MINISTRY OF ENERGY AND NATURAL RESOURCES OF GEORGIA

Information Memorandum Part 2 The Offering

June, 2011

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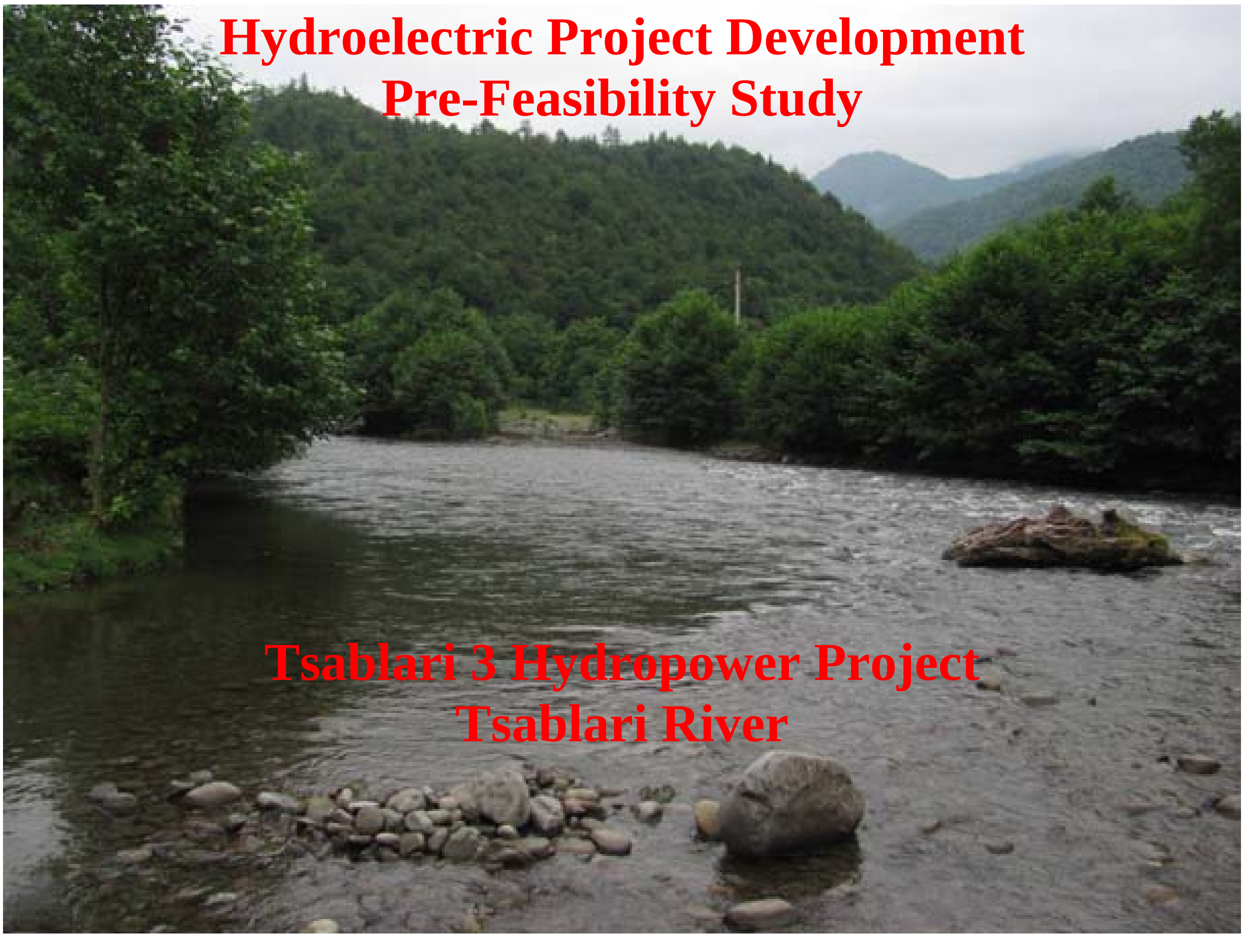
Hydroelectric Project Development
Pre-Feasibility Study



Tsablari 3 Hydropower Project
Tsablari River

Ministry of Energy and Natural Resources, Government of Georgia

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 3 HPP is located near the confluence of the Khanistskhali River and its tributary Tsablari River near the village of Tskaltashua in the Baghdati District of western Georgia's Imereti Region. The plant capacity will be 9.4 MW with annual generation production of approximately 40 GWh.

The Tsablari 3 HPP is envisioned to be the lower 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 all the Tsablari HPPs.

The Tsablari 3 HPP site offers moderately seasonally variable mean annual generation of approximately 40 GWh. There will be an intake structure, de-silting channels, surge shaft, penstock, above-ground powerhouse, tailrace, transformer substation, and transmission line connection. The intake captures flow from the Tsablari River about 5 km upstream from its confluence with the Khanistskali . The pressurized penstock minimizes head loss in the conduit therefore 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 3 HPP to the transmission network

The Tsablari 3 HPP development is expected to include a single intake facility. The intake will include a relatively low (3 m) concrete diversion weir with 18 m spillway, which ensures maximum water capture, reinforced concrete lined intake channel with de-silting basins with sluice. The power tunnel would be 5.6 km long and 2.5 m in diameter, with a 420 m steel pipe penstock to the powerhouse. A surge shaft will be located at the downstream end of the tunnel. The tailrace would be an open cut discharge 20 m long.

Project cost and construction schedule

The currently estimated cost of the Tsablari 3 HPP is USD 15.4 million or about USD 1,634/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 5.6 km 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 3 HPP Project provides a good opportunity for investment and should be further investigated by potential developers. The expected simple payback period is approximately 6 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 3 Hydropower Project**
Project location (political)	**Baghdati District of Western Georgia's Imereti Region**
Nearest town or city	**Tskaltashua village**
River name	**Tsablari River**
Total drainage area	**223.4 km^2**
Financial Estimates	
Estimated Construction Cost	**$15.4 Million**
Estimated Cost per kW capacity	**$1,634 /kW**
Simple Pay Back Period	**6 years**
Hydrological Data (Adjusted to Intake Location)	
Annual mean river flow at intake	**5.33 m^3/s**
Facility design discharge (m^3/s)	**9.2 m^3/s**
Annual average discharge through powerhouse	**4.29 m^3/s**
Preliminary design flood (100 yr return period)	**70 m^3/s**
Max. recorded flow	**65.14 m^3/s**
Intake Ponds	
Highest regulated water level (HRL)	**372 masl**
Minimum operating level (MOL)	**372 masl**
Sanitary or environmental flow (assumed)	**1-10% of mean monthly flow for each month**
Diversion Structures	
Stori River Diversion, Tyrolean Weir	
Crest elevation	**372 masl**
Abutment top elevation	**376 masl**
Collection channel water surface elevation	**371 masl**
Collection channel length	**18 m**
Collection channel width	**2 m**
Max height	**6 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	**372 masl**
Crest Length	**18 m**
Capacity at design flood level (374.0 masl)	**86.5 m^3/s**
Power water conductor/penstock	
De-silting basin	**2, 4.5 m avg depth x 3.4 m wide channels, 100 m long**
Power tunnel	**5.6 km**
Diameter	**2.5 m tunnel**
Slope	**0.20%**
Water velocity, at design flow	**1.874 m/s**

Surge Shaft	
Diameter of Shaft	**2.5 m minimum**
Total shaft height	**45 m**
Minimum ground elevation at top of shaft	**400 masl**
Penstock	
Invert elevation at pressure tunnel junction	**355 masl**
Turbine center-line elevation	**238 masl**
Penstock length	**420 m**
Outside diameter	**2000 mm**
Powerhouse	
Type	**Above-ground**
Installed capacity	**9.4 MW (at design flow)**
Units and net capacity at high-voltage transformer terminals	**1 x 3.5 MW and 1 x 6.7 MW, vertical Francis units**
Rated speed	**500 rpm**
Preliminary generator voltage	**15 kV or manufacturer's recommendation**
Rated generator capacity	**1 x 3.90 MVA and 1 x 7.45 at 0.90 Power Factor**
Size of powerhouse	**10 m x 38 m x 15 m high**
Tailrace	
Length	**20 m**
Width	**14 m**
Type	**Open channel**
Normal tailwater elevation	**240**

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	**131 m**
Total head loss at rated discharge	**8.74 m**
Net head at rated discharge	**122.26 m**
Estimated average annual head loss	**2.79**
Estimated average annual net head	**128.21**
Estimated average annual generation	**Approximately 40 GWh**
Nominal installed capacity	**9.4 MW**
Preliminary annual plant factor (also called CF)	**48.8%**

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 3 Hydropower Project involves the construction of an approximately 9.4 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 3 powerhouse will be located near the confluence of the Khanistskhali and its tributary the Tsablari River approximately 5 km upstream from the city of Baghdati and the gauging station. The diversion weir is approximately 5 km 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 3 project is 5 km south of Baghdati. Tskaltashua is the closest village to the Tsablari 3 HPP and consists of only a few houses.

The total area of 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 with 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 vegetated 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 2 HPP (see Appendix 3, Location Map). 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: Baghdati Municipal Economic Development Plan, Baghdati 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 3 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	**Tskaltashua**
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 3 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 3 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 an increase in elevation. The annual precipitation on average is in the range of 1,200 to 1,500 mm in Kutaisi, 25 miles north of the Tsablari 3 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 3 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	**223.4 km^2**
Adjustment factor	**0.341069**
Maximum plant discharge	**9.2 m^3/s**
Minimum plant discharge	**As low as 1.6 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 1.6– 9.2 m^3/s. Reasonable potential of approximately 40 GWh/year**
Flood flows (combined)	**Average Annual Flood (2.33 yr return period) = 30 m^3/s**
Highest recorded flow	**65.14 m^3/s**
Calculated 100 year flood	**70 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 3 HPP intake; meteorology stations for air temperature, precipitation, barometric pressure, relative humidity, wind speed and direction, solar insulation, and snow depth.** **These stream locations would also be used for other monitoring of suspended and bed load 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. This river discharge 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 3 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 10 km downstream from the Tsablari 3 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 0.341069 (223.4 km^2/655 km^2) was used to adjust flow record to the Tsablari 3 HPP intake location. Appendix 2 includes monthly and annual flow duration curves.

Table 4: Tsablari 2 HPP Intake Vicinity Characteristic Discharge Information (m3/sec)

Annual average flow (m^3/sec)	**6.78**
Maximum average daily flow of record (m^3/sec)	**65.1**
Minimum average daily flow of record (m^3/sec)	**0.98**
Average monthly discharge during seasonal runoff period (April, May, June, July August, September) (m^3/sec)	**9.77**
Average monthly discharge during winter Season (Oct – March) (m^3/sec)	**3.79**
Highest 30 day average discharge (m^3/sec)	**38.36**
Lowest 30 day average discharge (m^3/sec)	**4.37**
Average discharge during Georgian winter electric demand period (Dec-Feb) (m^3/sec)	**2.83**
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

Sediment sampling data available in the Tsablari and Khanistskali River basins is from the mid 1950's -1960's (see reference at the bottom of Table 5) It has been assumed that the Tsablari 3 HPP location carries about the same concentration of suspended sediment as the sediment sampling location near Didvali on the Khanistskali River. 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 valley slopes also contributes to bed load movement of coarse sediment, large rocks and debris.

Table 5 presents projected suspended sediment values at the diversion weir intake of Tsablari 3 HPP and volume of suspended sediment entering the de-silting basin based on the Didvali Gauge data 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 3 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: Tsablari 3 Intake Sediment Load Estimates

Suspended Sediment Volume Projected for Tsablari 3 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 Bed load 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 3 Adjusted total Suspended Sediment Load in Kg/Sec **/2**	1.72	1.33	1.21	1.13	1.01	0.79	0.48
Tsablari-3 Intake Sediment Estimate in T x1000 **/3**	43.28	33.39	30.30	28.44	25.35	19.78	12.06
Tsablari-3 Intake Sediment Estimate in Cubic Meters x 1000	28.85	22.26	20.20	18.96	16.90	13.19	8.04

Note 1/ Data Source : Surface water Resources Transcaucasia and Dagestan, Vol 9 West Caucausia Edition 1,
Administration of Hydrometerologic Service, Georgian SSR 1969
Note: /2 Adjusted total sediment load for Tsablari 3 is in the Tsablari HPP intake drainage area / Baghdati Gauge sampling location drainage area
Note: /3 to account for only the sediment flowing into the Tsablari 3 intake the ratio of the net useable area under the FDC curve divided by the area under the full FDC curve was used
Note: /4 No data available for Bed load 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 HPP project. It is recommended that as soon as project approval is complete a primary meteorology station should be installed at Sairme Resort located centrally in the Tsablari watershed.

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 3 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.

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	

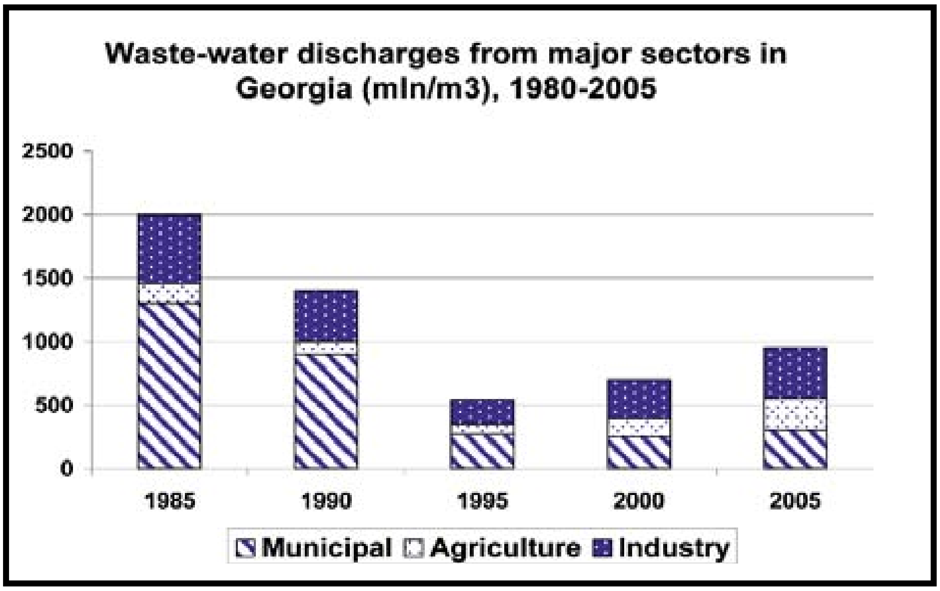
Source: Data on climate and meteorology for Kutaisi was provided by the Department of Hydrometeorology of Georgia.

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 proposed two 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.

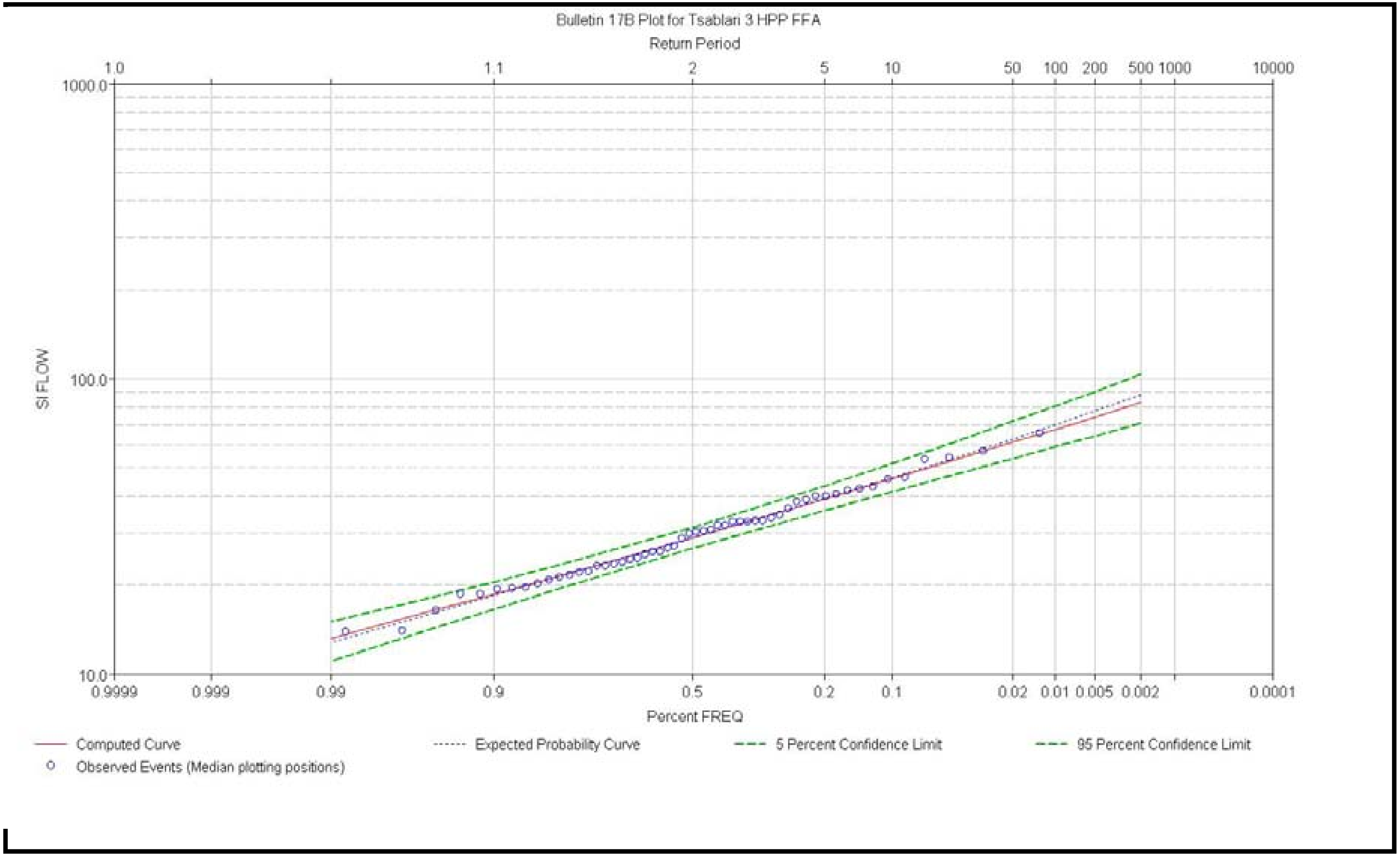
The proposed Tsablari 3 HPP run-of-river operations should have no impact on downstream water withdrawal users but during low flow period's coordination may be required to assure the local population that HPP operations are allowing adequate sanitary and environmental bypasses along with the other tributary inflows.

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 evaluate flood frequency and calculated flood discharge magnitude at the intake location for Tsablari 3 and to use as a comparative check on the 1969 Soviet Report flood frequency values (see reference in table 5 Note /1. The results are presented in the figure 3 below. A drainage basin adjustment of 0.341 was used to adjust these gage values to the proposed location of the Tsablari 3 intake location.

Figure 3: Tsablari 3 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 are made up of gardens, orchards, vineyards 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).

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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 Khanistskhali 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 head works 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.**

Based on the geological report, the assumptions relating to the construction of the tunnel are that the rock conditions will be extremely variable with the potential for a lot of joints and groundwater intrusion. The Geomorphology Map in Appendix 1 indicate special attention needs to be paid to major faults that may exist in the area of the Tsablari HPPs with particular impact on tunneling. Appropriate designs are needed for dealing with faults and water infiltration when encountered while tunneling. The Tsablari 3 water conductor layout has been developed to avoid tunneling through a major fault located a short distance upstream from the diversion weir.

4.0 HYDROPOWER PROJECT DESCRIPTION

4.1 PROJECT DESCRIPTION

The Tsablari 3 HPP development is expected to include a low Tyrolean weir across the Tsablari River, channeling flow to a 100-m-long de-silting channels, 5,600-m-long power tunnel and 420-m-long steel penstock. This primary diversion collects runoff from an area of about 223.4 km^2. There will be two de-silting channels with an average depth of 4.5 m and each will be 3.4 m wide. The power tunnel will have an inside diameter of 2.5 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.

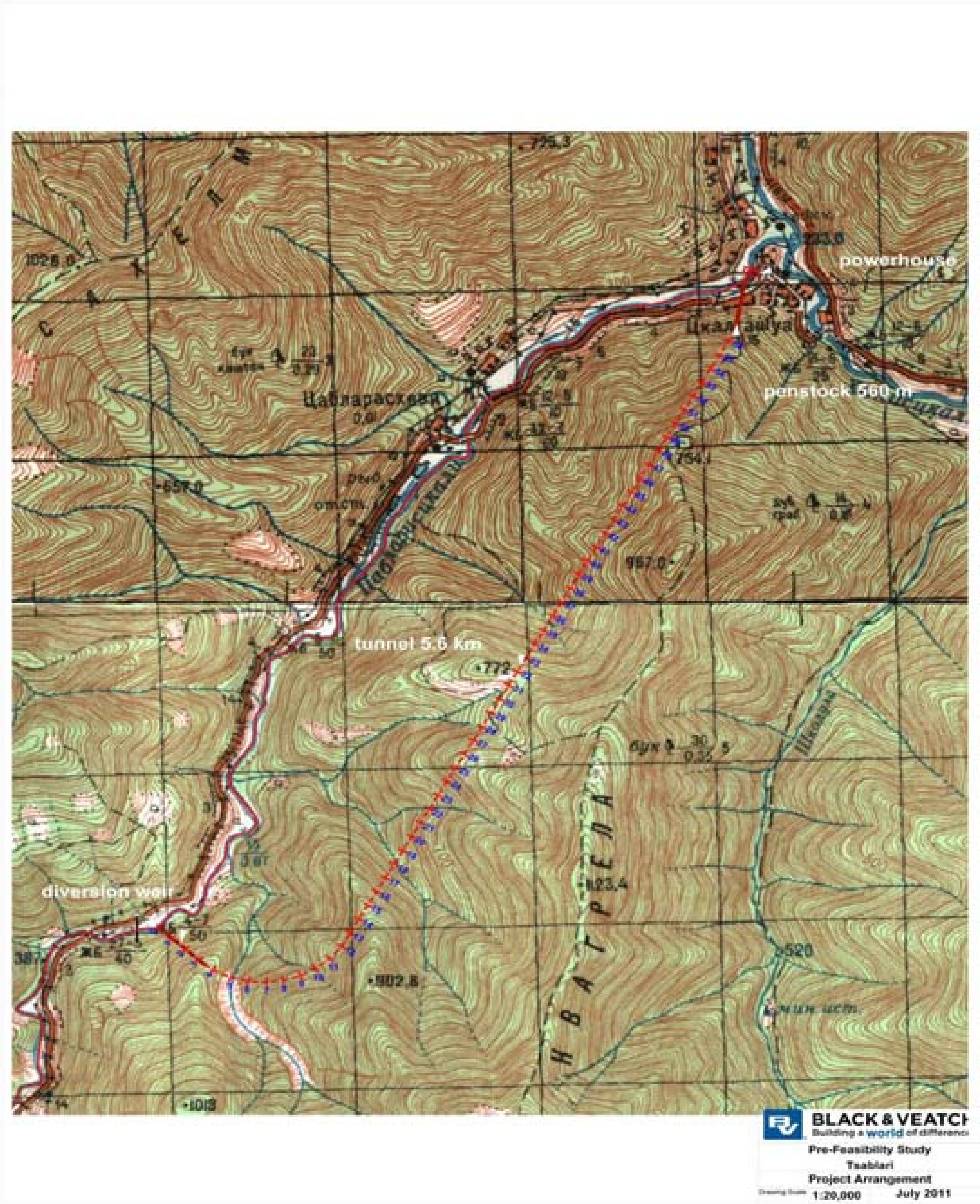
A 20-m-long excavated tailrace channel will discharge to the river.

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 3 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 fair. The intake and powerhouse are adjacent to a public gravel 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, where the penstock passes under the road. From the topographic maps available, it does not appear that it is practical to install a mid-tunnel adit. A steep pioneer road will be needed to access the downstream portal of the tunnel and upper penstock. This would allow tunnel excavation at 2 faces.

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

Figure 4: Tsablari 3 Hydropower Project General Layout



In the figure above, the dashed red line represents the power tunnel alignment and solid red line represents the penstock alignment. 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 3 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 3 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 18-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 10 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 3 as a function of return period in the table. Also, Table 5 strongly suggests necessary field data collection for sediment from Tsablari 3 intake location during the feasibility study.

4.1.3 Power Tunnel

The Tsablari River power tunnel will have a total length of 5,600 meters, with a finished inside diameter of 2.5 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 3 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, intersecting the natural slope above. 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 Penstock

A 420-m-long buried penstock 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. The 2000 mm diameter penstock is assumed to be steel, but other materials or the possibility of two parallel penstocks can be investigated during future studies.

4.1.6 Powerhouse

The above ground powerhouse size and arrangement will be determined primarily by the site availability and 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, 38 meters long, and 15 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 on an open deck outside 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 Optimization folder in Appendix 11).

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	500	1014	6.0	3.0	6.68	3.07
No. 2, Smaller	500	818	3.2	1.6	3.5	1.6
Plant Total			**9.2**		**10.18**	

This installation will result in a maximum electric power output, at the high-voltage transformer terminals, of about 9.4 MW.

The Pelton turbine option includes two equal-size units, producing a mechanical output of up to about 5.0 MW each (with only one unit operating, maximizing net head). They are vertical-shaft machines and have 4 jets each, a rotational speed of 250 rpm, and a runner pitch diameter of 1792 mm. These units are much larger than comparable Francis units at the Tsablari 3 rated head of 122.26 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 and Energo-Pro Dispatchers 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 proposed power plant discharge from the Tsablari 2 HPP.
- At a site where the dam length is relatively short and reasonable rock conditions appear to exist on both abutments.

The connecting pipelines, de-silting basin, and intake were located where there appear to be:

- 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 short penstock(s) was quickly selected because of the large quantity of water, space limitations, significant to high traffic on the narrow paved road to the resort, very steep slopes in the narrow canyon, and the generally acceptable geologic conditions along the potential tunnel alignment.

4.3 PROPOSED PROJECT COMPONENTS

In summary, the project includes the following components:

- Relatively short (500 m) access roads from public gravel roadway
- A pioneer road to access the downstream tunnel portal.
- A 18-m-long Tyrolean weir diversion structure on the Tsablari River
- De-silting structures
- Sluicing structures
- Tunnel portal
- Water conductors (channels, tunnels, penstocks)
- A 45 m surge shaft
- Above-ground power plant
- A short, excavated tailrace channel
- 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	**131 meters**
Maximum generation flow	**9.2 m^3/s**
Number of units	**2 Francis units**
Potential installed capacity	**9.4 MW**
Mean annual power output	**Approximately 40 GWh**
Construction time	**3-4 years including final feasibility, EIA and design.**
Anticipated Life-span	**30 years**

5.0 POWER AND ENERGY STUDIES

Tsablari 3 HPP energy assessment was completed using available Khani-Tsablari River flow records (54 years of record) and operating scenarios that fit the proposed site and watershed conditions. River flow records are described in Sections 2.2.2 – 2.2.4, 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 3 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) expectations 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 3 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 (i.e.: 5-10 m^3/s). Monthly results for a design flow of 9.2 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.

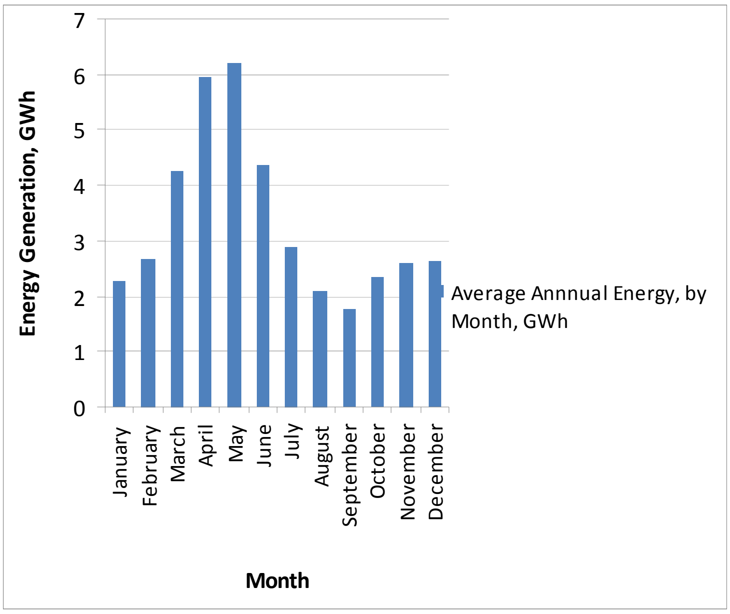
Table 12: Average Tsablari 3 HPP Power Production, 9.2 m^3/s Design Flow

Month	Mean Daily Power, MW	Minimum Daily Power, MW	Maximum Daily Power, MW
January	3.06	0.31	9.38
February	3.91	0.11	9.38
March	5.74	0.51	9.38
April	8.28	1.81	9.38
May	8.35	0.46	9.38
June	6.04	1.22	9.38
July	3.87	1.11	9.38
August	2.84	0.65	9.38
September	2.44	0.11	9.38
October	3.17	0.30	9.38
November	3.63	0.41	9.38
December	3.55	0.15	9.38
Annual	**4.57**	**0.11**	**9.38**

Table 13: Average Tsablari 3 HPP Energy Production, 9.2 m^3/s Design Flow

Month	Mean Daily Energy, GWh	Minimum Daily Energy, GWh	Maximum Daily Energy, GWh	Mean Annual by Month, GWh
January	0.07	0.01	0.23	2.28
February	0.09	0.00	0.23	2.65
March	0.14	0.01	0.23	4.27
April	0.20	0.04	0.23	5.96
May	0.20	0.01	0.23	6.21
June	0.14	0.03	0.23	4.35
July	0.09	0.03	0.23	2.88
August	0.07	0.02	0.23	2.11
September	0.06	0.00	0.23	1.75
October	0.08	0.01	0.23	2.36
November	0.09	0.01	0.23	2.61
December	0.09	0.00	0.23	2.64
Annual	**0.11**	**0.00**	**0.23**	**40.08**

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 km² 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 bordered by the Vani district in the west, the Terjola and Zestaphoni 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 3 project is 5 km south of Baghdati. Tskaltashua is the closest village to the Tsablari 3 HPP and consists of only a few houses.

6.1.1 Infrastructure

Infrastructure of the region is developed: Baghdati and Sairme are connected by a good road. A 35 kV high voltage transmission line serves the village of Sairme upriver from the proposed Tsablari 3 HPP.

There are 27 public schools, one museum, one theatre, 23 libraries and one vocational school in the Baghdati District. The district 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 3 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 settlement to the proposed HPP area is the village of Tskaltashua, which consists of only a few houses.

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 3 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 3 HPP.

The proposed Tsablari 3 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 3 HPP has two hydropower development activity periods that will impact environmental receptors, over different time horizons, and at different risk or impact levels. The following are the activity periods of interest:

- Construction: Compared to the lifecycle of the facility this is a short term impact period of approximately 3-4 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 3 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 3 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$ 15.3 million or $1,634 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 above ground 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 3 project both numbers were consistent, so we used the slightly higher 1% of capital cost in our financial analysis in Section 8.

Table 15: Tsablari 3 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			$552,000	$552,000				
Stream diversion and cofferdams	LS			$193,000	$96,500	$96,500			
Replace road at penstock and build to powerhouse	m	600	$685	$411,000	$205,500	$205,500			
Pioneer road to downstream tunnel portal	m	2,000	$150	$300,000		$300,000			
Tsablari 3 Tyrolean Weir	LS			$295,000		$295,000			
De-silting Structure	LS			$400,000		$200,000	$200,000		
River Portal	LS			$115,000		$57,500	$57,500		
Headrace Tunnel including rock bolts & shotcrete	m	5,600	$425	$2,378,000		$1,189,000	$1,189,000		
Surge Shaft	m	45	$849	$38,000			$38,000		
Penstock 2000mm steel buried	m	420	$700	$294,000			$294,000		
Power house in steel framed building	LS			$437,000		$437,000			
Tailrace open channel	m	25	$3,840	$96,000			$96,000		
Transformer Switchyard Civil Works	MW	9.40	$7,747	$73,000		$36,500	$36,500		
Electric and mechanical parts (turn-key)	MW	9.40	$558,391	$5,249,000		$2,624,500	$2,624,500		
Grid connection transmission line @ 35 KV	km	1	$100,000	$100,000		$50,000	$50,000		
Subtotal of Schedule Items				**$10,941,000**					
Geology (investigation field, lab and office) @ 1%	LS			$109,000	$109,000				
Feasibility study @ 1%	LS			$109,000	$109,000				
EIA @ 1%	LS			$109,000	$109,000				
EPCM @ 14%	LS			$1,532,000	$919,200	$306,400	$306,400		
Contingencies (Assumptions Variable) @ 20%	LS			$2,560,000	$422,040	$1,159,580	$978,380	$0	$0
Total				$15,360,000	$2,532,240	$6,957,480	$5,870,280	$0	$0
MW Capacity	9.40		CAPEX/kW	**$1,634**					

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 5.6 km of tunneling. 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 3 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 3 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 3 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 3 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 3 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 1% of the capital expenditure 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 9 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 the Tariffs presented in Table 16 and 17 appear in a memo included in Appendix 11.

Table 16: Tsablari 3 HPP Financial Analysis & Payback Period (9.4 MW and 9.2 m^3/s)

Month	Total CMS-HR Under Curve	Saleable CMS-HR per month	Saleable kWh	Price / kWh	Revenue		
January	2,393	2,124	2,269,659	0.0500	113,483		
February	2,900	2,486	2,656,471	0.0500	132,824		
March	5,377	3,956	4,227,200	0.0722	305,288		
April	8,640	5,468	5,843,438	0.0722	422,013		
May	8,069	5,956	6,365,316	0.0722	459,703		
June	4,630	4,131	4,414,781	0.0722	318,836		
July	2,863	2,692	2,876,266	0.0722	207,724		
August	2,083	1,963	2,098,096	0.0722	151,524		
September	1,747	1,634	1,746,156	0.0722	126,107		
October	2,640	2,210	2,361,797	0.0722	170,569	Weighted Average Tariff	
November	2,834	2,455	2,623,148	0.0722	189,444		
December	2,950	2,468	2,637,290	0.0500	131,864		
Totals	47,126	37,543	40,119,619	Total Revenue / Yr	2,729,380	$0.0680	
				(Site Electricity) @ 1%	($27,294)	7% of rev	1% of Cap
	Design discharge =	9.2	m3/s	(operating costs)	($189,146)	$189,146	$153,600
	CF =	47%		Net Operating Revenue	$2,512,940		
	Annual average m3/s through powerhouse =		4.29	**Estimated Capital Exp.**	**$15,360,000**		
				Pay Back Period	**6.11**		

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**.

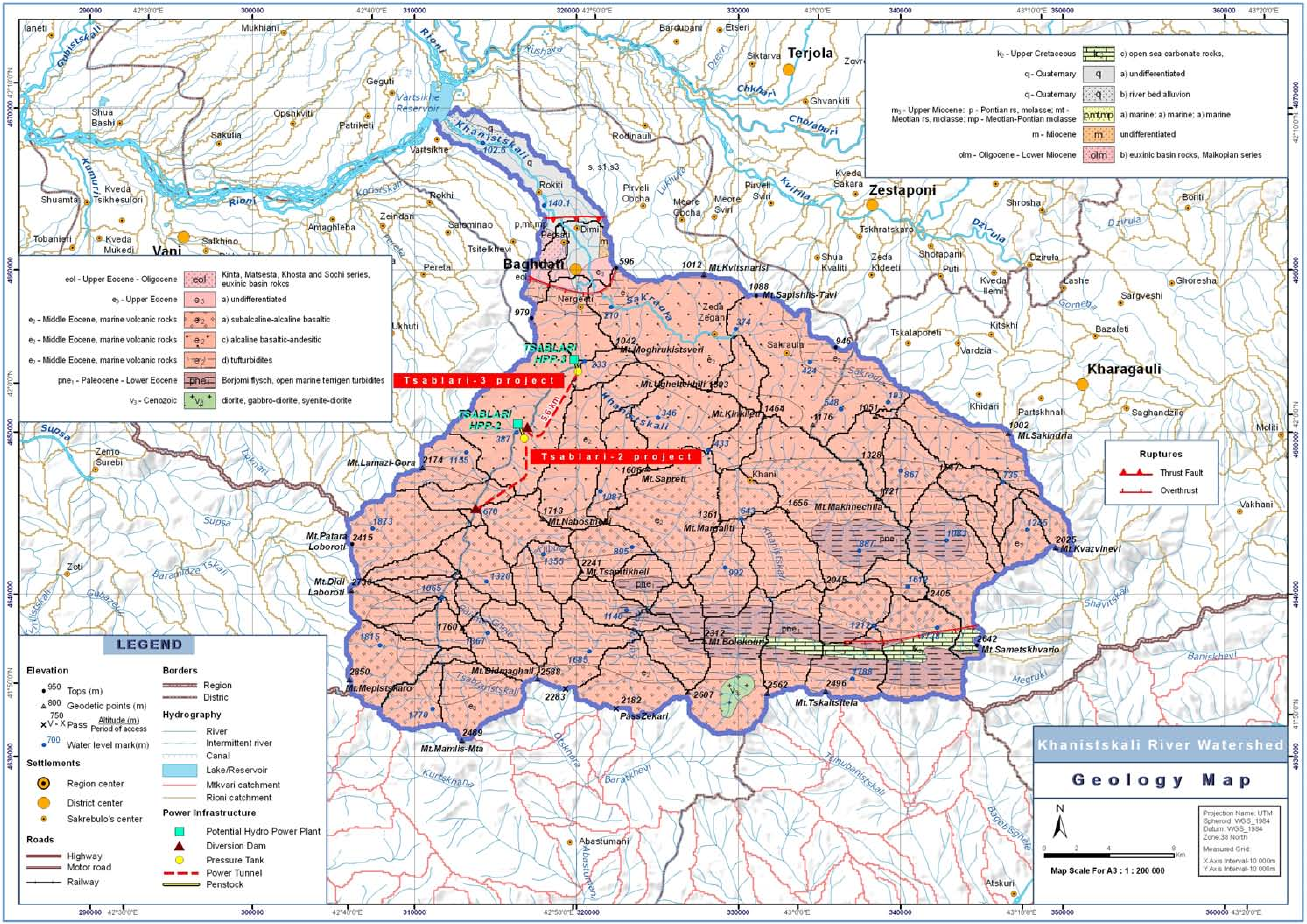
For additional information about an earthquake event and links to damage photos, click on the links in the **Addl Info** and **Tsu** columns.

