Hydropower Investment Promotion Project (HIPP)

KHELEDULA 2 HPP PRE-FEASIBILITY STUDY REPORT

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Hydroelectric Project Development
Pre-Feasibility Study

Kheledula 2 Hydropower Project
Kheledula River

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Definition of Technical Abbreviations

CAPEX	Capital Expenditure
CF	Capacity Factor (actual annual generation / theoretical annual installed capacity)
EIA	Environmental Impact Assessment
FDC	Flow Duration Curve
GEL	Georgian Lari
GIS	Geographic Information System
GoG	Government of Georgia
GW	Gigawatt
GWh	Gigawatt-hours
GSE	Georgian State Electrosystem
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

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EXECUTIVE SUMMARY

KHELEDULA 2 HYDROPOWER PROJECT OVERVIEW

Project Description

The site of the proposed Kheledula 2 HPP intake is located adjacent to Mananauri village on the Kheledula River, in the Lentekhi District of western Georgia's Racha-Lechkhumi and Kvemo Svaneti Region. The plant capacity will be 15.7 MW, with mean annual generation of approximately 68 GWh. The Kheledula River watershed is bounded by the Enguri watershed to the north and west; the river flows into the Tskhenistskali River from the west at the town of Lentekhi.

The Kheledula 2 HPP is envisioned to be the middle plant in a possible 3-HPP cascade (Kheledula 1, Kheledula 2, and proposed future Kheledula 3 with seasonal storage) on the Kheledula 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 of the Kheledula HPPs.

The Kheledula 2 HPP site is at high elevation and offers seasonally variable operating conditions with relatively low flows during the months of December, January and February. There will be a dam, intake structure, power canal, de-silting basin, box conduit, power tunnel, penstock, surface powerhouse, tailrace, transformer substation, and transmission line connection. The main intake captures flow from the Kheledula River just downstream from the village of Mananauri. The arrangement of the diversion structure and the water conductors efficiently exploits the usable head in the system, maximizing the energy output from the available water. The powerhouse location was selected to optimize the potential for Kheledula 3 dam and to avoid undesirable geologic conditions downstream.

Access to the site is difficult at this time. There is a good, paved national roadway to Lentekhi. From Lentekhi, an unpaved public road leads up to the diversion point. However, this road is often impassible due to washouts at tributaries, flooding from the Kheledula, bridge damage, etc. At the time of this writing, the road is easily passable at most times as far as Kheledi (the last major populated village), and by 4-wheel-drive vehicles to Mananauri. At that point, fording the Kheledula River is required and the road surface is poor to non-existent: most vehicles cannot pass.

The locations of both the powerhouse and diversion weir sites are adjacent to the public unpaved road. About 6 km of this unpaved road up to Kheledi will need minor restoration while 11 km between Kheledi and Mananauri will need major upgrade of the roadbed and cross drainage. This will assure good access for trucks and equipment during the construction and operation of this HPP.

A new 15-km-long 35 kV transmission line will be constructed along the public road to connect the Kheledula 2 HPP to the proposed Lentekhi HPP 220 kV substation. An additional connection to the existing 35 kV system in the village of Lentekhi may be worthwhile.

The Kheledula 2 HPP development is expected to include a diversion structure on the Kheledula River, just downstream from Mananauri village and the confluence of the Skiliri River. The concrete gravity-type diversion structure will be about 185 m long, and up to 18 meters high from the foundation to the crest.

The diversion structure will include a 20-m-wide overflow spillway, with a stilling basin at the downstream end to dissipate excess energy. The power intake will be near the left (north) end of the dam, and a low-level sluice controlled by a radial gate will be located a short distance south. The water conductors will include a power canal with a side spillway to limit the canal water surface; a two-channel de-silting basin; a closed reinforced concrete box power conduit, about 900 meters long; a 3.5-m-diameter, 5,245-m-long power tunnel; and a 320-m-long, 3.5-m-diameter surface penstock that branches just above the powerhouse to supply three turbine-generator units. The surface power plant will house three butterfly isolation valves, vertical Francis turbines, and generators as well as auxiliary equipment. An excavated tailrace will return flow to the river.

Two tributary streams will be tapped to provide additional flow, through connections to the power tunnel.

Project cost and construction schedule

The currently estimated cost of the Kheledula 2 HPP is USD 48.8 million or about USD 3,106/kW of installed capacity. The simple payback period is estimated as 14.4 years. The project is expected to have a 1 year pre-construction period and 3 year construction period. The critical path of the project appears to be through the tunneling and the large amount of concrete that needs placing in the dam, and power canal and de-silting channels.

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 Kheledula 2 HPP provides a good opportunity for investment and should be further investigated by potential developers. The expected simple payback period is approximately 14.4 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	**Kheledula 2 Hydropower Project**
Project location (political)	**Lentekhi District of western Georgia's Racha-Lechkhumi and Kvemo Svaneti Region**
Nearest town or city	**Mananauri**
River name	**Kheledula**
Total drainage area	**219 km^2**
Financial Estimates	
Estimated Construction Cost	**$48.8 Million**
Estimated Cost per kW capacity	**$3,106/kW**
Simple Pay Back Period	**14.4 years**
Hydrological Data (Adjusted to Intake Location)	
Annual mean river flow at intake	**10.63 m^3/s**
Facility design discharge (m^3/s)	**18.0 m^3/s**
Annual average discharge through powerhouse	**8.59 m^3/s**
Preliminary design flood (100 yr return period)	**137.5 m^3/s**
Max. recorded flow	**73.14 m^3/s**
Intake Pond	
Highest regulated water level (HRL)	**1102.5 masl during design flood**
Minimum operating level (MOL)	**1100 masl**
Surface area at normal operating level	**4 hectares**
Sanitary or environmental flow (assumed)	**1-10% of mean monthly flow for each month**
Kheledula River Diversion Structure	
Spillway crest elevation	**1100 masl**
Abutment top elevation	**1103 masl**
Maximum height	**18 m from assumed bedrock under the stilling basin to bridge deck**
Sluice gate	**One 3.0-m-wide x 5.0-m-tall radial sluice gate**
Flood Discharge Capacity	
Crest elevation	**1100 masl**
Crest Length	**20 m**
Capacity at design flood level (1102.5 masl)	**158 m^3/s**

Power water conductor/penstock	
Power canal	**3.5-m-deep, 3.0-m-wide reinforced concrete channel, 175 meters long**
De-silting basin	**2 x 5.5 m x 150 m will provide for sediment settling; plus 2 transition and gate structures, each 25 meters long.**
Power box conduit	**900 m**
Power tunnel length	**5245 m**
Power tunnel finished diameter	**3.5 m minimum**
Penstock length	**320 m**
Penstock outside diameter	**3.5 m**
Tributary 1 Diversion Structure	
Drainage area	**13.08 km^2**
Structure type	**Tyrolean weir**
Diversion crest elevation	**1105 masl**
Diversion capacity	**1.1 m^3/s**
Connection to tunnel	**0.8-m-diameter pipeline to connecting shaft**
Tributary 2 Diversion Structure	
Drainage Area	**7.03 km^2**
Structure type	**Wedge-wire screen diversion**
Diversion crest elevation	**1105 masl**
Diversion capacity	**0.5 m^3/s**
Connection to tunnel	**0.5-m-diameter pipeline to connecting shaft**
Powerhouse	
Type	**Above-ground**
Nominal installed capacity at high-voltage transformer terminals	**15.5 MW (at design flow)**
Size of powerhouse	**16 m wide x 60 m long x 15 m high**
Tailrace	
Length	**200 m**
Width	**10 m maximum**
Type	**Excavated channel**
Normal tailwater elevation	**990 to 992 masl**

Transmission line	
Interconnection location	**New transmission line, constructed along the public road, to Lentekhi HPP 220 kV substation.**
Distance to interconnection (km)	**About 15 km**
Voltage	**35 kV**
Power & Energy	
Gross head	**110 m**
Total head loss at rated discharge	**6.5 m**
Net head at rated discharge	**103.5 m**
Estimated average annual head loss	**1.729 m**
Estimated average annual net head	**108.271 m**
Turbine Output efficiency	**Unit 1: 92.5%** **Units 2 & 3: 90.7%**
Turbine Mechanical Output	**Unit 1: 12 MW Francis** **Units 2 & 3: 2.94 MW Francis**
Rated speed	**Unit 1: 375 RPM** **Units 2 & 3: 500 RPM**
Generator output @ 96% efficiency	**Unit 1: 11.52 MW** **Units 2 & 3: 2.82 MW**
Rated generator capacity	**Unit 1: 12.80 MVA at 0.90 Power Factor** **Units 2 & 3: 3.14 MVA at 0.90 Power Factor**
Preliminary generator voltage	**15 kV or manufacturer's recommendation**
Transformer output at high-voltage transformer terminals @ 97% efficiency	**2 x 8.72 MVA** **Plant at design flow: 15.7 MW**
Estimated average annual generation	**Approximately 68 GWh**
Nominal installed capacity	**15.7 MW**
Preliminary annual plant factor (also called CF)	**50%**

Construction Period	
Conceptual design, feasibility studies & EIA	**1 year**
Engineering, procurement and construction	**3 years**
Ongoing environmental monitoring	**Some studies and data collection will extend throughout construction.**
Environmental	
Critical environmental receptors	**Local communities throughout the development area**

Figure 1: Georgian Project Location Map

1.0 GENERAL INTRODUCTION TO THE PROJECT

1.1 DESCRIPTION OF THE DEVELOPMENT AREA

The proposed Kheledula 2 Hydropower Project involves the construction of an approximately 15.7 MW run-of-river HPP on the Kheledula River, in the Lentekhi District of western Georgia's Racha-Lechkhumi and Kvemo Svaneti Region. The approximate location is shown on the Georgian Project Location Map above. The Kheledula 2 powerhouse will be located 11 km upstream of the confluence of the Kheledula River with the Tskhenistskali River, 4 km upstream from the village of Kheledi. The diversion weir is approximately 7 km further up the Kheledula River from the powerhouse, below Mananauri. (See Figure 4 and Appendix 3).

The city of Lentekhi is the administrative center of the Lentekhi District. According to the statistical data, the district population is about 8,400 people, with a population density of 6.25 people/ km^2. The distance from Tbilisi to the administrative center of Lentekhi is about 290 km by road and the Kheledula 2 project is a further 11-18 km northwest of Lentekhi. Mananauri, Khacheshi and Kheledi are in the vicinity of the Kheledula 2 project.

The total area of Lentekhi District is 1,344 km^2 of which 440 km^2 is agricultural land. The landscape of the region is dominated by mountains that are separated by deep gorges. The average inclination of slopes is about 35°-45°. Forests occupy considerable areas of the territory. Mountain slopes are covered by mixed hardwoods and coniferous forests, with mountain meadows, rocky peaks, and glaciers above the tree line. See Section 2.6, Biodiversity and Appendix 7, Land Cover Map for further details.

The economy of the Lentekhi District is dominated by agriculture and logging, though some wood processing industry has also developed. The main agricultural activities of the Lentekhi District are growing potatoes and animal husbandry. Vineyards are also cultivated in some areas.

The town of Lentekhi will have a more stable water supply following completion of an ongoing project to rehabilitate the water and sewage systems being implemented by Georgia's Ministry of Regional Development and Infrastructure and Municipal Development Fund.

The transportation infrastructure of Lentekhi District is developed, but access to the site is difficult at this time. There is a good, paved national roadway to Lentekhi. From Lentekhi, an unpaved public road leads up to the diversion point. However, this road is often impassible due to washouts at tributaries, flooding from the Kheledula, bridge damage, etc. At the time of this writing, the road is easily passable at most times as far as Kheledi (the last major populated village), and by 4-wheel-drive vehicles to Mananauri. At that point, fording the Kheledula River is required and the road surface is poor to non-existent: most vehicles cannot pass..

The locations of both the powerhouse and diversion weir sites are adjacent to the public unpaved road. About 6 km of this unpaved road up to Kheledi will need minor restoration while 11 km between Kheledi and Mananauri will need major upgrade of the roadbed and cross drainage. This will assure good access for trucks and equipment during the construction and operation of this HPP.

The region is culturally rich represented by many old churches, monasteries, towers and other cultural relics. There are three listed sites in Kheledi, in the project area.

The Lentekhi District is also rich in minerals (arsenic, marble and quartzite) and mineral water. The remnants of the now-closed mineral extraction and processing industry are widespread along the Tskhenistskali River above Lentekhi, but not in the Kheledula watershed.

Table 2: Natural Resources in Lentekhi District

Name	Location	Amount in tonnes
Copper & Zinc	Villages: Zeskho, Laperi	25, 000
Lead	Village Rtskhmelebi	8, 000
Arsenic	Village Tsana	9, 126
Decorative stones	Village Choluri	1, 750 m^3
Limestone	Village Meris Khidi	3 242 m^3

Source: Diagnostic Report of Lentekhi Municipality (District); CARE Georgia; 2010

Racha-Lechkhumi and Kvemo Svaneti Planned Protected Area is located on the southern slope of main watershed of the Caucasus range, in Lentekhi, Tsageri, Ambrolauri and Oni Districts at 500-4600 m above sea level. Refer to Cultural and Recreational Resources in Baseline Environmental Data in Section 6.1 for more information.

Table 3: Development Area Significant Data

Project Location (Political)	**Lentekhi District of north-western Georgia's Racha-Lechkhumi and Kvemo Svaneti Region.**
Political Subdivisions	**Lentekhi District**
Area Population	**8,400**
Nearest Town or City	**Lentekhi**
River Name	**Tskhenistskali**
Watershed Name	**Upper Tskhenistskali**
Economic Activity in the Area	**Primarily agriculture**
Special Natural Resources	**Water (commercial bottled), timber, minerals (arsenic, lead, zinc, granite etc) and mineral waters**
Special Cultural Resources	**Churches, monasteries and historic defense towers**
Critical Environmental Receptors	**Racha-Lechkhumi and Kvemo Svaneti Planned Protected Areas**

1.2 DESCRIPTION OF THE LOCAL ELECTRIC POWER SYSTEM

The current transmission and high-voltage distribution system in the Kheledula project area is 35 kV. For this pre-feasibility study, it is assumed that the output of the Kheledula HPPs will be 35 kV. The network interconnection for the Kheledula HPPs could be directly to the Energo-Pro distribution system in Lentekhi or the planned Lentekhi HPP, just downstream of the confluence of the Kheledula River with the Tskhenistskali. The substation there would increase the voltage to 220 kV and relay the electricity to the Lajanuri HPP Substation near the town of Alpana, 15 km southeast of the town of Tsageri. This prefeasibility report presumes completion and operation of the Lentekhi and Tsageri Projects before either of the Kheledula HPPs is commissioned. If this is not the case the Kheledula developer will have to account for the extra transmission distance to interconnect at the Lajanuri substation and may wish to increase the transmission voltage because of the increased distance.

The distribution lines and all of the 35 kV lines in the area are owned and operated by Energo-Pro, the licensed distribution utility serving most of Georgia outside Tbilisi. Energo-Pro also owns the Lajanuri HPP and a 110 kV line running north from the Lajanuri Substation to the Jakhunderi SS, along the Tskhenistskali River east of Lentekhi. There are distribution lines running up the Kheledula Valley from Lentekhi; these are apparently operational only as far as Khacheshi.

A single-circuit 220-kV line, property of the government-owned Georgian State Electrosystem (GSE), connects the Lajanuri HPP Substation to the Tskaltubo Substation west of Kutaisi (See Appendix 3, Location Map).

2.0 BASELINE CONDITIONS

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

2.1 CLIMATE: GENERAL DESCRIPTION

The climate of much of western Georgia is humid and subtropical which becomes colder with more precipitation as the altitude increases. The foothills and mountainous areas (including both the Greater and Lesser Caucasus Mountains) experience cool wet summers and snowy winters (snow cover often exceeds 2 meters in many areas). The watershed area for the Kheledula 2 HPP is above 1100 m and experiences these mountain conditions.

The precipitation in the Kheledula watershed tends to be seasonal, with winter snowfall and spring rains followed by drier summer months with sporadic rain. The snowmelt is the main source of water for the Kheledula 2 HPP during the spring and summer. The rainfall can be particularly heavy during the autumn months until it turns to snowfall in the mountains. Appendix 6 displays Annual Precipitation Map for the Kheledula 2 HPP watershed region.

Air Quality: The monitoring of the air pollution is not carried out in Racha-Lechkhumi and Kvemo Svaneti Region. Only available data are those of stationary sources provided by the industry sector to the Ministry of Environment Protection of Georgia. According to the data emissions from the stationary sources are insignificant. (***Source:*** Caucasus Regional Environmental Center (REC)). During construction air quality is a receptor of importance and is included in the baseline section for this reason.

2.2 HYDROLOGY AND WATER RESOURCES:

2.2.1 Catchment Description including Land Cover and Current Water Resource Use

Originating on the northeastern slope of the of Egrisi Range and the southeastern slope of the Svaneti Range in the Greater Caucasus Mountains, with elevations up to 4,000 m at Mt. Lahili, the Kheledula River drains a watershed area of 315 km^2 and flows about 34 km into the Tskhenistskali River. The river is fed by snow, rain and groundwater. The Kheledula River flow is characterized by spring floods, autumn high flows, fairly stable summer flow based on the snowmelt in the alpine areas and relatively stable winter low flows. Table 4 summarizes the hydrological information that was available from a gauging station in Luji upstream from the town of Lentekhi on the Tskhenistskali River, in the same major watershed and with a watershed similar to the Kheledula, at a high elevation.

Table 4: Hydrology Significant Data

Records available	**Daily flow measurements for 39 years (1955-1993) at Luji Station, 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	**506 km^2**
Drainage area at the intake (including tributary areas)	**219 km^2**
Adjustment factor	**0.43281**
Maximum plant discharge	**18.0 m^3/s**
Minimum plant discharge	**As low as 1.5 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 1.5– 18.0 m^3/s. Reasonable potential of approximately 68 GWh/year**
Flood flows (combined)	**Average Annual Flood (2.33 yr return period) = 61 m^3/s**
Highest recorded flow	**73.5 m^3/s**
Calculated 100 year flood	**139 m^3/s (proportioned from Luji gauge)**
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 Kheledula 2 HPP intake or above Mananauri; meteorology stations for air temperature, precipitation, barometric pressure, wind speed and direction, solar insolation, and snow depth.** **These stream locations would also be used for other monitoring of suspended and bedload sediments, water quality parameters, water temperature, fish, etc.**

The Kheledula River watershed is dominated by mountains and ridges that are separated by deep gorges. The catchment area, with steep to very steep slopes and narrow riverbeds, creates the conditions for flash floods, landslides, debris flows, and avalanches. Mountain slopes are covered by mixed hardwoods and coniferous forests, with mountain meadows, rocky peaks, and glaciers above the tree line. A small percentage of the drainage area is occupied with agriculture where mild slopes or level topography allow. Elevations in the Kheledula 2 HPP watershed vary from 1,100 meters up to approximately 4,000 meters. At the Kheledula 2 HPP diversion site the watershed area is 219 km^2 including the tributaries.

Appendix 4 is the Watershed Map that outlines the watersheds that contribute to the various proposed HPPs diversion locations. 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 Kheledula HPPs are in the western Black Sea Drainage Basin. See Appendix 4, which is the Watershed Map.

2.2.3 Kheledula River:

The river's upper course is a collection of small tributaries from the high mountain ranges decending through steep canyons with many rapids and waterfalls. The river is fed by mixed sources: rain, snowmelt, glacial melting and groundwater. Table 5 displays the Kheledula 2 HPP intake area discharge characteristics. The flow is characterized by high snowmelt flows in spring and summer seasons; autumn experiences rising discharge levels as rain begins (until it turns to snow) and relatively stable low flow during the winter. About 78% of the annual discharge occurs in spring and summer, 14% in autumn and 8% in winter.

The nearest stream flow gauging station is the Luji Gauge approximately 20 km upstream from the town of Lentekhi. The gage has a drainage area of 506 km^2. The gauge data used for this pre-feasibility analysis included the calendar year period: 1955-1993. Interim missing data for shorter than a year were supplemented by average monthly daily discharge calculated from the actual period of record. A drainage basin adjustment of 0.43281 (219 km^2/506 km^2) was used to adjust flow record to the Kheledula 2 HPP intake location. Appendix 2 includes monthly and annual flow duration curves.

Table 5: River Flow in m3/s at Kheledula 2 HPP Intake

Annual average flow (m^3/s)	**10.63**
Maximum average daily flow of record (m^3/s)	**73.14**
Minimum average daily flow of record (m^3/s)	**1.55**
Average monthly discharge during seasonal runoff period (April, May, June, July August, September) (m^3/s)	**16.28**
Average monthly discharge during winter Season (Oct – March) (m^3/s)	**4.61**
Average discharge during Georgian winter electric demand period (Dec-Feb) (m^3/s)	**3.61**
Highest 30 day average discharge (m^3/s)	**53.71**
Lowest 30 day average discharge (m^3/s)	**1.86**
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 Kheledula 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

Upstream of the Kheledula 2 intake location, the Kheledula River carries a high concentration of suspended sediment and bedload during some periods. The watershed is steep-sloped generating a high-velocity surface runoff and river velocities. During high-flow periods large volumes of suspended sediment turn the river a grayish brown color. The erosion of river banks and valley slopes also contributes to very large bed load movement of coarse sediment, large rocks and debris.

Figure 2: Kheledula River near the Kheledula 2 Diversion Site

Table 6 presents monthly and annual sediment discharge in the Tskhenistskali River at the Luji Gauge, that has been adjusted to the area and flow at the Kheledula 2 intake to present expected sediment and bedload transfer at the Kheledula 2 intake. The table presents sediment loads that clearly support a significant and long term operations challenge for the Kheledula 2 HPP and the requirements to address sediment management during detailed feasibility design.

Section 6.2 and Appendix 10 address possible mitigation measures for sediment management during construction and operations. It is important to note that the Tskhenistskali River watershed is a primary sediment delivery system to the Rioni River and hence to the Black Sea coast near Poti, Georgia. This sediment volume is critical to the Black Sea coastal environment in that it contributes to maintaining a quasi equilibrium sediment budget that helps minimize beach erosion down-drift of the Rioni River mouth. Therefore, to the extent possible, the sediment that collects behind the diversion weir should be flushed downstream rather than being mechanically removed and disposed of in a landfill.

Table 6: Luji Gauge adjusted to Kheledula 2 Intake Sediment Load Estimates

Luji Guage Adjustment Factor	Adjusted to Kheledula 2 Flows Average Monthly Discharge of Sediment in kg/sec												Average Monthly Sediment Discharge in kg/s	Annual Sediment Discharge in Tonnes x1000
0.432806324	1	2	3	4	5	6	7	8	9	10	11	12		
Monthly Average	3.74	3.60	4.22	12.38	26.89	26.18	19.83	15.26	9.11	8.12	7.09	4.74	12.12	377
Monthly Maximum	5.06	4.67	6.10	17.23	30.51	32.37	27.74	25.28	11.99	12.33	10.17	6.41	N/A	N/A
Monthly Minimum	2.56	2.36	2.96	9.05	19.43	22.85	13.76	10.86	6.88	5.45	4.50	3.19	N/A	N/A
Estimated Daily Maximum	8.61	7.79	8.05	19.91	39.60	52.37	28.57	26.96	14.15	17.87	19.00	9.82		
Estimated Daily Minimum	1.47	1.60	1.96	5.76	13.42	10.47	8.74	5.02	3.64	3.98	2.90	2.25		
Monthly Average Suspended Sediment	2.59	2.49	2.93	8.58	18.64	18.14	13.74	10.58	6.31	5.63	4.91	3.28	8.15	
Monthly Average Bedload Sediment	1.15	1.10	1.30	3.80	8.25	8.03	6.09	4.68	2.79	2.49	2.18	1.45	3.61	
Average % of Kheledula 2 Flow Extraction	89%	89%	88%	80%	29%	19%	54%	82%	93%	93%	93%	88%		
Average Monthly Suspended Sediment in de-silting channels	2.31	2.21	2.58	6.88	5.46	3.45	7.41	8.72	5.87	5.23	4.55	2.90	4.80	151
Average monthly m3 Sediment in de-silting channels	4,100	3,600	4,600	11,900	9,800	6,000	13,200	15,600	10,100	9,300	7,900	5,200	8,400	

Note 1: This data is unpublished and provided by a consultant to the project team. It is presumed that the data was collected and originally processed by the predecessor agency to Hydromet, (The National Environmental Agency, Dept of Hydrometeorology, Government of Georgia).

Note 2: Average monthly m^3 assumes suspended sediment settled in de-silting channels is 1500 kg/m^3

2.2.5 Meteorological Conditions

For the analysis of the climatology of the Kheledula project area, information from the nearest Meteorological Station located in the Tsageri District village of Lailashi was used. Lailashi is located along the Lajanuri River, about 7 km east of the town of Tsageri and about 30 km southeast from the Kheledula 2 HPP.

The project team recognizes that Lailashi is the best available data near the watershed but is at a significantly lower elevation than the Kheledula 2 HPP watershed. It is recommended that as soon as project approval is complete, a primary meteorology station should be installed near the Kheledula 2 diversion weir or at the powerhouse location. Please see Table 6 for specific data from Lailashi Meteorological Station.

The climate of the greater Rioni River watershed is considered humid subtropical, but varies considerably with altitude. At the Lailashi Meteorological Station, the mean annual precipitation is 1558 mm.

Annual precipitation in the Lentekhi District is 1200-2500 mm. The Kheledula 2 HPP watershed is considerably higher than the Lailashi Meteorology Station and since precipitation increases considerably with elevation it is expected that the precipitation within the project area will be on the high end of the Lentekhi District range.

See Appendix 6 for the Mean 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 Lailashi , which is the nearest official precipitation gauge, but is at a lower elevation than the project watershed and therefore warmer and drier.

Further data collection and analysis has identified a discrepancy in meteorological data provided from various sources. There is a significant difference in the magnitude of monthly average rainfall included in Table 7 from the distributed rainfall data that appears in Appendix 6. At the pre-feasibility level of analysis, the discrepancy has been identified so that the developer's engineering team can research this data further and decide which is more appropriate or how to adjust one set to match the other. A potential developer is highly encouraged to establish a rain gauge at the intake location to develop a correlation with other existing sources of rainfall data.

Table 7: Lialashi Village Climate Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	
Data Type	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**mean**	**Annual Totals**
Average Monthly Air Temperature in °C	-1.4	-0.2	3.2	8.8	14	16.7	19	19.6	16	11.5	6	1.3	10	
Average Monthly Low Air Temperature in °C	-4	-3.5	-0.6	4.9	9	12.3	15	15.4	12	7.2	2.3	-1.4		
Lowest Recorded Air Temperature in °C	-26	-22	-15	-5	0	5	8	7	1	-7	-20	-24		
Average Monthly High Air Temperature in °C	2.6	4.5	8.2	14.4	19	22.4	25	25.2	22	16.9	11	5.4		
Highest Recorded Air Temperature in °C	17	22	31	34	36	37	39	40	41	33	28	19		
Average Relative Humidity in %	84	82	77	72	72	74	75	75	78	83	80	84	78	
Average Monthly Precipitation in mm	99	103	101	105	109	110	93	84	106	116	101	108	103	1235
Average Monthly Wind Speed in meters/sec.	0.6	0.7	1.1	1.4	1.3	1.2	1.2	1.1	1	0.8	0.7	0.5	1.0	

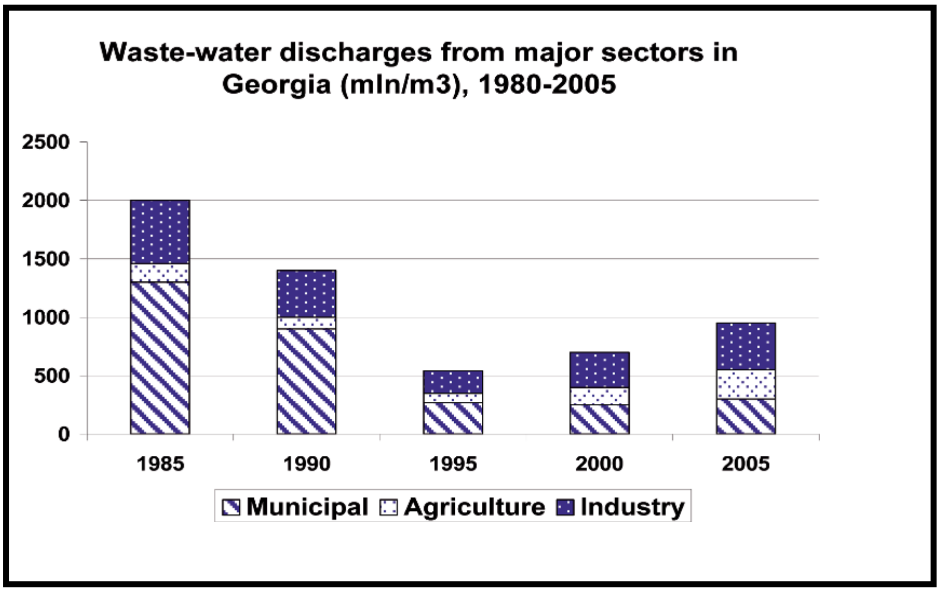
Source: Lajanuri HPP Environmental Impact Assessment Report (approved by the Ministry of Environmental Protection) reportedly from Meteorological Station Located in Lailashi village in Tsageri District

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 3: 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 Kheledula 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 on a regular basis (i.e., samples are taken and analyzed each month), another 26 on an 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

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

In the upper Tskhenistskali River watershed, there is logging activity and the rivers are used for timber transportation. Some provision needs to be made at the diversion weir to protect against damage from logs, as well as other large debris.

