0 m^3/s
Annual average discharge through powerhouse	3.5 m^3/s
Preliminary design flood (100 yr return period)	57 m^3/s
Max. recorded flow	53.2 m^3/s
Intake Ponds	
Highest regulated water level (HRL)	668 masl
Minimum operating level (MOL)	668 masl
Sanitary or environmental flow (assumed)	1-10% of mean monthly flow for each month
Diversion Structures	
Tsablari 2 Diversion, Tyrolean Weir	
Crest elevation	668 masl
Abutment top elevation	671 masl
Collection channel water surface elevation	667 masl
Collection channel length	14 m
Collection channel width	2 m
Max height	5 m from assumed bedrock
Trashrack	Integral with cross-river diversion channel
Channel-to-collection chamber discharge gate	2.0-m-wide x 2.5-m-high
Sluice gates (in flow collection chamber)	2 x 1.5-m-wide x 2.0-m-tall, one upstream and one downstream
Power intake gate (from collection chamber)	1 x 3.0 m wide x 3.0 m high
Flood Discharge Capacity	
Crest elevation	668 masl
Crest Length	14 m
Capacity at design flood level (670 masl)	67.3 m^3/s
Power water conductor/penstock	
De-silting basin	2, 4.5 m avg depth x 2.6 m wide channels, 100 m long
Power tunnel	6.3 km
Diameter	2.25 m inside diameter tunnel
Slope	0.20%
Water velocity, at design flow	1.75 m/s
Surge Shaft	
Diameter of Shaft	2.25 m minimum

Total shaft height	80 m
Minimum ground elevation at top of shaft	729 masl
Pressure tunnel	
Invert elevation at pressure tunnel junction	650.4 masl
Turbine center-line elevation	370 masl
Pressure tunnel length	550 m
Inside diameter	1800 mm
Powerhouse	
Type	Below-ground (cavern)
Installed capacity	16.7 MW (at design flow)
Units and net capacity at high-voltage transformer terminals	Unit 1: 12.0 MW vertical Francis Unit 2: 5.9 MW vertical Francis
Rated speed	Unit 1: 1000 rpm Unit 2: 750 rpm
Preliminary generator voltage	15 kV or manufacturer's recommendation
Rated generator capacity	Unit 1: 13.4 MVA at 0.90 Power Factor Unit 2: 6.7 MVA at 0.90 Power Factor
Size of powerhouse	10 m x 42 m x 16 m high
Tailrace	
Length	150 m
Width	2.5 m diameter
Type	Tunnel
Normal tailwater elevation	372 masl at Tsablari 3 diversion pond
Transmission line	
Interconnection location	35 kV transmission line passes powerhouse location and Tsablari Substation can connect directly
Distance to interconnection (km)	Less than 1.0 km
Voltage	35 kV
Power & Energy	
Gross head	295 m
Total head loss at rated discharge	9.103 m
Net head at rated discharge	285.9 m
Estimated average annual head loss	3.127 m
Estimated average annual net head	291.873 m
Estimated average annual generation	Approximately 73.0 GWh
Nominal installed capacity	16.7 MW
Preliminary annual plant factor (also called CF)	50%
Construction Period	
Conceptual design, feasibility studies & EIA	1 year
Engineering, procurement and construction	2-3 years
Ongoing environmental monitoring	Some studies and data collection will extend throughout construction.
Environmental	
Critical environmental receptors	Sairme Hot Spring and Resort

Figure 1: Georgian Project Location Map

1.0 GENERAL INTRODUCTION TO THE PROJECT

1.1 DESCRIPTION OF THE DEVELOPMENT AREA

The proposed Tsablari 2 Hydropower Project involves the construction of an approximately 16.7 MW run-of-river HPP on the Tsablari River, in the Baghdati District of western Georgia's Imereti Region. The approximate location is shown on the Georgian Project Location Map above. The Tsablari 2 powerhouse will be located 5 km upstream of the confluence of the Tsablari River with the Khanistskali River approximately 5 km upstream from the city of Baghdati and the gauging station. The diversion weir is approximately 5 km further up the Tsablari River from the powerhouse. (See Figure 5 and Appendix 3).

The city of Baghdati is the administrative center of the Baghdati District. According to the statistical data of 2009, the district population is about 29,000 people, with a population density of 35.9 people/ km^2. The distance from Tbilisi to the administrative center of Baghdati is about 220 km by road and the Tsablari 2 project is 10 km south of Baghdati. The Sairme Resort is the closest village to the Tsablari 2 HPP.

The total area of Baghdati District is 815 km^2 of which 82 km^2 is agricultural (See Appendix 7, Land Cover Map). About 65% of the Baghdati District is densely forested mountains and plateaus drained by five major rivers with a total length of 136 km. The economy currently relies heavily on manufacturing wood products for construction in Baghdati and agriculture in the lowlands, although Sairme resort is being renovated and expanded in the upper Tsablari River basin. The main agricultural activities of the region are tending vineyards and wine making, vegetable cultivation and animal husbandry.

Infrastructure of the area of the Tsablari HPPs is well developed: there is a paved public road that follows the river valley that is being used for the renovation and expansion of the Sairme Resort tourist development and will be the main access route for tourists. A 35 kV transmission line serves the valley and particularly the Sairme Resort.

About 65% of Baghdati District is covered by mountains and plateaus covered by coniferous and broadleaf forests. See Section 2.6, Biodiversity and Appendix 7, Land Cover Map for further details.

The district is rich in mineral waters. In the Baghdati District there are two mineral hot spring resorts, Sairme and Zekari. The Sairme mineral water spring is in the Tsablari River watershed above the Tsablari HPPs. This tourist resort is being renovated and expanded. In the Baghdati District, about 109,226 deciliters of spring water was commercially produced and bottled in 2005 (Source: Baghdadi Municipal Economic Development Plan, Baghdadi Municipality, 2007)

The region is culturally rich represented by many old churches, monasteries, towers and other cultural relics, although there are **no** cultural or historic sites within the Tsablari 2 HPP study area.

Table 2: Development Area Significant Data

Project Location (Political)	**Western Georgia's Imereti Region**
Political Subdivisions	**Baghdati District**
Area Population	**29,000**
Nearest Town or City	**Sairme Resort**
River Name	**Tsablari**
Economic Activity in the Area	**Primarily agriculture, logging, and processing wood products for construction**
Special Natural Resources	**Coniferous and deciduous forests and mineral water for bottling.**
Special Cultural Resources	**Churches, monasteries and hot spring**
Critical Environmental Receptors	**Sairme Mineral Springs and Tourist Resort**

1.2 DESCRIPTION OF THE LOCAL ELECTRIC POWER SYSTEM

The transmission assets in the Tsablari River area, including a 35 kV line in the immediate area of the Tsablari 2 powerhouse, are owned and operated by Energo-Pro, the licensed distribution utility serving most of Georgia outside Tbilisi. The 35 kV transmission system serves the Sairme tourist resort development above the Tsablari HPP cascade.

2.0 BASELINE CONDITIONS

In order to establish a comparison for environmental evaluation of the Tsablari 2 HPP a set of baseline environmental conditions have to be identified. International practice today uses the baseline data to address changes that would occur during project construction and operations. Using this baseline and affected environment approach the project can be viewed and assessed in an acceptable manner. Section 2 provides general baseline conditions for a range of environmental and site criteria (receptors). Section 6.2 addresses the Affected Environment, and Appendix 10 presents a series of tables that address the expected range of impacts to these receptors and recommendations for mitigation procedures and plans that are considered standard practice today.

2.1 CLIMATE: GENERAL DESCRIPTION

The climate of the Baghdati District lowland is humid and sub-tropical; with temperate to cold winters and long warm summers. The precipitation increases and air temperature decreases significantly with the increase in elevation. The annual precipitation on average is in the range of 1,200 to 1,500 in Kutaisi, 25 miles north of the Tsablari 2 HPP. Precipitation is maximum during the winter and minimal during the summer. Additional climatic information is presented in Section 6. Appendix 6 displays an Annual Precipitation Map for the Tsablari 2 HPP watershed.

2.2 HYDROLOGY AND WATER RESOURCES:

Table 3: Hydrology Significant Data

Records available	**Daily flow measurements for 54 years (1937-1990) at Baghdati, from the Department of Hydrometeorology.**
Method of analysis	**Monthly and annual flow-duration curves, flood frequency, 30 day minimum and maximum moving averages of daily discharge values**
Drainage area at gauge	**655 km^2**
Drainage area at the intake	**182.6 km^2**
Adjustment factor	**0.278779**
Maximum plant discharge	**7.0 m^3/s**
Minimum plant discharge	**As low as 1.2 m^3/s**
Stream flow for power generation	**Based on combined flow duration analysis and average daily discharge energy analysis. Expected normal discharge range of 1.2– 7.0 m^3/s. Reasonable potential of approximately 73.0 GWh/year**
Flood flows (combined)	**Average Annual Flood (2.33 yr return period) = 28 m^3/s**
Highest recorded flow	**53.2 m^3/s**
Calculated 100 year flood	**57 m^3/s**
Recommended additional data collection and study recommendations for feasibility and design	**Stream flow gauging at various critical locations in the basin as well as at the Tsablari 2 HPP intake; meteorology stations for air temperature, precipitation, barometric pressure, relative humidity, wind speed and direction, solar insolation, and snow depth.** **These stream locations would also be used for other monitoring of suspended and bedload sediments, water quality parameters, water temperature, fish, etc.**

2.2.1 Catchment Description including Land Cover and Current Water Resource Use

The Tsablari River is 29 km long and drains an area of 230 km^2. It originates on the northern slopes of the Meskheti Mountain Range at an elevation of 2,200 m above sea level and flows into the Khanistskali River. The average flow rate near the mouth of the Khanistskali River is 6.16 m^3/s; the flow is characterized by high flows in spring and autumn, and lower flows in summer and winter seasons. Table 3 summarizes the hydrological information that was available from a gauging station in Baghdati.

The catchment area is heavily wooded with significant steep to very steep slopes that can create flash flood conditions. The upper reaches of the catchment are in the Alpine zone with alpine meadows with snowpack during the winter. The catchment is subject to avalanches in the winter that carry significant debris into the tributary and river channels. The Tsablari River is characterized by a narrow riverbed and steep descending slopes. Downstream from the HPP sites, the Tsablari River flows into the Khanistskali River, which in turn flows into the Rioni River and into the Black Sea.

Appendix 4 is the Watershed Map that outlines the watersheds that contribute to the various proposed HPPs diversion locations on the Tsablari River. Appendix 6 presents the annual precipitation map while Appendix 7 presents land cover in the watershed.

2.2.2 Surface Water Resource:

The rivers in Georgia drain into two main drainage basins: the western rivers drain into the Black Sea, and the eastern rivers drain into the Caspian Sea. Georgia is rich in water resources. About 78 per cent of water resources of the country are concentrated west of the Likhi Mountain Range and only 22 per cent east of the Likhi Range. The Tsablari HPPs are in the western Black Sea Drainage Basin; see Appendix 4, which is the Watershed Map.

2.2.3 Tsablari River:

The Tsablari River's upper course flows through a deep gorge with many rapids until it joins the Khanistskali River. The river is fed by mixed sources; rain, snowmelt, and springs. Table 4 displays the Tsablari 2 HPP intake area flow characteristics. The flow is characterized by high flows in autumn winter and spring. There are relatively stable lower flows during the summer.

The stream flow gauging station is the Baghdati Gauge, approximately 15 km downstream from the Tsablari 2 HPP intake location. The gauge has a drainage area of 655 km^2. The gauge data used for this pre-feasibility analysis included the calendar periods: 1937 through 1990. A drainage basin adjustment of 0.278779 (182.6 km^2/655 km^2) was used to adjust flow records to the Tsablari 2 HPP intake location. Appendix 2 includes monthly and annual flow duration curves.

Table 4: River Flow in m3/sec at Tsablari 2 HPP Intake

Annual average flow (m^3/sec)	**4.35**
Maximum average daily flow of record (m^3/sec)	**53.2**
Minimum average daily flow of record (m^3/sec)	**0.18**
Average monthly discharge during seasonal runoff period (April, May, June, July August, September) (m^3/sec)	**5.20**
Average monthly discharge during winter Season (Oct – March) (m^3/sec)	**3.51**
Highest 30 day average discharge (m^3/sec)	**12.12**
Lowest 30 day average discharge (m^3/sec)	**1.25**
Average discharge during Georgian winter electric demand period (Dec-Feb) (m^3/sec)	**3.04**
Assumed river discharge reserved for environmental/sanitary/ and other beneficial natural channel functions and values *	**1-10% of average monthly discharge, for each month**

* This percentage range is a conservative average. Examination of the immediate tributary flows into the Tsablari River between the diversion dam and the powerhouse suggest that for several 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 gained if reserves are not required could be significant (on the order of 5% of average annual generation).

2.2.4 Sediments, Watershed Characteristics, and River Discharge

The Tsablari 2 HPP location carries about the same concentration of suspended sediment as the Baghdati Gage and sediment monitoring station approximately 15 km downstream. The watershed is steep-sloped, generating a high-velocity surface runoff and high river velocities. During high flow periods large volumes of suspended sediment can turn the river a grayish brown color. The erosion of river banks and steep valley slopes also contributes to bed load movement of coarse sediment, large rocks and debris.

Table 5 presents projected sediment values from the Baghdati Gauge for a range of return periods. The project team strongly recommends further suspended and bed load data sampling at the intake location to develop a clear understanding of sediment transport magnitudes and variations expected over a typical operations year. The table presents sediment loads that clearly support a significant and long term operation challenge for the Tsablari 2 HPP and the requirements to address sediment management during detailed feasibility design. Section 6.2 and Appendix 10 address possible mitigation measures for sediment management during construction and operations.

Table 5: Baghdati (at Didveli) Gauge and Tsablari 2 Intake Sediment Load Estimates

Suspended Sediment Volume Projected for Tsablari 2 Development							
Didveli Gage on Khanistskali River just downstream of Baghdati Drainage Area in Sq Km							907
Percent or Frequency	0.50%	1.00%	5.00%	10.00%	25.00%	75.00%	
Return Period in Yrs	200.00	100.00	20.00	10.00	4.00	1.33	Annual
Didveli Gage (Khanistskali R just downstream of Baghdati) Estimated Suspended Sediment in Kg/Sec /1	7.00	5.40	4.90	4.60	4.10	3.20	1.95
Didveli Gage (Khanistskali R just downstream of Baghdati) Estimated Bedload Sediment Estimate in Kg/sec **/1,/4**	0	0	0	0	0	0	0
Didveli Gage (Khanistskali R just downstream of Baghdati) Estimated total Sediment Load in Kg/Sec **/1**	7.00	5.40	4.90	4.60	4.10	3.20	1.95
Tsablari 2 Adjusted total Suspended Sediment Load in Kg/Sec **/2**	1.41	1.33	1.21	1.13	1.01	0.79	0.48
Tsablari-2 Intake Sediment Estimate in T x1000 **/3**	34.39	32.46	29.46	27.65	24.65	19.24	11.72
Tsablari-2 Intake Sediment Estimate in Cubic Meters x 1000	22.93	21.64	19.64	18.43	16.43	12.82	7.81

Note 1/ Data Source: Surface water Resources Transcaucasia and Dagestan, Vol 9 West Caucasia Edition 1, Administration of Hydrometerologic Service, Georgian SSR 1969

Note: /2 Adjusted total sediment load for Tsablari 2 is in the Tsablari HPP intake drainage area /

sediment sampling Location drainage area.

Note: /3 to account for only the sediment flowing into the Tsablari 2 intake I took the ratio of the net usable area under the flow duration curve and divided that by the area under the full flow duration curve as part of this calculation.

Note: /4 No data available for Bedload estimates.

2.2.5 Meteorological Conditions

For the analysis of the climatology of the Tsablari project area, information from the nearest Meteorological Station located in the town of Kutaisi was used. The project team recognizes that Kutaisi is the best available data near the watershed but is at a significantly lower elevation than the Tsablari 2 HPP. It is recommended that as soon as project approval is complete, a primary meteorology station should be installed at Sairme Resort located just upstream from the Tsablari 2 diversion weir.

The Imereti Region is characterized by a humid subtropical climate. As noted, the precipitation and air temperature changes with the increase in elevation. The average temperature in January of Imereti Region's lowland plains is 4.4^0C and minus 0.3^0C in mountains. The average temperature in July in the lowland plain ranges is 23^0C and 17^0C in the mountains.

Annual average precipitation for Imereti Region is 1200-1500 mm. The Tsablari 2 HPP watershed is considerably higher than the Kutaisi Meteorology Station and precipitation increases considerably with elevation.

See Appendix 6 for the Annual Precipitation Map, which shows the variations in annual precipitation for the entire watershed, HPP locations, catchment and sub-catchment boundaries. Table 6 displays monthly values and annual mean values of climatology data at Kutaisi, which is the nearest large city, but is at a lower elevation than the project watershed and therefore warmer and drier.

Further data collection and analysis has identified a discrepancy in the meteorological data provided by the Ministry of Environmental Protection, National Environmental Agency, Department of Hydrometeorology (Hydromet) and it's predecessor Ministry. The magnitude of monthly average rainfall included in Table 6 does not match well with the distributed rainfall data that appears in Appendix 6. At the pre-feasibility level of analysis, the discrepancy has been identified so that the developer's engineering team can research this data further and decide which is more appropriate or how to adjust one set to match the other. This discrepancy may result from differences in elevation between Kutaisi and the Khanistskali-Tsablari watershed.

Table 6: Kutaisi Climate Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	
Data Type	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**mean**	**Annual Totals**
Average Monthly Air Temperature in °C	5.2	5.8	8.4	12.9	17.9	21.0	23.2	23.6	20.5	16.4	11.5	7.5	14.5	
Lowest Average monthly Air Temperature in °C	2.0	2.5	4.4	8.4	12.7	16.2	18.7	19.3	15.9	12.1	8.2	4.6		
Lowest Air Temperature in °C	-17	-13	-10	-5	2	9	11	11	5	-2	-10	-13		
Highest Average Monthly Air Temperature in °C	9.0	9.9	13.3	18.9	24.1	27.0	28.4	28.9	26.0	21.8	15.9	11.4		
Highest Monthly Air Temperature in °C	21	25	32	35	37	40	41	42	40	35	30	25		
Average Relative Humidity in %	68	68	69	66	69	72	76	75	74	71	65	64	70	
Average Monthly Precipitation in mm	136	131	113	99	84	97	110	91	116	131	131	141		1380
Average Monthly Wind Speed in meters/sec.	0.6	0.7	1.1	1.4	1.3	1.2	1.2	1.1	1.0	0.8	0.7	0.5	1.0	

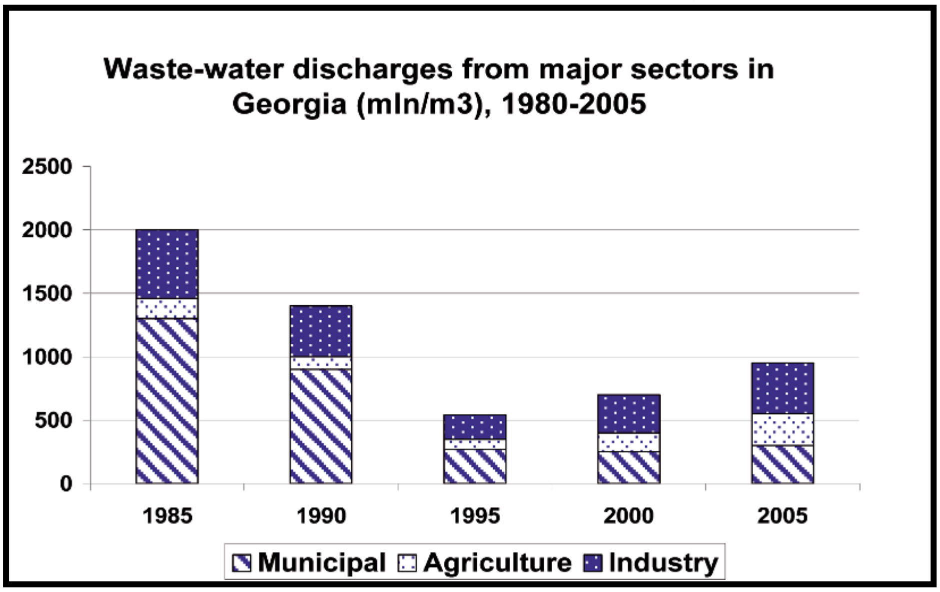
Source: Data on climate and meteorology for Kutaisi was provided by the Department of Hydrometeorology of Georgia.

2.3 WATER QUALITY

Water Quality is a key environmental receptor and is a basic measure for assessing impacts from construction and operations. Water supply quality in the country is at a fair level, and a safe drinking water supply is the key component of the general objective to ensure the environmental safety and health of the people of Georgia. Poorly maintained and non-functional wastewater treatment facilities in urban areas and septic systems and non-treated municipal, agricultural and industrial discharges to rivers in most parts of the country present major challenges to overall water quality. (Ref: Betsiashvili M. and Ubilava, M. "Water Quality and Wastewater Treatment Systems in Georgia", 2009).

Figure 2 presents wastewater discharges from major sectors in Georgia in millions of cubic meters.

Figure 2: Waste-water discharges



Ref: "Caucasus Environmental Outlook" Report of the Ministry of Environment and Natural Resources Protection of Georgia, 2005

After the break-up of the Soviet Union, contamination of surface waters in Georgia decreased, due to the major decrease of industrial production and subsequent wastewater discharges. This could have resulted in the temporary improvement of water quality. However, this is off-set by the fact that the majority of wastewater treatment facilities ceased to function or work at very low levels of efficiency. This lead to (and continues today) discharge of larger quantities of untreated wastewater directly into surface water bodies.

Field data for surface water quality in Georgia and the Tsablari River watershed is extremely limited. The water quality in Georgia is collected by the Environmental Baseline Monitoring Center of the State Department of Hydrometeorology (Hydromet). According to the Hydromet, 131 sampling points are chosen in Georgia for baseline water quality monitoring in the rivers and reservoirs. Due to the lack of funding, only 26 points are monitored at regular basis (i.e., samples are taken and analyzed each month), another 26 at irregular basis (i.e., samples are taken and analyzed 2 or 3 times per year), and the remaining 70 points are not monitored at this time. The infrequency of monitoring and questions about quality control during sample collection and analysis are of concern compared to international norms. Therefore, water quality sampling and resulting data should be included in any feasibility analysis to establish a **baseline** for water quality upstream of the HPP intake, in the bypass section of the river and in the river below where the tailrace merges with the river.

2.4 WATER WITHDRAWALS

Upriver from the two proposed Tsablari HPPs, the river may be used to power some watermills. The population use groundwater and springs as a source of drinking water and irrigation of plantings in the Sairme Resort development.

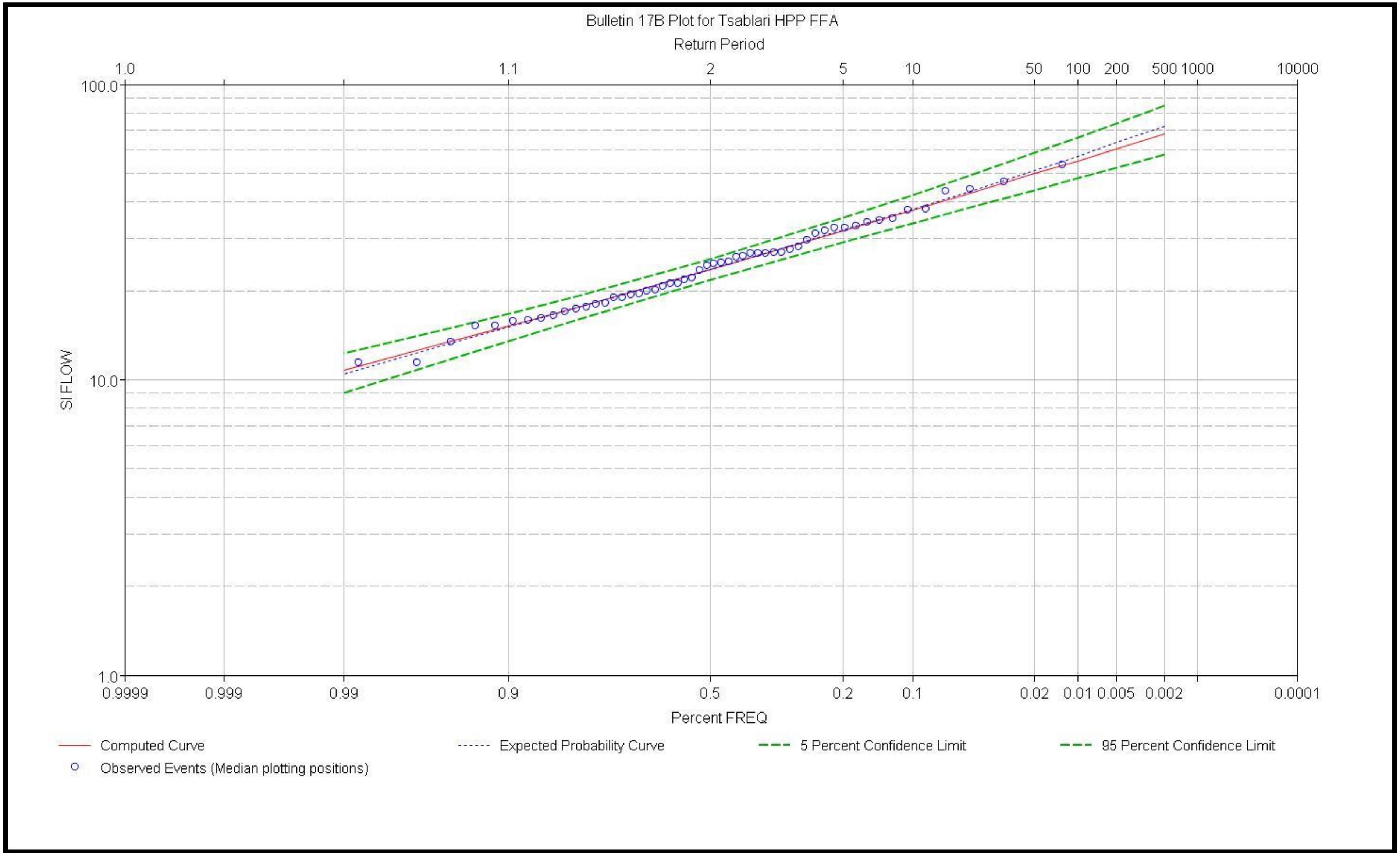
The proposed Tsablari 2 HPP run-of-river operations should have no impact on downstream water withdrawal users but during low flow periods coordination may be required to assure the local population that HPP operations are allowing adequate sanitary and environmental bypasses along with the other tributaries.

2.5 FLOODING AND FLOOD RISK

Flooding is characteristic in the Project watershed and in the project vicinity. Steep slopes, deep gorges, snowmelt runoff enhanced by warm temperatures and intense precipitation all contribute to major flooding risk for the project and the local environment.

With the availability of 54 years of record at the Baghdati Gauge, the U.S Army Corps of Engineers Hydrologic Engineering Center (USACE-HEC) Flood Frequency Analysis program (HEC-SSP) was used to check the earlier Soviet Report flood frequency values. The results are presented in the figure below. A drainage basin adjustment of 0.278779 was used to adjust these values to the proposed location of the Tsablari 2 intake location.

Figure 3: Tsablari 2 HPP Flood Frequency Analysis



2.6 BIODIVERSITY

2.6.1 Flora

The landscape of the potential HPP location area is dominated by mountains that are separated by deep gorges. Forests occupy considerable areas of the territory. Forests growing in the vicinity of proposed Tsablari HPPs watershed are State owned. The agricultural areas is made up of gardens, orchards, vinyards and plots of maize. Appendix 7, Land Cover Map, displays general forest cover in the watershed.

A significant area of Baghdati District is covered with native Colchic forest. Dominating trees are spruce (*Picea orientalis*), fir (*Abies nordmaniana*), pine (*Pinus kochiana*), ash (*Fraxinus excelsior*), beach (*Fagus orientalis*), birch (*Betuta pendula*), sycamore maple (*Acer pseudoplatanus*), hornbeam (*Carpinus betulus*), chestnut (*Castanea sativa*), lime-tree (*Tilia caucasica*), elm (*Ulmus glabra, Ulmus elliptica*), oak (*Quercus imeretina*), maple (*Acer laetum* & *Acer campestre*), and very occasionally yew (*Taxus baccata*).

The bushes that thrive within the forest include Pontic Rhododendron (*Rhododendron ponticum*), holly (*Ilex aquifolium*), Laurel Cherry (*Laurocerasus officinalis*), oriental hornbeam (*Carpinus orientalis*), Bilberry (*Vaccinium myrtillus*), Cornel cherry (*Cornus mas*), Medlar (*Mespilus germanica*), Hazelnut (*Corylus avellana*), Blackberry (*Rubus spp*.), raspberry (*Rubus idaeus*) (Encyclopedia of Georgia, 1984).

2.6.2 Fauna

Golden Eagles have a year-round presence in mountainous regions of Georgia. Because of its high landscape diversity and low latitude Georgia is home to about 1000 species of vertebrates, (330 birds, 160 fish, 48 reptiles, and 11 amphibians). A number of large carnivores live in the forests, namely Brown bears, wolves, and lynxes. The number of invertebrate species is presumed to be very high but data is distributed across a large number of publications and is not easily summarized.

The following mammals are found in the Baghdati District: wolf (*Canis lupus*), jackal (*Canis aureus*), roe deer (*Capreolus capreolus*), chamois (*Rupicapra rupicapra*), wild boar (*Sus scrofa*), fox (*Vulpes vulpes*), marten (*Martes martes, M. foina*), badger (*Meles meles*) and hare (*Lepus europaeus*).

The following bird species are relatively common throughout the watershed area: quail (*Coturnix coturnix*), woodcock (*Gallinago gallinago*), black grouse (*Tetrao mlokosiewiszi*), duck (*Anas plathyrhynchos*), corncrake (*Crex crex*), swan (*Cygnus olor*), wild pigeon (*Columba palumbus*), blackbird (*Turdus merula*), miscle thrush (*Turdus viscivorus*), chaffinch (*Fringilla coelebs*), woodpecker (*Dendrocopos spp*.), (Jordania R., Boeme B., Kuznetsov A., 1999).

2.6.3 Fish Population

The local fishery is also considered a primary environmental receptor for baseline comparison. The following fish species were reported to be found in the Khanistskali River: barbell (*Barbus capito*), mudfish (*Cobitis taenia satunini*) and trout *(Salmo fario).* The Red Book of Georgia classifies the trout as National Statute Vulnerable. (Elanidze, R. 1988).

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

Spawning periods for major fish species found in the river are noted in the table below.

Table 7: Stori River Fish Spawning Periods

Fish	Spawning Period
Trout	September-October
Mudfish	May-June
Barbell	May-June

3.0 GEOLOGY

3.1 GEOLOGICAL REPORT

The geologic data available at the time of the pre-feasibility study were geologic maps at the scale of 1:500,000 and a field reconnaissance report. A copy of this report and 1:100,000 geological maps covering the Tsablari and Khanistskali River watersheds are included in Appendix 1.

3.2 SEISMOLOGY

The geology of the project area is characterized by crossing the boundary between two tectonic zones: the Fold system of the greater Caucasus (Gagra-Djava Zone) and TransCaucasian Intermountain Area (Central Zone of Uplift). As a result of being on the boundary of these tectonic plates, according to the current Georgian seismic zoning classification the project is in hazardous zone 8 The design criteria for earthquake loads and resistance of structures must be defined in accordance with applicable standards and regulations.

Within 150 km of the Tsablari HPPs there have been several "significant" earthquakes. The source of this data is the National Geophysical Data Center / World Data Center (NGDC/WDC) Significant Earthquake Database, Bolder, CO, USA. (Available at http://www.ngdc.noaa.gov/nndc/struts/form?t=101650&s=1&d=1). The "significant" earthquakes in the area are listed in the table in Appendix 1, Geology.

The Tsablari River watershed is located on the southwestern part of the Fold system of Lesser Caucasus mountain range, which is an ongoing uplift area created by the collision of tectonic plates. This inevitably creates an earthquake hazard zone along both sides of the mountain range. Through proper design and construction, the risk from earthquake damage can be mitigated.

3.3 CURRENT STATUS OF GEOLOGICAL INVESTIGATION

Because of the nature of a pre-feasibility study, surface mapping of outcrops has not been done and no borings have been conducted. Geological studies, including core borings, must be part of the feasibility study. It is critical that a site investigation program be done for the headworks area, tunnel alignment and the powerhouse area, using test pits and core boring in all areas during the feasibility study.

Table 8: Geology Significant Data

Available data	**1:500,000 Scale Geological Map of Georgia (2003)**
Regional description	**Baghdati District of south western Georgia's Imereti Region**
Seismicity, including earthquake loadings	**Richter Scale 5.7, Georgian Seismic Zone 8**
Field reconnaissance	**Done in 2011. Report available in Appendix 1.**
Subsurface borings	**To be done at Feasibility Study stage**
Investigation recommendations for Final Feasibility and Design	**Geotechnical borings at diversion weir, and powerhouse locations.**

4.0 HYDROPOWER PROJECT DESCRIPTION

4.1 PROJECT DESCRIPTION

The Tsablari 2 HPP development is expected to include a low Tyrolean weir across the Tsablari River, channeling flow to 100-m-long de-silting channels, 6,300-m-long power tunnel and 550-m-long steel lined pressure tunnel. This diversion collects runoff from an area of about 182.6 km^2. There will be two de-silting channels with an average depth of 4.5 m and each will be 2.6 m wide. The power tunnel will have an inside diameter of 2.25 m. This diameter has been selected for both hydraulic and constructability reasons. Near the downstream end, a vertical surge shaft will be excavated in rock.