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
k2 - Upper Cretaceous
c) open sea carbonate rocks,
q - Quaternary
a) undifferentiated
q - Quaternary
b) river bed alluvion
m3 - Upper Miocene: p - Pontian rs, molasse; mt - Meotian rs, molasse; mp - Meotian-Pontian molasse
a) marine; a) marine; a) marine
m - Miocene
undifferentiated
olm - Oligocene - Lower Miocene
b) euxinic basin rocks, Maikopian series
eol - Upper Eocene - Oligocene
Kinta, Matsesta, Khosta and Sochi series, euxinic basin rokcs
e3 - Upper Eocene
a) undifferentiated
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
diorite, gabbro-diorite, syenite-diorite
Ruptures
Thrust Fault
Overthrust
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
Roads
Highway
Motor road
Railway
Borders
Region
Distric
Hydrography
River
Intermittent river
Canal
Lake/Reservoir
Mtkvari catchment
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Potential Hydro Power Plant
Diversion Dam
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Tsablari-2 project
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TSABLARI HPP-2
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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
Terjola
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Vani
Kharagauli
Khanistskali
Rioni
Mt.Kvitsnarisi
Mt.Sapishlis-Tavi
Mt.Moghrukistsveri
Mt.Sakindria
Mt.Lamazi-Gora
Mt.Sapreti
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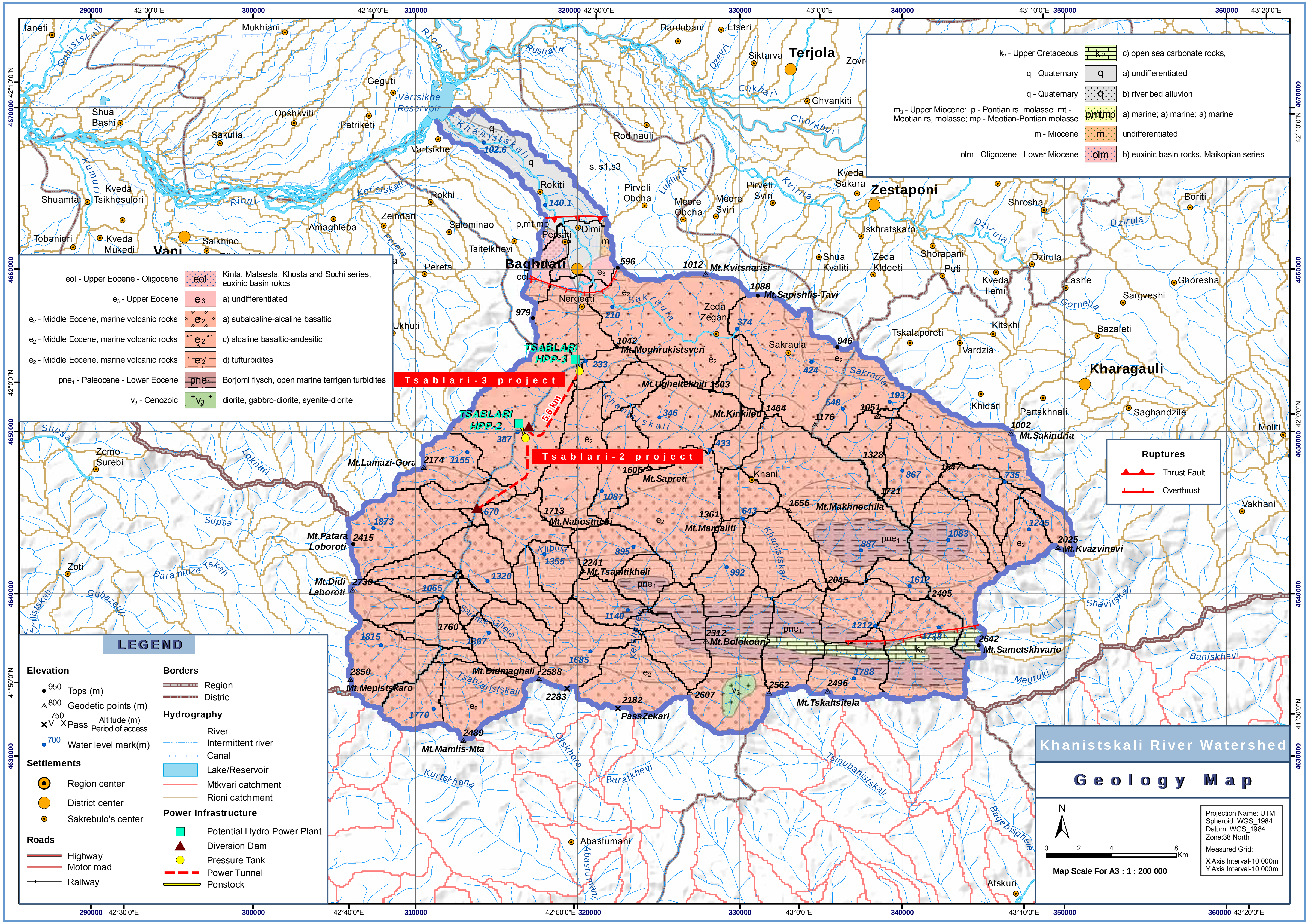
Mt.Nabostrevi
Mt.Margaliti
Mt.Kvazvinevi
Mt.Patara Loboroti
Mt.Didi Laboroti
Mt.Tsamtikheli
Mt.Bolokouri
Mt.Sametskhvario
Mt.Mepistskaro
Mt.Didmaghali
Pass Zekari
Mt.Tskaltsitela
Mt.Mamlis-Mta
Abastumani



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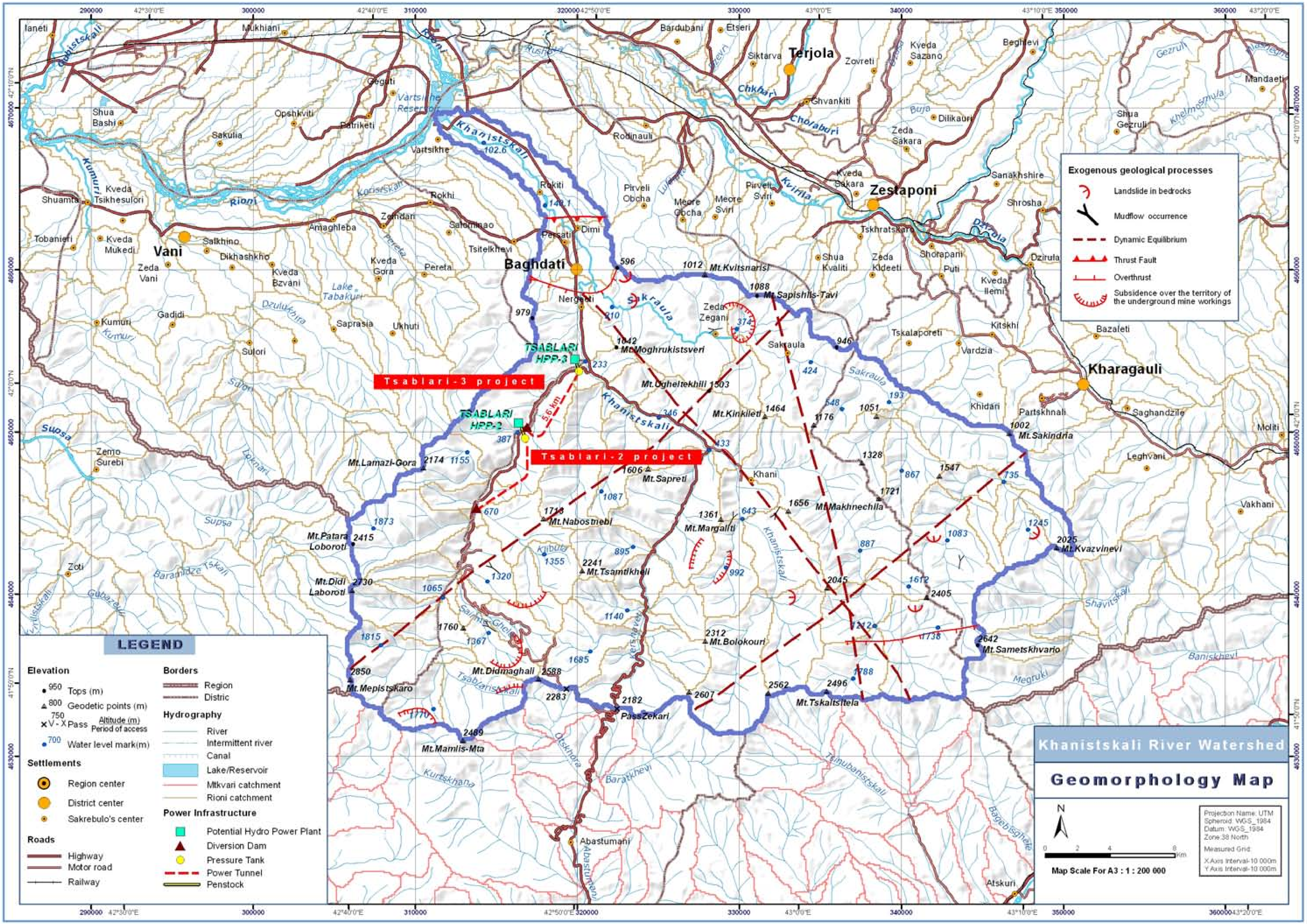
Sakraula
Rioni
Kvirila
Vartsikhe Reservoir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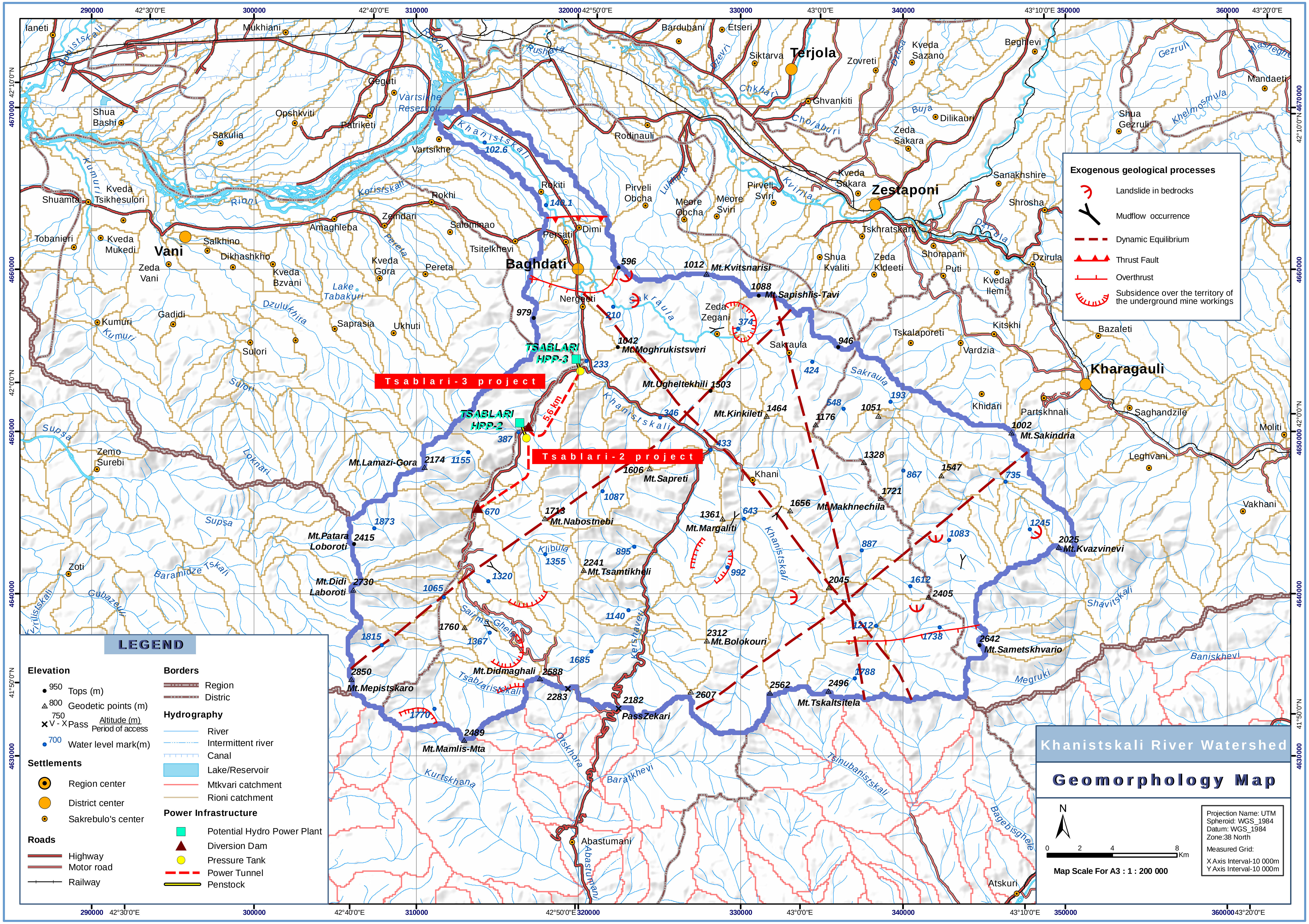
X Axis Interval-10 000m
Y Axis Interval-10 000m



Khanistskali River Watershed
Geomorphology Map
Exogenous geological processes
Landslide in bedrocks
Mudflow occurrence
Dynamic Equilibrium
Thrust Fault
Overthrust
Subsidence over the territory of the underground mine workings
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
Terjola
Zestaponi
Baghdati
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

CONTENTS

INTRODUCTION

The aim of conducting these geological-engineering studies is to evaluate prospects for driving of derivation pipelines and arranging of underground Hydro Power Plants at the pre-designing phase in the gorges of the rivers Khanistskali and Tsablari, on the territory of Baghdati region in Imereti.

Survey includes general geological, hydro-geological and geo-morphological description of the working area; determination of those geological formations which are spread over the working area; description of general physical-technical characters of formation host rocks and based on it determine separate geological-engineering complexes; furthermore, it includes general description of expected exogenic geological processes (landslides, rockslides, mudflows and others) activation of which will throw obstacles in building process and the object further exploitation way.

These are the major questions study of which at this phase gives opportunity to aim implementation of those goals and works, which contribute to further detailed study of the working area.

To meet the challenge at the preliminary phase there was collected the region geological, geological-engineering, hydrological and other existing archive and literature materials; there were arranged field reconnaissance routes and surveys within the working area.

Geological-engineering survey was prepared based on the collected materials and data of reconnaissance routes, also aero and satellite interpretation which is accompanied by geological map showing the sections and locations of hydro power plants.

Hydro power plants will be located on the left bank of the mid-belt of the river Khanistskali and on the right bank of the middle and lower belt of the river Tsablaristskali.

The length of derivation pipeline stretched along the left bank of the river Khanistskali is 4.2 km. Head buildings probable location will be in 5 km from the junction of the rivers, against the stream, at 300 m absolute altitude. There are considered to drive two water conductors on the river Tsablari which will parallel the right bank of the river lower and middle reaches. The length of the first pipeline is 5.1 km; head buildings probable location is in 5.7 km from the river-junction, against the stream, at 300 masl. The length of the second pipeline that is stretched along the right bank of the mid-belt of the river is 5.3 km; head buildings probable location is in 12 km to the south-west direction from the river-junction, at an elevation of 668.0 masl.

II Region Physical-Geographical Description

The study area is located in the Baghdati administrative region, to the south from the administrative center at 8-15 km distance and covers the gorges of the middle reaches of the river Khanistskali and middle and lower reaches of the river Tsablari, to the south from their junction along the 12 – 15 km distance. In the mentioned and its nearby territory, from the main orographic elements there is distinguished Didmagala-Tsamtekheli ridge having almost meridian direction, which is watershed of the rivers Tsablaristskali and Kershaveti. Highest peaks are: Tsamtekheli – 2240.5 m and Molobila – 2245.3 m. From the mentioned ridge the branches are coming out to the Tsablaristskali direction, which are watersheds of the right affluents of the river. The absolute altitude of the peaks of the watershed crests varies within 1700-1800 m. Didmagala-Tsamtekhili ridge is forked into 3 parts to the north. From them Kvagrdzeli is the western ridge which is watershed of the rivers Tsablaristskali and Skurdula. Absolute altitudes are: the mount Didikeli – 1632.6 m; the mount Usakhelo – 1535.9 m; Shua ridge which highest peak is the mount Kurta – 1379.8 m and represents the watershed of the rivers Skurdula and Kurta; and the east ridge which peak is the mount Sapreti – 1606.9 m represents the watershed of the rivers Kershaveti and Khanistskali.

The mentioned ridges in the south part of the region are characterized with quite steep slopes and narrow, rocky crests. In the north the crests of the ridges are becoming rather round shaped. Difference of the heights between the bottoms and the crests of the gorges is 300 – 800 m. Study area is characterized with quite dense hydrographic network about 2 – 2.5 km/km^2 where the rivers Khanistskali and Tsablari are abounding in waters.

The river Khanistskali takes its head from the Akhaltsikhe-Imereti ridge; the riverbed in the upper belt is located at 2000-2400 m absolute height; but the height in the working area falls to 300 m.

The river Tsablaristskali takes its head from the slope of the mount Mepistskaro (2850 m). It is flowing to the north-east direction and joins the river Khanistskal in the study area. The left affluents of the river Khanistskali such as Kurta, Skurdula and Kershaveti and also the right affluents of the river Tsablaristskali: Didmagalistskali and Sakalmakhesghele are draining within the study area and in its nearby territory.

Annual regime of the river flow depends on the river feeding character. The rivers that are draining within the study area belong to the mixed feeding river types, which are fed with underground, river and snow waters. The region is characterized with lack of underground waters therefore atmospheric precipitations and condensation play the basic role in river-feeding affairs. Water level is apparently increasing in spring and autumn during melting of snow and long-lasting rivers; during the snow melting the water flow module in the rivers is increasing 2.5-3 times.

Study area climate is moderately humid and warm. Average annual temperature is + 13°C. The sediments annual quantity varies from 1000 to 2000 mm a year, 1380 mm on average. The spring is quite hot and the winter is moderately cold. Atmospheric temperature is changing according to the heights. A big part of the territory is covered with forest; from about 600 m to 1200-1400 m absolute altitude the greenwood is spread (beech, hornbeam, lime-tree and others). In the south, mixed foliage-coniferous forest is observed. Pure coniferous species are spread to the south from the mixed forest (pine-tree, fir, spruce). We meet forest up to 1600 -1800 m height afterwards alpine meadow begins. Populated areas are generally located in the lower belt of the course of the river, that are the villages: Khani, Zekari, Kakaskhidi, Alis-Imereti and others. Asphalt and ground roads join the villages to each other and to the administrative center. The nearest railway station is Kutaisi, which is in 40-45 km distance from the working area.

Locals are Georgian people who are mainly busy with agriculture.

III Geological and Tectonic Texture

Mid-Eocene volcanogenic formations (₽$_2^2$) are extremely widely spread over the working area. At this stage, there is no grounds to make conclusions about consistent patterns of distribution of volcanogenic rocks of Middle Eocene and their compositions. Consequently, dismembering of the volcanogenic formation in the Suite is generally carried out based on lithological peculiarities. According to the rocks lithological specifications, the volcanogenes are divided into three suites: lower – variegated, layered tuffogenic suite, middle – tuff-breccias suite and upper – suite of trachyte tuffs.

The lower variegated layered tuffogenic suite (₽$_2^2$) is exposed in the north periphery of the Adjara-Imereti ridge which doesn't enter the working area so we abstain from their description.

The middle tuff-breccia suite (₽$_2^{2c}$) is widely spread within the study area. It builds mould and slope of syncline and composite part of anticline. The riverbeds of mid-belt course of the river Khanistskali and middle and lower course of the river Tsablaristskali and also the territory of the middle and lower course of the rivers Skurdula, Kurata and Kershaveti are built with the rocks of this suite. The suite is built with the heavy packs of the coarse-fragmented rocks of massive lava, lava-breccias, tuff-breccias with the layered tuffogenes and coverings of andesite basalt and porphyrite. Layered tuff-breccias, tuff and tuff-sandstones play an important role in the suite composition. In the gorge of the river and in the watershed sometimes there are exposed separate packs of alternation of coarse-fragmented tuffogenes and basalt-porphyrite coverings. Thickness of the separate pack varies within 90-30 m, separate layer of coverings – within 5-8m.

The upper part of the suite is represented with grey dense tuffogenic rocks with the packs of layered tuffogenes (tuffs, tuff-sandstones). The bottom of this part of the suite is shown on the map with dotted line. Overall thickness of the middle tuff-breccia suite on the north periphery of the north slope of Adjara-Imereti ridge reaches 1400 m.

The upper suite (₽$_2^{2B}$) of trachyte tuffs in conformity overlaps the rocks of middle suite of Mid-Eocene (₽$_2^{2C}$) and builds the mould and slope of synclinal folds.

The suite is generally represented with massive tuffs, lavas and trachyte composition lava-breccias with rare packs of layered tuffogenes. In the top of the suites sometimes there are observed layered (thickness up to 15 cm) plate-type aleurolites. The rocks of this suite are mainly spread over the south part of the working area covering the territory between the village Kakaskhidi and the gorge of the river Sakalmakhisgele, the right affluent of the river Tsablaristskali. They are exposed in the heads of the rivers Skurdula and Kurta.

Quaternary System

The study area quaternary coverings in view of youthful relief and consequently intense erosion is poorly developed. Basically, it is represented with alluvial and deluvial-proluvial sediments. Alluvial sediments in the study area are predominatingly met along the river-valley having comparatively worked-out profile. Bottomland alluvium of the river Khanistskali is represented with pebblestones with sand and loam admixture. Thickness of the sediments varies within 2-4m. Above-bottomland terraces along the river Khanistskali meet the separate residues in the surroundings of the village Alis-Imereti. Terrace sediments are represented with conglomerates, sandy-clayey cement. Thickness varies from 1 to 3 m.

In the lower part of the river-valley, the Tsablaristskali bottomland alluvium has the same composition and is analogue to the above descriptions.

Deluvial-proluvial sediments are met sometimes along the foot of the separate folded branches where their thickness varies within 2-5 m and the materials are represented with debris and blocks of various rocks.

Tectonics

From the tectonic standpoint, the study area belongs to the north zone of Adjara-Trialeti system and covers the central sub-zone. From the plicate dislocation developed over the study area the followings are isolated:

Tskhaltashui syncline (1-1) is traced along the north part of the territory having sub-latitudinal direction. It is characterized with symmetrical texture with the angles of inclination of slopes (20 - 30°).

Gurtini anticline (2-2) is located to the south from the above-described syncline and is stretched from Kinkileti to the south-west direction, towards the middle course of the river Tsablaristskali. Folds have symmetric texture with the inclination of slopes at 10 -20° angle.

Kakaskhidi syncline (3-3) is traced to the south, parallel to the above-described anticline. The folds have asymmetric texture, its north slope is dipping at 10-20° angle, and southern-has 70-80° angles of inclination.

In the texture of above mentioned folds on the surface there participate volcanogenic rocks of Mid-Eocene middle and partly upper suite.

No tectonic faults are observed within the territory of the study area.

IV Geomorphology

Study area enters the zone of the South-Georgian Plateau and covers mountain-valley type relief. According to surface relief-forming agents in the region there is isolated erosive type of relief which is divided into two types:

a. *Rugged relief* - formed on tuffogenic rocks of Mid-Eocene. This type of relief is developed in the gorge of the middle belt course of the river Tsablaristskali where derivation pipeline Tsablari-HPP-2 will be driven;

b. *Medium-mountain intensively dissected relief* with relatively round crests, steep slopes and deep V-shaped gorges. This zone belongs to small, second order ridges coming out of the main branch of Akhaltsikhe-Imereti ridge and worked-out volcanic Mid-Eocene formations. One of the most branches in the region of the mountains Nabostnebi and Dorgnauli forks into three parts. *Western* – is Kvagrdzela ridge with absolute signs – 1632.6 cm and 1535.3 m and is watershed of the rivers Skurdula and Tsablaristskali; *Middle* – is watershed of the rivers Skurdula and Kurta; *Eastern* – is watershed of the rivers Khanistskali and Kershaveti.

Mentioned system of the branches is gradually lowering to the northern direction. Crests of these ridges are quite narrow, with the width about 100 m, but all round-shaped. Mountain sides are smooth. Accumulative relief, represented with the river above-bottomland terraces is limited in spreading. It is met at the rivers Khanistskali and Kershaveti in those places, which don't enter the working area.

V Hydrogeology

According to the lithological composition tuffogene strata doesn't give favorable conditions for accumulation of underground waters. It should be mentioned that from tuffogenic rocks tuffbreccias and tuffsandstones are mostly fractured in consequence of their heterogeneous composition but they don't give any of isolated independent water-bearing horizons.

Atmospheric precipitations play a leading part in feeding of underground waters of the sediments. Their feeding area is located in alpine zone where dislocated and fractured surface of the plateau are directly exposed or covered with deluvial-proluvial sediments, which often work as a good water storage reservoir.

Water circulation is mainly associated to the fractures but they often come on the surface out of ground-deluvial coverings. Usually these sources are descending with debit from 0.05 to 0.5 liter/sec sometimes more.

On conditions of steeply inclined slopes and heavy dissected relief, the basins are fast draining. Therefore, tuffogenic plateau doesn't conduct significant reserves of underground waters. From the analyses, it is seen that waters of Eocene volcanogenic rocks are slightly mineralized, hardness varies within unit degree, they contain insignificant quantity of sulphate and chlorine.

According to the chemical composition the waters belong to hydro-carbonate-calcium-magnesium type. Water temperature in summer fluctuates within 7 - 11°C.

Waters of deluvial-proluvial sediments. These sediments in different places are represented with clayey soils, clayey-breakstone and boulder-breakstone materials. Thank to friability of these sediments they are often water bearing. Water reserve in them is not high and depends on the areas of deluvial-proluvial sediments. In the sediments feeding affairs atmospheric precipitations and steam condensation play a major role. These horizons partly are fed with fractured waters of baserocks. In deluvial-proluvial mass they form water-bearing lenses which are crossed at the riverbeds of the river heads and give source with debit of about 2-5 liter/sec.

Often descending sources with debit of about 0.05-0.3 liter/sec come out from such basins on the surface. Debit of such sources is changeable. Waters of deluvial-proluvial sediments bedded on the sandstones or tuffogenic sediments of Eocene stage are potable and fresh waters.

Waters of alluvial sediments don't outcrop so their role in practical utilization is insignificant.

VI Engineering-Geological-Geotechnical Conditions

Intensity of revealing of the recent geological processes, complications of geological-engineering conditions generally depend on lithological-petrographic peculiarities of the textural rocks and afterwards on different natural conditions. So, the study of geological-engineering conditions of the study area was conducted based on formation (lithological-genetic) principles, in accordance which the integration of geological-engineering complexes of the rocks having close geneses and compositions was carried out.

Middle Eocene volcanogenic formations of the north slope of Adjara-Imereti ridge in consequence of lithological peculiarities are divided into three suites: Lower suite – layered variegated tuffogenes (₽$_2^{2L}$), middle suite – tuff-breccias (₽$_2^{2M}$) and upper suite – trachyte-tuffs.

Because the project hydrotechnical constructions, such as derivation pipelines, head buildings over the HPP, control reservoir and others are going to build in the territory of only one – middle tuff-breccias suite (₽$_2^{2M}$) the only one lithological-genetic complex is determined in the study area, this is – **Middle Eocene Middle Suite Lithological-genetic Complex.**

The rocks of the complex are represented with the following varieties, such as:

Tuff-breccias – massive, coarse-layered, different colors. Consists of porphyrites, basalts, sandstones, andesites different sized scree debris cemented with tuff materials;

Lava-breccias – mostly coarse fragmented, and often is represented with large boulders (blocks) which diameter reaches 3 m. Lavabreccias consist of porphyrites, andesites and basalts;

Tuff-sandstones are greenish-gray, sometimes gray and yellowish-gray, different grained, cementing materials are represented with tuffogenic pelitic mass. The rock is strong, rocky and waterproof. Tuff-sandstone strength is decreasing with 50 % in weathering zone; the intense fracturing is typical for the rocks. The fractures are mainly filled up with calcite and clay.

Tuff-conglomerates start from greenish-gray to dark gray; thick layered, massive, and consists of round and angular-shaped fragments of limestones, also fragments of tuff-sandstones, marls and effusive rocks. The sizes of the fragments vary within 0.5-30 cm. The fragments are strictly consolidated/cemented with tuffogenic materials; the rocks are hard, strong and water-resistant; belongs to the Rocky Mass Class.

Tuffs – are from gray to light gray, greenish-gray, sometimes variegated; texture is psammitic. Tuff consists of fragments of basic mass of clayey and chloritized effusive, porphyrite plagioclase, biotite, andesite, augite and other minerals microlites.

Porphyrites – are light color, bluish-grayish and dark green; porphyry texture. The basic mass consists of chloritized and limonitized basis and plagioclase rare microlites. Porphyrites are dense, massive, various-grained, solid and waterproof.

Andesites – are dark gray, sometimes black; porphyry texture. Dense, massive, strong, and belong to Rocky Mass Class.

Basalts – are gray and dark gray, and also black; dense, massive, strong and belong to Rocky Mass Class.

Diabases – are greenish – gray, dense, strong, water resistant. They belong to Rocky Mass Class.

We meet porphyrites, andesites, basalts and diabases in forms of separate cover-layer which thickness reaches 7-12 m also in forms of low thickness layers in packs in alternation of different rocks.

Physical-technical properties of the above-listed rocks are given in Table # 1.

As it was mentioned there are no tectonic faults within the study area, and the zones of heavy, numerous, deep fractures are not observed either. In spite of this, the rocks of volcanic formations are characterized with quite intense fracturing. The fractures are exogenic, on surface and different directional. Different rocks are characterized with different fractures and porosity, consequently their water bearing characters are different. Tuff-breccias and lava-breccias are abounding in waters with about 0.1 and 1.2 liter/sec. The waters are unpressured, fractured-porous; mineralization is low - 0.1-0.3 gr/liter, hydrocarbonate-calcium-natrium (sodium) composition.

The waters in tuffs and tuff-sandstones are unpressured, hydrocarbonate-calcium type. Flow of the springs coming out from them reaches 0.1-1.0 liter, sometimes more. The water mineralization is low.

Water content in porphyrites and erupted rocks that are represented in forms of cover-layers in volcanogenic formations varies within 0.5-0.9 liter/sec. Mineralization is increasing together with the depth and reaches 0.5-0.6 gr/liter. The waters are low pressured. From the exogenic processes, the most expected are the stone-falling at the expense of gravity of destroyed materials accumulated on the bottom of the slope and the rock-avalanches with less probability. There are not observed any of centers for development of other disastrous exogenic phenomena within the study area besides the accumulated huge mass of destroyed rocks existed out of the boundaries of the study area located at the heads of the Sakalmakheti – the right affluents of the river Tsablaristskali, in the bottom of the peak Usakhelo at 2228.1 m. Area of accumulation, as it is seen from archive materials covers about 800 ha and during the long lasting heavy rains this mass is possible to move and run though the steeply inclined riverbed and attack the buildings of Tsablari – 2 HPP.

According to morphometric zoning (500-1500m) the study region belongs to foot, low mountain and low-medium-mountain zone. According to the riverbed horizontal inclined angle (5-11°m) the rivers belong to those group that is characterized with the riverbed deep cutoff and the sediments transit accumulation.

The region according to the horizontal dissection of the territory belongs to moderate 1-2.5 km/km^2 region. Study area relief peculiarities, existence of tectonic dislocations in the territory, volcanogenic rocks physical-technical properties and other factors stipulated quaternary formations limited distribution and low thickness within the working area; consequently, lithological-genetical complex of the quaternary sediments can't be determined.

VII Conclusions and Recommendations

Study area enters the medium and the high mountain tectomorphic-erosive-denudative relief zone of the middle part of Meskheti ridge north slope, the sub-region of volcanogenic formations.

The only Middle-Eocene volcanogenic formations participate in the study area geological construction. In consequence of this, the rocks of only one lithological-genetic complex are determined within the target. Due to limited spreading of quaternary rocks and low thickness of sediments, the lithological-genetic complex of this formation was not determined. The rocks of lithological-genetic complex of Middle-Eocene volcanogenic formations are known with high hardness. Generally, they belong to Rocky Mass Group. Besides some of their weathered varieties, all above described create favorable conditions for building of low hydro power plants, derivation pipelines, head buildings over the HPP and for other auxiliary communications and also further exploitation. As for the rocks water-bearing nature, it is low due to existence of deep and numerous fractures.

Huge accumulation of destroyed rocks existed out of the boundaries of the study area poses a threat for head buildings over Tsablari – 2 HPP as a source for origination of mudflows. It needs detailed study at the further phase.

It should be mentioned that, no special geological-engineering works were carried out within the working area besides the 1:200,000 scale work, which gives different data due to the target small-scale; therefore at the further phase some detailed works should be carried out not only within the territory of communications but out of its boundaries, in the gorges of the affluents of the rivers Tsablaristskali and Khanistskali, from the junction to the heads, to avoid disastrous exogenic processes (such as mudflows, avalanches) during the unfavorable climatic or other conditions.

In Baghdati and its neighborhoods there are known deposits of building materials (such as brick, clay, sand-gravel building materials). According to the complexity of geological-engineering conditions the study area belongs to the II category (medium complexity). The study area is located in 8 magnitude seismic zone according to the present seismic zoning scheme of Georgia.

LEGEND

a. Exogenic geological processes

მეწყერები – Landslides

რთული მეწყერი – Complicated landslide

ქვათაცვენა – Stone-fall

გვერდითი ეროზია – Side erosion

სიღრმული ეროზია – Deep erosion

გამოზიდვის კონუსი – Alluvial cone

სიბრტყითი გადარეცხვა – Surface washout

წყაროს № - Spring Number

დებიტი- Debit

b. Other signs

საზღვარი მეოთხეული ასაკის სხვადასხვა ტიპებს შორის – Boundaries between quaternary stage different genetic types

საზღვარი სხვადასხვა ასაკის საინჟინრო-გეოლოგიურ კომპლექსებს შორის – Boundaries between different aged engineering-geological complexes

საზღვარი თანაბარი ასაკის სხვადასხვა ლითოლოგიური შემადგენლობის მქონე ქანებს შორის – Boundaries between the equal aged rocks of different lithological compositions

ტექტონიკური რღვევები - Tectonic faults

LEGEND

Section on the line 1-1

Anticline axis

Syncline axis

Tectonic fault

Section on derivation tunnel

₽ $_2^2$mh Makhuntseti Suite – fine-fragmented, thin-layered tuffs, tuffbreccias, lavas

₽ $_2^2$cd$_2$ Chidila Suite – Lower sub-suite – massive lavabreccias and tuffbreccias with fine-grained tuffs and lava interlayers

₽ $_2^2$cd$_1$ Chidila Suite – Upper sub-suite – massive lavas, delenitic lense-like coverings and tuffs

₽ $_2^2$ng$_3$ Naghvarevi Suite– Upper sub-suite – tuffbreccias and tuffs with lava interlayers

₽ $_2^2$ng$_2$ Naghvarevi Suite– Middle sub-suite – coarse-fragmented tuffs, fine-grained tuffs and lavas

₽ $_2^2$ng$_1$ Naghvarevi Suite– Lower sub-suite – thin-layered, fine-grained pelitic tuffs and tuff-sandstones

Rocks physical-technical properties

Table # 1

Rock Name	Vol. Weigh. Kg/m3	Waterabsor. %	Ultimate strength in compression Kg/cm2		Softening coefficient	Ultimate strength after freezing Kg/cm2	Frost-resistant coefficient	Hardness coefficient	Accumulation category	Porosity %
			Air-dry condit.	After waterabsor.						
Tuffbreccias										
Fresh	2510	2.75	1263	895	0.71	650	0.72	>	VII	-
Weathered	2464	3.61	392	281	0.71	277	0.98	-	-	-
Lavabreccias	2630	3.58	909	885	0.97	-	-	-	-	-
Tuffconglomerates										
Fresh	2790	-	1670	1600	0.96	-	-	>	V	-
Unweathered	2435	-	1510	470	-	-	-	-	-	
Tuffs										
Fresh	2614	4.91	1177	1034	0.89	966	0.93	6	XII	-
Unweathered	2464	4.37	522	431	0.83	284	0.66	-	-	-
Tuffsandstones										
Fresh	2780	0.2	1700	1500	0.98	1400	0.93	6	-	0.6
Unweathered	2700	0.1	840	820	0.97	700	-	-	VII	0.5
Porphyrites										
Fresh	2699	1.39	1050	1024	0.98	843	0.83	15	XIII	
Unweathered	2420	3.77	384	305	0.80	224	0.73	10	X	
Diabases										
Fresh	2700	0.2	2800	2000	0.72	-	0.99	10	-	0.5%
Unweathered	2640	0.3	1500	1400	-	-	-	-	-	0.6%
Basalts										
Fresh	2670	1.3	1500	1300	0.86	1235	0.94	12	-	0.75%
Unweathered	2545	1.1	1020	810	0.79	800	-	9		2.77%
Andesites										
Fresh	2800	0.3	2900	2500	0.86	2645	1.03	10	-	
Unweathered	2700	0.7	1200	880	0.73	800	0.9	6	-	

Geological and Engineering-Geological Description of the Rocks Spread Over the Study Area

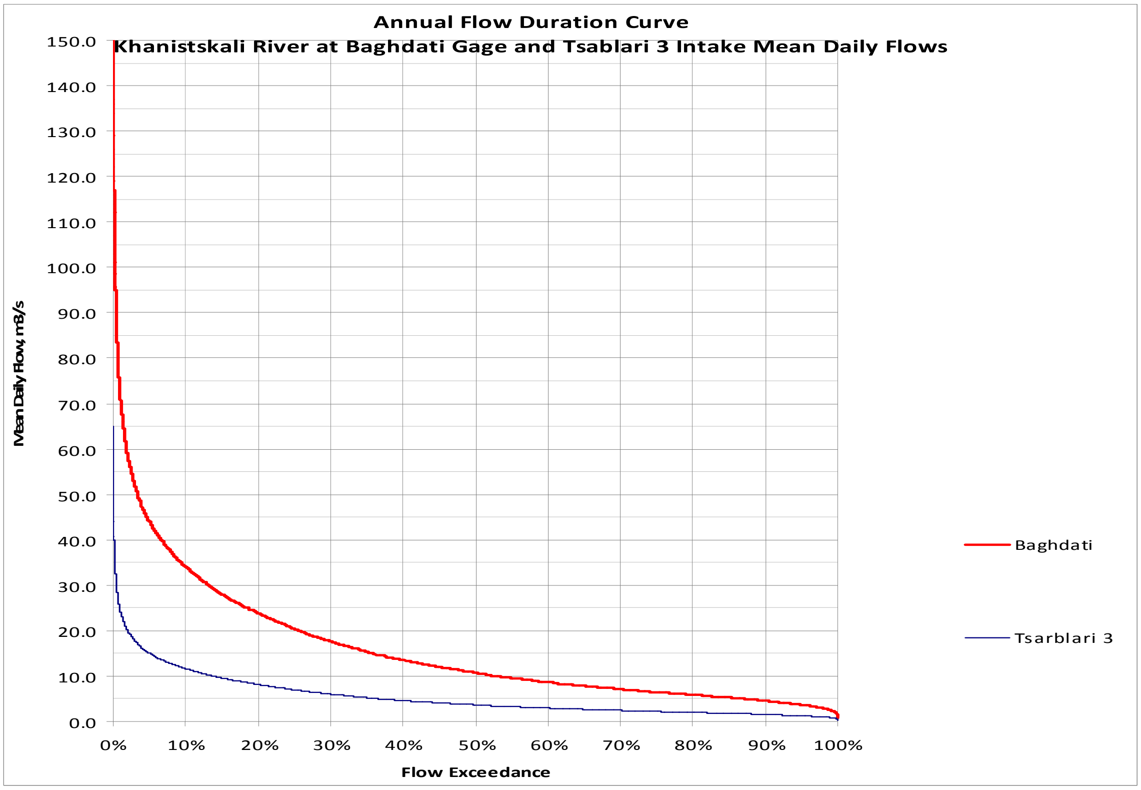
Structural Stage	Geotectonic. Unit	Formation	Rocks Lithological-genetic Complex.	Rocks complex geol. index	Rocks complex engineering-geological group		Rocks Physical Technical Properties			
					Semi-rocky	Rocky	Density in natural condition kg/m^3	Coefficient of hardness according to Protodiakonov kg/cm^2	Processing category	Uniaxial compression temporarily strength
Alpine	Adjara-Trialeti Folded System	Volcanogenic	Mid-Eocene Middle Suite Lithological-Genetic Complex	₽$_2^2$						
	Central Zone		Tuffbreccia, lavabreccia Tuffconglomerate			□	2510-2790	6-7	VIII -	700
			Weathered		□		2435-2464	-	-	
			Tuff, tuff-sandstone			□	2714-2780	6-6	XII VII	70
			Weathered		□		2464-2700	-	-	
			Porphyrite, basalt			□	2670-2696	9-15	X- XII -	1000
			Andesite, basalt			□	2700-2800	6-10 -	- - -	1000 600
			Weathered			□	2700-2640	-	-	

Appendix 2

Monthly and Annual Flow Duration Curves

Note related to this Appendix:

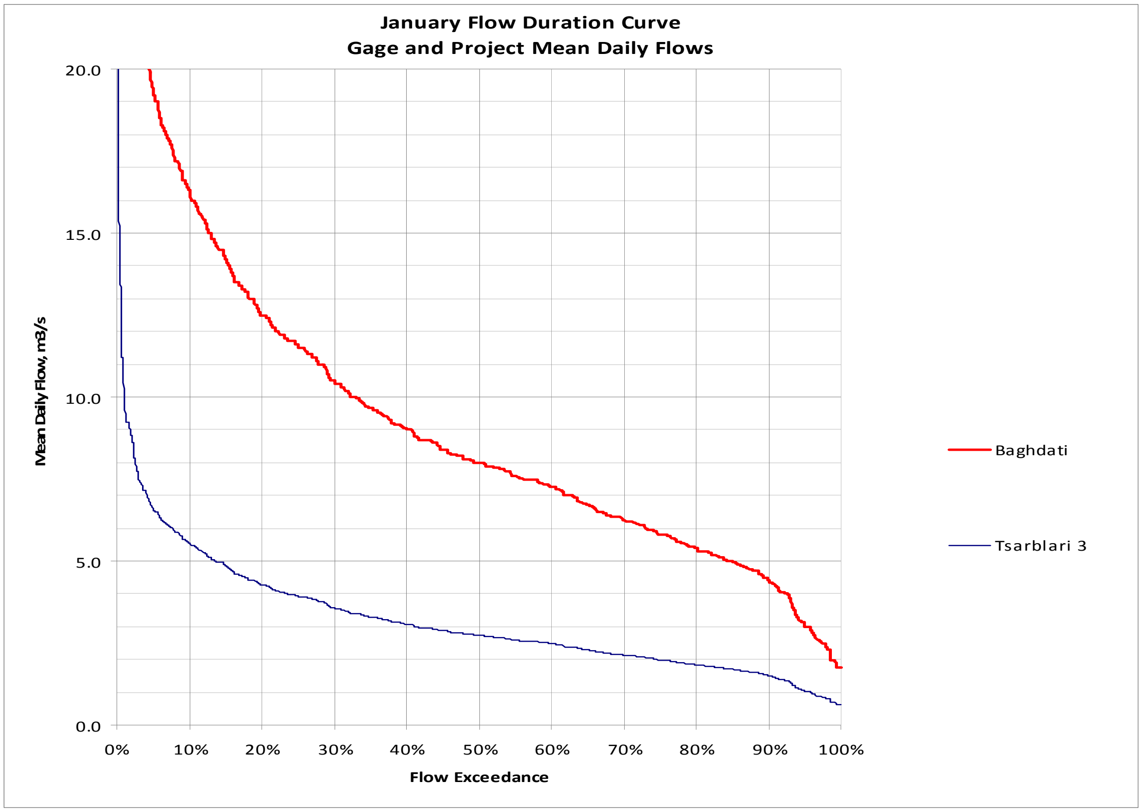
The generation tables following each Flow Duration Curve represent a conservative selection of input data and, therefore, a conservative analysis for monthly and annual HPP generation using this methodology.



Annual.