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.

Flood frequency analysis had been performed during the Soviet Era and was published in (Ref in Russian) “Surface Water Resources of the USSR, Volume 9, Transcaucasia and Dagestan, Edition 1, West Caucasia”, by Administration of Hydrometeorologic Service of the Georgian SSR, 1969. Table 8 displays flood discharge as a function of frequency for the Luji Gauging Station. A drainage basin adjustment of 0.015415 was used to adjust these values to the proposed location of the Kheledula HPP intake.

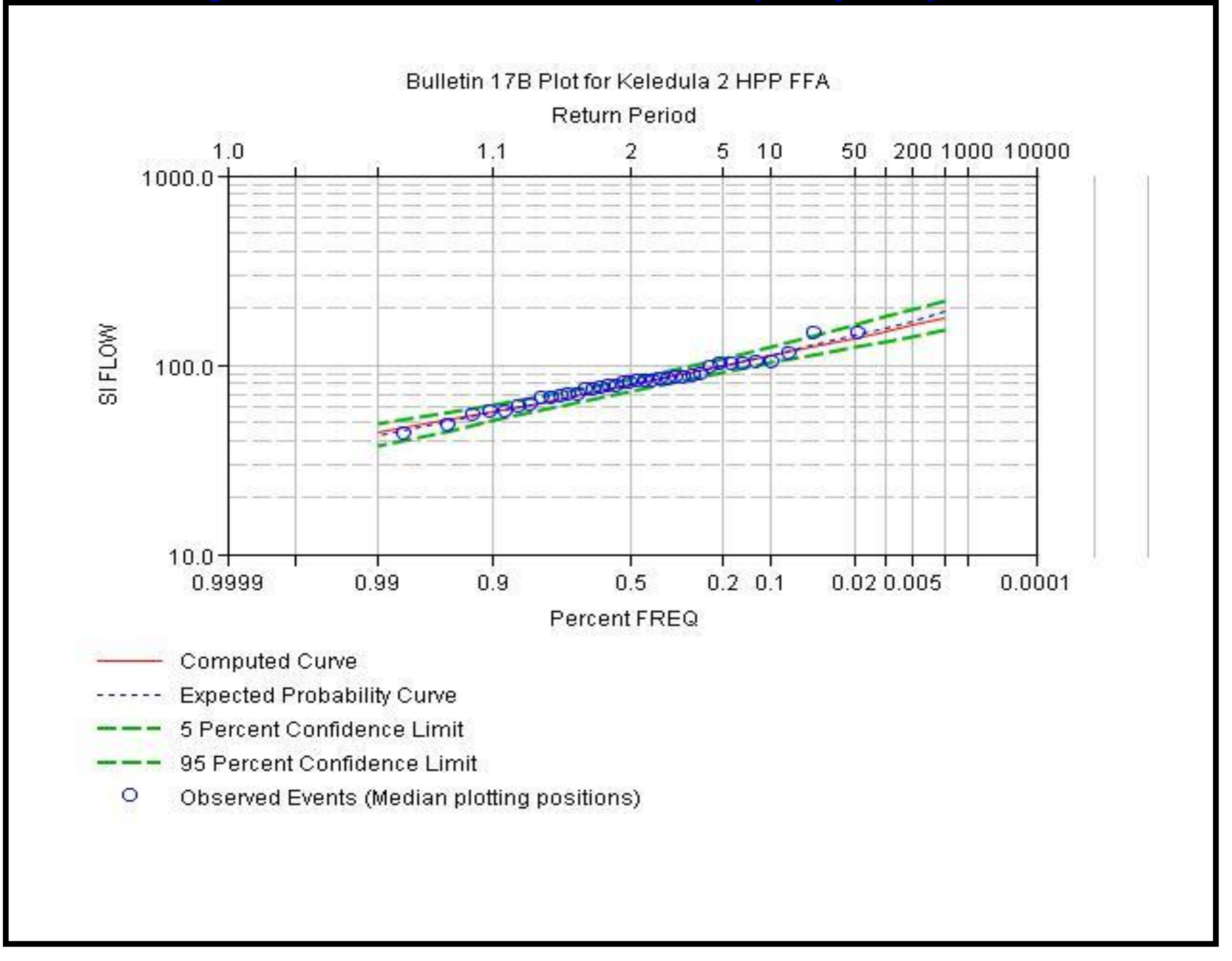
Table 8: Flood Frequency

Flood Frequency (Return Period in Years) *	Discharge in m^3/s
2.33 (mean)	58
10	78.5
20	91
50	120
100	138.5

- These values are initial extrapolated values for peak flood discharge for these flood frequencies (expressed as return period). Further analysis is required during detailed feasibility design to refine these values of peak discharge for use in HPP design and to map floodplains, and assess impacts to the affected environment.

With the availability of 39 years of record at the Luji Gauge, the U.S. Army Corps of Engineers Hydrologic Engineering Center (USACE-HEC) Flood Frequency Analysis program (HEC-SSP) was used to check the earlier Soviet Report flood frequency values. The results are presented in the figure below. A drainage basin adjustment of 0.43281 was used to adjust these values to the proposed location of the Kheledula 2 intake location.

Figure 4: Machakhela 2 HPP Flood Frequency Analysis



2.6 BIODIVERSITY

2.6.1 Flora

The landscape of the potential HPP location area is dominated by forested lower elevation mountains that are separated by gorges. Forests occupy almost all of the watershed areas of the territory. Forests growing in the vicinity of proposed Kheledula 2 HPP watershed are State owned. Appendix 7, Land Cover Map, displays general forest cover in the watershed.

The Kheledula River watershed is rich in biological resources. The majority of the watershed is covered with mixed hardwood and coniferous forests but above the tree line also contains alpine meadows, rocky peaks, and glaciers. The forests contain alder (*Alnus barbata*), oak (*Quercus iberica, Q. hartwissiana*), chestnut (*Castanea sativa*), hornbeam (*Carpinus caucasicus*), and beech (*Fagus orientalis*), a variety of Colchic evergreen species and pine (*Pinus Kochiana*). The forest understory consists of cherry-laurel (*Laurocerasus officinalis*), pontic rhododendron (*Rhododendron ponticum*), boxtree (*Buxus colchica*). lianas include green brier (*Smilax excelsa*) and ivy (*Hedera sp.*). (Source: 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.

Forests provide good feeding ground for various mammal species. Large mammal species found in the area include common otter (*Lutra lutra*), lynx (*Lynx lynx*) and wild boar (*Sus scrofa*). According to local residents wolves and brown bears inhabit the area in autumn and winter. The otters migrate to the area each year from July through October.

The birds of this mountainous area have not been studied in detail. The following bird species have been observed in the vicinity of the HPP: common buzzard (*Buteo buteo*), common kestrel (*Falco tinnunculus*) and golden eagle (*Aquila chrysaetos*).

Among reptiles two rare species inhabit the area surrounding the HPP: the Transcaucasian rat snake (*Elphe longissima*) and Caucasian viper (*Vipera kaznakovi*).

2.6.3 Fish Population

The local fishery is also considered a primary environmental receptor for baseline comparison. The following fish species were once found in the Tskhenistskali River: kolkhic barbel (*Barbus tauricus escherichi*), bream (*Abramis brama*), goby (*Gobius melanostomus*), trout (*Salmo fario*) and khramulya (*Varicorhinus siedolbi*) (Source: Elanidze, R. 1988). The Red Book of Georgia classifies the Khramulya as National Statute Vulnerable, so it needs to be protected.

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

Table 9: Fish Spawning Periods

Fish	Spawning Period
Kolkhic Barbel	May-August
Bream	April-June
Goby	March-September
Trout	September-October
Khramulya	May-June

Literature on fish composition of Tskhenistskali River dates back several decades, which was before any hydropower dams were built downstream of the town of Lentekhi. Therefore, it's hard to determine if any of the above species inhabit the study area. A sampling for fish species should be included in the environmental assessment as part of the feasibility study.

The construction area (dam, intake, tailrace) is not important from the point of view of a fishing industry. There are already power plants located downstream of the project area that prevent upstream migration and fish passage. Potential for a local fishery to develop as a benefit to the local community and recreation is possible.

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 geological maps covering the Kheledula River watershed are included in Appendix 1.

3.2 SEISMOLOGY

The Kheledula River watershed is located on the central part of the Fold System of Greater Caucasus (Gagra-Djava Zone), 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. Within 150 km of the Kheledula HPPs there have been several “significant” earthquakes. The “significant” earthquakes in the area are listed in a table in Appendix 1, Geology. 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).

According to the current Georgian seismic zoning classification the project is in hazard zone 9. The design criteria for earthquake loads and resistance of structures must be defined in accordance with applicable standards and regulations. Through proper design and construction, the risk from earthquake damage can be mitigated.

3.3 CURRENT STATUS OF GEOLOGICAL INVESTIGATION

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

Table 10: Geology Significant Data

Available data	**1:500,000 Scale Geological Map of Georgia (2003); 1:50,000 geologic quadrangle maps of the Kheledula area**
Regional description	**Central Caucasus Mountains**
Seismicity, including earthquake loadings	**Richter Scale 7.0, Georgian Seismic Zone 9**
Field reconnaissance	**Done in 2010 and 2011. Report available in Appendix 1.**
Subsurface borings	**To be done at Feasibility Study stage**
Investigation recommendations for Final Feasibility and Design	**Geotechnical core borings at diversion dams, surge shaft, tunnel portals and powerhouse locations. Geophysical studies to determine depth of alluvium in the valley and location of any hidden features that would affect the project design and construction. Investigations of materials for concrete aggregate supply and road surfacing.**

4.0 HYDROPOWER PROJECT DESCRIPTION

4.1 PROJECT DESCRIPTION

The Kheledula 2 HPP development is expected to include a diversion structure on the Kheledula River, just downstream from Mananauri village and the confluence with the Skiliri River. The concrete gravity-type structure will be about 185 m long, and up to 18 m high from the foundation to the crest. It will include a 20-m-wide overflow spillway, with a stilling basin at the downstream end to dissipate excess energy. The power intake will be near the left (north) end of the dam, and a low-level sluice controlled by a radial gate will be located a short distance south of the intake.

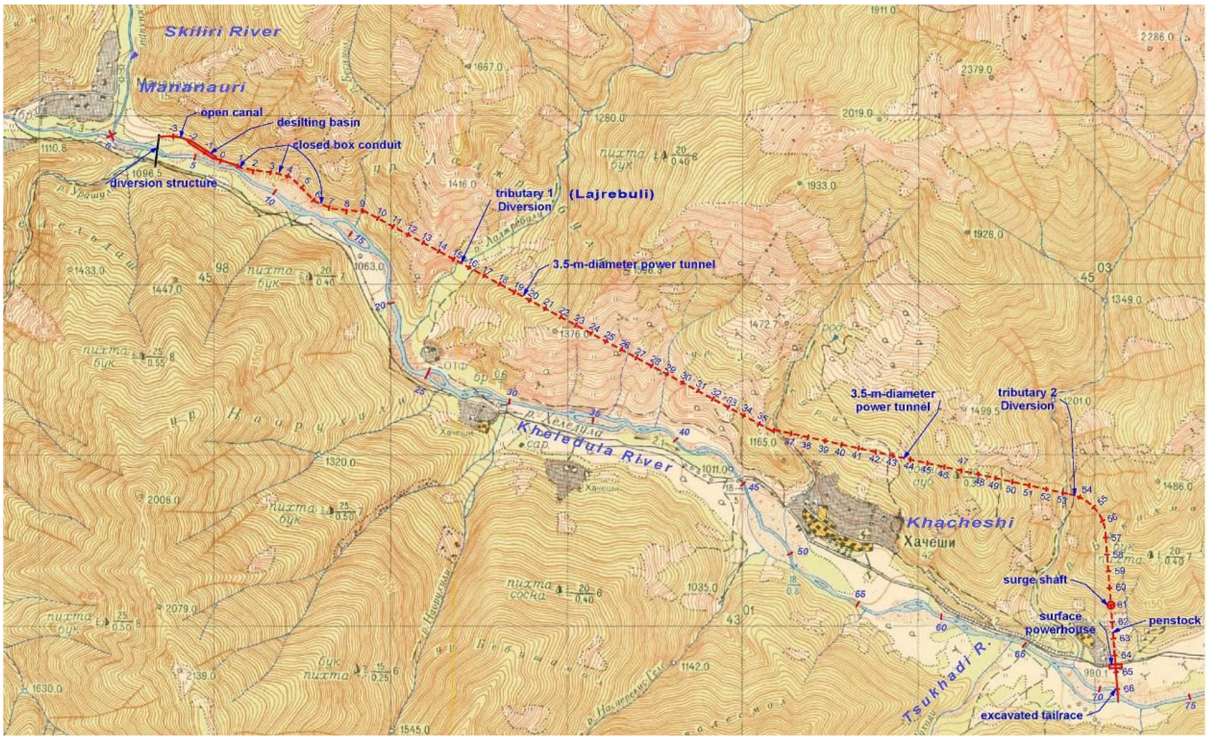
The water conductors will include a power canal with a side spillway to limit the canal water surface; a two-channel de-silting basin; a closed reinforced concrete box power conduit, about 900 meters long; a 3.5-m-diameter, 5,240-m-long power tunnel; and a 320-m-long, 3.5-m-diameter surface penstock that branches just above the powerhouse to supply three turbine-generator units. Two tributary streams will be tapped to provide additional flow, through connections to the power tunnel.

The surface power plant will house three butterfly isolation valves, vertical Francis turbines, and generators as well as auxiliary equipment. An excavated tailrace will return flow 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 Kheledula 2 plant, sufficient auxiliary backup power (probably a diesel generator) will be provided to allow black-starts when this plant is isolated from the national transmission network (island mode).

Road access to the site is described in Section 1.1 of this report, above. The locations of both the powerhouse and diversion weir sites are adjacent to an unpaved public road. About 8 km of this unpaved road, two bridges across the Kheledula, and cross drainage will need to be upgraded between Mananauri and the diversion site. This will assure good access for trucks and equipment during the construction and operation of this HPP.

An overall view of the project arrangement is shown in Figure 5.

Figure 5: Kheledula 2 Hydropower Project General Layout



In the figure above, the heavy red line represents the power canal, de-silting basin, box conduit, tunnel, and penstock. The figure also indicates the proposed locations of the diversion dam at the upstream end of the power canal and powerhouse on the downstream end of the penstock.

The 35 kV transmission line to connect the Kheledula 2 substation to the Lentekhi HPP 220 kV substation will follow the road and river. For this study, it is assumed that 15 km of new single-circuit 35 kV line will be constructed. During the feasibility study and design, the developer must negotiate with the developer owning the Tsageri and Lentekhi HPPs, as well as Energo-Pro, to connect the Kheledula plant transmission lines through their systems.

4.1.1 Diversion Structures

The diversion dam will be on the Kheledula River, a short distance downstream from the confluence with the Skiliri River, which enters from the north. It will have a height of as much as 18 meters from the assumed bedrock elevation at the base of the stilling basin to the access bridge above the spillway. There is no bedrock visible at the surface in this area. The river valley is filled with alluvium of an unknown depth, and the stream is intensely braided. There is evidence that the main river channel has changed often. The dam axis has been selected to minimize the height of the dam while avoiding the uncertain sediment and bedload transport conditions near the Skiliri confluence. However, the best available topographic information (Soviet-era topographic maps at a scale of 1:25,000 with 10-meter contours) is not adequate to select the optimal location. As more-detailed information becomes available on the topography and geology of the area—during feasibility and design—careful studies of the dam axis will be necessary to minimize the size and cost of the concrete gravity structure. Also, drilling and geophysical studies of the dam foundation area are necessary to determine the below-ground extent of the dam structures and to design the seepage-control measures that will be needed to address dam stability and water loss issues. For the cost estimate, it has been assumed that there will be 8 m of drilling for pressure grouting for each meter of dam length. Only the above recommended study can determine whether this is high or low.

Layout drawings of the proposed diversion dam and intake are included in Appendix 5.

The Kheledula 2 HPP will include a de-silting facility (described below), because the upstream pool at the diversion dam will not be large enough to allow sediment to settle. Please refer to Table 6 above for an estimate of monthly and annual sediment volume for Kheledula 2 as a function of monthly flow and sediment load in the water. During high flow months (May, June and July), only a small amount of the spring run-off will be utilized for generating electricity at design capacity and therefore only a percentage of the total suspended sediment will enter the de-silting channels. However, all of the bedload sediment will end up behind the dam and at least the area near the intake will need to be flushed frequently, through the sluice opening in the dam. Also, Table 6 strongly suggests the desirability of field data collection for sediment from the Kheledula 2 intake location during the feasibility study.

Two additional diversion structures will be constructed to capture flows from tributaries that cross the power tunnel alignment. The first is located on the Lajrebuli River, with a drainage area of about 13 km^2. It will contribute, on average, about 1.1 m^3/s or 6 percent of the total project design flow of 18 m^3/s. A Tyrolean weir will be constructed across the stream channel, diverting flow to a collection chamber and then through an 0.8-m-dia pipeline to a shaft constructed over the power tunnel. If future studies show that sediment may be a problem, there is space in this area to construct a small de-silting basin.

The second supplemental diversion is located on an un-named tributary that crosses the power tunnel in the Kacheshi area. It exploits a drainage area of about 7 km^2, and will divert a flow of up to about 0.5 m^3/s or 3 percent of the total project design flow. The diversion location is very narrow and steep, so a wedge-wire screen intake is proposed. If a narrow spacing between screen wires is specified, a de-silting basin should not be required. A 0.5-m-dia pipeline will convey water from the diversion's collection chamber to a shaft constructed over the tunnel.

4.1.2 Intake Facilities

The main intake facility will be integral with the dam, discharging into the power canal. It will be a reinforced concrete structure, and will include bar racks to keep large material (such as logs) from entering the channel, a bulkhead gate for maintenance, and a wheel gate for normal operation. The intake opening dimensions will be 3 m wide and 5 m high, and will be located upstream from a reduced section with 2.5 m x 2.5 m gates. About 70 m down the power canal will be a side spill overflow weir—discharging into the river below the dam—to control the level of water in the power canal during floods.

4.1.3 Power Canal and De-silting Structure

The Kheledula 2 power water intake leads to a 175-m-long power canal followed by 200-m-long de-silting basins, including 25-m-tapered sections at each end. The canal will be 3.0 m wide and have a normal flow depth of 3.5 m. The de-silting structure includes two parallel basins each 5.5-m-wide by 150-m-long, plus a 25-m-long transition and gate section at each end. Each of the basins can be isolated for flushing while the other operates. At the downstream limit if the basins, two under-sluices will return the settled material to the river during flushing operations.

Immediately downstream from the de-silting structure, a closed box conduit, 4 m wide, 3 m high, and 900 m long, will convey flow to the upstream tunnel portal. The conduit will be closed for structural reasons, to avoid landslide and avalanche material from blocking flows, and to provide an access route between the dam and tunnel portal.

4.1.4 Power Tunnel

The power tunnel will have a total length of about 5,245 meters, with a finished inside diameter of at least 3.5 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 may be excavated using conventional drill and blast methods or using a tunnel boring machine depending on the developer's preferences, cost, and schedule requirements. 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 at some points.

4.1.5 Surge Mitigation

There will be pressure surge considerations at the Kheledula 2 HPP, commensurate with the length of the power tunnel and the gross head. To reduce the pressure increase in the tunnel when turbines are shut down, a surge shaft will be excavated vertically through sound rock from a point near the junction of the power tunnel and penstock. 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 370 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.

4.1.6 Penstock

A 320-m-long, 3.5-m-diameter steel penstock will lead to the powerhouse. A trifurcation just above the powerhouse will channel the flow to three turbine-generator units.

4.1.7 Powerhouse

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

The powerhouse dimensions for the assumed installation of one large and two small Francis units will be about 16 meters wide, 60 meters long, and 15 meters above grade. It will include an overhead bridge crane with a capacity to lift the heaviest component in the large turbine generator set (a 10 tonne crane has been assumed for preliminary cost estimating purposes).

Draft tube gates and drainage pumps will be provided to dewater the unit draft tubes for inspection and maintenance. The draft tube gates will be downstream of the powerhouse and operators will be installed on a reinforced concrete deck.

4.1.8 Mechanical Equipment

There will be hydraulically operated butterfly valves, capable of closing against full flow, on the inlet pipes to isolate the turbines.

Turbine selection for the Kheledula 2 project must be evaluated in detail during feasibility studies. Preliminary turbine selections were made for Francis and Pelton turbine options using the TURBNPRO evaluation software produced by Hydro Info Systems. Appendix 11 contains the program output for the options. For this Kheledula 2 Pre-Feasibility Study, Francis units were selected because the available head is moderate and they were **much** smaller than the Pelton option. (See turbine specifications in Appendix 11). One large and two small turbines were selected to accommodate the wide range of flows expected at Kheledula 2. The table below lists the critical details from this turbine option evaluated for sizing tunnel, penstock, and powerhouse.

The Francis turbine option includes three unequal-size vertical-shaft units, two small units (3.0 m^3/s each) and one large unit (12.0 m^3/s). The unequal-sized units are needed to handle the highly variable seasonal flow in the Kheledula River. This configuration will produce a mechanical output totaling about 16.9 MW (with all three units operating, at minimum net head). This configuration is more appropriate than Pelton units at the Kheledula 2 gross head of 110 m.

Table 11: Turbine Characteristics

Unit	Speed, rpm	Runner Pitch Diameter, mm	Design Flow, m^3/s	Minimum Flow, m^3/s	Maximum Turbine Power, MW	Minimum Turbine Power, MW
No. 1	375	1,400	12.0	6.0	11.66	5.46
No. 2	500	802	3.0	1.5	2.94	1.36
No. 3	500	802	3.0	1.5	2.94	1.36
Plant Total			**18.0**		**16.90***	

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

This installation will result in a maximum electric power output, at the high-voltage transformer terminals, of about 15.7 MW.

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

Table 12: 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 six-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. Lower peak efficiency, about 90% 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
- Draft tube gates and operators

4.1.9 Electrical Equipment

Generators will be vertical-shaft synchronous machines compatible with the selected turbines. Stator output voltage will probably be about 15 kV or less, depending on the manufacturer's practice.

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 Kheledula 1 HPP discharge and below the confluence with the Skiliri River.

At a site where the dam length is relatively short, the height is moderate, the alluvium depth may not be excessive, and reasonable rock conditions may exist at the base and on both abutments. The various locations considered for the dam covered about a 500 meter reach of the Kheledula River. The final location and height will depend upon the same factors considered above but after detailed geotechnical investigations confirm the alluvium depth and rock conditions throughout the proposed area.

The water conductors and intakes were located where there appears to be reasonable space, good overall alignment, and acceptable geologic conditions.

- Good tunnel portal conditions for the main power tunnel entrance.
- Sound foundations on competent rock.

Various combinations of water conductors were evaluated, including canals, tunnels, pipelines and penstocks. The combination of a short canal and box conduit, followed by a long power tunnel section and a surface penstock was selected because of the large quantity of water, topography, and relatively gentle cross-slopes between the dam and tunnel portal locations.

The surface powerhouse was selected for cost reasons. The location was determined by analysis of the best location to avoid interference with the probable reservoir level of the proposed downstream Kheledula 3 HPP project. Several power plant locations have been considered along a reach of river that is about 5 kilometers long, between Kheledi and Kacheshi. These site locations were all influenced by plans for alternative downstream projects, some of which included seasonal storage reservoirs. During this study, the river profile and the expected geology in the Kheledi area were considered to select what appear to be good sites for a Kheledula 3 dam and the Kheledula 2 powerhouse. The resulting Kheledula 2 arrangement has both a lower gross head and shorter water conductor length than previous plans.

4.3 PROPOSED PROJECT COMPONENTS

In summary, the project includes the following components:

- A main river diversion structure
- Power canal
- Side overflow weir
- De-silting channels
- A closed box conduit section
- A power tunnel
- Two tributary diversion structures
- A steel surface penstock with a trifurcation
- Surface power plant
- A 200-m-long tailrace channel
- Electrical and mechanical plant equipment, including inlet valves, 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
- Upgrades to about 17 km of existing local road
- 15 km single-circuit 35 kV transmission line to connect to the proposed Lentekhi HPP 220 kV substation

Table 13: Hydropower Development Significant Data

Maximum gross head	**110 meters**
Maximum generation flow	**18.0 m³/s**
Number of units	**3 unequal-sized Francis units**
Potential installed capacity	**15.7 MW**
Mean annual power output	**Approximately 68 GWh**
Construction time	**4 years including final feasibility, EIA and design.**
Anticipated Life-span	**30 years**

5.0 POWER AND ENERGY STUDIES

The Kheledula 2 HPP energy assessment was completed using available Tskhenistskali River flow records from the Luji station (39 years of record) and operating scenarios that fit the proposed site and watershed conditions. River flow records are described in Section 2.2.2, Surface Water Resources. The energy assessment used three different approaches to estimate expected average annual and average monthly generation. Each approach will be summarized in the following paragraphs. There are differences between the three approaches that are due to differences in environmental/sanitary bypass calculation approach. Results are considered acceptable when the energy output is within approximately 1% for all approaches.

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 Kheledula 2 HPP 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 exceedance percentages to calculate generation (MWh) expectation(s) that becomes input in a turbine/generator selection.

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

5.2 DAILY DISCHARGE GENERATION ANALYSIS

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

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

Hydraulic losses and controlling elevations are summarized in the following table.

Table 14: Summary of Kheledula 2 Hydraulic Conditions

Description	Flow Condition						
	Design Flood	18 m^3/s	12 m^3/s	9 m^3/s	6 m^3/s	3 m^3/s	Static Condition
Main Reservoir Elevation	1,102.500	1,100.000	1,100.000	1,100.000	1,100.000	1,100.000	1,100.000
Intake Losses	0.145	0.145	0.065	0.036	0.016	0.004	0.000
Canal and Desilting Basin Losses	0.190	0.190	0.085	0.048	0.021	0.005	0.000
Box Conduit Losses	0.560	0.560	0.249	0.140	0.062	0.016	0.000
Power Tunnel Loss (3.5 m OD)	4.937	4.937	2.194	1.234	0.549	0.137	0.000
Energy Grade at Tunnel-Penstock Connection	1,096.668	1,094.168	1,097.407	1,098.542	1,099.352	1,099.838	1,100.000
Penstock Losses (3.5 m OD)	0.272	0.272	0.121	0.068	0.030	0.008	0.000
Power Plant Losses	0.437	0.437	0.194	0.109	0.049	0.012	0.000
Energy Grade at Turbine-Generator	1,095.959	1,093.459	1,097.092	1,098.365	1,099.273	1,099.818	1,100.000
Assumed Tailwater Elevation	993.000	990.000	990.000	990.000	990.000	990.000	990.000
Net Head	**102.959**	**103.459**	**107.092**	**108.365**	**109.273**	**109.818**	**110.000**

Power and energy production figures were calculated using a range of plant design flows to get a capacity factor just greater than 50% to maximize the water capture during the high flow and potentially higher tariff season. Monthly results for a design flow of 18.0 m^3/s are summarized in the following tables. This flow is probably 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.