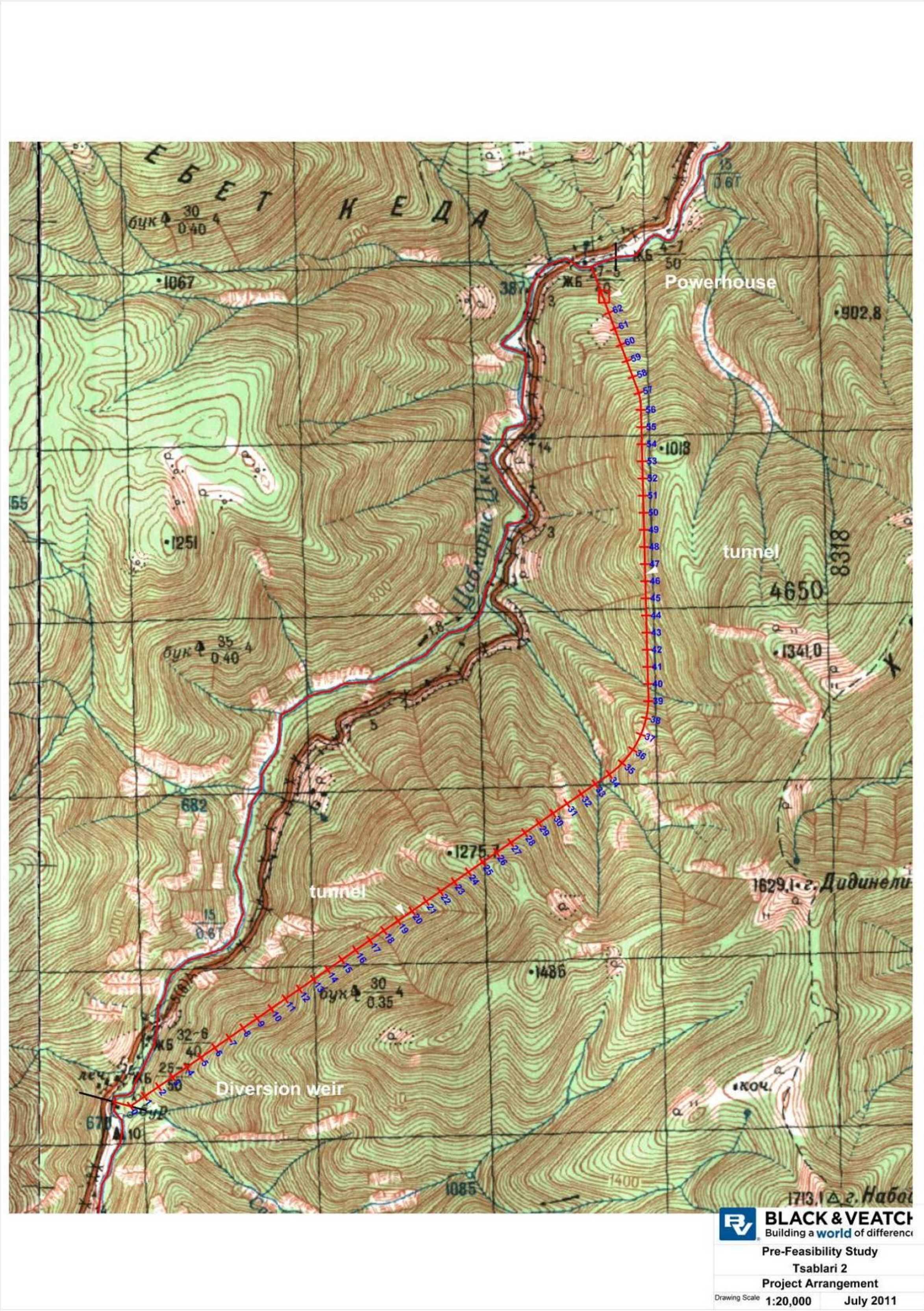
A 202-m-long excavated tailrace tunnel will discharge to the river just upstream of the Tsablari 3 diversion intake.

The power plant may 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 Tsablari 2 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).

Access to the site is good. The intake and powerhouse are adjacent to a public paved road that leads from Baghdati to the Sairme Hot Springs and Resort. This is a narrow, winding, steep road but is paved as far as the resort. It may be necessary to relocate short sections at the diversion and power plant site, with very short new roadways from the paved road to these facilities. From the topographic maps available, it does not appear that it is practical to install a mid-tunnel adit. The excavation of the powerhouse and pressure tunnel will be needed to access the downstream end of the power tunnel. This would allow tunnel excavation at 2 faces.

An overall view of the project arrangement is shown in Figure 4.

Figure 4: Tsablari 2 Hydropower Project General Layout



In the figure above, the heavy red line represents the power, pressure and tailrace tunnels. The figure also indicates the proposed locations of the diversion dam upstream end of the tunnel and powerhouse on the downstream end of the penstock.

The 35 kV transmission line to connect the Tsablari 2 plant to the network follows the road and river. During the feasibility study and design, the developer must negotiate with Energo-Pro to connect to the existing line directly through the Tsablari 2 plant substation. This should require less than 1 km of transmission line.

4.1.1 Diversion Structures

The Tyrolean weir is named for the region of Europe, in the Alps, where the design was developed. (The Tyrol region now spans the border between Austria and Italy.) The weir design is used to divert flow from steep mountain streams which may carry large volumes of debris and rocky bed load. It includes a collection channel, perpendicular to the flow of the stream, which would be constructed of reinforced concrete, similar to a trench drain. A system of closely spaced bars, parallel to the stream flow and at a small slope from upstream to downstream, prevents the larger unwanted material from entering the collection channel, while allowing water to pass down into the channel. The larger material is washed downstream by bypass flow.

The collection channel is sloped from one side of the river to the other, carrying water under open channel flow conditions into a collection chamber at the lower end of the channel. The channel for the Tsablari River diversion will be about 14-meters-long and have channel width of about 2 meters. The inside dimensions of the collection chamber will be about 2.5 m by 4.0 m, and the total depth (including walls reaching above flood elevation) will be about 5 meters above the assumed bedrock level. From the collection chamber, flows enter the water conductor through a gated intake.

A set of low-level sluicing gates will be included in the collection chamber of the diversion weir, to flush sediment accumulations during high-flow periods. The sluice will be located perpendicular to and immediately before the power intake. This sluice will be controlled by hydraulically operated slide gates installed upstream and downstream from the intake.

Layouts of the proposed diversion weir, intake, and de-silting facility are included in Appendix 5.

4.1.2 Intake and De-Silting Facility

There will be a de-silting facility a very short distance downstream from the intake, following a short concrete transition. It will be designed to remove most of the suspended sediment in the flow that will be used for generation. This will serve to minimize abrasion damage to the facilities, especially the turbines. It will be segmented for flushing and maintenance purposes, so plant operation can continue while one segment of the de-silting basin is being flushed. Two gates will be located at the upstream end of the structure and two at the downstream end, one at each end of each of the two longitudinal segments. Construction will be reinforced concrete or shotcrete lined channels with a reinforced concrete divider with steel gates, railings, etc. There will be a second, lower-level set of gates, one from each of the two de-silting segments, controlling two under-sluices that return sediment from the de-stilting facility to the Tsablari River downstream of the diversion.

Please refer to Table 5 above because there is an estimate of annual sediment tonnage and volume for Tsablari 2 as a function of return period in the table. Also, Table 5 strongly suggests necessary field data collection for sediment from Tsablari 2 intake location during the feasibility study.

4.1.3 Power Tunnel

The Tsablari River power tunnel will have a total length of 6,300 meters, with a finished inside diameter of 2.25 m. Rock quality is expected to be good, on average, but there are areas of weak rock along bedding planes, in contact areas, and in weak strata found in the area.

The power tunnel could be excavated using a TBM, or conventional drill and blast methods. The proposed alignment is shown on the Project Layout, Figure 4, above.

Most of the tunnel length will probably be supported using rock bolts and shotcrete. Sections through poor rock will require steel supports and reinforced concrete lining, and special measures may be needed to control groundwater inflow.

4.1.4 Surge Shaft

There will be pressure surge considerations at the Tsablari 2 HPP, commensurate with the length of the power tunnel and the gross head. To reduce the pressure increase in the tunnel when turbines are shut down, a surge shaft will be excavated vertically through sound rock from a point near the end of the power tunnel, where it transitions into the steel lined pressure tunnel to the powerhouse. The chamber will be open to the atmosphere (not pressurized), and will probably be concrete-lined. This will provide attenuation of pressure waves at a location approximately 500 m upstream from the powerhouse. The exact location of the surge shaft will be selected for topographic and geological reasons during feasibility and design studies.

4.1.5 Pressure Tunnel

A 550-m-long 1800 mm diameter steel lined pressure tunnel will lead to the powerhouse. A bifurcation just above the powerhouse will channel the flow to two turbine-generator units. There will be hydraulically operated butterfly valves on the inlet pipes to isolate the turbines.

4.1.6 Powerhouse

The below ground (cavern) powerhouse size and arrangement will be determined primarily by the size of the turbine-generator units selected for installation. The powerhouse will include the unit shutoff valves and most auxiliary systems, in addition to the units themselves.

The powerhouse dimensions for the assumed installation of two different size Francis units will be about 10 meters wide, 42 meters long, and 16 meters tall. It will include an overhead bridge crane with a capacity sufficient to lift the heaviest component in the turbine generator set (a 10 tonne crane capacity has been assumed for preliminary cost estimating purposes).

Draft tube gates and drainage pumps will be provided to dewater the units for inspection and maintenance. The draft tube gates and operators will be located in the powerhouse or separate small chambers downstream of the powerhouse.

4.1.7 Mechanical Equipment

There will be a butterfly-type turbine isolation valve for each unit, capable of closing against full flow. Operators will use high-pressure hydraulic power.

Turbine selection for the Tsablari 2 project must be evaluated in detail during feasibility studies. Preliminary turbine selections were made for Pelton and Francis options using the TURBNPRO evaluation software produced by Hydro Info Systems. Appendix 11 contains the program output for three options: two equal sized Francis units, two different sized Francis units and two equal Pelton units. The combination of different sized Francis Turbines was found to produce more energy per year than either of the alternatives (See turbine specifications in Appendix 11). Table 9 displays the critical details from this turbine option evaluated for sizing tunnel, penstock, and powerhouse.

Vertical-shaft Francis units have been selected at this stage of study, although horizontal-shaft Francis or Pelton units may be feasible as well. The proposed Francis units will have different capacities, to make the plant operating range as broad as possible. The characteristics of the two units, based on the TURBNPRO unit selection software calculations, are shown in the following table:

Table 9: Turbine Characteristics

Unit	Speed, rpm	Runner Discharge Diameter, mm	Design Flow, m^3/s	Minimum Flow, m^3/s	Maximum Turbine Power, MW	Minimum Turbine Power, MW
No. 1, Larger	1000	742	4.7	2.4	12.0	5.54
No. 2, Smaller	750	582	2.4	1.2	5.9	2.76
Plant Total			**7.0**		**16.7**	

This installation will result in a maximum electric power output, at the high-voltage transformer terminals, of about 16.7 MW.

The Pelton turbine option includes two equal-size units, producing a mechanical output of up to about 9.4 MW each (with only one unit operating, maximizing net head). These units were found to be much larger than comparable Francis units at the Tsablari 2 rated head of 285.9 m.

Some of the advantages and disadvantages of each turbine type, which must be considered during feasibility studies, are listed in the following table:

Table 10: Advantages and Disadvantages of Turbine Types

Advantages	Disadvantages
Pelton Turbines	
Very wide operating flow range at high efficiency (typically 85 to 90 percent, over 10% to 100% of flow, for a three-jet machine) Jet deflectors allow very fast machine shutdown without stopping the water flow, greatly reducing surge control problems.	Slower rotational speed, which results in physically large turbines and generators. Runner must be set higher than maximum tailwater elevation, and the head between the runner centerline and tailwater is lost.
Francis Turbines	
High rotational speed, resulting in smaller turbine and generator dimensions Higher peak efficiencies (typically up to 93%) The full head on the unit is available for generation.	Narrow range of operation as compared to Pelton turbines. Special measures are needed to control pressure rise during unit shutdown.

Unit governors will be electronically controlled, with high-pressure hydraulic components.

Other powerhouse mechanical systems will include:

- Potable water supply
- Wastewater disposal
- Ventilation
- Fire suppression
- Compressed air
- Drainage and dewatering pump systems
- Powerhouse bridge crane
- Draft tube gates and operators

4.1.8 Electrical Equipment

Generators will be vertical-shaft synchronous machines compatible with the selected turbines. Stator output voltage will probably be about 15 kV.

Static exciters will be used.

Medium-voltage breakers will probably be vacuum type.

Computerized relays, controls and monitoring will be used. Automatic generator control will be installed. The system will be in direct communication with the GSE dispatch center in Tbilisi over fiber-optic, microwave, or satellite communication links.

Power transformers will be 15/35 kV and oil insulated.

Other electrical systems will include:

- A diesel generator to provide backup power and black-start capability
- Station service, including lighting, motor-control centers, etc.
- DC power supply including station batteries and chargers
- Lightning protection

4.2 ALTERNATIVES EVALUATED

Various powerhouse and diversion locations were investigated and evaluated. The current diversion location was selected to locate the dam:

- A short distance below the Sairme Resort, which needs full river flow to enhance the Resort's attraction to tourists.
- At a site where the dam length is relatively short and reasonable rock conditions appear to exist on both abutments.
- Avoiding conflict with the roadway

The connecting pipelines, de-silting basin, and intake were located where they are proposed in Figure 4 to take advantage of:

- Good tunnel portal conditions for the main power tunnel entrance.
- Adequate (but not generous) space for de-silting facilities.
- Sound foundations on competent rock.

Various combinations of water conductors were briefly evaluated, including canals, tunnels, pipelines and penstocks. The combination of a power tunnel followed by a pressure tunnel was quickly selected because of the large quantity of water, space limitations, high traffic on the narrow paved road to the resort, very steep slopes in the narrow canyon, and the generally acceptable geologic conditions along a potential tunnel alignment.

The underground (cavern) powerhouse was dictated because there is no area for an above ground powerhouse in the narrow valley which is primarily dominated by the river and road.

4.3 PROPOSED PROJECT COMPONENTS

In summary, the project includes the following components:

- Relatively short (300 m) access roads from public paved roadway
- A 14-m-long Tyrolean weir diversion structure on the Tsablari River
- De-silting structures
- Sluicing structures
- Tunnel portal
- Water conductors (power tunnel and pressure tunnel)
- A 79 m surge shaft
- Below-ground power plant
- A 200 m tailrace tunnel
- Electrical and mechanical plant equipment, including incoming valves with governors, turbines, generators, switch gear, etc.
- Auxiliary backup power to allow black-starts when isolated from network (island mode)
- Power plant substation, including two power transformers
- 1 km of 35 kV transmission line to connect to existing lines

Table 11: Hydropower Development Significant Data

Maximum gross head	**295 meters**
Maximum generation flow	**7.0 m³/s**
Number of units	**2 Francis units**
Potential installed capacity	**16.7 MW**
Mean annual power output	**Approximately 73.0 GWH**
Construction time	**3-4 years including final feasibility, EIA and design.**
Anticipated Life-span	**30 years**

5.0 POWER AND ENERGY STUDIES

Tsablari 2 HPP energy assessment was completed using available Tsablari River at Baghdati flow records (54 years of record) and operating scenarios that fit the proposed site and watershed conditions. River flow records are described in Section 2.2.2, Surface Water Resources. The energy assessment used three different approaches to estimate expected average annual and average monthly generation. Each approach will be summarized in the following paragraphs. There are differences between the three approaches that are due to differences in calculation approach. Results are considered acceptable when the energy output is within approximately 1% for each approach.

5.1 MONTHLY AND ANNUAL FLOW DURATION CURVE ANALYSIS

Flow duration curve analysis (FDC Analysis) is a standard practice used by hydrologists, scientists, and engineers to examine flow records and develop an understanding of discharge (in m^3/s) as a function of the percentage of time a flow value is equal to or exceeds a given value during a period of time. The time frame used in this analysis is both **monthly** and **annual** in hours. The area under a flow duration curve represents the available flow in a given time period (m^3/s-hrs). Available flow is defined as the flow or discharge magnitude available for hydropower generation in the time period selected. Both **monthly** and **annual** flow duration curves for the Tsablari 2 HPP are presented in Appendix 2.

The Flow Duration Curve Analysis approach uses an EXCEL workbook that provides a range of user selected input values required for calculating expected HPP generation. This includes a percentage of time a river discharge value is equal to or exceeds (**monthly** or **annual**), average HPP efficiency, estimates of gross head loss, and reserves for in-stream requirements. The FDC approach does not require the analyst/engineer to preselect an installed turbine capacity. Rather it provides a range of discharge values as a function of selected exceedence percentages to calculate generation (MWh) expectation(s) that becomes input in a turbine/generator selection.

Appendix 2 also contains a selected representative sample of an exceedence percentage and associated monthly discharge that would be expected to be available for HPP generation (in m^3/s-hr). This analysis subtracts reserve flows for in-stream requirements to identify net m^3/s-hr available for HPP generation. This value combined with average monthly HPP unit efficiency and average annual head loss is used to calculate average monthly generation in MWh.

Operations scenarios represent a conceptual understanding of how the Tsablari 2 HPP would be operated under a variety of flow conditions. Several factors are important in calculating the net available discharge for HPP generation. Plant operations decisions (oversee/check automatic operating system) must respond to environmental regulations, available river discharge for HPP generation, electricity demand, maintenance, etc. The FDC analysis can generally account for these operational variables by lumping them into overall HPP operations efficiency, changes to reserve percentages, and selection of appropriate equal to or exceeded percentage for river flow. The FDC analysis should be refined in significant detail during the feasibility study stage of project development. The FDC analysis approach provides an initial expectation of generation by **month** and **annually** and is expected to bring the analysis for energy to be within 1% of each other and the Daily Discharge Generation analysis. It is also used to help select the appropriate turbine discharge for the HPP installation. Monthly and annual curves and estimated generation are presented in Appendix 2.

5.2 DAILY DISCHARGE GENERATION ANALYSIS

When a proposed project design flow had been selected, a separate MS EXCEL workbook was used to calculate the power and energy production during each day within the period of stream flow records. The analysis accounts for:

- Adjustment of stream gauge flows to the project intake location, using a drainage basin area ratio.
- The month and season during which the flow occurs.
- The assumed bypass flow during the month in which the flow occurs.
- Water conductor diameter, calculated based on a target velocity at the full design flow.
- Friction losses using Manning's equation, water conductor length and diameter, and hydraulic roughness ("n").

Power and energy production figures were calculated using a range of plant design flows to get a capacity factor of 50% to maximize the water capture during the high flow and potentially higher tariff season. Monthly results for a design flow of 7.0 m^3/s are summarized in the following tables. This flow is the maximum economical development for run-of-river operation. A somewhat smaller flow may be optimum, depending on the value of energy during the peak flow season.

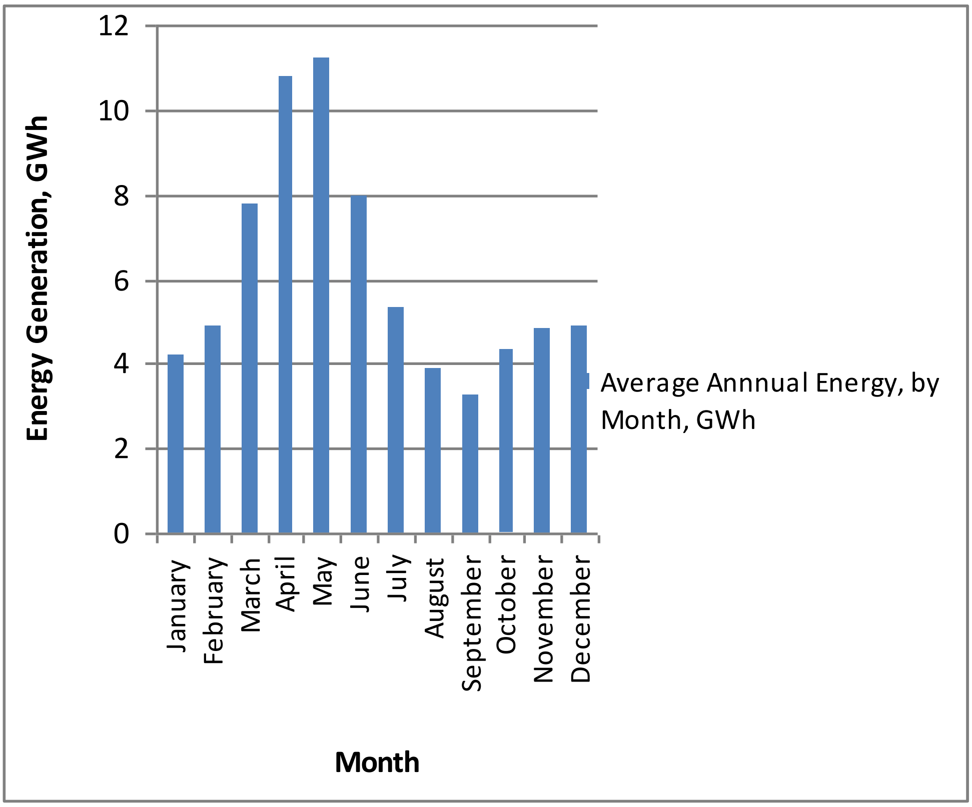
Table 12: Average Tsablari 2 HPP Power Production, 7.0 m^3/s Design Flow

Month	Mean Daily Power, MW	Minimum Daily Power, MW	Maximum Daily Power, MW
January	5.66	0.57	16.69
February	7.22	0.20	16.69
March	10.51	0.94	16.69
April	14.98	3.33	16.69
May	15.14	0.85	16.69
June	11.12	2.24	16.69
July	7.14	2.04	16.69
August	5.24	1.20	16.69
September	4.50	0.19	16.69
October	5.83	0.56	16.69
November	6.70	0.75	16.69
December	6.55	0.27	16.69
Annual	**8.38**	**0.19**	**16.69**

Table 13: Average Tsablari 2 HPP Energy Production, 7.0 m^3/s Design Flow

Month	Mean Daily Energy, GWh	Minimum Daily Energy, GWh	Maximum Daily Energy, GWh	Mean Annual by Month, GWh
January	0.14	0.01	0.40	4.21
February	0.17	0.00	0.40	4.89
March	0.25	0.02	0.40	7.82
April	0.36	0.08	0.40	10.79
May	0.36	0.02	0.40	11.26
June	0.27	0.05	0.40	8.01
July	0.17	0.05	0.40	5.31
August	0.13	0.03	0.40	3.90
September	0.11	0.00	0.40	3.24
October	0.14	0.01	0.40	4.34
November	0.16	0.02	0.40	4.82
December	0.16	0.01	0.40	4.87
Annual	**0.20**	**0.00**	**0.40**	**73.46**

Figure 5: Monthly Distribution of Average Annual Energy



6.0 ENVIRONMENTAL AND SOCIAL STUDIES

6.1 COMMUNITY AND SOCIO-ECONOMIC BASELINE DATA

The Baghdati District is located in Western Georgia’s Imereti Region. Baghdati District has an area of 815 km^2 and according to the official statistical data from 2009, a population of 29,000. The population density in the district is 35.9 people/km^2. The Baghdati district is surrounded by the Vani district in the west, the Terjola and Zestaponi districts to the Northeast, the Kharagauli district to the east, Akhaltsikhe and Adigeni districts to the south.

The city of Baghdati is the administrative center of the Baghdati District. The distance from Tbilisi to the administrative center of Baghdati is about 220 km by road and the Tsablari 2 HPP (Powerhouse) is 5 km south of Baghdati. Tskaltashua is the closest village to the Tsablari 2 HPP and consists of only a few houses. Sairme village and resort are upstream and close to the Tsablari 2 HPP diversion weir

6.1.1 Infrastructure

Infrastructure of the region is developed: Baghati and Sairme are connected by a good road. A 35 kV high voltage transmission line serves the village of Sairme and resport upriver from the proposed Tsablari 2 HPP.

There are 27 public schools, one museum, one theatre, 23 libraries and one vocational school in the Baghdati District. The area is rich in old churches, monasteries and other cultural relics.

Rehabilitation of water supply, sewage systems and roads is ongoing. The project is being implemented by Georgia’s Ministry of Regional Development and Infrastructure and Municipal Development Fund.

At Sairme Resort the drinking and irrigation water source is groundwater and springs.

6.1.2 Population and Settlements

The proposed Tsablari 2 HPP is located in Baghdati District of Imereti Region. The table below shows basic data of Baghdati District. Some socio-economic characteristics of this district are described below.

Table 14: Baghdati District Statistics

Location:	Baghdati District
Administrative District:	Baghdati
Area:	815 km^2
Population:	29,000
Population density:	35.9 people/km^2
Administrative center:	Baghdati

The major industrial activity is wood manufacturing, mainly for construction products. The leading agricultural activities are winegrowing, vegetables and animal husbandry.

The closest settlements to the proposed HPP area are the village of Tskaltashua, which consists of only a few houses and the village of Sairme and the Sairme Resort.

6.1.3 Cultural Heritage and Recreational Resources

Archeological sites, churches, towers, and related cultural and heritage sites are important baseline environmental data. The Baghdati District is rich in old churches, monasteries and other cultural relics. According to the literature review, no registered archeological and/or historical assets are located within the Tsablari 2 project development area. The table in Appendix 9 shows some of existing cultural resources of the Baghdati District.

6.2 ENVIRONMENTAL RECEPTOR IMPACTS & MITIGATION PRACTICES

An important component of feasibility studies is addressing impacts to the receptors in the affected environment. Further, minimizing environmental and social impacts through accepted international practices are very important criteria for the evaluation, construction and operation of the Tsablari 2 HPP.

The proposed Tsablari 2 HPP site **baseline conditions** have been described in sections 2, 3 and 6.1 above. Appendix 10 presents tables of expected environmental receptor impacts and appropriate mitigation practices which should be included in feasibility studies. Effects on and mitigation approaches to protect Environmental Receptors are identified to provide a source of focus for environmental assessments studies that will help evaluate the overall impacts on the site and the local vicinity.

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

Affected Environment Assessment: The Tsablari 2 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 2-3 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 are evaluated as Low, Medium, or High and should be refined further during the feasibility study. Risk evaluation also includes whether the impacts to receptors are (R) Reversible or (IR) Irreversible and (T) Temporary or (P) Permanent.

An important part of project feasibility design is to incorporate a set of mitigation practices that address impacts during the expected activities periods. These mitigation practices should be detailed, focused on environmental receptors, and be the standard and acceptable practices at the time of each activity period.

Tables for each environmental receptor listed above have been prepared in order to provide general assessment with respect to the proposed construction and operation of the Tsablari 2 HPP. These tables are presented in Appendix 10

From an affected natural environmental perspective the Tsablari 3 HPP can be developed so that the project overall minimizes its construction and operations impacts on the local and watershed environment. Appropriate attention must be given to overall construction management planning and execution to assure inclusion of the necessary safety, health, and environmental mitigation practices to construct and operate Tsablari 2 HPP in an acceptable, legal, environmentally sensitive manner while complying with all regulations.

7.0 PROJECT COST ESTIMATE AND CONSTRUCTION SCHEDULE

7.1 CAPITAL EXPENDITURE

The capital expenditure is as important to the feasibility of a hydropower project as the energy that can be produced or the tariff that is expected for the energy generated. Based on this cost estimate, we have confidence that the completed project will cost about US$ 15.7 million or $940 per kW of installed capacity, which is used in the financial analysis in Section 8.0

As mentioned in other sections, this project could be implemented with either Francis or Pelton turbines. This will be determined by the developer during the feasibility stage, based on various characteristics of the two turbine types. For the purpose of this cost estimate, to maximize water utilization, efficiency and revenue, it was assumed that two different sized Francis turbines are housed in the below-ground (cavern) powerhouse.

Unit costs are based on a comparable hydropower project in Georgia started in 2009 and are increased or decreased depending on, volumes, flows, kW capacity, etc. All costs are in US dollars to avoid exchange rate issues and because a large part of the mechanical and electrical equipment will be imported.

7.2 ESTIMATE OF OPERATING COSTS

Operating costs generally can be estimated in two ways: as approximately 5-7% of revenues or 1% of capital expenditure. On the Tsablari 2 project both numbers were consistent, so we used the slightly higher 7% of revenue in our financial analysis in Section 8.

Table 15: Tsablari 2 HPP Estimated Capital Expenditure

	Units	Amt	Unit Cost	Total US$	Year 1	Year 2	Year 3	Year 4	Year 5
Land purchase	ha	1	$10,000	$10,000	$10,000				
Preparatory & infrastructure works	LS			$420,000	$420,000				
Stream diversion and cofferdams	LS			$147,000	$73,500	$73,500			
Tsablari 2 Tyrolian Weir	LS			$241,000			$241,000		
De-silting Structure	LS			$400,000			$200,000	$200,000	
Upstream power tunnel portal	LS			$117,000			$58,500	$58,500	
Headrace Tunnel including rockbolts & shotcrete	m	5,840	$344	$2,009,000		$602,700	$803,600	$602,700	
Surge Shaft	m	80	$688	$55,000				$55,000	
Pressure tunnel with steel lining	m	550	$763	$420,000				$420,000	
Underground power house	LS			$3,127,000		$938,100	$1,250,800	$938,100	
Tailrace tunnel	m	150	$344	$52,000				$52,000	
Underground transformer switchyard civil works	LS			$141,717			$70,858	$70,858	
Electric and mechanical parts (turn-key)	MW	7.00	$558,391	$3,909,000			$1,954,500	$1,954,500	
Grid connection transmission line @ 35 KV	km	1	$100,000	$100,000			$50,000	$50,000	
Subtotal of Schedule Items				**$11,148,717**					
Geology (investigation field, lab and office) @ 1%	LS			$111,000	$111,000				
Feasibility study @ 1%	LS			$111,000	$111,000				
EIA @ 1%	LS			$111,000	$111,000				
EPCM @ 14%	LS			$1,561,000	$936,600	$312,200	$312,200		
Contingencies (Assumptions Variable) @ 20%	LS			$2,608,543	$354,620	$385,300	$988,292	$880,332	$0
Total				$15,651,260	$2,127,720	$2,311,800	$5,929,750	$5,281,990	$0
MW Capacity	16.70		CAPEX/kW	**$937**					

7.3 CONSTRUCTION SCHEDULE

The construction schedule is envisioned to be one year for Geotechnical investigation, Feasibility Study and Environmental Assessment followed by two to three years of construction. Geotechnical investigation will include borings along the route of the tunnel, at the dam site and at the powerhouse site. Field observations and laboratory testing on the rock cores will contribute invaluable insight into the character of the rock in the tunneling zone. It may be advantageous to build the pioneer road to the downstream tunnel portal and upper penstock location. The Feasibility Study must include a much more detailed design and cost estimate based on the ultimate configuration determined by the developer.

The extent of the construction appears to be a 2-3 year schedule, with the critical path through the 6.5 km of tunneling plus excavation and fit-out of the underground powerhouse and transformer bay. It appears that work on the diversion weir can be done throughout most of the year. During the spring runoff season (April through July) the water level and velocity in the narrow canyon may be too high for cofferdams to hold. All flow impediments, such as cofferdams, may need to be removed before the spring runoff period.

8.0 ECONOMIC AND FINANCIAL ANALYSIS

According to preliminary assessments the plant offers a good opportunity to sell energy during winter inside Georgia, replacing expensive thermal power, and export part of the energy during the remainder of the year to take advantage of the seasonal differentials in power prices between Georgia and its neighboring countries. It may be possible for the developer to offset some of his costs by trading “carbon credits” in an available market. This economic and financial analysis does not consider the complex issue of trading carbon credits but the potential developer should consider their applicability when reviewing the project’s overall financial returns.

Currently Georgia only needs new power capacity to meet its winter demand. The developer of the Tsablari 2 HPP may therefore need to find viable buyers of power in the region for the remainder of the year. One potential market for sale of the power from the HPPs is Turkey. The growth in electricity sales in Turkey is high and demand is quickly out-stripping supply. In addition, Turkey is joining the European transmission network in 2011 which provides the possibility to sell into the lucrative EU power market. The installation of the new 400 kV electricity transmission line between Georgia and Turkey is scheduled to be complete in 2012. Access to the Turkish and European market is dependent on the negotiation of the Georgia-Turkey Cross Border Energy Agreement.

To sell Tsablari 2 HPP power to markets in other countries, there must be transmission access at affordable tariffs. Investigations by Georgian and Turkish utilities are ongoing concerning the capacity of the transmission network as well as the structure of tariffs to ensure that the sale of power is not impeded. To get current information on tariffs and cross-border sales the developer of the Tsablari 2 HPP should work closely with GSE, EnergoTrans and the Georgian National Energy and Water Supply Regulatory Commission.

Table 19 is a calculation of the monthly revenue and payback period for the investment. It starts with the m^3/s-hrs of water that can be captured at the Tsablari 2

HPP based on the monthly flow-duration curves (see Appendix 2) and an assumed bypass of 1-10% of the low monthly flows as flow reserved for in-steam habitat and environmental functions and values. This environmental bypass is not deducted during high flow periods when excess water is running over the spillway. This leads to the saleable kWh that can be generated per month. The net price per kWh at the plant is determined by applying the assumed tariffs for Georgia and Turkey and subtracting dispatch and transmission fees. These calculations are shown in Tables 17 and 18 for the Georgian and Turkish markets respectively. The net price for Georgia and Turkey are distributed according to the apparent demand pattern throughout the year. The monthly generation capacity of Tsablari 2 HPP is multiplied by net price per kWh for that month to get monthly net revenue at the plant. From this the amount of electricity used at the plant and therefore could not have been sold (we assumed 1% of generated capacity was used within the project) and operating costs at 7% of the annual revenue are deducted to get net operating revenue. Based on this, the expected payback period (not including the cost of capital or time value of money) is calculated at approximately 5 years.

The price per kWh exported to the grid is based on the following current tariffs by starting with the gross tariff, deducting all dispatch and transmission costs to get the net tariff to the developer at the point the power is exported into the grid. It is presumed that the three month winter sales will be to ESCO with no dispatch or transmission tariff. Justification for Tables 16 and 17 appear in a memo included in Appendix 11.

Table 16: Tsablari 2 HPP Financial Analysis & Payback Period (16.7 MW and 7.0 m^3/s)

Month	Total CMS-HR Under Curve	Saleable CMS-HR per month	Saleable kWh	Price / kWh	Revenue		
January	1,956	1,729	4,205,326	0.0500	210,266		
February	2,370	2,005	4,876,978	0.0500	243,849		
March	4,395	3,147	7,655,394	0.0722	552,719		
April	7,062	4,245	10,327,180	0.0722	745,622		
May	6,595	4,640	11,287,041	0.0722	814,924		
June	3,785	3,311	8,056,043	0.0722	581,646		
July	2,340	2,185	5,315,747	0.0722	383,797		
August	1,703	1,601	3,893,870	0.0722	281,137		
September	1,428	1,330	3,234,862	0.0722	233,557		
October	2,158	1,780	4,330,517	0.0722	312,663	Weighted Average Tariff	
November	2,316	1,983	4,824,769	0.0722	348,348		
December	2,412	1,994	4,851,138	0.0500	242,557		
Totals	38,520	29,949	72,858,865	Total Revenue / Yr	4,951,088	$0.0680	
				(Site Electricity) @ 1%	($49,511)	7% of rev	1% of Cap
	Design discharge =	7.0	m3/s	(operating costs)	($343,110)	$343,110	$156,513
	CF =	50%		Net Operating Revenue	$4,558,466		
	Annual average m3/s through powerhouse =		3.42	Estimated Capital Exp.	$15,651,260		
				Pay Back Period	3.43		

This simple payback period represents only the engineering, construction and operating costs. It does not address considerations such as the time value of money, borrowing, interest, internal rate of return on assets or equity, etc.

Appendix 1

Geology Report & Associated Maps

27 Significant Earthquakes where (Latitude <= 43.5 and Latitude >= 40.5) and (Longitude <= 45 and Longitude >= 41)

View parameter descriptions and statistical information by clicking on **column headings**.