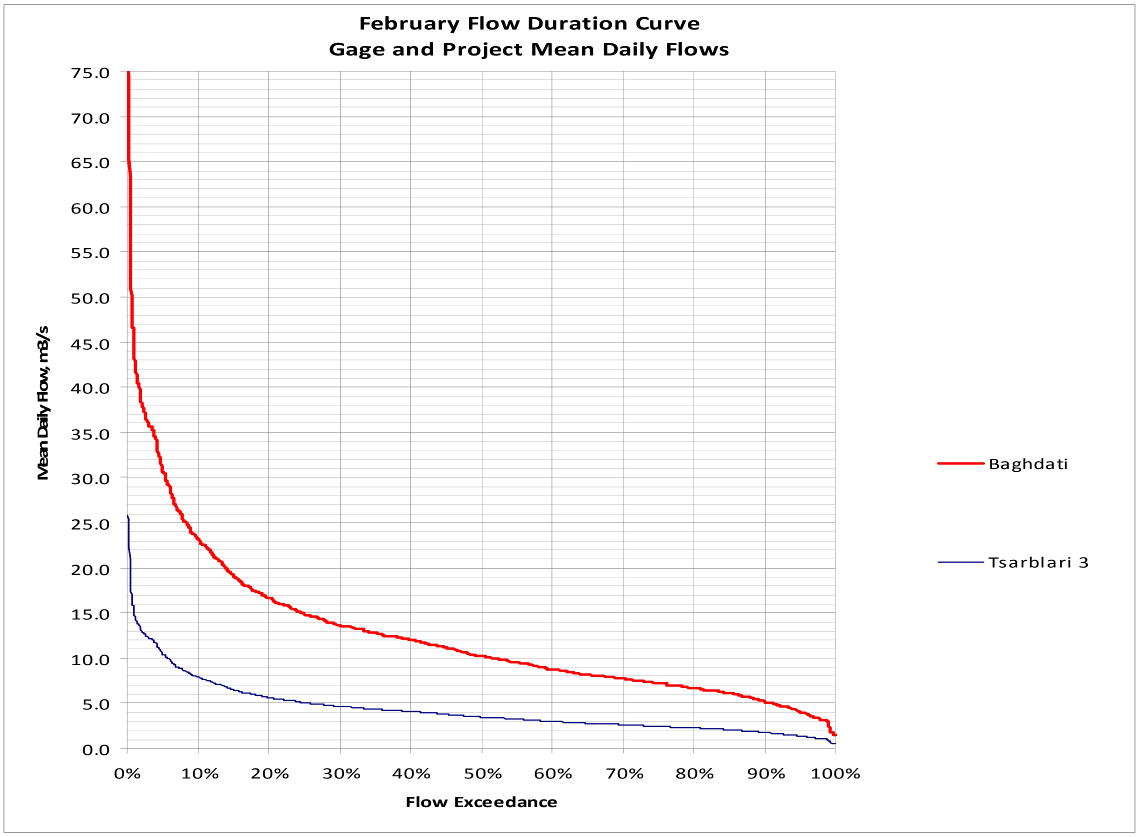
Area under Adjusted Flow Duration Curve in CMS-Hrs	47,492
Select Discharge equal to or exceeded % For HPP	16.24%
Equivalent Total Turbine Discharge at Selected CF in CMS	9.19
Non-useable portion of FDC at selected CF or Exceedance %	7435
Gross Available CMS-HRS for Generation at selected CF	40,058
Annual Average Daily Discharge in CMS	5.42
Select Env/Sanitary Flow as a % of Monthly Avg Dalily Discharge	5%
Environmental/Sanitary Flow in CMS	0.27
Non-useable Environmental/Sanitary CMS-HRS	2,332
Net CMS-HRS Available for Generation	37,726
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	240
Gross Head for Generation in Meters	131
Length of Penstock/Pipeline/tunnel in Km	6
Head Loss (from daily head loss calculation average) in Meters	2.79
Net Head for Generation in Meters	128.21
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Annual Generation in MWH	40,315

Monthly Summary of FDC Generation based on % Exceedance and Average HPP Unit Efficiency				
Month	Exceedance %	Equivalent Discharge in CMS	Estimated Av Monthly Efficiency	Average Monthly Energy in MWH
Jan	2%	9.23	85%	2,270
Feb	7%	9.23	85%	2,656
Mar	25%	9.21	85%	4,227
Apr	59%	9.21	85%	5,843
May	58%	9.21	85%	6,365
Jun	16%	9.21	85%	4,415
Jul	4%	9.16	85%	2,876
Aug	2%	9.06	85%	2,098
Sep	1%	9.28	85%	1,746
Oct	1%	9.23	85%	2,362
Nov	6%	9.17	85%	2,623
Dec	7%	9.17	85%	2,637
Annual Average Values	16%	9.20	85%	
FDC Summed Annual Average Generation				40,120



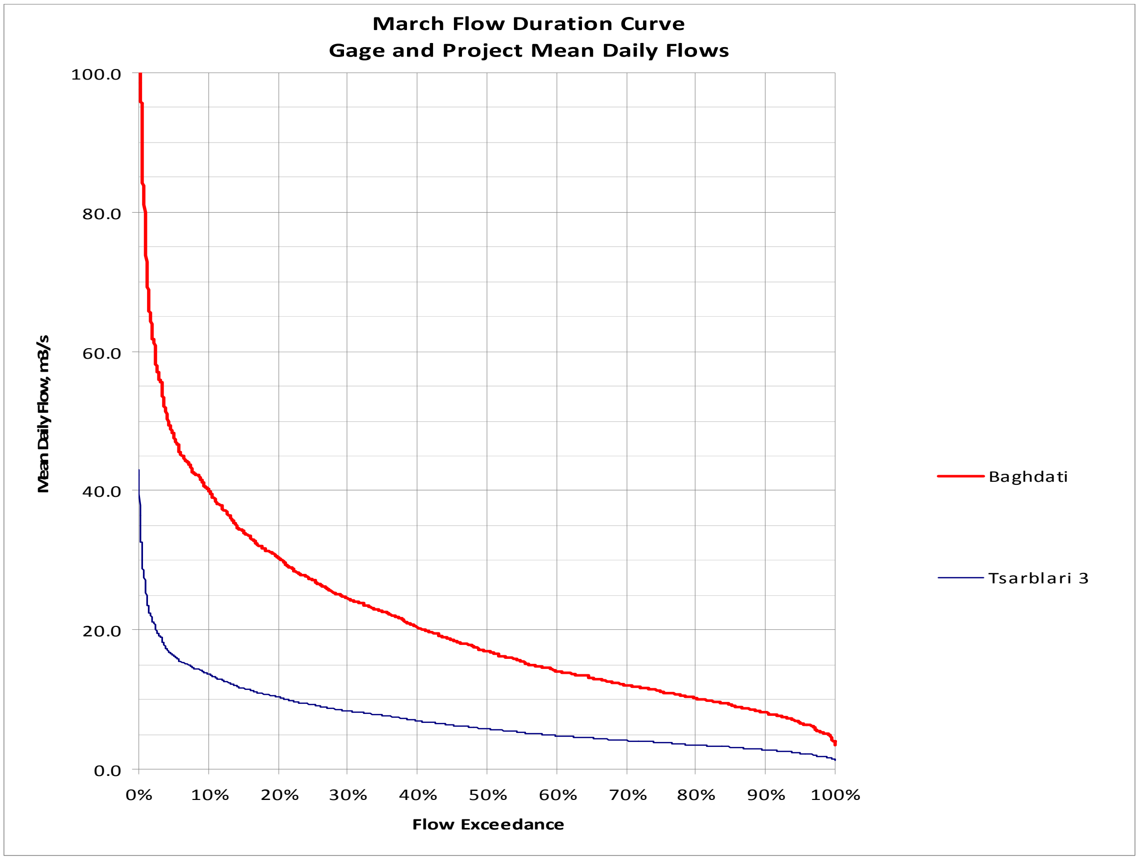
January

Area under Adjusted Flow Duration Curve in CMS-Hrs	2,393
Select Discharge equal to or exceeded % For HPP	1.73%
Equivalent Total Turbine Discharge at Selected CF in CMS	9.23
Non-useable portion of FDC at selected CF or Exceedance %	29
Gross Available CMS-HRS for Generation at selected CF	2,364
Monthly Average Daily Discharge in CMS	3.23
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	240
Net CMS-HRS Available for Generation	2124
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	240
Gross Head for Generation in Meters	131
Length of Penstock/Pipeline/tunnel in Km	6
Head Loss (from daily head loss calculation average) in Meters	2.79
Net Head for Generation in Meters	128.21
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	2,269,659
MWh	2,270



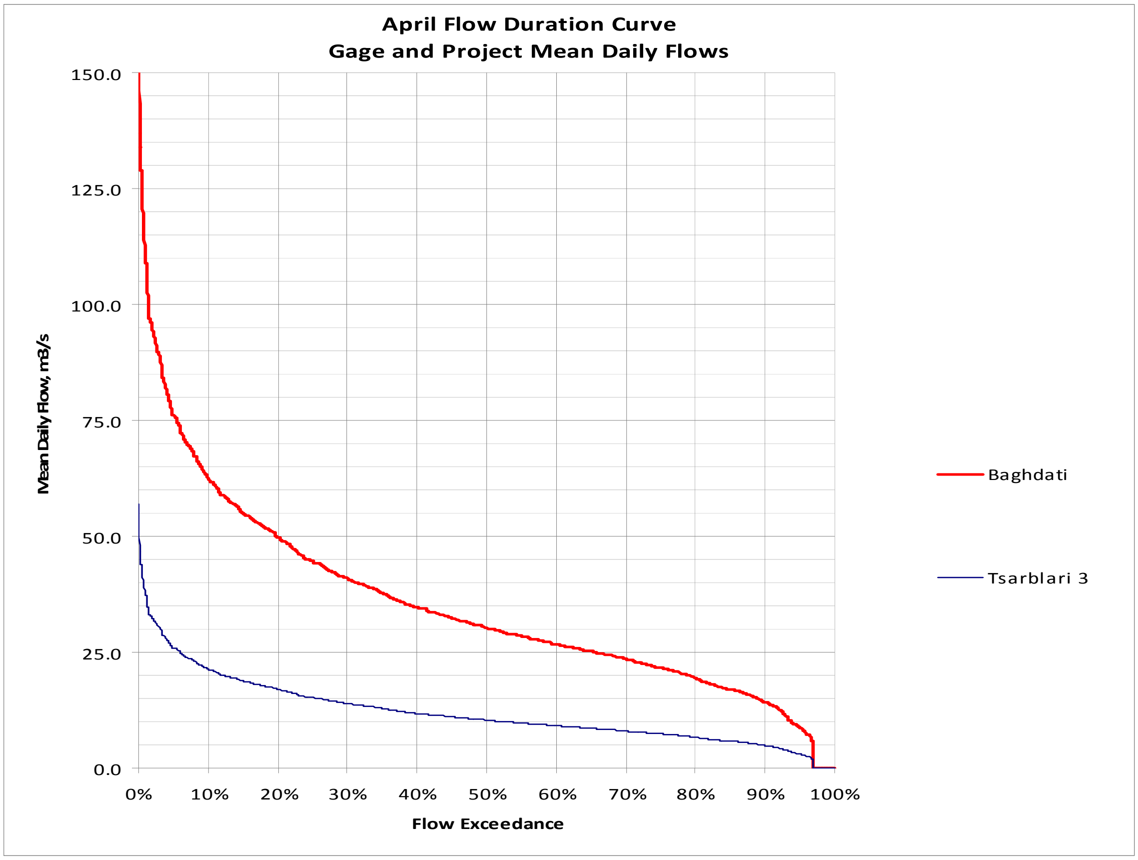
February

Area under Adjusted Flow Duration Curve in CMS-Hrs	2,900
Select Discharge equal to or exceeded % For HPP	6.95%
Equivalent Total Turbine Discharge at Selected CF in CMS	9.23
Non-useable portion of FDC at selected CF or Exceedance %	149
Gross Available CMS-HRS for Generation at selected CF	2,751
Monthly Average Daily Discharge in CMS	4.32
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	10%
Environmental/Sanitary Flow in CMS	0.39
Non-useable Environmental/Sanitary CMS-HRS	265
Net CMS-HRS Available for Generation	2486
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	240
Gross Head for Generation in Meters	131
Length of Penstock/Pipeline/tunnel in Km	6
Head Loss (from daily head loss calculation average) in Meters	2.79
Net Head for Generation in Meters	128.21
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	2,656,471
MWh	2,656



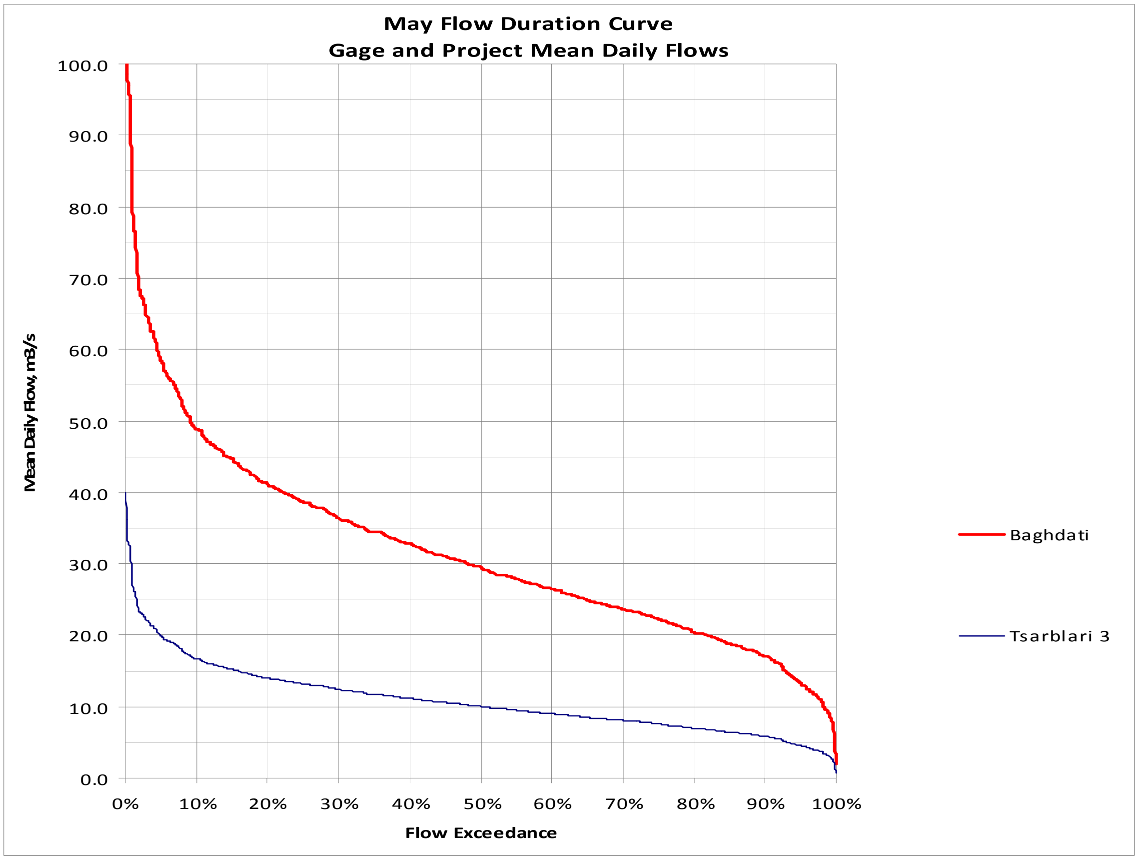
March

Area under Adjusted Flow Duration Curve in CMS-Hrs	5,377
Select Discharge equal to or exceeded % For HPP	25.40%
Equivalent Total Turbine Discharge at Selected CF in CMS	9.21
Non-useable portion of FDC at selected CF or Exceedance %	883
Gross Available CMS-HRS for Generation at selected CF	4,494
Monthly Average Daily Discharge in CMS	7.24
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	10%
Environmental/Sanitary Flow in CMS	0.72
Non-useable Environmental/Sanitary CMS-HRS	539
Net CMS-HRS Available for Generation	3956
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	240
Gross Head for Generation in Meters	131
Length of Penstock/Pipeline/tunnel in Km	6
Head Loss (from daily head loss calculation average) in Meters	2.79
Net Head for Generation in Meters	128.21
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	4,227,200
MWh	4,227



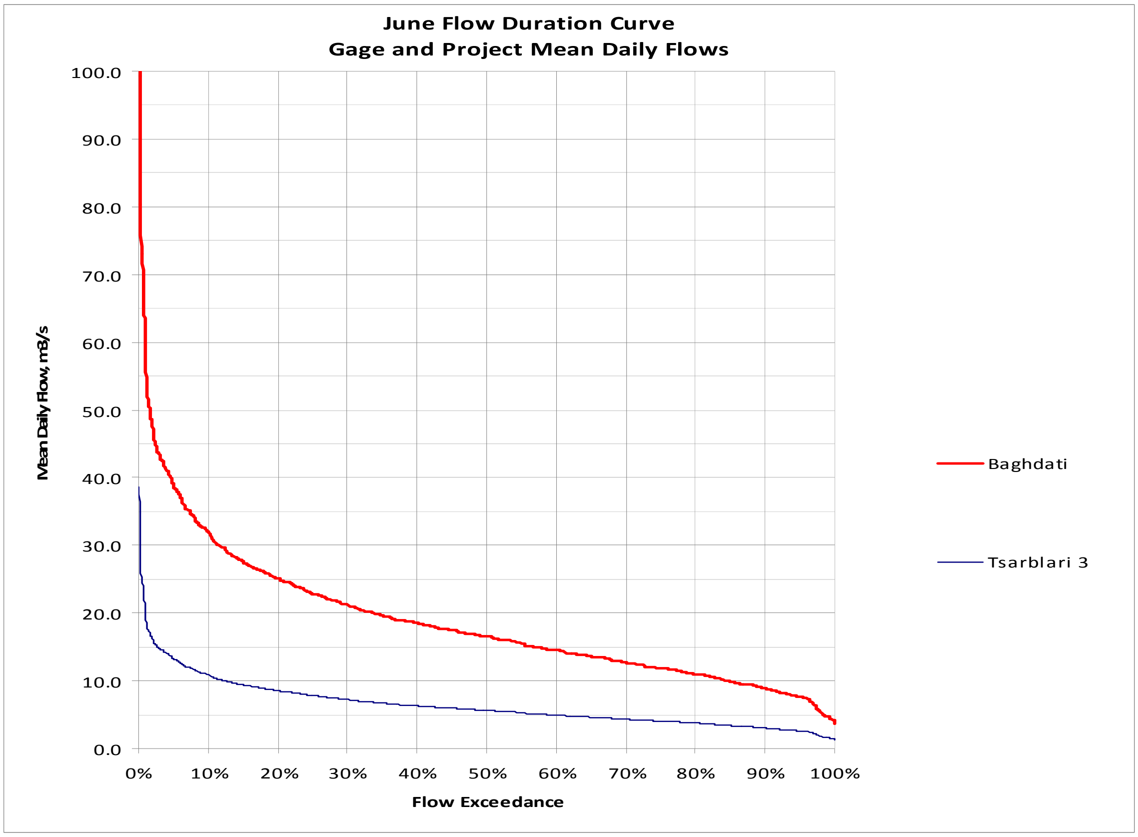
April

Area under Adjusted Flow Duration Curve in CMS-Hrs	8,640
Select Discharge equal to or exceeded % For HPP	59.40%
Equivalent Total Turbine Discharge at Selected CF in CMS	9.21
Non-useable portion of FDC at selected CF or Exceedance %	2920
Gross Available CMS-HRS for Generation at selected CF	5,720
Monthly Average Daily Discharge in CMS	12.42
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	3%
Environmental/Sanitary Flow in CMS	0.35
Non-useable Environmental/Sanitary CMS-HRS	252
Net CMS-HRS Available for Generation	5468
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	240
Gross Head for Generation in Meters	131
Length of Penstock/Pipeline/tunnel in Km	6
Head Loss (from daily head loss calculation average) in Meters	2.79
Net Head for Generation in Meters	128.21
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	5,843,438
MWh	5,843



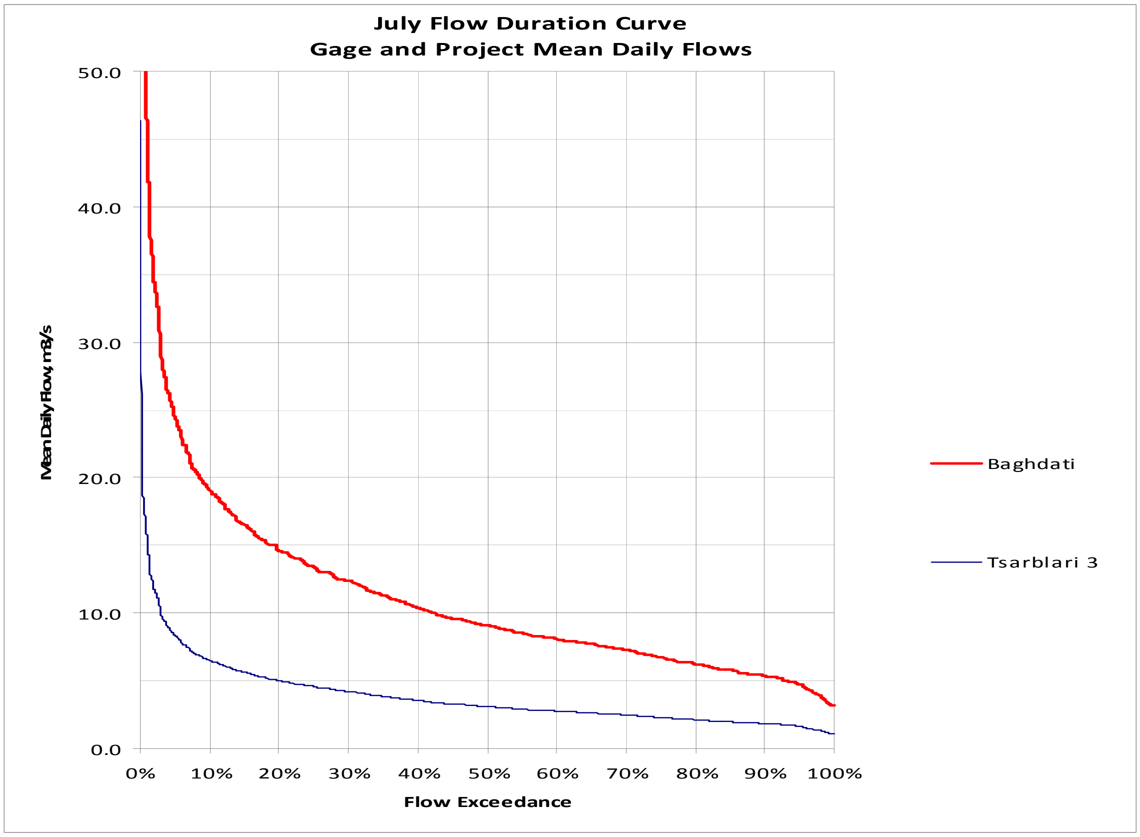
May

Area under Adjusted Flow Duration Curve in CMS-Hrs	8,069
Select Discharge equal to or exceeded % For HPP	58.36%
Equivalent Total Turbine Discharge at Selected CF in CMS	9.21
Non-useable portion of FDC at selected CF or Exceedance %	1951
Gross Available CMS-HRS for Generation at selected CF	6,118
Monthly Average Daily Discharge in CMS	10.86
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	2%
Environmental/Sanitary Flow in CMS	0.22
Non-useable Environmental/Sanitary CMS-HRS	162
Net CMS-HRS Available for Generation	5,956
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	240
Gross Head for Generation in Meters	131
Length of Penstock/Pipeline/tunnel in Km	6
Head Loss (from daily head loss calculation average) in Meters	2.79
Net Head for Generation in Meters	128.21
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	6,365,316
MWh	6,365



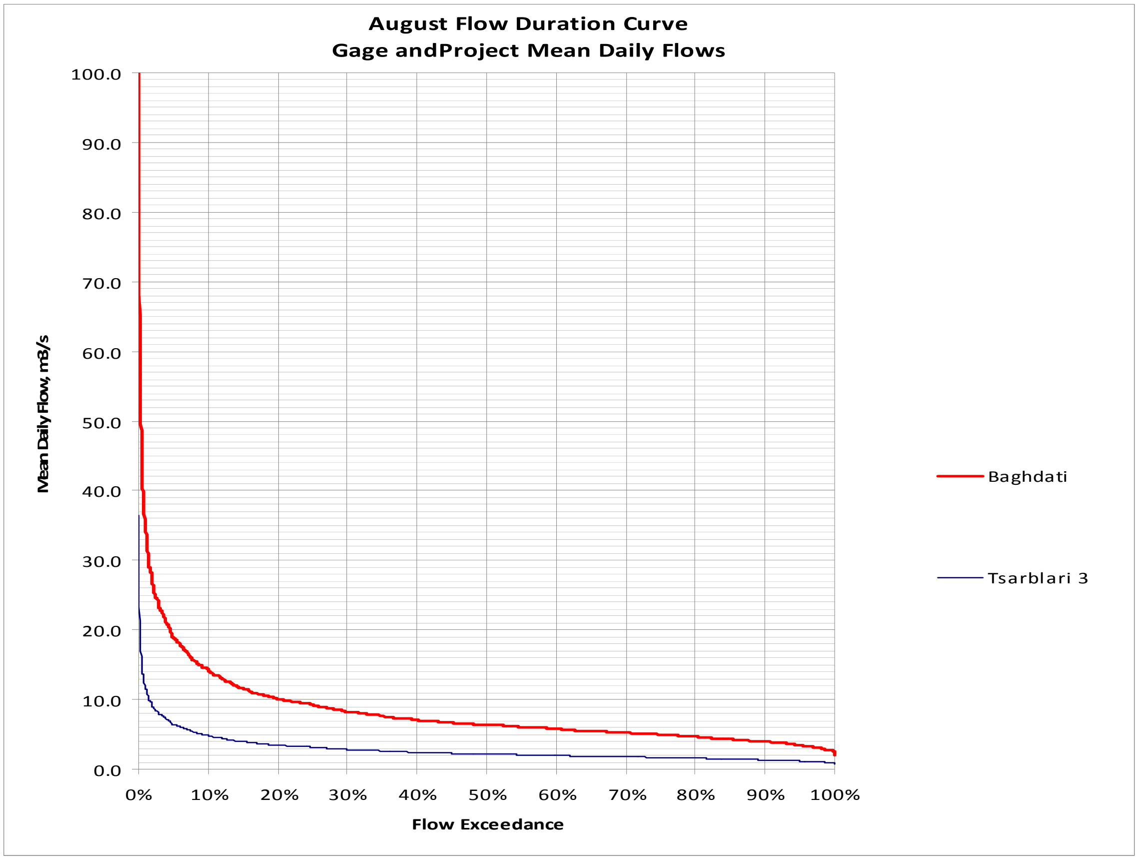
June

Area under Adjusted Flow Duration Curve in CMS-Hrs	4,630
Select Discharge equal to or exceeded % For HPP	16.00%
Equivalent Total Turbine Discharge at Selected CF in CMS	9.21
Non-useable portion of FDC at selected CF or Exceedance %	409
Gross Available CMS-HRS for Generation at selected CF	4,221
Monthly Average Daily Discharge in CMS	6.44
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	2%
Environmental/Sanitary Flow in CMS	0.13
Non-useable Environmental/Sanitary CMS-HRS	90
Net CMS-HRS Available for Generation	4,131
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	240
Gross Head for Generation in Meters	131
Length of Penstock/Pipeline/tunnel in Km	6
Head Loss (from daily head loss calculation average) in Meters	2.79
Net Head for Generation in Meters	128.21
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	4,414,781
MWh	4,415



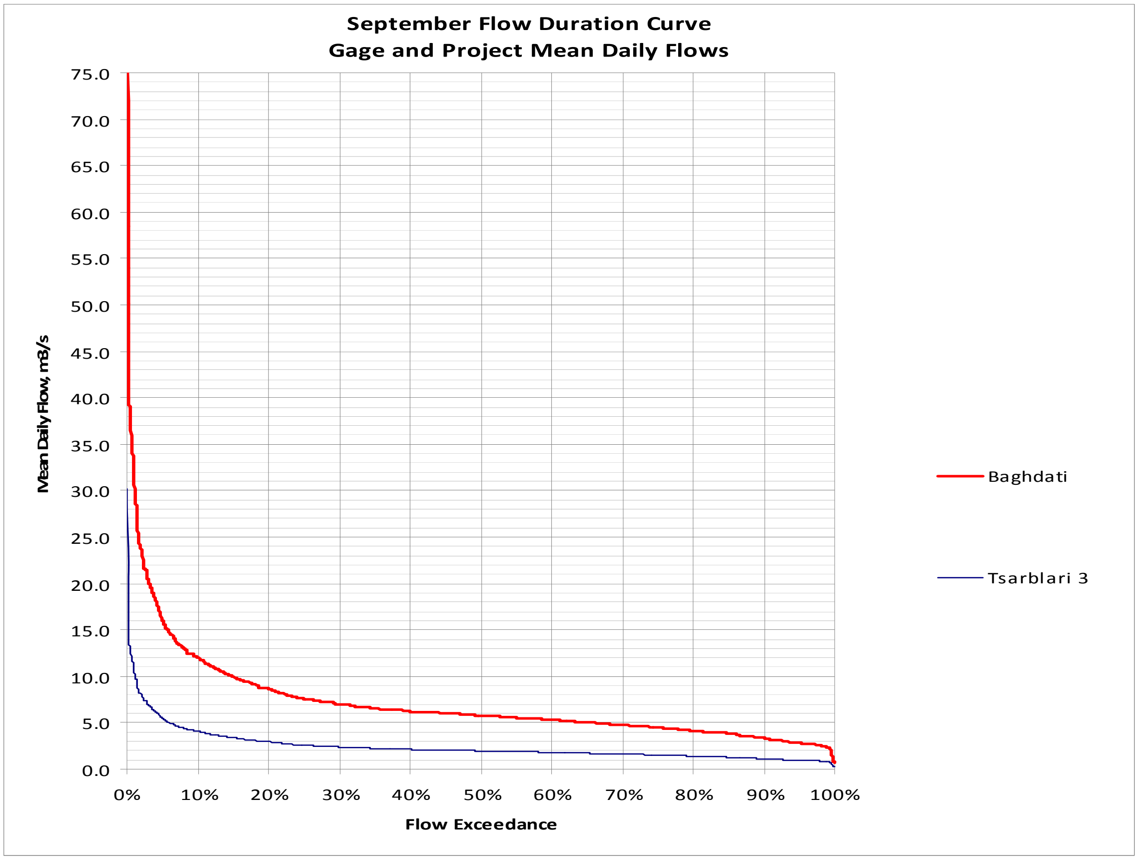
July

Area under Adjusted Flow Duration Curve in CMS-Hrs	2,863
Select Discharge equal to or exceeded % For HPP	3.80%
Equivalent Total Turbine Discharge at Selected CF in CMS	9.16
Non-useable portion of FDC at selected CF or Exceedance %	114
Gross Available CMS-HRS for Generation at selected CF	2,749
Monthly Average Daily Discharge in CMS	3.86
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	2%
Environmental/Sanitary Flow in CMS	0.08
Non-useable Environmental/Sanitary CMS-HRS	57
Net CMS-HRS Available for Generation	2,692
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	240
Gross Head for Generation in Meters	131
Length of Penstock/Pipeline/tunnel in Km	6
Head Loss (from daily head loss calculation average) in Meters	2.79
Net Head for Generation in Meters	128.21
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	2,876,266
MWh	2,876



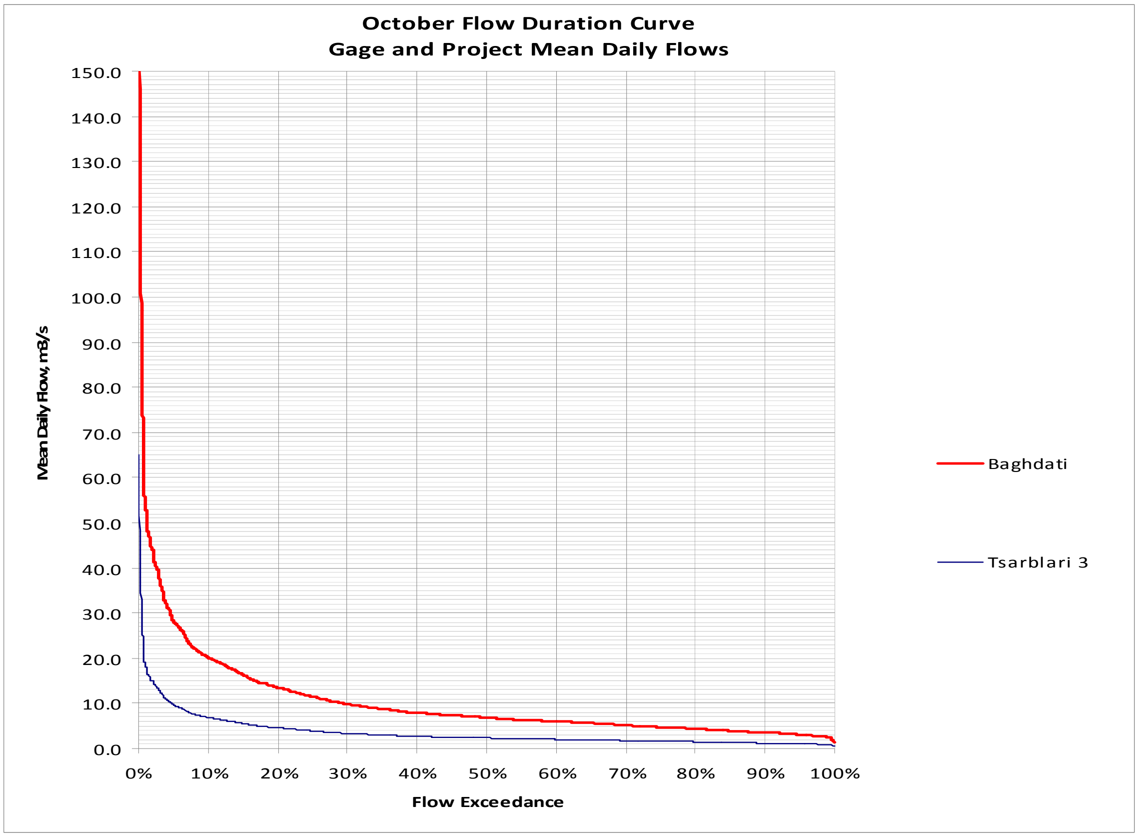
August

Area under Adjusted Flow Duration Curve in CMS-Hrs	2,083
Select Discharge equal to or exceeded % For HPP	2.10%
Equivalent Total Turbine Discharge at Selected CF in CMS	9.06
Non-useable portion of FDC at selected CF or Exceedance %	57
Gross Available CMS-HRS for Generation at selected CF	2,026
Monthly Average Daily Discharge in CMS	2.81
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	3%
Environmental/Sanitary Flow in CMS	0.08
Non-useable Environmental/Sanitary CMS-HRS	63
Net CMS-HRS Available for Generation	1963
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	240
Gross Head for Generation in Meters	131
Length of Penstock/Pipeline/tunnel in Km	6
Head Loss (from daily head loss calculation average) in Meters	2.79
Net Head for Generation in Meters	128.21
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	2,098,096
MWh	2,098



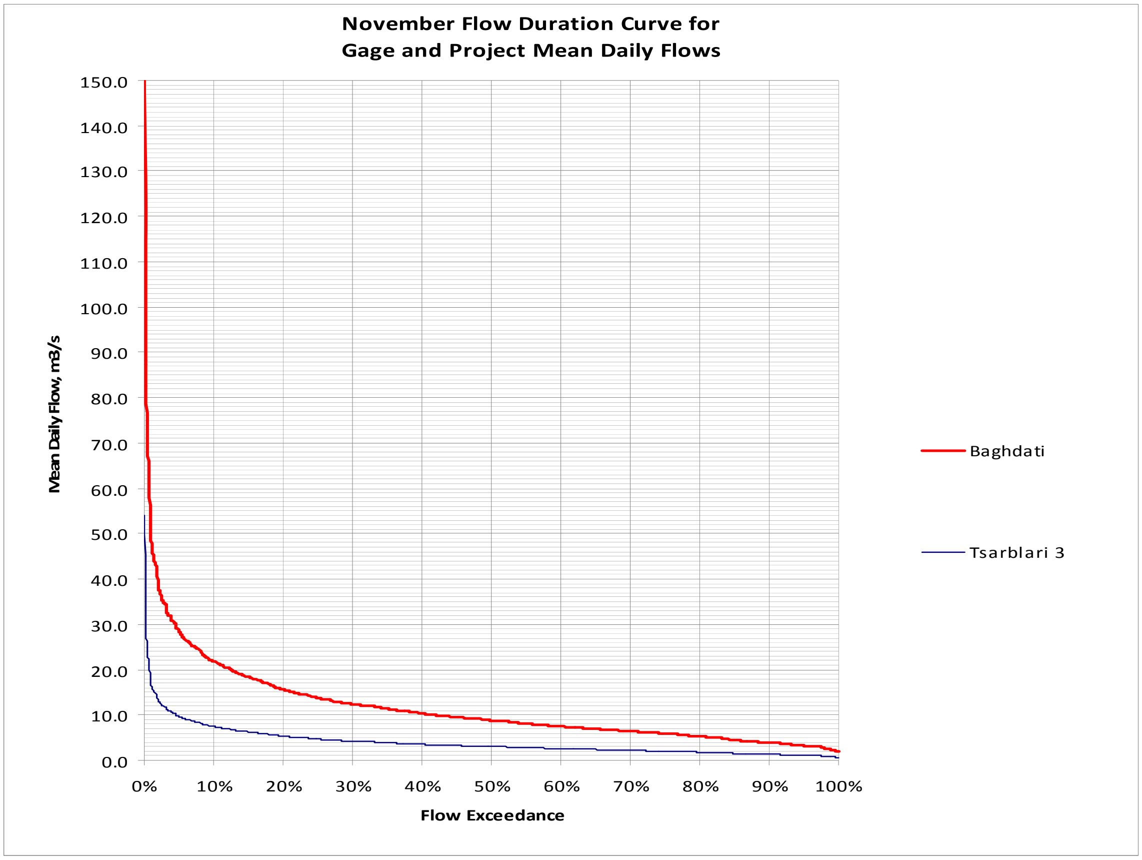
September

Area under Adjusted Flow Duration Curve in CMS-Hrs	1,747
Select Discharge equal to or exceeded % For HPP	1.45%
Equivalent Total Turbine Discharge at Selected CF in CMS	9.28
Non-useable portion of FDC at selected CF or Exceedance %	28
Gross Available CMS-HRS for Generation at selected CF	1,719
Monthly Average Daily Discharge in CMS	2.44
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	5%
Environmental/Sanitary Flow in CMS	0.12
Non-useable Environmental/Sanitary CMS-HRS	85
Net CMS-HRS Available for Generation	1634
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	240
Gross Head for Generation in Meters	131
Length of Penstock/Pipeline/tunnel in Km	6
Head Loss (from daily head loss calculation average) in Meters	2.79
Net Head for Generation in Meters	128.21
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	1,746,156
MWh	1,746



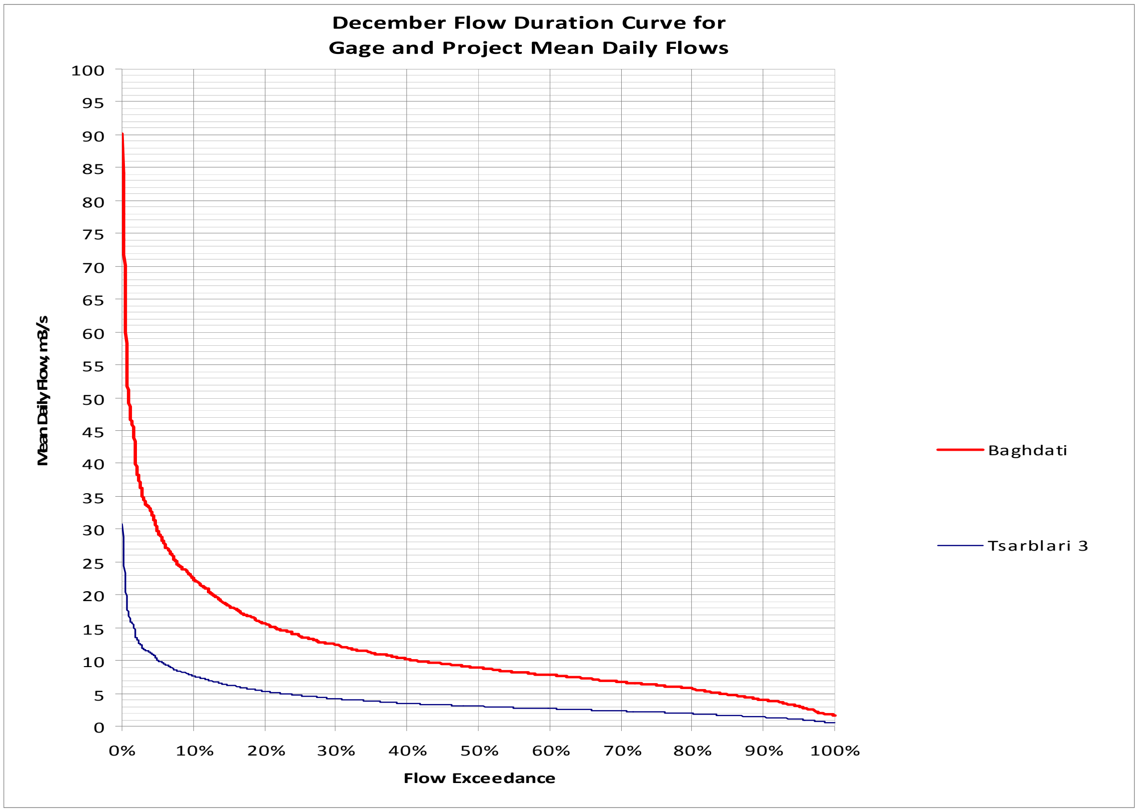
October

Area under Adjusted Flow Duration Curve in CMS-Hrs	2,640
Select Discharge equal to or exceeded % For HPP	5.79%
Equivalent Total Turbine Discharge at Selected CF in CMS	9.23
Non-useable portion of FDC at selected CF or Exceedance %	270
Gross Available CMS-HRS for Generation at selected CF	2,369
Monthly Average Daily Discharge in CMS	3.57
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	6%
Environmental/Sanitary Flow in CMS	0.21
Non-useable Environmental/Sanitary CMS-HRS	159
Net CMS-HRS Available for Generation	2210
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	240
Gross Head for Generation in Meters	131
Length of Penstock/Pipeline/tunnel in Km	6
Head Loss (from daily head loss calculation average) in Meters	2.79
Net Head for Generation in Meters	128.21
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	2,361,797
MWh	2,362



November

Area under Adjusted Flow Duration Curve in CMS-Hrs	2,834
Select Discharge equal to or exceeded % For HPP	5.85%
Equivalent Total Turbine Discharge at Selected CF in CMS	9.17
Non-useable portion of FDC at selected CF or Exceedance %	186
Gross Available CMS-HRS for Generation at selected CF	2,647
Monthly Average Daily Discharge in CMS	3.95
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	7%
Environmental/Sanitary Flow in CMS	0.27
Non-useable Environmental/Sanitary CMS-HRS	193
Net CMS-HRS Available for Generation	2455
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	240
Gross Head for Generation in Meters	131
Length of Penstock/Pipeline/tunnel in Km	6
Head Loss (from daily head loss calculation average) in Meters	2.79
Net Head for Generation in Meters	128.21
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	2,623,148
MWh	2,623