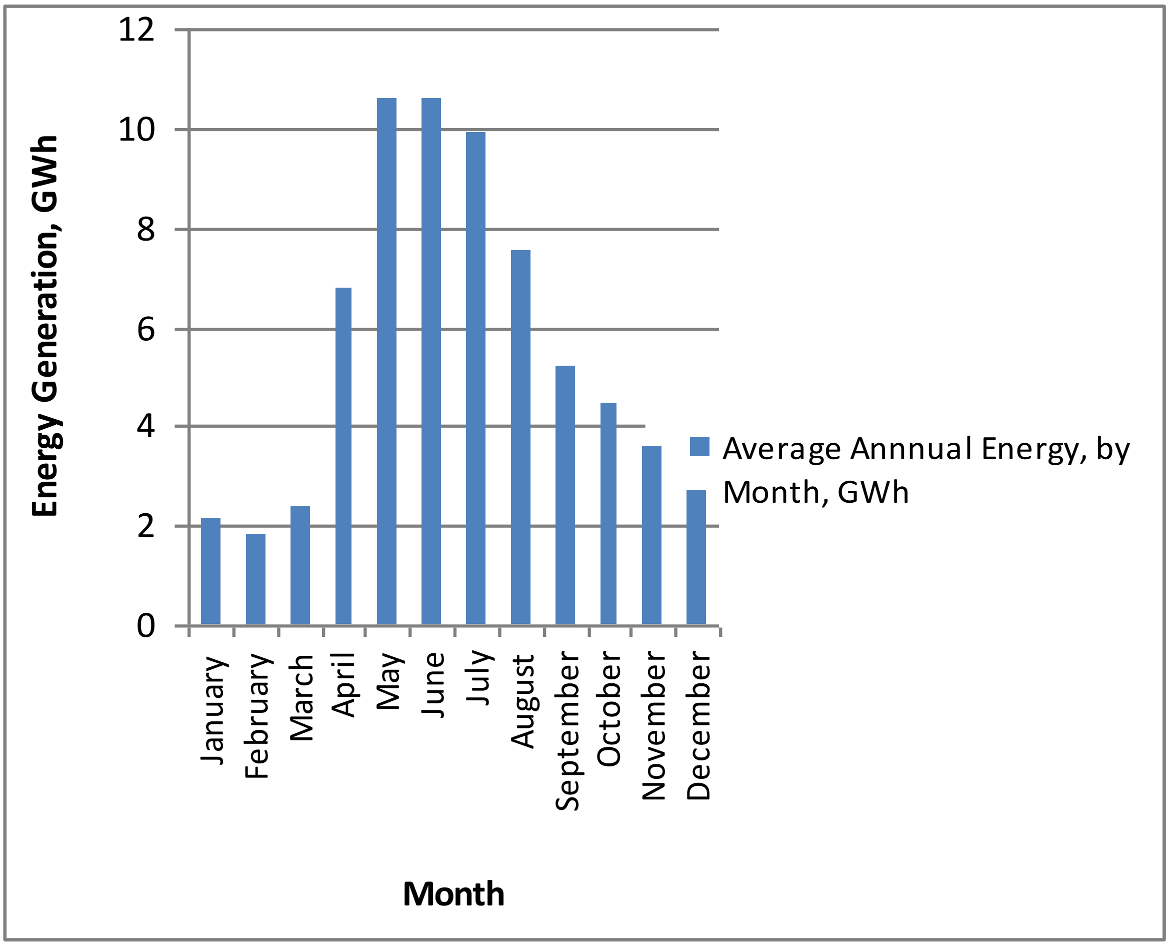
Table 15: Average Kheledula 2 HPP Power Production, 18 m^3/s Design Flow

Month	Mean Daily Power, MW	Minimum Daily Power, MW	Maximum Daily Power, MW
January	2.87	1.28	8.95
February	2.65	1.30	6.87
March	3.21	1.24	11.27
April	9.47	1.46	15.70
May	14.44	2.08	15.70
June	14.96	6.21	15.70
July	13.50	5.50	15.70
August	10.24	1.07	15.70
September	7.26	1.28	15.70
October	6.05	2.46	15.70
November	5.03	1.92	15.70
December	3.63	1.53	13.83
Annual	**7.78**	**1.07**	**15.70**

Table 16: Average Kheledula 2 HPP Energy Production, 18.0 m3/s Design Flow

Month	Mean Daily Energy, GWh	Minimum Daily Energy, GWh	Maximum Daily Energy, GWh	Mean Annual by Month, GWh
January	0.07	0.03	0.21	2.13
February	0.06	0.03	0.16	1.79
March	0.08	0.03	0.27	2.39
April	0.23	0.03	0.38	6.82
May	0.35	0.05	0.38	10.74
June	0.36	0.15	0.38	10.77
July	0.32	0.13	0.38	10.04
August	0.25	0.03	0.38	7.62
September	0.17	0.03	0.38	5.23
October	0.15	0.06	0.38	4.50
November	0.12	0.05	0.38	3.62
December	0.09	0.04	0.33	2.70
Annual	**0.19**	**0.03**	**0.38**	**68.36**

Figure 6: Monthly Distribution of Average Annual Energy



6.0 ENVIRONMENTAL AND SOCIAL STUDIES

6.1 COMMUNITY AND SOCIO-ECONOMIC BASELINE DATA

Racha-Lechkhumi and Kvemo Svaneti Region occupies 8% of Georgia's overall territory and it covers an area of 4,954 km². According to the official statistical data from 2002, the Racha-Lechkhumi and Kvemo Svaneti Region has a population of 50,969 people. Since 1990 the main demographic trends for the Racha-Lechkhumi and Kvemo Svaneti Region have been an increase in mortality, decrease in birth rate and migration to larger cities. This region is the most sparsely populated in the country. Administrative districts within the Racha-Lechkhumi and Kvemo Svaneti Region are: Ambrolauri, Oni, Tsageri and Lentekhi.

The town of Lentekhi, located near the confluence of the Kheledula and Tskhenistskali rivers, is the administrative center of the district. The distance from Tbilisi to Lentekhi is about 290 km.

6.1.1 Infrastructure

Infrastructure of the Racha-Lechkhumi and Kvemo Svaneti Region is developed: there are highways and high voltage transmission lines at 35 and 110 kV. Tsageri and Lentekhi towns are connected by a newly upgraded paved road.

There is an ongoing project to rehabilitate the water and sewage systems. The project is being implemented by Georgia's Ministry of Regional Development and Infrastructure and Municipal Development Fund.

There are 28 public schools, one museum, one theatre and one library in the Lentekhi District.

Proposed HPP will be located within the administrative borders of Lentekhi District.

6.1.2 Population and Settlements

The proposed Kheledula 2 HPP is located in Lentekhi District of Northern Georgia, Racha-Lechkhumi and Kvemo Svaneti Region. The table below shows basic data of Lentekhi District. Some socio-economic characteristics of this district are described below.

The Lentekhi District has an area of 1,344 km². According to the official statistical data, the District has a population of 8,400. The population density in this mountainous district is 6.25 people/km^2. The main economic activities of the district are growing potatoes and animal husbandry. Vineyards are also cultivated in some areas, especially in areas adjacent to Tsageri District.

Table 17: Khelvachauri District Statistics

Location:	Northern Georgia, Racha-Lechkhumi and Kvemo Svaneti Region
Administrative District:	**Lentekhi**
Area:	**1,344 km^2**
Population:	**8,400**
Population density:	**6.7 people/km^2**
Administrative center:	**Lentekhi**

The closest settlements to the proposed HPP project are the villages of Mananauri, Khacheshi and Kheledi.

6.1.3 Cultural Heritage and Recreational Resources

Archeological sites, churches, towers, and related cultural and heritage sites are important baseline environmental data. The Racha-Lechkhumi and Kvemo Svaneti Region is rich in old churches, monasteries and other cultural relics. The table in Appendix 9 shows some of existing cultural resources of Lentekhi District of Racha-Lechkhumi and Kvemo Svaneti Region. According to the literature review, there are three cultural sites in Kheledi village, which is located 1 km downstream from the Kheledula 2 powerhouse.

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 Kheledula 2 HPP.

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

General Categories for Environmental Receptors:

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

Affected Environment Assessment: The Kheledula 2 HPP has two hydropower development activity periods that will impact environmental receptors, over different time horizons, and at different risk or impact levels. The following are the activity periods of interest:

- Construction: Compared to the lifecycle of the facility this is a short term impact period of approximately 2-3 years. It includes all phases of construction from initial land and water resource disturbance to startup of plant operations.
- Operations: Time horizon for full operational lifecycle before major component replacement is 30 to 40 years.

Risks to an environmental receptor from the activities are evaluated as Low, Medium, or High and should be refined further during the feasibility study. Risk evaluation also includes whether the impacts to receptors are (R) Reversible or (IR) Irreversible and (T) Temporary or (P) Permanent.

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

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

The Georgia Hydropower Investment Promotion Project (HIPP) team held a public awareness workshop in Tsageri to advise the local residents and officials of the proposed development of the Lentekhi and Tsageri HPPs and to get input from the public on sensitive environmental and social concerns. The minutes of this workshop are included in Appendix 10. Although the Kheledula projects were not explicitly described during that meeting, residents and officials of the Lentekhi Municipality raised the possibility of Kheledula River developments during discussions following the formal meeting. The comments were generally cautiously pro-development. Another meeting, specifically addressing the Kheledula projects, is expected to be scheduled during fall 2011, probably in Lentekhi.

From an affected natural environmental perspective the Kheledula 2 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 Kheledula 2 HPP in an acceptable, legal, environmentally sensitive manner while complying with all regulations.

7.0 PROJECT COST ESTIMATE AND CONSTRUCTION SCHEDULE

7.1 CAPITAL EXPENDITURE

The capital expenditure is as important to the feasibility of a hydropower project as the energy that can be produced or the tariff that is expected for the energy generated. Based on this cost estimate, we have confidence that the completed project will cost about US$ 48.8 million or $3,106 per kW of installed capacity, which is used in the financial analysis in Section 8.0.

As mentioned in other sections, because of the low head this project appears to be most practically implemented with Francis turbines. For the purpose of this cost estimate, to maximize water utilization, efficiency and revenue, it was assumed that three vertical-shaft 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 Kheledula 2 project both numbers were consistent, so we used the higher 1% of original capital expenditure in our financial analysis in Section 8.

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. 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 3 year schedule, with the critical path through the tunneling and the large amount of concrete that needs placing in the dam, power canal, de-silting channels and box conduit. It appears that work on the diversion dam may only be done during the spring summer and autumn months when there is no chance of freezing weather that could damage fresh concrete. During the spring runoff season (April through July) the water level and velocity may require some cofferdams to control the flow of water to allow work to proceed on other segments of the dam.

Table 18: Kheledula 2 HPP Estimated Capital Expenditure

	Units	Amt	Unit Cost	Total US$	Year 1	Year 2	Year 3	Year 4	Year 5
Land purchase	ha	4.0	$10,000	$40,000	$40,000				
Preparatory & infrastructure works	LS			$1,080,000	$1,080,000				
Access road improvements	m	17,000	$11	$182,000	$182,000				
Stream diversion and cofferdams	LS			$378,000		$189,000	$189,000		
Kheledula Main Dam	LS			$6,959,000		$2,087,700	$2,783,600	$2,087,700	
Sluicing Channel	LS			$424,550			$297,185	$127,365	
Power Canal	LS			$1,075,975			$753,183	$322,793	
De-silting Structure	LS			$3,915,560			$2,740,892	$1,174,668	
Upstream power tunnal portal	LS			$3,552,000				$3,552,000	
Power tunnel including rockbolts & shotcrete	m	5,245	$832	$4,365,000		$2,182,500	$2,182,500		
Tributary 1 diversion and tunnel connection	LS			$343,107			$343,107		
Tributary 2 diversion and tunnel connection	LS			$171,554				$171,554	
Penstock 3.5 m dia.	m	320	$1,593	$510,000			$255,000	$255,000	
Surge Shaft	m	35	$832	$29,000				$29,000	
Above ground power house civil works	LS			$1,269,000		$507,600	$761,400		
Tailrace Channel	m	200	$240	$48,000		$48,000			
Transformer Switchyard	MW	15.7	$7,747	$122,000		$61,000	$61,000		
Electric and mechanical parts (turn-key)	MW	15.7	$558,391	$8,767,000		$2,630,100	$3,506,800	$2,630,100	
Grid connection transmission line @ 35 KV	km	15	$100,000	$1,500,000				$1,500,000	
Subtotal of Schedule Items				**$34,731,746**					
Geology (investigation field, lab and office) @ 1%	LS			$347,000	$347,000				
Feasibility study @ 1%	LS			$347,000	$347,000				
EIA @ 1%	LS			$347,000	$347,000				
EPCM @ 14%	LS			$4,862,000	$2,917,200	$972,400	$972,400		
Contingencies (Assumptions Variable) @ 20%	LS			$8,126,949	$1,052,040	$1,735,660	$2,969,213	$2,370,036	$0
Total				$48,761,695	$6,312,240	$10,413,960	$17,815,280	$14,220,215	$0
MW Capacity	15.70	CAPEX/kW		**$3,106**					

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

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

Table 21 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 Kheledula 2 HPP based on the monthly flow-duration curves (see Appendix 2) and an assumed bypass of 1-10% of the low monthly flows as flow reserved for in-steam habitat and environmental functions and values. This environmental bypass is not deducted during high flow periods when excess water is running over the spillway. This leads to the saleable kWh that can be generated per month. The net price per kWh at the plant is determined by applying the assumed tariffs for Georgia and Turkey and subtracting dispatch and transmission fees. These calculations are shown in Tables 19 and 20 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 Kheledula 2 HPP is multiplied by net price per kWh for that month to get monthly net revenue at the plant. From this the amount of electricity used at the plant and therefore could not have been sold (we assumed 1% of generated capacity was used within the project) and operating costs at 1% of the initial capital cost 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 14.4 years.

The price per kWh exported to the grid is based on the following current tariffs by starting with the gross tariff, deducting all dispatch and transmission costs to get the net tariff to the developer at the point the power is exported into the grid. It is presumed that the three month winter sales will be to ESCO with no dispatch or transmission tariff. Justification for Tables 19 and 20 appear in a memo included in Appendix 12.

Table 19: Kheledula 2 HPP Financial Analysis & Payback Period (15.7 MW and 18 m^3/s)

Month	Total CMS-HR Under Curve	Saleable CMS-HR per month	Saleable kWh	Price / kWh	Revenue		
January	2,585	2,323	2,096,786	0.0500	104,839		
February	2,155	1,947	1,756,737	0.0500	87,837		
March	2,926	2,631	2,373,992	0.0585	138,879		
April	8,593	7,361	6,642,885	0.0585	388,609		
May	16,647	12,025	10,852,200	0.0585	634,854		
June	17,781	12,044	10,868,980	0.0585	635,835		
July	13,962	11,008	9,933,738	0.0585	581,124		
August	9,467	8,512	7,681,725	0.0585	449,381		
September	6,107	5,481	4,946,704	0.0585	289,382		
October	5,298	4,974	4,488,874	0.0585	262,599	Weighted Average Tariff	
November	4,288	3,987	3,598,445	0.0585	210,509		
December	3,282	2,952	2,664,433	0.0500	133,222		
Totals	93,091	75,246	67,905,499	Total Revenue / Yr	3,917,069	$0.0577	
				(Site Electricity) @ 1%	($39,171)	7% of rev	1% of Cap
				(operating costs)	($487,617)	$271,453	$487,617
				Net Operating Revenue	$3,390,281		
				Estimated Capital Exp.	$48,761,695		
				Pay Back Period	14.38		

Design discharge = 18.0 m3/s

Plant Factor (or CF) = 47.7%

Annual average m3/s through powerhouse = 8.59

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

Company DELOITTE

USAID Hydropower Investment Promotion Project (HIPP)

Geological-Engineering Survey in LowerSvaneti region in the middle portion of the Tskhenistskali River

Prospect for arrangement of hydropower center

(Pre-feasibility phase)

Tbilisi 2011

CONTENTS

Geological - Engineering Survey

1. Introduction

The purpose of this geotechnical investigations is to evaluate the proposed water-catchment area, dam site, power tunnel and underground hydropower plant construction within Lentekhi district and “MuriCanyon”interval in the TskhenistskaliRiver at the pre-feasibility phase.

For completing the present task, summarization and systemization of the existing data about the region was performed. The next phase included reconnaissance routes and surveys on 1:50,000 scale within the above mentioned section of the gorge conducted by Project Chief Engineer (A. Lomiashvili) and Geological-Engineer (v. Sulkhanishvili).

General geological-engineering survey was designed based on pre-feasibility level data gathering to identify issues to be addressed in detail during the feasibility study. The 1:50,000 scale geological- engineering map indicating sections and locations of hydropower plants is attached to graphic survey. It is understood that if the project is implementation, it will include building an underground hydropower plant of 120 thousand kilo-watt capacity and driving an 12.1 km long, 4.4 m diameter power tunnel.

2. Region Physical-Geological Description

Study area is located in Lentekhi administration region at a distance of 307-325 km from Tbilisi and covers the interval in the middle portion of the course of the TskhenistskaliRiver from Lentekhi through MuriCanyon. Sub-latitudinal ridges, particularly Egrisi and Lechkhumi are general orographic elements on this area. The mentioned ridges and their branchs are characterized with steep slopes (35-45°) and narrow rocky crests. The high mountain area of the region is completely cut with the network of deep gorges. Differences of elevation between the gorge bottom and watershed crests range between 300 m and 1000 m. The study area is also characterized by a dense hydrographic network. The TskhenistskaliRiver is a major river which runs in a north to south direction in this interval. The following rivers are its largest tributaries: Devashi, Lakhashuri, Lamanasheri, Rtskhmeluri and Khopuri.

Heavily fractured mountain relief contributes to climate vertical zoning and micro-climate process development. The study area climate is moderately humid and is characterized by cold winters and warm long summers. The regional climate is damp, subtropical according to atmospheric circulation, humidity and rainfall amount.

A great part of the study area is covered with dense forest. Coniferous forest (pine and fir-tree) is widely spread below the alpine pasture, and mixed hardwood forest is prevalent in gorges where beech, oak and hornbeam are dominant. Timber production plays an important role in the region's economic policy.

The study area and its vicinity are rich with mineral resources. Among metallic minerals, there exists one copper and polymetal deposit (Rtskhmeluri) and several prospective ore-occurrences. The region is especially rich with industrial minerals deposits such as diabase(Kvedreshi), limestone (Meriskhili); brick clay (Tsageri, Khoperi, Tsiplakakia), gravel (Tskhenistskali, Lasuriashi); building sand (Tsiplakakia, Rtskhmeluri) and sandstone (Devashi, Lakhashuri) deposits. Reserves at most of these deposits are not practically depleted.

The Kutaisi-Lentekhi asphalt road running along the river Tskhenistskali is the main highway of the region, which is kept open during the whole year. Gravel roads connect the villages to one another. Generally, the populated areas are located along the banks of the TskhenistskaliRiver and in the downstream portions of itslarger tributaries - on alluvial cones and terraces. The inhabitants engage in arable farming, gardening and cattle-breeding.

The study area is located in seismic hazardous zone of magnitude 9 according to present seismic zoning scheme of Georgia.

3. Geological - Tectonic Structure

Study area is located in the sub-zones of Khaishi and Racha-Lechkhumi syncline of Gagra-Java Zone of Caucasus South Slope Folded System and is built with formations of lower Mid-Jurassic clay shale and sandstones, volcanogenic-sedimentary formations of Bajocianporphyrite suite and cretaceous system epicontinental sediments. Lower and Mid-Jurassic terrigene sediments are spread over the north and central parts of the study area and are known as Sori suite (J^3_{1-2} S). In geological section it is in conformity continued with Mid-LiasMuashi (J^2_1ms) suite aspid slates. Sori suite itself is divided into two sub-suites: Lower (J^3_1 S_1) and Upper (J_2 S_2). The first one is composed of interlayers of dark gray clay shales and coarse-grained micaceous sandstones. The thickness of separate sandstone layers sometimes reach 1-1.5m. Sub-suite thickness varies between 400 m and 500m. The Upper Lias layer is determined according to fauna interpretation.

The Sori suite upper sub-suite (J_2 S_2) sediments continue the section in conformity and are Composed of alternation of dark clay shales, micaceous-quartzy fine-grained sandstones and aleurolites. The quantity and thickness of sandstone layers in the upper part of the sub-suite is increasing. The thickness of those sediments is 400-450m and their Aalenian (Mid-Jurassic) stage is also determinedaccording to fauna interpretation.

The Bajocianporphyrite suite in the study area is known as Khojali suite (J_2***h***d). The suite volcanogenic-sedimentary formations are spread over the lower part of the study area and are Composed of tuff-breccias, tuff-conglomerates, various porphyrite heavy coverings and their tuffs. Tuffogenic sandstones and sandy clay shales are alternating in the lower and upper part of the suite. The rocks' listed varieties don't belong to any determined stratigraphic horizon, they alternate one another very quickly in lateral as well as in vertical section and create a complicated pyroclastic, lava and sedimentary complex with thickness varying within a wide range of 850 m to 2000m.

The Lower Cretaceous epicontinental sediments transgressively proceed Bajocianporphyrite suite. These sediments participate in construction of the north flank of a large structural unit, the Racha-Lechkhumu syncline, and are spread throughout theMuriCanyon area.

The geological section of the Lower cretaceous sediments starts with the Berriasian - Hauterivian (K_1br-***h***)micro-conglomerates and sandstones low thickness (up to 10m) basalt patch that proceeds the same age thick-layered, dolomitized limestones (thickness 50m) and Barremian age (K_2 b) light gray, fine-grained massive limestones, dolomitized limestones, clayey limestone and marl suite with thickness reaching 250m. Aptian stage (K_2 ap)epicontinental sediments in MuriCanyon vicinities are composed of layered polymorphic marl limestones and marls (20-50m). Albian stage layered blue clays and clayey marls with thickness of 30-40m continue participation in the upward section of the mentioned sediments.

The Upper cretaceous begins with Cenomanian (K_2cm) sediments. Due to lithological peculiarities they strictly differ from the sediments located above and below them in the section and are composed of coarse grained glauconitic sandstones, sandy marls and clays. Their thicknesses vary within the range of 10-180 m.

Turonian and Coniacian stages (K_2t +cn) are composed of alternation of dense layered limestones and greenish marls. These rocks are exposed in the vicinities of Tsageri town and Muri Bridge. Their thicknesses vary within a range of 20-120m. Santonian and Campanian stages (K_2st +cp)are composed of light gray and yellowish polymorphic or cryptocrystalline lithographic limestones (50-150 m). In upward section they are continued with Maastrichtian(K_2 m) dense fine-layered limestones (50-150m).

The Cretaceous system is finished with Danian (K_2 d) massive or medium and thick-layered crystal limestones which vary in thickness in the range of 60-150m. The mentioned sediments in geological section are proceeded by Paleogene system carbonate rocks which are exposed outside the study area and there is no point in discussing them now.

The quaternary system in the study area is composed of the upper (Q III) and recent quaternary (Q IV) formations. The upper quaternary alluvial sediments (a Q III) are limited in area and are located in some terraces remained on the river Tskhenistskali. They are composed of different proportions of cobbles, gravels and sands. Also, upper quaternary deluvial and deluvial-proluvial sediments are not widely spread. Rather hard proluvial formations are spread in the vicinities of Rtskhmeluri and Kvedreshi villages. These villages are actually populated on alluvial fans, their thicknesses are 15-20m. Deluvial-proluvial sediments are also met in both banks of the river Khopuri (the left affluent of the riv. Tskhenistskali), from the middle portion of the flow until the river mouth.

Recent alluvial formations (a Q IV) in the study area are composed of boulder-cobble bed, cobble-sands and rarely clays that work as river-bed fillers. Their more-or-less high accumulations are observed in those places in the gorge where accumulation zones are developed.

Proluvial sediments generally create alluvial fans of side tributaries. Genetically, these sediments are generally related to mudflows which periodically occur during the heavy rain. Their composition is directly dependent on the base rocks which are spread in tributaries and are composed of crushed stone-clayey materials.

Deluvial sediments (d Q IV) are spread over the mountain slopes underneath which they create more-or-less heavy plumes. Their composition is also determined by the base rocks lithology and is represented by angular debris and the clay soil which consolidates them. Intrusive rocks on the study area are composed of Mid-Jurassic diabase(βJ_2) and quartzyporphyrite (q бJ_2) sub-volcanic bodies. These rocks create dykes and sands of various thicknesses and spreading ability. Generally, they are concentrated in Rtskhmeluri ore field contour and play significant role in localization of polymetal mineralization. Above mentioned Low and Mid-Jurassic terrigene and volcanogenic sedimentary formations of Khaishi sub-zone are intensively folded and create several thicker, asymmetrical folds linearly stretched to sub-latitudinal direction which flanks are complicated with secondary folds and disjunctives. Among the folded structures developed in this part we should mention the followings (from north to south):

Lamanashuri, Khopuri, Tsiplakakia, Tarigoni, Rtskhmeluri and Lajanuri anticlines and synclinal folds that are arranged among them.

Geological construction of the study area is greatly complicated with faulting structures of various directions and amplitudes. Among them we should distinguish Idliani-Rtskhmeluri uplift type deep fault observed in the south part of the region. The fault has a NW-SE direction and is inclined at 70-75° angles. The Sori suite terrigene rocks located in the upper partalong the fault is over-thrusted on Bajocianporphyrite suite formations. Vertical amplitude is up to 300m. The fault to the east when approaching the Rtskhmeluri River is gradually ending. The mentioned fault belongs to the pre-Middle-Jurassic stage and intrusions of porphyrite suite magma components along it probably occurred while it was in progress. This opinion is supported by the arrangement of porphyrite and diabase dykes along the fault, which must be the magma outcrop canal. The Idliani-Rtskhmeluri fault is paralleled by a number of low amplitude scaly faults – satellite faults of a heavy deep fault.

To the south of the Idliani-Rtskhmeluri faults there is located the Racha-Lechkhumi syncline sub zone. The mentioned sub-zone is a distinctly expressed syncline structure, which is traced along the general Caucasus direction 60 km from the village of Kulbaki in the west to the village of Skhvavi in the east. Mid-Jurassic, Cretaceous, Paleogene and Neogene sediments participate in its construction. The structure originated during the Bathonianorogenic phase as a united composite syncline that got distinct shapes during later phases. The fold is evidently of asymmetric construction. The rock layers are mostly vertical (80-90^0) in its north flank. The south flank is less slopping (30-40°) and is complicated by multiple folds from secondary folding stages.

4. Geomorphology

The study area is located in the south part of the Caucasus Alpine System where the general morphologic units are the followings: sub-latitudinal Egrisi ridge (mount Tsikori – 3173m), Lechkhumi Ridge (mount Tekali – 3043m) and meridionally located gorge of the river Tskhenistskali. According to a wide range of geological peculiarities, relief dissecting quality and base rocks sustainability against denudative processes the following three types of relief are distinguished:

1. Alpine erosive – denudative relief with old marks of glaciations, developed on the substrates constructed with Lower and Mid-Jurassic intensively folded Sori suite terrigene rocks;

2. High and Medium mountainous erosive relief, developed on dislocated substrate constructed by Bajocian volcanogenic-sedimentary formations; and

3. Medium and Low mountainous erosive relief developed on Cretaceous carbonate sediments.

The first type relief is spread over the central and north part of the region where are spread Lower and Mid-Jurassic Sori suite intensively folded sandstones and clay-shales that are not well sustainable against the denudative processes and complicated with fractured and rupture dislocations. Due to the dense hydrographic network, relief is here highly dissected. Dissection depth varies within a 300-1000 m range. Relief positive shapes – watersheds and their branchings are characterized with narrow rocky and sharp crests; and gorges are characterized with narrow and deep V-shaped transversal profiles and steep inclining slopes (35-45°).

The second type of relief is developed in the south part of the region where the Bajocian volcanogenic-sedimentary formations are spread. The rocks here are composed of massive porphyrite dykes sustainable against denudative processes and lava coverings, tuff-breccias, tuff-conglomerates and poorly sustainable layered rocks – tuffogenic sandstones and tuffs. Variegation of these rocks is observed while forming of alpine petromorphic relief which stipulates distinctiveness of relief shapes and intense dissection of the surface. Porphyrites, tuffo-breccias and tuff-conglomerates in the crest parts of the ridges originate rocky, tent-style or tower-like forms, on the slopes – inclined, dissected relief or hanging walls. In contrast, rather soft rocks – tuff-sandstones and tuffs create saddles on the watershed crests and smoother relief on the slopes. Narrow and deep gorges, steeply inclined stepped slopes are typical for the multiple affluents. Numerous waterfalls are observed in the gorges of a few affluents which heights sometimes reach 30-40m.

The third type of relief is developed in the south part of the study area where Cretaceous sediments are composed of limestones, marls, glauconitic sandstones, clays, sandy clays, dolomitized limestones and others. This type of relief is spread along the narrow line among Jurassic sediments in the north –and among Paleogene sediments in the south and is connected to the north flank of Racha-Lechkhumi syncline. Thus, rocks lithology as well as tectonic structure of their spreading zone stipulate relief morphological feature. Relief various shapes, distinct shapes, walls of 30-35m heights are typical for this type of relief that are developed in the gorge of the river Tskhenistskali to the north from Tsageri in the Upper cretaceous limestones. Much higher walls we can meet in Muri Bridge vicinities where the river Tskhenistskali creates a deep antecedent gorge in Cretaceous carbonate rocks which is known as "Muri Canyon". Here, the slopes of the gorge are almost vertical and the river-bed width doesn't exceed 15m. As for the river Tskhenistskali, it creates meridional lateral erosive gorge in the study area (crosses the folded structure at a more-or-less right angle) with V-shaped transversal profile which has unequal width. In the wider sections of the gorge, in some places, accumulation zones are observed with well-developed embankment and the terrace arranged above the embankment.

5. Hydrology

The water-bearing nature of the rock in the study area is determined by lithological-structural as well as morphological and climate conditions. Considering all these factors, here are distinguished several water-bearing complexes and one impermeable horizon spreading zones. The first water-bearing complex is connected to clay shales and sandstones of Lower and Mid-Jurassic Sori suite. Underground water circulation in these rocks is going in the fractures resulting from the weathering and along the layer surface as well and in fractures and fault structures that originated in tectonic dislocation zones. Most of the springs are connected to upper, more weathered zones of sandstones and shales with thickness reaching to some dozen meters. Recharge of water-bearing complex mainly occurs by means of atmospheric precipitations and at the expenses of water obtained after melting of snow but discharges into the hydrographic network. Spring discharges vary between 0.5-5.0 l/sec. The springs related to diluvions are characterized with less discharge – 0.02-1.0 l/sec. Shallow (or depthless) circulation waters are hydrocarbonate-calcium-magnesium or hydrocarbonate-calcium-sodium compositions. These waters total mineralization is low - about 0.07-0.7 g/l; total hardness varies within 0.7-5.0 mgr/eq.; carbonate hardness – within 0.8-3.4 mgr/eq. PH – 5.0-7.0; water temperature of 5-14°C. Chemistry of springs of deluvial cover is also similar.