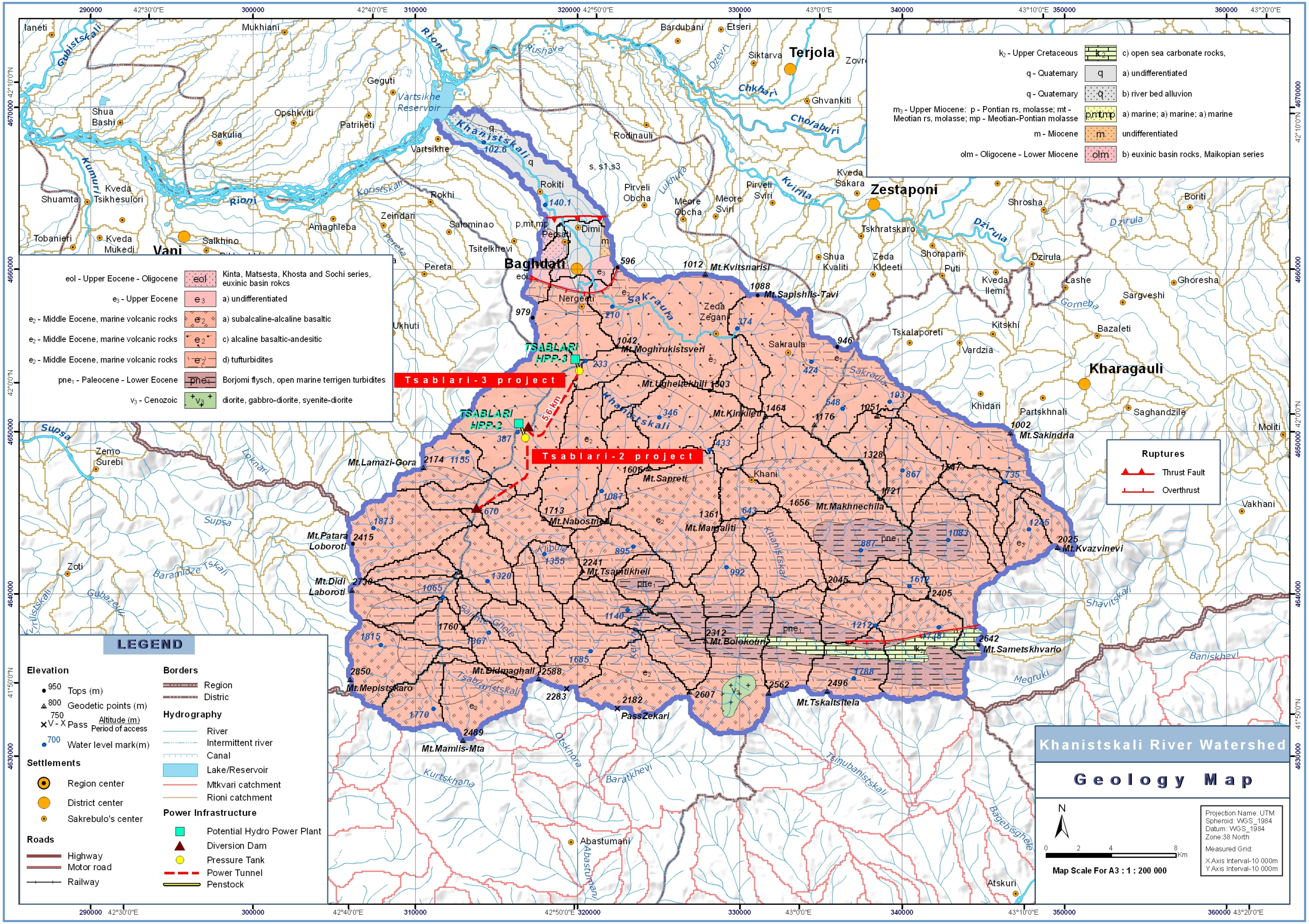
For additional information about an earthquake event and links to damage photos, click on the links in the **Addl Info** and **Tsu** columns.

Date						*Assoc*		*Addl EQ Info*	*Earthquake Location*			*Earthquake Parameters*			*Earthquake Effects*									
															Deaths		Injuries		Damage		Houses Destroyed		Houses Damaged	
Year	Mo	Dy	Hr	Mn	Sec	Tsu	Vol		Name	Latitude	Longitude	Focal Depth	Mag	MMI Int	Num	De	Num	De	$Mill	De	Num	De	Num	De
-50						Tsu		*	GEORGIA: DYOSCURIA [SUKHUMI]	43.000	41.000		5.5	8						2				
1003								*	TURKEY: KARS, DIGOR, ANI (ARMENIA)	40.500	43.300	20	4.2	7		3				2				
1046								*	TURKEY: ANI (ARMENIA)	40.500	43.500	15	5.5	8		3				3				
1088	4	22						*	GEORGIA: TMOGVI	41.400	43.200	10	5.3			3				3				
1275	4	14						*	GEORGIA	42.100	44.200	28	6.7			3				3				
1283								*	GEORGIA: SAMTSKHE, DZHAVAKHET	41.700	43.200	14	6.3	9						3				
1350								*	GEORGIA: CHEGEM GORGE, CHREBALO	43.000	43.000	20	6.5	9						3				
1868	10	18	17					*	GEORGIA: SPASK	41.200	43.800	15	4.5	7						2				
1888	9	22	10					*	TURKEY	41.300	43.300		6.1			3				2				
1899	12	31	7	50				*	TURKEY	41.600	43.500		5.6		247	3				2				
1903	5	28	3	58				*	TURKEY: VARGINIS,CARDAHLI,MEHKEREK	40.900	42.700		5.8	8	1000	3				3				
1905	10	21	11	1				*	GEORGIA: CAUCASUS	42.000	42.000	60	7.5											
1920	2	20	11	44	25.0			*	GEORGIA: CAUCASUS: GORI, TIFLIS	42.000	44.100	11	6.2			3				3				3
1925	1	9	17	38	24.0			*	TURKEY: ARDAHAN	41.200	42.800		5.8	8	200	3								
1926	10	22	19	59				*	TURKEY; ARMENIA	40.700	43.700	7	5.7	9	360	3				4				
1940	5	7	22	23				*	TURKEY-CIS	41.700	43.800	19	6.0		16	1				2				
1976	3	25	11	55	39.4			*	TURKEY	41.130	43.010	18	4.8		1	1				2				
1976	4	29	22	18	9.1			*	TURKEY	40.890	42.850	44	5.5		4	1				2				
1984	9	18	13	26	1.8			*	TURKEY: E, ERZURUM, OLUR-SENKAYA	40.885	42.219	10	6.4	8	3	1	38	1		2	75000	4		
1984	10	18	9	46	24.6			*	TURKEY: E, SENKAYA	40.545	42.403	60	5.3		3	1	35	1		3	75000	4		
1986	5	13	8	44	2.1			*	GEORGIA: AKHALKALAKI, SUSUZ	41.431	43.737	10	5.7	7	2	1				3	1500	4	1500	4
1988	12	7	7	41	24.2			*	ARMENIA: LENINAKAN, SPITAK, KIROVAKAN	40.987	44.185	5	6.8	10	25000	4			16200.000	4		4		
1991	4	29	9	12	48.1			*	GEORGIA: DZHAVA, CHIATURA, AMBROLAURI	42.453	43.673	17	7.0	9	270	3			1700.000	4		4		
1991	5	15	14	28	50.1			*	GEORGIA: KHEKHETI	42.565	43.349	14	4.9	5						2				
1991	6	15	0	59	20.3			*	GEORGIA: DZHAVA, TSKHINVALI, OSSETIA	42.461	44.009	9	6.1	8	8	1				3				
2002	4	25	17	41	21.5			*	GEORGIA: TBILISI	41.765	44.960	10	4.3		5	1	52	2		3			2400	4
2009	9	6	22	41	37.3			*	GEORGIA: NORTHWESTERN	42.660	43.443	15	6.0				1	1		2				

27 events returned.

For more information regarding the Significant Earthquake Database please see the Introduction.

Return to Significant Earthquake Database Search



Khanistskali River Watershed
Geology Map
Tsablari-3 project
Tsablari-2 project
TSABLARI HPP-3
TSABLARI HPP-2
5.6 km
k2 - Upper Cretaceous
c) open sea carbonate rocks,
q - Quaternary
a) undifferentiated
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b) river bed alluvion
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a) marine; a) marine; a) marine
m - Miocene
undifferentiated
olm - Oligocene - Lower Miocene
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eol - Upper Eocene - Oligocene
Kinta, Matsesta, Khosta and Sochi series, euxinic basin rokcs
e3 - Upper Eocene
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e2 - Middle Eocene, marine volcanic rocks
a) subalcaline-alcaline basaltic
e2 - Middle Eocene, marine volcanic rocks
c) alcaline basaltic-andesitic
e2 - Middle Eocene, marine volcanic rocks
d) tufturbidites
pne1 - Paleocene - Lower Eocene
Borjomi flysch, open marine terrigen turbidites
v3 - Cenozoic
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Sakraula
Mt.Sakindria
Mt.Kvazvinevi
Mt.Sametskhvario
Mt.Mepistskaro
Mt.Mamlis-Mta
Mt.Didmaghali
Mt.Bolokouri
Mt.Tskaltsitela
Mt.Makhnechila
Mt.Sapreti
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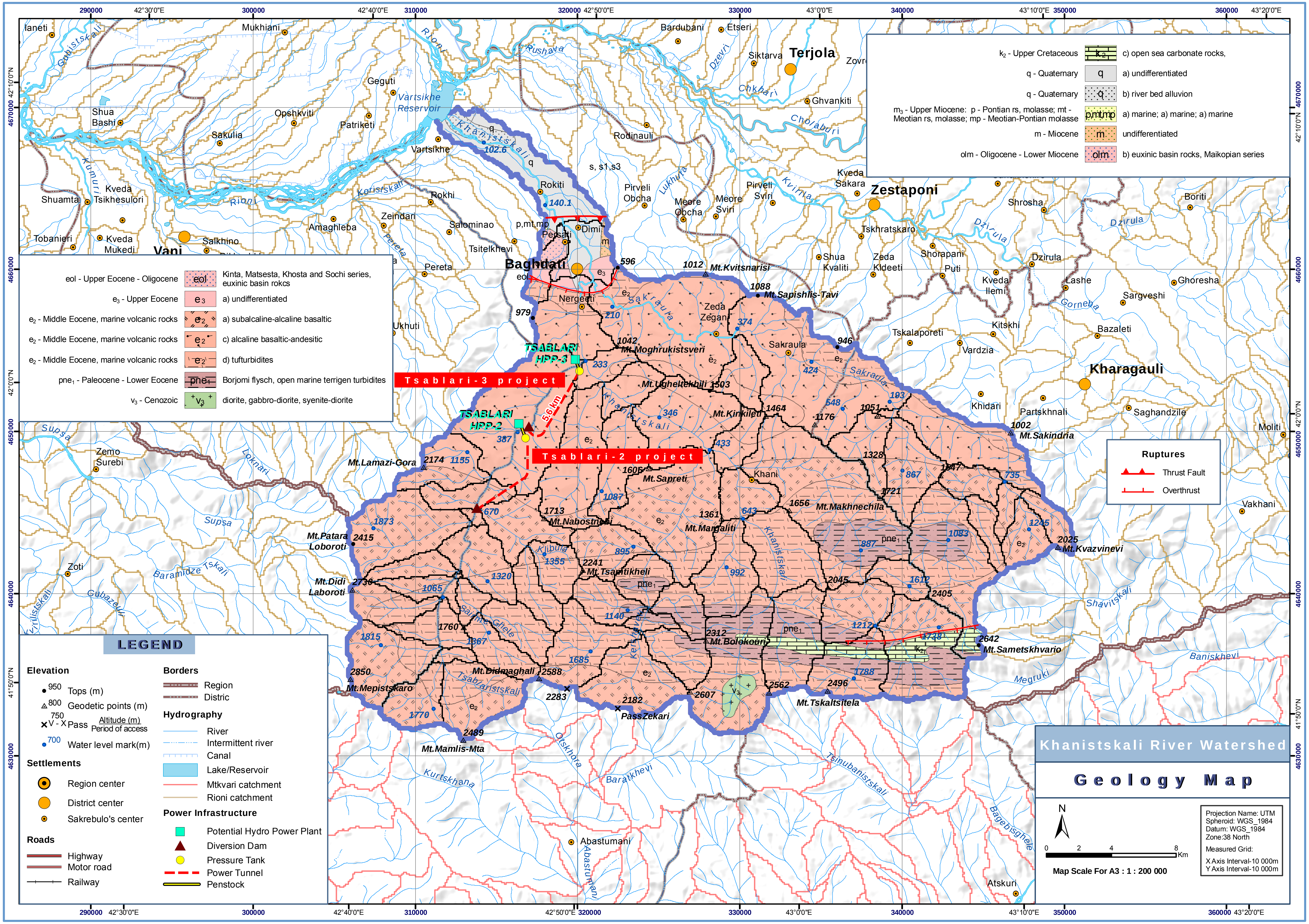
Mt.Tsamtikheli
Mt.Margaliti
Pass Zekari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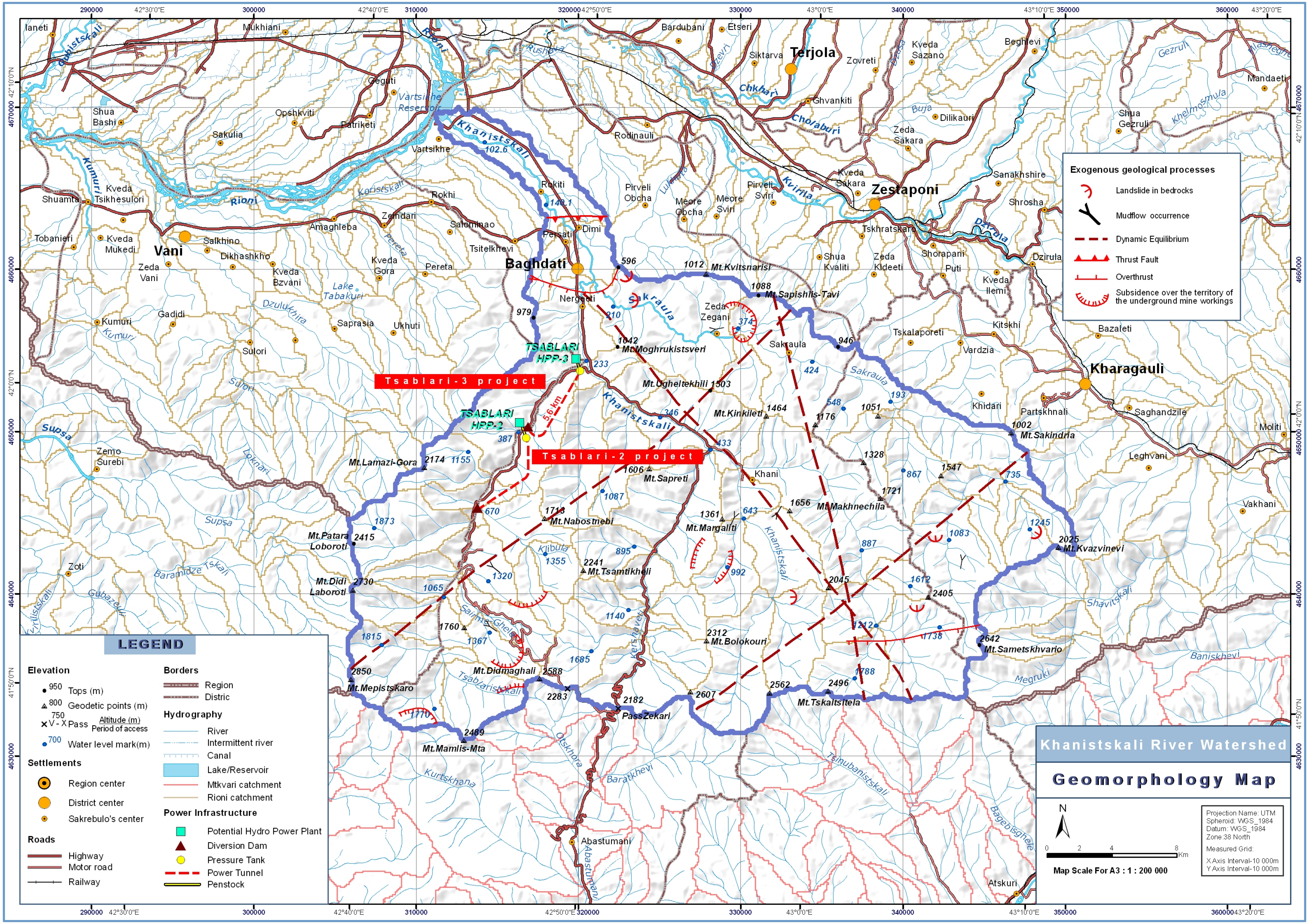
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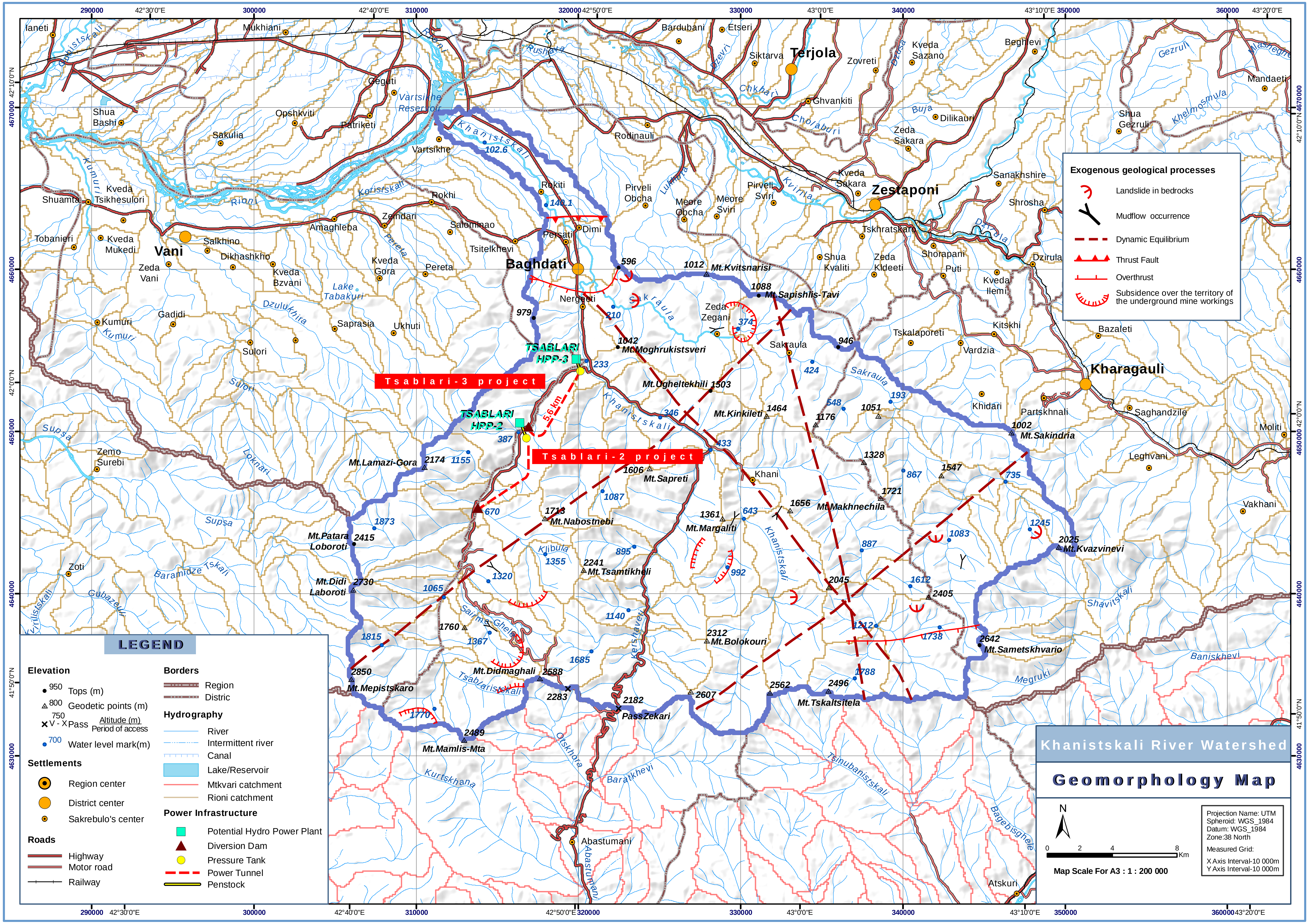
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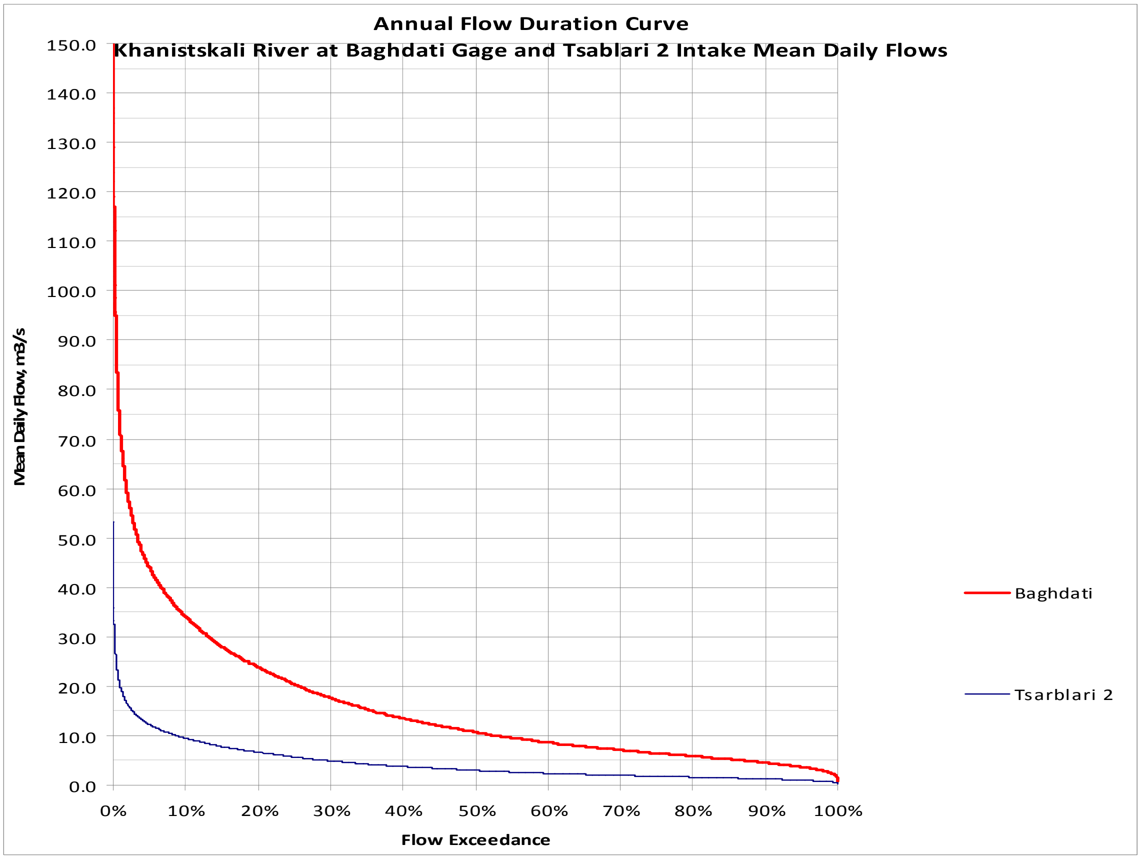
Canal
Lake/Reservoir
Mtkvari catchment
Rioni catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Pressure Tank
Power Tunnel
Penstock
Tsablari-3 project
Tsablari-2 project
TSABLARI HPP-3
TSABLARI HPP-2
5.6 km
Baghdati
Zestaponi
Terjola
Vani
Kharagauli
Abastumani
Map Scale For A3 : 1 : 200 000
0 2 4 8 Km
N
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m

Appendix 2

Monthly and Annual Flow Duration Curves

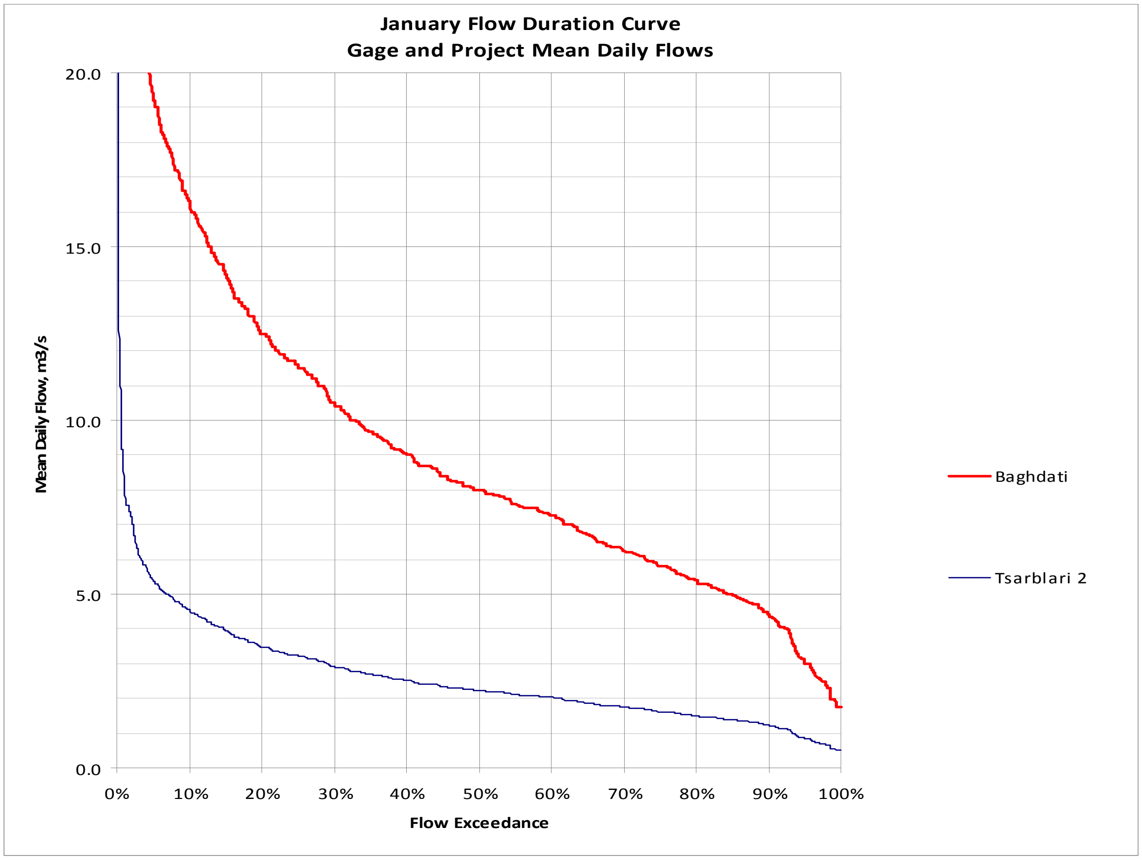
Note related to this Appendix:

The generation tables following each Flow Duration Curve represent a conservative selection of input data and, therefore, a conservative analysis for monthly and annual HPP generation using this methodology.



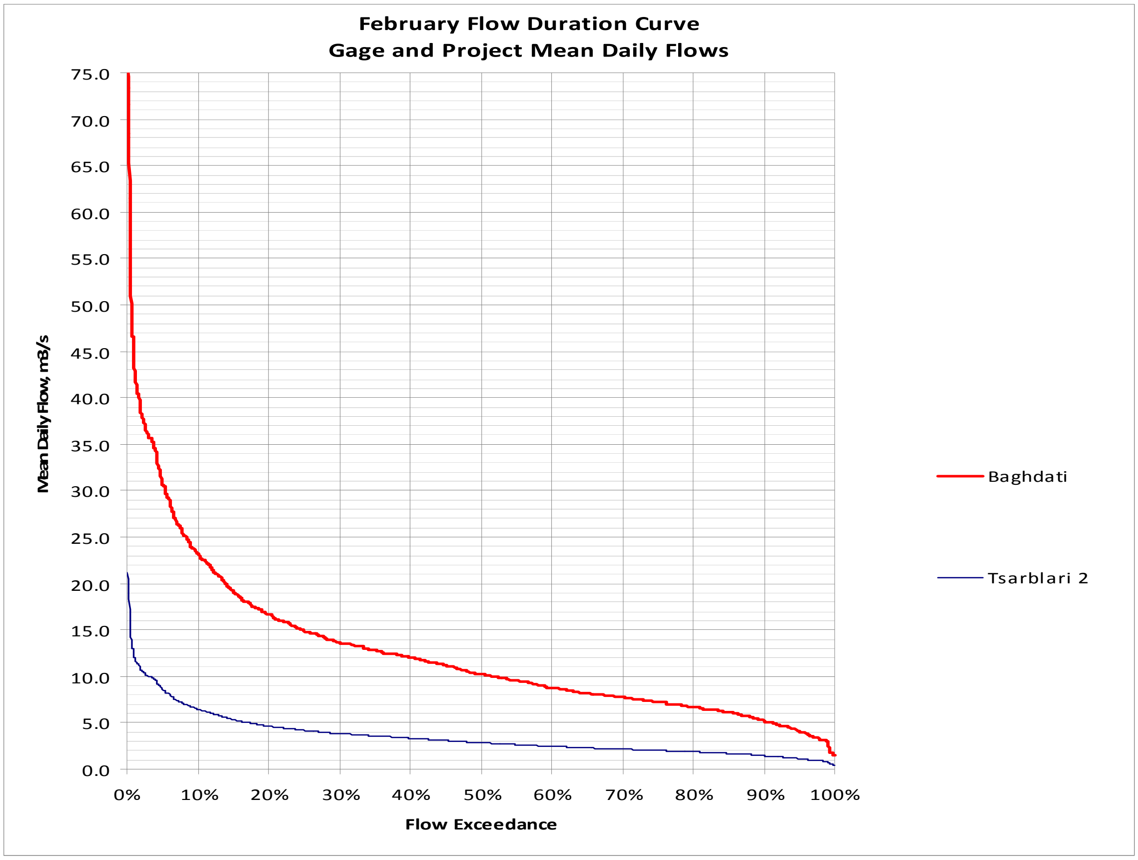
Annual.

Area under Adjusted Flow Duration Curve in CMS-Hrs	38,841
Select Discharge equal to or exceeded % For HPP	18.50%
Equivalent Total Turbine Discharge at Selected CF in CMS	7.00
Non-useable portion of FDC at selected CF or Exceedance %	6875
Gross Available CMS-HRS for Generation at selected CF	31,966
Annual Average Daily Discharge in CMS	4.43
Select Env/Sanitary Flow as a % of Monthly Avg Dalily Discharge	5%
Environmental/Sanitary Flow in CMS	0.22
Non-useable Environmental/Sanitary CMS-HRS	1,906
Net CMS-HRS Available for Generation	30,060
Estimated Intake Elevation in Meters	667
Estimated Discharge Elevation in Meters	372
Gross Head for Generation in Meters	295
Length of Penstock/Pipeline/tunnel in Km	6.3
Head Loss (from daily head loss calculation average) in Meters	3.127
Net Head for Generation in Meters	291.873
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Annual Generation in MWH	73,129



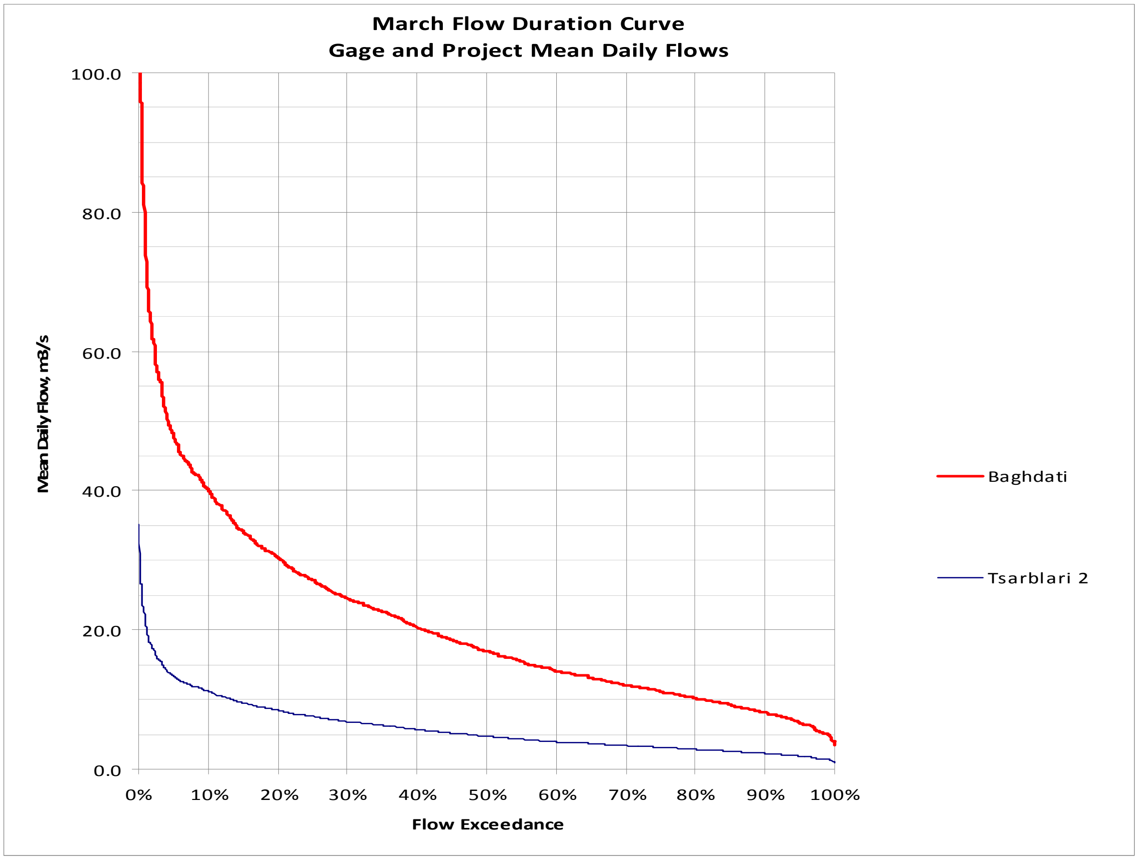
January

Area under Adjusted Flow Duration Curve in CMS-Hrs	1,956
Select Discharge equal to or exceeded % For HPP	2.27%
Equivalent Total Turbine Discharge at Selected CF in CMS	7.03
Non-useable portion of FDC at selected CF or Exceedance %	31
Gross Available CMS-HRS for Generation at selected CF	1,925
Monthly Average Daily Discharge in CMS	2.64
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	10%
Environmental/Sanitary Flow in CMS	0.26
Non-useable Environmental/Sanitary CMS-HRS	196
Net CMS-HRS Available for Generation	1729
Estimated Intake Elevation in Meters	667
Estimated Discharge Elevation in Meters	372
Gross Head for Generation in Meters	295
Length of Penstock/Pipeline/tunnel in Km	6.3
Head Loss (from daily head loss calculation average) in Meters	3.127
Net Head for Generation in Meters	291.873
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	4,205,326
MWh	4,205