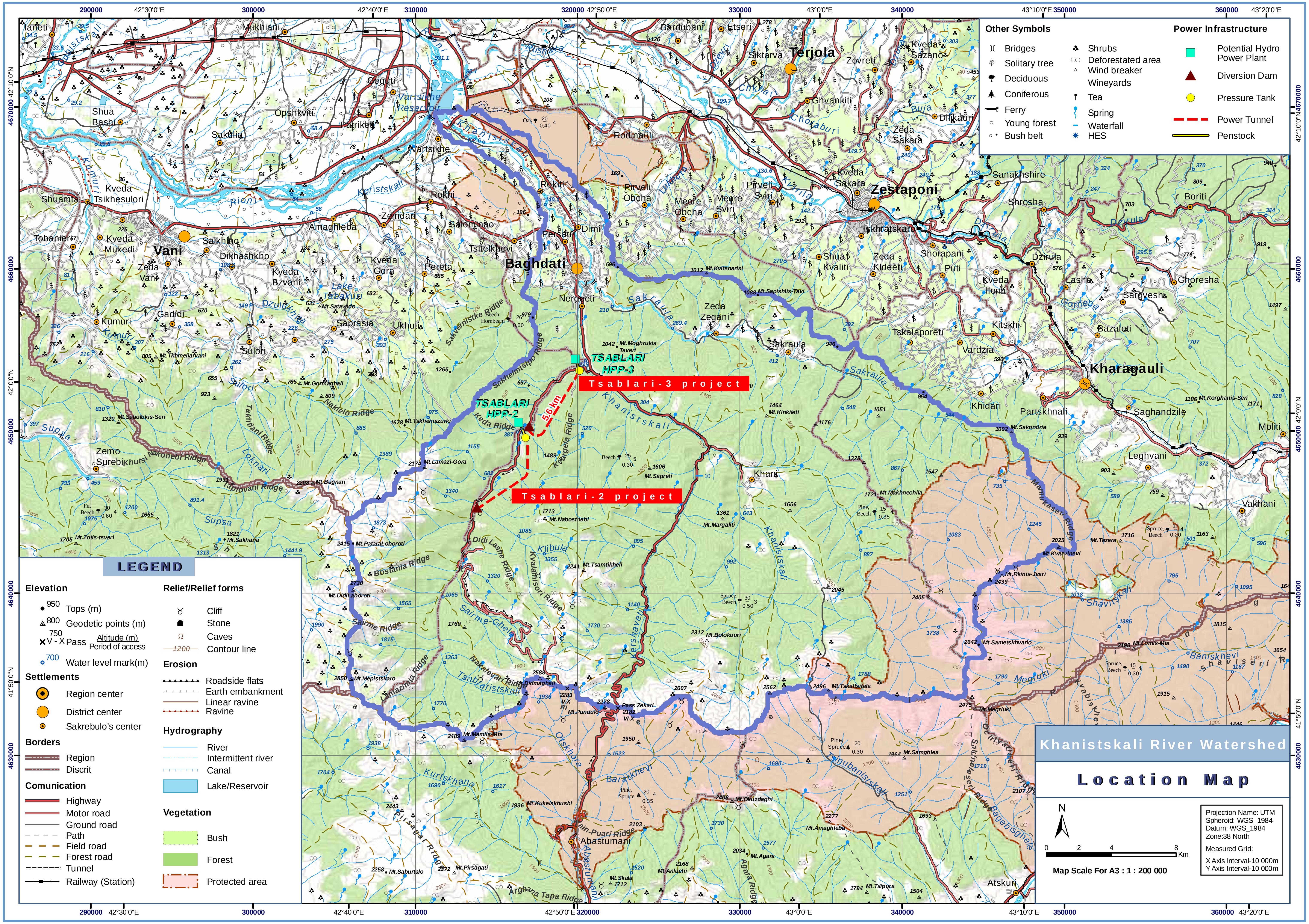


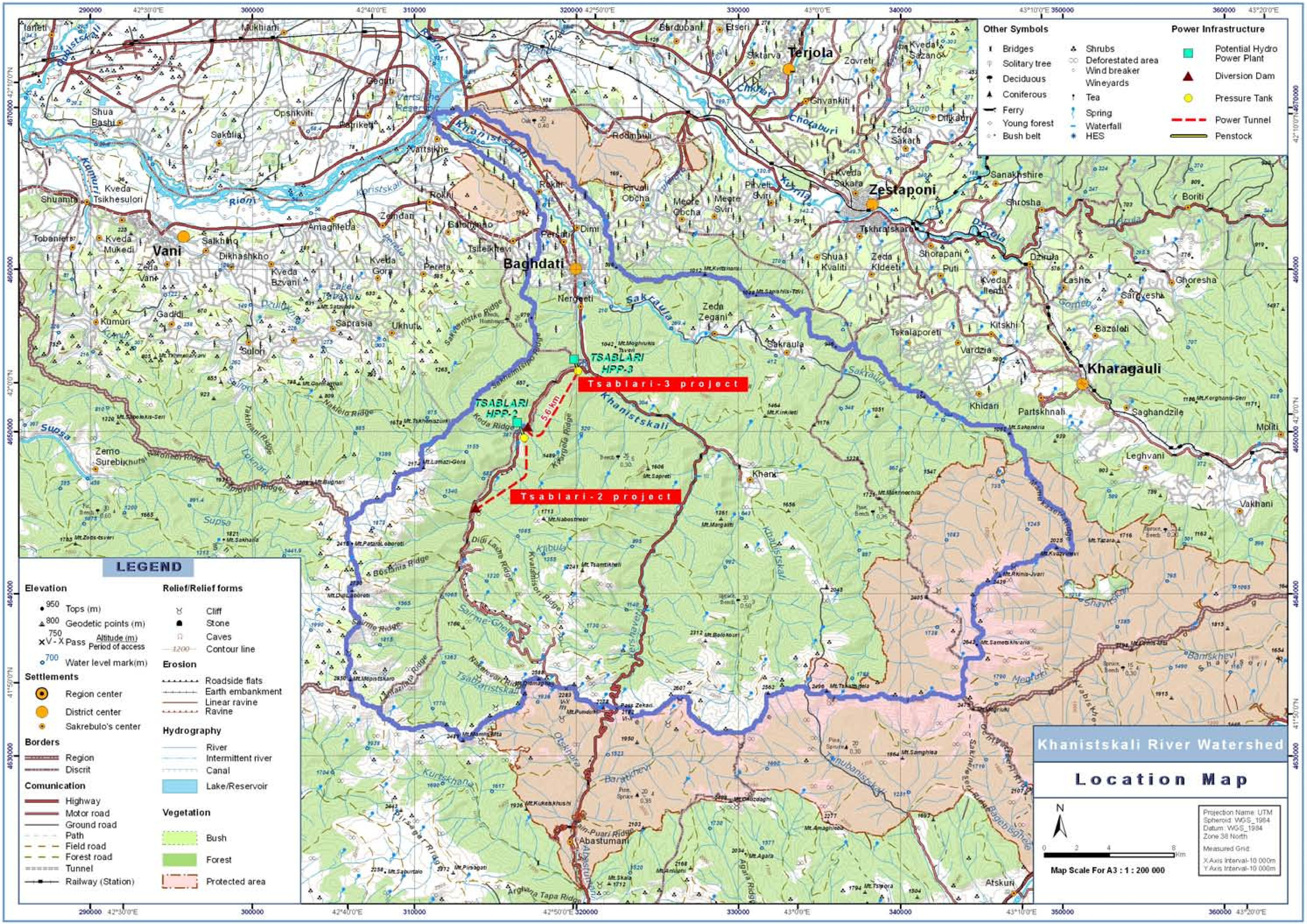
December

Area under Adjusted Flow Duration Curve in CMS-Hrs	2,950
Select Discharge equal to or exceeded % For HPP	6.60%
Equivalent Total Turbine Discharge at Selected CF in CMS	9.17
Non-useable portion of FDC at selected CF or Exceedance %	187
Gross Available CMS-HRS for Generation at selected CF	2,764
Monthly Average Daily Discharge in CMS	3.98
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	10%
Environmental/Sanitary Flow in CMS	0.40
Non-useable Environmental/Sanitary CMS-HRS	296
Net CMS-HRS Available for Generation	2468
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	240
Gross Head for Generation in Meters	131
Length of Penstock/Pipeline/tunnel in Km	6
Head Loss (from daily head loss calculation average) in Meters	2.79
Net Head for Generation in Meters	128.21
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	2,637,290
MWh	2,637

Appendix 3

Location Map


Khanistskali River Watershed
Location Map
TSABLARI HPP-3
Tsablari-3 project
TSABLARI HPP-2
Tsablari-2 project
5.6 km
Baghdati
Vani
Terjola
Zestaponi
Kharagauli
Abastumani
Khanistskali
Sakraula
Rioni
Kvirila
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
Borders
Region
Discrit
Comunication
Highway
Motor road
Ground road
Path
Field road
Forest road
Tunnel
Railway (Station)
Relief/Relief forms
Cliff
Stone
Caves
1200 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
Deforested area
Wind breaker
Wineyards
Tea
Spring
Waterfall
HES
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Pressure Tank
Power Tunnel
Penstock
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
Location Map
TSABLARI HPP-3
Tsablari-3 project
TSABLARI HPP-2
Tsablari-2 project
5.6 km
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
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LEGEND
Elevation
Tops (m)
Geodetic points (m)
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Ground road
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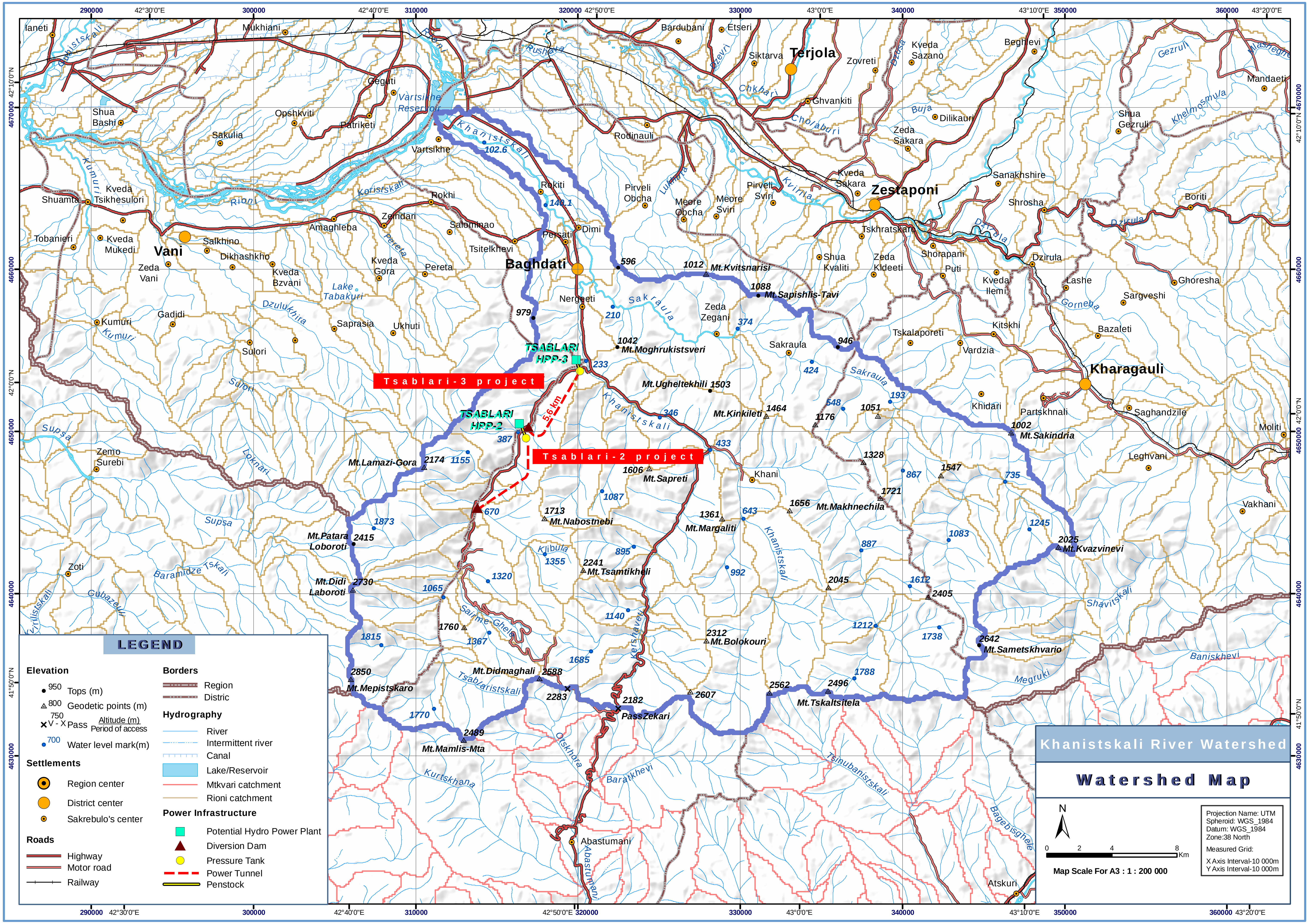
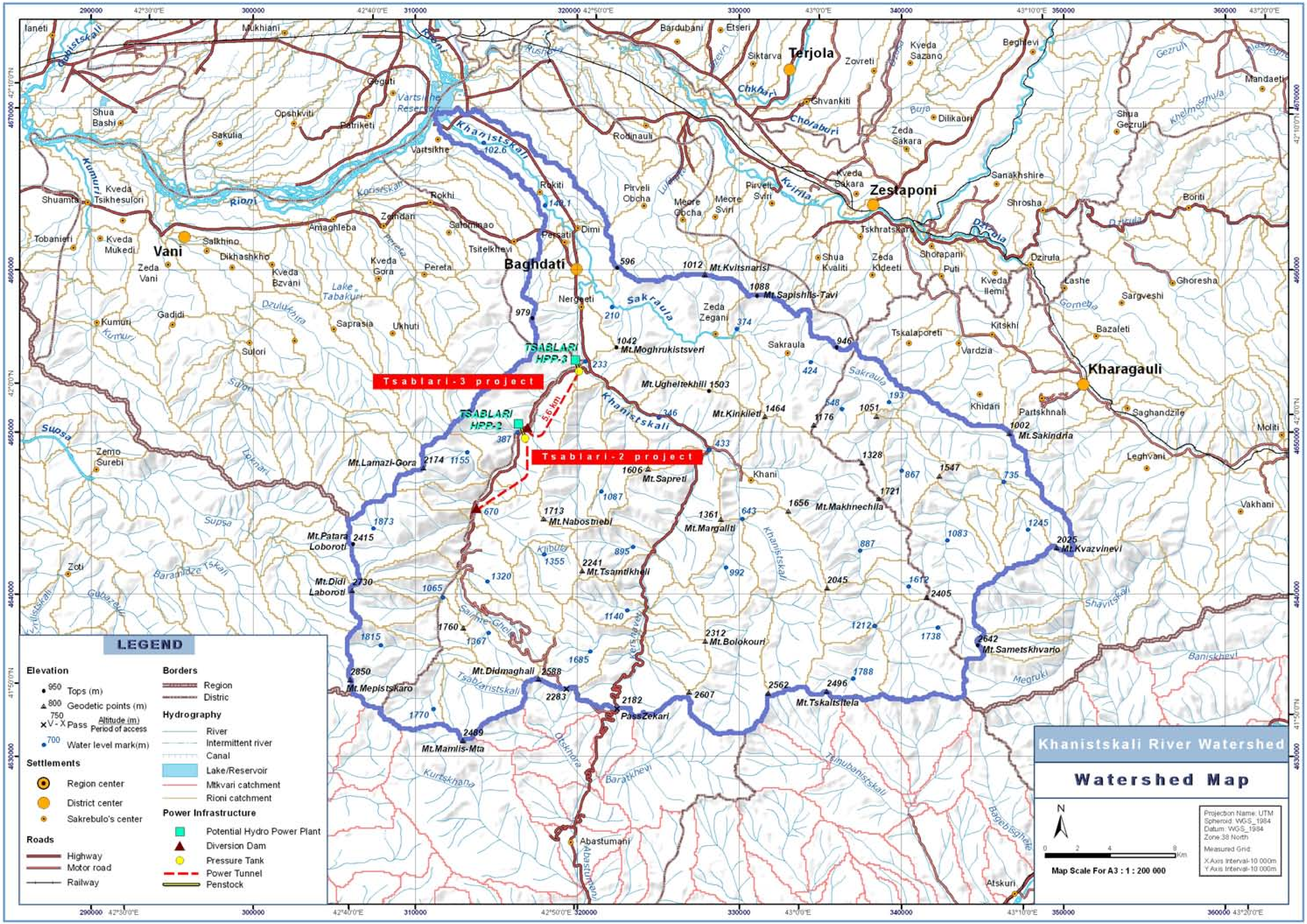
Field road
Forest road
Tunnel
Railway (Station)
Relief/Relief forms
Cliff
Stone
Caves
Contour line
Erosion
Roadside flats
Earth embankment
Linear ravine
Ravine
Hydrography
River
Intermittent river
Canal
Lake/Reservoir
Vegetation
Bush
Forest
Protected area
Map Scale For A3 : 1 : 200 000
Projection Name: 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
Rioni
Sakraula

Appendix 4

Watershed Map

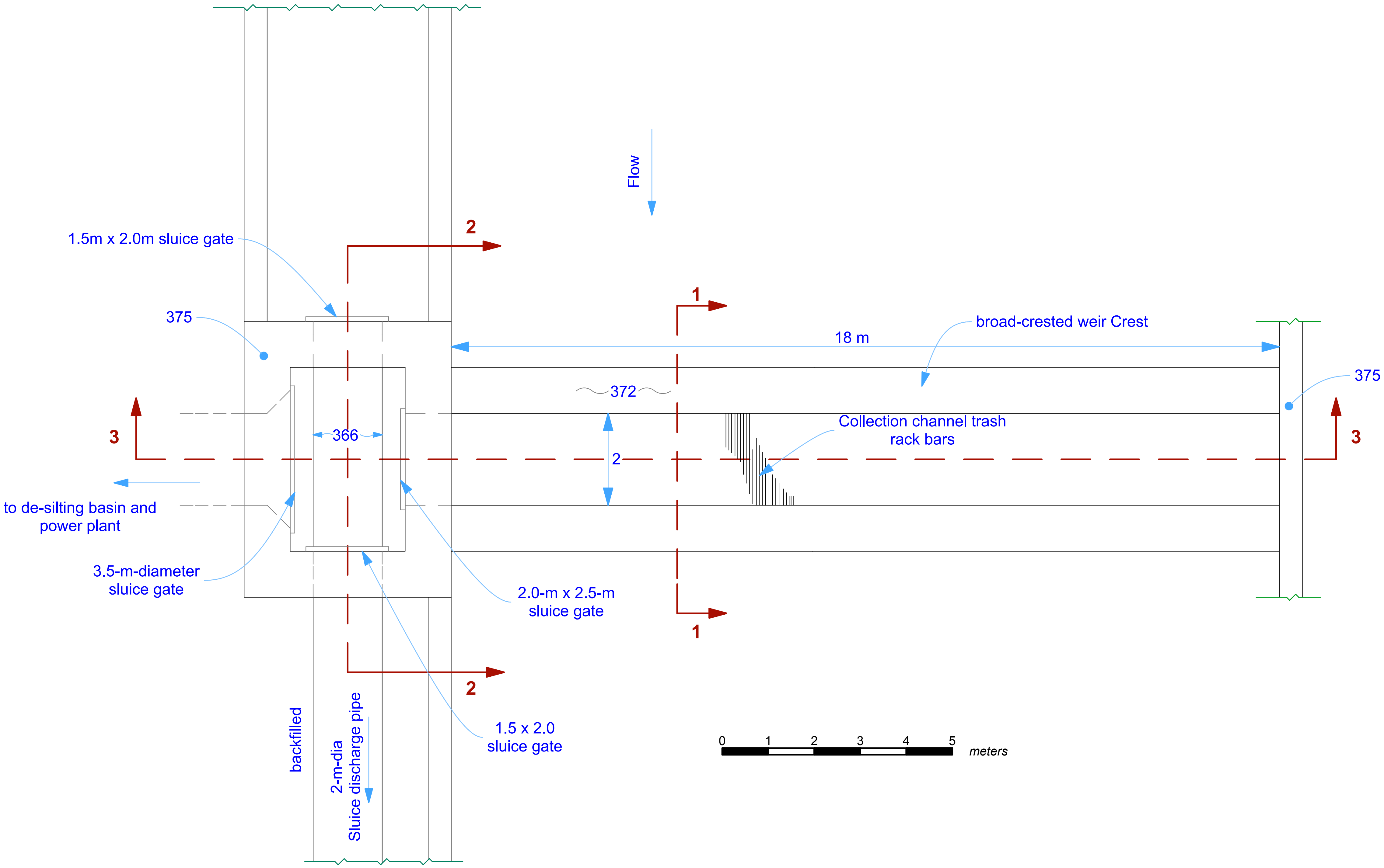


Khanistskali River Watershed
Watershed Map
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Roads
Highway
Motor road
Railway
Borders
Region
Distric
Hydrography
River
Intermittent river
Canal
Lake/Reservoir
Mtkvari catchment
Rioni catchment
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
Terjola
Zestaponi
Kharagauli
Abastumani
Khanistskali
Rioni
Sakraula
Vartsikhe Reservoir
Mt.Kvitsnarisi
Mt.Sapishlis-Tavi
Mt.Moghrukistsveri
Mt.Ugheltekhili
Mt.Kinkileti
Mt.Sakindria
Mt.Lamazi-Gora
Mt.Sapreti
Mt.Nabostnebi
Mt.Margaliti
Mt.Makhnechila
Mt.Kvazvinevi
Mt.Patara Loboroti
Mt.Tsamtikheli
Mt.Didi Laboroti
Mt.Bolokouri
Mt.Sametskhvario
Mt.Didmaghali
Mt.Mepistskaro
Pass Zekari
Mt.Tskaltsitela
Mt.Mamlis-Mta


Khanistskali River Watershed
Watershed Map
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
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
Km
Baghdati
Vani
Terjola
Zestaponi
Kharagauli
Khanistskali
Rioni
Kvirila
Dzirula
Sakraula
Chkhari
Chólaburi
Kumuri
Supsa
Vartsikhe Reservoir
Abastumani
Mt.Kvitsnarisi
Mt.Sapishlis-Tavi
Mt.Moghrukistsveri
Mt.Ugheltekhili
Mt.Kinkileti
Mt.Sakindria
Mt.Lamazi-Gora
Mt.Sapreti
Mt.Nabostmebi
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
Mt.Tskaltsitela
Pass Zekari

Appendix 5

Site HPP Figure

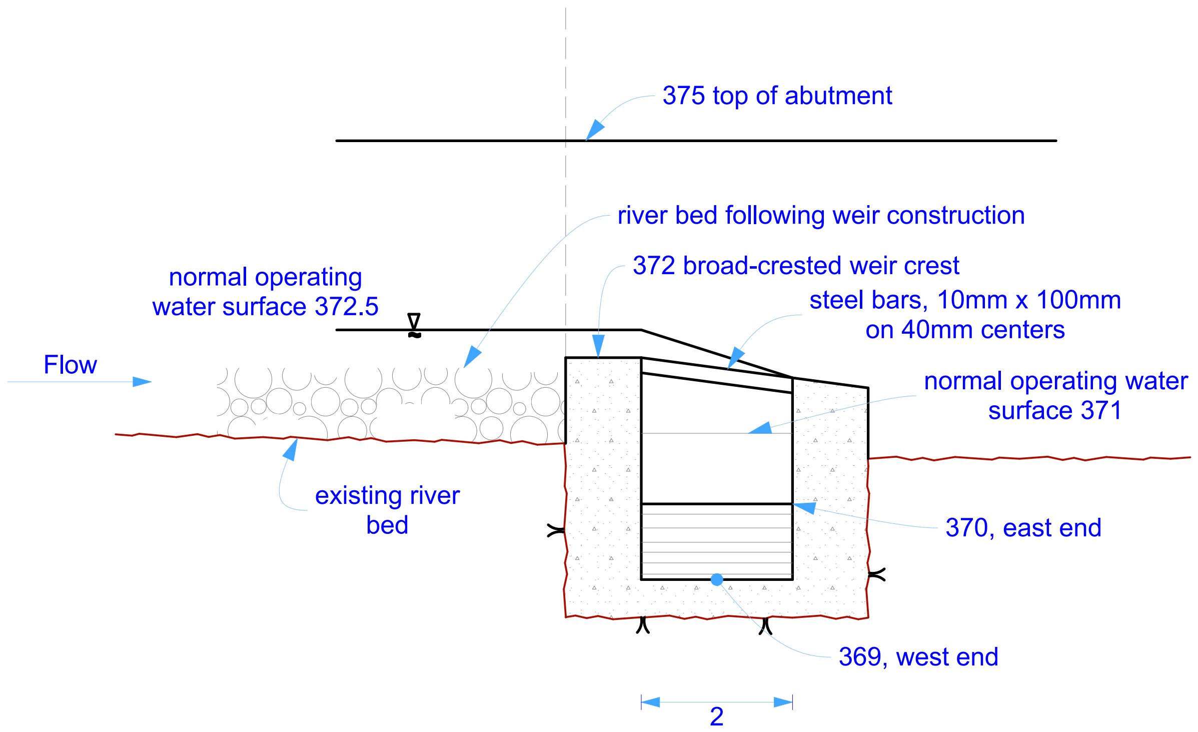


BLACK & VEATCH
Building a world of difference.

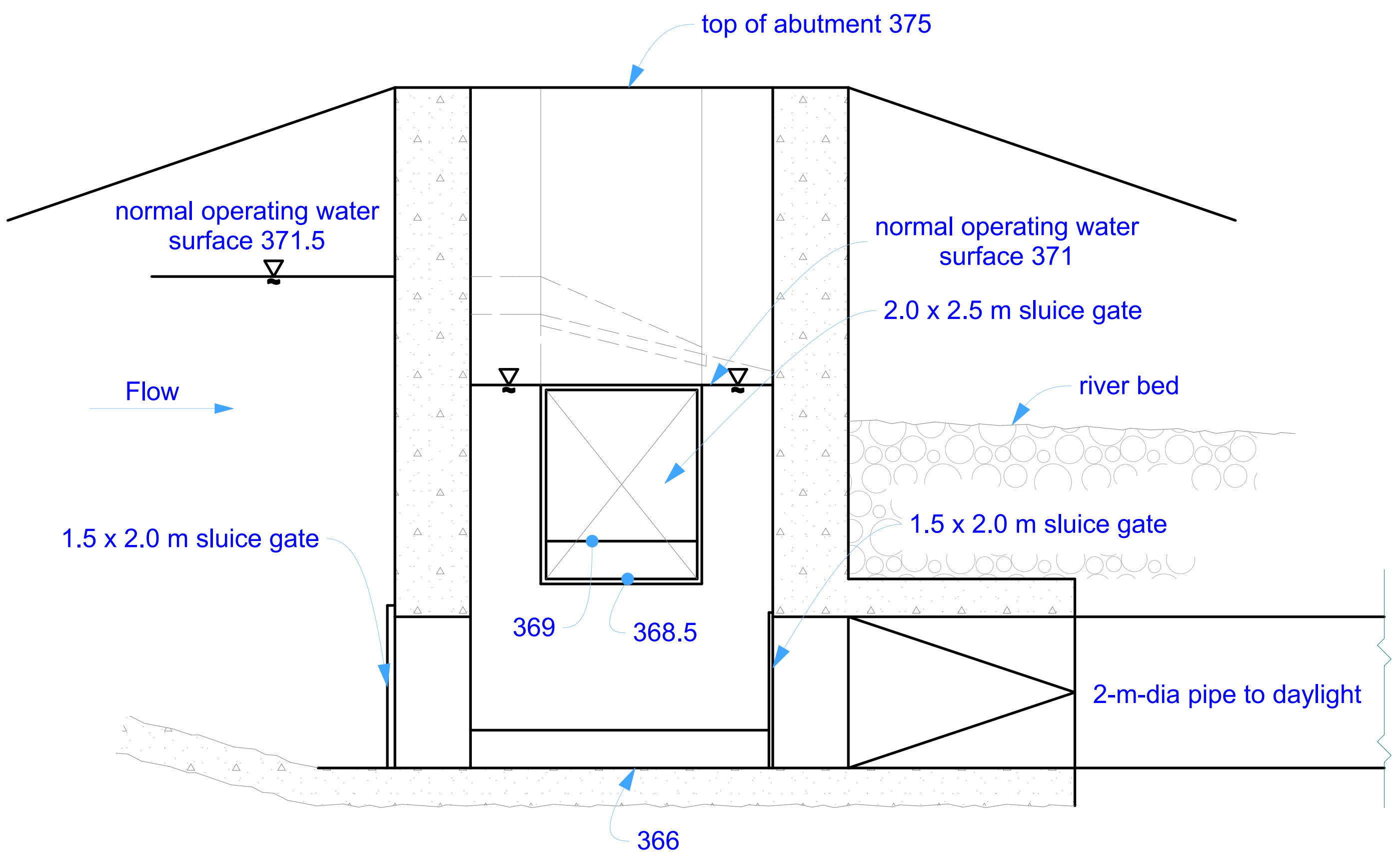
Pre-Feasibility Study
Tsablari 3

Tsablari Diversion Weir and Intake
Collection Chamber Plan

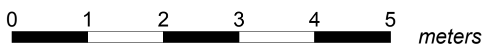
Drawing Scale	
1:100	**July 2011**



Section 1-1



Section 2-2



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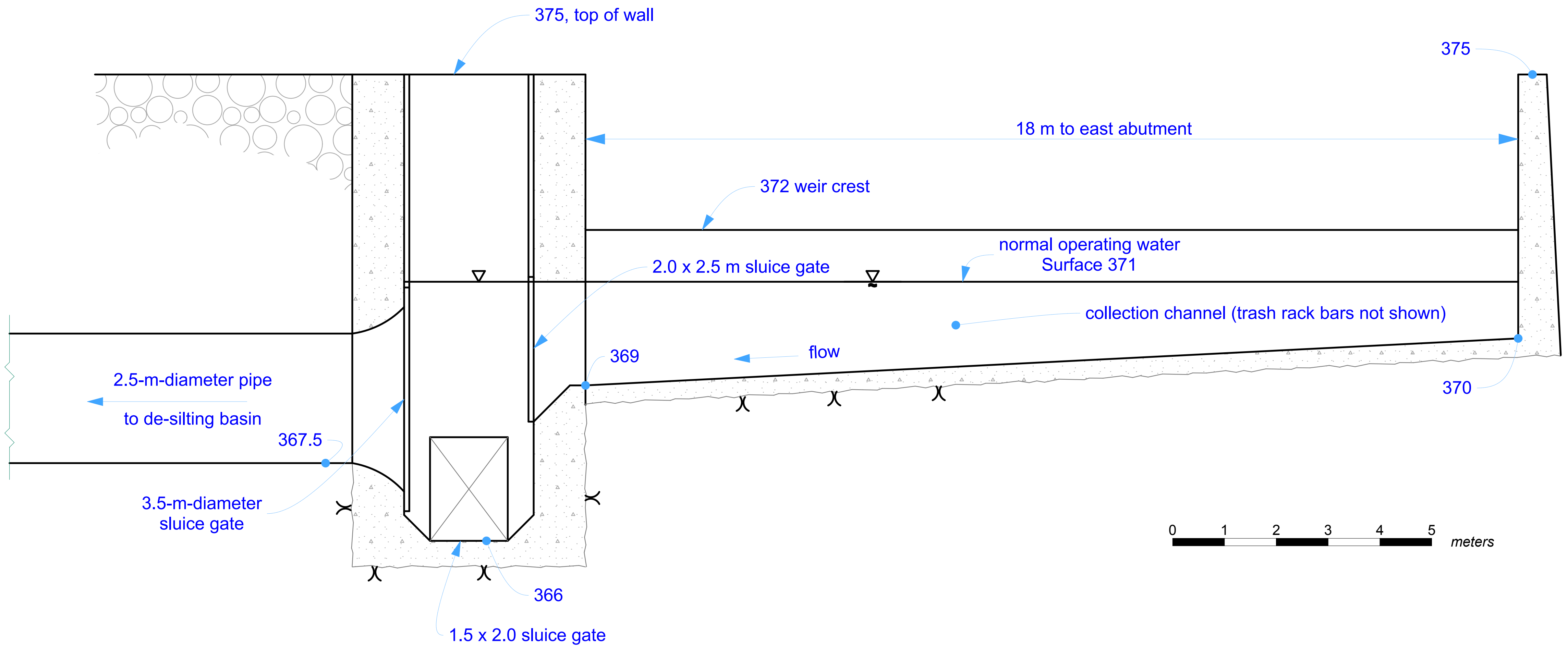
Building a world of difference.

Pre-Feasibility Study
Tsablari 3

Tsablari Diversion Weir and Intake Sections

Drawing Scale 1:100

July 2011



Section 3-3

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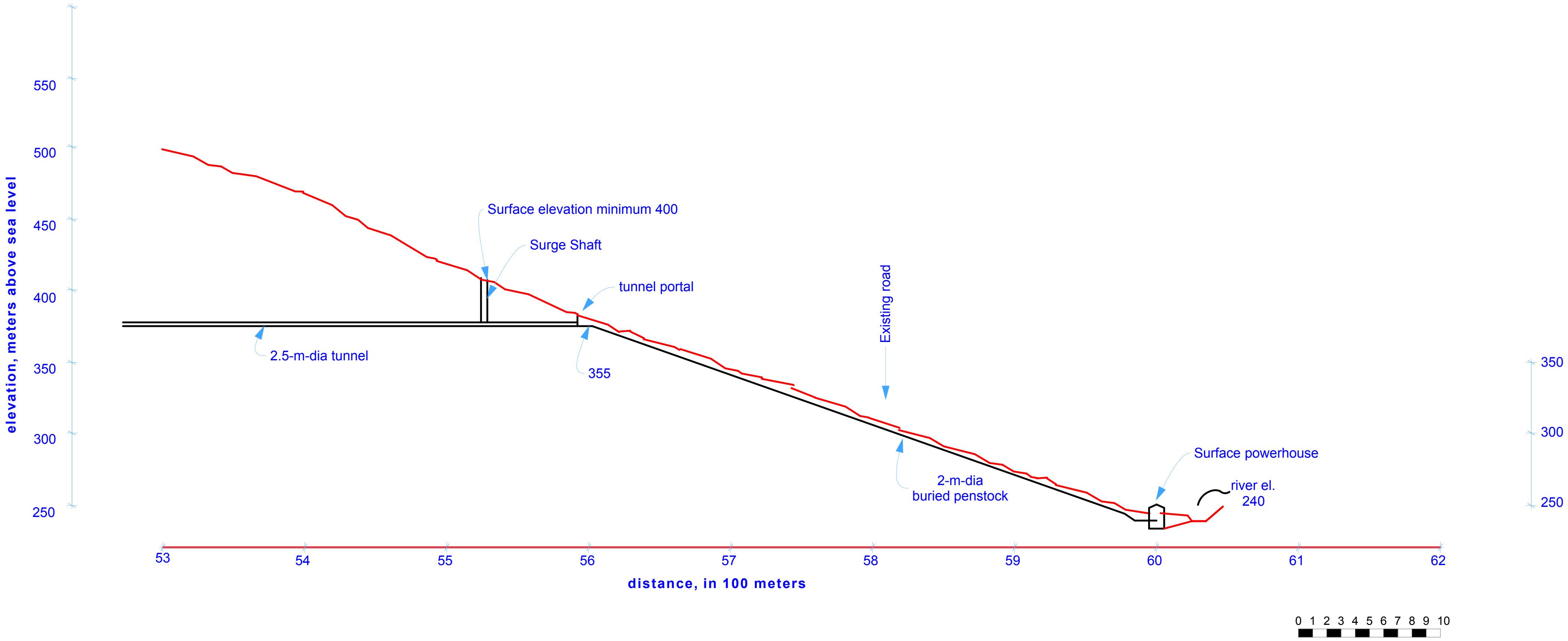
Pre-Feasibility Study
Tsablari 3
Tsablari Diversion Weir and Intake Sections

Drawing Scale	1:100	July 2011



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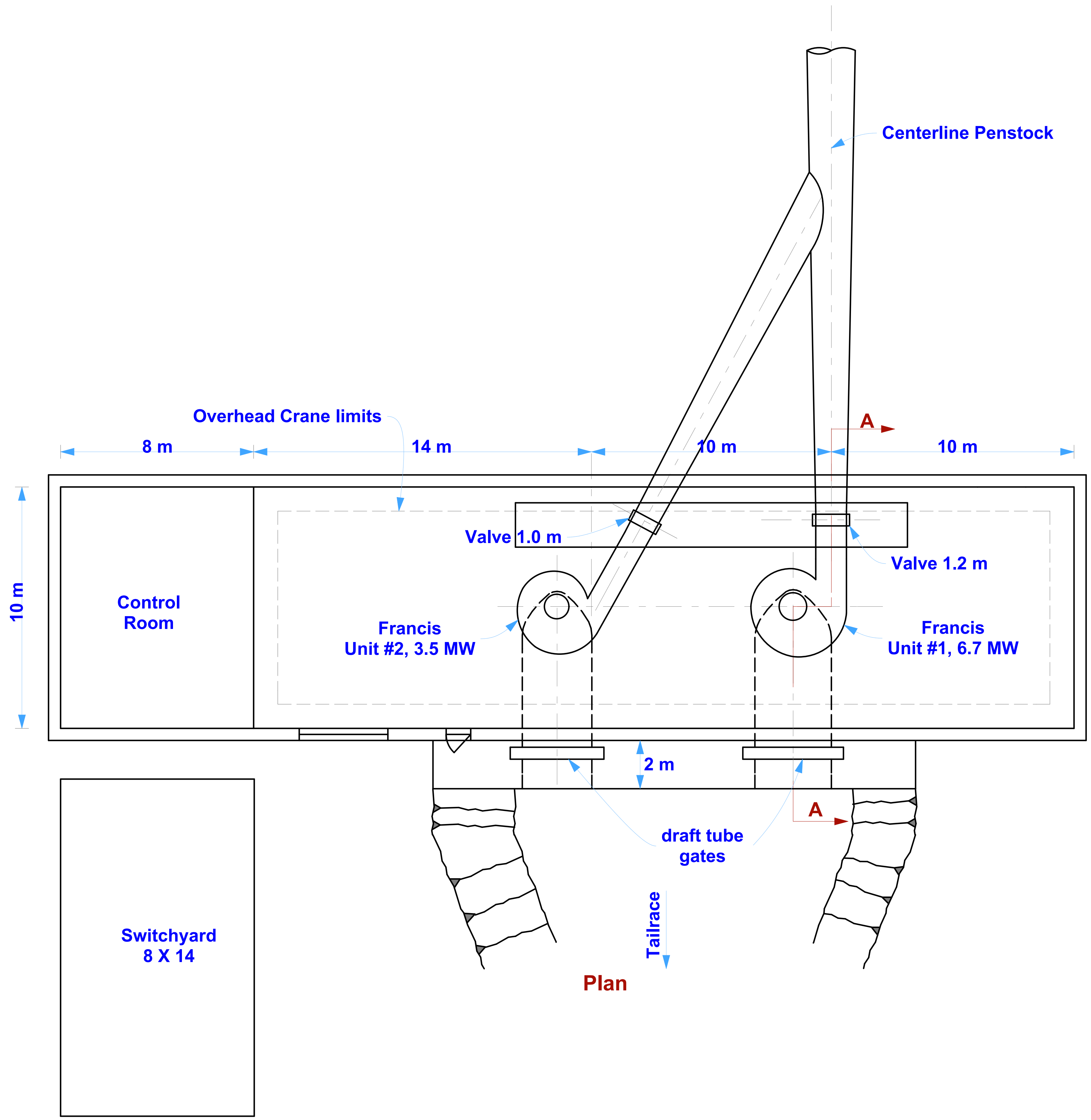
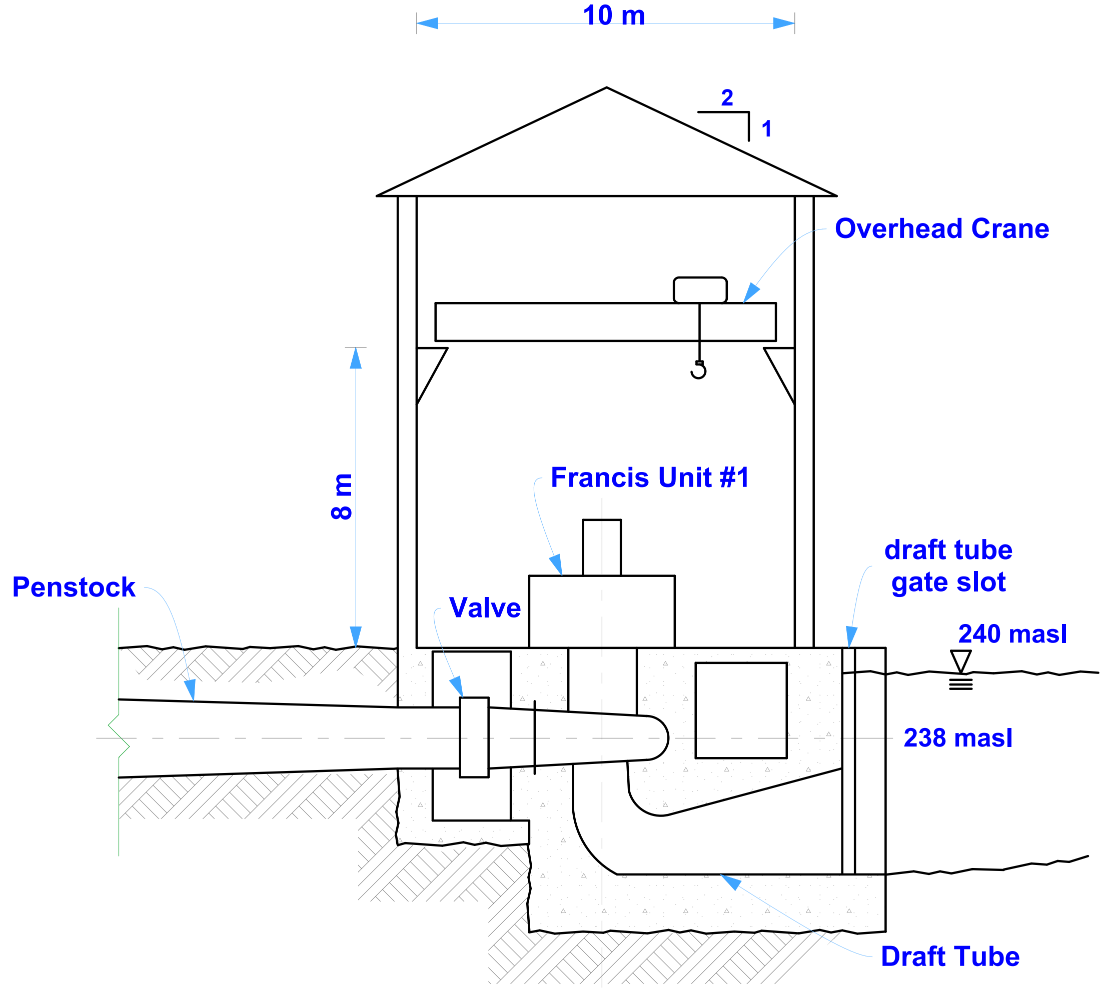
Pre-Feasibility Study
Tsablari 3