Deep circulation underground waters are generally hydrocarbonate-calcium-sodium compositions. Such a mineral spring with significant flow (several thousand liters during twenty-four hours) is located on the right bank of the river Tskhenistskali near the village Tsiplakakia. At a distance of 11 km, to the south from Lentekhi, the spring is related to a fault zone and directly springs out from the base rock. Water temperature is 14 ° C, mineralization – 3.3 g/l. Carbon dioxide is emitted. Low-flow springs of the same composition are found in the gorges of the river Lamanasheri and near the village of Chkheteli.

The second water-bearing complex of underground water circulation connected to the Khojali suite volcanogenic-sedimentary formations originates in fractures as well as in rock pores. Generally, poor water encroachment is typical for the Khojali suite but its flow significantly surpasses flow of Liasianterrigene sediments. Recharge of shallow circulation underground waters is at the expense of atmospheric precipitations and consequently is characterized by seasonal variability. They get additional recharge from melting of snow, flow of which is between 0.9-2.0 l/s, and mineralization - 0.09gr/l. The discharge of deep circulation underground water varies between 2.5-4.0 l/s, with mineralization between 0.28-0.3 gr/l. The discharge of waters flowing out from deluvial-colluvial cover reaches 1.0 l/s.

Shallow circulation waters generally have hydrocarbonate-calcium-magnesium-sodium chemical composition. In some springs related to tectonic dislocations we can observe increase of sulphate-ion and chlorine-ion content (up to 30 mgr/eq %). Dry residues vary within 0.06-0.3 gr/l. Total hardness doesn't exceed 5 mgr/eq. PH – 5.7. Underground water temperature varies between 5 - 14° C. Deep circulation underground waters are mainly composed of mineral waters containing sulphur, hydrogen, chlorine, sulphate, -calcium, -sodium, and bicarbonate.

The third water-bearing complex is related to Cretaceous carbonate sediments which participate in construction of the north flank of Racha-Lechkhumi syncline in our study area and is composed of sandstones, limestones, dolomitic limestones, marlylimestones, marls, and clays. Limestones in this complex are dolomitic that are more fractured than sandstones and marls that contributes to circulation of atmospheric precipitations and origination of underground waters. Consequently, the springs of this complex mainly belong to fractured genesis. In some places,karstic phenomena are observed that is found in all types of limestones with various intensity especially, in Turonian - Cenomanianlimestones. According to circulation terms, there are distinguished two zonesin underground waters. The first covers hypsometrically elevated area and total exposure part of carbonate sediments over erosion basis. The second zone is located under it and is composed of deep circulation waters. Debit of shallow circulation springs varies within 0.3-2.0 l/sec. Chemically, they are bicarbonate-calcium-sodium composition. Chlorine and sulphate ion content doesn't exceed 7 mgr/eq.%, but sodium and magnesium ions rarely reach 20 mgr/eq%; mineralization is low – about 0.08-0.4 gr/l, total hardness – 0.4-4.0 mgr/eq. PH – 5.6-60, temperature – 12-15°C. Chemistry of waters related to deluvial cover is also analogue. The waters of this complex are widely used for potable water supply. One of the impermeable horizons in the study area is connected to Aptian-Albian (K_1ap-al) sediments. These rocks participate in the construction of Racha-Lechkhumi syncline north flank in form of low thickness patch and are composed of marl limestones, marls and clays. The rocks are characterized with weak fracturing and related water debit doesn't surpass 0.05 l/sec; they are bicarbonite-calcium composition; total mineralization – 0.2 gr/; total hardness of waters – 2.0 mgr/eq; temperature 10-12 °C.

Besides the water-bearing complex related to above discussed base rocks, water-bearing horizon of underground waters of alluvial-proluvial genesis plays an important role in the study area which are spread over alluvial-proluvial sediments of the Tskhenistskali River embankment and terrace existing above the embankment. Water-bearing horizon is also developed in alluvion of big tributaries and in quite heavy alluvial cones. These sediments are composed of boulders, cobbles, gravels, crushed stones, and sands. High filtration character and consequently abounding in water are typical for them. Underground water debit related to recent alluvial sediments varies within 1.0-8 l/sec. Total mineralization is low – 0.1-0.5 g/l. To the chemical standpoint they have bicarbonate-calcium-magnesium or bicarbonate-calcium-sodium composition. Total hardness is 0.4-0.7 mgr/eq. pH 6-7, temperature 4-15 °C. Depth of arrangements of water-bearing horizon surface varies within 0.2-0.4 m. Recharge is generally going with river-waters and partly with infiltration of atmospheric precipitation; regime is changeable and depends on changes in river-water level. The waters of this horizon are characterized with good drinking qualities and their prospective value is low due to limit in spreading.

6. Geological-Engineering (Geotechnical) Conditions

According to geological-engineering zoning of Georgia, the study area belongs to an area of alpine and medium-altitude mountains of the Caucasus South Slope Folded System. Among geotechnical groups of rock: hard-rock, soft-rock and friable-unconsolidated rock zones. Bajocianporphyrite waters (J_2***h***d) tuff-breccias, tuff-conglomerates, porphyrites lava coverings, cretaceous limestones and dolomitized limestones constitute the hard-rock group. The same geotechnical group includes Mid-Jurassic sub-volcanic formations: diabase-porphyrites(J_2) and quartzyporphyrites (J_2).

Clay shales of Low and Mid-Jurassic Sori suite with sandstone interlayers that are mostly dominant in the study area constitute the soft-rock group.

Friable-unconsolidated rock group includes fragmented and processed materials of river beds, embankments, above-embankment terraces and alluvial fans of Upper-Quaternary Q_{III} and recent Q_{IV} alluvial-proluvial origin, such as: cobbles gravel, crushed stone, and sand, with inclusions of various sized boulders. The same group includes diluvial, alluvial-diluvial and colluvial sediments spread over the slopes and plumes developed in some places in the bottom of the slope. Their spreading is too limited and is mainly related to the local areas relief specific shapes. Their thicknesses vary, generally in the range of 0.3-1.5 m and rarely greater than 2.0-3.0 m. Consequently, their value in forming of region geotechnical conditions is insignificant. The study area geotechnical conditions are directly related to physical-mechanical property of above-mentioned rocks. The main part of the project hydropower construction is a dam, power tunnel, pressure tunnel, hydropower plant and tailrace, which will be developed underground and around the hard and soft rock zones. Rock Quality Designations (uniaxial compression strength Rc)vary within a wide range (see tab. #1). The quality designations for the same rock are also variable in the upper weathered zones of the vertical section and in unaltered zones below it. For instance, the quality designation of weathered clay shale is 50 kg/cm^2, and un-weathered clay shale is 800 kg/ cm^2. Also, rocks physical-mechanical properties are different in tectonic dislocated and alternated zones. All above-mentioned factors cause complications in evaluating geotectonic conditions and require detailed investigations at the exact locations of potential construction work during the feasibility study phase.

Exogenic processes are important for determination of geotechnical conditions on the study area. Characteristics and peculiarities of these processes are determined by region complex geological-geomorphologic structure, hydrometeorological and climate conditions, neotectonics, seismic-technical activations, rocks geotechnical properties and sometimes population domestic activities. The most common among developed exogenic processes are: rocks physical-chemical weathering, denudation, landslides, mudflows and snow avalanches.

Weathering processes on the study are is quite intensive; high mountain climate conditions, rocks high level exposure, intense fracturing and consequently high water-permeability play key roles in weathering processes. These rocks cause disintegration and origination of friable-fragmented materials. The significant accumulation of the latter in the slopes of the gorges and in river beds creates mudflow feeding area. Erosion is the most active process among denudation processes on the study area which is composed of spatial as well as linear forms. Spatial erosion processes are developed in heads of tributaries and slopes of the gorge. There is no information about process speeding value. We should think that it is significantly increased during rains and snow melting period.

Linear erosion processes are observed in every river and gorge of the region and represent both lateral and vertical forms. Lateral erosion mainly is developed in the river Tskhenistskali and its abundant tributaries where broadening of the bottom of the gorge is produced by the meandering of the river. Lateral erosions average speed is 0.5-5.0 m per year, based on monitoring on some sections of the river Tskhenistskali. However, sometimes this value can reach 5.0-8.0 m in 24 hours during particularly high runoff events. Deep or regressive erosion is developed from the mouth of tributary or temporary streams going towards the head and forms longitudinal profilebalance, that is, where the slope is steepest and water is flowing fastest, vertical scour happens fastest. There is no data about its speed value.

Among denudation processes one of the most important is the karstic effect. Based on technical opinion the proposed underground hydropower plant is supposed to be placed in the complex of Upper Cretaceous carbonate rocks. As we already mentioned, the limestones in this complex are characterized with heavy fracturing that contributes to precipitation infiltration, circulation and origination of underground water, which in turn creates convenient circumstances for development of karstic processes. It is true that the karst cavities are not specifically known in the vicinity of the proposed powerhouse, but a great number of high discharge karstic springs in the mentioned limestonelayered zone show their probable existence. In regard to this, one of the main tasks at the feasibility phase of the geotechnical survey should be a study of speed of karst forming conditions, to help avoid major complications during construction of the hydropower plant or its operational period.

Landslides and mudflows are considered as the most widespread and hazardous geodynamic processes which historically did harm to local inhabitants and continue to cause significant problems even today. The landslides that develop in the region are plastic and floatingly-plastic. According to accessible depth, they are mainly surface form (up to 5.0 m deep), rarely there are deep forms (15-20 m). In some cases we have landslides of complex morphology when base rock is moving together with cover. Such types of landslides are generally connected to the rocks of Lower and Mid-Jurassic Sori suite.

Besides the landslides, other types of gravity displacements such as slope collapses and screes which create obstructions to roads during long-lasting rains and snow melting period.

Mudflows (or debris flows) deserve a great deal of attention due to their destructive forces. Coincidence of several natural conditions are necessary for their origination. Among them the most important are:

1. Alpine relief with steep exposed slopes and significant slope of the rivers or temporary stream beds;
2. Significant accumulations of friable-fragmented materials originated from weathering in beds and on the slopes of a gorge;
3. Climate properties that are expressed by periodically fast melting of high snow cover that is typical for this region, and by long-lasting heavy rains.

Generally, observations show that mudflows originate after long-term rains that last for several hours and gradually change into short-term heavy rains (lasting for several minutes) with intensities equal or exceeding 0.8 mm/s. Heavy mudflows are periodically experienced in the gorges of the following rivers: Devashi, Lakashuri, Khopuri, Kvedreshi, Rtskhmeluri, and others. Mudflow does harm to public utilities in the region, destroys buildings and plot of lands that are the core reasons why people are forced to change their residencies.

Snow avalanches are also quite frequent within the study area. They are similar natural phenomena to slope collapses which also have great destructive force. Avalanche prone areas are located on the slopes of the gorge, in funnel-shaped or circ-shaped depressions. Snow avalanche debris is deposited in avalanche cones; and after melting different sized fragments remain. The main destructive force is an air blast wave that immediately proceeds the impact of a snow avalanche.

Flooding is also frequent in the study area. During long-lasting rains and melting of snow not only the basic rivers but small brooks or gullies are characterized with rapid increase of water flow rates, which greatly exceed the average value (flash floods). Flooding generally occurs in the spring time when snow is melting. Minimum water levels in the rivers usually occur in the late autumn and winter periods.

General description and physical-mechanical indicators of the rocks spread over the study are given in the attached table.

7. Conclusions and Recommendations

- According to complication of geotechnical conditions, the study area due to complex tectonic structure and high seismic activivity is classified as “quite complicated III category”;
- Alluvial-proluvial, sedimentary, volcanogenic-sedimentary and magmatic rocks are spread throughout the study area; they belong to geotechnical engineering groups of friable-unconsolidated, soft- The mentioned rocks according to their physical-mechanical properties create more-or-less convenient conditions for building of hydrotechnical construction and for long-term operations;
- The study area is rich in industrial minerals. Here are found: diabase, limestone, sandstone, gravel, and building sand deposits which reserves surpass quantity of materials needed for construction of this hydropower project and their utilization helps its minerals’ supply problem. At the next phase of survey, separation of these deposits reserves into A and B category is essential and complete evaluation of quality of industrial minerals to accomplish the relevant demands is necessary;
- Intense recent geodynamic processes are deemed to be the main obstacles for building and operating of the proposed hydropower plant and may present serious obstacles for implementation of the project in particular areas. Building of protection structures should be considered during detailed design to mitigate risk from geodynamic processes.

Geologist-Engineer - V. Sulkhanishvili

Structural floor	Tectonic unit	Formation and its genesis	Rock geologic – genetic complex	Rock complex geologic index		Rock complex engineer geologic group		
						Loose-unlinked	Half cragged	cragged
	Crinkled system I of the Caucasus Transcaucasia intermountain area II	Continental sediment	Splinted and processed material of the cones and river ruts of alluvial prolluvial origin. Kachar-kenchar, gravel, road- metal, Khvintcha and sand, with rubbles	apQ_{IV}				
Alpine	Transcaucasia intermountain area II Central elevation Zone II	Sediment	Clay, marls, sandstones, as of the inter strata and reams	Oligocene Miocene	E_{3+} N_1			
			Marled limestones, marls, somewhere clay and glauconitic sandstone strata, dolomitized limestones	Chalk	K			
	The Caucasus crinkled system II	Magmatic intrusive	Diabase	Inside Jura	$_{11}J_2$			
	Chkalta- Laili I_4 and Gagra – Djava I_5 zones	Volcanogenic sediment (dregs)	Tuff conglomerates, tuff sand stones tuff siltstones		J_2B			
		Metamorphosed sediment	Clay shales, scaly shales, dark grey, rarely black, quartz sandstone interstrata	Lower Jura	P_Z+T			
			Metamorphosed clay shales and phylitized shales, sandstones, marbled grey limestone lens ((diza row)	Palaeozoic and Triassic				

Physical mechanic qualities of Rock					
density in natural condition	Firmness coefficient according to M. Protodiakonov		Filtration coefficient K m	Priming calculating resistance Ro 0.1 mpa	Resistance on one axis shrink R_o 0,1 mpa
			4.0-10.0 Broad diapason		
					Clay 5-30 Sandstone 80-600 Marl 5-100 Limestone 500-900 Clay 5-30 Dolom limestone 150-2000
					2850-2900
					Tuff sandstone 950-2700 Tuff conglomerates 500-2000
					Scaly shale 600-1100 Clay shales 50-600
					Clay shales 660-1350 Marble 600-1400 Metamorphosed sandstone 1200-2190

Geodynamic events and processes


Landslip and snow slip of rocks


Splitting line

Side erosion


Silt


Split blocks

Other marks


Bounder between geologic genetic complexes


Tectonic destructions and chinks

Incision line

Project hydro tectonic tract

Mark of source building and flood m.

Derivation diameter and length m.

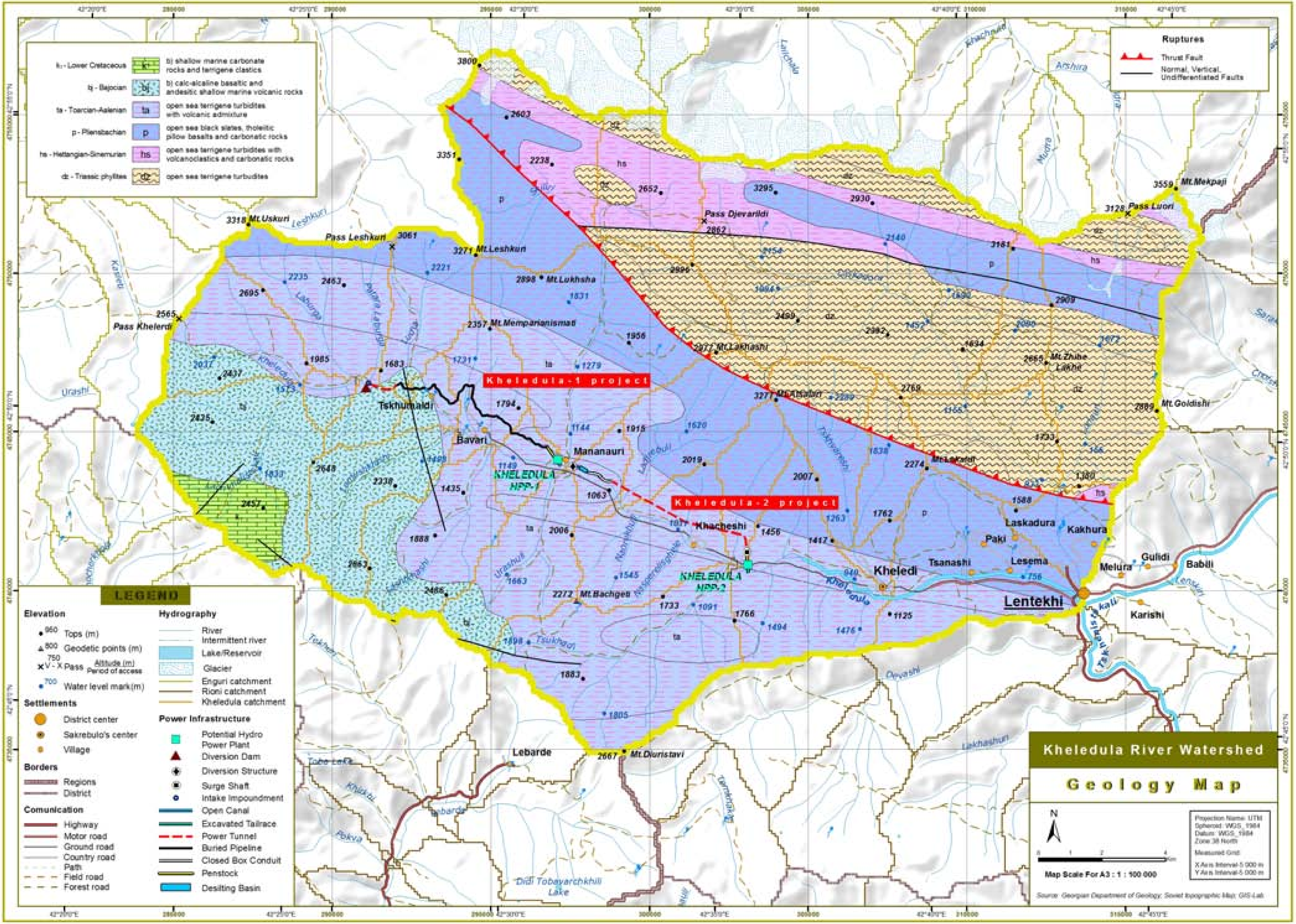
Hydro power building and tail water mark m.

Number of hydro power

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

Structural Stage	Geotectonic Unit	Formation	Rock geological genetic complex	Rock Complexes Geological Index		Rock Complexes Geological-Engineering Group			Rock Physical-Mechanical Properties				
						Friable-unconsolidated	Semi-rocky	Rocky	Density in Natural Condition P g/cm^3	Hardness Ratio according to M. Protodiakonov	Flotation Ratio K m/per day	Ground Calculation Resistance Ro 0.1 mPa	Resistance on One-axis Compression Ro 0.1 mPa
Quaternary	Caucasus South Slope Folded System I Transcaucasian intermountain area II	Continental sediment	Alluvial-Proluvial formations, river beds, embankment, alluvial fans, fragmented and processed materials. Cobbles boulders, gravel, crusted stone and sand.	ap Q_{IV}		■				0.5-1.5	4.0-10.0 Broad interval	1.0-3.0	-
Alpine	Transcaucasian intermountain area II Central Zone of uplift II_2	Epicontinental-Carbonate Sediment	Clay, Marls, Sandstone, as interlayers and packs	Oligocene Miocene	E_3+N_1		■		1.70-2.00 2.64-2.70 2.20-2.60	1.0-1.5 8.0 2.0	-	-	Clay 5-30 Sandstone 80-600 Marl 5-100
			Marly limestone, marl, glauconitic sandstone, Limestone, dolomitized-limestone.	Chalk	K			■	2.61-2.63 1.70-2.00 1.80-2.22	8.0 1.5 4.0-5.0	-	-	Limestone 500-900 Clay 5-30 Dolomitized.limestone 150-2000
	Caucasus South Slope Folded System I Chkhalta-Laila Zone I_4 and Gagra-Djava Zone I_5 Khaishi sub-zone	Magmatic intrusion	Quartzy porphyrite, Diabase, diabase-porphyrite	Middle Jurassic	uJ_2			■	2.77-2.90	1.0	-	-	Porphyr.covers 1170-2140
		Volcanogenic-Sediment	Tuff-breccia, tuff-conglomerate, Tuffogenic sandstone, tuff, porphyrite lava covering. (porphyrite Series)		J_2 b			■	2.57-2.82	6.0-8.0	-	-	Tuffogenic sandstones 950-2700 Tuff-breccia. 500-2000
		Metamorphic Marine-Sediment	Clay shale, scaly shale, dark gray and occasionally black micaceous quartzy sandstone inter-strata (Sori and Muashi Series)	Lower Jurassic	J_1		■		2.45-2.55 2.52-2.60	5.0-6.0 4.0-5.0	-	-	Scaly shale 600-1100 Clay shale 50-600
			Metamorphic clay shale and phyllite shale, sandstone and gray marble lenses (Dizi Series)	Paleozoic and Triassic	Pz+T			■	2.70-2.72 2.69-2.70 2.80-2.81	6.0 8.0 8.0	-	-	Clay-shales 600-1350 Marble 600-1400 Metamorphic Sandstone 1200-2190

Geodynamic events and processes	Other marks	Project hydro tectonic tract
Landslip and snow slip of rocks	Bounder between geologic genetic complexes	Mark of source building and flood m.
Splitting line	Tectonic destructions and chinks	Derivation diameter and length m.
Side erosion	III — III' Incision line	Hydro power building and tail water mark m.
Silt		Number of hydro power
Split blocks		



Kheledula River Watershed
Geology Map
Ruptures
Thrust Fault
Normal, Vertical, Undifferentiated Faults
k1 - Lower Cretaceous
b) shallow marine carbonate rocks and terrigene clastics
bj - Bajocian
b) calc-alcaline basaltic and andesitic shallow marine volcanic rocks
ta - Toarcian-Aalenian
open sea terrigene turbidites with volcanic admixture
p - Pliensbachian
open sea black slates, tholeiitic pillow basalts and carbonatic rocks
hs - Hettangian-Sinemurian
open sea terrigene turbidites with volcanoclastics and carbonatic rocks
dz - Triassic phyllites
open sea terrigene turbudites
LEGEND
Elevation
Tops (m)
Geodetic points (m)
Pass
Altitude (m) Period of access
Water level mark(m)
Settlements
District center
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Village
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Lentekhi
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Tskhumaldi
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Tsanashi
Paki
Laskadura
Lesema
Kakhura
Melura
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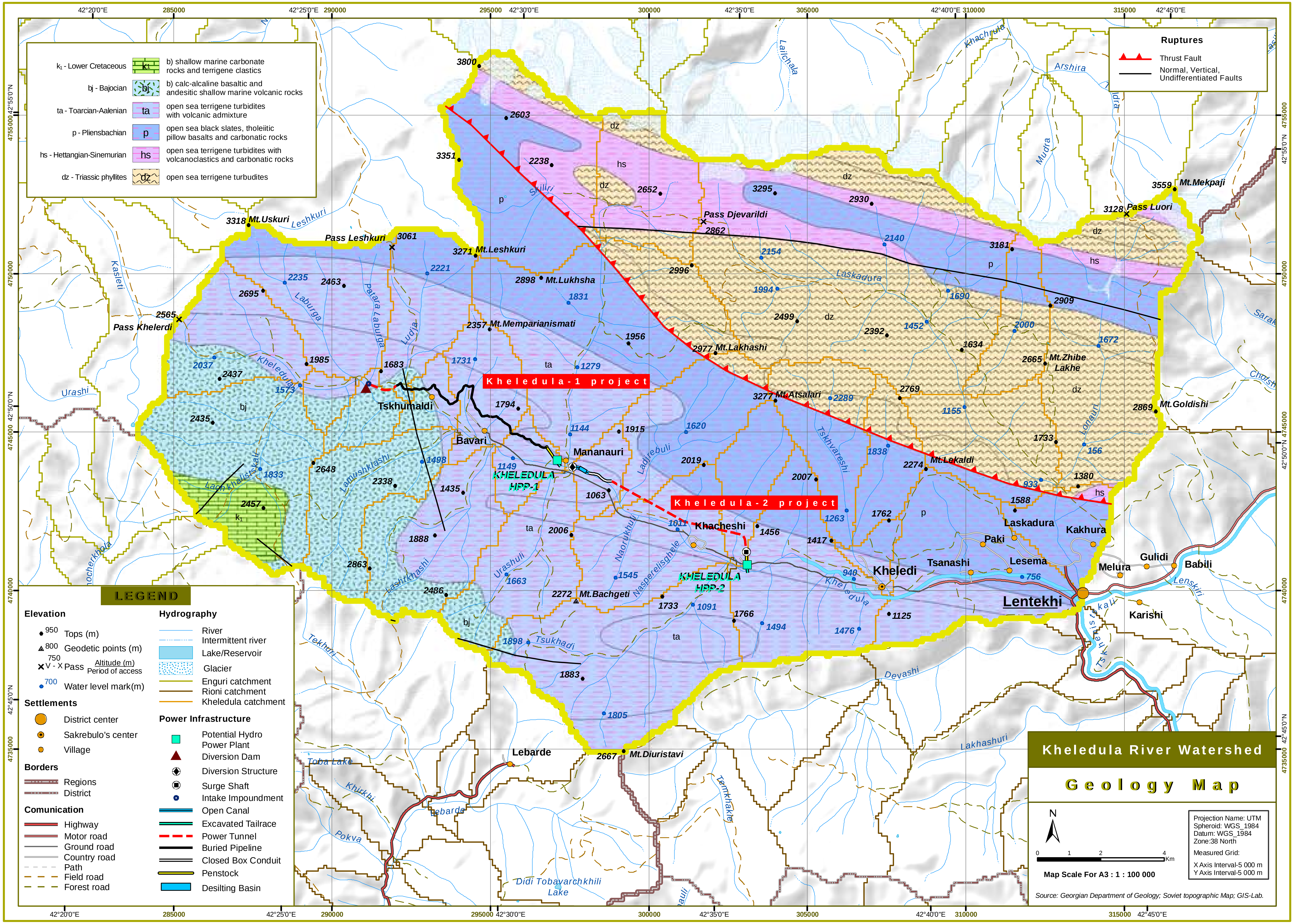
Babili
Karishi
Lebarde
Mt.Uskuri
Pass Leshkuri
Mt.Leshkuri
Mt.Lukhsha
Mt.Mempanianismati
Pass Khelerdi
Pass Djevarildi
Mt.Lakhashi
Mt.Mekpaji
Pass Luori
Mt.Goldishi
Mt.Bachgeti
Mt.Diuristavi
Mt.Zhibe Lakhe
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-5 000 m
Y Axis Interval-5 000 m
Map Scale For A3 : 1 : 100 000
Source: Georgian Department of Geology; Soviet topographic Map; GIS-Lab