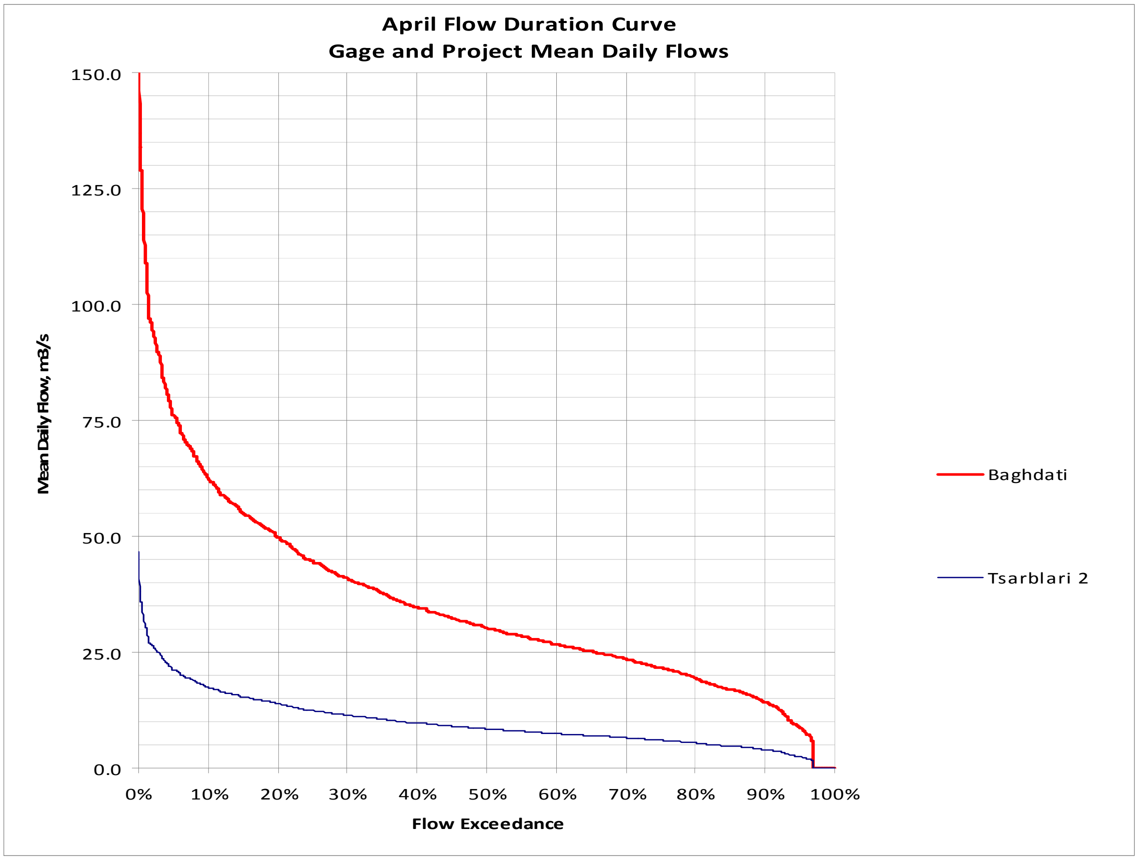
February

Area under Adjusted Flow Duration Curve in CMS-Hrs	2,370
Select Discharge equal to or exceeded % For HPP	8.30%
Equivalent Total Turbine Discharge at Selected CF in CMS	7.03
Non-useable portion of FDC at selected CF or Exceedance %	149
Gross Available CMS-HRS for Generation at selected CF	2,221
Monthly Average Daily Discharge in CMS	3.53
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	10%
Environmental/Sanitary Flow in CMS	0.32
Non-useable Environmental/Sanitary CMS-HRS	217
Net CMS-HRS Available for Generation	2005
Estimated Intake Elevation in Meters	667
Estimated Discharge Elevation in Meters	372
Gross Head for Generation in Meters	295
Length of Penstock/Pipeline/tunnel in Km	6.3
Head Loss (from daily head loss calculation average) in Meters	3.127
Net Head for Generation in Meters	291.873
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	4,876,978
MWh	4,877



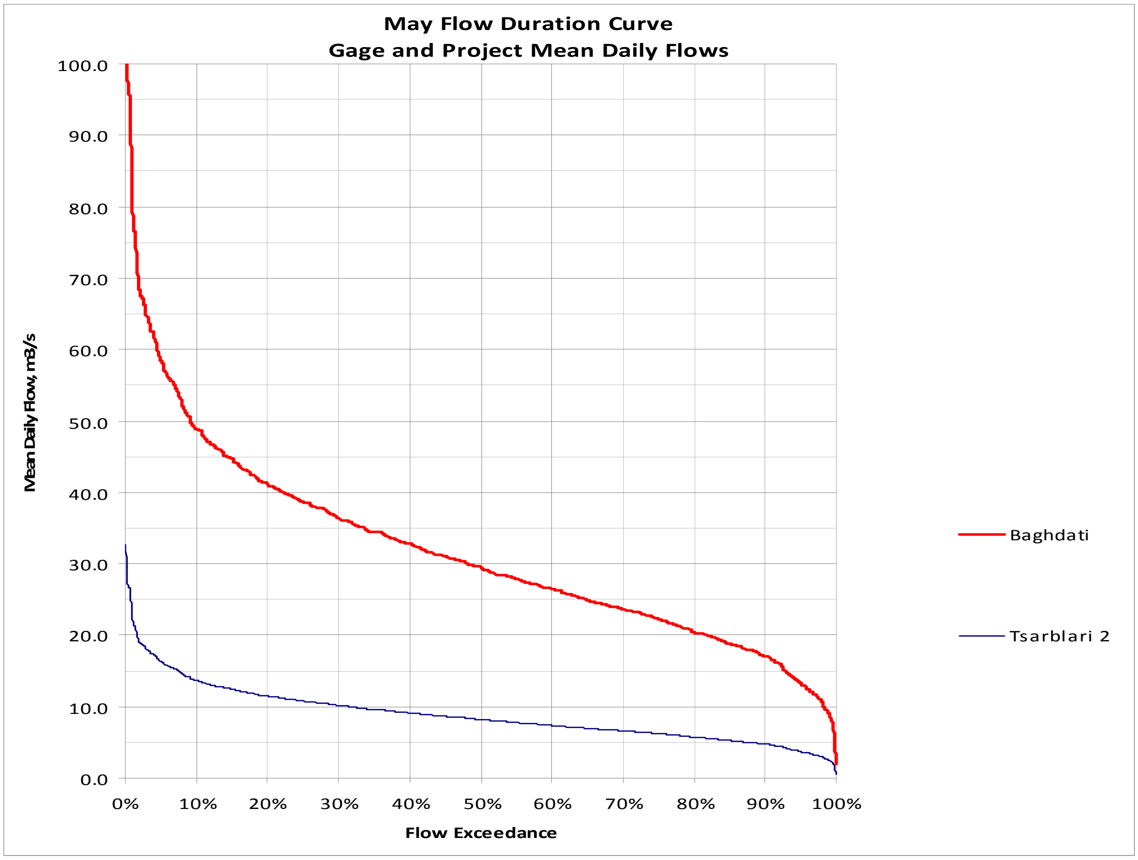
March

Area under Adjusted Flow Duration Curve in CMS-Hrs	4,395
Select Discharge equal to or exceeded % For HPP	28.00%
Equivalent Total Turbine Discharge at Selected CF in CMS	7.08
Non-useable portion of FDC at selected CF or Exceedance %	808
Gross Available CMS-HRS for Generation at selected CF	3,587
Monthly Average Daily Discharge in CMS	5.92
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	10%
Environmental/Sanitary Flow in CMS	0.59
Non-useable Environmental/Sanitary CMS-HRS	440
Net CMS-HRS Available for Generation	3147
Estimated Intake Elevation in Meters	667
Estimated Discharge Elevation in Meters	372
Gross Head for Generation in Meters	295
Length of Penstock/Pipeline/tunnel in Km	6.3
Head Loss (from daily head loss calculation average) in Meters	3.127
Net Head for Generation in Meters	291.873
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	7,655,394
MWh	7,655



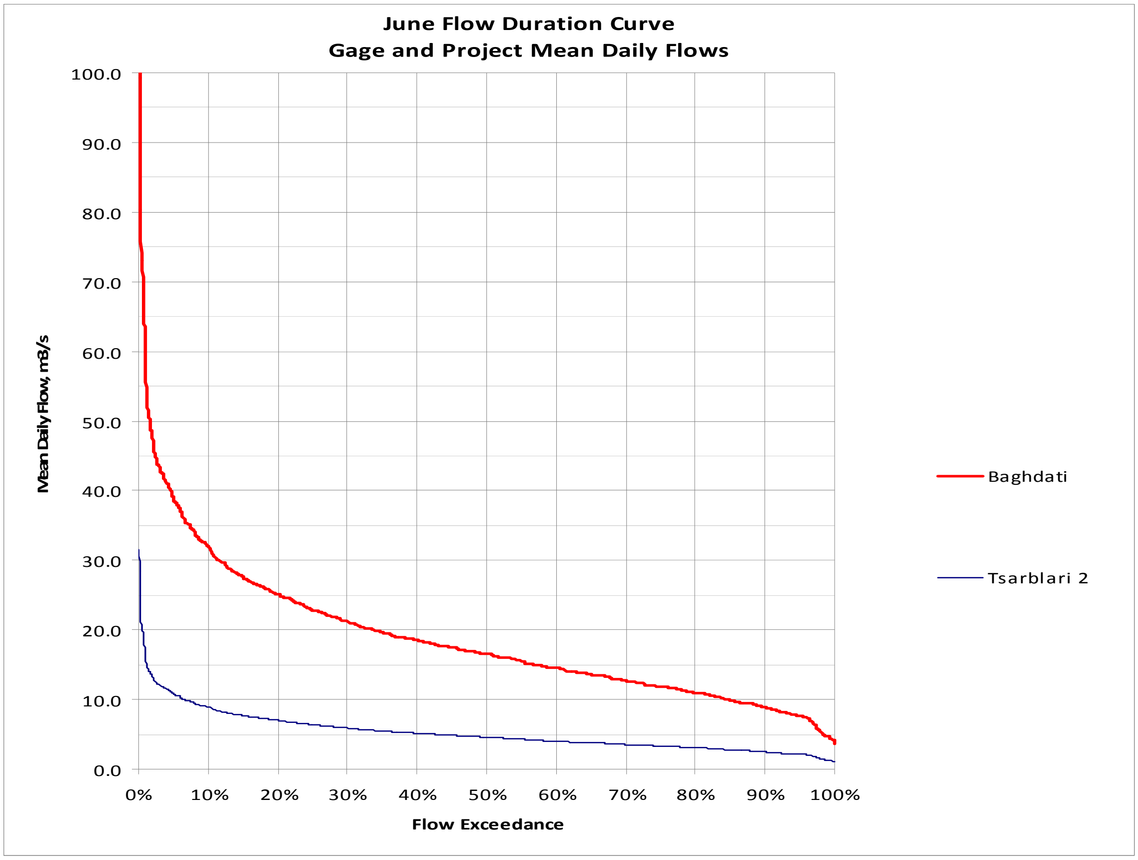
April

Area under Adjusted Flow Duration Curve in CMS-Hrs	7,062
Select Discharge equal to or exceeded % For HPP	65.00%
Equivalent Total Turbine Discharge at Selected CF in CMS	7.03
Non-useable portion of FDC at selected CF or Exceedance %	2611
Gross Available CMS-HRS for Generation at selected CF	4,451
Monthly Average Daily Discharge in CMS	10.15
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	3%
Environmental/Sanitary Flow in CMS	0.29
Non-useable Environmental/Sanitary CMS-HRS	206
Net CMS-HRS Available for Generation	4245
Estimated Intake Elevation in Meters	667
Estimated Discharge Elevation in Meters	372
Gross Head for Generation in Meters	295
Length of Penstock/Pipeline/tunnel in Km	6.3
Head Loss (from daily head loss calculation average) in Meters	3.127
Net Head for Generation in Meters	291.873
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	10,327,180
MWh	10,327



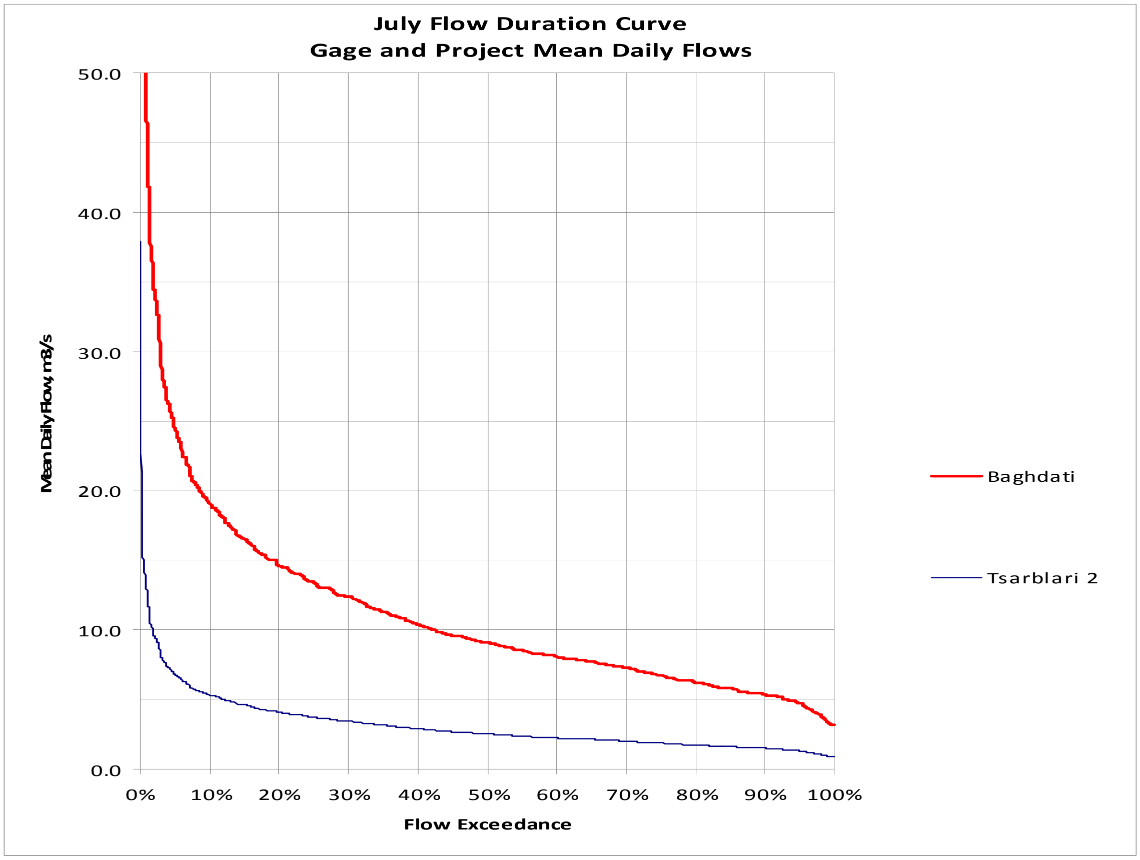
May

Area under Adjusted Flow Duration Curve in CMS-Hrs	6,595
Select Discharge equal to or exceeded % For HPP	64.50%
Equivalent Total Turbine Discharge at Selected CF in CMS	7.03
Non-useable portion of FDC at selected CF or Exceedance %	1824
Gross Available CMS-HRS for Generation at selected CF	4,772
Monthly Average Daily Discharge in CMS	8.87
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	2%
Environmental/Sanitary Flow in CMS	0.18
Non-useable Environmental/Sanitary CMS-HRS	132
Net CMS-HRS Available for Generation	4,640
Estimated Intake Elevation in Meters	667
Estimated Discharge Elevation in Meters	372
Gross Head for Generation in Meters	295
Length of Penstock/Pipeline/tunnel in Km	6.3
Head Loss (from daily head loss calculation average) in Meters	3.127
Net Head for Generation in Meters	291.873
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	11,287,041
MWh	11,287



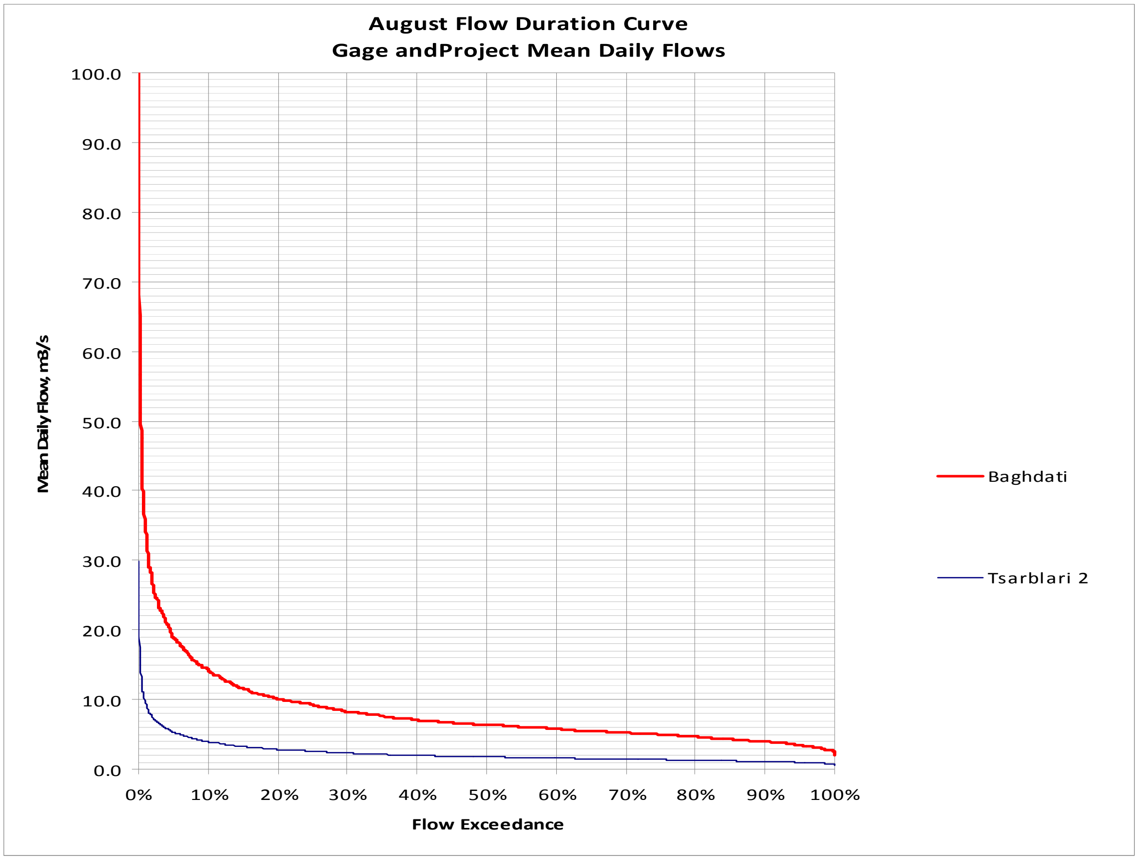
June

Area under Adjusted Flow Duration Curve in CMS-Hrs	3,785
Select Discharge equal to or exceeded % For HPP	20.00%
Equivalent Total Turbine Discharge at Selected CF in CMS	7.03
Non-useable portion of FDC at selected CF or Exceedance %	400
Gross Available CMS-HRS for Generation at selected CF	3,385
Monthly Average Daily Discharge in CMS	5.27
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	2%
Environmental/Sanitary Flow in CMS	0.10
Non-useable Environmental/Sanitary CMS-HRS	74
Net CMS-HRS Available for Generation	3,311
Estimated Intake Elevation in Meters	667
Estimated Discharge Elevation in Meters	372
Gross Head for Generation in Meters	295
Length of Penstock/Pipeline/tunnel in Km	6.3
Head Loss (from daily head loss calculation average) in Meters	3.127
Net Head for Generation in Meters	291.873
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	8,056,043
MWh	8,056



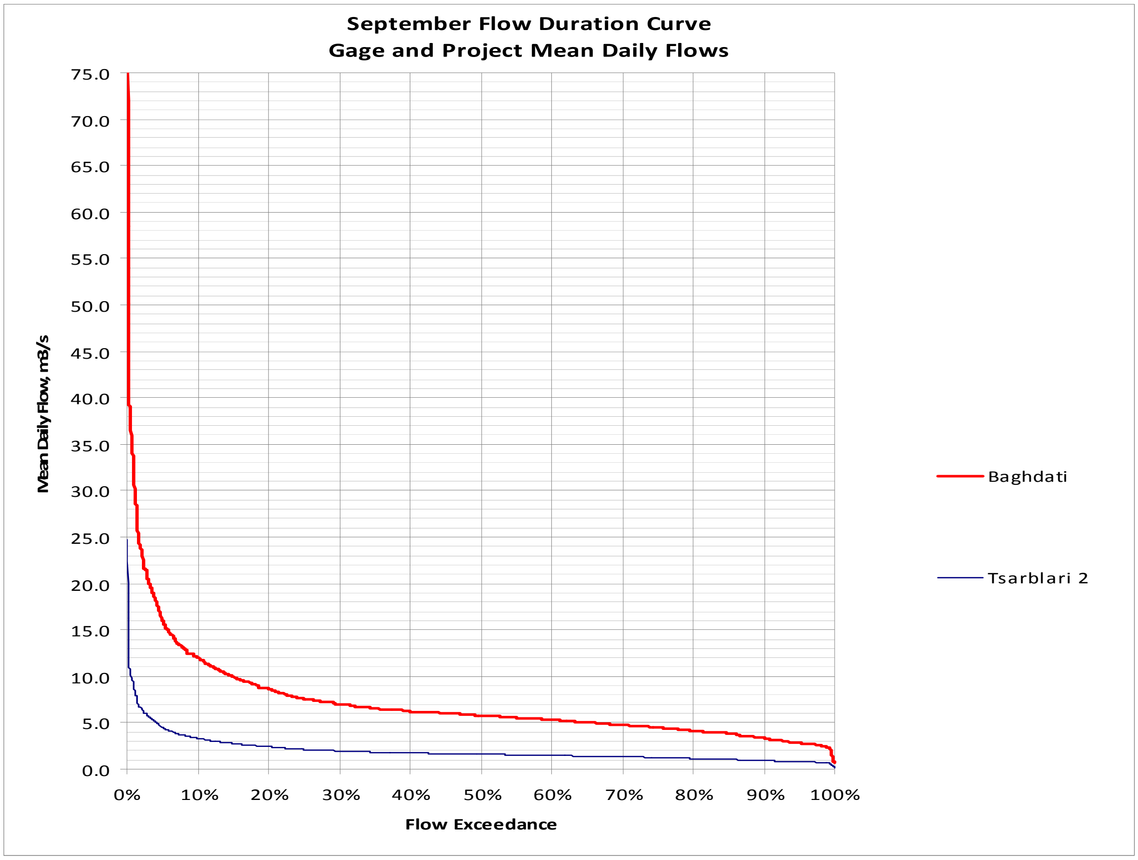
July

Area under Adjusted Flow Duration Curve in CMS-Hrs	2,340
Select Discharge equal to or exceeded % For HPP	4.60%
Equivalent Total Turbine Discharge at Selected CF in CMS	7.07
Non-useable portion of FDC at selected CF or Exceedance %	108
Gross Available CMS-HRS for Generation at selected CF	2,232
Monthly Average Daily Discharge in CMS	3.16
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	2%
Environmental/Sanitary Flow in CMS	0.06
Non-useable Environmental/Sanitary CMS-HRS	47
Net CMS-HRS Available for Generation	2,185
Estimated Intake Elevation in Meters	667
Estimated Discharge Elevation in Meters	372
Gross Head for Generation in Meters	295
Length of Penstock/Pipeline/tunnel in Km	6.3
Head Loss (from daily head loss calculation average) in Meters	3.127
Net Head for Generation in Meters	291.873
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	5,315,747
MWh	5,316



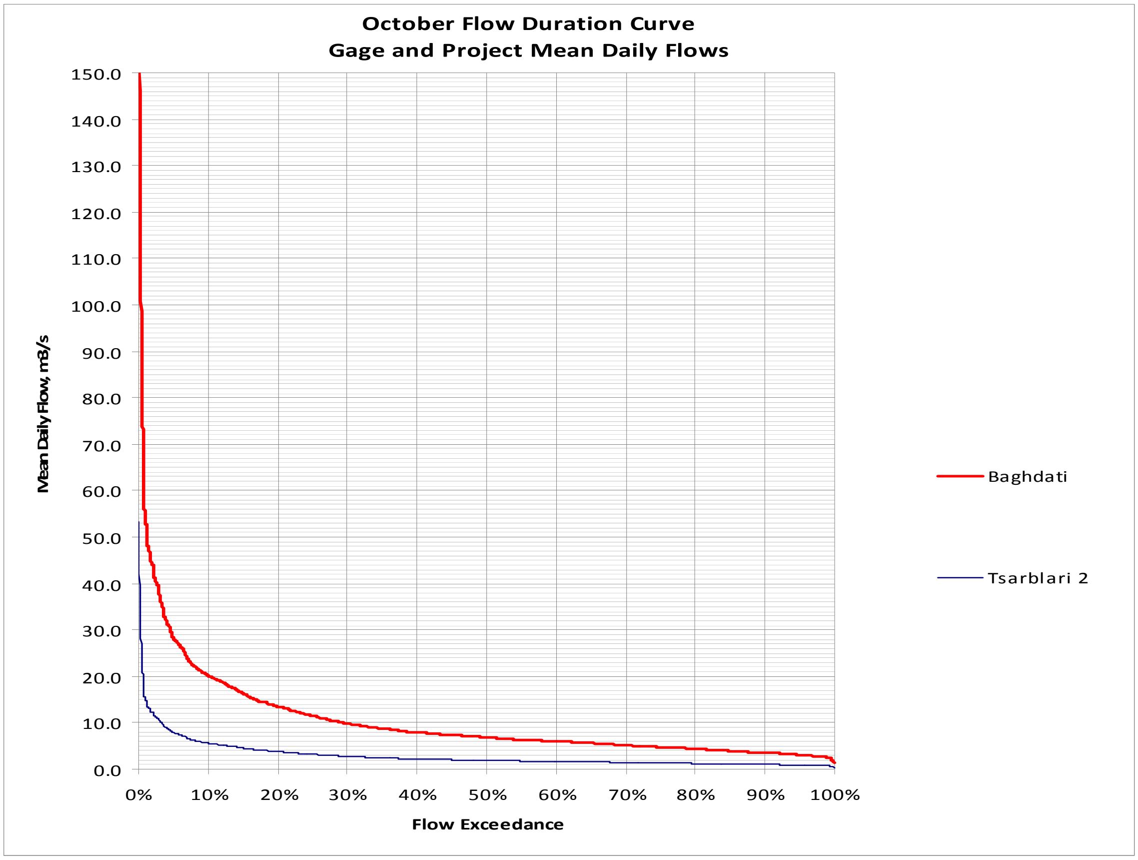
August

Area under Adjusted Flow Duration Curve in CMS-Hrs	1,703
Select Discharge equal to or exceeded % For HPP	2.50%
Equivalent Total Turbine Discharge at Selected CF in CMS	7.01
Non-useable portion of FDC at selected CF or Exceedance %	51
Gross Available CMS-HRS for Generation at selected CF	1,652
Monthly Average Daily Discharge in CMS	2.30
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	3%
Environmental/Sanitary Flow in CMS	0.07
Non-useable Environmental/Sanitary CMS-HRS	51
Net CMS-HRS Available for Generation	1601
Estimated Intake Elevation in Meters	667
Estimated Discharge Elevation in Meters	372
Gross Head for Generation in Meters	295
Length of Penstock/Pipeline/tunnel in Km	6.3
Head Loss (from daily head loss calculation average) in Meters	3.127
Net Head for Generation in Meters	291.873
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	3,893,870
MWh	3,894



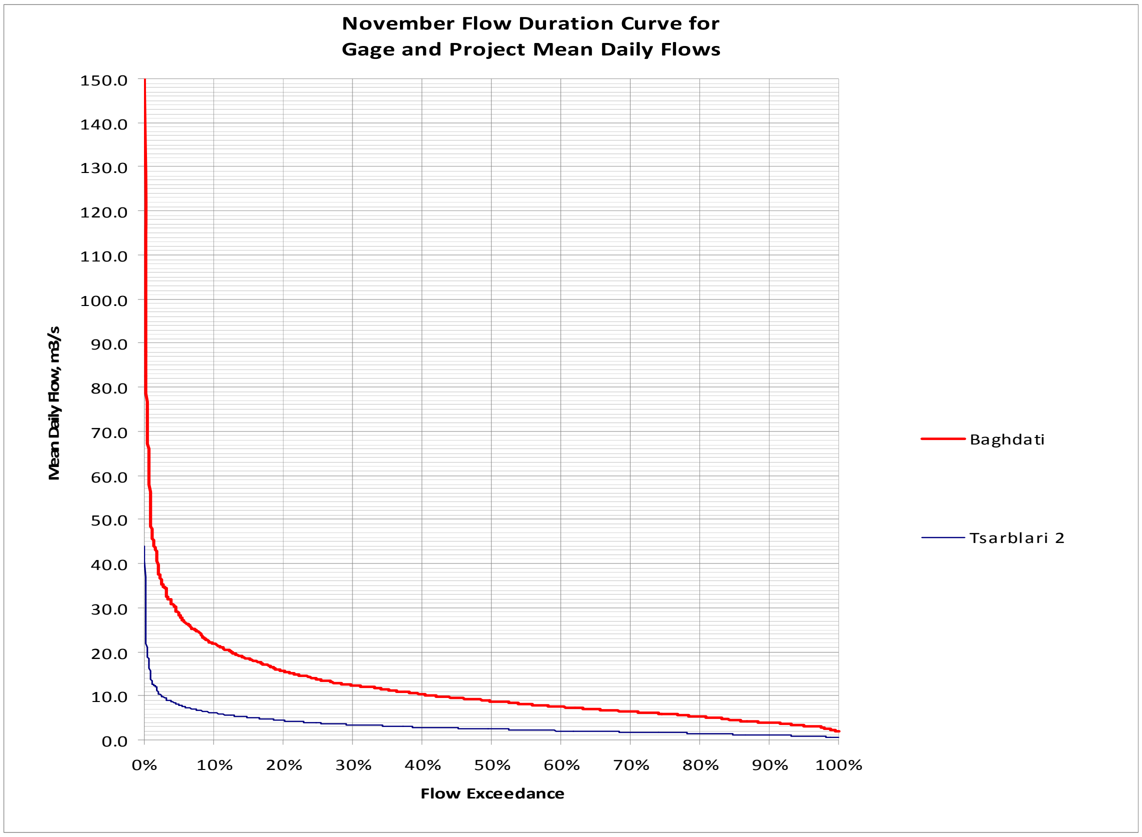
September

Area under Adjusted Flow Duration Curve in CMS-Hrs	1,428
Select Discharge equal to or exceeded % For HPP	1.70%
Equivalent Total Turbine Discharge at Selected CF in CMS	7.03
Non-useable portion of FDC at selected CF or Exceedance %	29
Gross Available CMS-HRS for Generation at selected CF	1,399
Monthly Average Daily Discharge in CMS	1.99
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	5%
Environmental/Sanitary Flow in CMS	0.10
Non-useable Environmental/Sanitary CMS-HRS	69
Net CMS-HRS Available for Generation	1330
Estimated Intake Elevation in Meters	667
Estimated Discharge Elevation in Meters	372
Gross Head for Generation in Meters	295
Length of Penstock/Pipeline/tunnel in Km	6.3
Head Loss (from daily head loss calculation average) in Meters	3.127
Net Head for Generation in Meters	291.873
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	3,234,862
MWh	3,235



October

Area under Adjusted Flow Duration Curve in CMS-Hrs	2,158
Select Discharge equal to or exceeded % For HPP	6.70%
Equivalent Total Turbine Discharge at Selected CF in CMS	7.03
Non-useable portion of FDC at selected CF or Exceedance %	247
Gross Available CMS-HRS for Generation at selected CF	1,910
Monthly Average Daily Discharge in CMS	2.92
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	6%
Environmental/Sanitary Flow in CMS	0.17
Non-useable Environmental/Sanitary CMS-HRS	130
Net CMS-HRS Available for Generation	1780
Estimated Intake Elevation in Meters	667
Estimated Discharge Elevation in Meters	372
Gross Head for Generation in Meters	295
Length of Penstock/Pipeline/tunnel in Km	6.3
Head Loss (from daily head loss calculation average) in Meters	3.127
Net Head for Generation in Meters	291.873
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	4,330,517
MWh	4,331