Powerhouse Area Water Conductor Profile

Drawing Scale 1:2,000	July 2011



Plan



Section A:A

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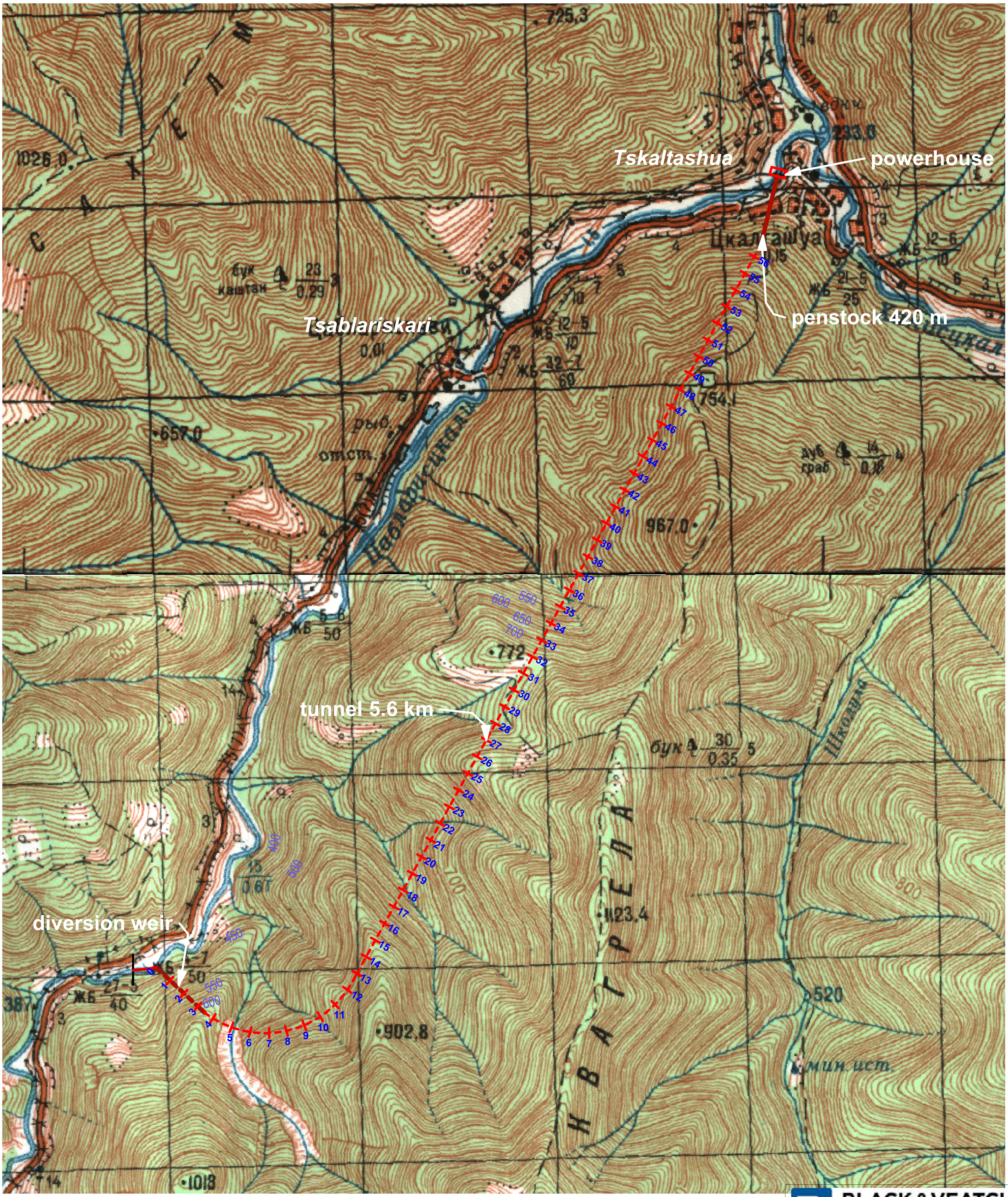
Pre-Feasibility Study
Tsablari 3

Powerhouse Plan and Section

Drawing Scale 1:200	July 2011



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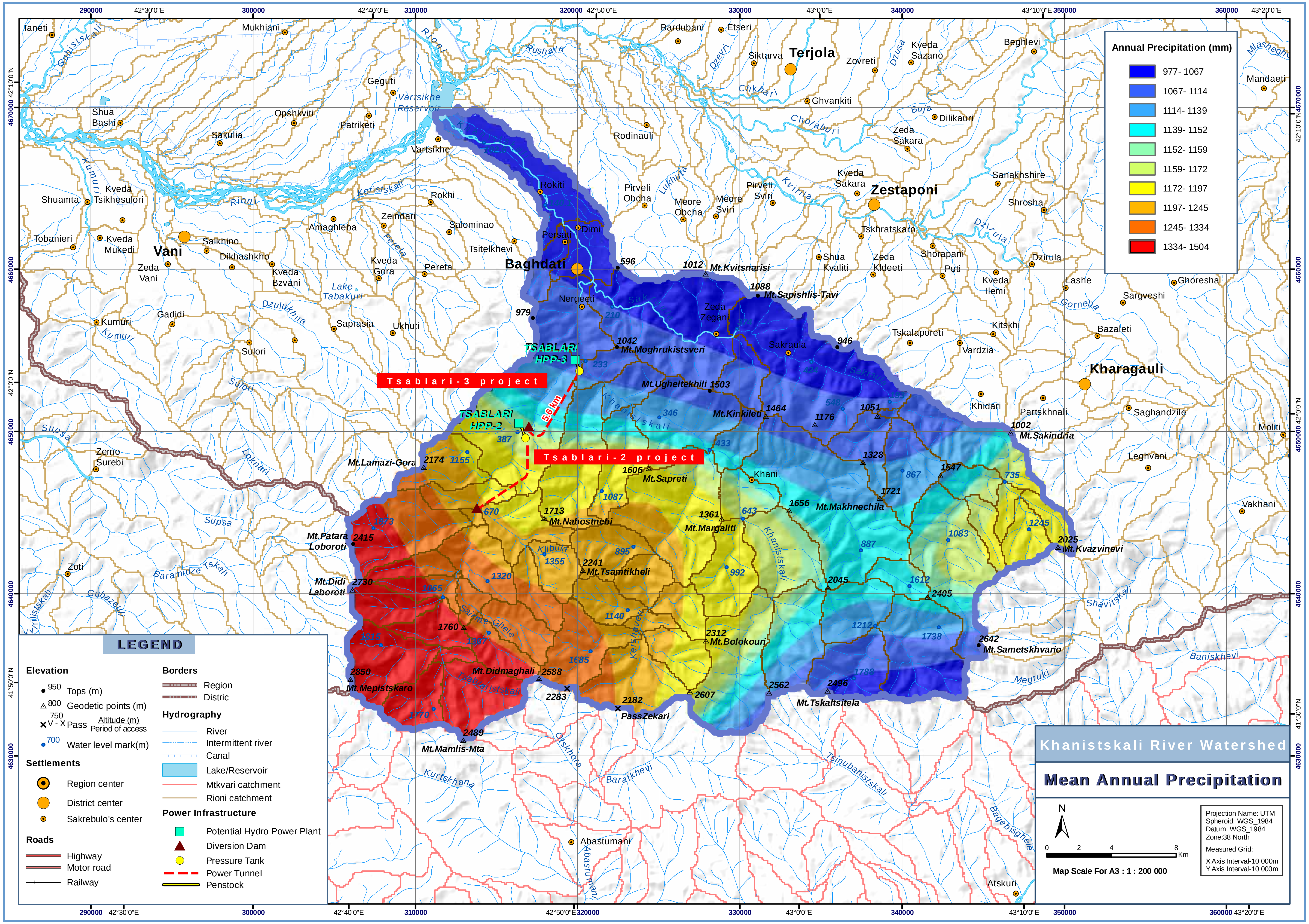
Building a world of difference

Pre-Feasibility Study
Tsablari 3
Project Arrangement

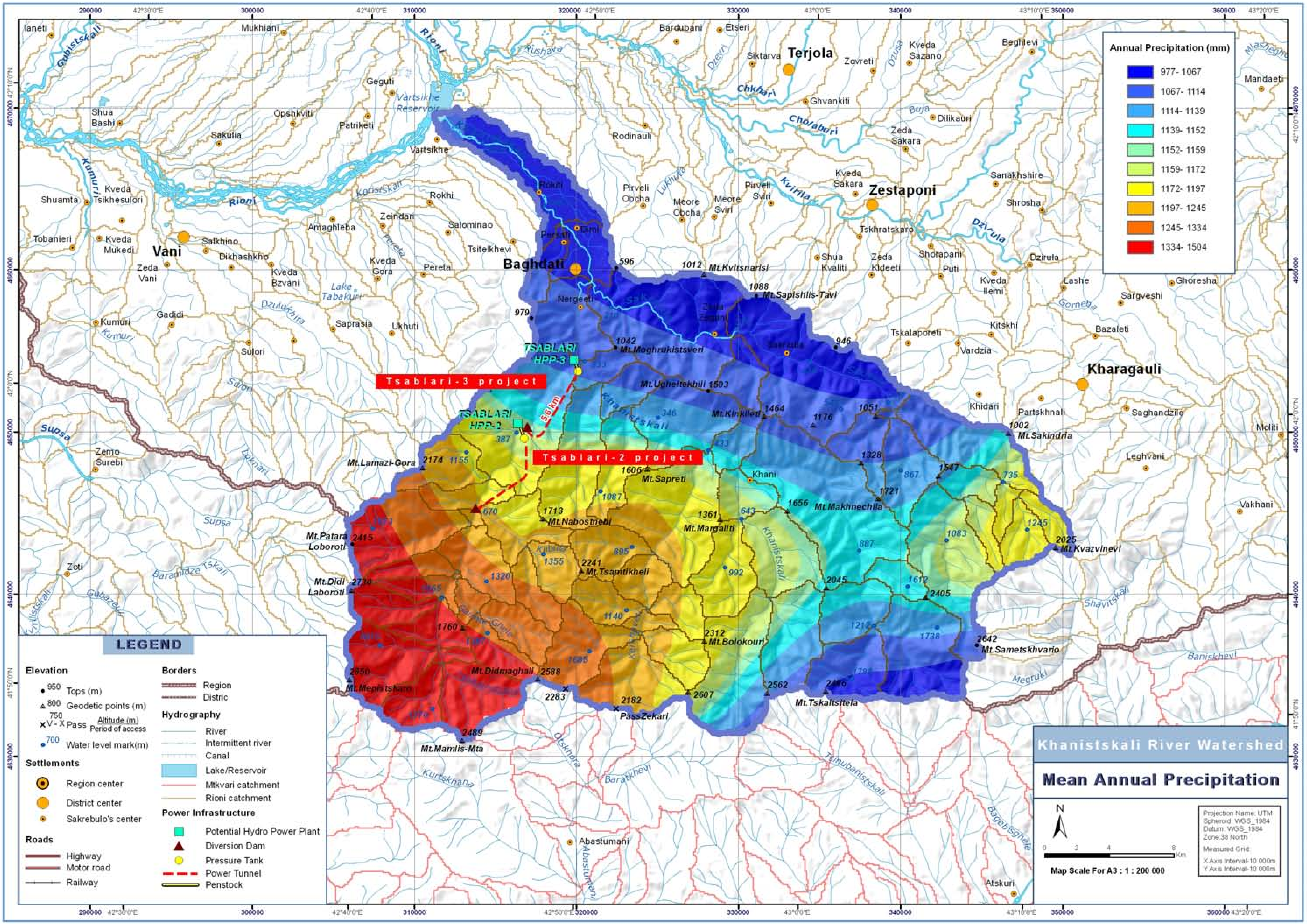
Drawing Scale 1:20,000 | July 2011

Appendix 6

Annual Precipitation Map

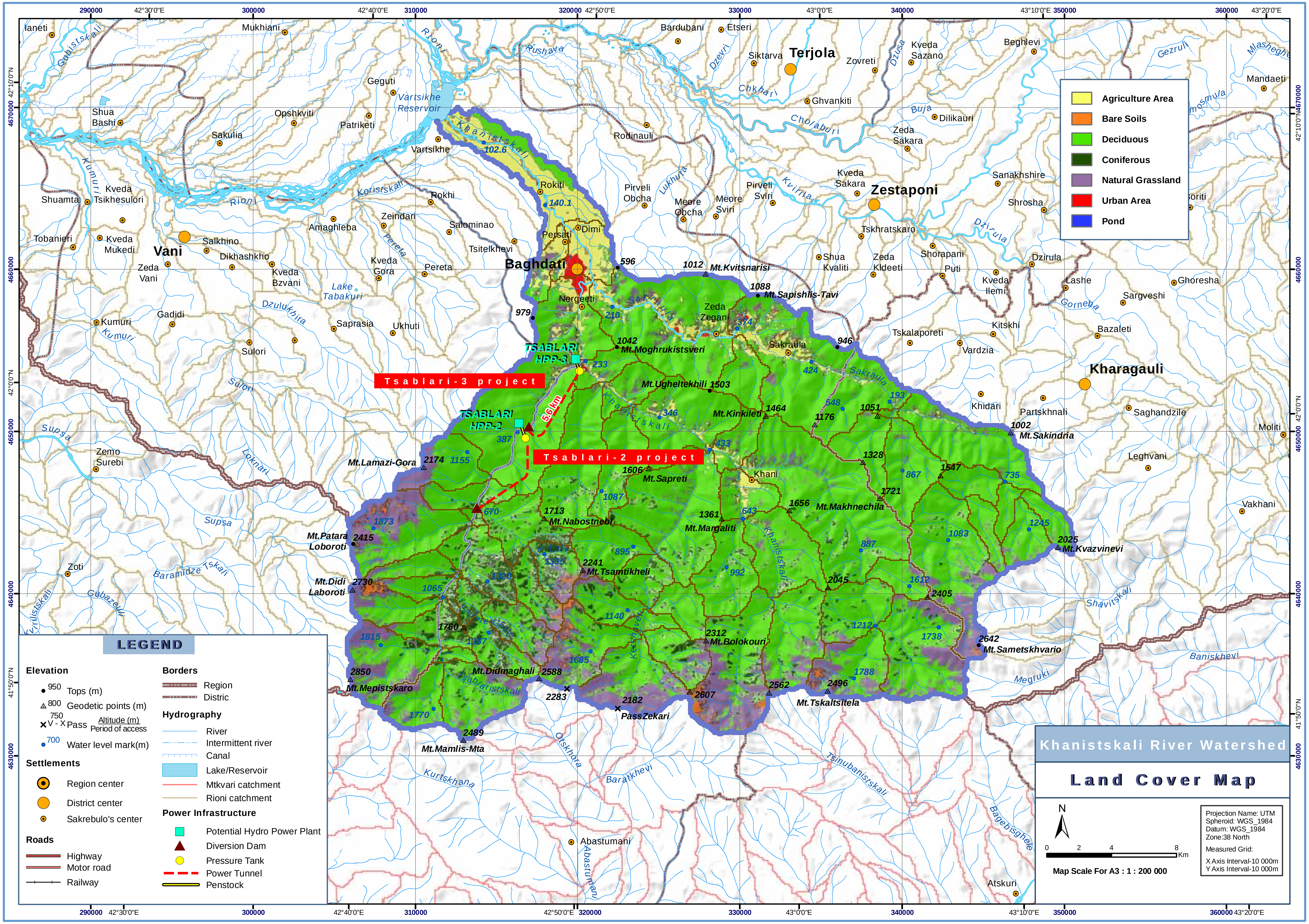


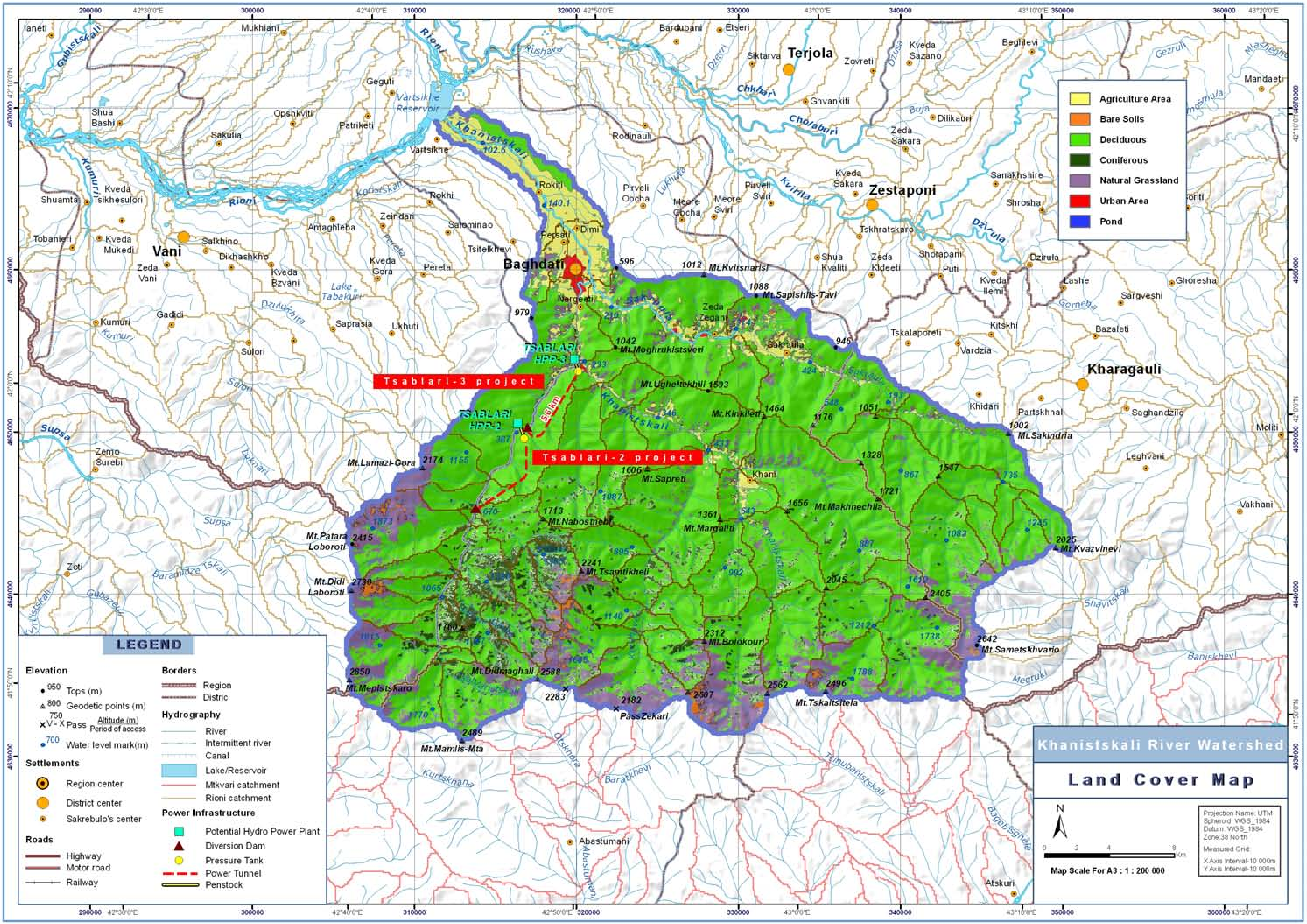
Khanistskali River Watershed
Mean Annual Precipitation
Annual Precipitation (mm)
977- 1067
1067- 1114
1114- 1139
1139- 1152
1152- 1159
1159- 1172
1172- 1197
1197- 1245
1245- 1334
1334- 1504
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level 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
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
Terjola
Zestaponi
Baghdati
Vani
Kharagauli


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
Tops (m)
Geodetic points (m)
V - X Pass Altitude (m) Period of access
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
Baghdati
Vani
Terjola
Zestaponi
Kharagauli
Rioni
Kvirila
Khanistskali
Mt.Sakindria
Mt.Kvazvinevi
Mt.Sametskhvario
Mt.Tskaltsitela
Mt.Bolokouri
Mt.Mamlis-Mta
Mt.Didmaghali
Mt.Mepltskaro
Mt.Didi Laboroti
Mt.Patara Loboroti
Mt.Lamazi-Gora
Mt.Nabostrebi
Mt.Tsamtkheli
Mt.Sapreti
Mt.Margaliti
Mt.Makhnechila
Mt.Kinkileti
Mt.Ugheltekhili
Mt.Moghrukistsveri
Mt.Kvitsnarisi
Mt.Sapishlis-Tavi
Pass Zekari
Abastumani
Vartsikhe Reservoir

Appendix 7

Land Cover Map

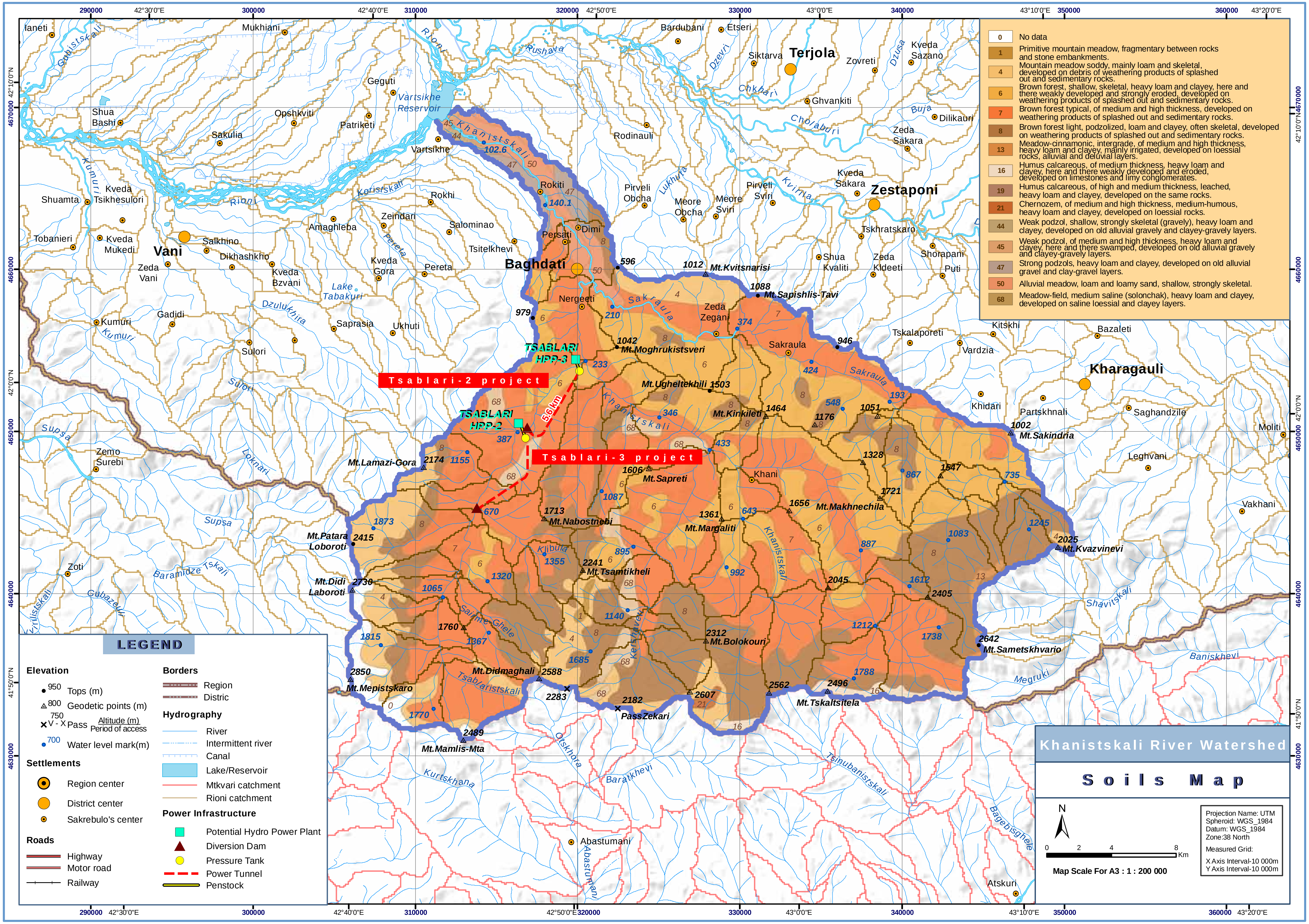

Khanistskali River Watershed
Land Cover Map
Agriculture Area
Bare Soils
Deciduous
Coniferous
Natural Grassland
Urban Area
Pond
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
Region center
District center
Sakrebulo's 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-3 project
Tsablari-2 project
TSABLARI HPP-3
TSABLARI HPP-2
5.6 km
Baghdati
Terjola
Zestaponi
Kharagauli
Vani
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



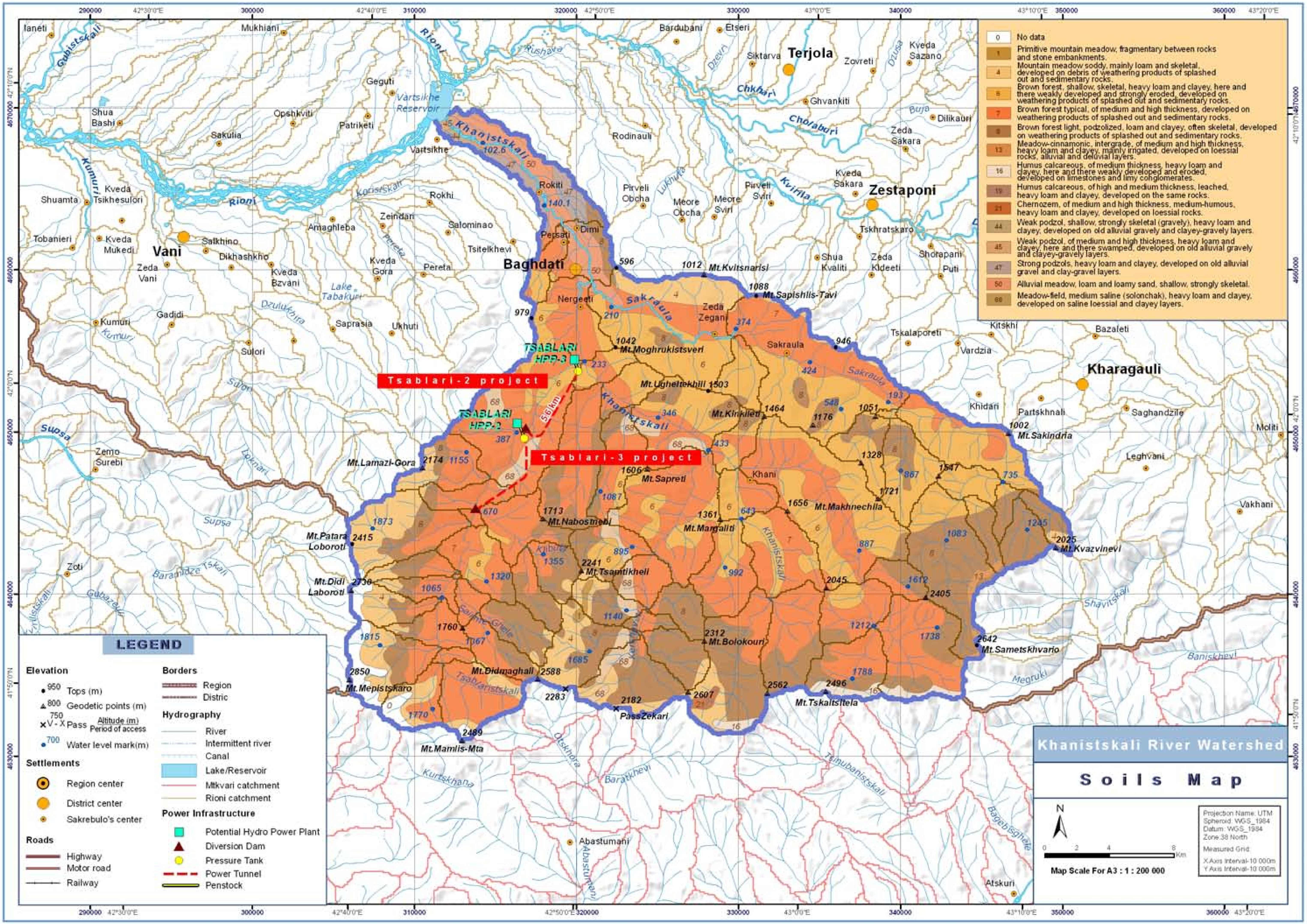
Khanistskali River Watershed
Land Cover Map
Agriculture Area
Bare Soils
Deciduous
Coniferous
Natural Grassland
Urban Area
Pond
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
Region center
District center
Sakrebulo's 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
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
N
Baghdati
Vani
Terjola
Zestaponi
Kharagauli
Vartsikhe Reservoir
Khanistskali
Rioni
Kvirila
Chkhari
Chkhari
Sakraula
Supsa
Sulori
Kumuri
Dzirula
Mt.Kvitsnarisi
Mt.Sapishlis-Tavi
Mt.Moghrukistsveri
Mt.Ugheltekhili
Mt.Kinkileti
Mt.Sakindria
Mt.Lamazi-Gora
Mt.Sapreti
Mt.Nabostnebi
Mt.Makhnechila
Mt.Margaliti
Mt.Patara Loboroti
Mt.Didi Laboroti
Mt.Tsamtkheli
Mt.Kvazvinevi
Mt.Bolokouri
Mt.Sametskhvario
Mt.Didmaghali
Mt.Mepistskaro
Mt.Mamlis-Mta
Mt.Tskaltsitela
PassZekari
Abastumani
Khani
Zeda Zegani
Nergeeti
Dimi
Persati
Rokiti
Vartsikhe
Atskuri

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 gravelly and clayey-gravely layers.
45 Weak podzol, of medium and high thickness, heavy loam and clayey, here and there swamped, developed on old alluvial gravelly and clayey-gravelly 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
Canal
Lake/Reservoir
Mtkvari catchment
Rioni catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Pressure Tank
Power Tunnel
Penstock
Tsablari-2 project
Tsablari-3 project
TSABLARI HPP-2
TSABLARI HPP-3
5.6km
Baghdati
Vani
Terjola
Zestaponi
Kharagauli
Khanistskali
Sakraula
Rioni
Vartsikhe Reservoir
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-10 000m
Y Axis Interval-10 000m
0 2 4 8 Km
Map Scale For A3 : 1 : 200 000
N



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 (gravely), 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
Canal
Lake/Reservoir
Mtkvari catchment
Rioni catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Pressure Tank
Power Tunnel
Penstock
Tsablari-2 project
Tsablari-3 project
TSABLARI HPP-3
TSABLARI HPP-2
5.6km
Baghdati
Vani
Terjola
Zestaponi
Kharagauli
Rioni
Khanistskali
Sakraula
Kvirila
Mt.Kvitsnarisi
Mt.Sapishlis-Tavi
Mt.Moghrukistsveri
Mt.Ugheltekhili
Mt.Kirkileti
Mt.Sakindria
Mt.Lamazi-Gora
Mt.Sapreti
Mt.Nabostrebi
Mt.Margaliti
Mt.Makhnechila
Mt.Kvazvinevi
Mt.Patara Loboroti
Mt.Didi Loboroti
Mt.Tsamtikheli
Mt.Bolokouri
Mt.Sametskhvario
Mt.Mepistskaro
Mt.Didmaghali
Mt.Tskaltsitela
Mt.Mamlis-Mta
Pass Zekari
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

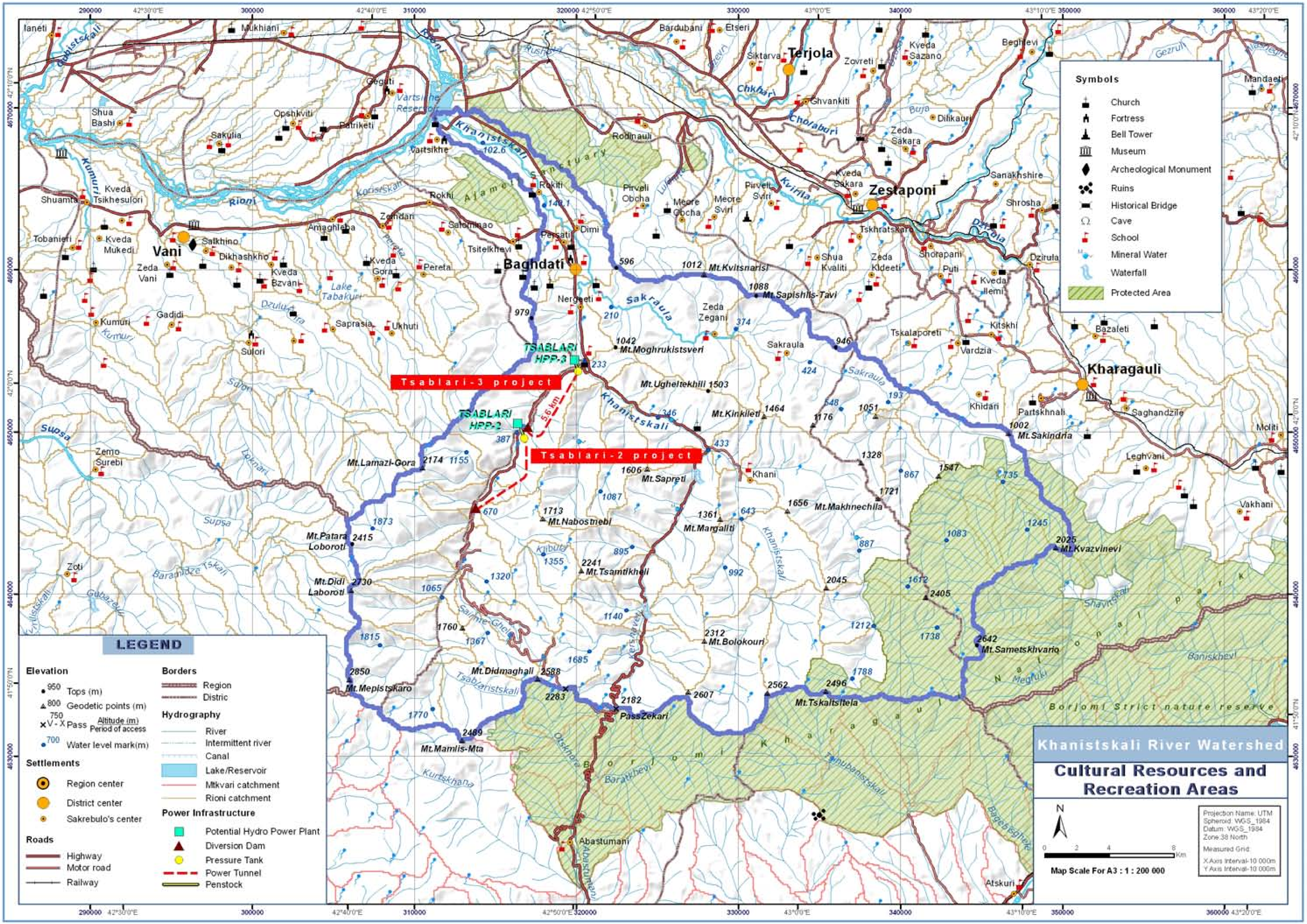
Appendix 9

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
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
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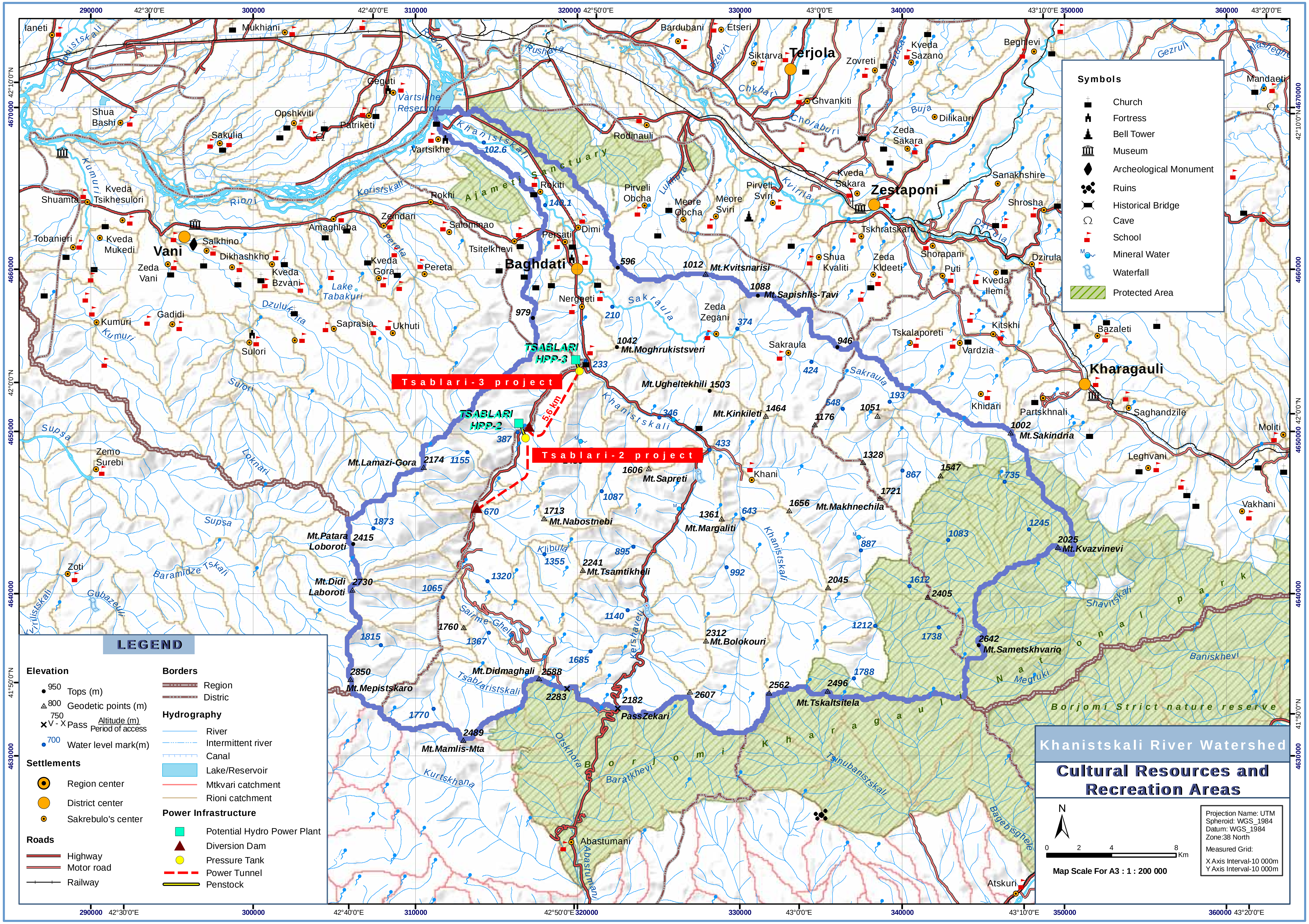
Canal
Lake/Reservoir
Mtkvari catchment
Rioni catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Pressure Tank
Power Tunnel
Penstock
Tsablari-3 project
Tsablari-2 project
TSABLARI HPP-3
TSABLARI HPP-2
Borjomi Strict nature reserve
Map Scale For A3 : 1 : 200 000
Projection Name: UTM
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



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 HPP-3
TSABLARI HPP-2
Tsablari-3 project
Tsablari-2 project
5.6 km
Vani
Baghdati
Zestaponi
Terjola
Kharagauli
Abastumani
Vartsikhe Reservoir
Ajameti Sanctuary
Borjomi Kharagauli National park
Borjomi Strict nature reserve
Khanistskali
Sakraula
Rioni
Kvirila
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.Patara Loboroti
Mt.Didi Laboroti
Mt.Tsamtikheli
Mt.Kvazvinevi
Mt.Bolokouri
Mt.Sametskhvariq
Mt.Mepistskaro
Mt.Didmaghali
Mt.Mamlis-Mta
Mt.Tskaltsitela
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

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 _______________ 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. -------------------------- **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 -------------------- VSH	H/IR/T --------------------- VL/R/P	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 ----------------------- 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: c:\turbnpro\tsab3m.dat

TURBINE SIZING CRITERIA

Rated Discharge:	162.4	cfs	/	4.6	m3/s
Net Head at Rated Discharge:	405.2	feet	/	123.5	meters
Gross Head:	429.8	feet	/	131.0	meters
Site Elevation:	787	feet	/	240	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:	405.2	feet	/	123.5	meters
Maximum Net Head:	426.5	feet	/	130.0	meters

FRANCIS TURBINE SOLUTION DATA

Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT
Intake Type: SPIRAL CASE
Draft Tube Type: ELBOW
Runner Diameter: 36.6 inches / 929 mm
Unit Speed: 500.0 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:	22.7	86.6
At Peak Efficiency Condition:	21.7	82.8

SOLUTION PERFORMANCE DATA

At Rated Net Head of: 405.2 feet / 123.5 meters

% of Rated Discharge	Output (KW)	Efficiency (%)	cfs	m3/s
** 109.1	5466	89.9	177.2	5.0
100	5087	91.3	162.4	4.6
* 90.9	4648	91.7	147.7	4.2
75	3795	90.8	121.8	3.5
50	2350	84.3	81.2	2.3
25	918	65.9	40.6	1.2
+ 46.5	2140	82.6	75.5	2.1

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

At Maximum Net Head of: 426.5 feet / 130.0 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.050	5871	89.9	180.8	5.1

At Minimum Net Head of: 405.2 feet / 123.5 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.049	5466	89.9	177.2	5.0

TURBNPRO Version 3 - FRANCIS TURBINE SOLUTION SUMMARY

Solution File Name: c:\turbnpro\tsab3m.dat

MISCELLANEOUS DATA

Maximum Runaway Speed (at Max. Net Head):	823 rpm	
Turbine Discharge at:		
Runaway Speed (at Rated Net Head & 100% gate):	70 cfs /	2.0 m3/s
Synchronous Speed-No-Load (at Rated Net Head):	12 cfs /	0.4 m3/s
Site's Atmospheric Pressure minus Vapor Pressure:	32.2 feet /	9.8 meters
Sigma Allowable (at 100% Output & Rated Net Head):	0.037	
Sigma Plant (at 100% Output & Rated Net Head):	0.096	
Maximum Hydraulic Thrust (at Max. Net Head):	26325 lbs /	11966 kg
Approximate Runner and Shaft Weight:	4692 lbs /	2133 kg
Vel. at Draft Tube Exit (at Rated Head & Discharge):	3.2 fps /	1.0 m/s

DIMENSIONAL DATA

Intake Type: SPIRAL CASE

	inches	mm
Inlet Diameter:	36.0	914
Inlet Offset:	64.3	1633
Centerline to Inlet:	67.5	1714
Outside Radius A:	82.3	2090
Outside Radius B:	78.7	1998
Outside Radius C:	73.8	1875
Outside Radius D:	67.3	1710

Draft Tube Type: ELBOW

	inches	mm
Centerline to Invert:	118.4	3008
Shaft Axis to Exit Length:	175.6	4459
Exit Width:	109.7	2787
Exit Height:	65.8	1672

Shafting Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT

	inches	mm
Centerline to Shaft Coupling:	96.0	2438
Turbine Shaft Diameter:	10.4	265