Kheledula River Watershed
Geology Map
k1 - Lower Cretaceous — b) shallow marine carbonate rocks and terrigene clastics
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ta - Toarcian-Aalenian — open sea terrigene turbidites with volcanic admixture
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dz - Triassic phyllites — open sea terrigene turbidites
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950 Tops (m)
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750 V - X Pass Altitude (m) Period of access
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2667 Mt.Diuristavi
Toba Lake
Didi Tobavarchkhili Lake
N
Map Scale For A3 : 1 : 100 000
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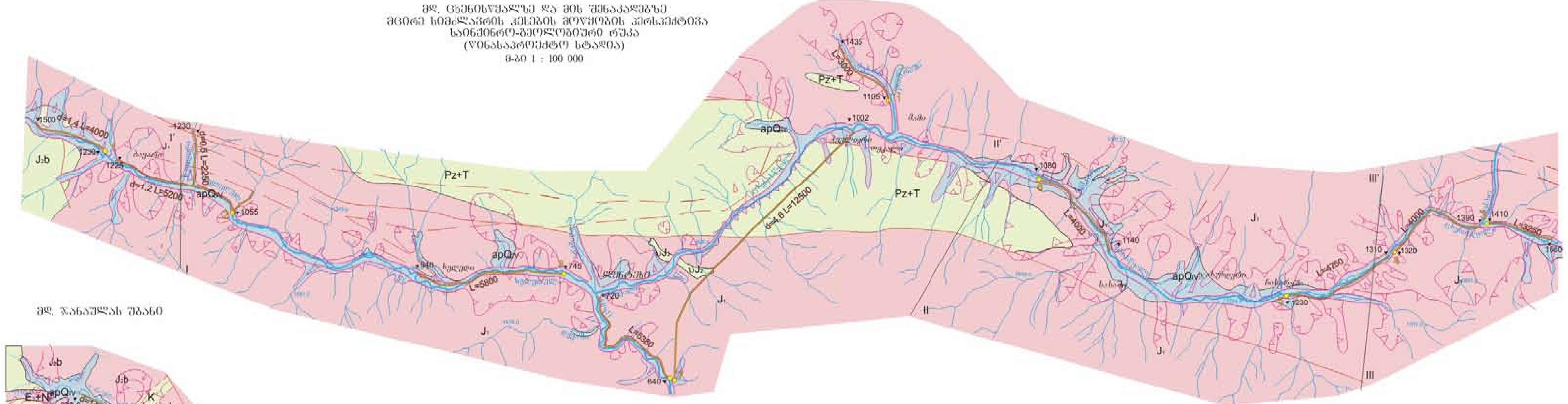
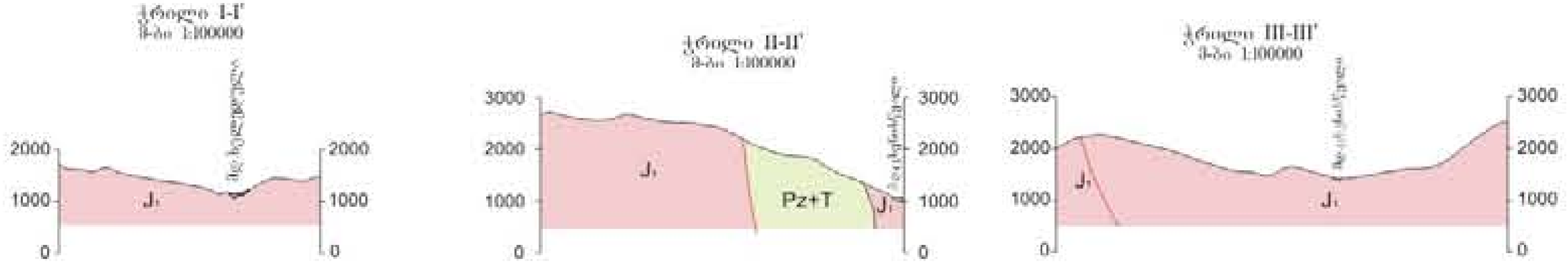
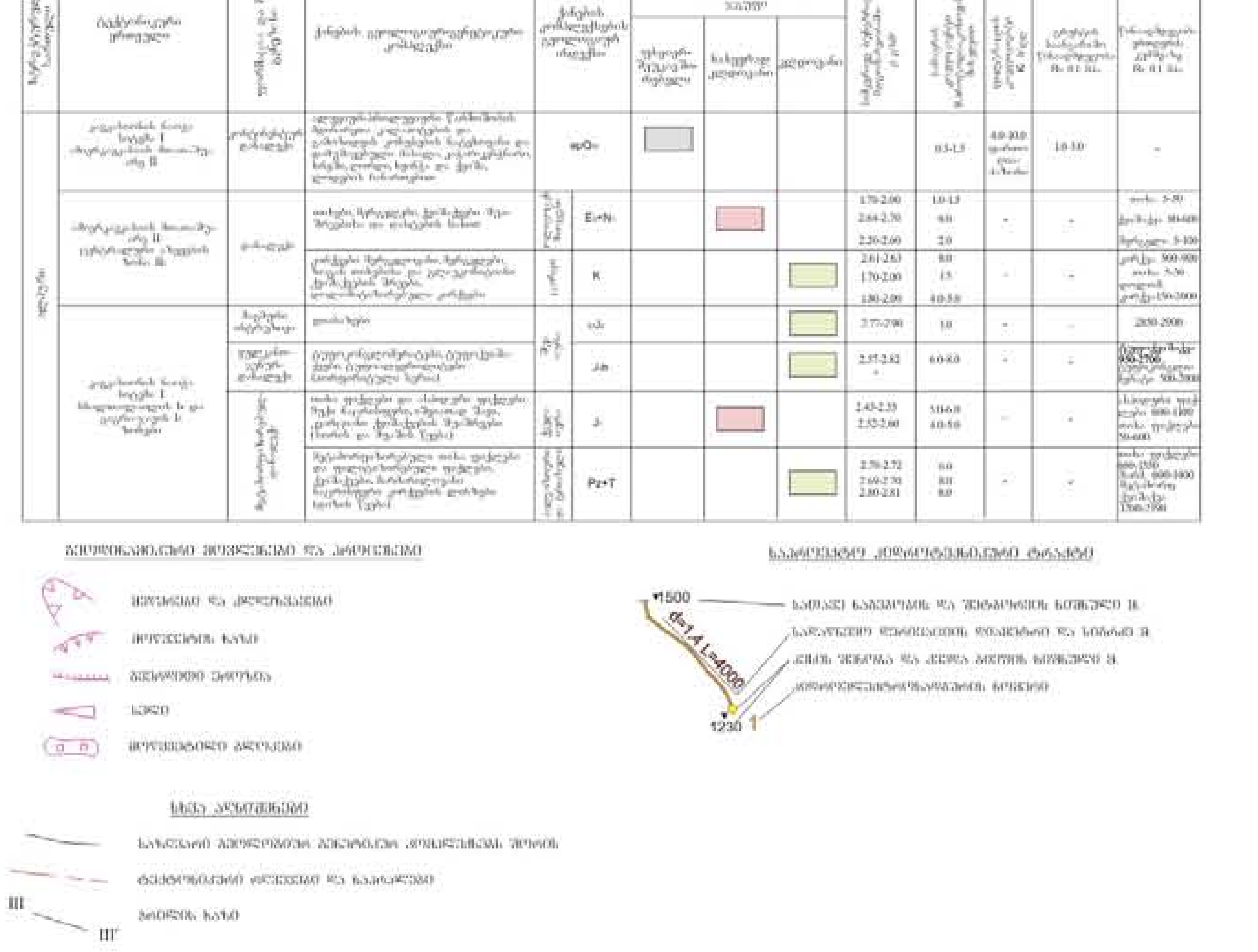
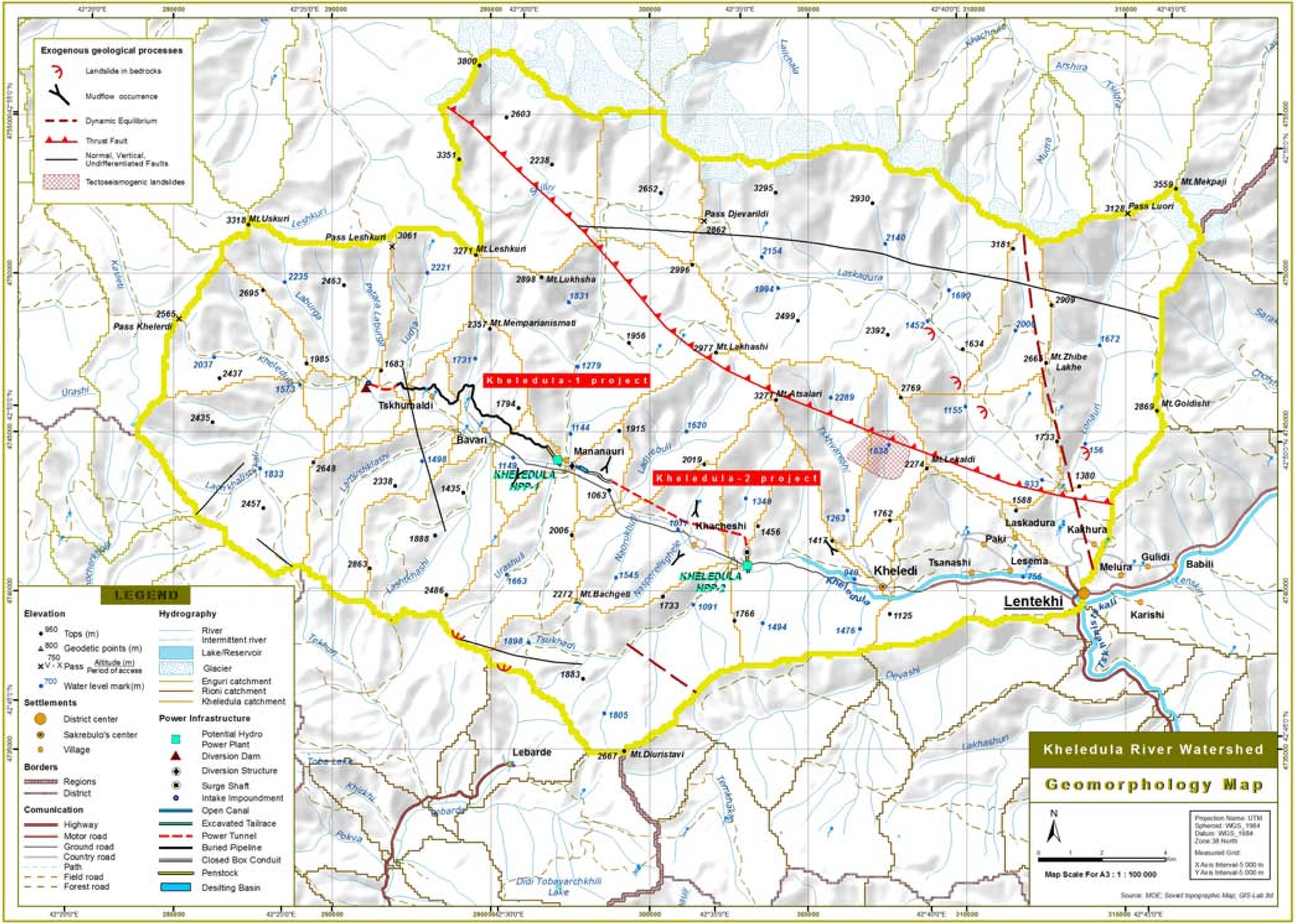
მდ. ცხენისწყალზე და მის შენაკადებზე
მცირე სიმძლავრის ჰესების მოწყობის პერსპექტივა
საინჟინრო-გეოლოგიური რუკა
(წინასაპროექტო სტადია)
მ-ბი 1 : 100 000









Kheledula River Watershed
Geomorphology Map
Exogenous geological processes
Landslide in bedrocks
Mudflow occurrence
Dynamic Equilibrium
Thrust Fault
Normal, Vertical, Undifferentiated Faults
Tectoseismogenic landslides
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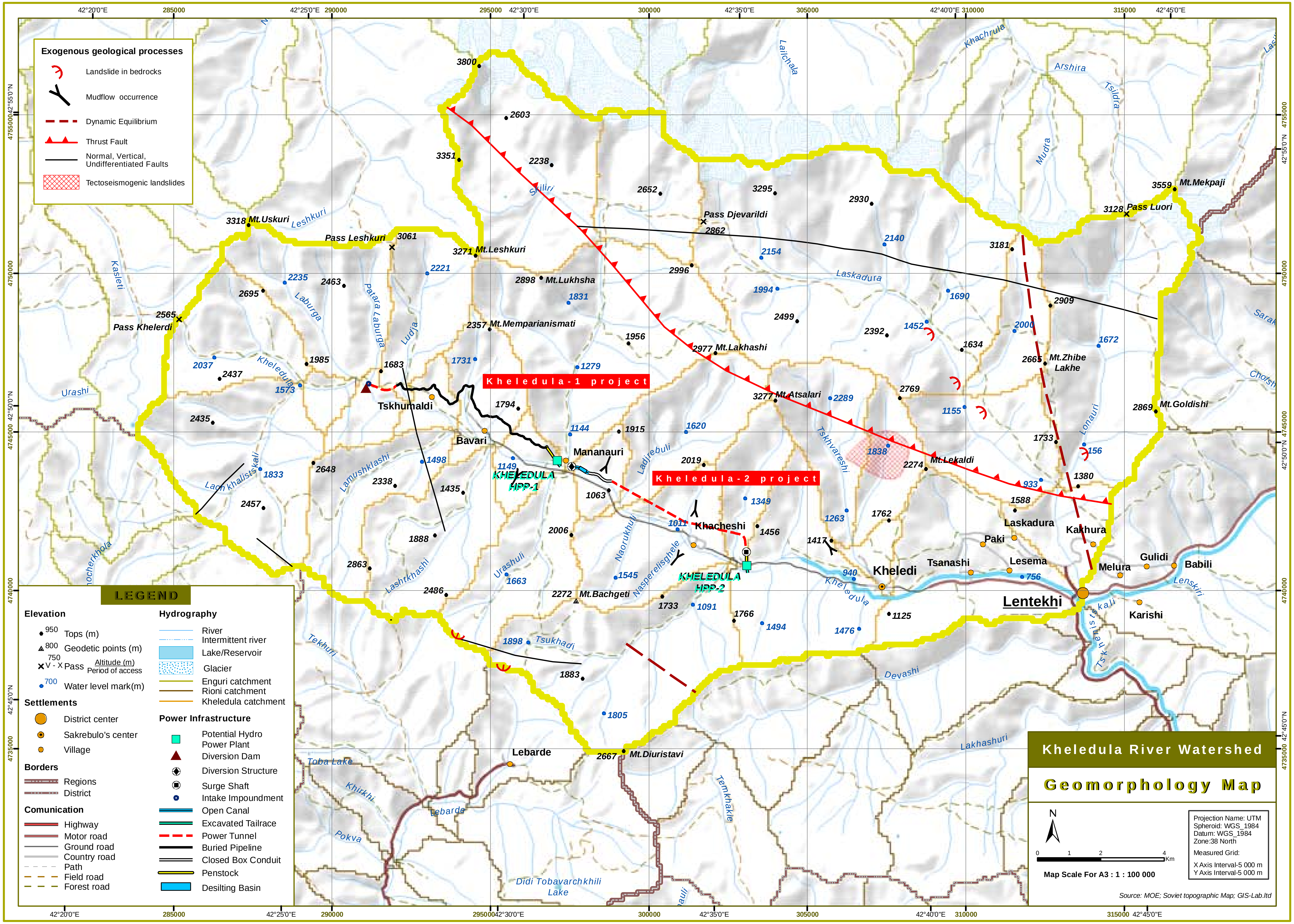
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For additional information about an earthquake event and links to damage photos, click on the links in the **Addl Info** and **Tsu** columns.

Date						*Assoc*		*Addl EQ Info*	*Earthquake Location*		*Earthquake Parameters*			*Earthquake Effects*										*Photos*
														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					
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					
1899	12	31	7	50				*	TURKEY	41.600	43.500		5.6		247	3				2					
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	
1940	5	7	22	23				*	TURKEY-CIS	41.700	43.800	19	6.0		16	1				2					
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					
2009	9	6	22	41	37.3			*	GEORGIA: NORTHWESTERN	42.660	43.443	15	6.0				1	1		2					

12 events returned.

მდ. ცხენისწყალზე და მის შენაკადებზე მცირე სიმძლავრის ჰესების მოწყობის პერსპექტივა
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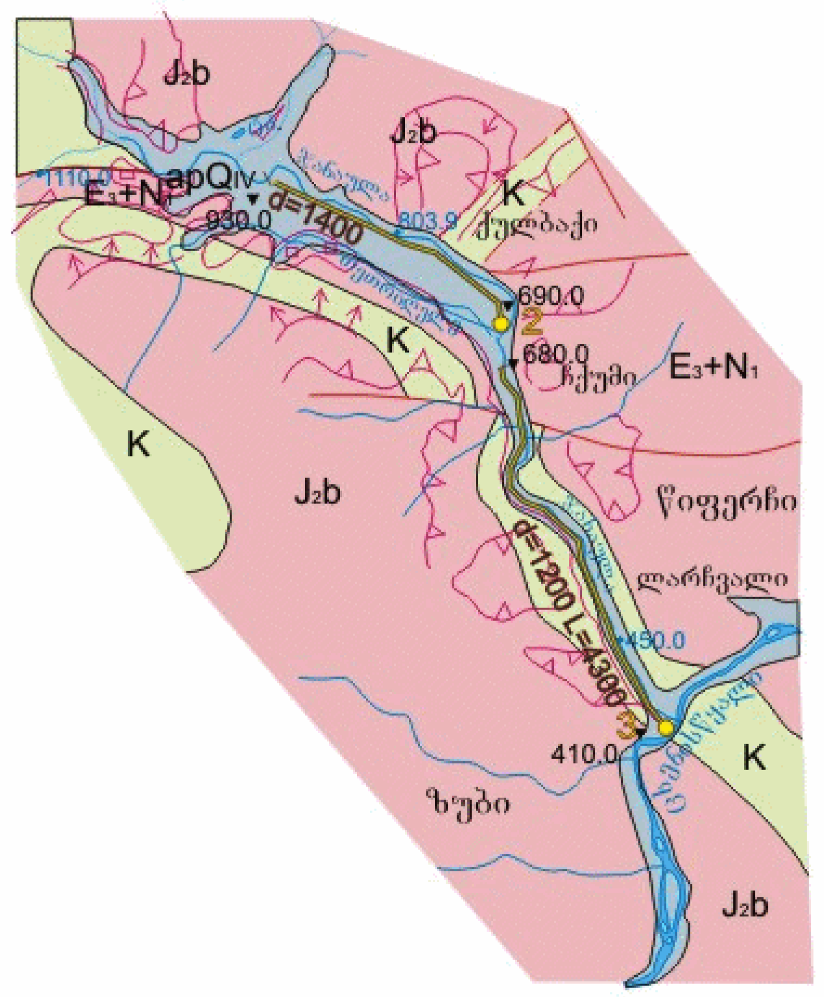
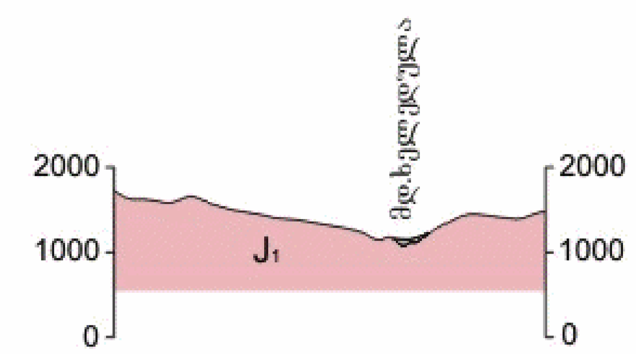
მ-ბი 1 : 100 000

მდ. ჯანაულას უბანი



ჭრილი I-I'
მ-ბი 1:100000



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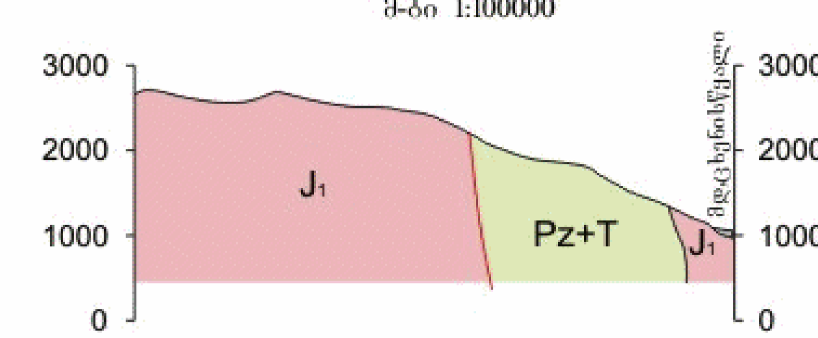
მ-ბი 1:100000



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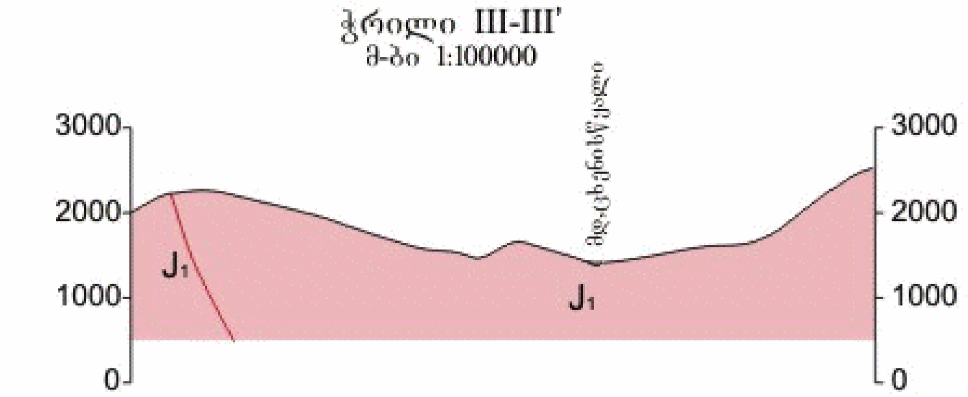


სტრუქტურული სართული	ტექტონიკური ერთეული	ფორმაცია და მისი გენეზისი	ქანების გეოლოგიურ-გენეტიკური კომპლექსი	ქანების კომპლექსების გეოლოგიური ინდექსი		ქანების კომპლექსების საინჟინრო-გეოლოგიური ჯგუფი			ქანების ფიზიკურ-მექანიკური თვისებები				
						ფხვიერ-შეუკავშირებელი	ნახევრად კლდოვანი	კლდოვანი	სიმკვრივე ბუნებრივ მდგომარეობაში ρ გ/სმ³	სიმტკიცის კოეფიციენტი პროტოდიაკონოვის მიხედვით	ფილტრაციის კოეფიციენტი K მ/დღ	გრუნტის საანგარიშო წინაღობა R₀ 0.1 მპა	წინააღმდეგობა ერთღერძა კუმშვაზე R₀ 0.1 მპა
ალპური	კავკასიონის ნაოჭა სისტემა I ამიერკავკასიის მთათაშუა არე II	კონტინენტური დანალექი	ალუვიურ-პროლუვიური წარმოშობის მდინარეთა კალაპოტების და გამოზიდვის კონუსების ნატეხოვანი და დამუშავებული მასალა, კაჭარ-კენჭნარი, ხრეში, ღორღი, ხვინჭა და ქვიშა, ლოდების ჩანართებით		apQIV	■				0.5-1.5	4.0-10.0 ფართო დია-პაზონი	1.0-3.0	-
	ამიერკავკასიის მთათაშუა არე II (ცენტრალური აზევების ზონა II₂)	დანალექი	თიხები, მერგელები, ქვიშაქვები შუა-შრეებისა და დასტების სახით	ოლიგოცენ-მიოცენი	E_3+N_1		■		1.70-2.00 2.64-2.70 2.20-2.60	1.0-1.5 8.0 2.0	-	-	თიხა 5-30 ქვიშაქვა 80-600 მერგელი 5-100
			კირქვები მერგელოვანი, მერგელები, ზოგან თიხებისა და გლაუკონიტიანი ქვიშაქვების შრეები, დოლომიტიზირებული კირქვები	(ცარცი)	K			■	2.61-2.63 1.70-2.00 1.80-2.00	8.0 1.5 4.0-5.0	-	-	კირქვა 500-900 თიხა 5-30 დოლომ. კირქვა150-2000
	კავკასიონის ნაოჭა სისტემა I ჩხალთა-ლაილის I₄ და გაგრა-ჯავის I₅ ზონები	მაგმური ინტრუზივი	დიაბაზები	შუა იურა	uJ_2			■	2.77-2.90	1.0	-	-	2850-2900
		ვულკანო-გენურ-დანალექი	ტუფოკონგლომერატები, ტუფოქვიშა-ქვები, ტუფოალევროლიტები (პორფირიტული სერია)		J_2b			■	2.57-2.82 -	6.0-8.0	-	-	ტუფოქვიშაქვა 950-2700 ტუფოკონგლო-მერატი 500-2000
		მეტამორფიზირებულ-დანალექი	თიხა ფიქლები და ასპიდური ფიქლები, მუქი ნაცრისფერი, იშვიათად შავი, კვარციანი ქვიშაქვების შუაშრეები (სორის და მუაშის წყება)	ქვედა იურა	J_1		■		2.45-2.55 2.52-2.60	5.0-6.0 4.0-5.0	-	-	ასპიდური ფიქლები 600-1100 თიხა ფიქლები 50-600
			მეტამორფიზირებული თიხა ფიქლები და ფილიტიზირებული ფიქლები, ქვიშაქვები, მარმარილოვანი ნაცრისფერი კირქვების ლინზები (დიზის წყება)	პალეოზოური და ტრიასული	$Pz+T$			■	2.70-2.72 2.69-2.70 2.80-2.81	6.0 8.0 8.0	-	-	თიხა ფიქლები 660-1350 მარმ. 600-1400 მეტამორფ. ქვიშაქვა 1200-2190

გეოდინამიკური მოვლენები და პროცესები

- მეწყრები და კლდეზვავები
- მოწყვეტის ხაზი
- გვერდითი ეროზია
- სელი
- მოწყვეტილი ბლოკები

სხვა აღნიშვნები

- საზღვარი გეოლოგიურ გენეტიკურ კომპლექსებს შორის
- ტექტონიკური რღვევები და ნაპრალები
- III — III' ჭრილის ხაზი

საპროექტო ჰიდროტექნიკური ტრაქტი

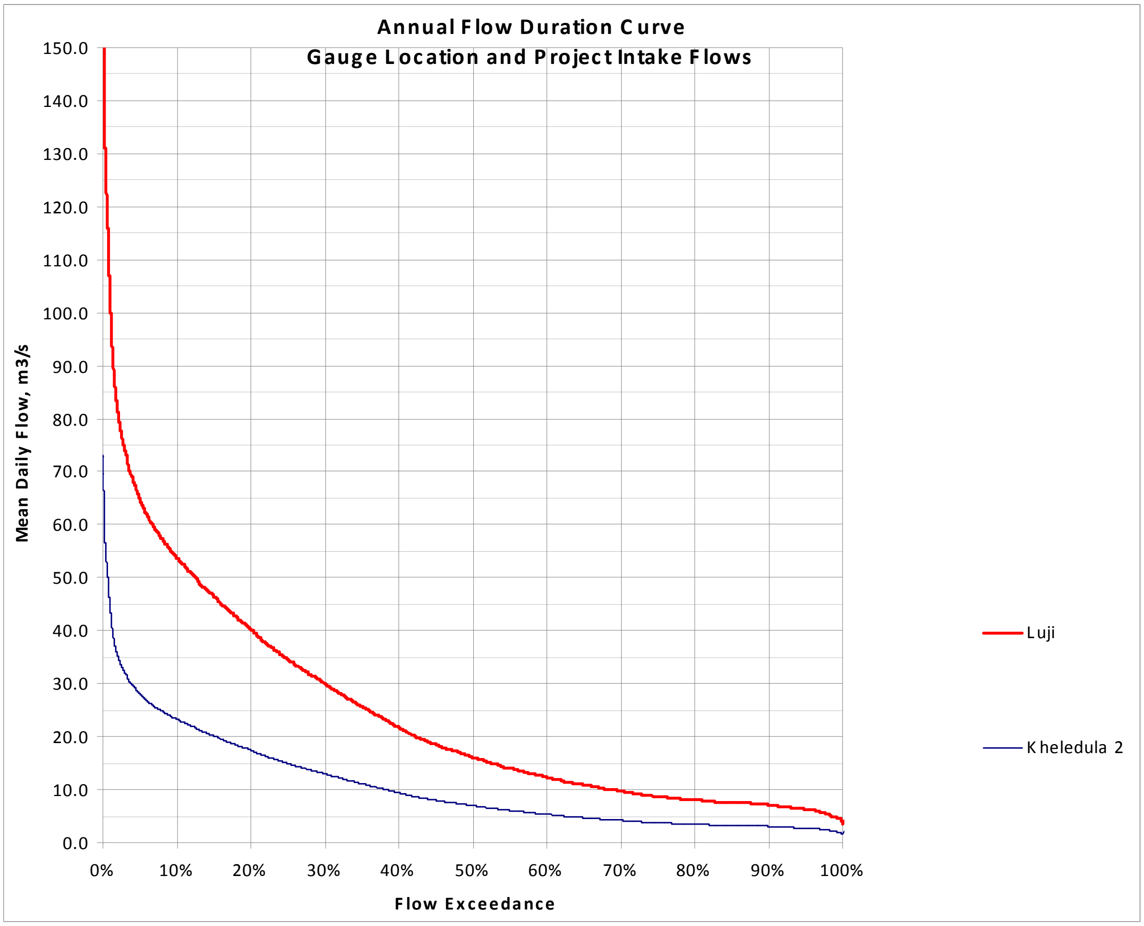
- სათავე ნაგებობის და შეტბორვის ნიშნული მ.
- სადაწნეო დერივაციის დიამეტრი და სიგრძე მ.
- ჰესის შენობა და ქვედა ბიეფის ნიშნული მ.
- ჰიდროელექტროსადგურის ნომერი

Appendix 2

Monthly and Annual Flow Duration Curves

Note related to this Appendix:

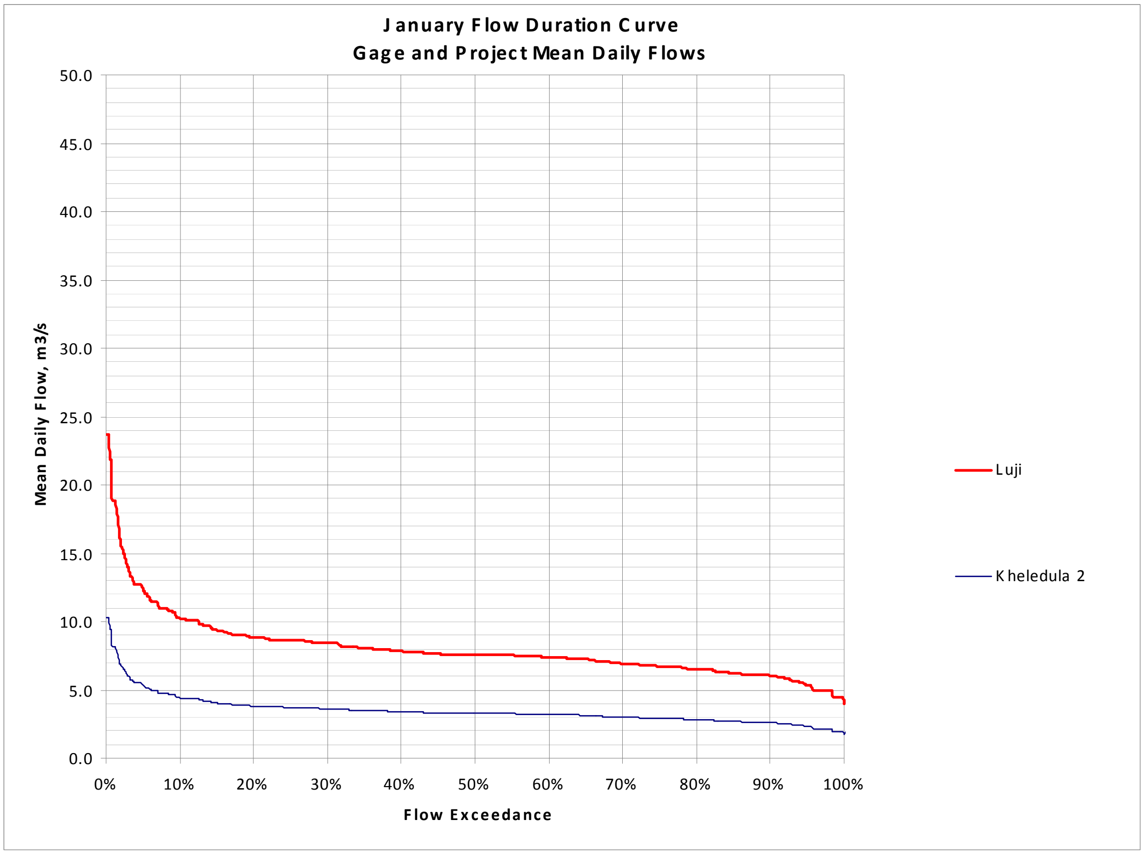
The generation tables following each Flow Duration Curve represent a conservative selection of input data and, therefore, a conservative analysis for monthly and annual HPP generation using this methodology.