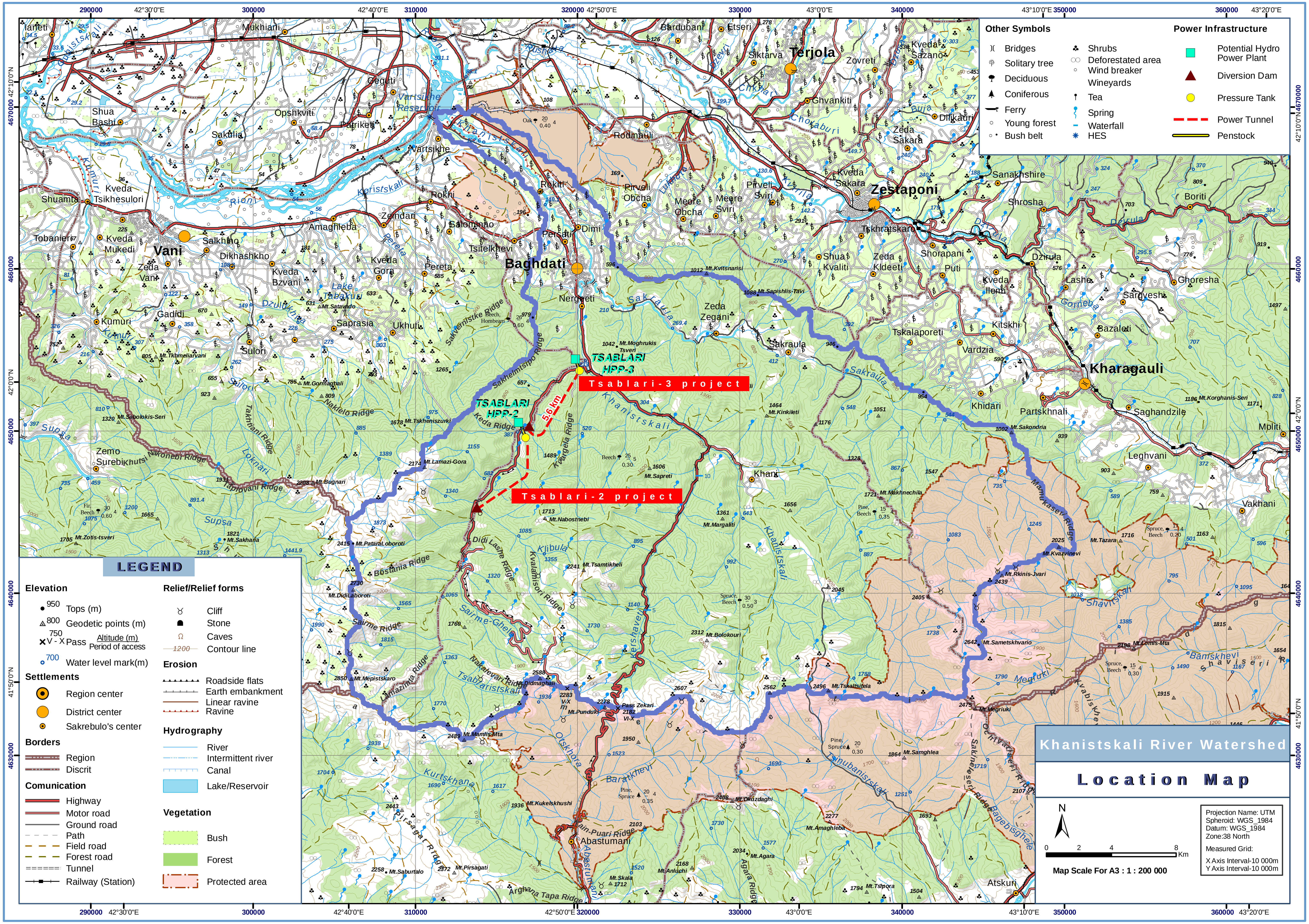


November

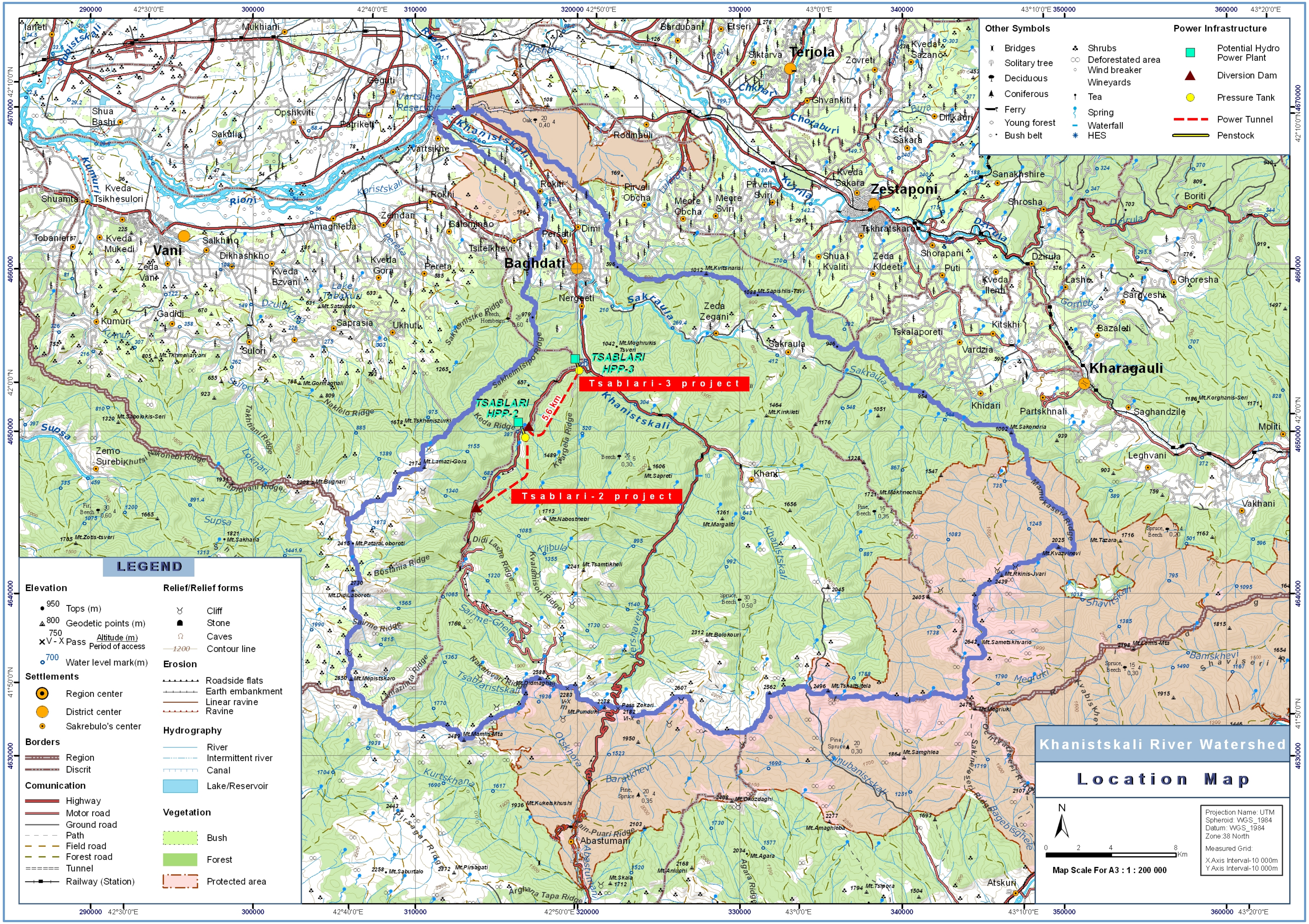
Area under Adjusted Flow Duration Curve in CMS-Hrs	2,316
Select Discharge equal to or exceeded % For HPP	7.00%
Equivalent Total Turbine Discharge at Selected CF in CMS	7.03
Non-useable portion of FDC at selected CF or Exceedance %	175
Gross Available CMS-HRS for Generation at selected CF	2,141
Monthly Average Daily Discharge in CMS	3.23
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	7%
Environmental/Sanitary Flow in CMS	0.22
Non-useable Environmental/Sanitary CMS-HRS	158
Net CMS-HRS Available for Generation	1983
Estimated Intake Elevation in Meters	667
Estimated Discharge Elevation in Meters	372
Gross Head for Generation in Meters	295
Length of Penstock/Pipeline/tunnel in Km	6.3
Head Loss (from daily head loss calculation average) in Meters	3.127
Net Head for Generation in Meters	291.873
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	4,824,769
MWh	4,825

Appendix 3

Location Map



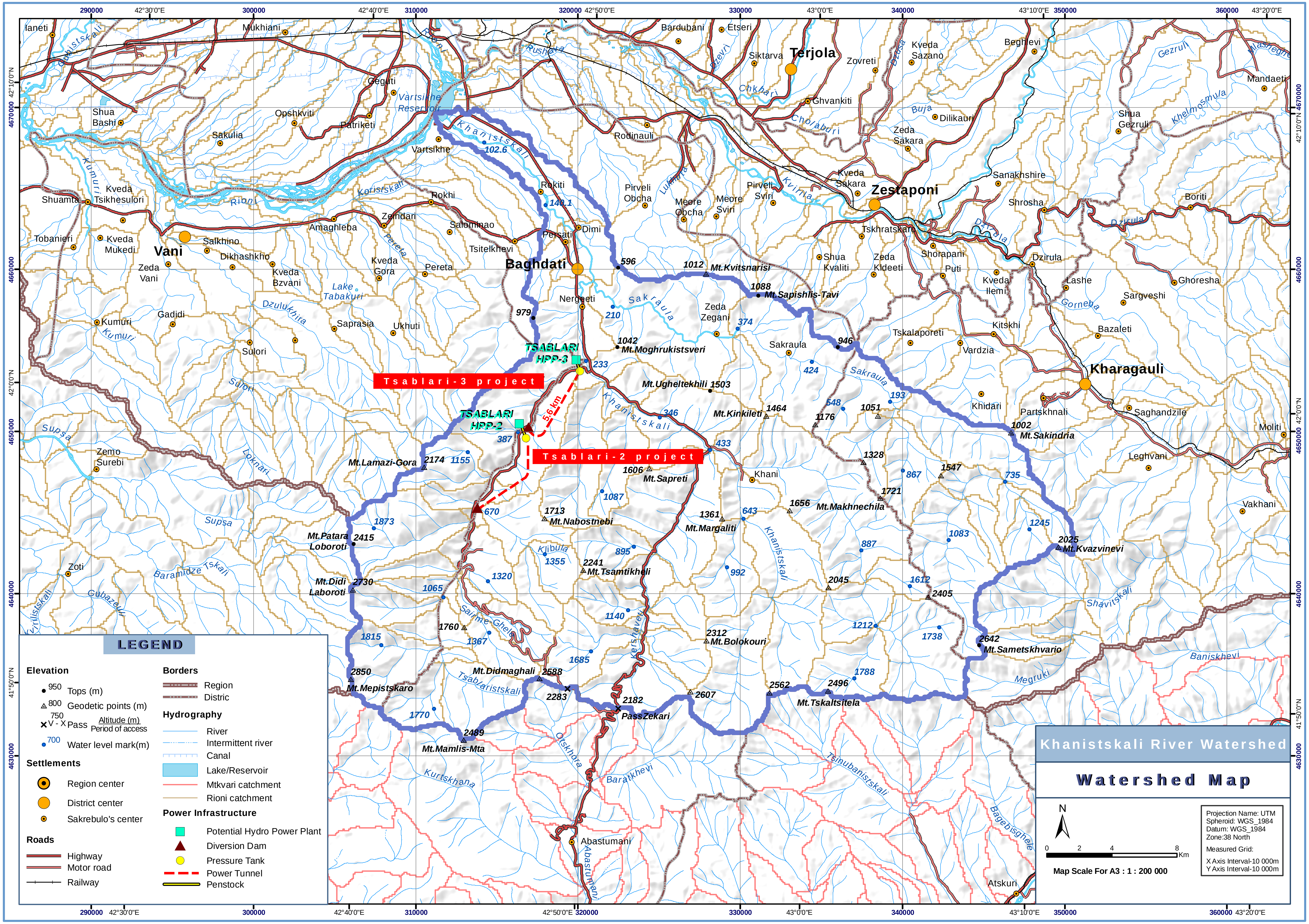
Khanistskali River Watershed
Location Map
Other Symbols
Bridges
Solitary tree
Deciduous
Coniferous
Ferry
Young forest
Bush belt
Shrubs
Deforestated area
Wind breaker
Wineyards
Tea
Spring
Waterfall
HES
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Pressure Tank
Power Tunnel
Penstock
LEGEND
Elevation
Tops (m)
Geodetic points (m)
Pass
Altitude (m)
Period of access
Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Borders
Region
Discrit
Comunication
Highway
Motor road
Ground road
Path
Field road
Forest road
Tunnel
Railway (Station)
Relief/Relief forms
Cliff
Stone
Caves
Contour line
Erosion
Roadside flats
Earth embankment
Linear ravine
Ravine
Hydrography
River
Intermittent river
Canal
Lake/Reservoir
Vegetation
Bush
Forest
Protected area
Tsablari-3 project
Tsablari-2 project
TSABLARI HPP-3
TSABLARI HPP-2
5.6 km
Baghdati
Zestaponi
Terjola
Vani
Kharagauli
Abastumani
Khanistskali
Sakraula
Rioni
Map Scale For A3 : 1 : 200 000
Km
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m

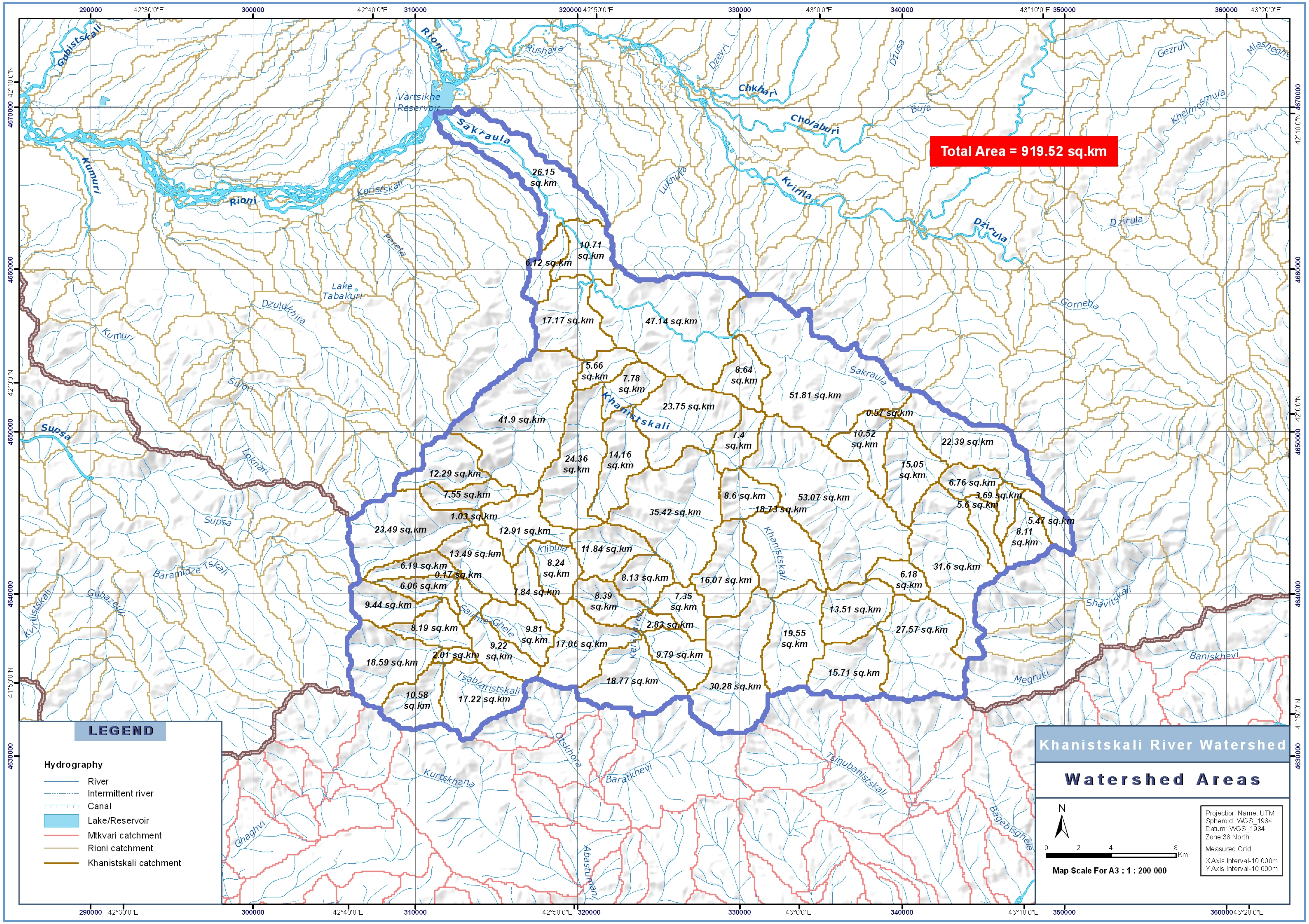


Khanistskali River Watershed
Location Map
Tsablari-3 project
Tsablari-2 project
TSABLARI HPP-3
TSABLARI HPP-2
5.6 km
LEGEND
Elevation
Tops (m)
Geodetic points (m)
Pass Altitude (m) Period of access
Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Borders
Region
Discrit
Comunication
Highway
Motor road
Ground road
Path
Field road
Forest road
Tunnel
Railway (Station)
Relief/Relief forms
Cliff
Stone
Caves
Contour line
Erosion
Roadside flats
Earth embankment
Linear ravine
Ravine
Hydrography
River
Intermittent river
Canal
Lake/Reservoir
Vegetation
Bush
Forest
Protected area
Other Symbols
Bridges
Solitary tree
Deciduous
Coniferous
Ferry
Young forest
Bush belt
Shrubs
Deforestated area
Wind breaker
Wineyards
Tea
Spring
Waterfall
HES
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Pressure Tank
Power Tunnel
Penstock
Map Scale For A3 : 1 : 200 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m
Terjola
Zestaponi
Vani
Baghdati
Kharagauli
Abastumani
Khanistskali
Sakraula
Rioni

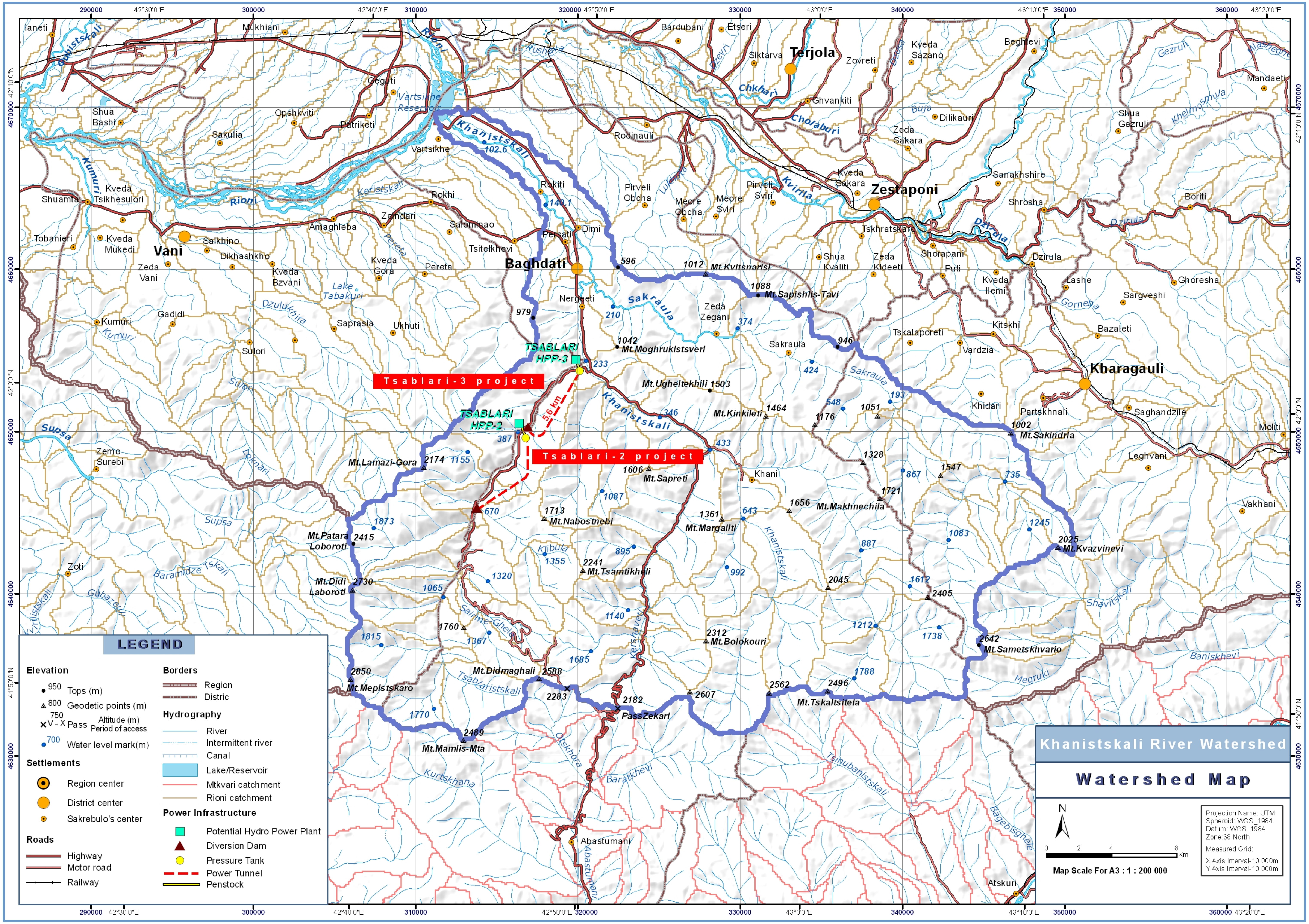
Appendix 4

Watershed Map


Khanistskali River Watershed
Watershed Map
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 Altitude (m)
V - X Pass Period of access
700 Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Roads
Highway
Motor road
Railway
Borders
Region
Distric
Hydrography
River
Intermittent river
Canal
Lake/Reservoir
Mtkvari catchment
Rioni catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Pressure Tank
Power Tunnel
Penstock
Tsablari-3 project
Tsablari-2 project
TSABLARI HPP-3
TSABLARI HPP-2
5.6 km
Map Scale For A3 : 1 : 200 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m
Km
Baghdati
Vani
Terjola
Zestaponi
Kharagauli
Abastumani
Khanistskali
Sakraula
Rioni
Kvirila
Dzirula
Vartsikhe Reservoir
Mt.Kvitsnarisi
Mt.Sapishlis-Tavi
Mt.Moghrukistsveri
Mt.Ugheltekhili
Mt.Kinkileti
Mt.Sakindria
Mt.Sapreti
Mt.Lamazi-Gora
Mt.Nabostnebi
Mt.Margaliti
Mt.Makhnechila
Mt.Kvazvinevi
Mt.Patara Loboroti
Mt.Didi Laboroti
Mt.Tsamtikheli
Mt.Bolokouri
Mt.Sametskhvario
Mt.Mepistskaro
Mt.Didmaghali
Mt.Mamlis-Mta
Mt.Tskaltsitela
Pass Zekari



Total Area = 919.52 sq.km
Khanistskali River Watershed
Watershed Areas
LEGEND
Hydrography
River
Intermittent river
Canal
Lake/Reservoir
Mtkvari catchment
Rioni catchment
Khanistskali catchment
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m
Map Scale For A3 : 1 : 200 000
N
0 2 4 8 Km
Rioni
Sakraula
Khanistskali
Kvirila
Dzirula
Chkhari
Cholaburi
Vartsikhe Reservoir
Lake Tabakuri
Supsa
Kumuri
Tsablaristskali
26.15 sq.km
10.71 sq.km
6.12 sq.km
17.17 sq.km
47.14 sq.km
51.81 sq.km
41.9 sq.km
23.75 sq.km
22.39 sq.km
53.07 sq.km
35.42 sq.km
31.6 sq.km
27.57 sq.km
30.28 sq.km
23.49 sq.km
18.59 sq.km
17.22 sq.km
18.77 sq.km
17.06 sq.km
19.55 sq.km
15.71 sq.km
13.51 sq.km
16.07 sq.km


Khanistskali River Watershed
Watershed Map
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Roads
Highway
Motor road
Railway
Borders
Region
Distric
Hydrography
River
Intermittent river
Canal
Lake/Reservoir
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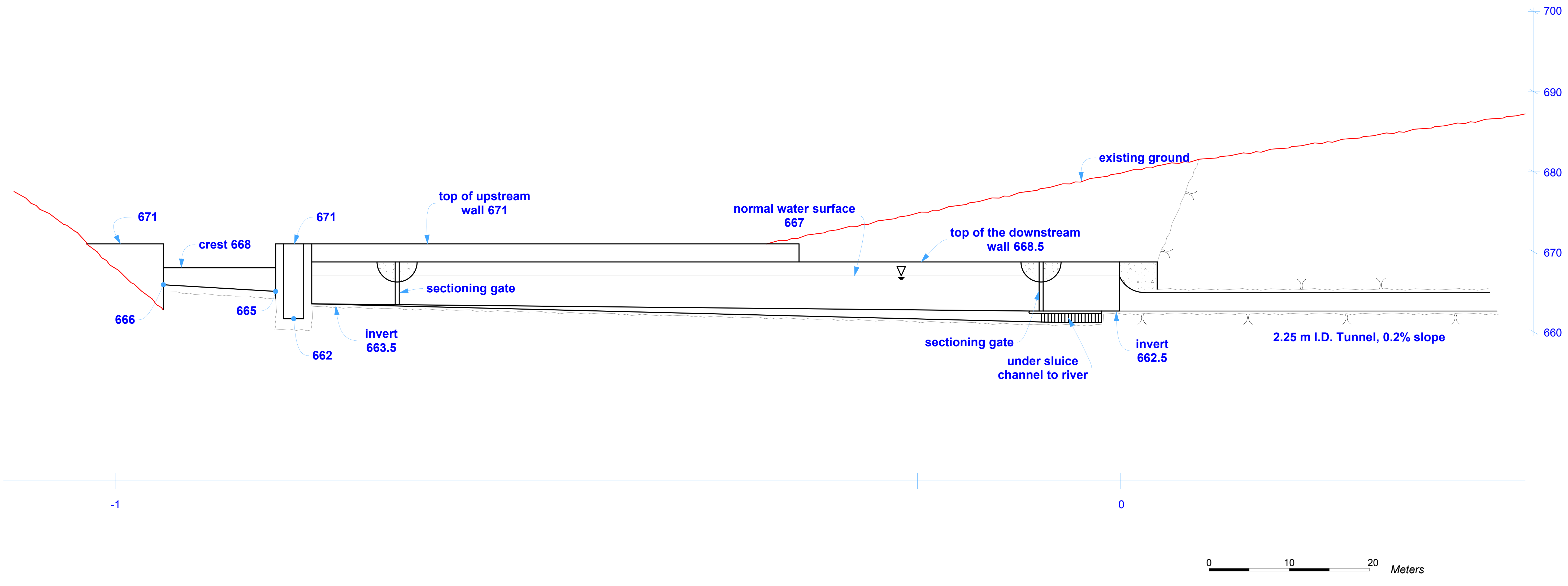
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Pressure Tank
Power Tunnel
Penstock
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m
Map Scale For A3 : 1 : 200 000
N
0 2 4 8 Km
Tsablari-3 project
Tsablari-2 project
TSABLARI HPP-3
TSABLARI HPP-2
5.6 km
Baghdati
Vani
Zestaponi
Terjola
Kharagauli
Khanistskali
Rioni
Sakraula
Kvirila
Dzirula
Vartsikhe Reservoir
Vartsikhe
Rokiti
Dimi
Persati
Nergeeti
Mt.Kvitsnarisi
Mt.Sapishlis-Tavi
Mt.Moghrukistsveri
Mt.Ugheltekhili 1503
Mt.Kinkileti
Mt.Sakindria
Mt.Lamazi-Gora
Mt.Sapreti
Mt.Nabostnebi
Mt.Margaliti
Mt.Makhnechila
Mt.Kvazvinevi
Mt.Patara Loboroti
Mt.Didi Laboroti
Mt.Tsamtikheli
Mt.Bolokouri
Mt.Sametskhvario
Mt.Didmaghali
Mt.Mepistskaro
Mt.Mamlis-Mta
Pass Zekari
Mt.Tskaltsitela
Abastumani
Khani
Kershaveti
Sairme-Gheli
Tsablaristskali
Otskhora
Baratkhevi
Kurtskhana
Tsinubanistskali
Bagebisghele
Megruki
Baniskhevi
Shavitskali
Supsa
Sulori
Kumuri
Dzulukhira
Lake Tabakuri
Pereta
Koristskali
Chkhari
Cholaburi
Buja
Gezruli
Khelmosmula
Gorneba
Atskuri

Appendix 5

Site HPP Figure



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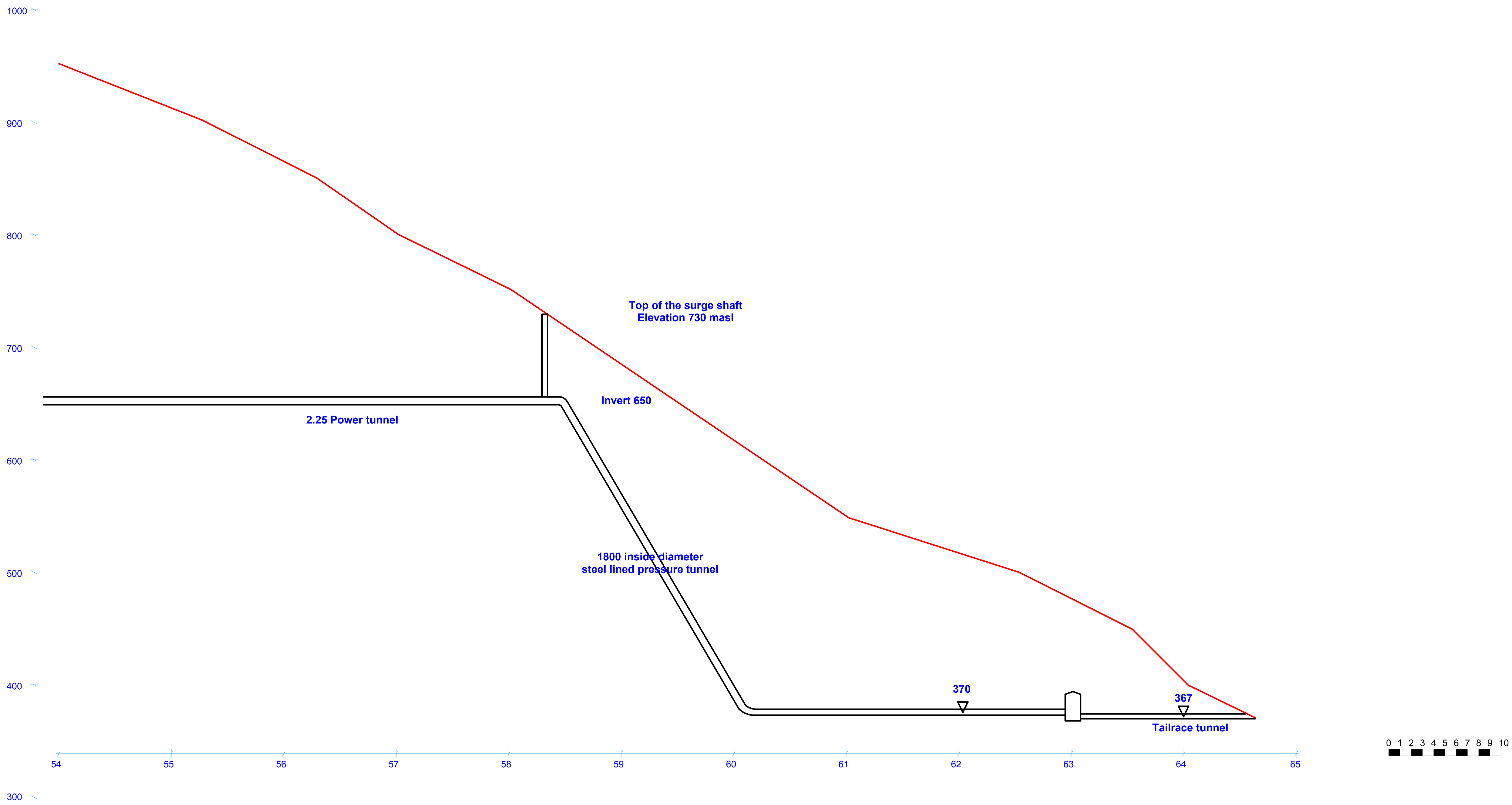
Building a world of difference.

Pre-Feasibility Study
Tsablari 2

Intake, Desilting Basin and Tunnel Portal Profile

Drawing Scale 1:500	August 2011



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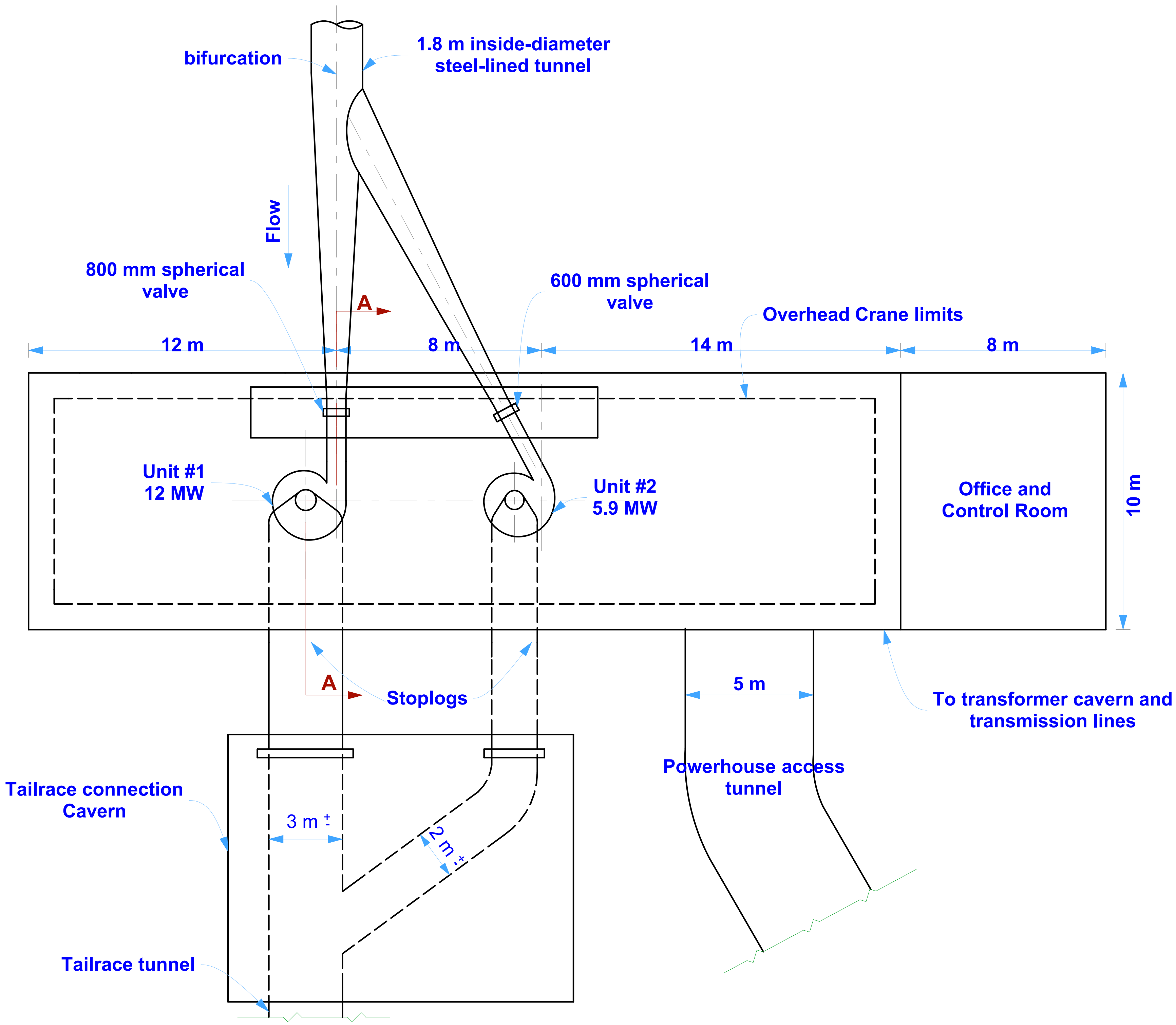
Pre-Feasibility Study
Tsablari 2

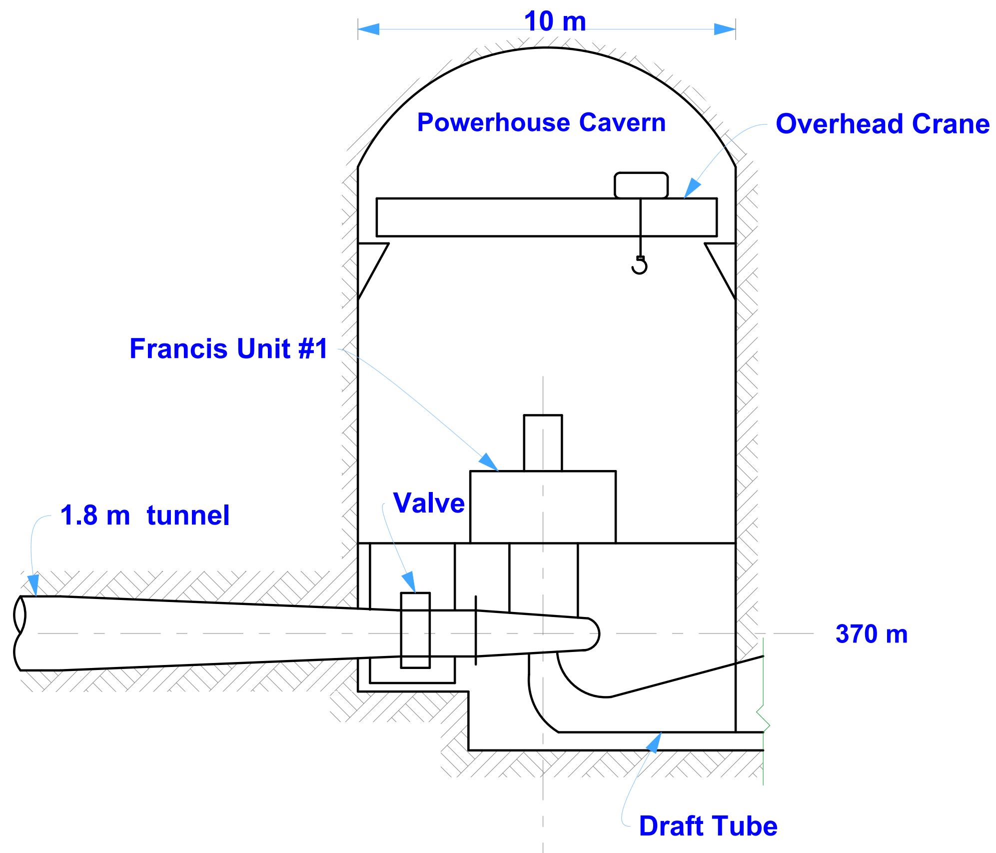
Powerhouse Area Water Conductor Profile

Drawing Scale 1:2,000

July 2011



Plan



Section A:A

0 1 2 3 4 5

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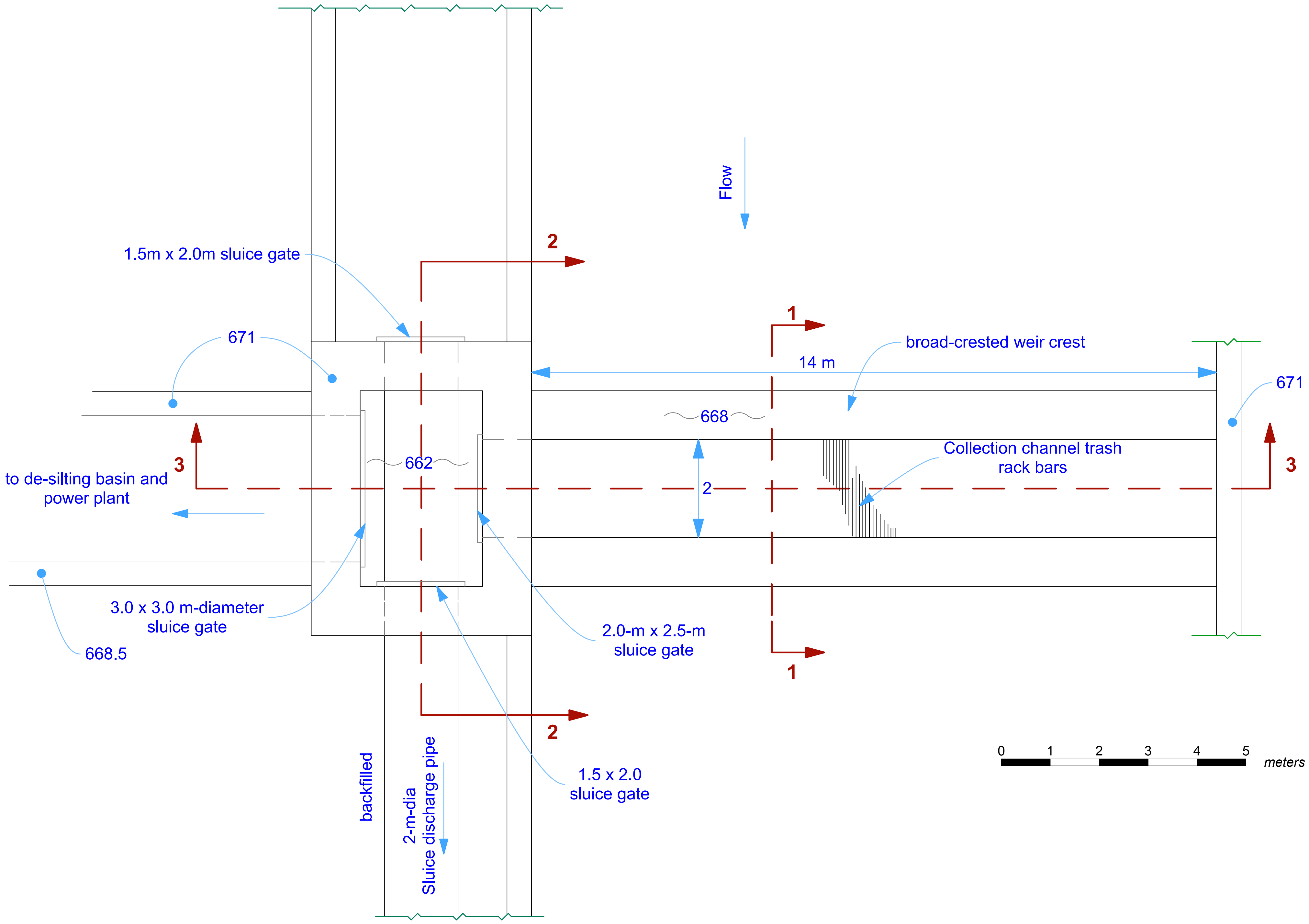
Building a world of difference.