Miscellaneous:

	inches	mm
Wicket Gate Height:	5.9	150
Wicket Gate Circle Diameter:	62.1	1578

**** 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: c:\turbnpro\tsab3m.dat
Runner Diameter:                  929   mm
Net Head at Rated Discharge:     123.50  meters
Unit Speed:                      500.0  rpm
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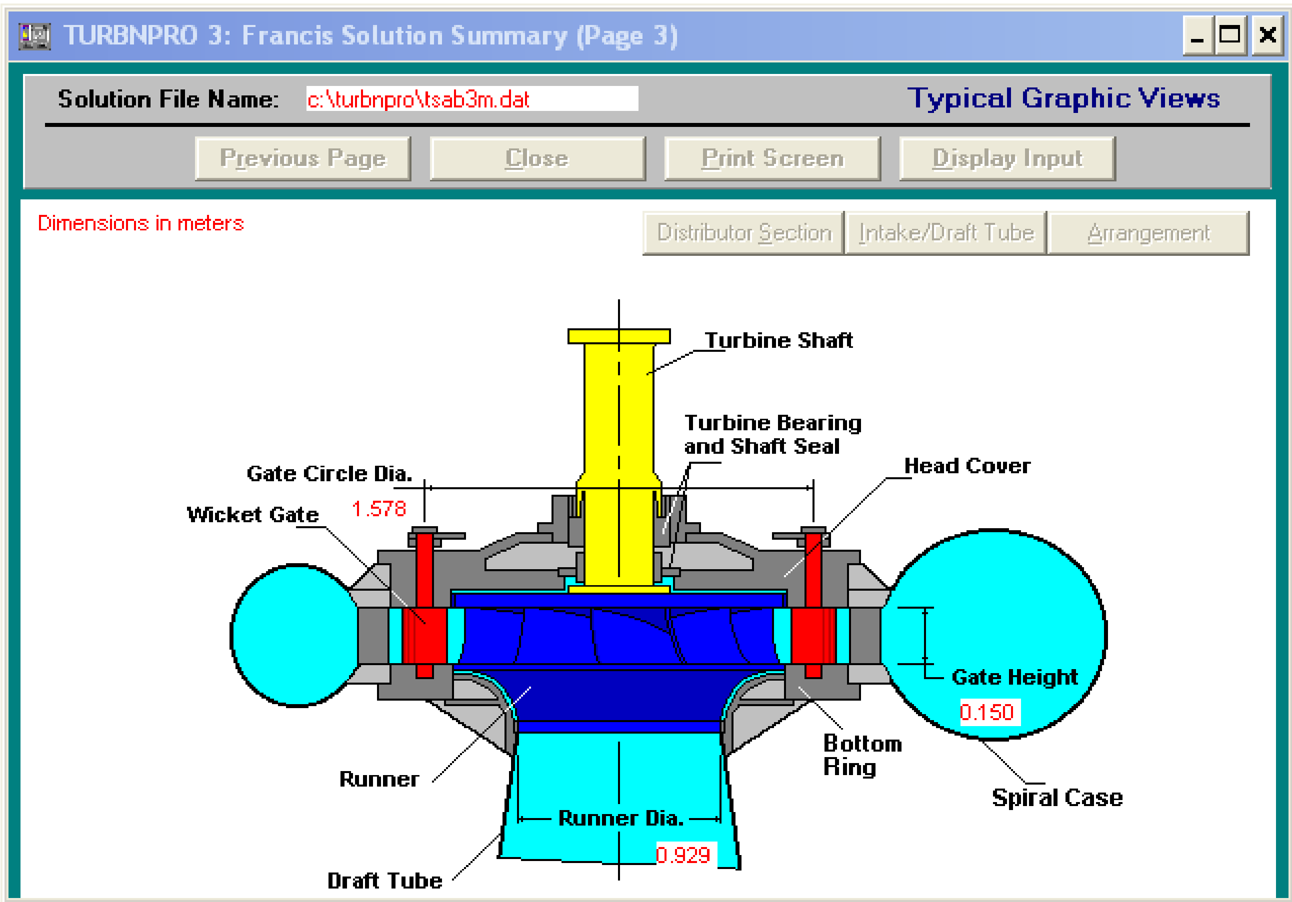
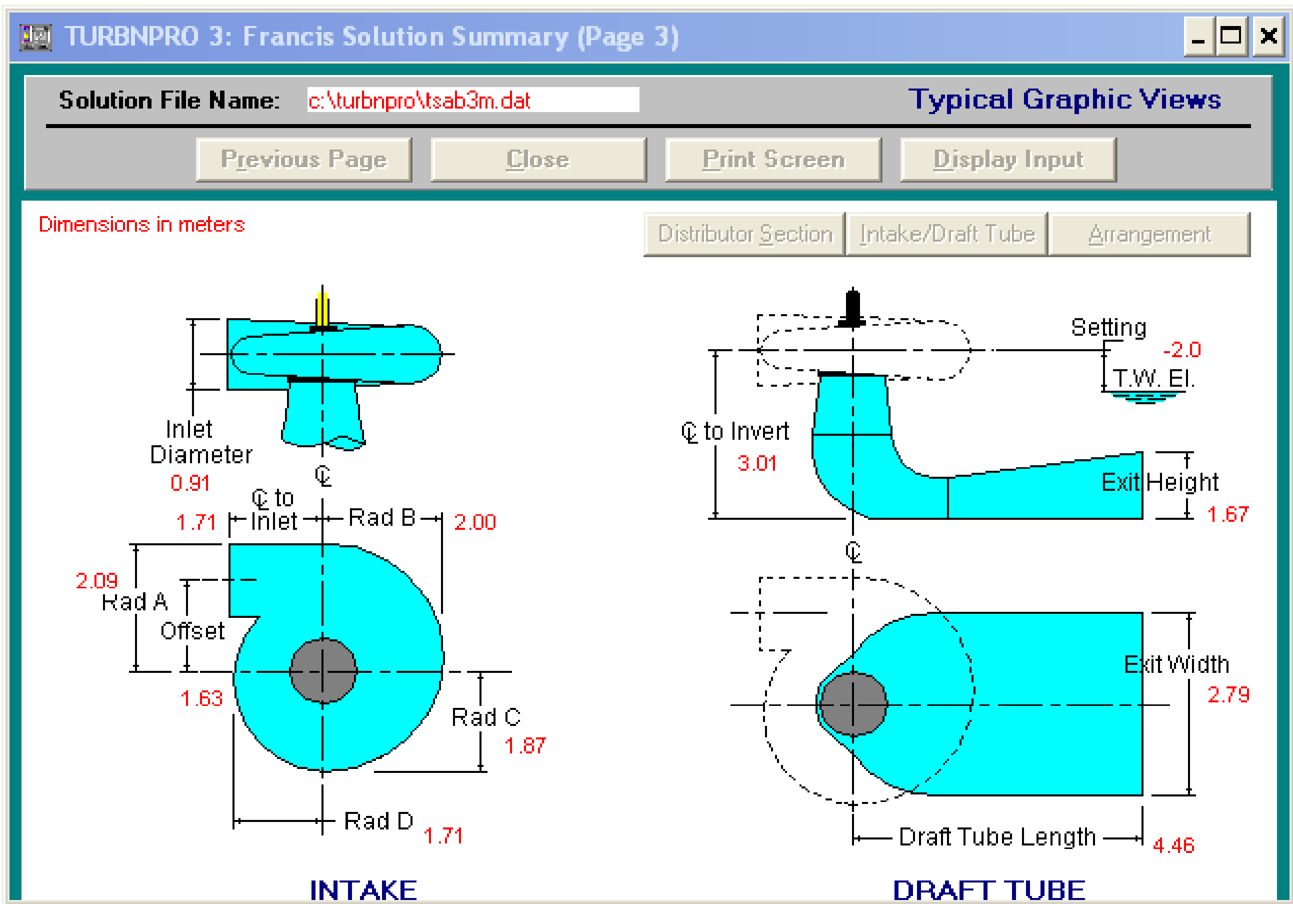
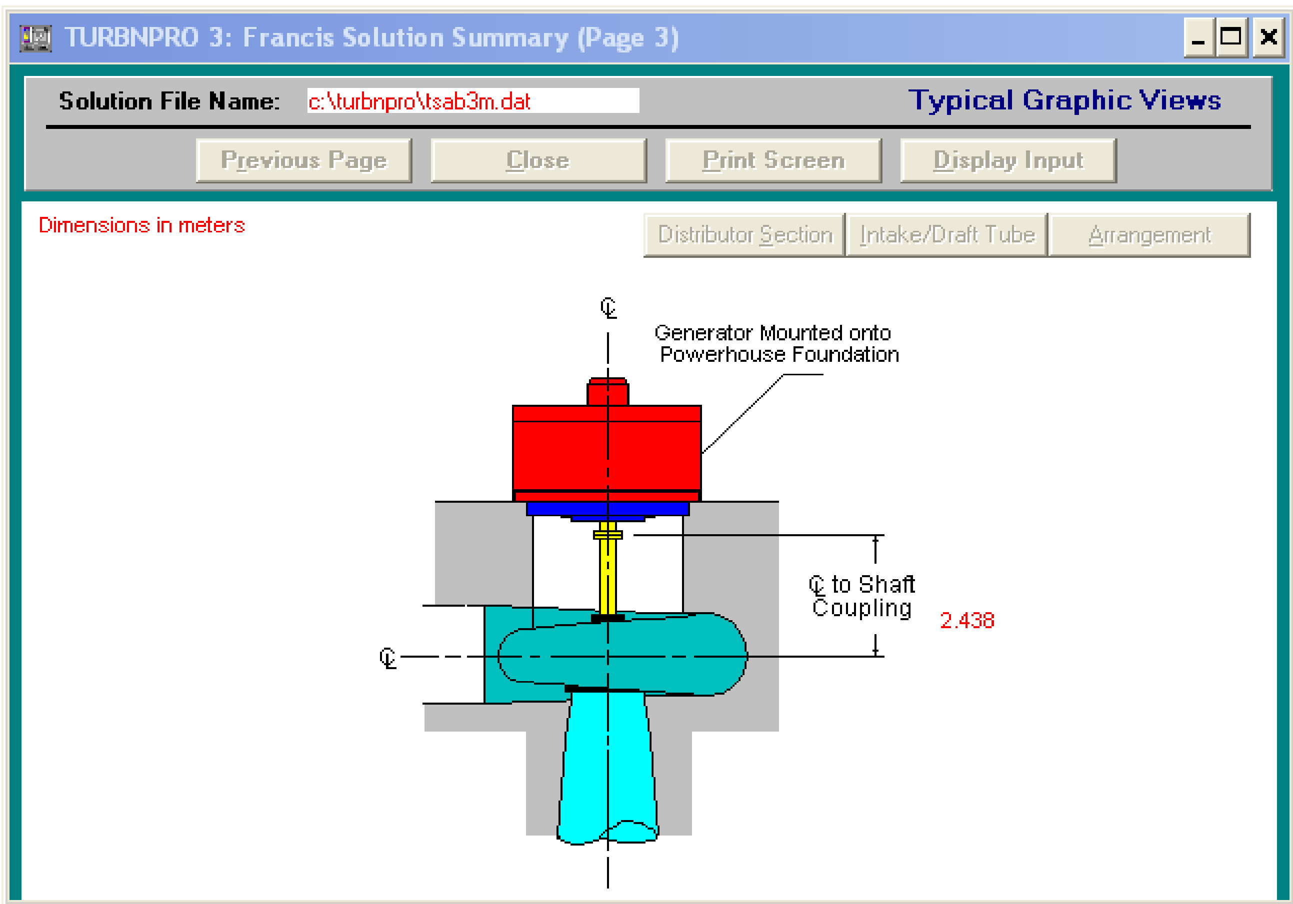


Solution File Name: c:\turbnpro\tsab3m.dat
Runner Diameter: 929 mm
Net Head at Rated Discharge: 123.50 meters
Unit Speed: 500.0 rpm



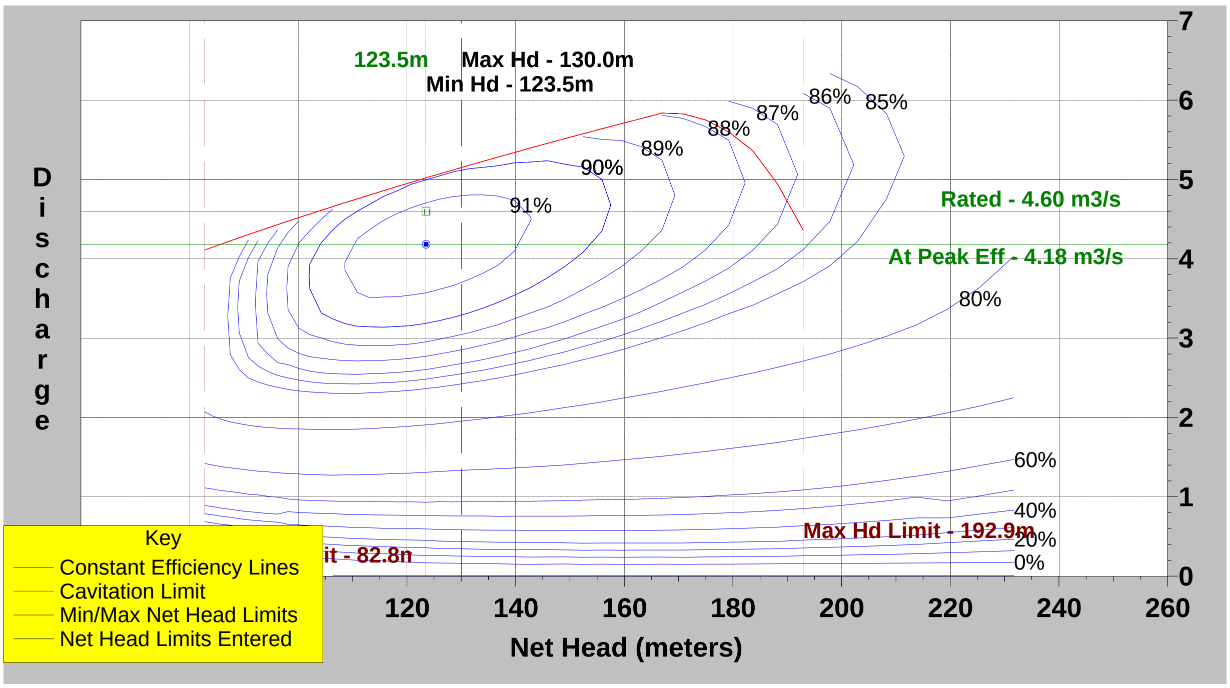
TURBNPRO Version 3.0 - FRANCIS TURBINE SOLUTION GRAPHICS

```
Solution File Name: c:\turbnpro\tsab3m.dat
Runner Diameter:                  929   mm
Net Head at Rated Discharge:    123.50  meters
Unit Speed:                     500.0  rpm
```



Solution File Name: c:\turbnpro\tsab3m.dat

Runner Diameter:	929	mm
Net Head at Rated Discharge:	123.50	meters
Unit Speed:	500.0	rpm
Peak Efficiency:	91.7	%
Multiplier Efficiency Modifier:	1.000	
Flow Squared Efficiency Modifier:	0.0000	

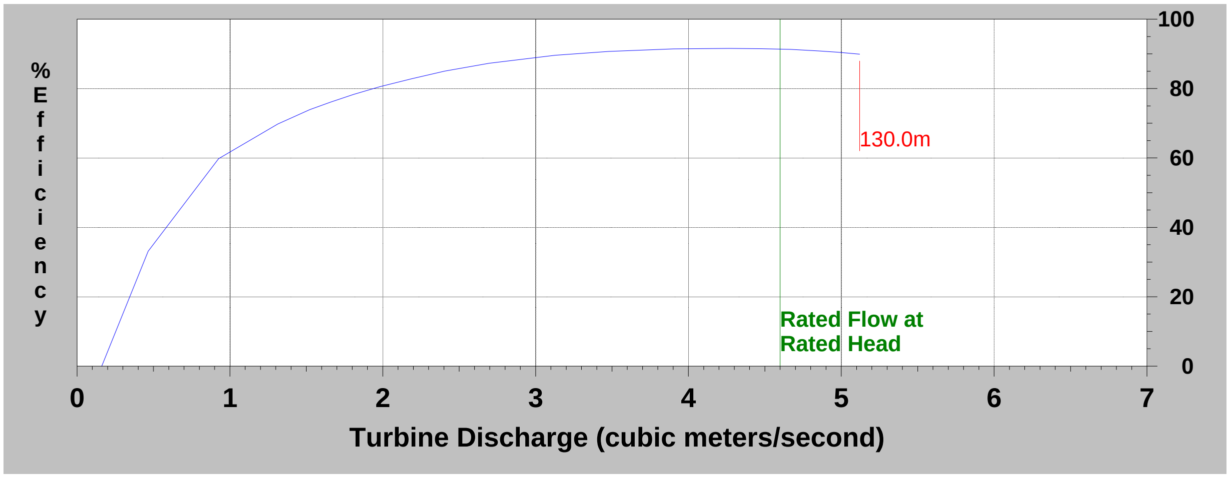


NOTE: Discharge is in cubic meters per second

TURBNPRO Version 3 - FRANCIS TURBINE CROSS PLOT

Solution File Name: c:\turbnpro\tsab3m.dat
Runner Diameter: 929 mm
Net Head at Rated Discharge: 123.50 meters
Unit Speed: 500.0 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

Performance Data Shown is for a Net Head of: 130



TURBNPRO Version 3 - FRANCIS TURBINE SOLUTION SUMMARY

Solution File Name: c:\turbnpro\tsab3l.dat

TURBINE SIZING CRITERIA

Rated Discharge:	211.9	cfs	/	6.0	m3/s
Net Head at Rated Discharge:	405.2	feet	/	123.5	meters
Gross Head:	429.8	feet	/	131.0	meters
Site Elevation:	787	feet	/	240	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:	405.2	feet	/	123.5	meters
Maximum Net Head:	426.5	feet	/	130.0	meters

FRANCIS TURBINE SOLUTION DATA

Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT
Intake Type: SPIRAL CASE
Draft Tube Type: ELBOW
Runner Diameter: 39.9 inches / 1014 mm
Unit Speed: 500.0 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:	26.0	99.2
At Peak Efficiency Condition:	24.9	94.9

SOLUTION PERFORMANCE DATA

At Rated Net Head of: 405.2 feet / 123.5 meters

% of Rated Discharge	Output (KW)	Efficiency (%)	cfs	m3/s
** 109.1	7177	90.5	231.2	6.5
100	6677	91.9	211.9	6.0
* 90.9	6101	92.3	192.6	5.5
75	4979	91.3	158.9	4.5
50	3067	84.4	105.9	3.0
25	1178	64.8	53.0	1.5
+ 47.8	2894	83.2	101.3	2.9

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

At Maximum Net Head of: 426.5 feet / 130.0 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.055	7708	90.5	235.9	6.7

At Minimum Net Head of: 405.2 feet / 123.5 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.055	7177	90.5	231.2	6.5

Solution File Name: c:\turbnpro\tsab3l.dat

MISCELLANEOUS DATA

Maximum Runaway Speed (at Max. Net Head):	833 rpm	
Turbine Discharge at:		
Runaway Speed (at Rated Net Head & 100% gate):	96 cfs	2.7 m3/s
Synchronous Speed-No-Load (at Rated Net Head):	17 cfs	0.5 m3/s
Site's Atmospheric Pressure minus Vapor Pressure:	32.2 feet	9.8 meters
Sigma Allowable (at 100% Output & Rated Net Head):	0.041	
Sigma Plant (at 100% Output & Rated Net Head):	0.096	
Maximum Hydraulic Thrust (at Max. Net Head):	33071 lbs	15032 kg
Approximate Runner and Shaft Weight:	5523 lbs	2511 kg
Vel. at Draft Tube Exit (at Rated Head & Discharge):	3.5 fps	1.1 m/s

DIMENSIONAL DATA

Intake Type: SPIRAL CASE

	inches	mm
Inlet Diameter:	42.0	1067
Inlet Offset:	65.0	1652
Centerline to Inlet:	77.4	1967
Outside Radius A:	86.0	2185
Outside Radius B:	82.3	2089
Outside Radius C:	76.3	1939
Outside Radius D:	69.7	1771

Draft Tube Type: ELBOW

	inches	mm
Centerline to Invert:	128.3	3260
Shaft Axis to Exit Length:	191.6	4867
Exit Width:	119.8	3042
Exit Height:	71.9	1825

Shafting Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT

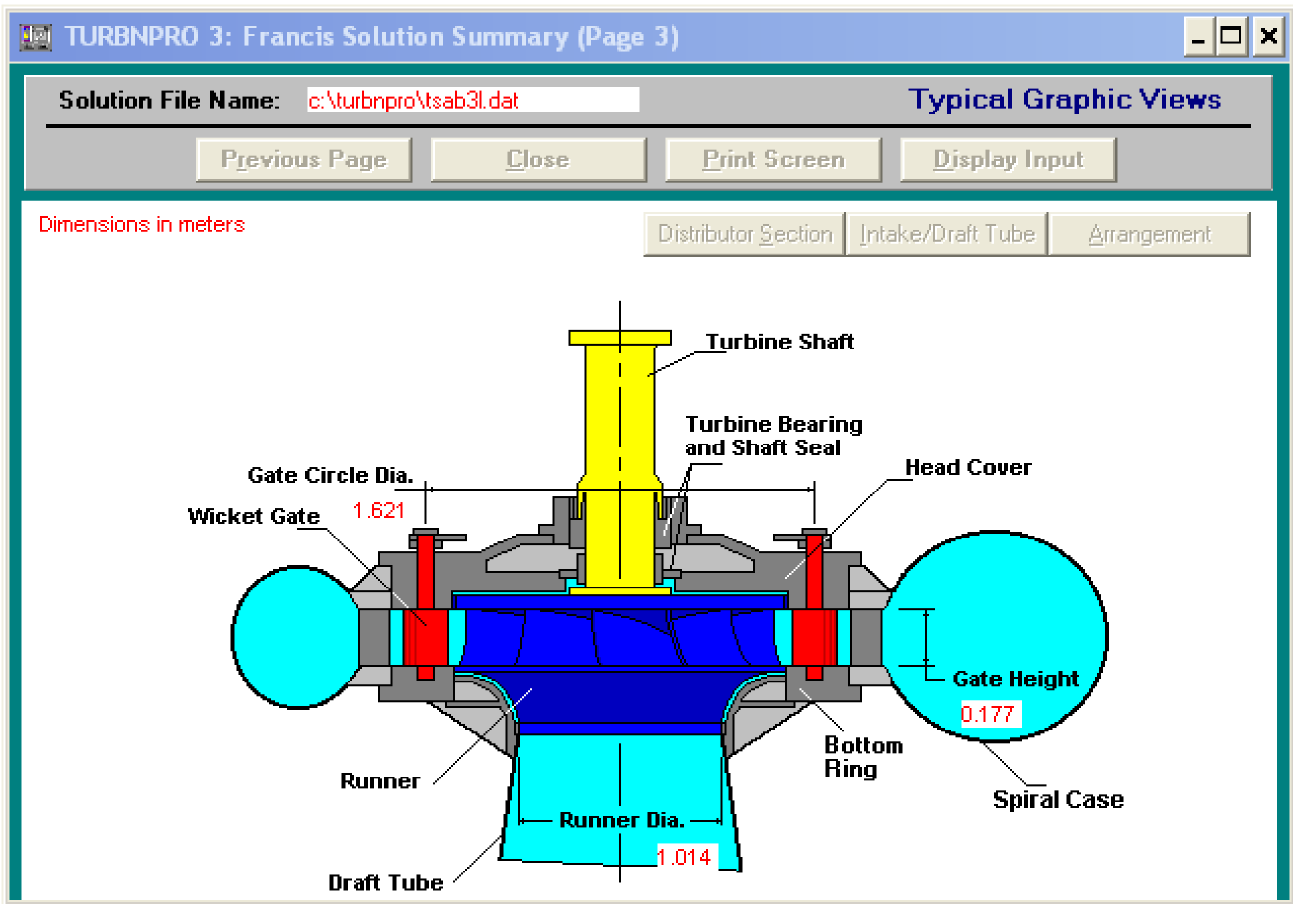
	inches	mm
Centerline to Shaft Coupling:	96.0	2438
Turbine Shaft Diameter:	11.4	290

Miscellaneous:

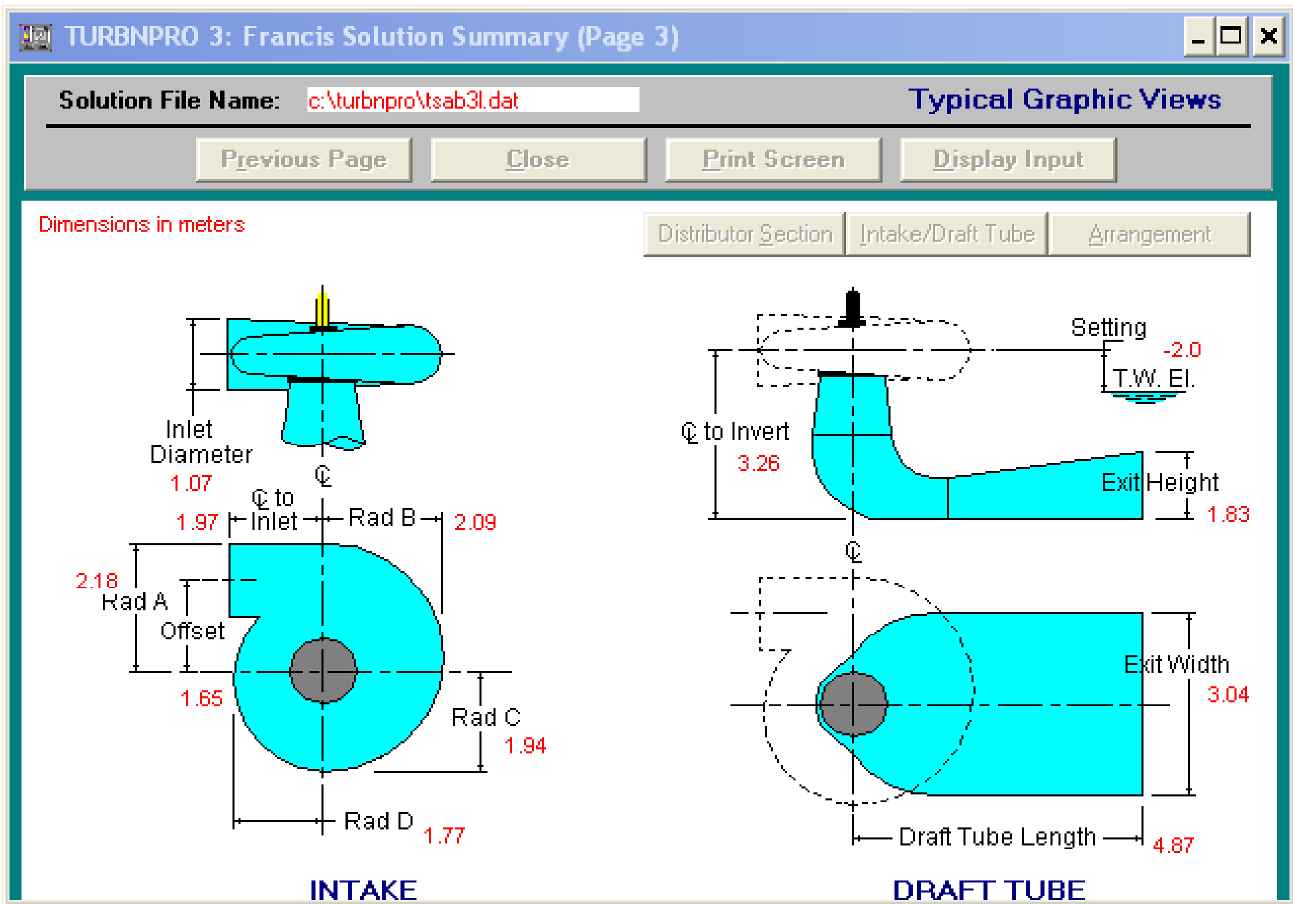
	inches	mm
Wicket Gate Height:	7.0	177
Wicket Gate Circle Diameter:	63.8	1621

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

Solution File Name: c:\turbnpro\tsab3l.dat
Runner Diameter: 1014 mm
Net Head at Rated Discharge: 123.50 meters
Unit Speed: 500.0 rpm

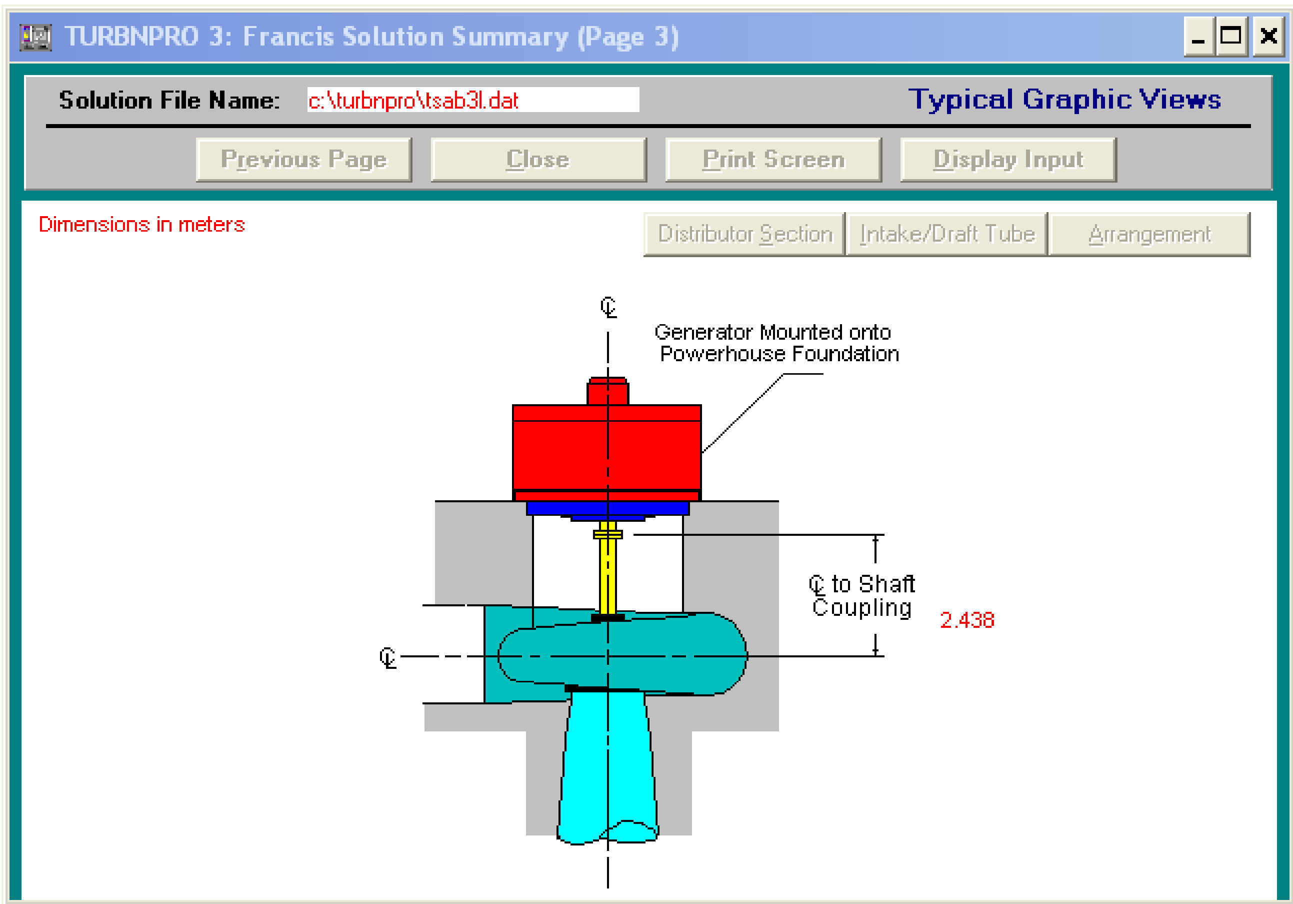


Solution File Name: c:\turbnpro\tsab3l.dat
Runner Diameter: 1014 mm
Net Head at Rated Discharge: 123.50 meters
Unit Speed: 500.0 rpm



TURBNPRO Version 3.0 - FRANCIS TURBINE SOLUTION GRAPHICS

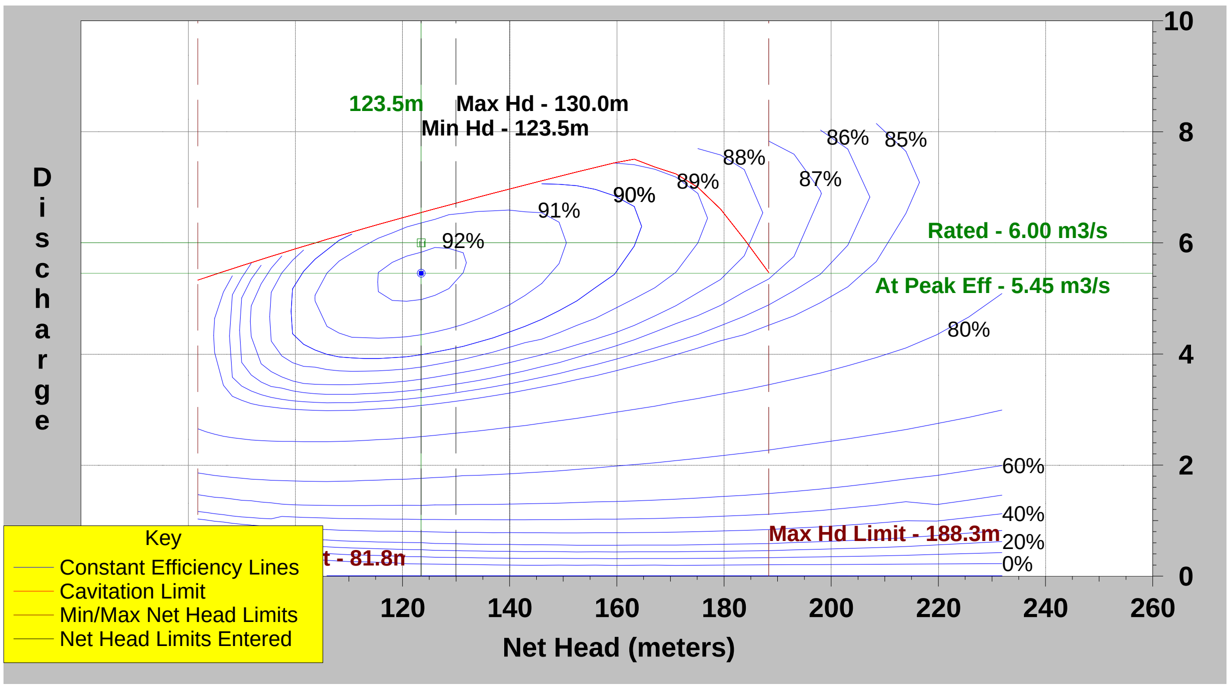
Solution File Name: c:\turbnpro\tsab3l.dat
Runner Diameter: 1014 mm
Net Head at Rated Discharge: 123.50 meters
Unit Speed: 500.0 rpm



TURBNPRO Version 3 - FRANCIS TURBINE HILL CURVE

```
Solution File Name: c:\turbnpro\tsab3l.dat

Runner Diameter:                  1014   mm
Net Head at Rated Discharge:      123.50  meters
Unit Speed:                       500.0   rpm
Peak Efficiency:                   92.3   %
Multiplier Efficiency Modifier:     1.000
Flow Squared Efficiency Modifier:   0.0000
```

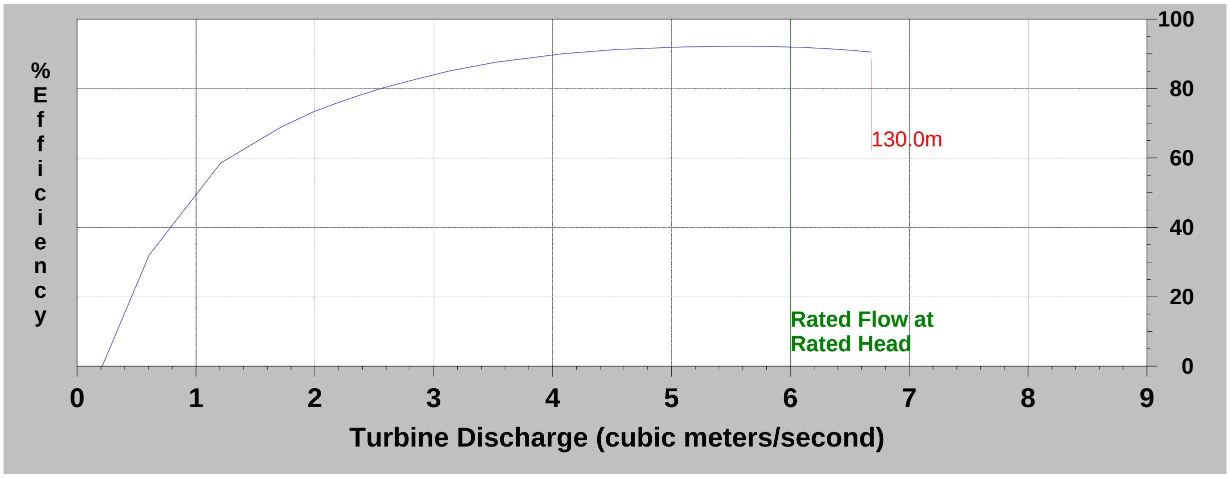


NOTE: Discharge is in cubic meters per second

TURBNPRO Version 3 - FRANCIS TURBINE CROSS PLOT

```
Solution File Name: c:\turbnpro\tsab3l.dat
Runner Diameter:                  1014  mm
Net Head at Rated Discharge:      123.50  meters
Unit Speed:                       500.0  rpm
Multiplier Efficiency Modifier:    1.000
Flow Squared Efficiency Modifier:  0.0000
```

Performance Data Shown is for a Net Head of: 130



TURBNPRO Version 3 - PELTON TURBINE SOLUTION SUMMARY

Solution File Name: c:\turbnpro\tsab3p.dat

TURBINE SIZING CRITERIA

Rated Discharge:	162.4	cfs	/	4.60	m3/s
Net Head at Rated Discharge:	405.2	feet	/	123.5	meters
Gross Head:	429.8	feet	/	131.0	meters
Efficiency Priority:			5		
System Frequency:			50 Hz		
Minimum Net Head:	405.2	feet	/	123.5	meters
Maximum Net Head:	421.8	feet	/	128.6	meters

PELTON TURBINE SOLUTION DATA

Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT
Intake Type: 4 - JET
Runner Pitch Diameter: 70.6 inches / 1792 mm
Unit Speed: 250.0 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

Specific Speed at Rated Net Head (turbine) -	(US Cust.)	(SI Units)
At 100% Turbine Output:	11.3	42.9
At Peak Efficiency Condition:	10.3	39.2

Specific Speed at Rated Net Head (per jet) -	(US Cust.)	(SI Units)
At 100% Turbine Output:	5.6	21.5
At Peak Efficiency Condition:	5.1	19.6

SOLUTION PERFORMANCE DATA

At Rated Net Head of: 405.2 feet / 123.5 meters

% of Rated Discharge	Output (KW)	Efficiency (%)	cfs	m3/s
** 116.6	5783	89.0	189.4	5.37
100	4993	89.6	162.4	4.60
* 83.3	4168	89.7	135.4	3.83
75	3745	89.6	121.8	3.45
50	2467	88.5	81.2	2.30
25	1211	86.9	40.6	1.15

** - Overcapacity
* - Peak Efficiency Condition

At Maximum Net Head of: 421.8 feet / 128.6 meters

Max. Output (KW)	Efficiency (%)	cfs	m3/s
6137	88.9	193.3	5.47

At Minimum Net Head of: 405.2 feet / 123.5 meters

Max. Output (KW)	Efficiency (%)	cfs	m3/s
5786	89.0	189.5	5.37

Solution File Name: c:\turbnpro\tsab3p.dat

MISCELLANEOUS DATA

Maximum Runaway Speed (at Max. Net Head):	444 rpm	
D/B Ratio (Runner Pitch Dia./Bucket Width):	2.88	
Maximum Hydraulic Thrust (at Max. Net Head):	9742 lbs	4428 kg
Hydraulic Thrust per Jet (at Max. Net Head):	6890 lbs	3132 kg
Estimated Axial Thrust:	20741 lbs	9428 kg
Approximate Runner and Shaft Weight:	19669 lbs	8940 kg

DIMENSIONAL DATA

Intake Type: 4 - JET

	inches	mm
Inlet Diameter:	39.2	996
Nozzle Diameter:	23.2	589
Jet Orifice Diameter:	7.4	188
Needle Stroke:	7.0	179
Inlet Piping Spiral Radius:	157.8	4008

Jet to Jet Included Angle: 90 Degrees

Housing/Discharge Geometry:

	inches	mm
Centerline to Housing Top:	49.7	1263
Housing Diameter:	235.5	5982
Discharge Width:	176.6	4487
Tailwater Depth:	26.9	684
Discharge Ceiling to T.W.:	42.3	1075
Centerline to Tailwater:	115.9	2943

Shafting Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT

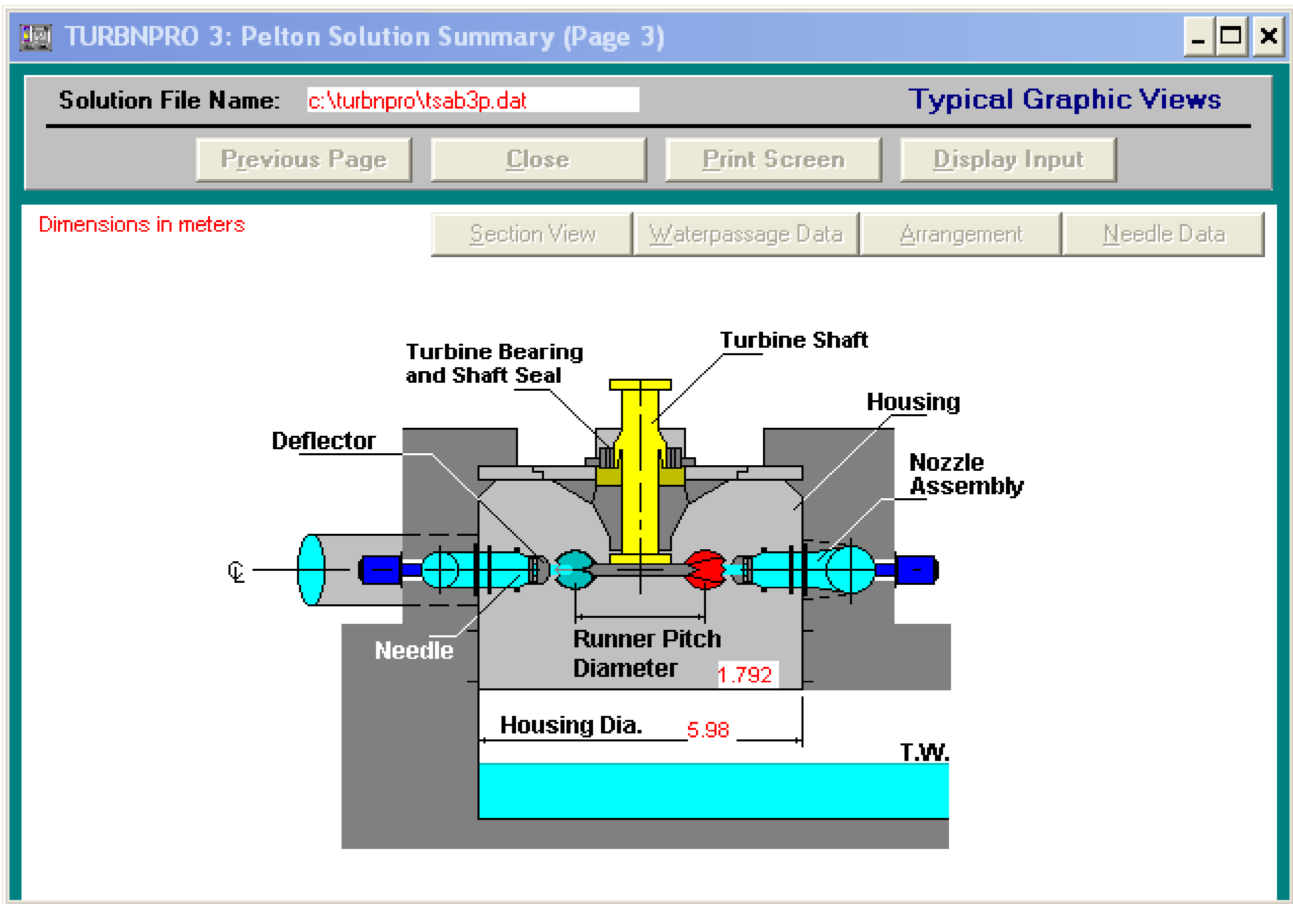
	inches	mm
Centerline to Shaft Coupling:	99.4	2525
Turbine Shaft Diameter:	14.8	376