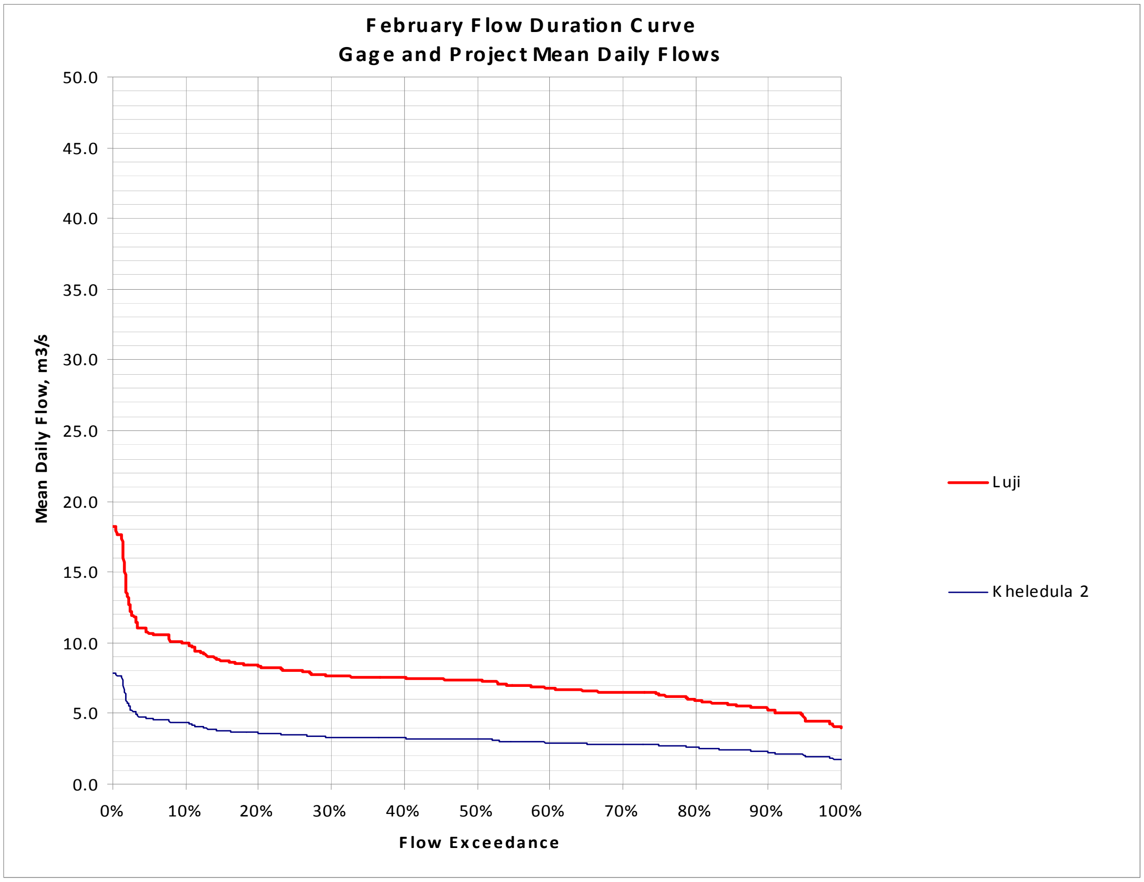
Annual.

Area under Adjusted Flow Duration Curve in CMS-Hrs	93,098
Select Discharge equal to or exceeded % For HPP	18.80%
Equivalent Total Turbine Discharge at Selected CF in CMS	18.05
Non-useable portion of FDC at selected CF or Exceedance %	13471
Gross Available CMS-HRS for Generation at selected CF	79,627
Annual Average Daily Discharge in CMS	10.63
Select Env/Sanitary Flow as a % of Monthly Avg Dalily Discharge	4.7%
Environmental/Sanitary Flow in CMS	0.50
Non-useable Environmental/Sanitary CMS-HRS	4,377
Net CMS-HRS Available for Generation	75,250
Estimated Intake Elevation in Meters	1100
Estimated Discharge Elevation in Meters	990
Gross Head for Generation in Meters	110
Length of Penstock/Pipeline/tunnel in Km	6.4
Head Loss (from daily head loss calculation average) in Meters	1.729
Net Head for Generation in Meters	108.271
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Annual Generation in MWH	67,909

Monthly Summary of FDC Generation based on % Exceedance and Average HPP Unit Efficiency					
Month	Exceedance %	Equivalent Discharge in CMS	Estimated Av Monthly Efficiency	Monthly Env/Sanitary CMS-HRS	Average Monthly Energy in MWH
Jan	1%	8.14	85%	259	2,097
Feb	1%	7.49	85%	216	1,757
Mar	2%	10.86	85%	293	2,374
Apr	17%	18.00	85%	516	6,643
May	69%	17.96	85%	333	10,852
Jun	79%	18.00	85%	356	10,869
Jul	44%	17.98	85%	559	9,934
Aug	15%	17.98	85%	285	7,682
Sep	2%	17.90	85%	612	4,947
Oct	2%	17.85	85%	319	4,489
Nov	0%	17.72	85%	301	3,598
Dec	2%	13.85	85%	329	2,664
Annual Average Values	19%	15.31	85%		
FDC Summed Annual Average Generation				4,378	67,905

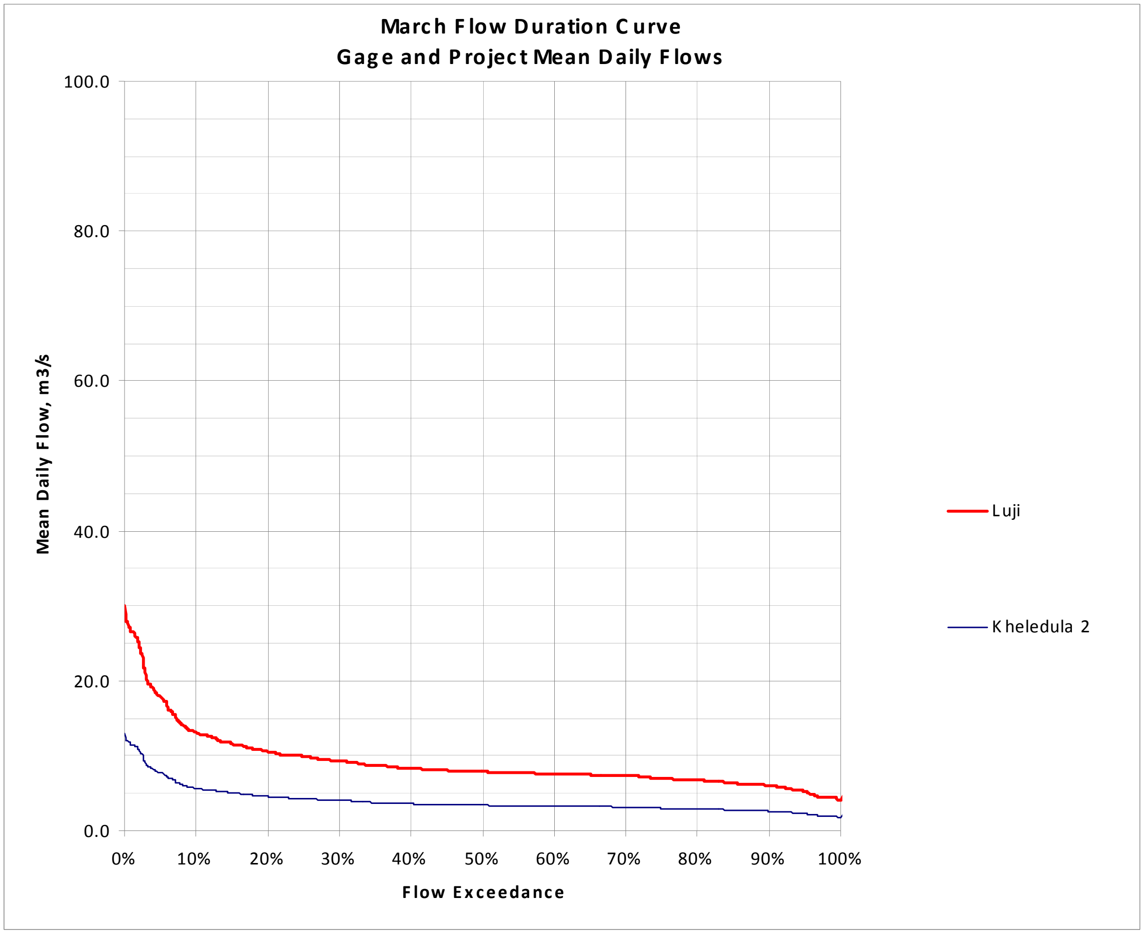


January	
Area under Adjusted Flow Duration Curve in CMS-Hrs	2,585
Select Discharge equal to or exceeded % For HPP	1.00%
Equivalent Total Turbine Discharge at Selected CF in CMS	8.14
Non-useable portion of FDC at selected CF or Exceedance %	3
Gross Available CMS-HRS for Generation at selected CF	2,582
Monthly Average Daily Discharge in CMS	3.48
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	10%
Environmental/Sanitary Flow in CMS	0.35
Non-useable Environmental/Sanitary CMS-HRS	259
Net CMS-HRS Available for Generation	2323
Estimated Intake Elevation in Meters	1100
Estimated Discharge Elevation in Meters	990
Gross Head for Generation in Meters	110
Length of Penstock/Pipeline/tunnel in Km	6.4
Head Loss (from daily head loss calculation average) in Meters	1.729
Net Head for Generation in Meters	108.271
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	2,096,786
MWh	2,097



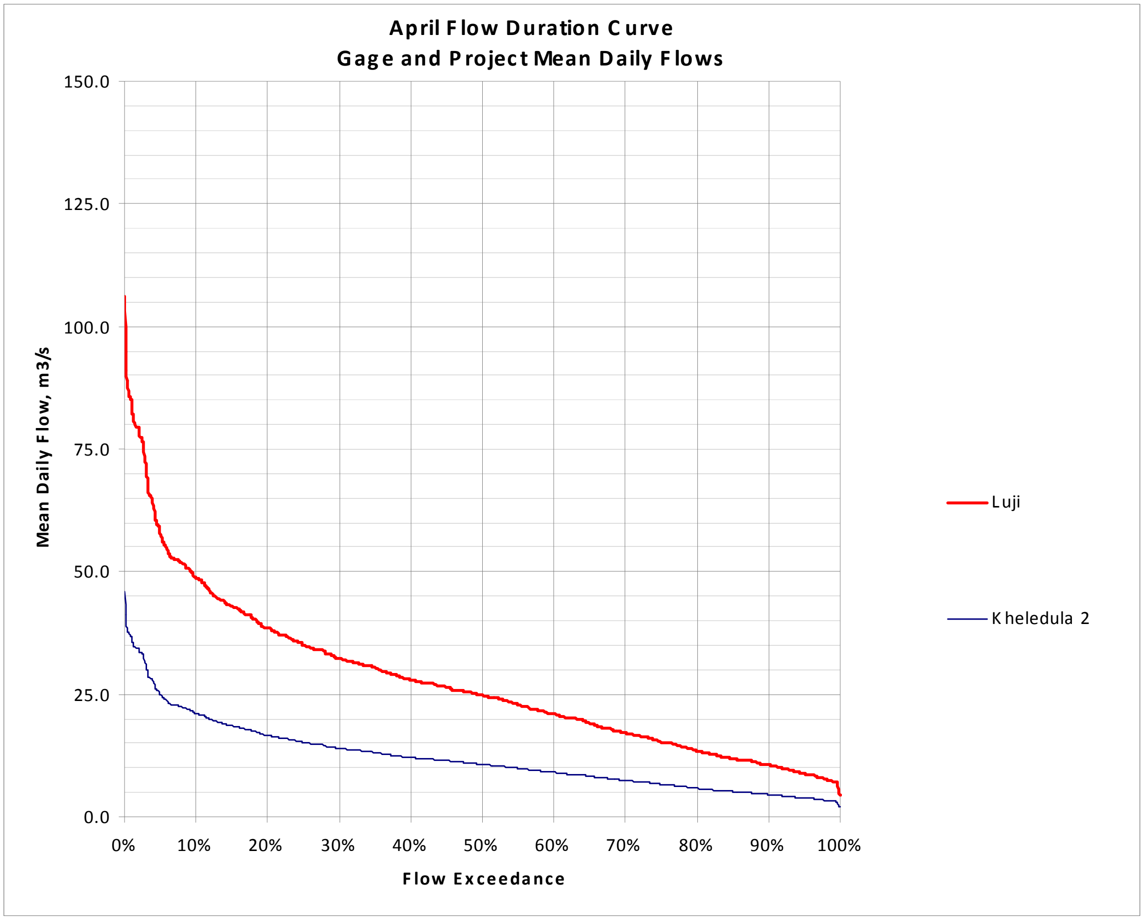
February

Area under Adjusted Flow Duration Curve in CMS-Hrs	2,155
Select Discharge equal to or exceeded % For HPP	1.45%
Equivalent Total Turbine Discharge at Selected CF in CMS	7.49
Non-useable portion of FDC at selected CF or Exceedance %	-7
Gross Available CMS-HRS for Generation at selected CF	2,162
Monthly Average Daily Discharge in CMS	3.21
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	216
Net CMS-HRS Available for Generation	1947
Estimated Intake Elevation in Meters	1100
Estimated Discharge Elevation in Meters	990
Gross Head for Generation in Meters	110
Length of Penstock/Pipeline/tunnel in Km	6.4
Head Loss (from daily head loss calculation average) in Meters	1.729
Net Head for Generation in Meters	108.271
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	1,756,737
MWh	1,757



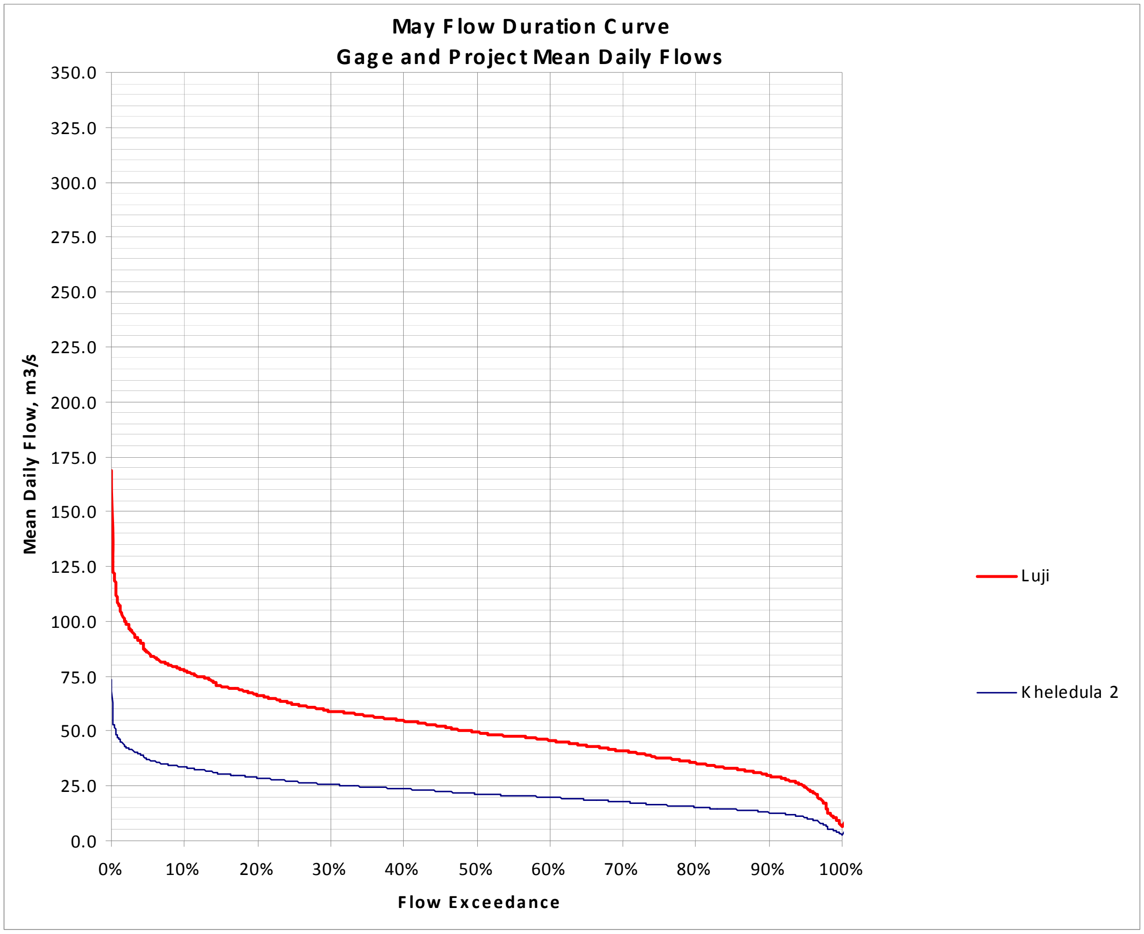
March

Area under Adjusted Flow Duration Curve in CMS-Hrs	2,926
Select Discharge equal to or exceeded % For HPP	2.00%
Equivalent Total Turbine Discharge at Selected CF in CMS	10.86
Non-useable portion of FDC at selected CF or Exceedance %	2
Gross Available CMS-HRS for Generation at selected CF	2,924
Monthly Average Daily Discharge in CMS	3.94
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	293
Net CMS-HRS Available for Generation	2631
Estimated Intake Elevation in Meters	1100
Estimated Discharge Elevation in Meters	990
Gross Head for Generation in Meters	110
Length of Penstock/Pipeline/tunnel in Km	6.4
Head Loss (from daily head loss calculation average) in Meters	1.729
Net Head for Generation in Meters	108.271
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	2,373,992
MWh	2,374



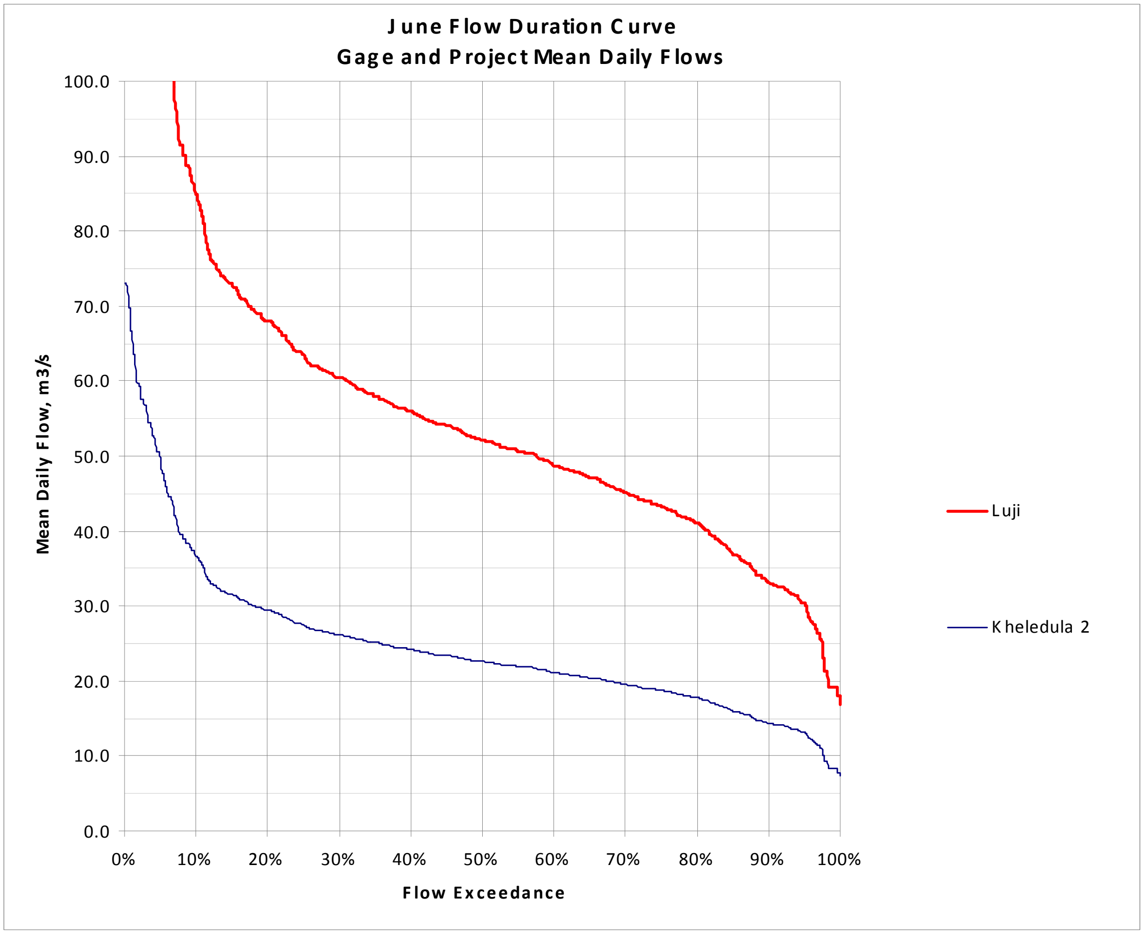
April

Area under Adjusted Flow Duration Curve in CMS-Hrs	8,593
Select Discharge equal to or exceeded % For HPP	16.80%
Equivalent Total Turbine Discharge at Selected CF in CMS	18.00
Non-useable portion of FDC at selected CF or Exceedance %	715
Gross Available CMS-HRS for Generation at selected CF	7,877
Monthly Average Daily Discharge in CMS	23.91
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	3%
Environmental/Sanitary Flow in CMS	0.72
Non-useable Environmental/Sanitary CMS-HRS	516
Net CMS-HRS Available for Generation	7361
Estimated Intake Elevation in Meters	1100
Estimated Discharge Elevation in Meters	990
Gross Head for Generation in Meters	110
Length of Penstock/Pipeline/tunnel in Km	6.4
Head Loss (from daily head loss calculation average) in Meters	1.729
Net Head for Generation in Meters	108.271
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	6,642,885
MWh	6,643



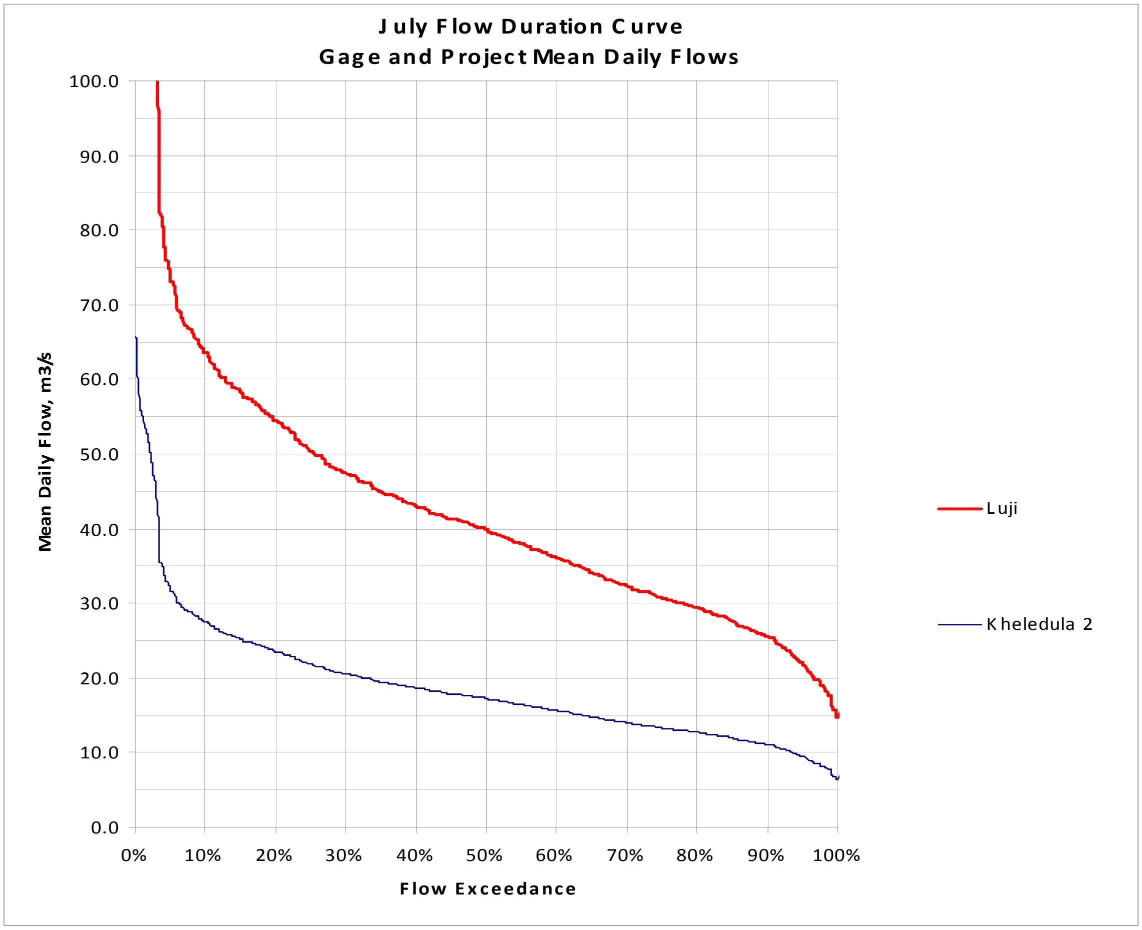
May

Area under Adjusted Flow Duration Curve in CMS-Hrs	16,647
Select Discharge equal to or exceeded % For HPP	68.70%
Equivalent Total Turbine Discharge at Selected CF in CMS	17.96
Non-useable portion of FDC at selected CF or Exceedance %	4288
Gross Available CMS-HRS for Generation at selected CF	12,359
Monthly Average Daily Discharge in CMS	22.41
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	2%
Environmental/Sanitary Flow in CMS	0.45
Non-useable Environmental/Sanitary CMS-HRS	333
Net CMS-HRS Available for Generation	12,025
Estimated Intake Elevation in Meters	1,100
Estimated Discharge Elevation in Meters	990
Gross Head for Generation in Meters	110
Length of Penstock/Pipeline/tunnel in Km	6.4
Head Loss (from daily head loss calculation average) in Meters	1.729
Net Head for Generation in Meters	108.271
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	10,852,200
MWh	10,852