Pre-Feasibility Study
Tsablari 2

Powerhouse Plan and Section

Drawing Scale	1:200	July 2011



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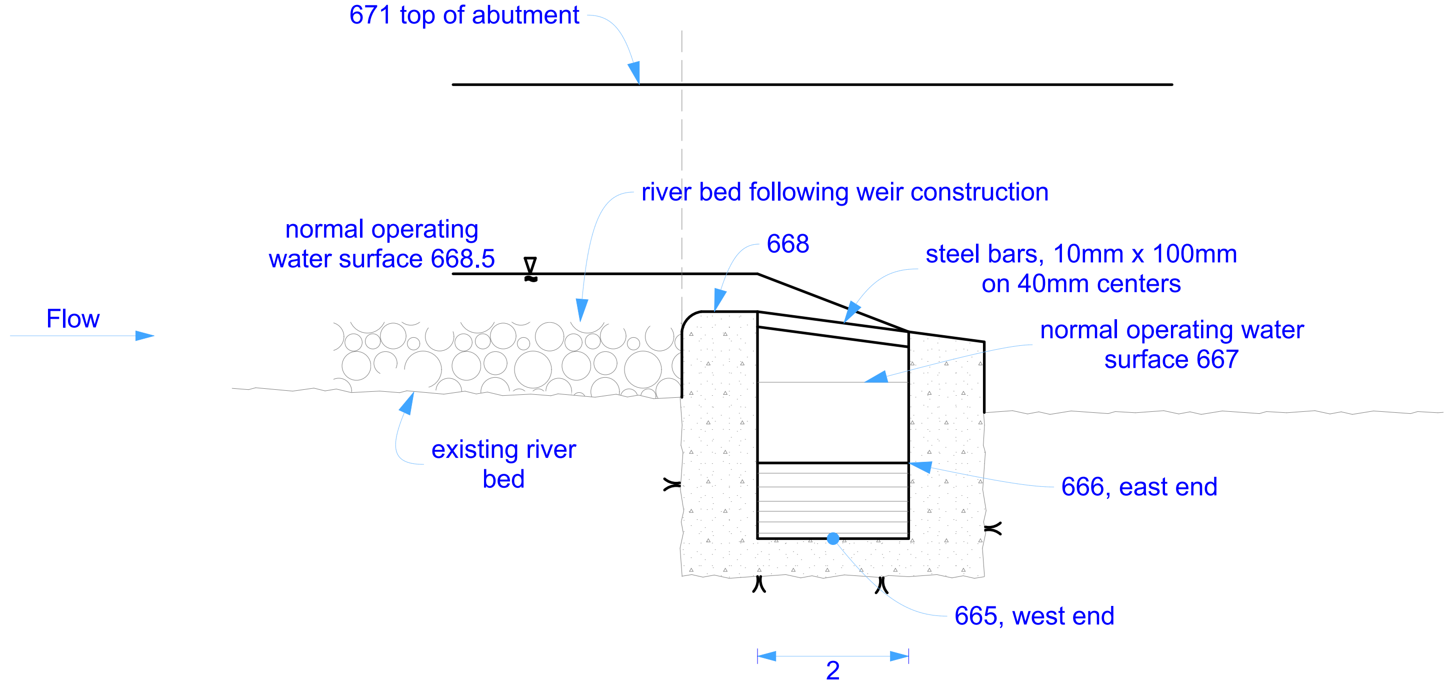
Building a world of difference.

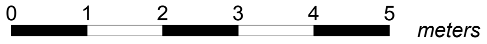
Pre-Feasibility Study
Tsablari 2

Tsablari Diversion Weir and Intake
Collection Chamber Plan

Drawing Scale **1:100** | **August 2011**



Section 1-1

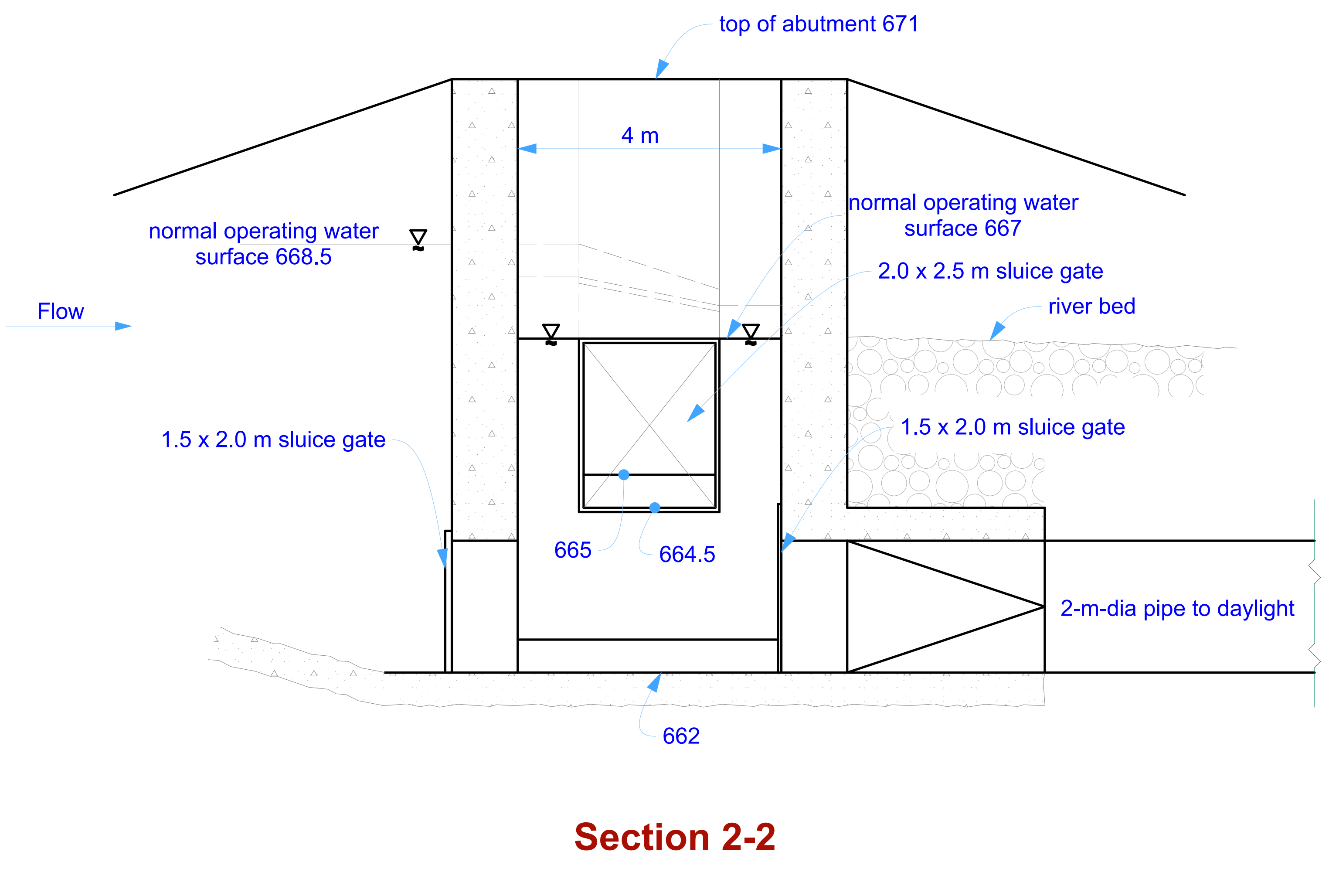


BLACK & VEATCH
Building a world of difference.

Pre-Feasibility Study
Tsablari 2

Tsablari Diversion Weir and
Intake Sections

Drawing Scale 1:100	August 2011



Section 2-2

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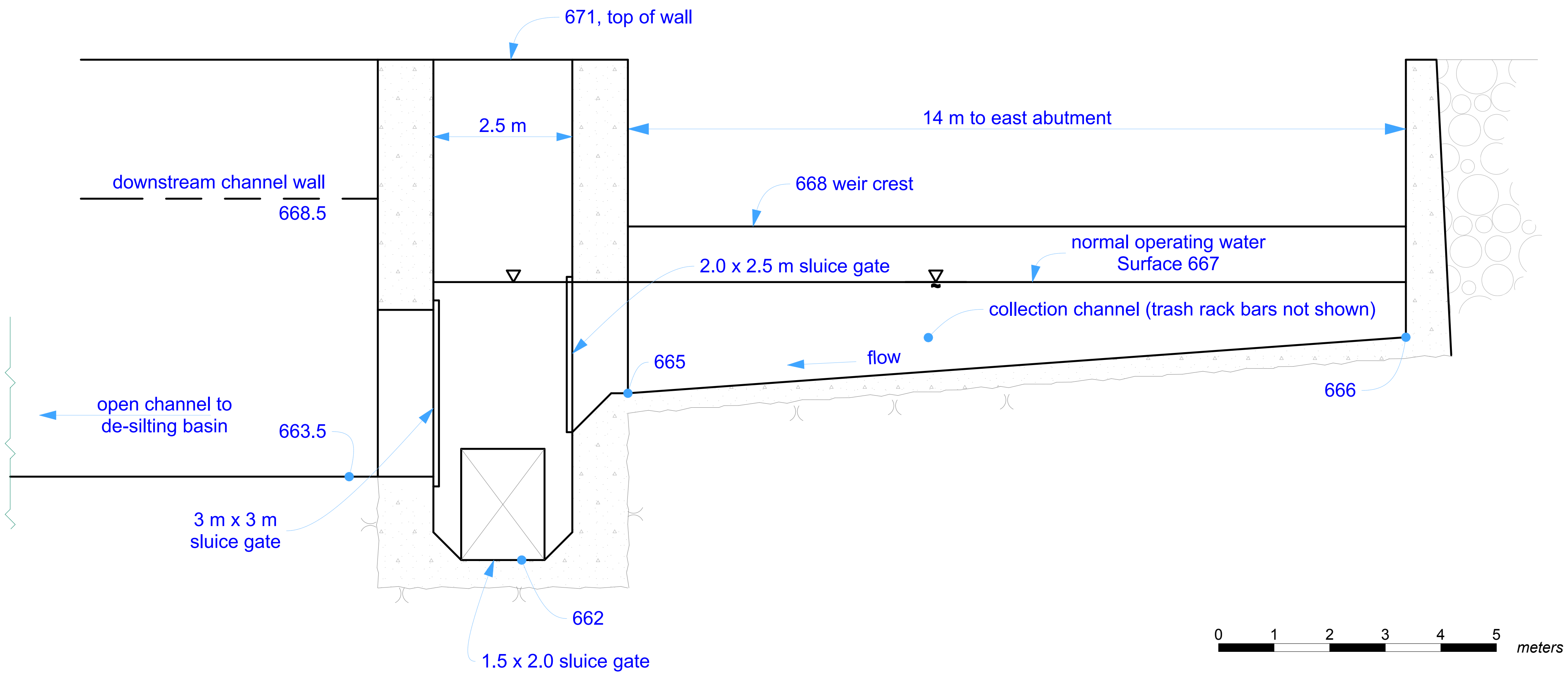
Pre-Feasibility Study
Tsablari 2

Tsablari Diversion Weir and Intake Sections

Drawing Scale	
1:100	August 2011



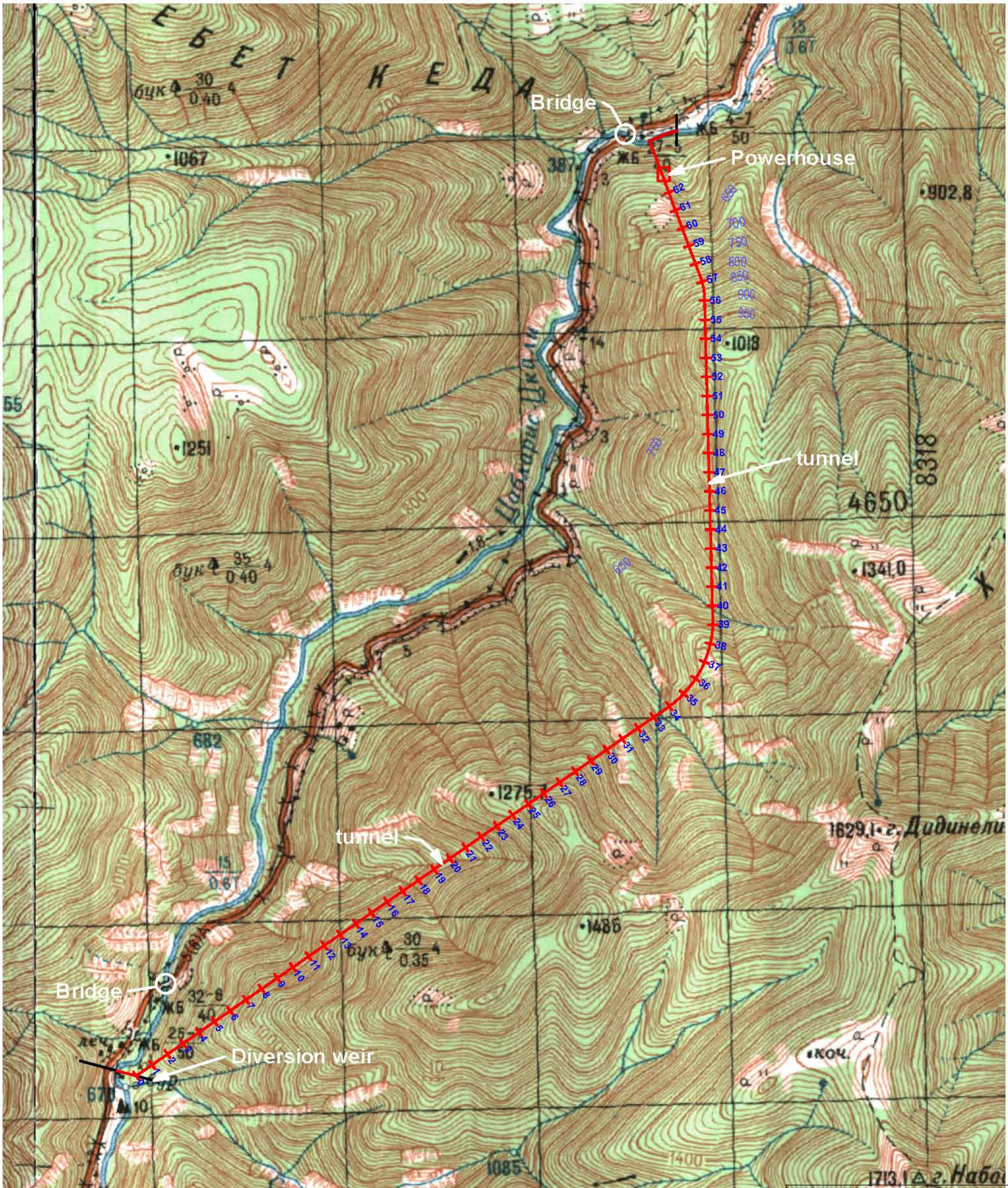
Section 3-3

BLACK & VEATCH
Building a world of difference.

Pre-Feasibility Study
Tsablari 2

Tsablari Diversion Weir and Intake Sections

Drawing Scale	1:100	August 2011



BLACK & VEATCH
Building a world of difference

Pre-Feasibility Study

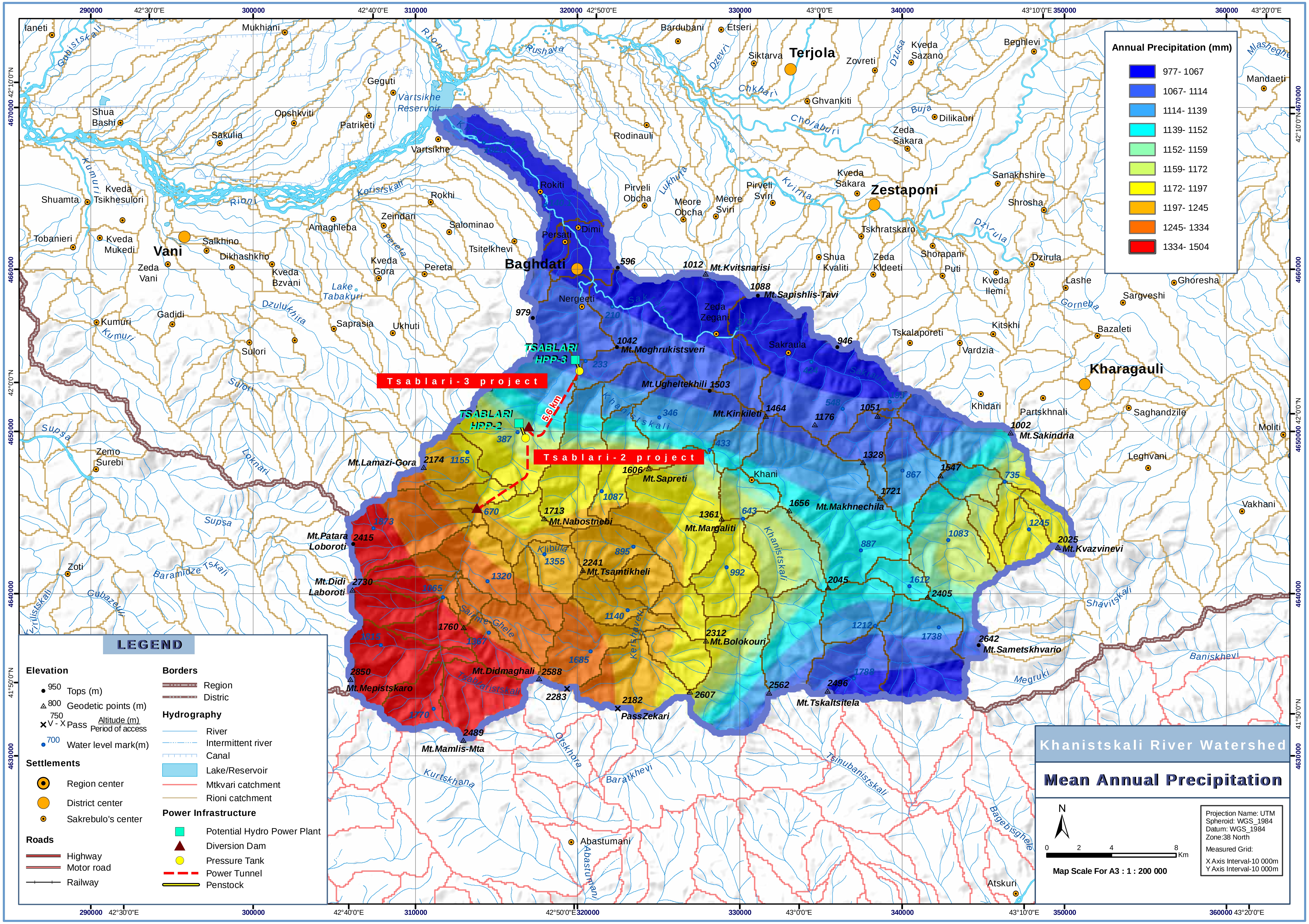
Tsablari 2

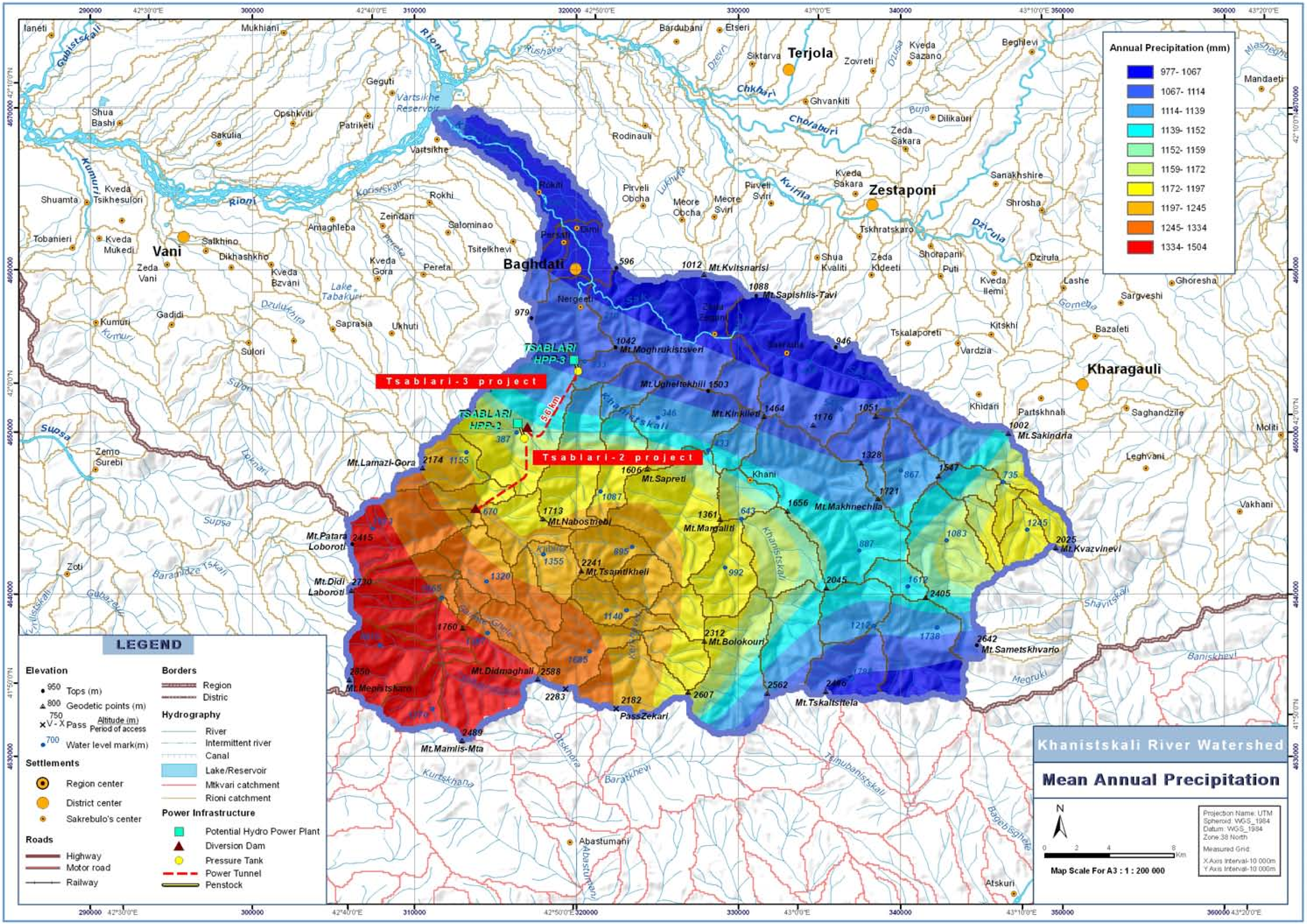
Project Arrangement

Drawing Scale 1:20,000	July 2011

Appendix 6

Annual Precipitation Map


Khanistskali River Watershed
Mean Annual Precipitation
Annual Precipitation (mm)
977- 1067
1067- 1114
1114- 1139
1139- 1152
1152- 1159
1159- 1172
1172- 1197
1197- 1245
1245- 1334
1334- 1504
Tsablari-3 project
Tsablari-2 project
TSABLARI HPP-3
TSABLARI HPP-2
5.6 km
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Roads
Highway
Motor road
Railway
Borders
Region
Distric
Hydrography
River
Intermittent river
Canal
Lake/Reservoir
Mtkvari catchment
Rioni catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Pressure Tank
Power Tunnel
Penstock
Map Scale For A3 : 1 : 200 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m
Terjola
Zestaponi
Baghdati
Vani
Kharagauli
Mt.Kvitsnarisi
Mt.Sapishlis-Tavi
Mt.Moghrukistsveri
Mt.Ugheltekhili
Mt.Kinkileti
Mt.Sakindria
Mt.Sapreti
Mt.Makhnechila
Mt.Nabostnebi
Mt.Margaliti
Mt.Kvazvinevi
Mt.Tsamtkheli
Mt.Bolokouri
Mt.Sametskhvario
Mt.Tskaltsitela
Mt.Didmaghali
Mt.Mepistskaro
Mt.Mamlis-Mta
Mt.Lamazi-Gora
Mt.Patara Loboroti
Mt.Didi Laboroti
Pass Zekari
Abastumani


Khanistskali River Watershed
Mean Annual Precipitation
Annual Precipitation (mm)
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1067- 1114
1114- 1139
1139- 1152
1152- 1159
1159- 1172
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1197- 1245
1245- 1334
1334- 1504
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950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
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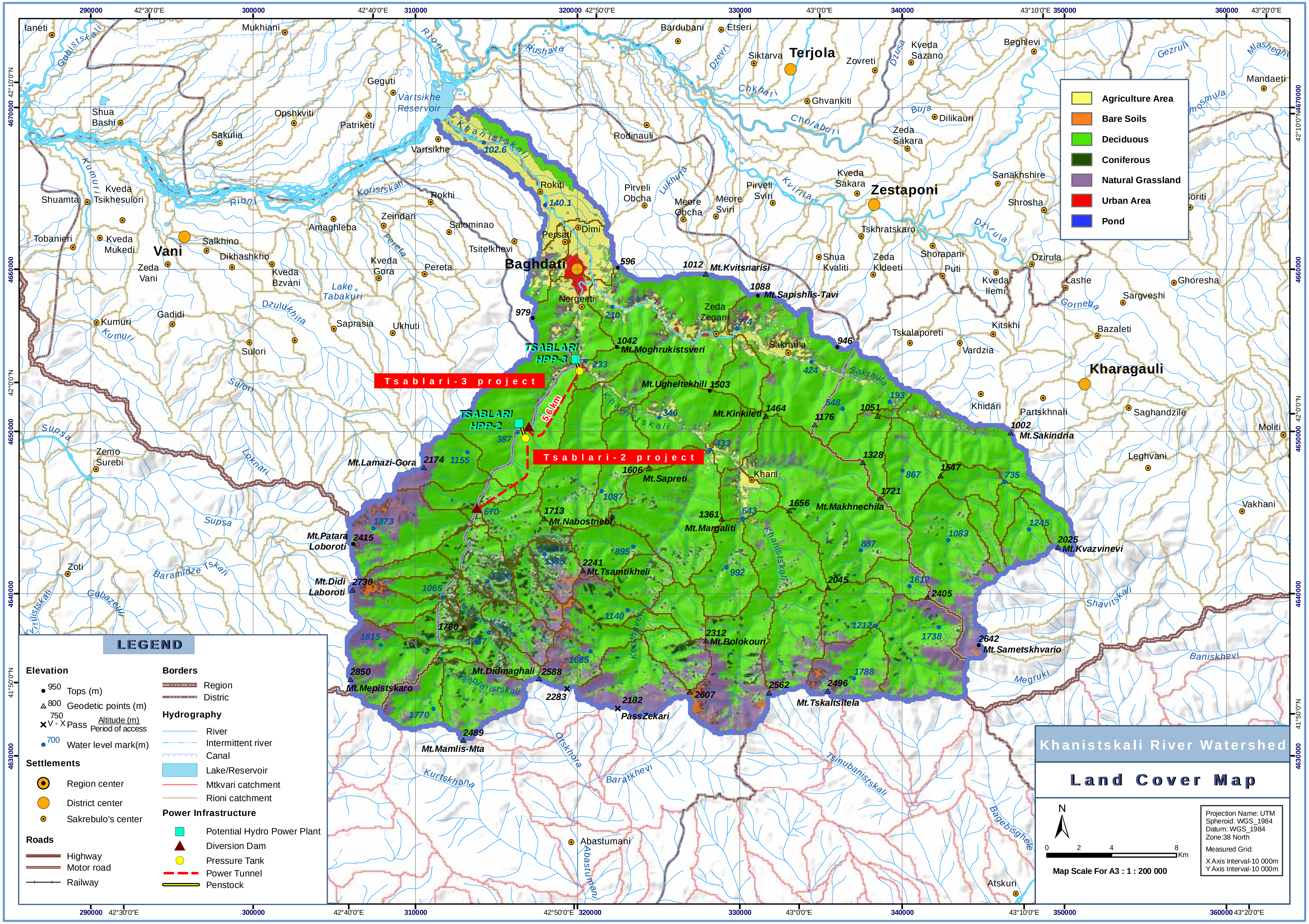
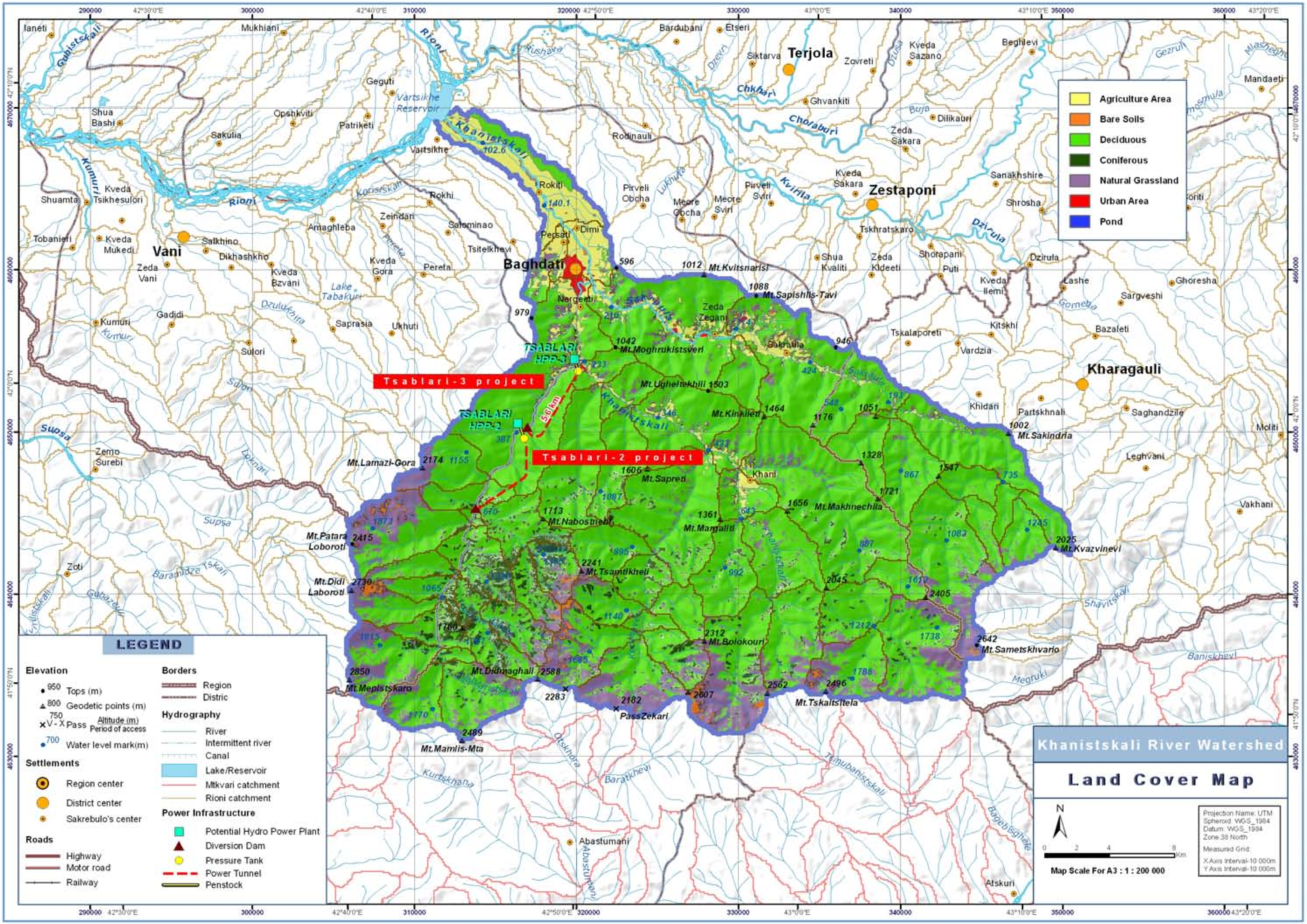
Region center
District center
Sakrebulo's center
Roads
Highway
Motor road
Railway
Borders
Region
Distric
Hydrography
River
Intermittent river
Canal
Lake/Reservoir
Mtkvari catchment
Rioni catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Pressure Tank
Power Tunnel
Penstock
Tsablari-3 project
Tsablari-2 project
TSABLARI HPP-3
TSABLARI HPP-2
5.6 km
Baghdati
Vani
Terjola
Zestaponi
Kharagauli
Vartsikhe Reservoir
Rioni
Kvirila
Khanistskali
Mt.Kvitsnarisi
Mt.Sapishlis-Tavi
Mt.Moghrukistsveri
Mt.Ugheltekhili
Mt.Kinkileti
Mt.Sakindria
Mt.Lamazi-Gora
Mt.Sapreti
Mt.Nabostrebi
Mt.Margaliti
Mt.Makhnechila
Mt.Kvazvinevi
Mt.Patara Loboroti
Mt.Didi Laboroti
Mt.Tsamtkheli
Mt.Bolokouri
Mt.Sametskhvario
Mt.Mepistskaro
Mt.Didmaghali
Mt.Mamlis-Mta
Mt.Tskaltsitela
PassZekari
Khani
Abastumani
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m
Map Scale For A3 : 1 : 200 000
N
0 2 4 8 Km