Miscellaneous:

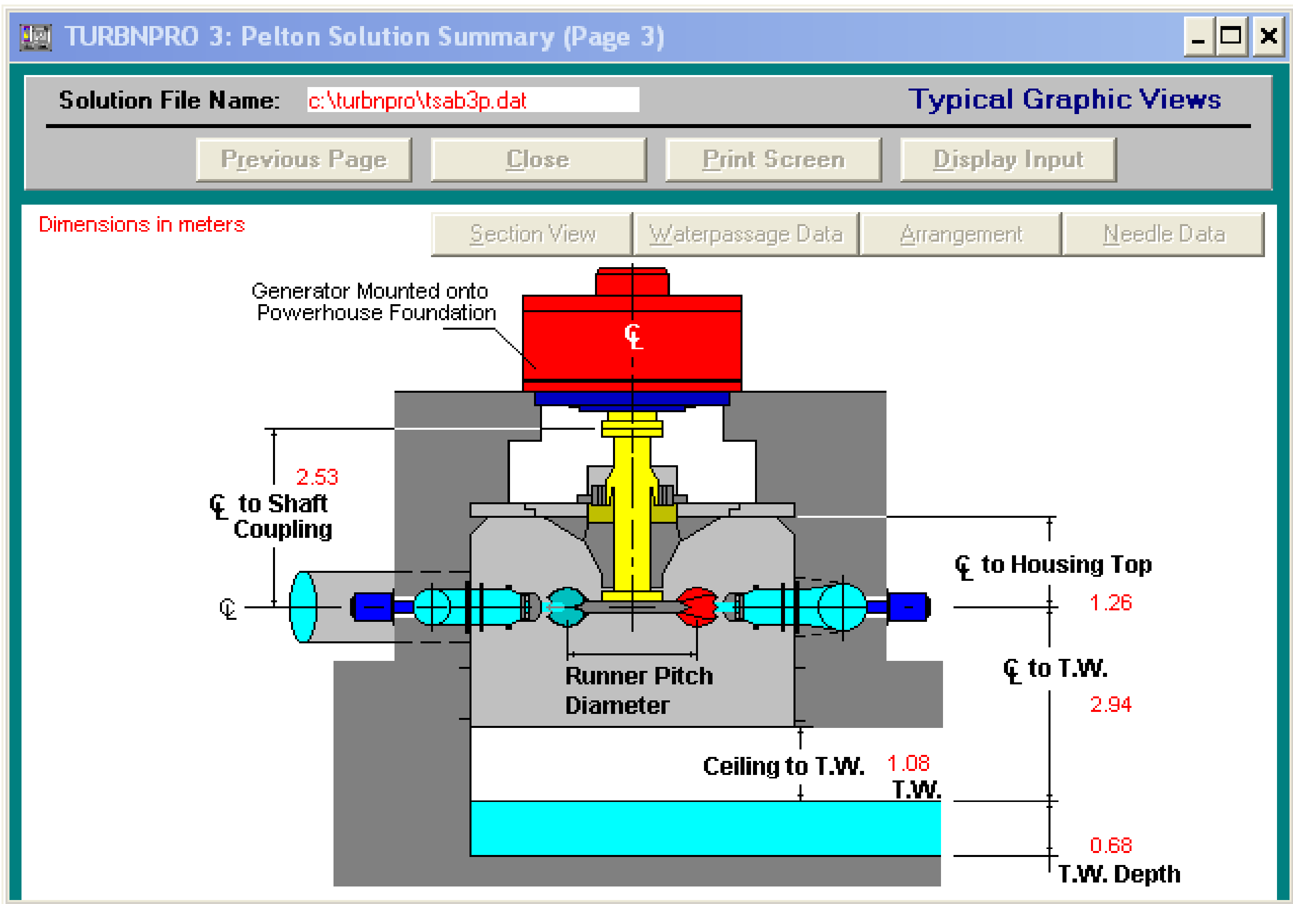
	inches	mm
Runner Outside Diameter:	95.1	2415
Runner Bucket Width:	24.5	623

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

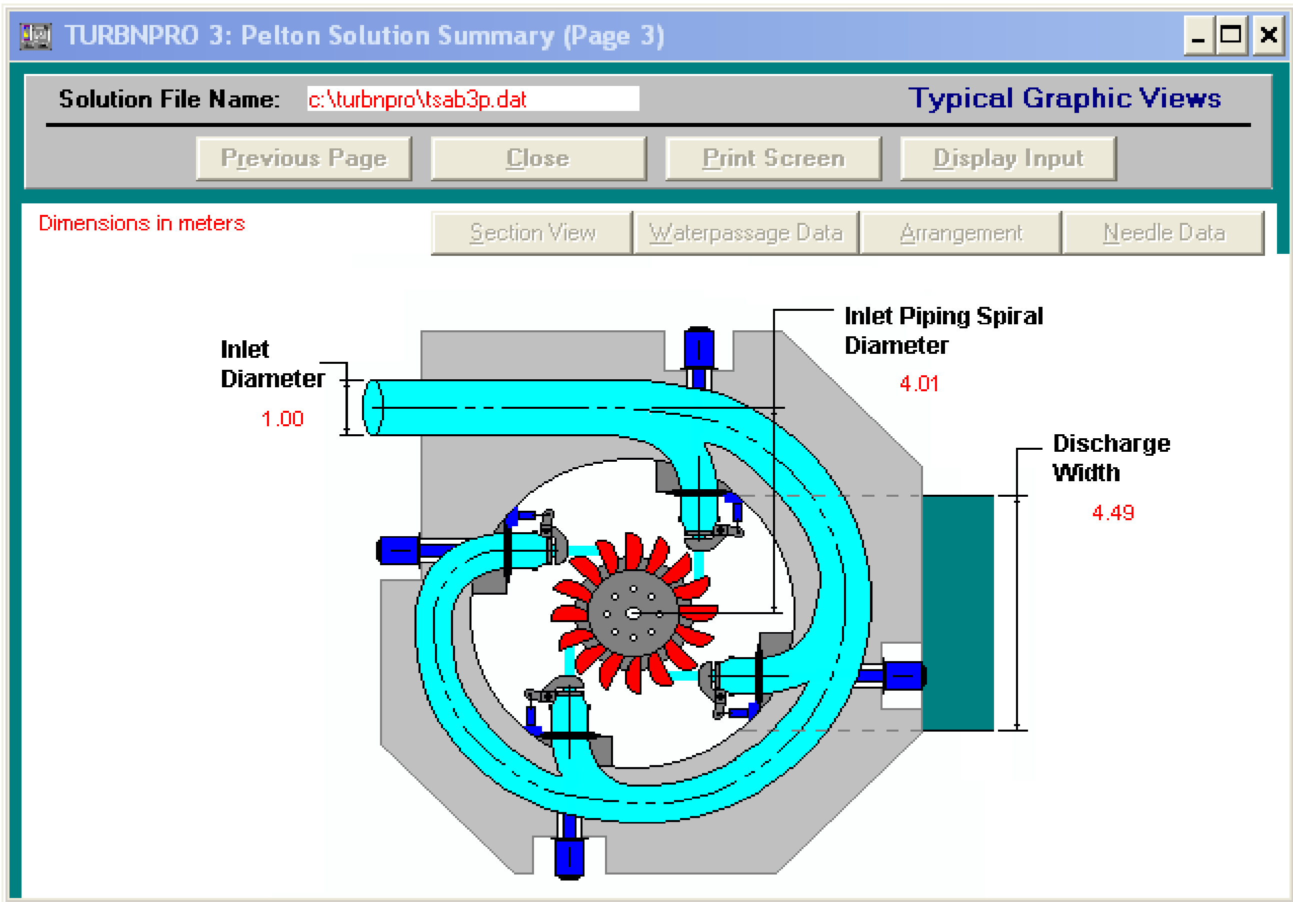
Solution File Name: c:\turbnpro\tsab3p.dat
Intake Type: 4 - JET
Runner Diameter: 1792 mm
Net Head at Rated Discharge: 123.50 meters
Unit Speed: 250.0 rpm



```
Solution File Name: c:\turbnpro\tsab3p.dat
Intake Type:                      4 - JET
Runner Diameter:                  1792  mm
Net Head at Rated Discharge:      123.50  meters
Unit Speed:                       250.0  rpm
```



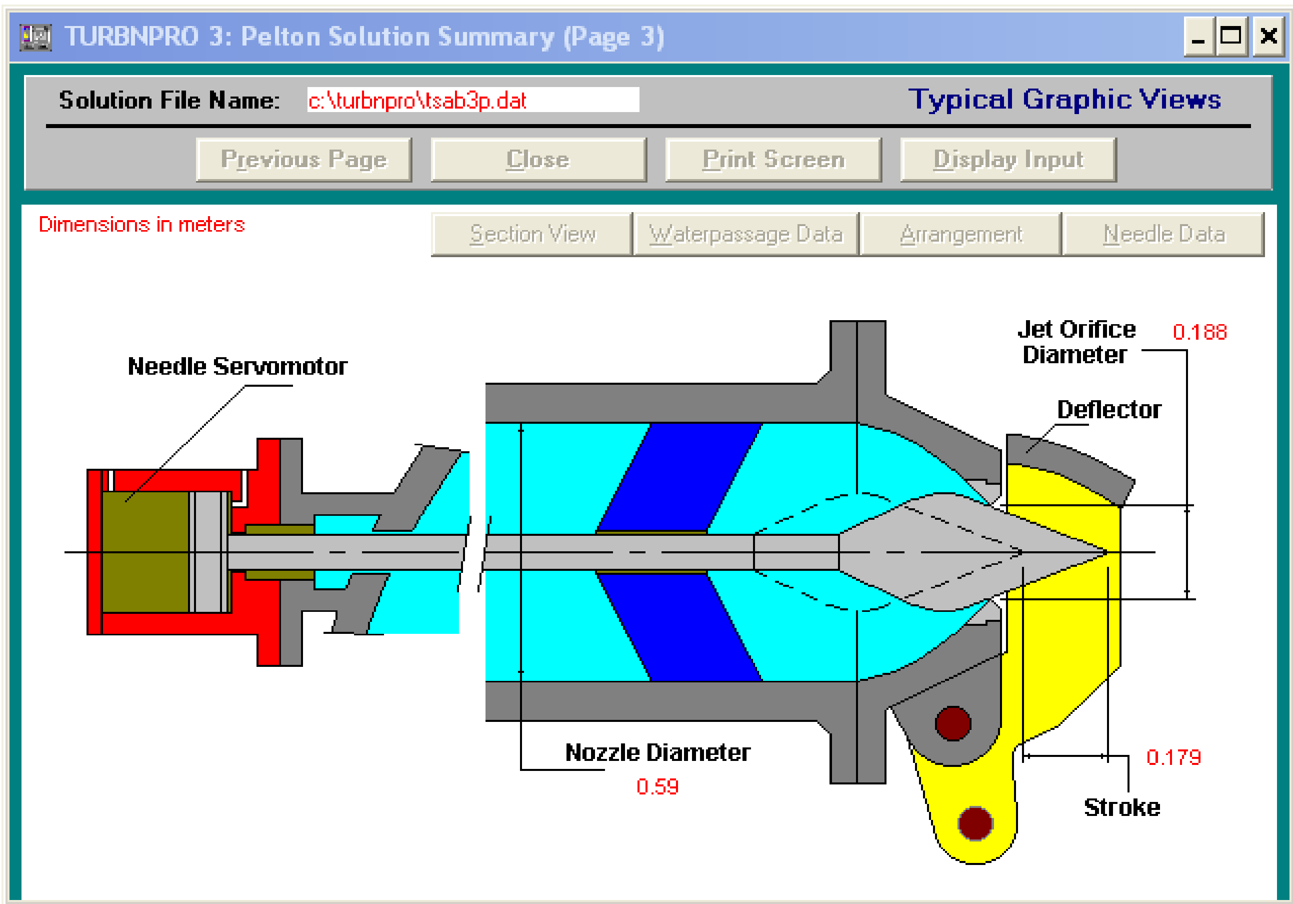
```
Solution File Name: c:\turbnpro\tsab3p.dat
Intake Type:                      4 - JET
Runner Diameter:                  1792  mm
Net Head at Rated Discharge:      123.50  meters
Unit Speed:                       250.0  rpm
```



TURBNPRO Version 3.0 - PELTON TURBINE SOLUTION GRAPHICS

Solution File Name: c:\turbnpro\tsab3p.dat

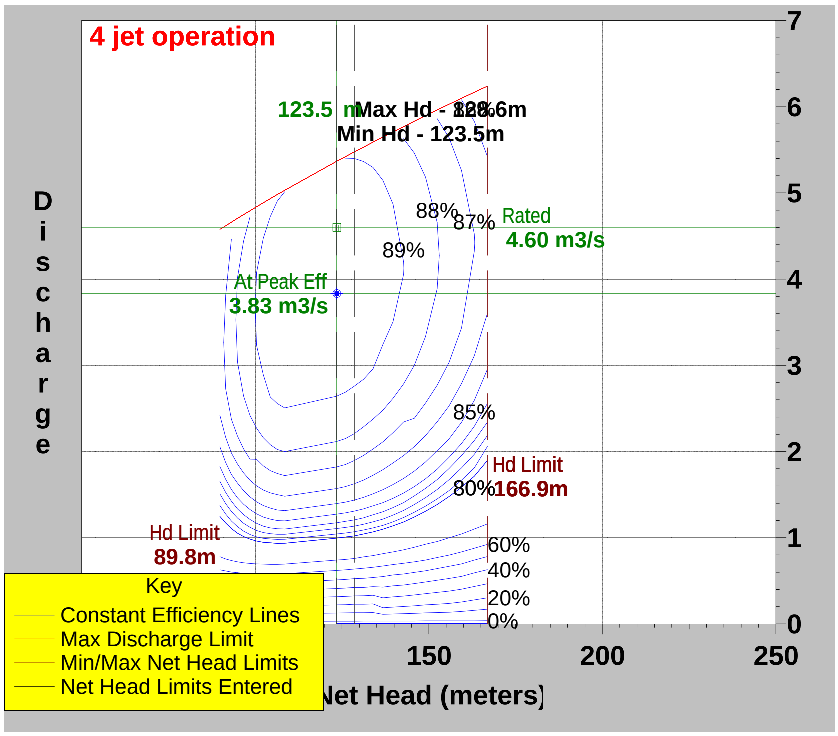
Intake Type:	4 - JET
Runner Diameter:	1792 mm
Net Head at Rated Discharge:	123.50 meters
Unit Speed:	250.0 rpm



TURBNPRO Version 3 - PELTON TURBINE HILL CURVE

```
Solution File Name: c:\turbnpro\tsab3p.dat

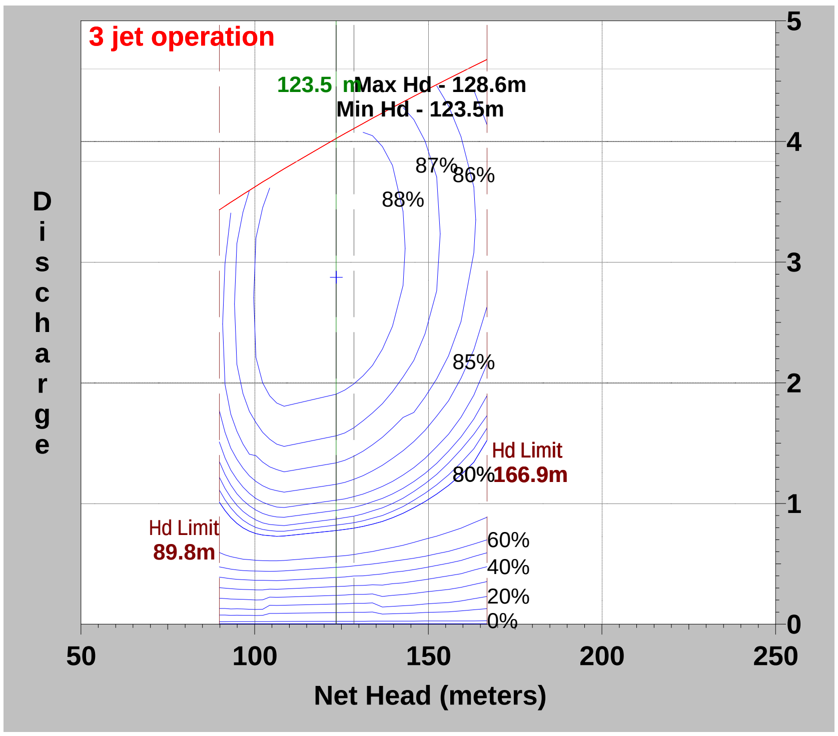
Intake Type:                      4 - JET
Runner Pitch Diameter:            1792  mm
Net Head at Rated Discharge:      123.50  meters
Unit Speed:                       250.0  rpm
Peak Efficiency:                   89.7  %
Multiplier Efficiency Modifier:    1.000
Flow Squared Efficiency Modifier:  0.0000
```



NOTE: Discharge is in cubic meters per second

```
Solution File Name: c:\turbnpro\tsab3p.dat

Intake Type:                      4 - JET
Runner Pitch Diameter:            1792  mm
Net Head at Rated Discharge:      123.50  meters
Unit Speed:                       250.0  rpm
Peak Efficiency:                   89.7  %
Multiplier Efficiency Modifier:    1.000
Flow Squared Efficiency Modifier:  0.0000
```

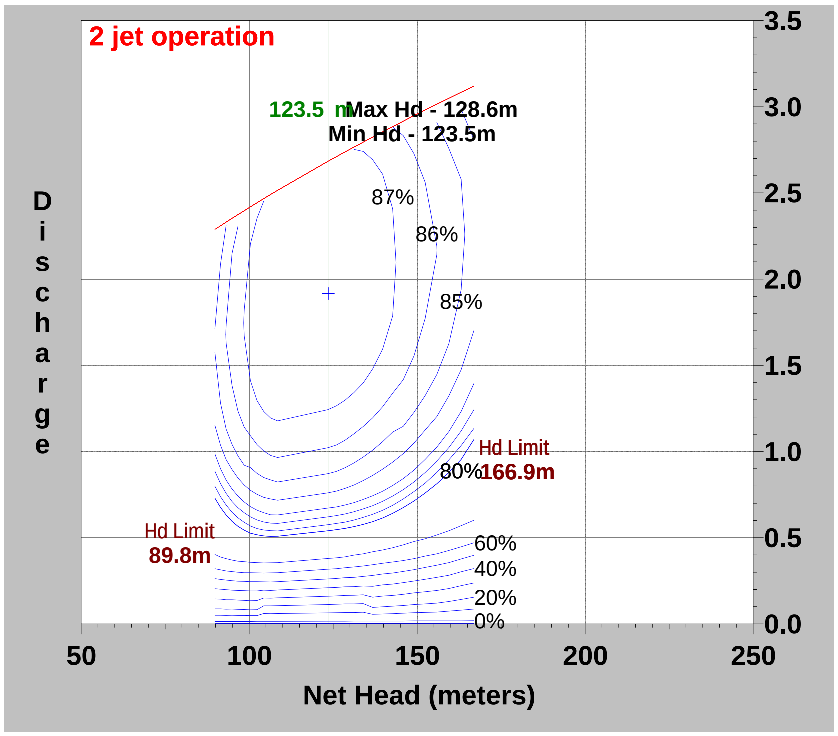


NOTE: Discharge is in cubic meters per second

TURBNPRO Version 3 - PELTON TURBINE HILL CURVE

Solution File Name: c:\turbnpro\tsab3p.dat

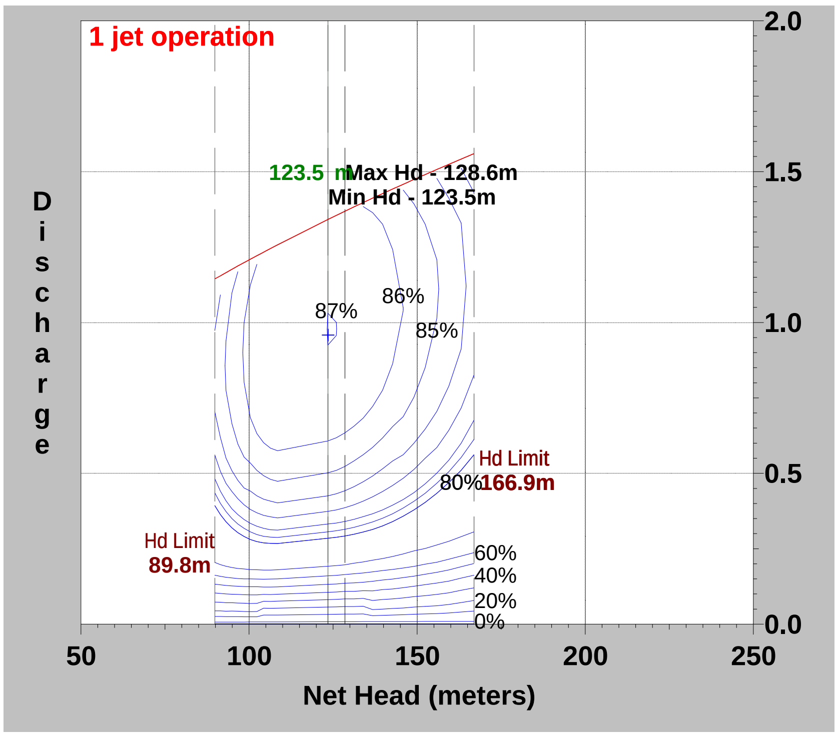
Intake Type:	4 - JET
Runner Pitch Diameter:	1792 mm
Net Head at Rated Discharge:	123.50 meters
Unit Speed:	250.0 rpm
Peak Efficiency:	89.7 %
Multiplier Efficiency Modifier:	1.000
Flow Squared Efficiency Modifier:	0.0000



NOTE: Discharge is in cubic meters per second

```
Solution File Name: c:\turbnpro\tsab3p.dat

Intake Type:                      4 - JET
Runner Pitch Diameter:            1792  mm
Net Head at Rated Discharge:      123.50  meters
Unit Speed:                       250.0  rpm
Peak Efficiency:                   89.7  %
Multiplier Efficiency Modifier:     1.000
Flow Squared Efficiency Modifier:  0.0000
```

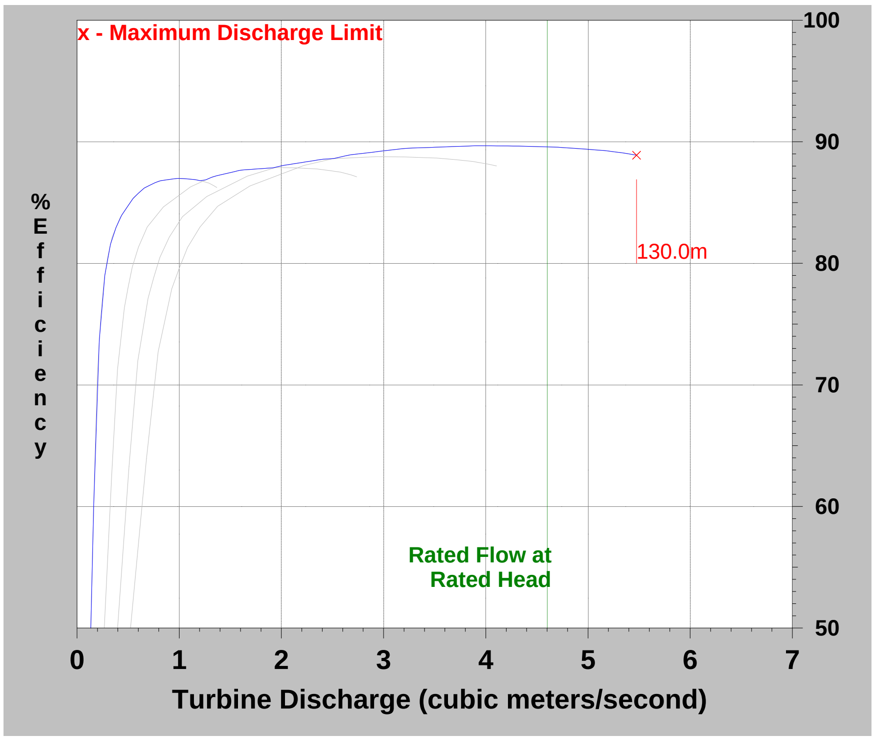


NOTE: Discharge is in cubic meters per second

TURBNPRO Version 3 - PELTON TURBINE HILL CURVE

```
Solution File Name: c:\turbnpro\tsab3p.dat
Intake Type:                        4 - JET
Runner Pitch Diameter:              1792  mm
Net Head at Rated Discharge:        123.50  meters
Unit Speed:                         250.0  rpm
Multiplier Efficiency Modifier:       1.000
Flow Squared Efficiency Modifier:   0.0000
```

Performance Data Shown is for a Net Head of: 130



TURBNPRO Version 3 - FRANCIS TURBINE SOLUTION SUMMARY

Solution File Name: No File Name

TURBINE SIZING CRITERIA

Rated Discharge:	113.0	cfs	/	3.2	m3/s
Net Head at Rated Discharge:	405.2	feet	/	123.5	meters
Gross Head:	429.8	feet	/	131.0	meters
Site Elevation:	787	feet	/	240	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:	405.2	feet	/	123.5	meters
Maximum Net Head:	426.5	feet	/	130.0	meters

FRANCIS TURBINE SOLUTION DATA

Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT
Intake Type: SPIRAL CASE
Draft Tube Type: ELBOW
Runner Diameter: 32.2 inches / 818 mm
Unit Speed: 500.0 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:	18.9	72.0
At Peak Efficiency Condition:	18.0	68.8

SOLUTION PERFORMANCE DATA

At Rated Net Head of: 405.2 feet / 123.5 meters

% of Rated Discharge	Output (KW)	Efficiency (%)	cfs	m3/s
** 109.1	3774	89.2	123.3	3.5
100	3511	90.6	113.0	3.2
* 90.9	3208	91.0	102.7	2.9
75	2621	90.1	84.7	2.4
50	1633	84.2	56.5	1.6
25	649	67.0	28.2	0.8
+ 44.9	1426	81.9	50.7	1.4

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

At Maximum Net Head of: 426.5 feet / 130.0 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.043	4054	89.2	125.8	3.6

At Minimum Net Head of: 405.2 feet / 123.5 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.042	3774	89.2	123.3	3.5

TURBNPRO Version 3 - FRANCIS TURBINE SOLUTION SUMMARY

Solution File Name: No File Name

MISCELLANEOUS DATA

Maximum Runaway Speed (at Max. Net Head):	811 rpm	
Turbine Discharge at:		
Runaway Speed (at Rated Net Head & 100% gate):	46 cfs /	1.3 m3/s
Synchronous Speed-No-Load (at Rated Net Head):	8 cfs /	0.2 m3/s
Site's Atmospheric Pressure minus Vapor Pressure:	32.2 feet /	9.8 meters
Sigma Allowable (at 100% Output & Rated Net Head):	0.032	
Sigma Plant (at 100% Output & Rated Net Head):	0.096	
Maximum Hydraulic Thrust (at Max. Net Head):	19195 lbs /	8725 kg
Approximate Runner and Shaft Weight:	3716 lbs /	1689 kg
Vel. at Draft Tube Exit (at Rated Head & Discharge):	2.9 fps /	0.9 m/s

DIMENSIONAL DATA

Intake Type: SPIRAL CASE

	inches /	mm
Inlet Diameter:	36.0	914
Inlet Offset:	60.4	1534
Centerline to Inlet:	83.7	2127
Outside Radius A:	78.4	1991
Outside Radius B:	74.8	1899
Outside Radius C:	70.9	1800
Outside Radius D:	65.4	1662

Draft Tube Type: ELBOW

	inches /	mm
Centerline to Invert:	105.1	2670
Shaft Axis to Exit Length:	154.6	3926
Exit Width:	96.6	2454
Exit Height:	58.0	1472

Shafting Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT

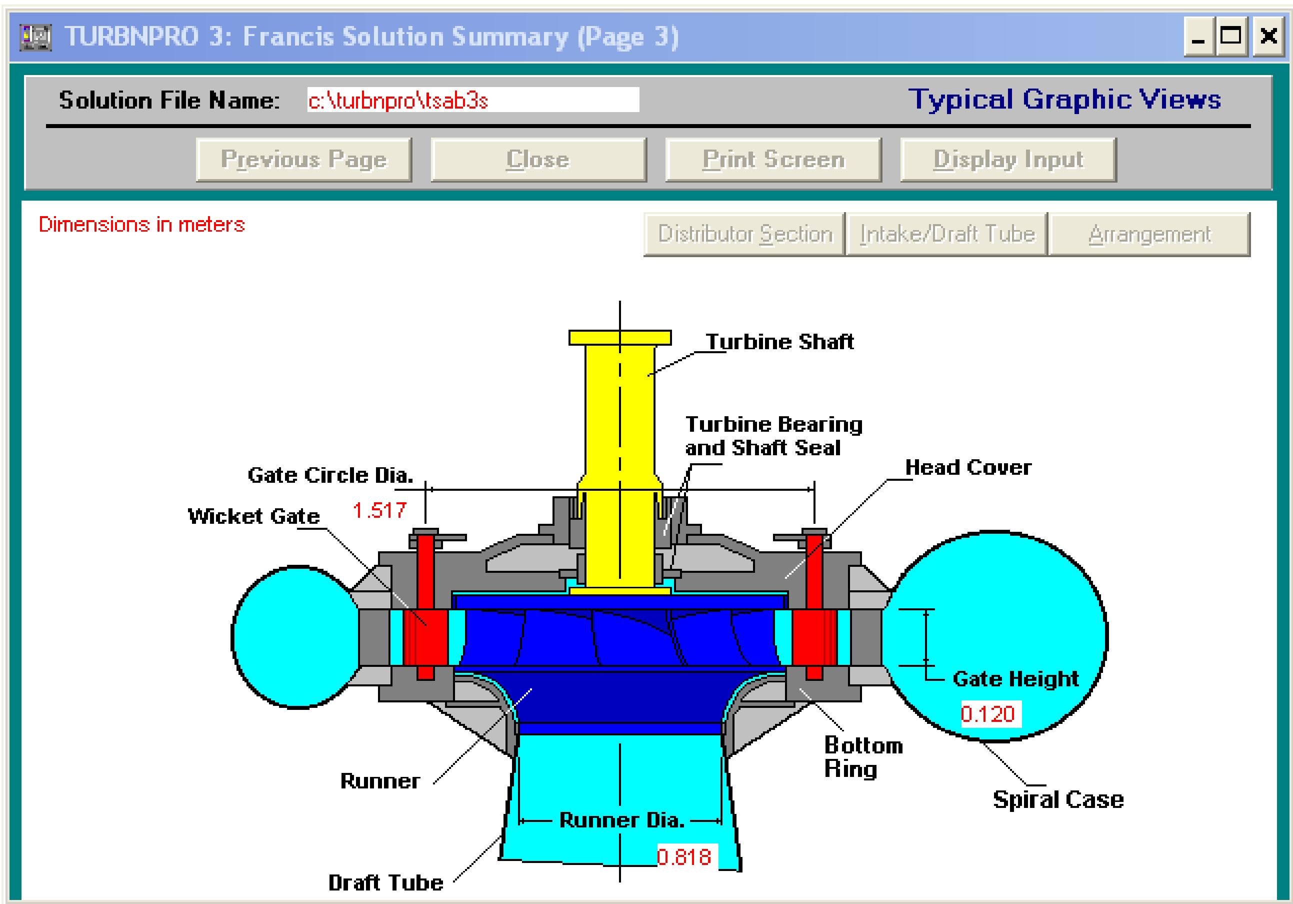
	inches /	mm
Centerline to Shaft Coupling:	96.0	2438
Turbine Shaft Diameter:	9.2	234

Miscellaneous:

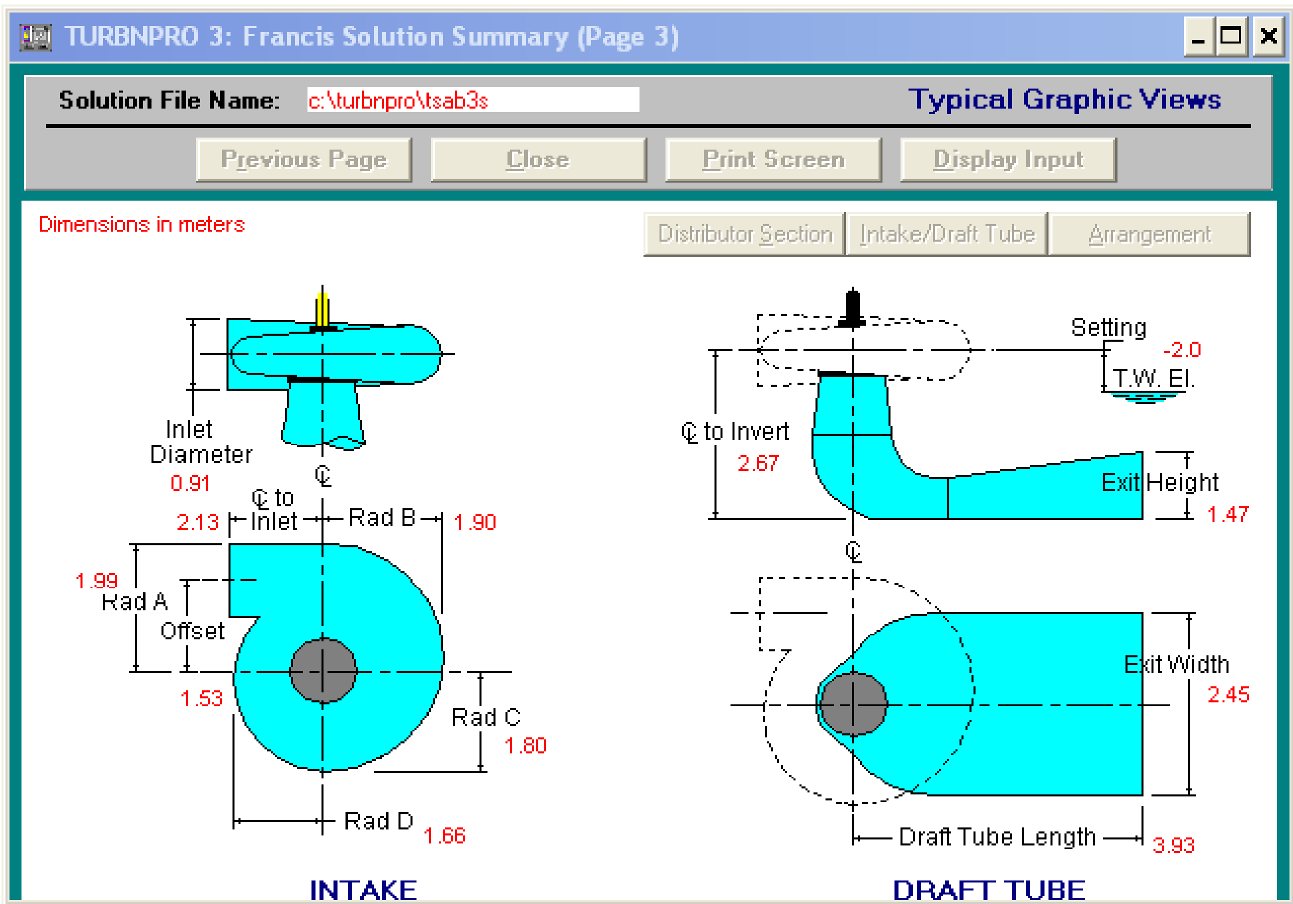
	inches /	mm
Wicket Gate Height:	4.7	120
Wicket Gate Circle Diameter:	59.7	1517

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

Solution File Name: c:\turbnpro\tsab3s
Runner Diameter: 818 mm
Net Head at Rated Discharge: 123.50 meters
Unit Speed: 500.0 rpm

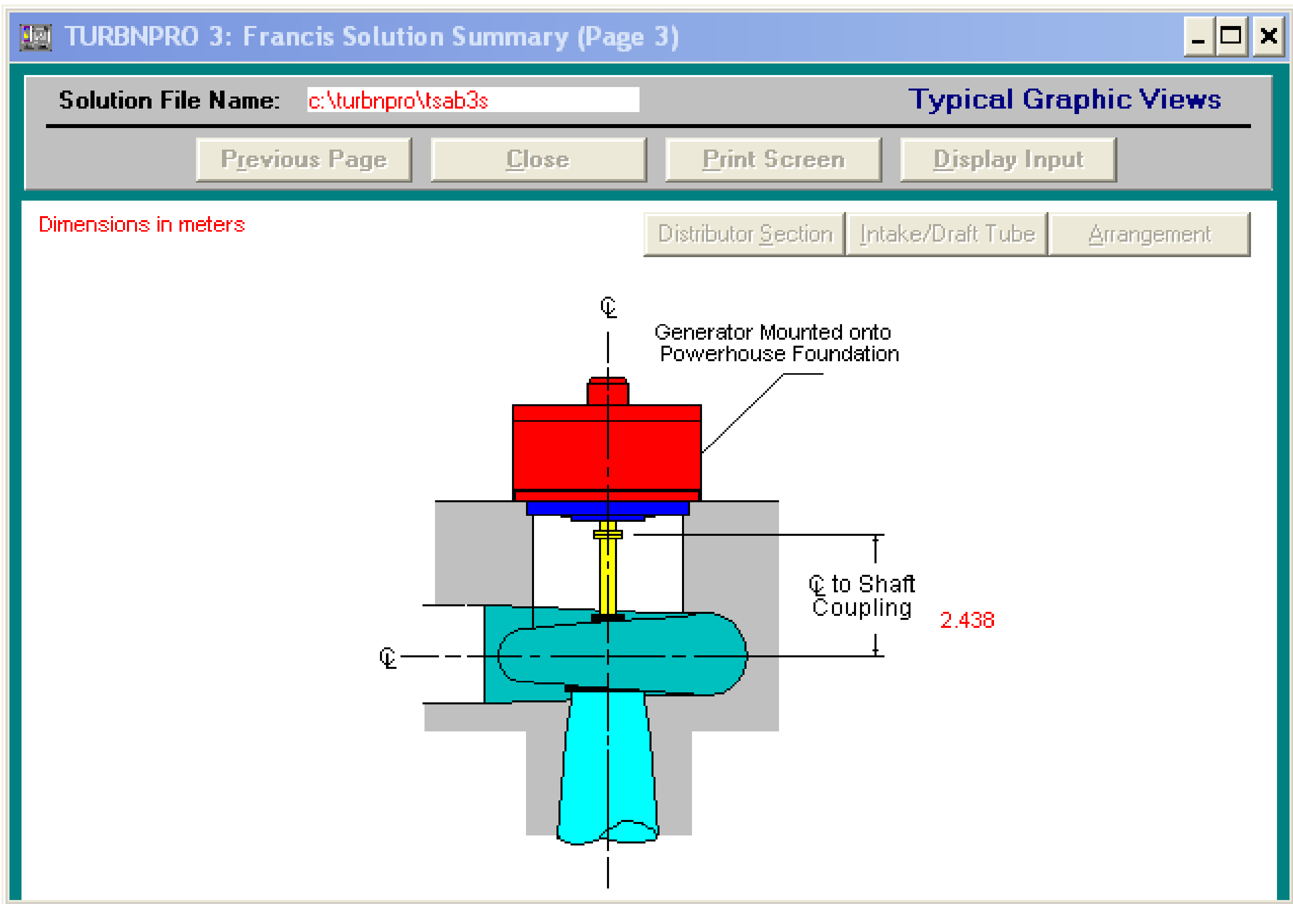


Solution File Name: c:\turbnpro\tsab3s
Runner Diameter: 818 mm
Net Head at Rated Discharge: 123.50 meters
Unit Speed: 500.0 rpm



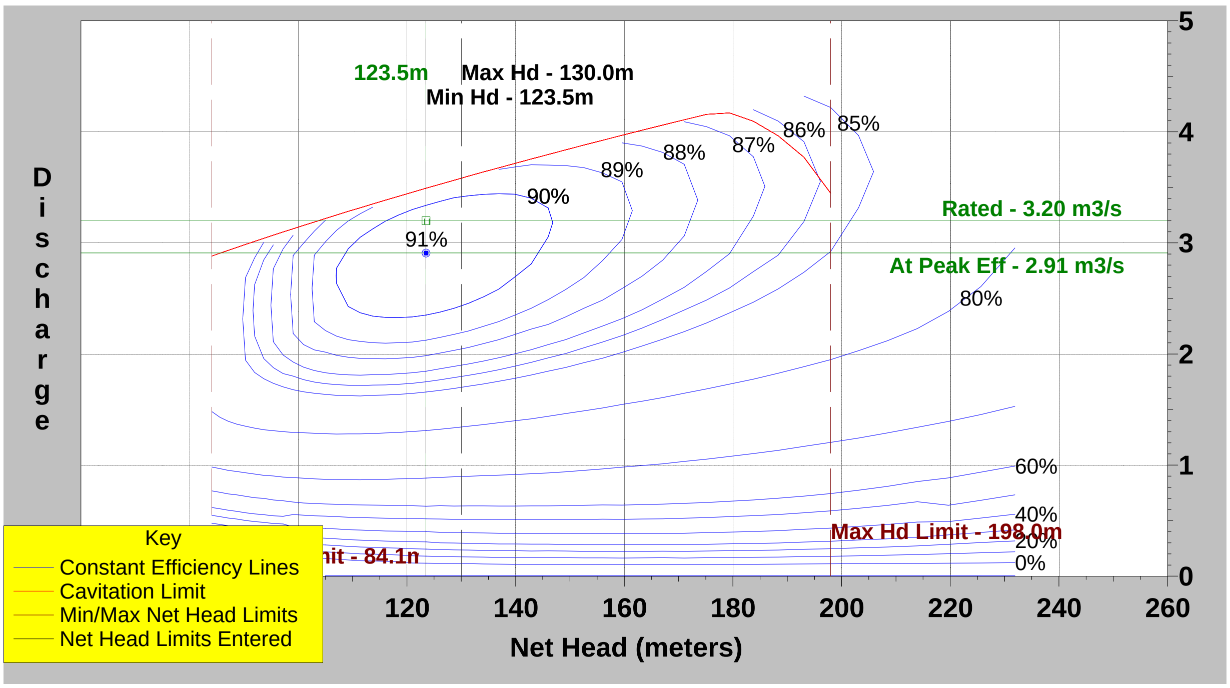
TURBNPRO Version 3.0 - FRANCIS TURBINE SOLUTION GRAPHICS