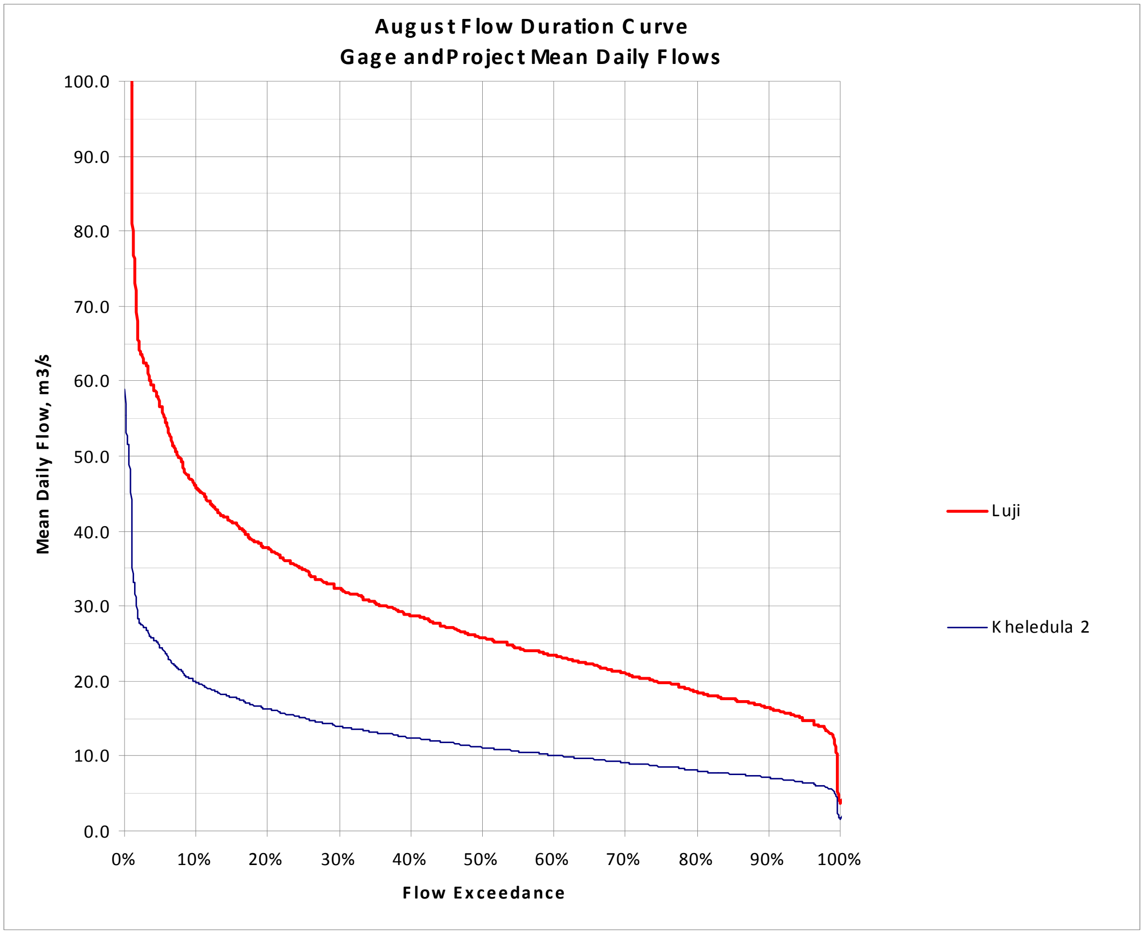
June

Area under Adjusted Flow Duration Curve in CMS-Hrs	17,781
Select Discharge equal to or exceeded % For HPP	79.00%
Equivalent Total Turbine Discharge at Selected CF in CMS	18.00
Non-useable portion of FDC at selected CF or Exceedance %	5381
Gross Available CMS-HRS for Generation at selected CF	12,400
Monthly Average Daily Discharge in CMS	24.73
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	2%
Environmental/Sanitary Flow in CMS	0.49
Non-useable Environmental/Sanitary CMS-HRS	356
Net CMS-HRS Available for Generation	12,044
Estimated Intake Elevation in Meters	1,100
Estimated Discharge Elevation in Meters	990
Gross Head for Generation in Meters	110
Length of Penstock/Pipeline/tunnel in Km	6.4
Head Loss (from daily head loss calculation average) in Meters	1.729
Net Head for Generation in Meters	108.271
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	10,868,980
MWh	10,869



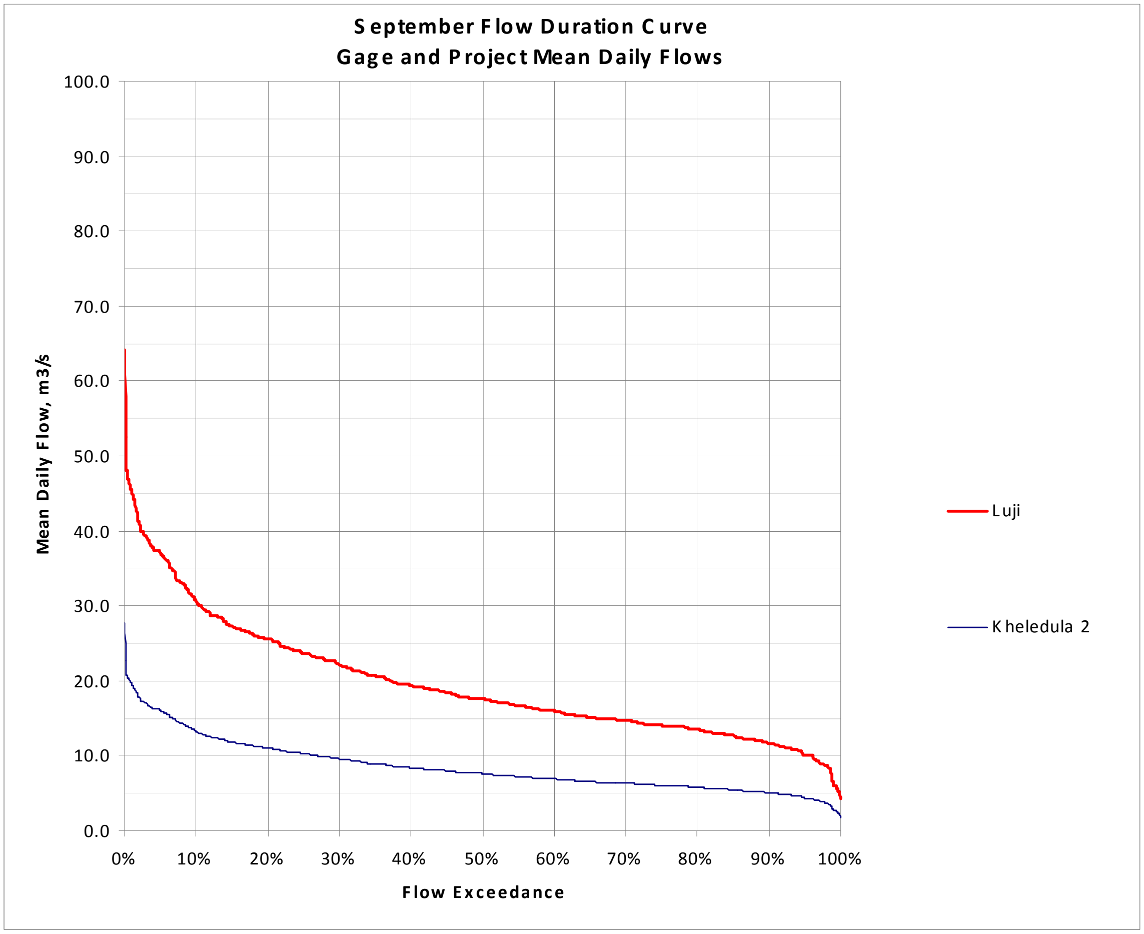
July

Area under Adjusted Flow Duration Curve in CMS-Hrs	13,962
Select Discharge equal to or exceeded % For HPP	44.10%
Equivalent Total Turbine Discharge at Selected CF in CMS	17.98
Non-useable portion of FDC at selected CF or Exceedance %	2395
Gross Available CMS-HRS for Generation at selected CF	11,567
Monthly Average Daily Discharge in CMS	37.59
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	2%
Environmental/Sanitary Flow in CMS	0.75
Non-useable Environmental/Sanitary CMS-HRS	559
Net CMS-HRS Available for Generation	11,008
Estimated Intake Elevation in Meters	1,100
Estimated Discharge Elevation in Meters	990
Gross Head for Generation in Meters	110
Length of Penstock/Pipeline/tunnel in Km	6.4
Head Loss (from daily head loss calculation average) in Meters	1.729
Net Head for Generation in Meters	108.271
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	9,933,738
MWh	9,934



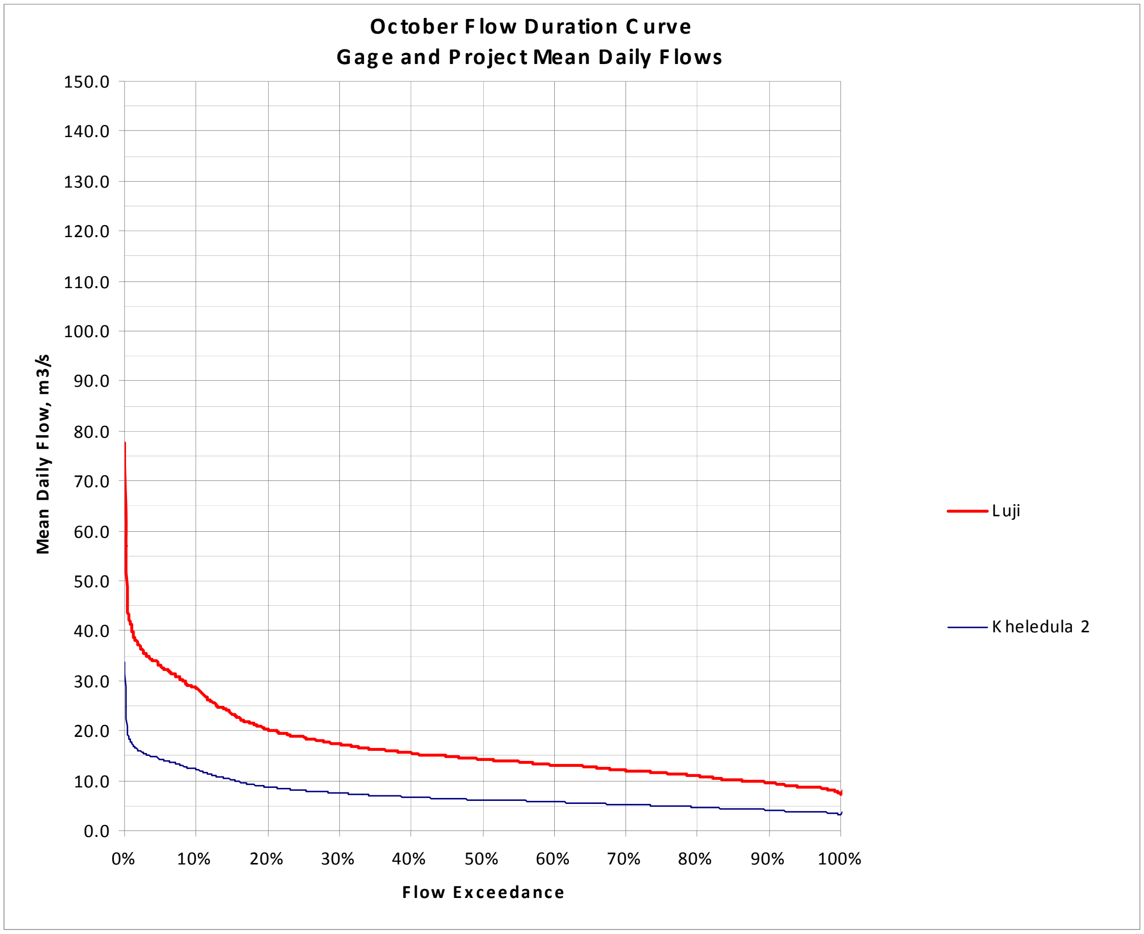
August

Area under Adjusted Flow Duration Curve in CMS-Hrs	9,467
Select Discharge equal to or exceeded % For HPP	14.60%
Equivalent Total Turbine Discharge at Selected CF in CMS	17.98
Non-useable portion of FDC at selected CF or Exceedance %	670
Gross Available CMS-HRS for Generation at selected CF	8,797
Monthly Average Daily Discharge in CMS	12.75
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	3%
Environmental/Sanitary Flow in CMS	0.38
Non-useable Environmental/Sanitary CMS-HRS	285
Net CMS-HRS Available for Generation	8512
Estimated Intake Elevation in Meters	1100
Estimated Discharge Elevation in Meters	990
Gross Head for Generation in Meters	110
Length of Penstock/Pipeline/tunnel in Km	6.4
Head Loss (from daily head loss calculation average) in Meters	1.729
Net Head for Generation in Meters	108.271
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	7,681,725
MWh	7,682



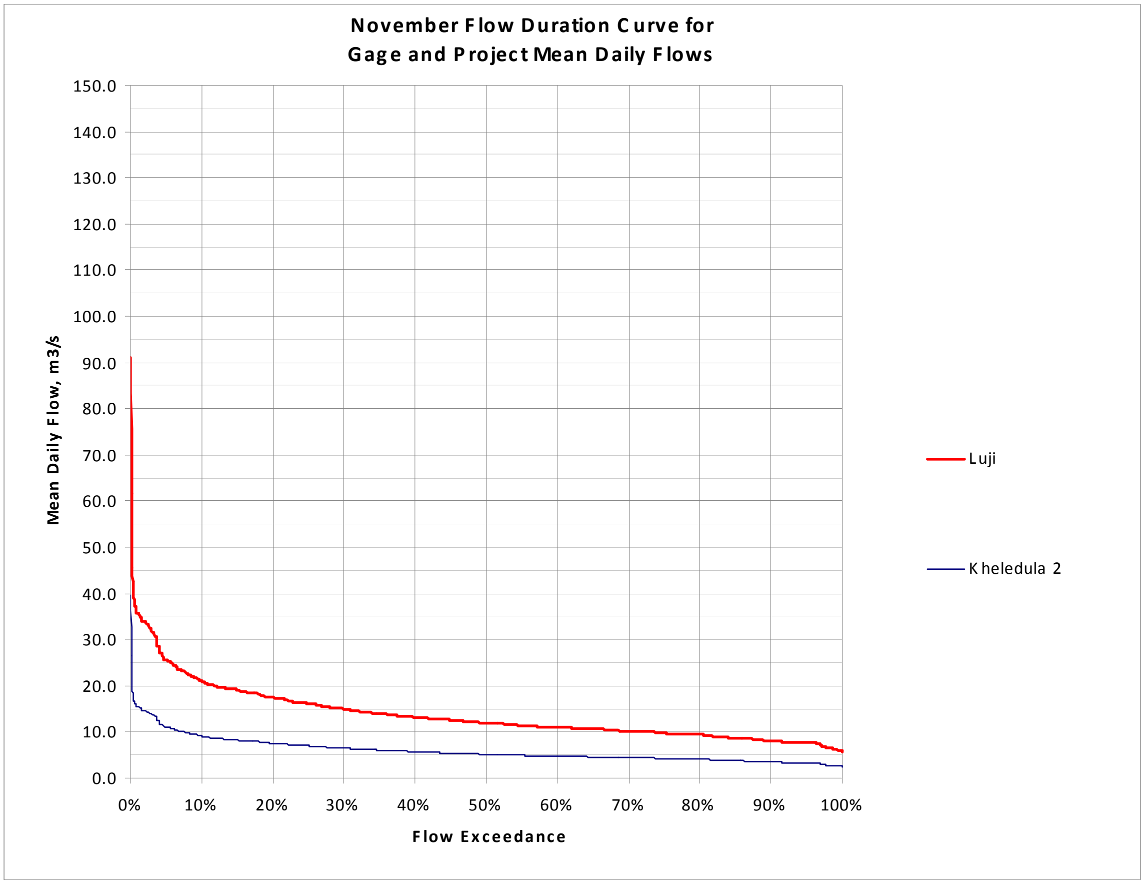
September

Area under Adjusted Flow Duration Curve in CMS-Hrs	6,107
Select Discharge equal to or exceeded % For HPP	1.97%
Equivalent Total Turbine Discharge at Selected CF in CMS	17.90
Non-useable portion of FDC at selected CF or Exceedance %	14
Gross Available CMS-HRS for Generation at selected CF	6,093
Monthly Average Daily Discharge in CMS	16.99
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	5%
Environmental/Sanitary Flow in CMS	0.85
Non-useable Environmental/Sanitary CMS-HRS	612
Net CMS-HRS Available for Generation	5481
Estimated Intake Elevation in Meters	1100
Estimated Discharge Elevation in Meters	990
Gross Head for Generation in Meters	110
Length of Penstock/Pipeline/tunnel in Km	6.4
Head Loss (from daily head loss calculation average) in Meters	1.729
Net Head for Generation in Meters	108.271
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	4,946,704
MWh	4,947



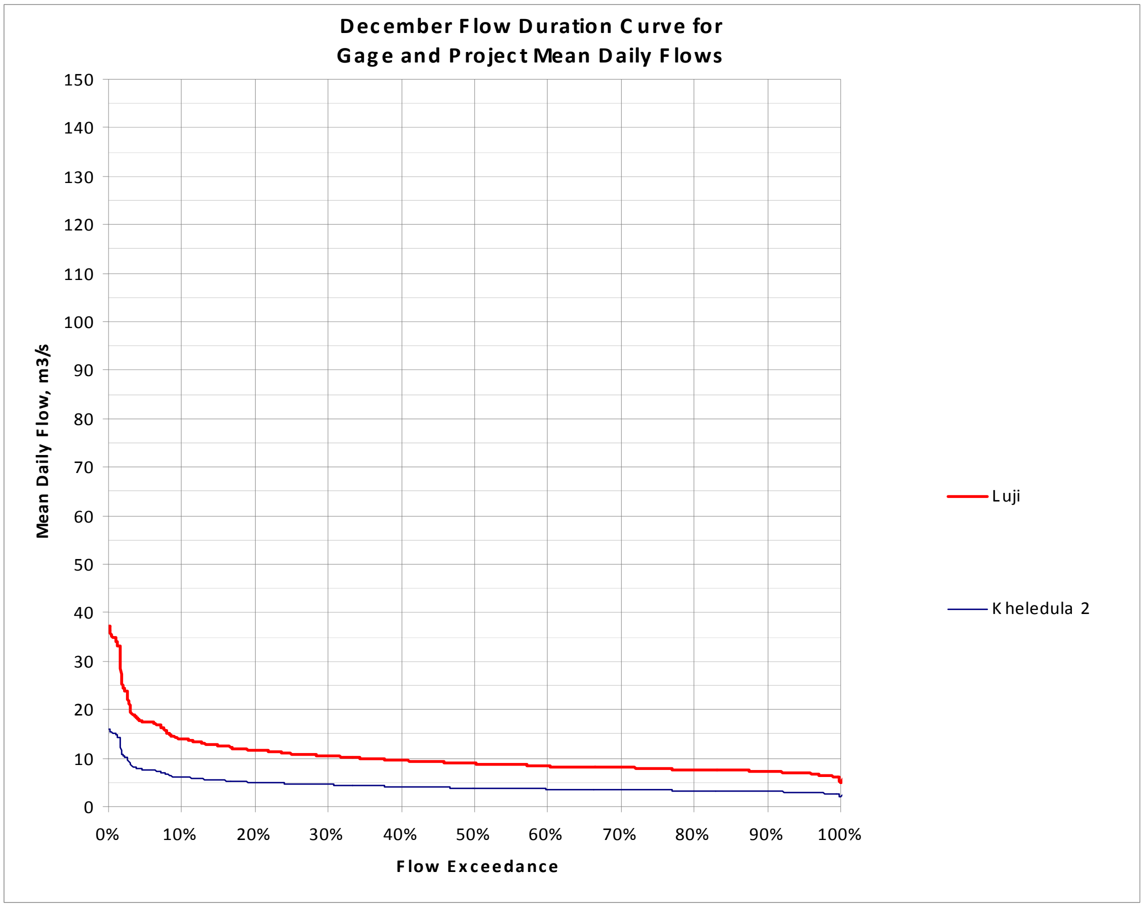
October

Area under Adjusted Flow Duration Curve in CMS-Hrs	5,298
Select Discharge equal to or exceeded % For HPP	1.00%
Equivalent Total Turbine Discharge at Selected CF in CMS	17.85
Non-useable portion of FDC at selected CF or Exceedance %	6
Gross Available CMS-HRS for Generation at selected CF	5,293
Monthly Average Daily Discharge in CMS	7.14
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	6%
Environmental/Sanitary Flow in CMS	0.43
Non-useable Environmental/Sanitary CMS-HRS	319
Net CMS-HRS Available for Generation	4974
Estimated Intake Elevation in Meters	1100
Estimated Discharge Elevation in Meters	990
Gross Head for Generation in Meters	110
Length of Penstock/Pipeline/tunnel in Km	6.4
Head Loss (from daily head loss calculation average) in Meters	1.729
Net Head for Generation in Meters	108.271
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	4,488,874
MWh	4,489



November

Area under Adjusted Flow Duration Curve in CMS-Hrs	4,288
Select Discharge equal to or exceeded % For HPP	0.45%
Equivalent Total Turbine Discharge at Selected CF in CMS	17.72
Non-useable portion of FDC at selected CF or Exceedance %	0
Gross Available CMS-HRS for Generation at selected CF	4,289
Monthly Average Daily Discharge in CMS	5.97
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	7%
Environmental/Sanitary Flow in CMS	0.42
Non-useable Environmental/Sanitary CMS-HRS	301
Net CMS-HRS Available for Generation	3987
Estimated Intake Elevation in Meters	1100
Estimated Discharge Elevation in Meters	990
Gross Head for Generation in Meters	110
Length of Penstock/Pipeline/tunnel in Km	6.4
Head Loss (from daily head loss calculation average) in Meters	1.729
Net Head for Generation in Meters	108.271
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	3,598,445
MWh	3,598

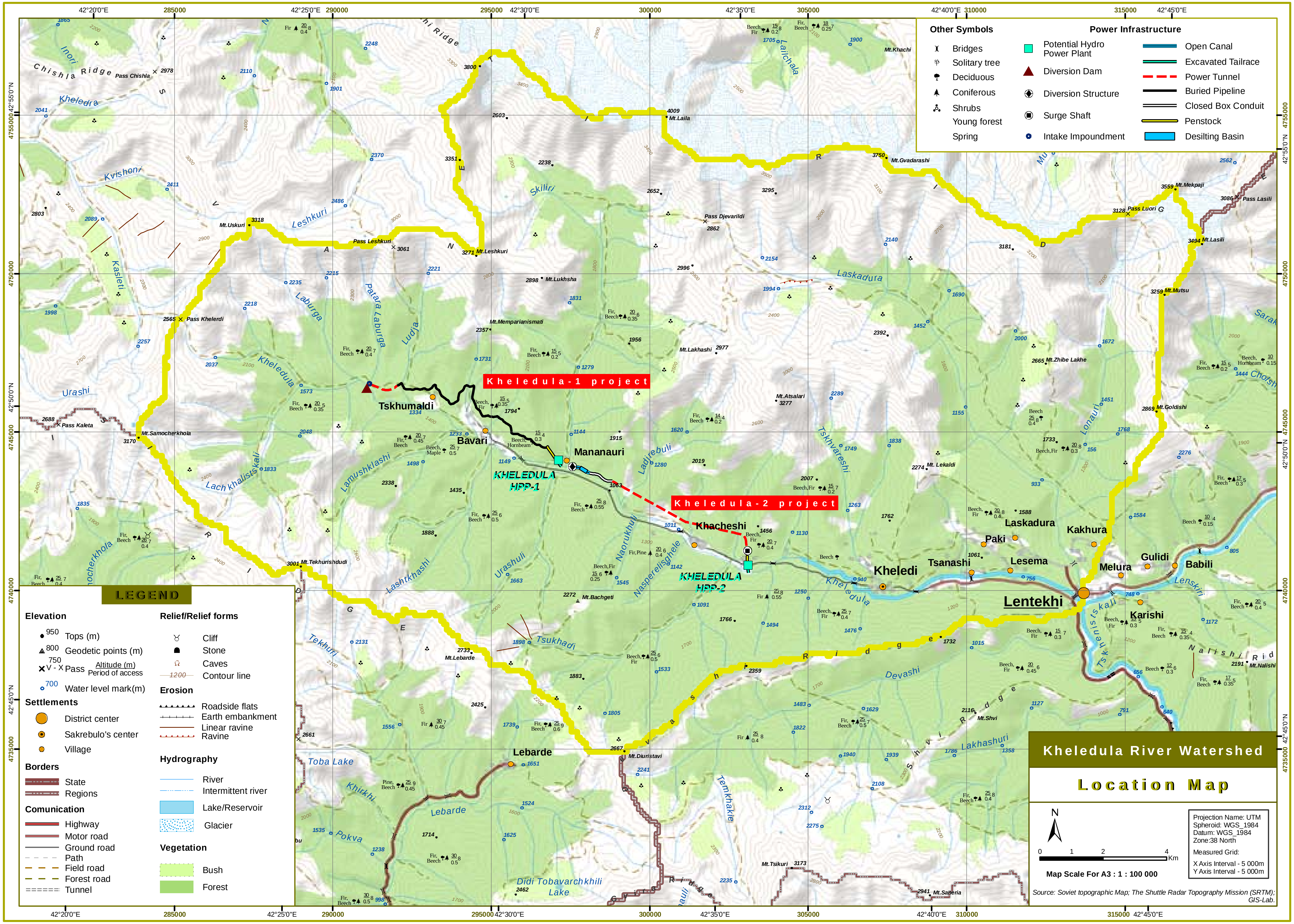


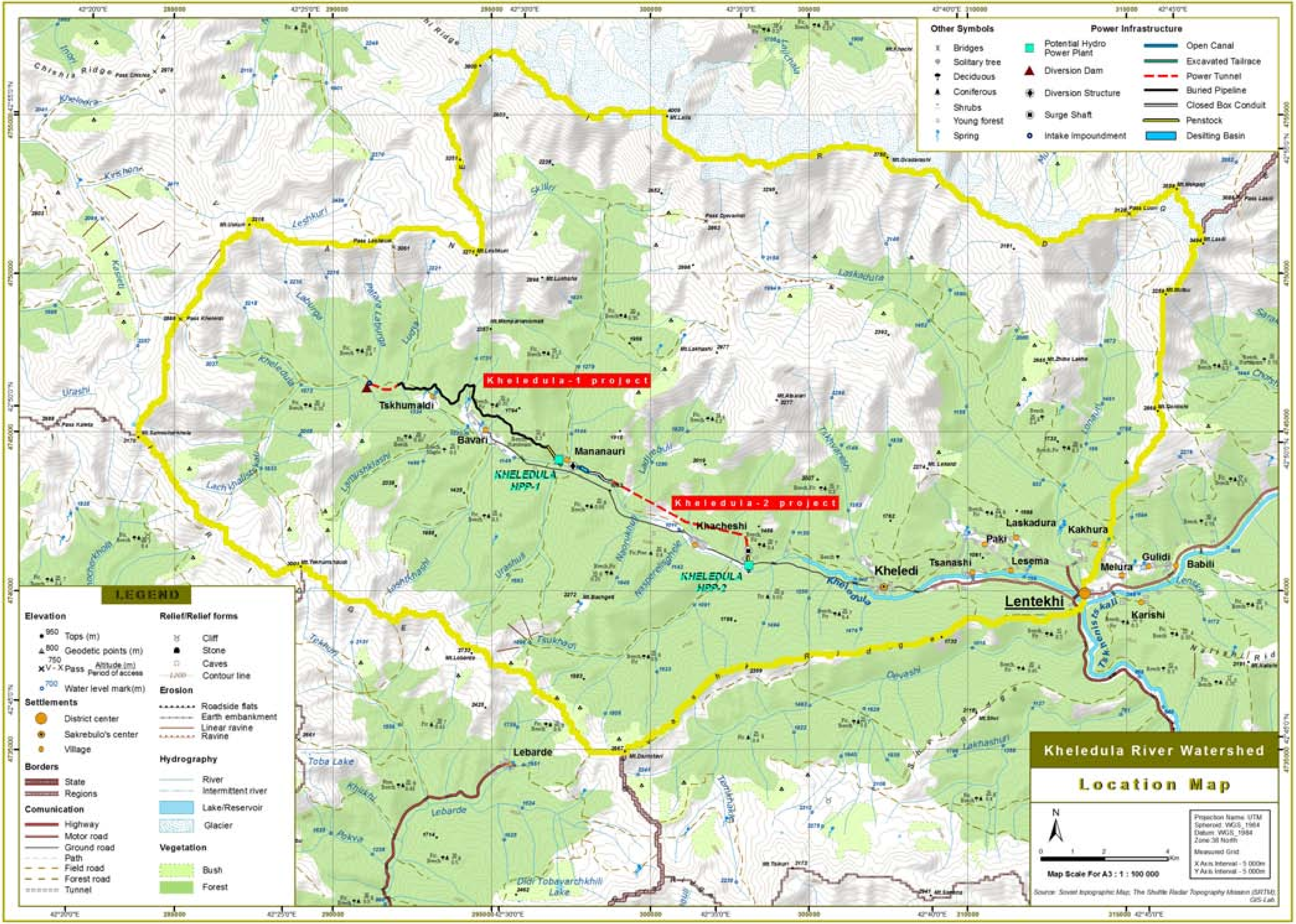
December

Area under Adjusted Flow Duration Curve in CMS-Hrs	3,282
Select Discharge equal to or exceeded % For HPP	1.60%
Equivalent Total Turbine Discharge at Selected CF in CMS	13.85
Non-useable portion of FDC at selected CF or Exceedance %	1
Gross Available CMS-HRS for Generation at selected CF	3,281
Monthly Average Daily Discharge in CMS	4.42
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	10%
Environmental/Sanitary Flow in CMS	0.44
Non-useable Environmental/Sanitary CMS-HRS	329
Net CMS-HRS Available for Generation	2952
Estimated Intake Elevation in Meters	1100
Estimated Discharge Elevation in Meters	990
Gross Head for Generation in Meters	110
Length of Penstock/Pipeline/tunnel in Km	6.4
Head Loss (from daily head loss calculation average) in Meters	1.729
Net Head for Generation in Meters	108.271
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	2,664,433
MWh	2,664