Appendix 7

Land Cover Map


Khanistskali River Watershed
Land Cover Map
Agriculture Area
Bare Soils
Deciduous
Coniferous
Natural Grassland
Urban Area
Pond
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Roads
Highway
Motor road
Railway
Borders
Region
Distric
Hydrography
River
Intermittent river
Canal
Lake/Reservoir
Mtkvari catchment
Rioni catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Pressure Tank
Power Tunnel
Penstock
TSABLARI HPP-3
TSABLARI HPP-2
Tsablari-3 project
Tsablari-2 project
5.6 km
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m
N
0 2 4 8 Km
Map Scale For A3 : 1 : 200 000
290000
300000
310000
320000
330000
340000
350000
360000
4670000
4660000
4650000
4640000
4630000
42°30'0"E
42°40'0"E
42°50'0"E
43°0'0"E
43°10'0"E
43°20'0"E
42°10'0"N
42°0'0"N
41°50'0"N
Terjola
Zestaponi
Baghdati
Vani
Kharagauli
Vartsikhe Reservoir
Khanistskali
Rioni
Kvirila
Sakraula
Rokiti
Dimi
Persati
Nergeeti
Zeda Zegani
Sakraula
Khani
Mt.Kvitsnarisi
Mt.Sapishlis-Tavi
Mt.Moghrukistsveri
Mt.Ugheltekhili
Mt.Kinkileti
Mt.Lamazi-Gora
Mt.Sapreti
Mt.Nabostnebi
Mt.Margaliti
Mt.Makhnechila
Mt.Sakindria
Mt.Kvazvinevi
Mt.Patara Loboroti
Mt.Didi Laboroti
Mt.Tsamtkheli
Mt.Bolokouri
Mt.Sametskhvario
Mt.Didmaghali
Mt.Mepistskaro
Mt.Mamlis-Mta
Mt.Tskaltsitela
PassZekari
Abastumani
Atskuri


Khanistskali River Watershed
Land Cover Map
Agriculture Area
Bare Soils
Deciduous
Coniferous
Natural Grassland
Urban Area
Pond
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Roads
Highway
Motor road
Railway
Borders
Region
Distric
Hydrography
River
Intermittent river
Canal
Lake/Reservoir
Mtkvari catchment
Rioni catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Pressure Tank
Power Tunnel
Penstock
Tsablari-3 project
Tsablari-2 project
TSABLARI HPP-3
TSABLARI HPP-2
5.6km
Baghdati
Vani
Terjola
Zestaponi
Kharagauli
Khanistskali
Rioni
Sakraula
Vartsikhe Reservoir
Mt.Kvitsnarisi
Mt.Sapishlis-Tavi
Mt.Moghrukistsveri
Mt.Ugheltekhili
Mt.Kinkileti
Mt.Sakindria
Mt.Lamazi-Gora
Mt.Sapreti
Mt.Nabostiebi
Mt.Margaliti
Mt.Makhnechila
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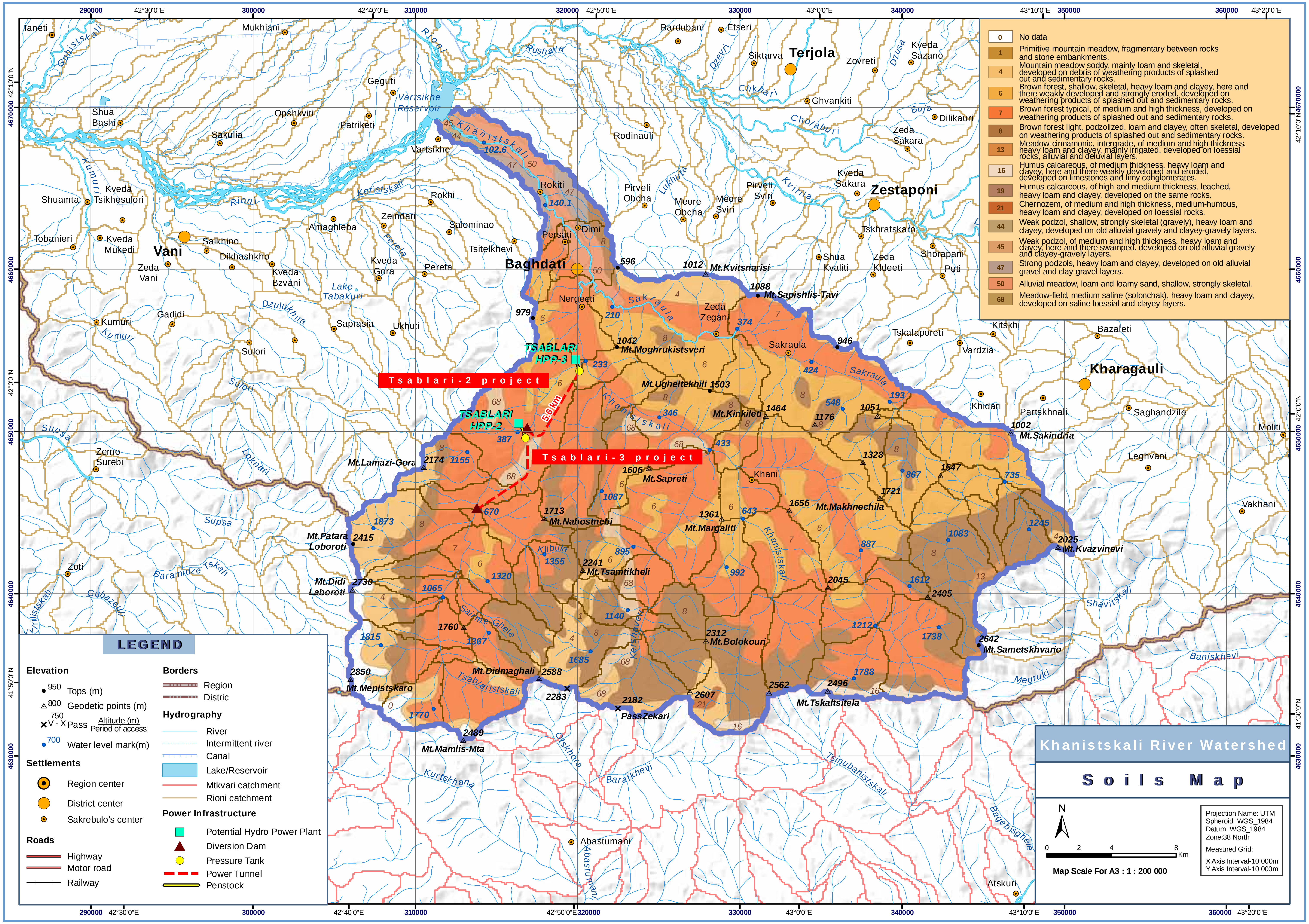
Mt.Tsamtkheli
Mt.Kvazvinevi
Mt.Didi Laboroti
Mt.Bolokouri
Mt.Sametskhvario
Mt.Didmaghali
Mt.Mepistskaro
Mt.Tskaltsitela
Mt.Mamlis-Mta
PassZekari
Abastumani
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone 38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m
Map Scale For A3 : 1 : 200 000
0 2 4 8 Km

Appendix 8

Soils Map



Khanistskali River Watershed
Soils Map
0 No data
1 Primitive mountain meadow, fragmentary between rocks and stone embankments.
4 Mountain meadow soddy, mainly loam and skeletal, developed on debris of weathering products of splashed out and sedimentary rocks.
6 Brown forest, shallow, skeletal, heavy loam and clayey, here and there weakly developed and strongly eroded, developed on weathering products of splashed out and sedimentary rocks.
7 Brown forest typical, of medium and high thickness, developed on weathering products of splashed out and sedimentary rocks.
8 Brown forest light, podzolized, loam and clayey, often skeletal, developed on weathering products of splashed out and sedimentary rocks.
13 Meadow-cinnamonic, intergrade, of medium and high thickness, heavy loam and clayey, mainly irrigated, developed on loessial rocks, alluvial and deluvial layers.
16 Humus calcareous, of medium thickness, heavy loam and clayey, here and there weakly developed and eroded, developed on limestones and limy conglomerates.
19 Humus calcareous, of high and medium thickness, leached, heavy loam and clayey, developed on the same rocks.
21 Chernozem, of medium and high thickness, medium-humous, heavy loam and clayey, developed on loessial rocks.
44 Weak podzol, shallow, strongly skeletal (gravelly), heavy loam and clayey, developed on old alluvial gravely and clayey-gravely layers.
45 Weak podzol, of medium and high thickness, heavy loam and clayey, here and there swamped, developed on old alluvial gravely and clayey-gravely layers.
47 Strong podzols, heavy loam and clayey, developed on old alluvial gravel and clay-gravel layers.
50 Alluvial meadow, loam and loamy sand, shallow, strongly skeletal.
68 Meadow-field, medium saline (solonchak), heavy loam and clayey, developed on saline loessial and clayey layers.
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Roads
Highway
Motor road
Railway
Borders
Region
Distric
Hydrography
River
Intermittent river
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Rioni catchment
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Penstock
Tsablari-2 project
Tsablari-3 project
TSABLARI HPP-2
TSABLARI HPP-3
5.6km
Baghdati
Vani
Terjola
Zestaponi
Kharagauli
Vartsikhe Reservoir
Khanistskali
Sakraula
Rioni
Kvirila
Mt.Sapishlis-Tavi
Mt.Moghrukitsveri
Mt.Ugheltekhili
Mt.Kinkileti
Mt.Sakindria
Mt.Sapreti
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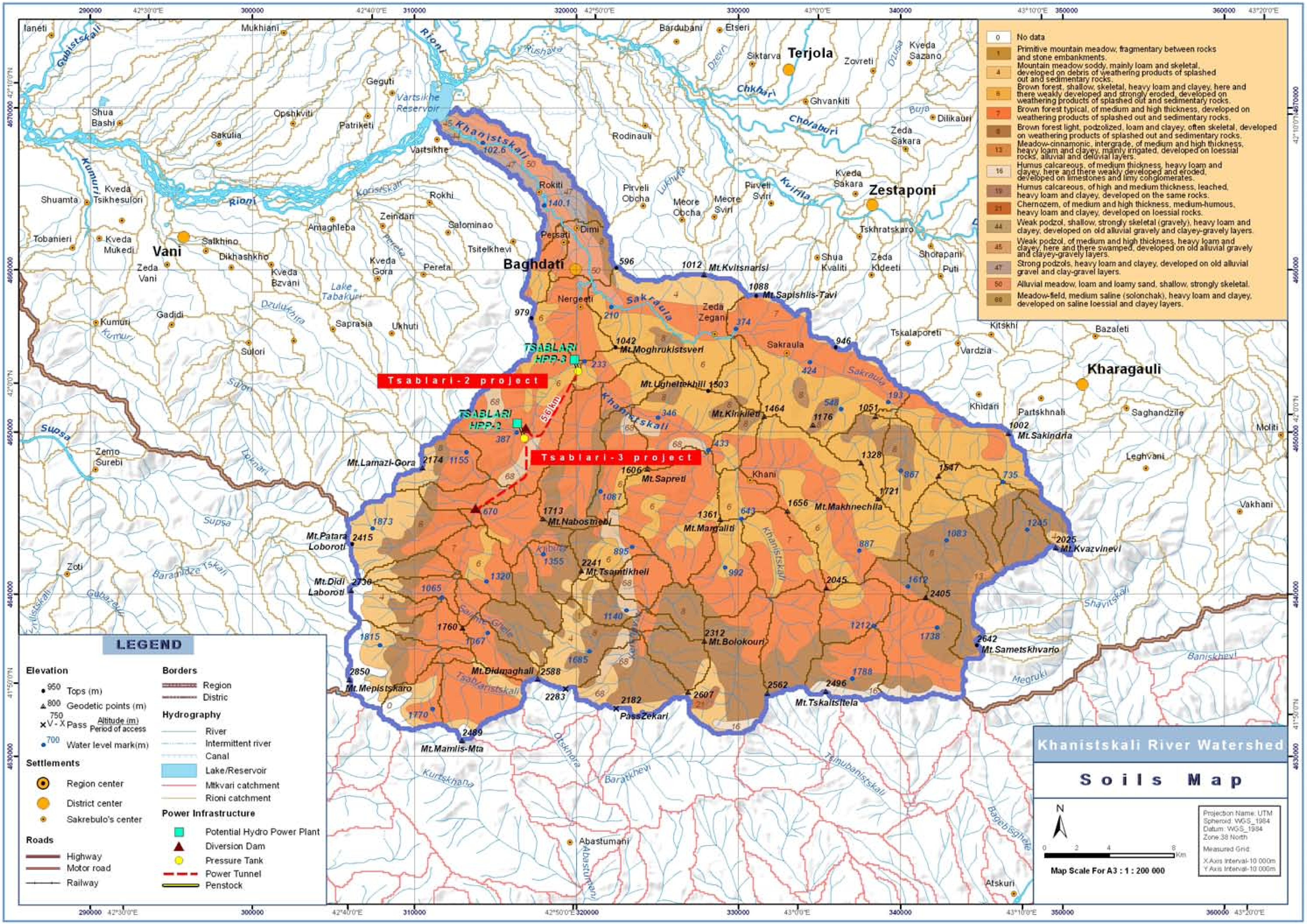
Mt.Sametskhvario
Mt.Didmaghali
Mt.Mepistskaro
Mt.Tskaltsitela
Mt.Mamlis-Mta
PassZekari
Abastumani
N
0 2 4 8 Km
Map Scale For A3 : 1 : 200 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m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Soils Map
0 No data
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8 Brown forest light, podzolized, loam and clayey, often skeletal, developed on weathering products of splashed out and sedimentary rocks.
13 Meadow-cinnamonic, intergrade, of medium and high thickness, heavy loam and clayey, mainly irrigated, developed on loessial rocks, alluvial and deluvial layers.
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District center
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Tsablari-3 project
TSABLARI HPP-3
TSABLARI HPP-2
5.6km
Baghdati
Vani
Terjola
Zestaponi
Kharagauli
Vartsikhe Reservoir
Rioni
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Mt.Lamazi-Gora
Mt.Bolokouri
Mt.Didmaghali
Mt.Tsamtikheli
Mt.Nabostmebi
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Mt.Margaliti
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Mt.Kinkileti
Mt.Ugheltekhili
Mt.Moghrukistsveri
Mt.Kvitsnarisi
Mt.Sapishlis-Tavi
Pass Zekari
Abastumani
N
Map Scale For A3 : 1 : 200 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone 38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m

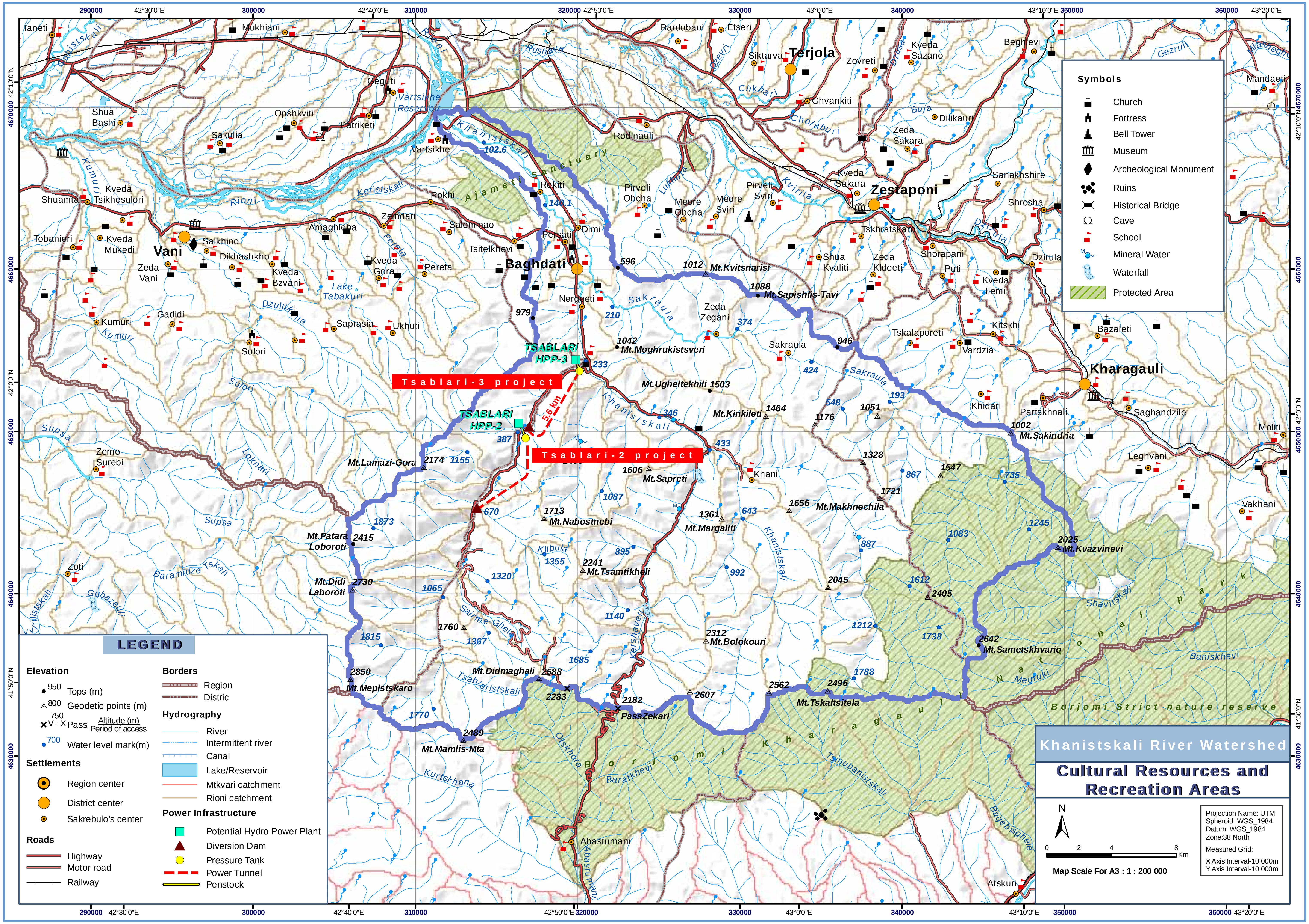
Appendix 9

Cultural Resources & Recreation Areas

Historical, Cultural and Archeological Resources in the Baghdati District

#	Name	Location	Dated
1	Rodopolicy (Remnants of the historical city)	Vartsikhe village	VI century A.D.
2	Bagdati Castle	Bagdati	1703
3	Tower building " Dimni"	Dimi Village	III century B.C.
4	Church of 12 Apostles	Khani Village	II century A.D.
5	Church of "Peristsvaleba"	Rokity Village	Medieval
6	Church	Tsitelikhevi Village	Medieval

Source: Ministry of Culture of Georgia


Khanistskali River Watershed
Cultural Resources and Recreation Areas
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
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Sakrebulo's center
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Hydrography
River
Intermittent river
Canal
Lake/Reservoir
Mtkvari catchment
Rioni catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Pressure Tank
Power Tunnel
Penstock
Symbols
Church
Fortress
Bell Tower
Museum
Archeological Monument
Ruins
Historical Bridge
Cave
School
Mineral Water
Waterfall
Protected Area
Tsablari-3 project
Tsablari-2 project
TSABLARI HPP-3
TSABLARI HPP-2
5.6 km
Ajameti Sanctuary
Borjomi Kharagauli National park
Borjomi Strict nature reserve
Terjola
Zestaponi
Vani
Baghdati
Kharagauli
Abastumani
Vartsikhe Reservoir
Khanistskali
Rioni
Sakraula
Mt.Kvitsnarisi
Mt.Sapishlis-Tavi
Mt.Moghrukistsveri
Mt.Ugheltekhili
Mt.Kinkileti
Mt.Sakindria
Mt.Lamazi-Gora
Mt.Sapreti
Mt.Nabostnebi
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Mt.Kvazvinevi
Mt.Patara Loboroti
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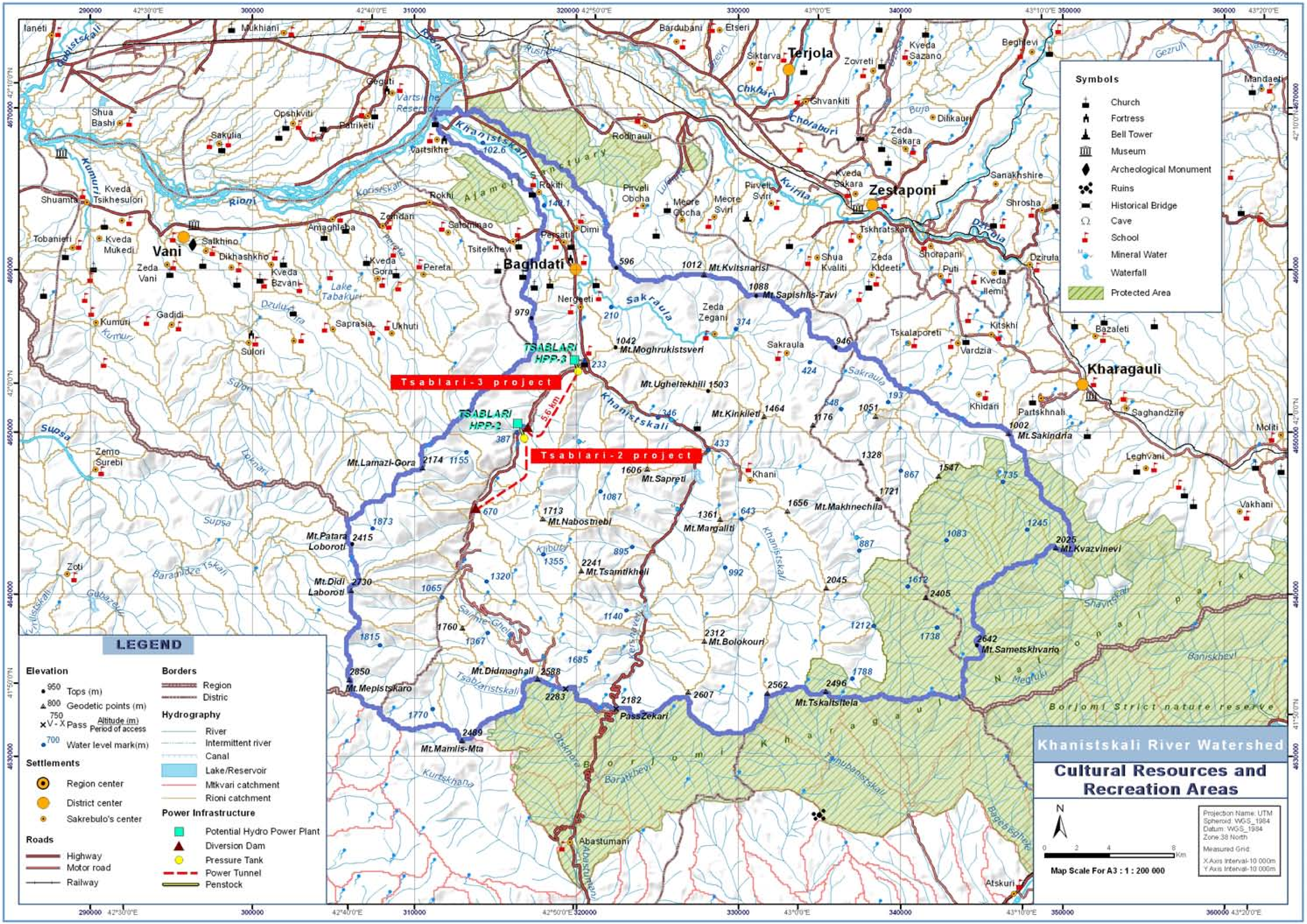
Mt.Tsamtikheli
Mt.Bolokouri
Mt.Sametskhvariq
Mt.Mepistskaro
Mt.Didmaghali
Mt.Tskaltsitela
Mt.Mamlis-Mta
Pass Zekari
N
0 2 4 8 Km
Map Scale For A3 : 1 : 200 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m


Khanistskali River Watershed
Cultural Resources and Recreation Areas
Symbols
Church
Fortress
Bell Tower
Museum
Archeological Monument
Ruins
Historical Bridge
Cave
School
Mineral Water
Waterfall
Protected Area
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Roads
Highway
Motor road
Railway
Borders
Region
Distric
Hydrography
River
Intermittent river
Canal
Lake/Reservoir
Mtkvari catchment
Rioni catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Pressure Tank
Power Tunnel
Penstock
Tsablari-3 project
Tsablari-2 project
TSABLARI HPP-3
TSABLARI HPP-2
5.6 km
Baghdati
Vani
Zestaponi
Terjola
Kharagauli
Abastumani
Vartsikhe Reservoir
Khanistskali
Rioni
Kvirila
Sakraula
Supsa
Ajameti Sanctuary
Borjomi Strict nature reserve
Borjomi Kharagauli National park
Mt.Kvitsnarisi
Mt.Sapishlis-Tavi
Mt.Moghrukistsveri
Mt.Ugheltekhili 1503
Mt.Kinkileti
Mt.Sakindria
Mt.Lamazi-Gora
Mt.Sapreti
Mt.Makhnechila
Mt.Nabostnebi
Mt.Margaliti
Mt.Kvazvinevi
Mt.Patara Loboroti
Mt.Tsamtkheli
Mt.Didi Laboroti
Mt.Bolokouri
Mt.Sametskhvario
Mt.Didmaghali
Mt.Mepistskaro
Mt.Tskaltsitela
Pass Zekari
Mt.Mamlis-Mta
N
Map Scale For A3 : 1 : 200 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone 38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m

Appendix 10

Environmental and social impacts Significant Data

Appendix 10: Description of Tables

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

The table column headers are described as follows:

Column 1: Receptors

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

- Water Resources
  - Surface Water Resources
  - Surface Water Quality
  - Flood Risk
- Soils, Geology, and Landscape
- Air Quality
- Biodiversity
  - Terrestial Flora
  - Terrestial 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 ---------------------- 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. -------------------------- **Operation Phase:** effects on surface water resources during facility operations	SH SH SH LG ---------------------------- LG	VL/R/T VL/R/T VL/R/T L/IR/P ------------------------------------ L/R/T	Very high sediment and bed load transport by upper Tsablari 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. ---------- 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	SH SH	VL/R/T VL/R/T	Very high sediment and bed load transport by upper Tsablari 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

 ------------------------- M/L	disturbance • Temporary Diversion of River away from Dam and intake structure --------------------------- **Operation Phase:** effects on surface water resources during facility operations	 ---------------------------- LG	 ------------------------------------ L/R/T	process. Few if any uncertainties, assume runoff controls and spill prevention plans and monitoring are included 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	L/R/T ------------------------------------- M/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)** H/L ---------------------- H/L	**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	H/R and IR/T and P depending on seismic characteristics ------------------ H/R and IR/T and P depending on seismic characteristics	Well understood process. The project structures to be built in the area have to have appropriate design specifications which are in line with the national and international standards. Severe activity can lead to failure, flooding, property damage and loss of human life. Emergency site shut down and Evacuation plans should be included in construction management planning. ------------------ 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)** H/L	**Landslides and Mudslides** **Construction Phase (HPP and Transmission Facility)**: improper stockpiling of materials, poor siting, 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 siting 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

--------------------- H/L	--------------------------- **Operation Phase:** Minimize increasing the impacts from this natural occurrence from HPP operations	------------------------------- SH	---------------------------------- L/R/T	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) ------------------------ 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 --------------------------- **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 ------------------- SH	VL/R/T ---------------------- VL/R/P	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 ----------------------- 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/L**	--------------------------- **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/L** **--------------------** **L/L**	**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; --------------------------- **Operation Phase:** there would be minor or no impact on flora during the operation phase	MD ------------ VSH	M/R/T ----------------- VL/R/P	Well understood process. Restoration and reinstatement of soil cover; re-vegetation and/or reforestation activities. -------------------------- Monitoring restoration activities.
Terrestrial fauna **(Vulnerability (H, M, L, None) and Value (H, L)** **L/L**	**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	MD	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/L**	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	------------ VSH	------------------ VL/R/P	--------------------------- Implementing and monitoring the wildlife management plan.
Fishery **(Vulnerability (H, M, L, None) and Value (H, L)** **L/L** **------------------------** **L/L**	**Construction Phase HPP**: Impact on fish species due to construction in the riverbed and altering the river flow through temporary diversion channel, and blasting activities. -------------------------- **Operation Phase:** impacts on fish species due to diverting river flow to the powerhouse (mortality fish species in the turbines/generators). Exposure of bypass section of river to very low to no flow.	MD --------------- MD	M/R/T -------------------------- M/R/T	Installing fish protecting/screening facilities at the entrance of the HPP feeding tunnels/channels. Scheduling of construction activities. Avoiding the stock piling in the riverbed. Proper scheduling of construction activities; Monitoring of vibration and blasting activities from construction equipment ---------------- Well understood process. Permanent monitoring of sanitary water flow;, compliance with environmental and in-stream flow requirements with monitoring.