Solution File Name: c:\turbnpro\tsab3s
Runner Diameter: 818 mm
Net Head at Rated Discharge: 123.50 meters
Unit Speed: 500.0 rpm



Solution File Name: No File Name

Runner Diameter:	818	mm
Net Head at Rated Discharge:	123.50	meters
Unit Speed:	500.0	rpm
Peak Efficiency:	91.0	%
Multiplier Efficiency Modifier:	1.000	
Flow Squared Efficiency Modifier:	0.0000	

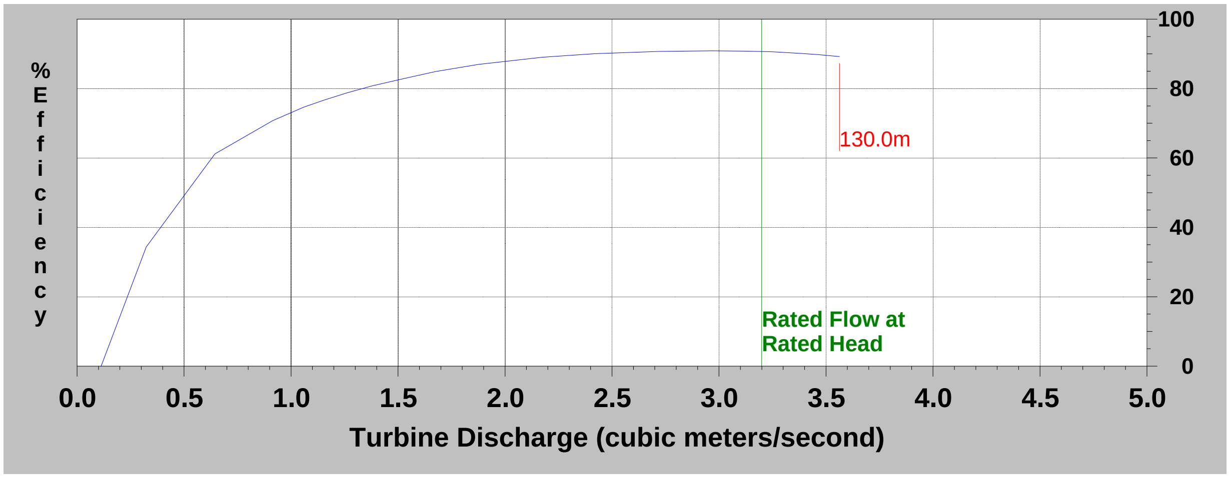


NOTE: Discharge is in cubic meters per second

TURBNPRO Version 3 - FRANCIS TURBINE CROSS PLOT

Solution File Name: No File Name
Runner Diameter: 818 mm
Net Head at Rated Discharge: 123.50 meters
Unit Speed: 500.0 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

Performance Data Shown is for a Net Head of: 130



TURBNPRO Version 3 - ANNUAL ENERGY PRODUCTION GRAPHIC

With site flow/head data as defined in file name: c:\turbnpro\tsab3sit.dat

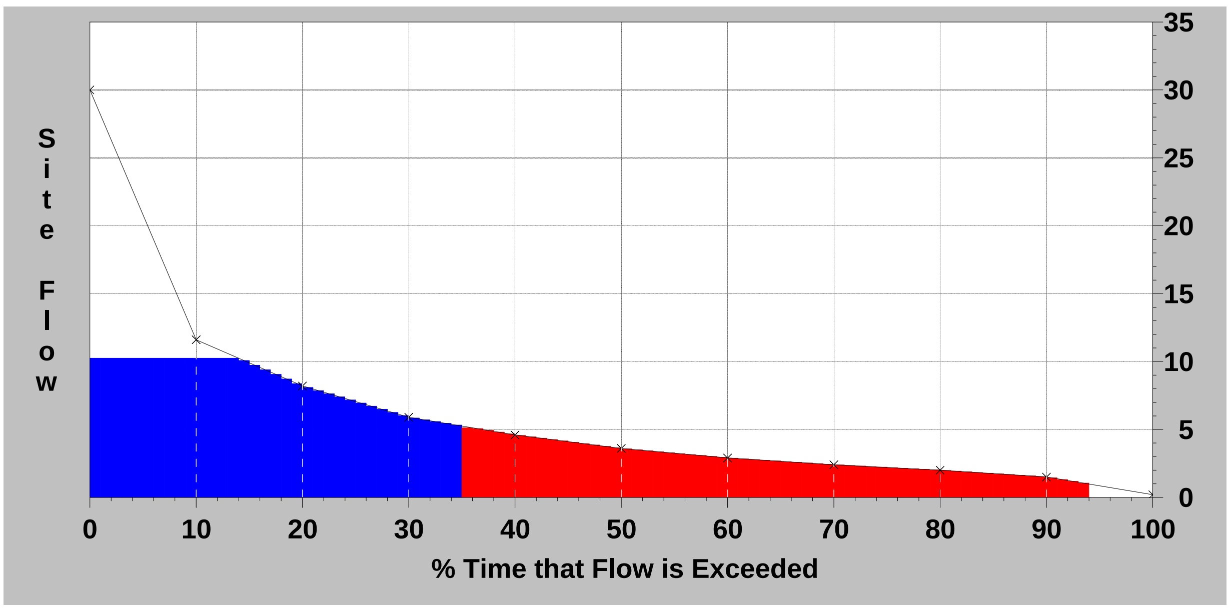
. . . and applying the following turbine solution(s):

Solution #1 File Name: c:\turbnpro\tsab3m.dat
Number of Units: 1
Runner Diameter: 36.6 inches / 929 mm

and

Solution #2 File Name: c:\turbnpro\tsab3m.dat
Number of Units: 1
Runner Diameter: 36.6 inches / 929 mm

Total Annual Energy Production (in MW-Hrs)
using the above Turbine Solution(s) is: 46577.72



TURBNPRO Version 3 - ANNUAL ENERGY PRODUCTION REPORT

With site flow/head data as defined in file name: c:\turbnpro\tsab3sit.dat

Site Net Head Range (m) -	130.0	to	131.0
Site Net Head Range (ft) -	426.4	to	429.8
Site Flow Range (m3/s) -	30.0	to	0.2
Site Flow Range (cfs) -	1059.3	to	7.1

. . . and applying the following turbine solution(s):

Solution #1 File Name: c:\turbnpro\tsab3m.dat

Number of Units:	1	
Runner Diameter:	36.6 inches	/ 929 mm
Multiplier Efficiency Modifier:	1.000	
Flow Squared Efficiency Modifier:	0.0000	
Turbine Rated Head:	405.2 feet	/ 123.5 meters
Rated Discharge:	162.4 cfs	/ 4.6 m3/s
Minimum Net Head Limit of:	271.6 feet	/ 82.8 meters
Maximum Net Head Limit of:	633.0 feet	/ 192.9 meters

and

Solution #2 File Name: c:\turbnpro\tsab3m.dat

Number of Units:	1	
Runner Diameter:	36.6 inches	/ 929 mm
Multiplier Efficiency Modifier:	1.000	
Flow Squared Efficiency Modifier:	0.0000	
Turbine Rated Head:	405.2 feet	/ 123.5 meters
Rated Discharge:	162.4 cfs	/ 4.6 m3/s
Minimum Net Head Limit of:	271.6 feet	/ 82.8 meters
Maximum Net Head Limit of:	633.0 feet	/ 192.9 meters

ANNUAL ENERGY RESULTS IN 100 TIME INCREMENTS

Time Incr	Avail. Flow-m3/s	Net Hd-m	Sol. #1 Qty x KW	Sol. #2 Qty x KW	Total Disch-m3/s	Total Output-KW	Energy MW-Hrs
1	29.1	130.0	1 x 5869	1 x 5869	10	11738	1028.29
2	27.2	130.0	1 x 5872	1 x 5872	10	11745	1028.83
3	25.4	130.1	1 x 5875	1 x 5875	10	11751	1029.38
4	23.6	130.2	1 x 5879	1 x 5879	10	11757	1029.91
5	21.7	130.2	1 x 5882	1 x 5882	10	11763	1030.45
6	19.9	130.3	1 x 5885	1 x 5885	10	11769	1030.98
7	18.0	130.4	1 x 5888	1 x 5888	10	11775	1031.51
8	16.2	130.4	1 x 5891	1 x 5891	10	11781	1032.03
9	14.4	130.5	1 x 5894	1 x 5894	10	11787	1032.55
10	12.5	130.6	1 x 5896	1 x 5896	10	11793	1033.06
11	11.4	130.6	1 x 5898	1 x 5898	10	11796	1033.37
12	11.1	130.6	1 x 5899	1 x 5899	10	11797	1033.46
13	10.8	130.6	1 x 5899	1 x 5899	10	11799	1033.55
14	10.4	130.6	1 x 5900	1 x 5900	10	11800	1033.65
15	10.1	130.7	1 x 5824	1 x 5824	10	11647	1020.30
16	9.7	130.7	1 x 5662	1 x 5662	10	11324	992.02
17	9.4	130.7	1 x 5490	1 x 5490	9	10980	961.87
18	9.0	130.7	1 x 5304	1 x 5304	9	10608	929.22

19	8.7	130.7	1 x	5110	1 x	5110	9	10221	895.34
20	8.4	130.7	1 x	4912	1 x	4912	8	9823	860.50
21	8.1	130.7	1 x	4742	1 x	4742	8	9483	830.72
22	7.9	130.7	1 x	4604	1 x	4604	8	9209	806.70
23	7.6	130.7	1 x	4462	1 x	4462	8	8924	781.74
24	7.4	130.7	1 x	4319	1 x	4319	7	8637	756.62
25	7.2	130.8	1 x	4176	1 x	4176	7	8352	731.59
26	6.9	130.8	1 x	4033	1 x	4033	7	8066	706.54
27	6.7	130.8	1 x	3883	1 x	3883	7	7767	680.35
28	6.5	130.8	1 x	3735	1 x	3735	6	7470	654.34
29	6.2	130.8	1 x	3587	1 x	3587	6	7174	628.46
30	6.0	130.8	1 x	3432	1 x	3432	6	6863	601.22
31	5.8	130.8	1 x	3311	1 x	3311	6	6622	580.12
32	5.7	130.8	1 x	3225	1 x	3225	6	6450	565.00
33	5.6	130.8	1 x	3139	1 x	3139	6	6278	549.98
34	5.4	130.8	1 x	3054	1 x	3054	5	6108	535.06
35	5.3	130.8	1 x	2966	1 x	2966	5	5932	519.65
36	5.2	130.8	1 x	5908	0 x	0	5	5908	517.54
37	5.1	130.8	1 x	5849	0 x	0	5	5849	512.41
38	4.9	130.8	1 x	5728	0 x	0	5	5728	501.78
39	4.8	130.8	1 x	5599	0 x	0	5	5599	490.46
40	4.7	130.8	1 x	5466	0 x	0	5	5466	478.82
41	4.6	130.8	1 x	5338	0 x	0	5	5338	467.60
42	4.4	130.9	1 x	5225	0 x	0	4	5225	457.74
43	4.4	130.9	1 x	5111	0 x	0	4	5111	447.68
44	4.3	130.9	1 x	4995	0 x	0	4	4995	437.54
45	4.1	130.9	1 x	4875	0 x	0	4	4875	427.06
46	4.1	130.9	1 x	4756	0 x	0	4	4756	416.58
47	4.0	130.9	1 x	4636	0 x	0	4	4636	406.12
48	3.9	130.9	1 x	4513	0 x	0	4	4513	395.37
49	3.8	130.9	1 x	4388	0 x	0	4	4388	384.41
50	3.7	130.9	1 x	4264	0 x	0	4	4264	373.49
51	3.6	130.9	1 x	4158	0 x	0	4	4158	364.24
52	3.5	130.9	1 x	4071	0 x	0	3	4071	356.63
53	3.4	130.9	1 x	3981	0 x	0	3	3981	348.73
54	3.4	130.9	1 x	3890	0 x	0	3	3890	340.76
55	3.3	130.9	1 x	3799	0 x	0	3	3799	332.82
56	3.2	130.9	1 x	3709	0 x	0	3	3709	324.91
57	3.1	130.9	1 x	3619	0 x	0	3	3619	317.04
58	3.1	130.9	1 x	3525	0 x	0	3	3525	308.83
59	3.0	130.9	1 x	3431	0 x	0	3	3431	300.55
60	2.9	130.9	1 x	3337	0 x	0	3	3337	292.32
61	2.9	130.9	1 x	3257	0 x	0	3	3257	285.32
62	2.8	130.9	1 x	3191	0 x	0	3	3191	279.52
63	2.8	130.9	1 x	3125	0 x	0	3	3125	273.75
64	2.7	130.9	1 x	3059	0 x	0	3	3059	268.00
65	2.7	130.9	1 x	2992	0 x	0	3	2992	262.13
66	2.6	130.9	1 x	2923	0 x	0	3	2923	256.07
67	2.6	130.9	1 x	2855	0 x	0	3	2855	250.07
68	2.5	130.9	1 x	2787	0 x	0	3	2787	244.10
69	2.5	130.9	1 x	2719	0 x	0	2	2719	238.18
70	2.4	130.9	1 x	2652	0 x	0	2	2652	232.30
71	2.4	130.9	1 x	2590	0 x	0	2	2590	226.88
72	2.3	130.9	1 x	2534	0 x	0	2	2534	221.99
73	2.3	130.9	1 x	2479	0 x	0	2	2479	217.14
74	2.3	130.9	1 x	2424	0 x	0	2	2424	212.32
75	2.2	130.9	1 x	2369	0 x	0	2	2369	207.55
76	2.2	130.9	1 x	2315	0 x	0	2	2315	202.79
77	2.1	130.9	1 x	2261	0 x	0	2	2261	198.03
78	2.1	130.9	1 x	2207	0 x	0	2	2207	193.30
79	2.1	130.9	1 x	2153	0 x	0	2	2153	188.61

80	2.0	130.9	1 x	2100	0 x	0	2	2100	183.97
81	2.0	130.9	1 x	2041	0 x	0	2	2041	178.76
82	1.9	130.9	1 x	1973	0 x	0	2	1973	172.83
83	1.9	130.9	1 x	1906	0 x	0	2	1906	166.97
84	1.8	130.9	1 x	1840	0 x	0	2	1840	161.18
85	1.8	130.9	1 x	1773	0 x	0	2	1773	155.36
86	1.7	130.9	1 x	1707	0 x	0	2	1707	149.56
87	1.7	130.9	1 x	1642	0 x	0	2	1642	143.84
88	1.6	130.9	1 x	1577	0 x	0	2	1577	138.13
89	1.6	130.9	1 x	1512	0 x	0	2	1512	132.47
90	1.5	130.9	1 x	1449	0 x	0	2	1449	126.90
91	1.4	131.0	1 x	1330	0 x	0	1	1330	116.52
92	1.3	131.0	1 x	1165	0 x	0	1	1165	102.07
93	1.2	131.0	1 x	999	0 x	0	1	999	87.49
94	1.0	131.0	1 x	843	0 x	0	1	843	73.88
95	0.9	131.0	0 x	0	0 x	0	0	0	0.00
96	0.8	131.0	0 x	0	0 x	0	0	0	0.00
97	0.7	131.0	0 x	0	0 x	0	0	0	0.00
98	0.5	131.0	0 x	0	0 x	0	0	0	0.00
99	0.4	131.0	0 x	0	0 x	0	0	0	0.00
100	0.3	131.0	0 x	0	0 x	0	0	0	0.00

Total Annual Energy Production (in MW-Hrs)
using the above Turbine Solution(s) is: 46577.72

Of the Total Energy Generated
The following percentage is produced by Turbine Solution #1: 67.8
The following percentage is produced by Turbine Solution #2: 32.2

*** Note that the above energy figure does not include losses due to generator (or speed increaser) inefficiencies or losses due to transformer and transmission line inefficiencies.

TURBNPRO Version 3 - ANNUAL ENERGY PRODUCTION GRAPHIC (Pelton Type Units)

With site flow/head data as defined in file name: c:\turbnpro\tsab3ps

. . . and applying the following turbine solution(s):

Solution #1 File Name: c:\turbnpro\tsab3p.dat

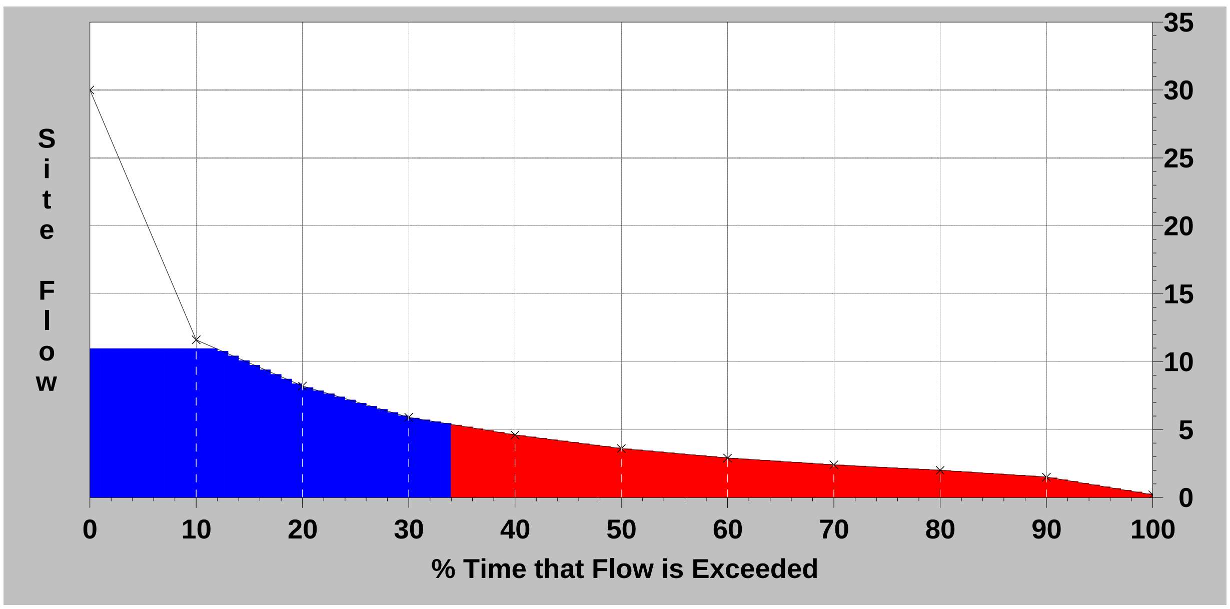
Number of Units:	1		
Runner Pitch Diameter:	70.6 inches	/	1792 mm
Intake Type:	4 - JET		

and

Solution #2 File Name: c:\turbnpro\tsab3p.dat

Number of Units:	1		
Runner Pitch Diameter:	70.6 inches	/	1792 mm
Intake Type:	4 - JET		

Total Annual Energy Production (in MW-Hrs)
using the above Turbine Solution(s) is: 47293.16



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With site flow/head data as defined in file name: c:\turbnpro\tsab3ps

Site Net Head Range (m) -	128.9	to	129.0
Site Net Head Range (ft) -	423.0	to	423.2
Site Flow Range (m3/s) -	30.0	to	0.2
Site Flow Range (cfs) -	1059.3	to	7.1

....

. . . and applying the following turbine solution(s):

Solution #1 File Name: c:\turbnpro\tsab3p.dat

Number of Units:	1		
Runner Diameter:	70.6 inches	/	1792 mm
Multiplier Efficiency Modifier:	1.000		
Flow Squared Efficiency Modifier:	0.0000		
Turbine Rated Head:	405.2 feet	/	123.5 meters
Rated Discharge:	162.4 cfs	/	4.6 m3/s
Minimum Net Head Limit of:	294.8 feet	/	89.8 meters
Maximum Net Head Limit of:	547.7 feet	/	166.9 meters

and

Solution #2 File Name: c:\turbnpro\tsab3p.dat

Number of Units:	1		
Runner Diameter:	70.6 inches	/	1792 mm
Multiplier Efficiency Modifier:	1.000		
Flow Squared Efficiency Modifier:	0.0000		
Turbine Rated Head:	405.2 feet	/	123.5 meters
Rated Discharge:	162.4 cfs	/	4.6 m3/s
Minimum Net Head Limit of:	294.8 feet	/	89.8 meters
Maximum Net Head Limit of:	547.7 feet	/	166.9 meters

....

ANNUAL ENERGY RESULTS IN 100 TIME INCREMENTS

Time Incr	Avail. Flow-m3/s	Net Hd-m	Sol. #1 Qty x KW	Sol. #2 Qty x KW	Total Disch-m3/s	Total Output-KW	Energy MW-Hrs
1	29.1	128.9	1 x 6156	1 x 6156	11	12313	1078.59
2	27.2	128.9	1 x 6157	1 x 6157	11	12313	1078.66
3	25.4	129.0	1 x 6157	1 x 6157	11	12314	1078.72
4	23.6	129.0	1 x 6157	1 x 6157	11	12315	1078.78
5	21.7	129.0	1 x 6158	1 x 6158	11	12315	1078.83
6	19.9	129.0	1 x 6158	1 x 6158	11	12316	1078.88
7	18.0	129.0	1 x 6158	1 x 6158	11	12316	1078.92
8	16.2	129.0	1 x 6158	1 x 6158	11	12317	1078.96
9	14.4	129.0	1 x 6159	1 x 6159	11	12317	1079.00
10	12.5	129.0	1 x 6159	1 x 6159	11	12318	1079.03
11	11.4	129.0	1 x 6159	1 x 6159	11	12318	1079.04
12	11.1	129.0	1 x 6159	1 x 6159	11	12318	1079.05
13	10.8	129.0	1 x 6056	1 x 6056	11	12111	1060.95
14	10.4	129.0	1 x 5877	1 x 5877	10	11754	1029.62
15	10.1	129.0	1 x 5693	1 x 5693	10	11386	997.41
16	9.7	129.0	1 x 5507	1 x 5507	10	11014	964.84
17	9.4	129.0	1 x 5320	1 x 5320	9	10640	932.09
18	9.0	129.0	1 x 5130	1 x 5130	9	10260	898.76

19	8.7	129.0	1 x	4939	1 x	4939	9	9879	865.37
20	8.4	129.0	1 x	4748	1 x	4748	8	9496	831.81
21	8.1	129.0	1 x	4587	1 x	4587	8	9173	803.58
22	7.9	129.0	1 x	4456	1 x	4456	8	8913	780.77
23	7.6	129.0	1 x	4325	1 x	4325	8	8649	757.69
24	7.4	129.0	1 x	4193	1 x	4193	7	8385	734.54
25	7.2	129.0	1 x	4061	1 x	4061	7	8121	711.41
26	6.9	129.0	1 x	3929	1 x	3929	7	7857	688.30
27	6.7	129.0	1 x	3797	1 x	3797	7	7594	665.21
28	6.5	129.0	1 x	3665	1 x	3665	6	7330	642.14
29	6.2	129.0	1 x	3531	1 x	3531	6	7063	618.68
30	6.0	129.0	1 x	3397	1 x	3397	6	6794	595.12
31	5.8	129.0	1 x	3292	1 x	3292	6	6584	576.73
32	5.7	129.0	1 x	3216	1 x	3216	6	6432	563.46
33	5.6	129.0	1 x	3141	1 x	3141	6	6281	550.22
34	5.4	129.0	1 x	3065	1 x	3065	5	6130	537.00
35	5.3	129.0	1 x	5993	0 x	0	5	5993	524.99
36	5.2	129.0	1 x	5856	0 x	0	5	5856	512.97
37	5.1	129.0	1 x	5715	0 x	0	5	5715	500.64
38	4.9	129.0	1 x	5573	0 x	0	5	5573	488.20
39	4.8	129.0	1 x	5430	0 x	0	5	5430	475.71
40	4.7	129.0	1 x	5287	0 x	0	5	5287	463.13
41	4.6	129.0	1 x	5158	0 x	0	5	5158	451.85
42	4.4	129.0	1 x	5046	0 x	0	4	5046	442.03
43	4.4	129.0	1 x	4934	0 x	0	4	4934	432.21
44	4.3	129.0	1 x	4821	0 x	0	4	4821	422.36
45	4.1	129.0	1 x	4708	0 x	0	4	4708	412.45
46	4.1	129.0	1 x	4595	0 x	0	4	4595	402.55
47	4.0	129.0	1 x	4482	0 x	0	4	4482	392.64
48	3.9	129.0	1 x	4368	0 x	0	4	4368	382.63
49	3.8	129.0	1 x	4253	0 x	0	4	4253	372.56
50	3.7	129.0	1 x	4138	0 x	0	4	4138	362.50
51	3.6	129.0	1 x	4041	0 x	0	4	4041	353.96
52	3.5	129.0	1 x	3960	0 x	0	3	3960	346.92
53	3.4	129.0	1 x	3880	0 x	0	3	3880	339.89
54	3.4	129.0	1 x	3800	0 x	0	3	3800	332.86
55	3.3	129.0	1 x	3720	0 x	0	3	3720	325.84
56	3.2	129.0	1 x	3639	0 x	0	3	3639	318.80
57	3.1	129.0	1 x	3558	0 x	0	3	3558	311.65
58	3.1	129.0	1 x	3476	0 x	0	3	3476	304.47
59	3.0	129.0	1 x	3394	0 x	0	3	3394	297.31
60	2.9	129.0	1 x	3312	0 x	0	3	3312	290.15
61	2.9	129.0	1 x	3242	0 x	0	3	3242	284.03
62	2.8	129.0	1 x	3184	0 x	0	3	3184	278.93
63	2.8	129.0	1 x	3126	0 x	0	3	3126	273.84
64	2.7	129.0	1 x	3068	0 x	0	3	3068	268.76
65	2.7	129.0	1 x	3010	0 x	0	3	3010	263.66
66	2.6	129.0	1 x	2951	0 x	0	3	2951	258.51
67	2.6	129.0	1 x	2892	0 x	0	3	2892	253.30
68	2.5	129.0	1 x	2832	0 x	0	3	2832	248.11
69	2.5	129.0	1 x	2775	0 x	0	2	2775	243.07
70	2.4	129.0	1 x	2718	0 x	0	2	2718	238.09
71	2.4	129.0	1 x	2666	0 x	0	2	2666	233.56
72	2.3	129.0	1 x	2620	0 x	0	2	2620	229.50
73	2.3	129.0	1 x	2574	0 x	0	2	2574	225.44
74	2.3	129.0	1 x	2527	0 x	0	2	2527	221.39
75	2.2	129.0	1 x	2481	0 x	0	2	2481	217.34
76	2.2	129.0	1 x	2435	0 x	0	2	2435	213.29
77	2.1	129.0	1 x	2389	0 x	0	2	2389	209.25
78	2.1	129.0	1 x	2343	0 x	0	2	2343	205.22
79	2.1	129.0	1 x	2297	0 x	0	2	2297	201.19

80	2.0	129.0	1	x	2251	0	x	0	2	2251	197.15
81	2.0	129.0	1	x	2198	0	x	0	2	2198	192.58
82	1.9	129.0	1	x	2141	0	x	0	2	2141	187.51
83	1.9	129.0	1	x	2084	0	x	0	2	2084	182.56
84	1.8	129.0	1	x	2028	0	x	0	2	2028	177.63
85	1.8	129.0	1	x	1971	0	x	0	2	1971	172.70
86	1.7	129.0	1	x	1915	0	x	0	2	1915	167.78
87	1.7	129.0	1	x	1859	0	x	0	2	1859	162.86
88	1.6	129.0	1	x	1803	0	x	0	2	1803	157.93
89	1.6	129.0	1	x	1746	0	x	0	2	1746	152.96
90	1.5	129.0	1	x	1689	0	x	0	2	1689	147.94
91	1.4	129.0	1	x	1586	0	x	0	1	1586	138.93
92	1.3	129.0	1	x	1437	0	x	0	1	1437	125.90
93	1.2	129.0	1	x	1291	0	x	0	1	1291	113.12
94	1.0	129.0	1	x	1150	0	x	0	1	1150	100.74
95	0.9	129.0	1	x	1006	0	x	0	1	1006	88.15
96	0.8	129.0	1	x	861	0	x	0	1	861	75.44
97	0.7	129.0	1	x	714	0	x	0	1	714	62.56
98	0.5	129.0	1	x	565	0	x	0	1	565	49.49
99	0.4	129.0	1	x	416	0	x	0	0	416	36.41
100	0.3	129.0	1	x	262	0	x	0	0	262	22.96

....

Total Annual Energy Production (in MW-Hrs)
using the above Turbine Solution(s) is: 47293.16

Of the Total Energy Generated
The following percentage is produced by Turbine Solution #1: 68.5
The following percentage is produced by Turbine Solution #2: 31.5

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*** Note that the above energy figure does not include losses due to generator (or speed increaser) inefficiencies or losses due to transformer and transmission line inefficiencies.

TURBNPRO Version 3 - ANNUAL ENERGY PRODUCTION GRAPHIC

With site flow/head data as defined in file name: c:\turbnpro\tsab3sit.dat

. . . and applying the following turbine solution(s):

Solution #1 File Name: c:\turbnpro\tsab3s

Number of Units: 1

Runner Diameter: 32.2 inches / 818 mm

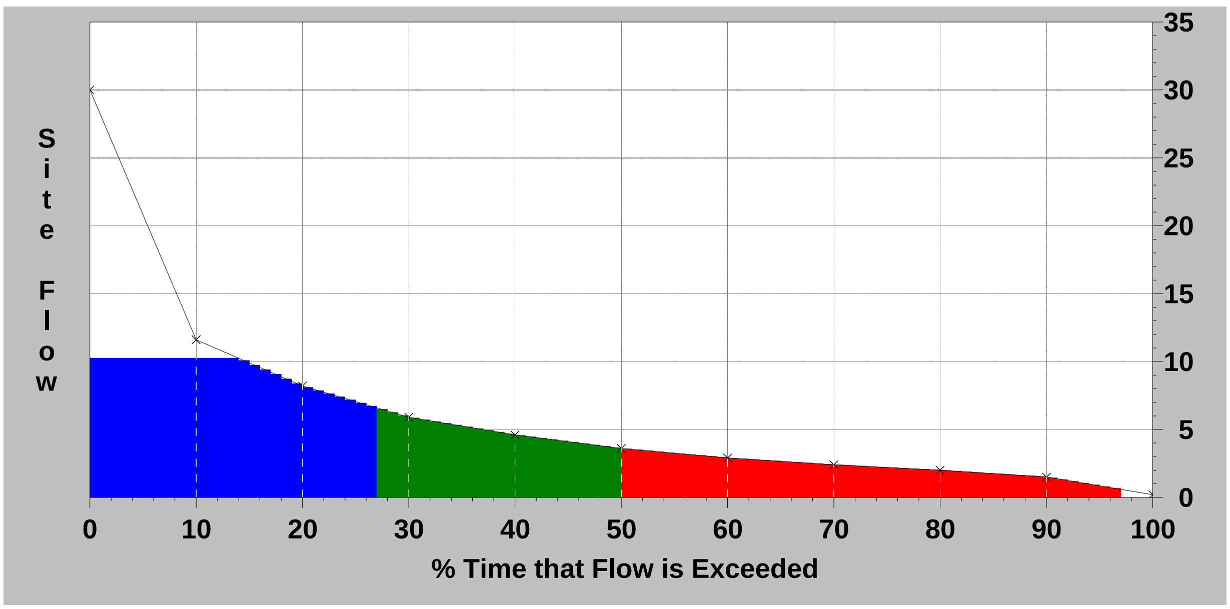
and

Solution #2 File Name: c:\turbnpro\tsab3l.dat

Number of Units: 1

Runner Diameter: 39.9 inches / 1014 mm

Total Annual Energy Production (in MW-Hrs)
using the above Turbine Solution(s) is: 47434.68



TURBNPRO Version 3 - ANNUAL ENERGY PRODUCTION REPORT

With site flow/head data as defined in file name: c:\turbnpro\tsab3sit.dat

Site Net Head Range (m) -	130.0	to	131.0
Site Net Head Range (ft) -	426.4	to	429.8
Site Flow Range (m3/s) -	30.0	to	0.2
Site Flow Range (cfs) -	1059.3	to	7.1

. . . and applying the following turbine solution(s):

Solution #1 File Name: c:\turbnpro\tsab3s

Number of Units:	1		
Runner Diameter:	32.2 inches	/	818 mm
Multiplier Efficiency Modifier:	1.000		
Flow Squared Efficiency Modifier:	0.0000		
Turbine Rated Head:	405.2 feet	/	123.5 meters
Rated Discharge:	113.0 cfs	/	3.2 m3/s
Minimum Net Head Limit of:	275.9 feet	/	84.1 meters
Maximum Net Head Limit of:	649.6 feet	/	198.0 meters

and

Solution #2 File Name: c:\turbnpro\tsab3l.dat

Number of Units:	1		
Runner Diameter:	39.9 inches	/	1014 mm
Multiplier Efficiency Modifier:	1.000		
Flow Squared Efficiency Modifier:	0.0000		
Turbine Rated Head:	405.2 feet	/	123.5 meters
Rated Discharge:	211.9 cfs	/	6.0 m3/s
Minimum Net Head Limit of:	268.5 feet	/	81.8 meters
Maximum Net Head Limit of:	617.9 feet	/	188.3 meters

ANNUAL ENERGY RESULTS IN 100 TIME INCREMENTS

Time Incr	Avail. Flow-m3/s	Net Hd-m	Sol. #1 Qty x KW	Sol. #2 Qty x KW	Total Disch-m3/s	Total Output-KW	Energy MW-Hrs
1	29.1	130.0	1 x 4053	1 x 7707	10	11759	1030.09
2	27.2	130.0	1 x 4055	1 x 7711	10	11765	1030.64
3	25.4	130.1	1 x 4057	1 x 7715	10	11771	1031.18
4	23.6	130.2	1 x 4059	1 x 7719	10	11778	1031.72
5	21.7	130.2	1 x 4061	1 x 7723	10	11784	1032.26
6	19.9	130.3	1 x 4063	1 x 7727	10	11790	1032.79
7	18.0	130.4	1 x 4065	1 x 7731	10	11796	1033.32
8	16.2	130.4	1 x 4067	1 x 7735	10	11802	1033.84
9	14.4	130.5	1 x 4069	1 x 7738	10	11808	1034.36
10	12.5	130.6	1 x 4071	1 x 7742	10	11814	1034.87
11	11.4	130.6	1 x 4073	1 x 7745	10	11817	1035.18
12	11.1	130.6	1 x 4073	1 x 7745	10	11818	1035.27
13	10.8	130.6	1 x 4073	1 x 7746	10	11819	1035.37
14	10.4	130.6	1 x 4074	1 x 7747	10	11820	1035.46
15	10.1	130.7	1 x 4020	1 x 7644	10	11664	1021.79
16	9.7	130.7	1 x 3908	1 x 7432	10	11341	993.45
17	9.4	130.7	1 x 3790	1 x 7206	9	10996	963.24
18	9.0	130.7	1 x 3661	1 x 6962	9	10622	930.52

19	8.7	130.7	1 x	3527	1 x	6708	9	10235	896.59
20	8.4	130.7	1 x	3390	1 x	6446	8	9837	861.68
21	8.1	130.7	1 x	3273	1 x	6223	8	9496	831.85
22	7.9	130.7	1 x	3178	1 x	6043	8	9221	807.80
23	7.6	130.7	1 x	3080	1 x	5856	8	8936	782.77
24	7.4	130.7	1 x	2982	1 x	5667	7	8648	757.59
25	7.2	130.8	1 x	2883	1 x	5479	7	8362	732.51
26	6.9	130.8	1 x	2785	1 x	5290	7	8075	707.39
27	6.7	130.8	1 x	2683	1 x	5093	7	7775	681.12
28	6.5	130.8	0 x	0	1 x	7566	6	7566	662.77
29	6.2	130.8	0 x	0	1 x	7337	6	7337	642.70
30	6.0	130.8	0 x	0	1 x	7094	6	7094	621.42
31	5.8	130.8	0 x	0	1 x	6892	6	6892	603.71
32	5.7	130.8	0 x	0	1 x	6741	6	6741	590.55
33	5.6	130.8	0 x	0	1 x	6591	6	6591	577.39
34	5.4	130.8	0 x	0	1 x	6435	5	6435	563.70
35	5.3	130.8	0 x	0	1 x	6279	5	6279	550.00
36	5.2	130.8	0 x	0	1 x	6122	5	6122	536.31
37	5.1	130.8	0 x	0	1 x	5964	5	5964	522.40
38	4.9	130.8	0 x	0	1 x	5799	5	5799	508.01
39	4.8	130.8	0 x	0	1 x	5636	5	5636	493.67
40	4.7	130.8	0 x	0	1 x	5472	5	5472	479.38
41	4.6	130.8	0 x	0	1 x	5329	5	5329	466.78
42	4.4	130.9	0 x	0	1 x	5197	4	5197	455.28
43	4.4	130.9	0 x	0	1 x	5066	4	5066	443.76
44	4.3	130.9	0 x	0	1 x	4935	4	4935	432.30
45	4.1	130.9	0 x	0	1 x	4805	4	4805	420.89
46	4.1	130.9	0 x	0	1 x	4672	4	4672	409.30
47	4.0	130.9	0 x	0	1 x	4535	4	4535	397.26
48	3.9	130.9	0 x	0	1 x	4399	4	4399	385.31
49	3.8	130.9	0 x	0	1 x	4263	4	4263	373.46
50	3.7	130.9	0 x	0	1 x	4129	4	4129	361.71
51	3.6	130.9	1 x	4081	0 x	0	4	4081	357.49
52	3.5	130.9	1 x	4020	0 x	0	3	4020	352.15
53	3.4	130.9	1 x	3954	0 x	0	3	3954	346.39
54	3.4	130.9	1 x	3886	0 x	0	3	3886	340.37
55	3.3	130.9	1 x	3815	0 x	0	3	3815	334.18
56	3.2	130.9	1 x	3741	0 x	0	3	3741	327.69
57	3.1	130.9	1 x	3663	0 x	0	3	3663	320.90
58	3.1	130.9	1 x	3584	0 x	0	3	3584	313.99
59	3.0	130.9	1 x	3504	0 x	0	3	3504	306.99
60	2.9	130.9	1 x	3423	0 x	0	3	3423	299.85
61	2.9	130.9	1 x	3352	0 x	0	3	3352	293.62
62	2.8	130.9	1 x	3292	0 x	0	3	3292	288.42
63	2.8	130.9	1 x	3233	0 x	0	3	3233	283.23
64	2.7	130.9	1 x	3174	0 x	0	3	3174	278.04
65	2.7	130.9	1 x	3112	0 x	0	3	3112	272.65
66	2.6	130.9	1 x	3051	0 x	0	3	3051	267.23
67	2.6	130.9	1 x	2989	0 x	0	3	2989	261.83
68	2.5	130.9	1 x	2927	0 x	0	3	2927	256.43
69	2.5	130.9	1 x	2866	0 x	0	2	2866	251.05
70	2.4	130.9	1 x	2805	0 x	0	2	2805	245.68
71	2.4	130.9	1 x	2747	0 x	0	2	2747	240.64
72	2.3	130.9	1 x	2696	0 x	0	2	2696	236.15
73	2.3	130.9	1 x	2645	0 x	0	2	2645	231.68
74	2.3	130.9	1 x	2594	0 x	0	2	2594	227.22
75	2.2	130.9	1 x	2543	0 x	0	2	2543	222.77
76	2.2	130.9	1 x	2493	0 x	0	2	2493	218.35
77	2.1	130.9	1 x	2439	0 x	0	2	2439	213.70
78	2.1	130.9	1 x	2386	0 x	0	2	2386	209.05
79	2.1	130.9	1 x	2334	0 x	0	2	2334	204.43

80	2.0	130.9	1 x	2281	0 x	0	2	2281	199.83
81	2.0	130.9	1 x	2222	0 x	0	2	2222	194.68
82	1.9	130.9	1 x	2158	0 x	0	2	2158	189.01
83	1.9	130.9	1 x	2093	0 x	0	2	2093	183.36
84	1.8	130.9	1 x	2025	0 x	0	2	2025	177.41
85	1.8	130.9	1 x	1958	0 x	0	2	1958	171.53
86	1.7	130.9	1 x	1892	0 x	0	2	1892	165.71
87	1.7	130.9	1 x	1826	0 x	0	2	1826	159.94
88	1.6	130.9	1 x	1757	0 x	0	2	1757	153.93
89	1.6	130.9	1 x	1690	0 x	0	2	1690	148.00
90	1.5	130.9	1 x	1623	0 x	0	2	1623	142.15
91	1.4	131.0	1 x	1503	0 x	0	1	1503	131.69
92	1.3	131.0	1 x	1333	0 x	0	1	1333	116.73
93	1.2	131.0	1 x	1163	0 x	0	1	1163	101.90
94	1.0	131.0	1 x	997	0 x	0	1	997	87.32
95	0.9	131.0	1 x	832	0 x	0	1	832	72.84
96	0.8	131.0	1 x	667	0 x	0	1	667	58.43
97	0.7	131.0	1 x	518	0 x	0	1	518	45.36
98	0.5	131.0	0 x	0	0 x	0	0	0	0.00
99	0.4	131.0	0 x	0	0 x	0	0	0	0.00
100	0.3	131.0	0 x	0	0 x	0	0	0	0.00

Total Annual Energy Production (in MW-Hrs)
using the above Turbine Solution(s) is: 47434.68

Of the Total Energy Generated
The following percentage is produced by Turbine Solution #1: 40.6
The following percentage is produced by Turbine Solution #2: 59.4

*** Note that the above energy figure does not include losses due to generator (or speed increaser) inefficiencies or losses due to transformer and transmission line inefficiencies.