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

Cultural Resources and Recreation				
Receptor s	**IMPACT (Description of effect)**	**Duration LG/MD/SH/VSH term)**	**Risk Level (VL, L, M, H, and Irreversible/ reversible; temporary/ permanent**	**Mitigation Practices**
Cultural and historic assets **(Vulnerability (H, M, L, None) and Value (H, L)** L/H	**Construction Phase HPP and Transmission Facility)**: There are no archaeological and/or cultural heritage sites in the vicinity of the projects. However, during construction works they might occur. Archaeological objects should be protected from damage.	VSH	H/IR/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)** M/H ------------------------ M/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 -------------------------- **Operation Phase:** new infrastructure (e.g. access roads) may positively impact on local population, provide better access to markets for agricultural products	MD ------------------------ LG	M/R/P ------------------ M/R/P	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 ---------------------------- N/A
Population **(Vulnerability (H, M, L, None) and Value (H, L)** L/H ----------------------- L/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 -- **Operation Phase**: The noise/vibration source during the operation will be generators and turbines located in the powerhouse. Since they are located in	SH -------------------- N/A	M/R/T -------------------- N/A	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/A

	the close building, it will have not any considerable nuisance.			
Recreation (Vulnerability (H, M, L, None) and Value (H, L) **M/H** **--------------------** **M/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	MD ---------------- LG	M/R/T ----------------- VL/R/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:**	MD -------------- 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. ------------------------ Ensure compliance with local and regional laws that effect the community
Public Health **(Vulnerability (H, M, L, None) and Value**	**Construction Phase (HPP and Transmission Facility)**: construction activities might cause health impact to	MD	M/R/P	Health and safety plan should be in line with national and international standards. Occupational health and safety measures should be identified and

(H, L) **M/H** **-------------------------** **L/H**	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.	----------------------- MD	--------------- M/R/P	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 11

Turbine Information

TURBNPRO Version 3 - FRANCIS TURBINE SOLUTION SUMMARY

Solution File Name: **Tsablari 2 Unit #1**

TURBINE SIZING CRITERIA

Rated Discharge:	166.0 cfs	/	4.7	m3/s
Net Head at Rated Discharge:	937.3 feet	/	285.7	meters
Gross Head:	967.8 feet	/	295.0	meters
Site Elevation:	1220 feet	/	372	meters
Water Temperature:	68 Degrees F	/	20	Degrees C
Setting to Tailwater:	-6.6 feet	/	-2.0	meters
Efficiency Priority:		5		
System Frequency:		50 Hz		
Minimum Net Head:	937.3 feet	/	285.7	meters
Maximum Net Head:	964.6 feet	/	294.0	meters

FRANCIS TURBINE SOLUTION DATA

Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT
Intake Type: SPIRAL CASE
Draft Tube Type: ELBOW
Runner Diameter: 29.2 inches / 742 mm
Unit Speed: 1000.0 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

Specific Speed at Rated Net Head -	(US Cust.)	(SI Units)
At 100% Turbine Output:	24.5	93.4
At Peak Efficiency Condition:	23.4	89.3

SOLUTION PERFORMANCE DATA

At Rated Net Head of: 937.3 feet / 285.7 meters

% of Rated Discharge	Output (KW)	Efficiency (%)	cfs	m3/s
** 101.2	12152	91.2	167.9	4.8
100	12030	91.3	166.0	4.7
* 90.9	10991	91.8	150.9	4.3
75	8972	90.8	124.5	3.5
50	5540	84.1	83.0	2.4
25	2144	65.1	41.5	1.2
+ 47.2	5144	82.7	78.4	2.2

** - Overcapacity
* - Peak Efficiency Condition
\+ - Peak Draft Tube Surging Condition

At Maximum Net Head of: 964.6 feet / 294.0 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.040	12574	91.2	168.7	4.8

At Minimum Net Head of: 937.3 feet / 285.7 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.041	12154	91.2	167.9	4.8

TURBNPRO Version 3 - FRANCIS TURBINE SOLUTION SUMMARY

Solution File Name: No File Name

MISCELLANEOUS DATA

Maximum Runaway Speed (at Max. Net Head):	1638 rpm	
Turbine Discharge at:		
Runaway Speed (at Rated Net Head & 100% gate):	74 cfs /	2.1 m3/s
Synchronous Speed-No-Load (at Rated Net Head):	13 cfs /	0.4 m3/s
Site's Atmospheric Pressure minus Vapor Pressure:	31.7 feet /	9.7 meters
Sigma Allowable (at 100% Output & Rated Net Head):	0.039	
Sigma Plant (at 100% Output & Rated Net Head):	0.041	
Maximum Hydraulic Thrust (at Max. Net Head):	41465 lbs /	18848 kg
Approximate Runner and Shaft Weight:	4220 lbs /	1918 kg
Vel. at Draft Tube Exit (at Rated Head & Discharge):	5.2 fps /	1.6 m/s

DIMENSIONAL DATA

Intake Type: SPIRAL CASE

	inches /	mm
Inlet Diameter:	30.0	762
Inlet Offset:	49.2	1250
Centerline to Inlet:	56.0	1422
Outside Radius A:	64.2	1631
Outside Radius B:	61.4	1559
Outside Radius C:	57.3	1454
Outside Radius D:	52.3	1327

Draft Tube Type: ELBOW

	inches /	mm
Centerline to Invert:	94.2	2393
Shaft Axis to Exit Length:	140.2	3562
Exit Width:	87.6	2226
Exit Height:	52.6	1336

Shafting Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT

	inches /	mm
Centerline to Shaft Coupling:	96.0	2438
Turbine Shaft Diameter:	11.0	280

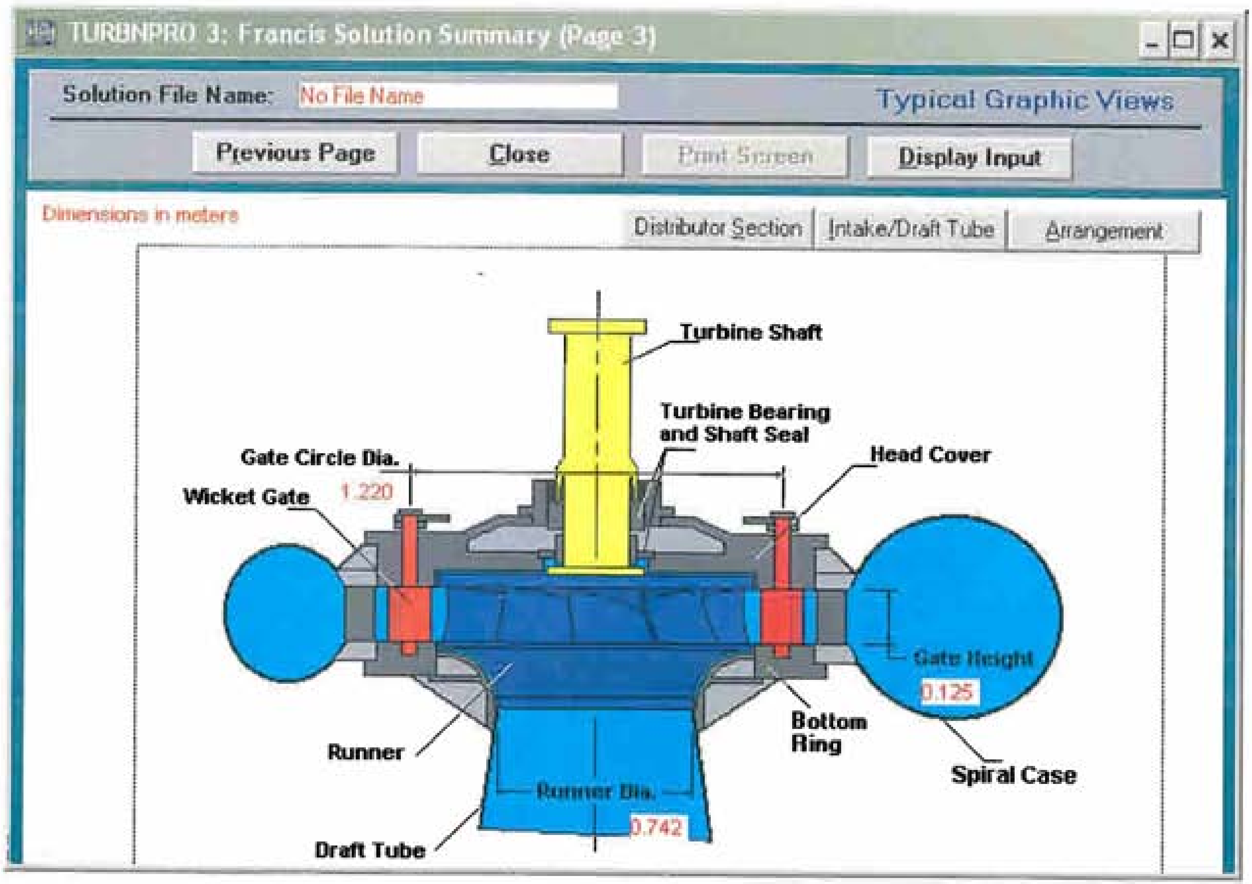
Miscellaneous:

	inches /	mm
Wicket Gate Height:	4.9	125
Wicket Gate Circle Diameter:	48.0	1220

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

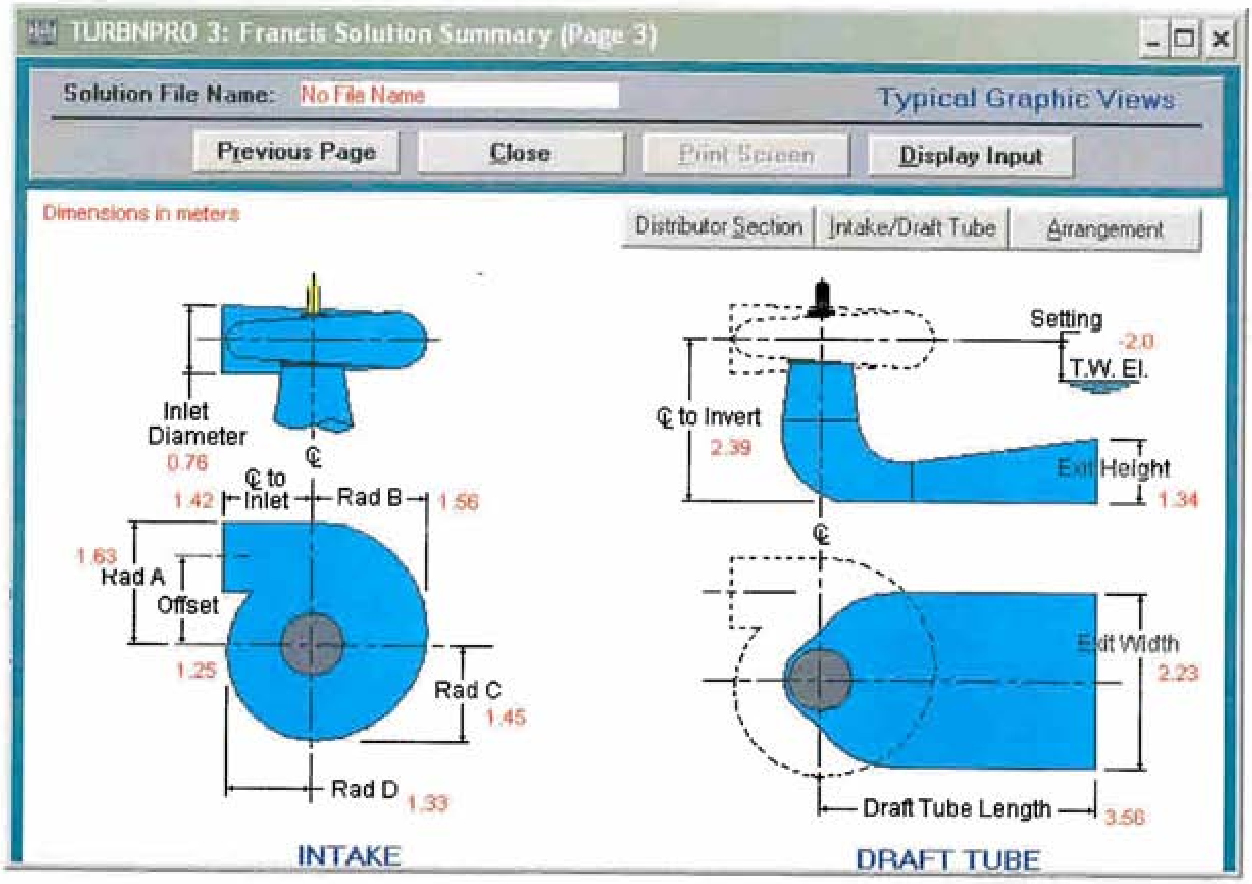
TURBNPRO Version 3.0 - FRANCIS TURBINE SOLUTION GRAPHICS

```
Solution File Name: No File Name
Runner Diameter:                742  mm
Net Head at Rated Discharge:   285.70  meters
Unit Speed:                   1000.0  rpm
```



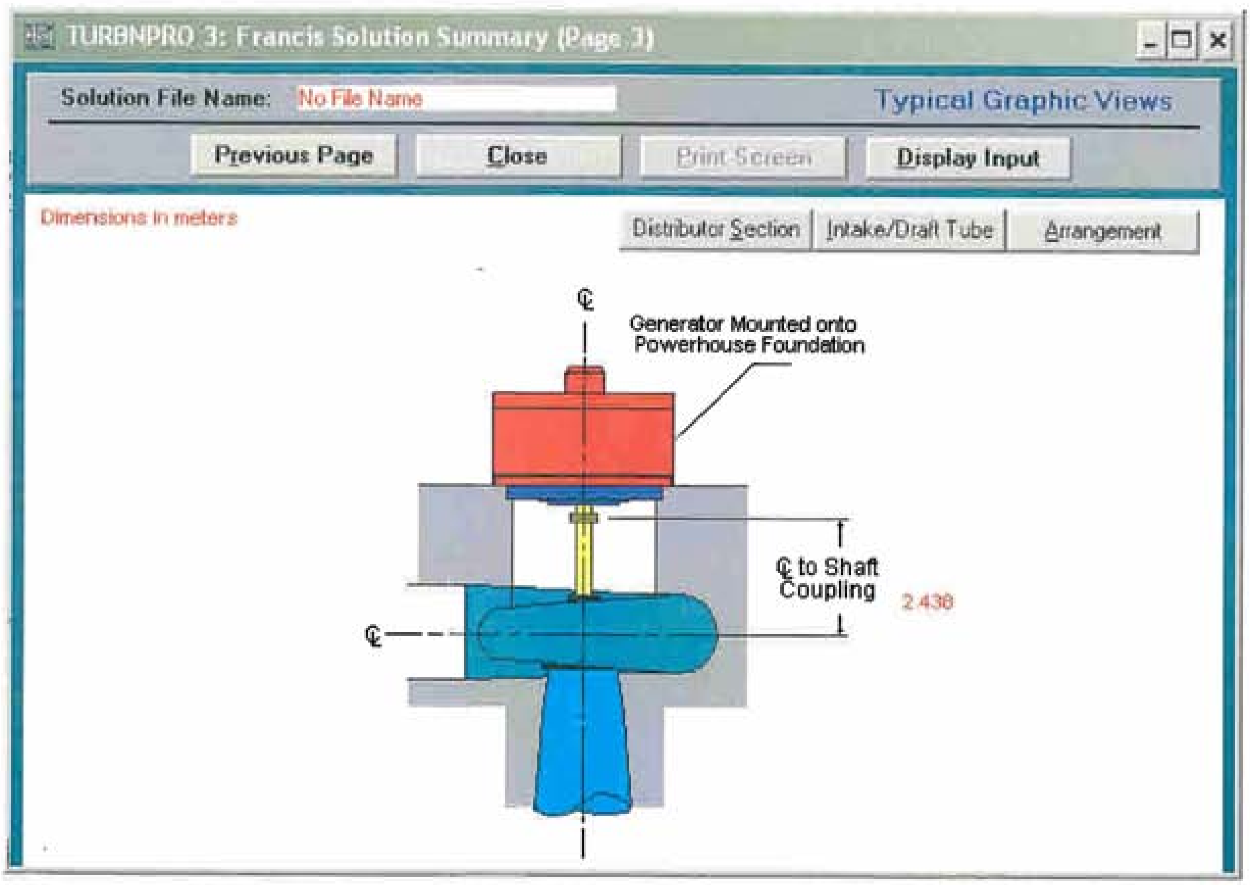
TURBNPRO Version 3.0 - FRANCIS TURBINE SOLUTION GRAPHICS

Solution File Name: No File Name
Runner Diameter: 742 mm
Net Head at Rated Discharge: 285.70 meters
Unit Speed: 1000.0 rpm



TURBNPRO Version 3.0 - FRANCIS TURBINE SOLUTION GRAPHICS

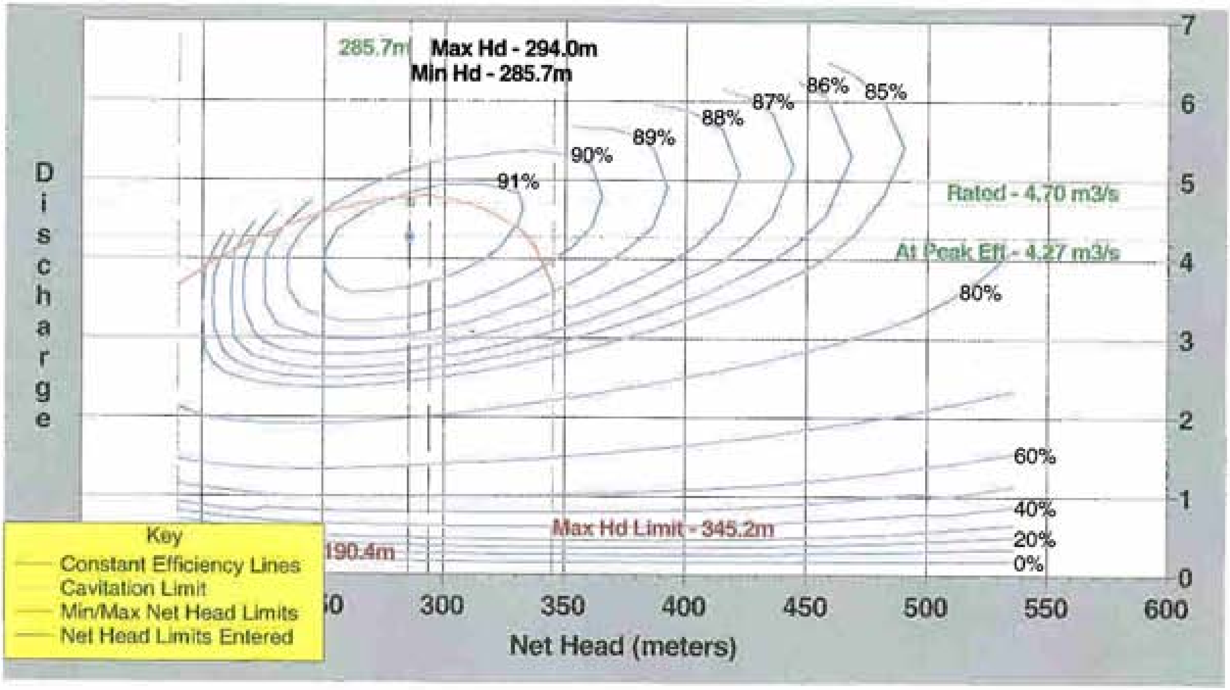
```
Solution File Name: No File Name
Runner Diameter:                742  mm
Net Head at Rated Discharge:  285.70  meters
Unit Speed:                  1000.0  rpm
```



TURBNPRO Version 3 - FRANCIS TURBINE HILL CURVE

Solution File Name: No File Name

Runner Diameter:	742 mm
Net Head at Rated Discharge:	285.70 meters
Unit Speed:	1000.0 rpm
Peak Efficiency:	91.8 %
Multiplier Efficiency Modifier:	1.000
Flow Squared Efficiency Modifier:	0.0000

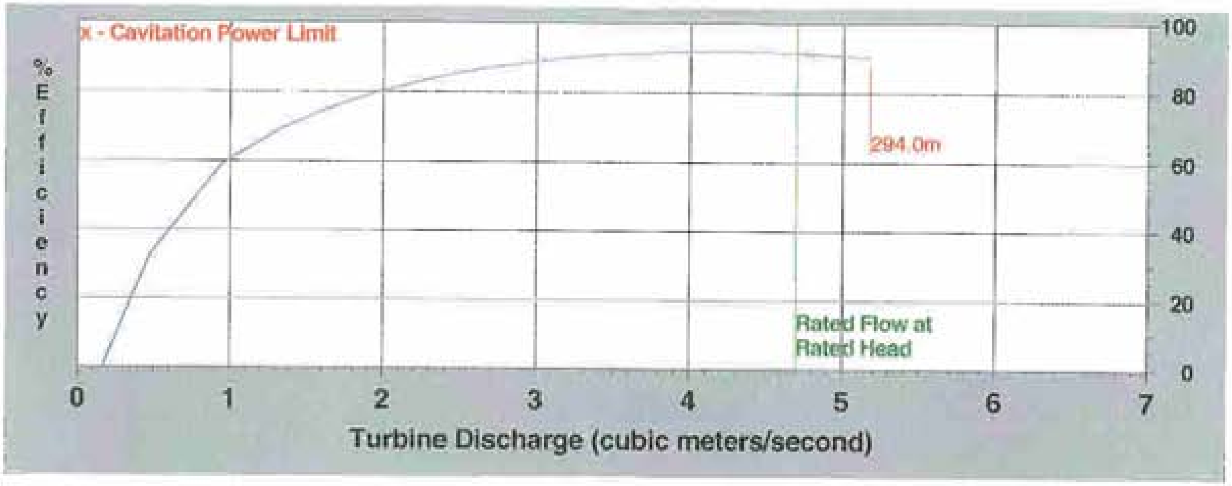


NOTE: Discharge is in cubic meters per second

TURBNPRO Version 3 - FRANCIS TURBINE CROSS PLOT

```
Solution File Name: No File Name
Runner Diameter:                   742  mm
Net Head at Rated Discharge:     285.70  meters
Unit Speed:                     1000.0  rpm
Multiplier Efficiency Modifier:    1.000
Flow Squared Efficiency Modifier:  0.0000
```

Performance Data Shown is for a Net Head of: 294



TURBNPRO Version 3 - FRANCIS TURBINE SOLUTION SUMMARY

Solution File Name: **Tsablari 2 Unit # 2**

TURBINE SIZING CRITERIA

Rated Discharge:	83.0	cfs	/	2.4	m3/s
Net Head at Rated Discharge:	937.3	feet	/	285.7	meters
Gross Head:	967.8	feet	/	295.0	meters
Site Elevation:	1220	feet	/	372	meters
Water Temperature:	68	Degrees F	/	20	Degrees C
Setting to Tailwater:	-6.6	feet	/	-2.0	meters
Efficiency Priority:			5		
System Frequency:			50 Hz		
Minimum Net Head:	937.3	feet	/	285.7	meters
Maximum Net Head:	964.6	feet	/	294.0	meters

FRANCIS TURBINE SOLUTION DATA

Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT
Intake Type: SPIRAL CASE
Draft Tube Type: ELBOW
Runner Diameter: 22.9 inches / 582 mm
Unit Speed: 1000.0 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

Specific Speed at Rated Net Head -	(US Cust.)	(SI Units)
At 100% Turbine Output:	17.2	65.5
At Peak Efficiency Condition:	16.4	62.6

SOLUTION PERFORMANCE DATA

At Rated Net Head of: 937.3 feet / 285.7 meters

% of Rated Discharge	Output (KW)	Efficiency (%)	cfs	m3/s
** 109.1	6365	88.6	90.6	2.6
100	5922	89.9	83.0	2.4
* 90.9	5410	90.4	75.4	2.1
75	4421	89.5	62.2	1.8
50	2762	83.9	41.5	1.2
25	1106	67.2	20.7	0.6
+ 44.2	2369	81.4	36.7	1.0

** - Overcapacity
* - Peak Efficiency Condition
+ - Peak Draft Tube Surging Condition

At Maximum Net Head of: 964.6 feet / 294.0 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.039	6616	88.6	91.5	2.6

At Minimum Net Head of: 937.3 feet / 285.7 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.039	6365	88.6	90.6	2.6

TURBNPRO Version 3 - FRANCIS TURBINE SOLUTION SUMMARY

Solution File Name: No File Name

MISCELLANEOUS DATA

Maximum Runaway Speed (at Max. Net Head):	1594 rpm	
Turbine Discharge at:		
Runaway Speed (at Rated Net Head & 100% gate):	33 cfs /	0.9 m3/s
Synchronous Speed-No-Load (at Rated Net Head):	6 cfs /	0.2 m3/s
Site's Atmospheric Pressure minus Vapor Pressure:	31.7 feet /	9.7 meters
Sigma Allowable (at 100% Output & Rated Net Head):	0.029	
Sigma Plant (at 100% Output & Rated Net Head):	0.041	
Maximum Hydraulic Thrust (at Max. Net Head):	23031 lbs /	10469 kg
Approximate Runner and Shaft Weight:	2668 lbs /	1213 kg
Vel. at Draft Tube Exit (at Rated Head & Discharge):	4.2 fps /	1.3 m/s

DIMENSIONAL DATA

Intake Type: SPIRAL CASE

	inches /	mm
Inlet Diameter:	24.0	610
Inlet Offset:	46.1	1170
Centerline to Inlet:	57.2	1453
Outside Radius A:	58.1	1475
Outside Radius B:	55.6	1411
Outside Radius C:	52.7	1340
Outside Radius D:	48.9	1243

Draft Tube Type: ELBOW

	inches /	mm
Centerline to Invert:	75.0	1906
Shaft Axis to Exit Length:	110.0	2794
Exit Width:	68.7	1746
Exit Height:	41.2	1048

Shafting Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT

	inches /	mm
Centerline to Shaft Coupling:	96.0	2438
Turbine Shaft Diameter:	8.7	221

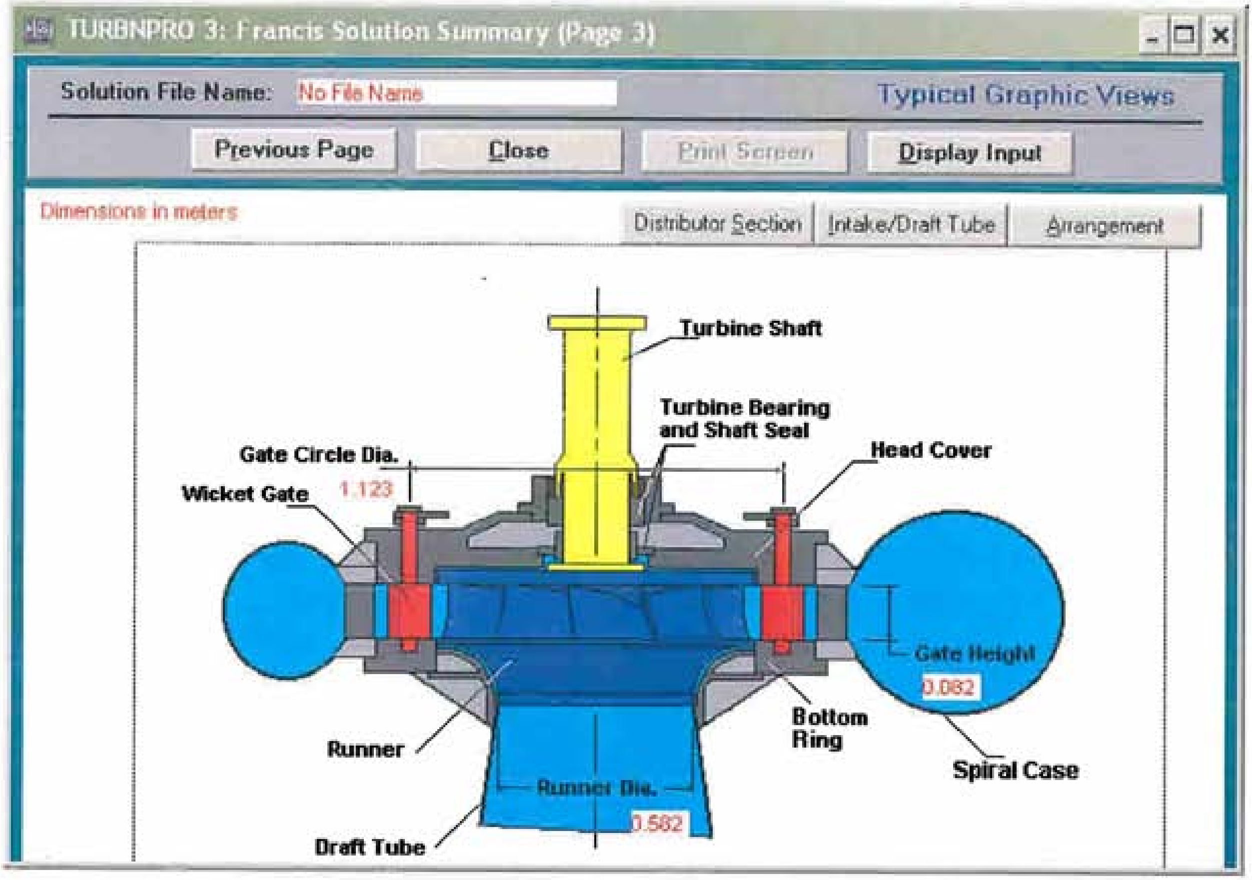
Miscellaneous:

	inches /	mm
Wicket Gate Height:	3.2	82
Wicket Gate Circle Diameter:	44.2	1123

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

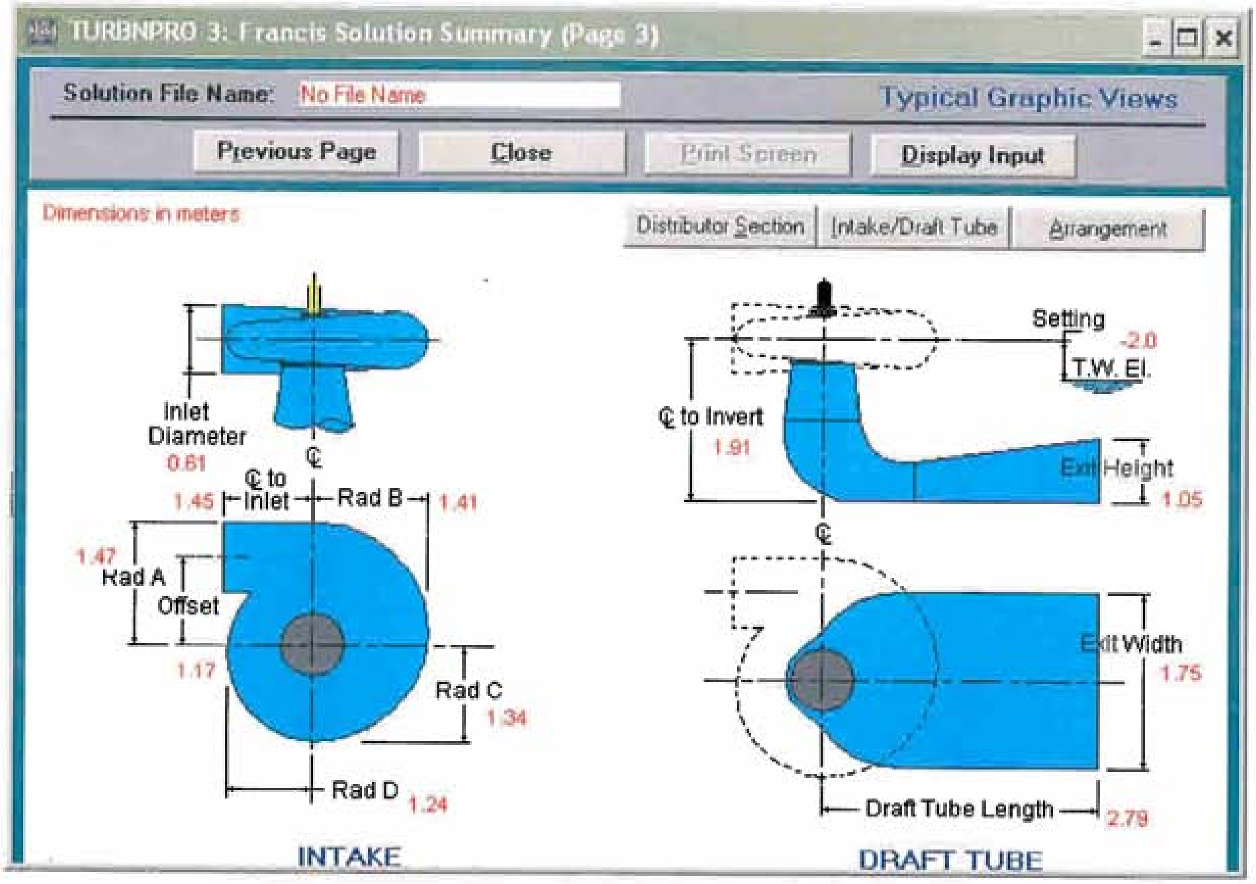
TURBNPRO Version 3.0 - FRANCIS TURBINE SOLUTION GRAPHICS

```
Solution File Name: No File Name
Runner Diameter:                  582   mm
Net Head at Rated Discharge:    285.70  meters
Unit Speed:                    1000.0  rpm
```

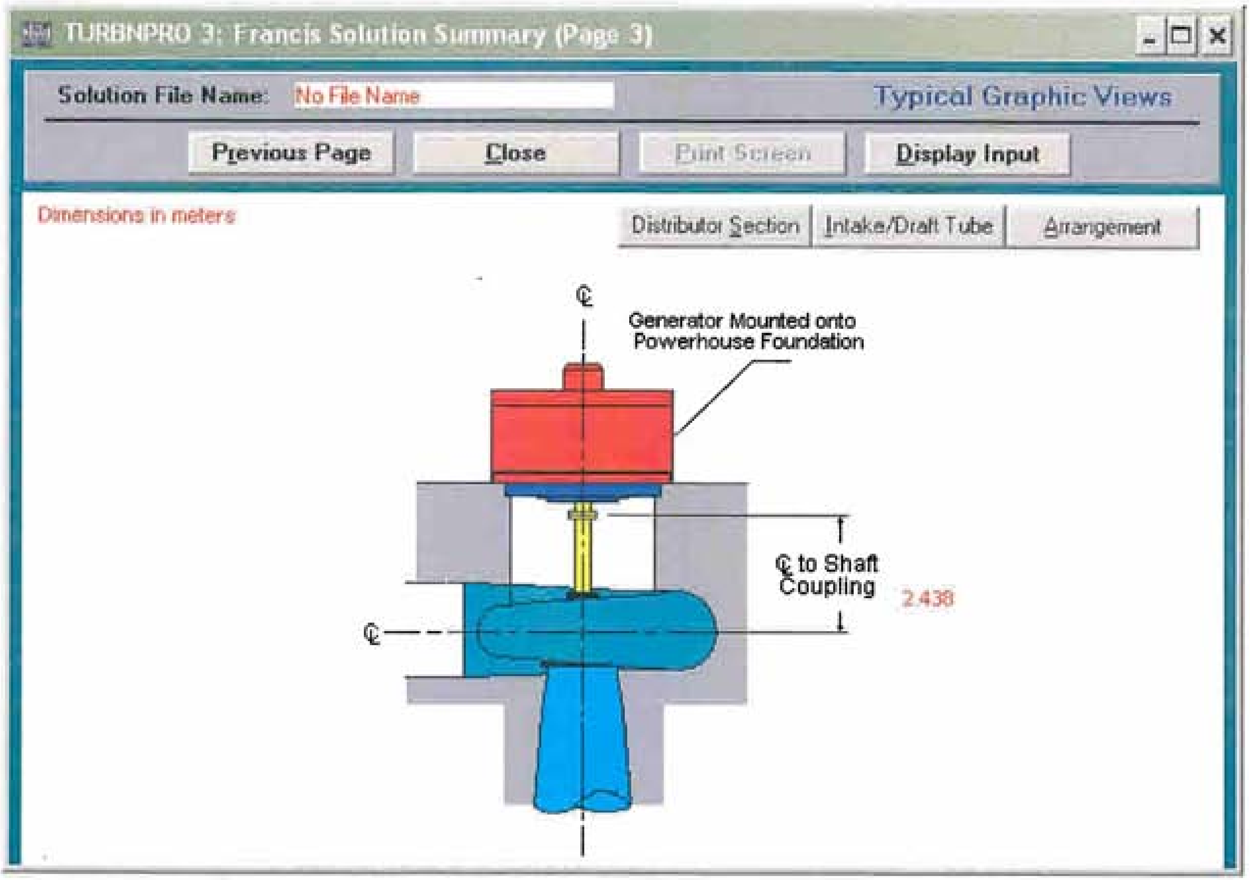


TURBNPRO Version 3.0 - FRANCIS TURBINE SOLUTION GRAPHICS

```
Solution File Name: No File Name
Runner Diameter:                   582   mm
Net Head at Rated Discharge:     285.70  meters
Unit Speed:                     1000.0  rpm
```



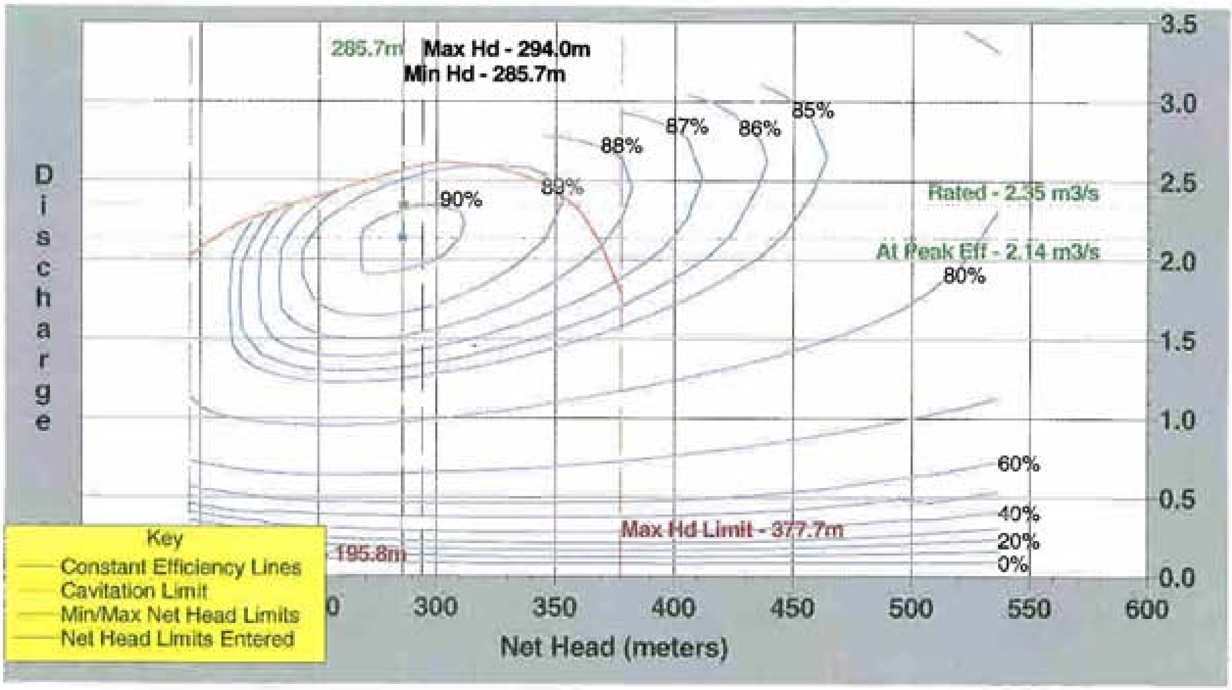
Solution File Name: No File Name
Runner Diameter: 582 mm
Net Head at Rated Discharge: 285.70 meters
Unit Speed: 1000.0 rpm



TURBNPRO Version 3 - FRANCIS TURBINE HILL CURVE

Solution File Name: No File Name

Runner Diameter:	582 mm
Net Head at Rated Discharge:	285.70 meters
Unit Speed:	1000.0 rpm
Peak Efficiency:	90.4 %
Multiplier Efficiency Modifier:	1.000
Flow Squared Efficiency Modifier:	0.0000



NOTE: Discharge is in cubic meters per second

TURBNPRO Version 3 - FRANCIS TURBINE CROSS PLOT

Solution File Name: No File Name
Runner Diameter: 582 mm
Net Head at Rated Discharge: 285.70 meters
Unit Speed: 1000.0 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

Performance Data Shown is for a Net Head of: 294