Appendix 3

Location Map

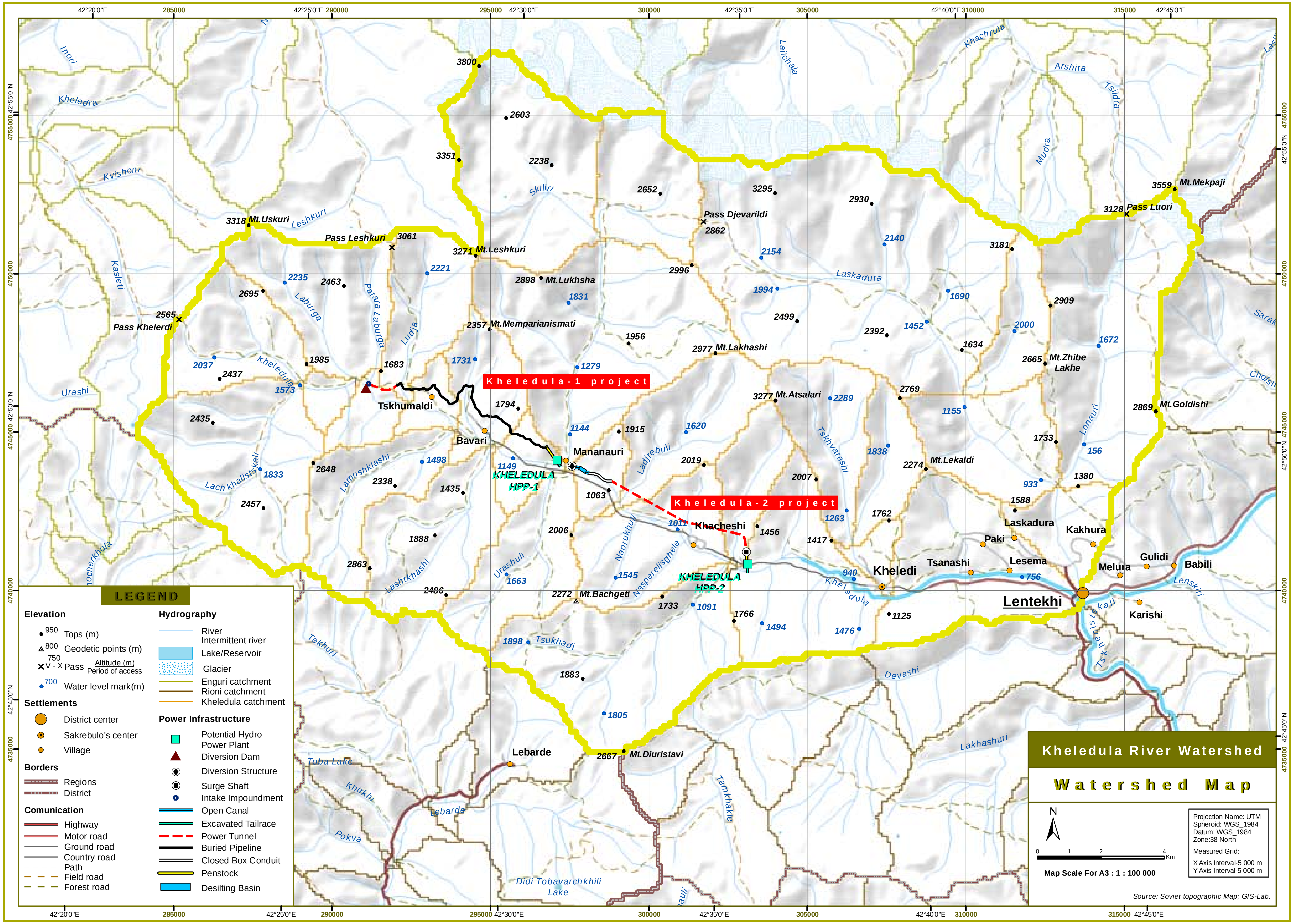

Kheledula River Watershed
Location Map
Kheledula-1 project
Kheledula-2 project
KHELEDULA HPP-1
KHELEDULA HPP-2
Lentekhi
Kheledi
Tskhumaldi
Bavari
Mananauri
Khacheshi
Tsanashi
Lesema
Paki
Laskadura
Kakhura
Melura
Gulidi
Babili
Karishi
Lebarde
Other Symbols
Bridges
Solitary tree
Deciduous
Coniferous
Shrubs
Young forest
Spring
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Diversion Structure
Surge Shaft
Intake Impoundment
Open Canal
Excavated Tailrace
Power Tunnel
Buried Pipeline
Closed Box Conduit
Penstock
Desilting Basin
LEGEND
Elevation
Tops (m)
Geodetic points (m)
V - X Pass Altitude (m) Period of access
Water level mark(m)
Settlements
District center
Sakrebulo's center
Village
Borders
State
Regions
Comunication
Highway
Motor road
Ground road
Path
Field road
Forest road
Tunnel
Relief/Relief forms
Cliff
Stone
Caves
Contour line
Erosion
Roadside flats
Earth embankment
Linear ravine
Ravine
Hydrography
River
Intermittent river
Lake/Reservoir
Glacier
Vegetation
Bush
Forest
Map Scale For A3 : 1 : 100 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval - 5 000m
Y Axis Interval - 5 000m
Source: Soviet topographic Map; The Shuttle Radar Topography Mission (SRTM); GIS-Lab.



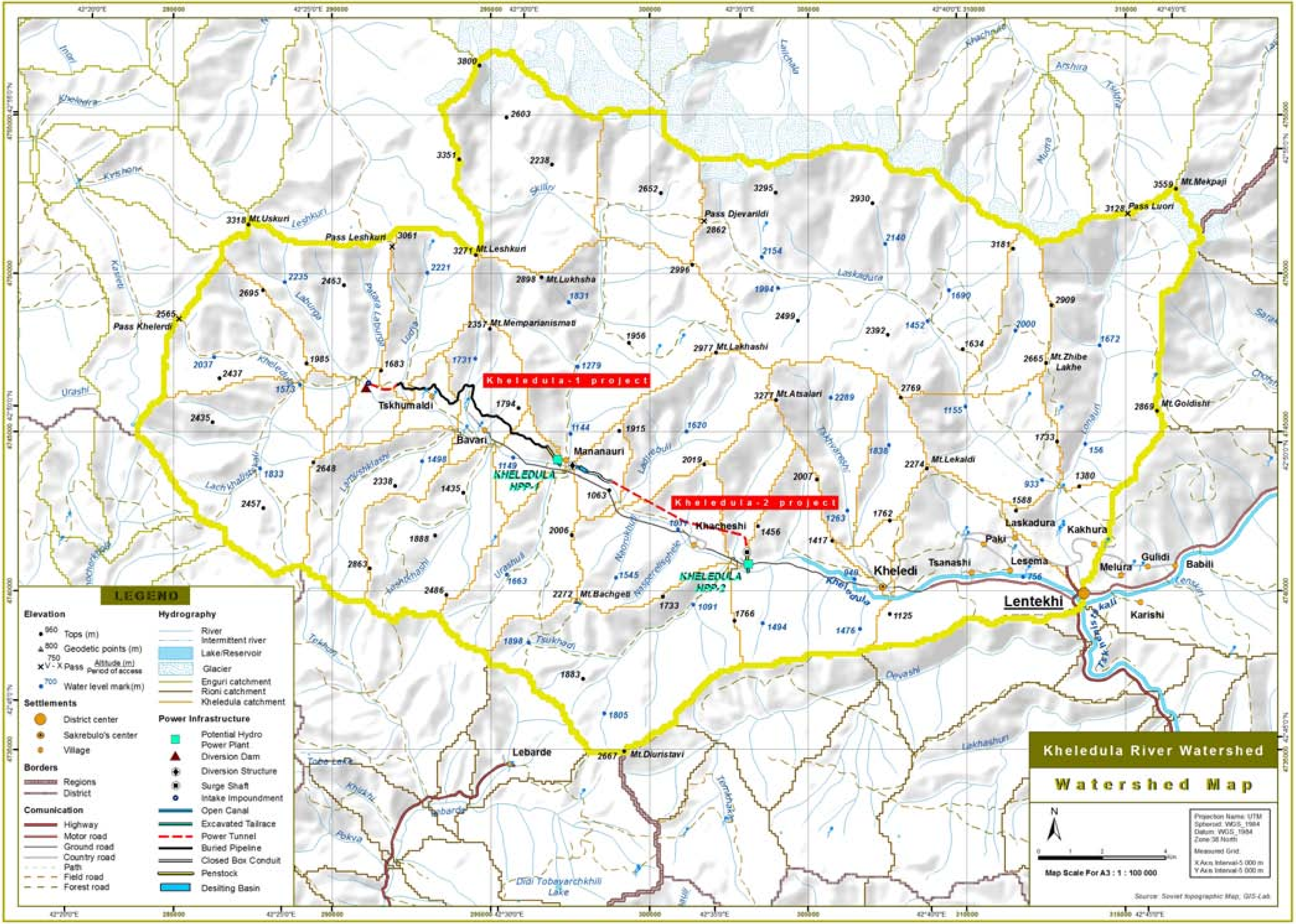
Kheledula River Watershed
Location Map
Kheledula-1 project
Kheledula-2 project
KHELEDULA HPP-1
KHELEDULA HPP-2
Tskhumaldi
Bavari
Mananauri
Khacheshi
Kheledi
Tsanashi
Paki
Laskadura
Lesema
Kakhura
Melura
Gulidi
Babili
Lentekhi
Karishi
Lebarde
Other Symbols
Bridges
Solitary tree
Deciduous
Coniferous
Shrubs
Young forest
Spring
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Diversion Structure
Surge Shaft
Intake impoundment
Open Canal
Excavated Tailrace
Power Tunnel
Buried Pipeline
Closed Box Conduit
Penstock
Desilting Basin
LEGEND
Elevation
Tops (m)
Geodetic points (m)
Pass
Water level mark(m)
Settlements
District center
Sakrebulo's center
Village
Borders
State
Regions
Comunication
Highway
Motor road
Ground road
Path
Field road
Forest road
Tunnel
Relief/Relief forms
Cliff
Stone
Caves
Contour line
Erosion
Roadside flats
Earth embankment
Linear ravine
Ravine
Hydrography
River
Intermittent river
Lake/Reservoir
Glacier
Vegetation
Bush
Forest
Map Scale For A3 : 1 : 100 000
Source: Soviet topographic Map; The Shuttle Radar Topography Mission (SRTM) GIS-Lab

Appendix 4

Watershed Map



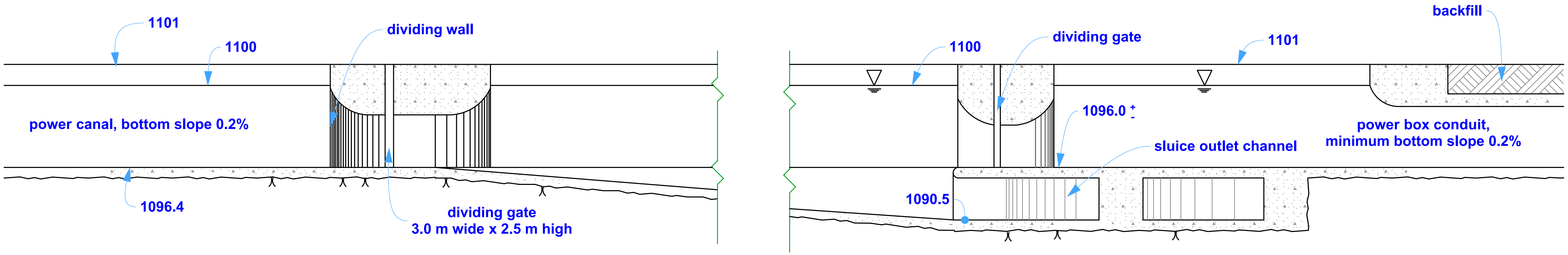
Kheledula River Watershed
Watershed Map
Kheledula-1 project
Kheledula-2 project
KHELEDULA HPP-1
KHELEDULA HPP-2
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
District center
Sakrebulo's center
Village
Borders
Regions
District
Comunication
Highway
Motor road
Ground road
Country road
Path
Field road
Forest road
Hydrography
River
Intermittent river
Lake/Reservoir
Glacier
Enguri catchment
Rioni catchment
Kheledula catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Diversion Structure
Surge Shaft
Intake Impoundment
Open Canal
Excavated Tailrace
Power Tunnel
Buried Pipeline
Closed Box Conduit
Penstock
Desilting Basin
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-5 000 m
Y Axis Interval-5 000 m
Map Scale For A3 : 1 : 100 000
Source: Soviet topographic Map; GIS-Lab.
Lentekhi
Kheledi
Tskhumaldi
Bavari
Mananauri
Khacheshi
Tsanashi
Lesema
Paki
Laskadura
Kakhura
Melura
Gulidi
Babili
Karishi
Lebarde
Mt.Uskuri
Mt.Leshkuri
Mt.Lukhsha
Mt.Memparianismati
Mt.Lakhashi
Mt.Atsalari
Mt.Lekaldi
Mt.Zhibe Lakhe
Mt.Goldishi
Mt.Mekpaji
Mt.Bachgeti
Mt.Diuristavi
Pass Leshkuri
Pass Khelerdi
Pass Djevarildi
Pass Luori
Kheledula
Laskadura
Ladjrebuli
Tskhvareshi
Lamushklashi
Urashi
Naoruknuli
Nasperelisghele
Tsukhadi
Devashi
Lakhashuri
Toba Lake
Didi Tobavarchkhili Lake
Lenskiri
Tskhenistskali



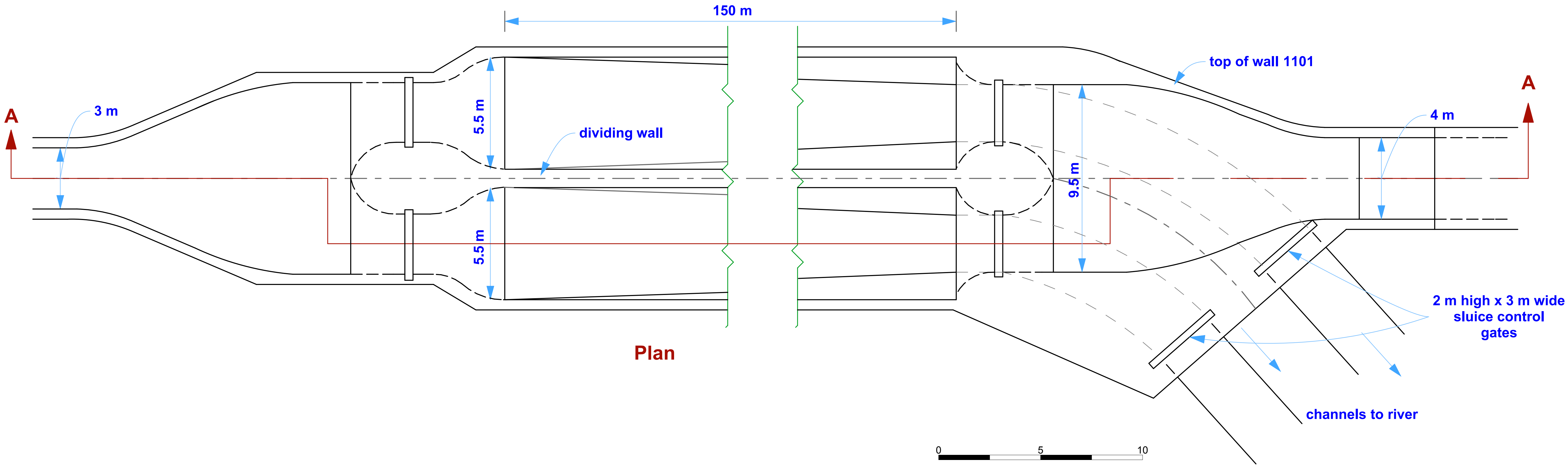
Kheledula River Watershed
Watershed Map
Kheledula-1 project
Kheledula-2 project
KHELEDULA HPP-1
KHELEDULA HPP-2
Lentekhi
Kheledi
Tskhumaldi
Bavari
Mananauri
Khacheshi
Tsanashi
Paki
Laskadura
Kakhura
Lesema
Melura
Gulidi
Babili
Karishi
Lebarde
Mt.Uskuri
Pass Leshkuri
Mt.Leshkuri
Mt.Lukhsha
Mt.Memparianismati
Pass Khelerdi
Pass Djevanildi
Mt.Lakhashi
Mt.Atsalari
Mt.Lekaldi
Mt.Zhibe Lakhe
Mt.Goldishi
Pass Luori
Mt.Mekpaji
Mt.Bachgeti
Mt.Diuristavi
Kheledula
Tskhenistskali
Laskadura
Devashi
Lakhashuri
Tsiskhadi
Didi Tobavarchkhili Lake
Toba Lake
LEGEND
Elevation
Tops (m)
Geodetic points (m)
Pass Altitude (m) Period of access
Water level mark(m)
Settlements
District center
Sakrebulo's center
Village
Borders
Regions
District
Comunication
Highway
Motor road
Ground road
Country road
Path
Field road
Forest road
Hydrography
River
Intermittent river
Lake/Reservoir
Glacier
Enguri catchment
Rioni catchment
Kheledula catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Diversion Structure
Surge Shaft
Intake Impoundment
Open Canal
Excavated Tailrace
Power Tunnel
Buried Pipeline
Closed Box Conduit
Penstock
Desilting Basin
Map Scale For A3 : 1 : 100 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-5 000 m
Y Axis Interval-5 000 m
Source: Soviet topographic Map; GIS-Lab

Appendix 5

Site HPP Figure



Section A-A



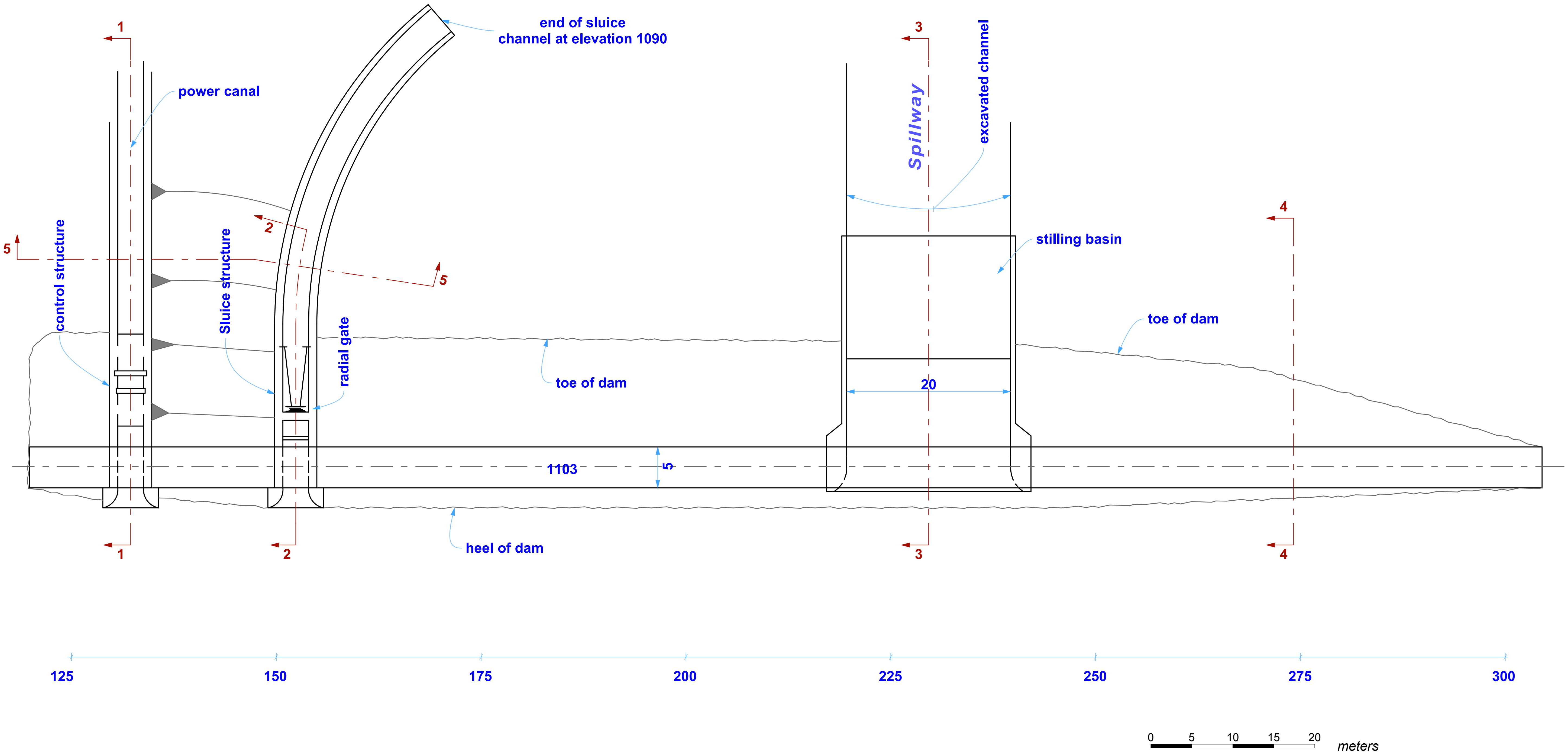
Plan

BLACK & VEATCH
Building a world of difference.

Pre-Feasibility Study
Kheledula 2

De-Silting Basin, Plan and Section

Drawing Scale 1:200	September 2011



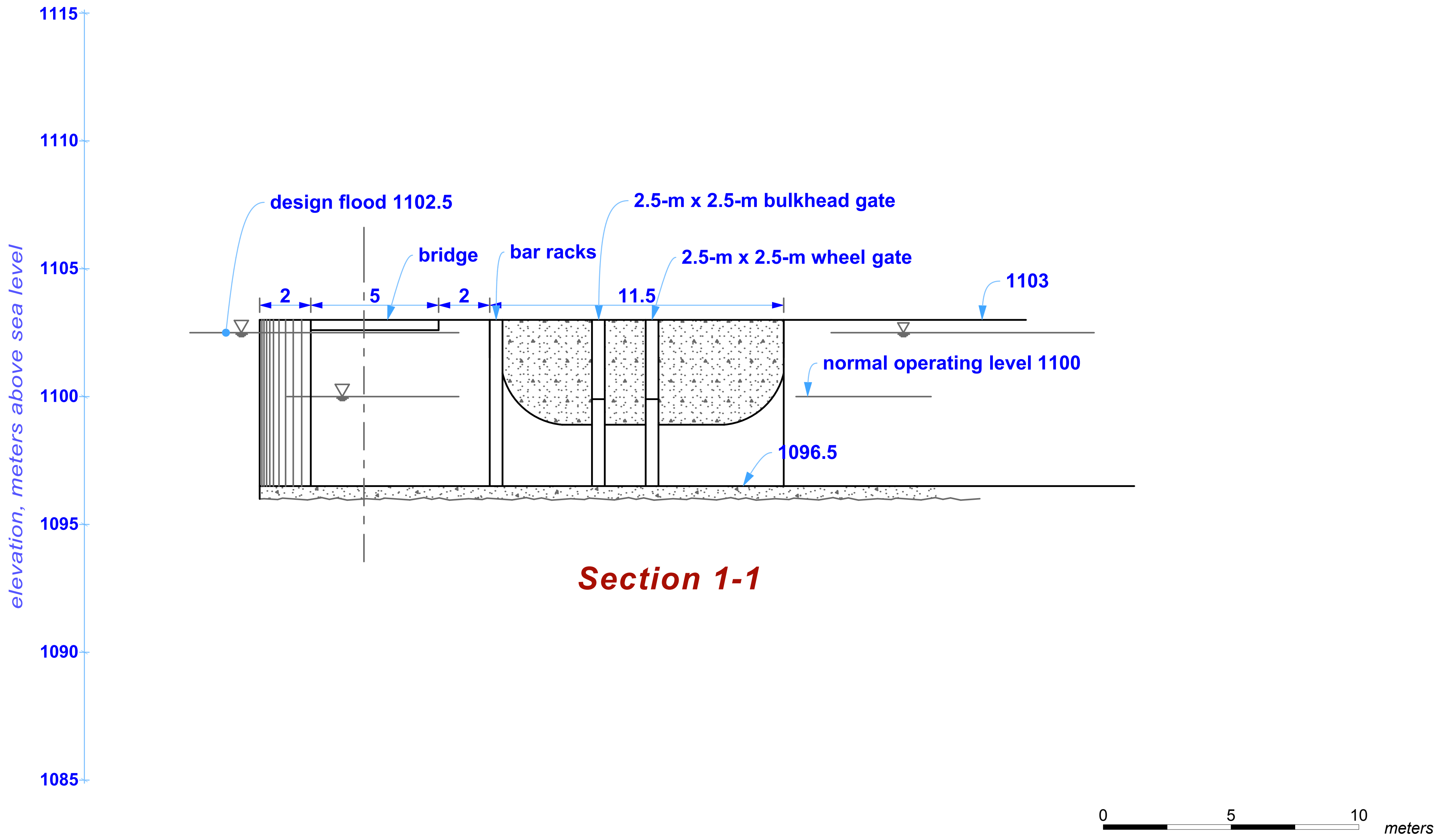
BLACK & VEATCH
Building a world of difference.

Pre-Feasibility Study
Kheledula 2

Diversion Structure
Plan

Drawing Scale 1:500

September 2011



Section 1-1

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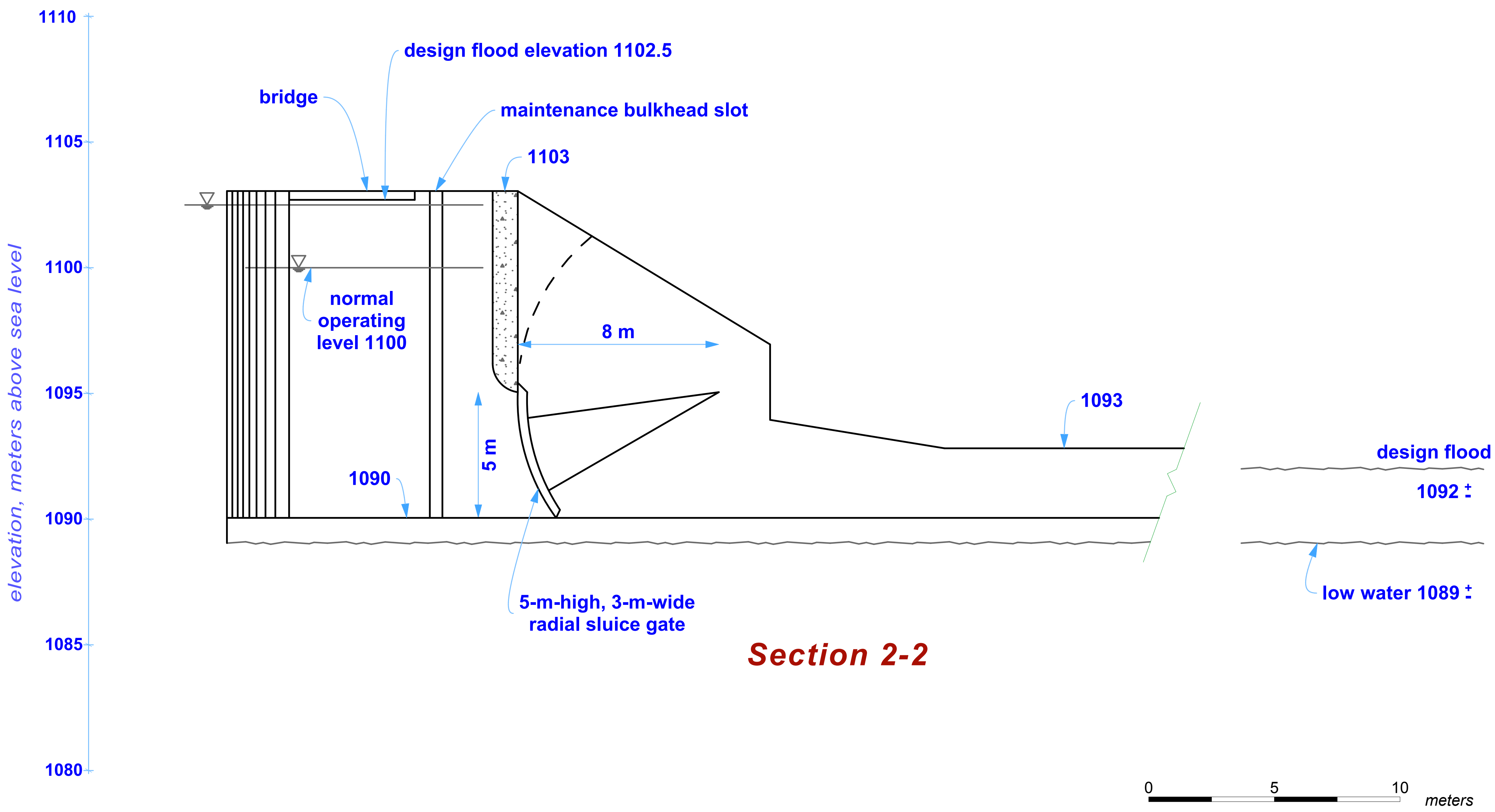
Building a world of difference.

Pre-Feasibility Study
Kheledula 2

Diversion Structure
Section 1-1

Drawing Scale 1:200	September 2011



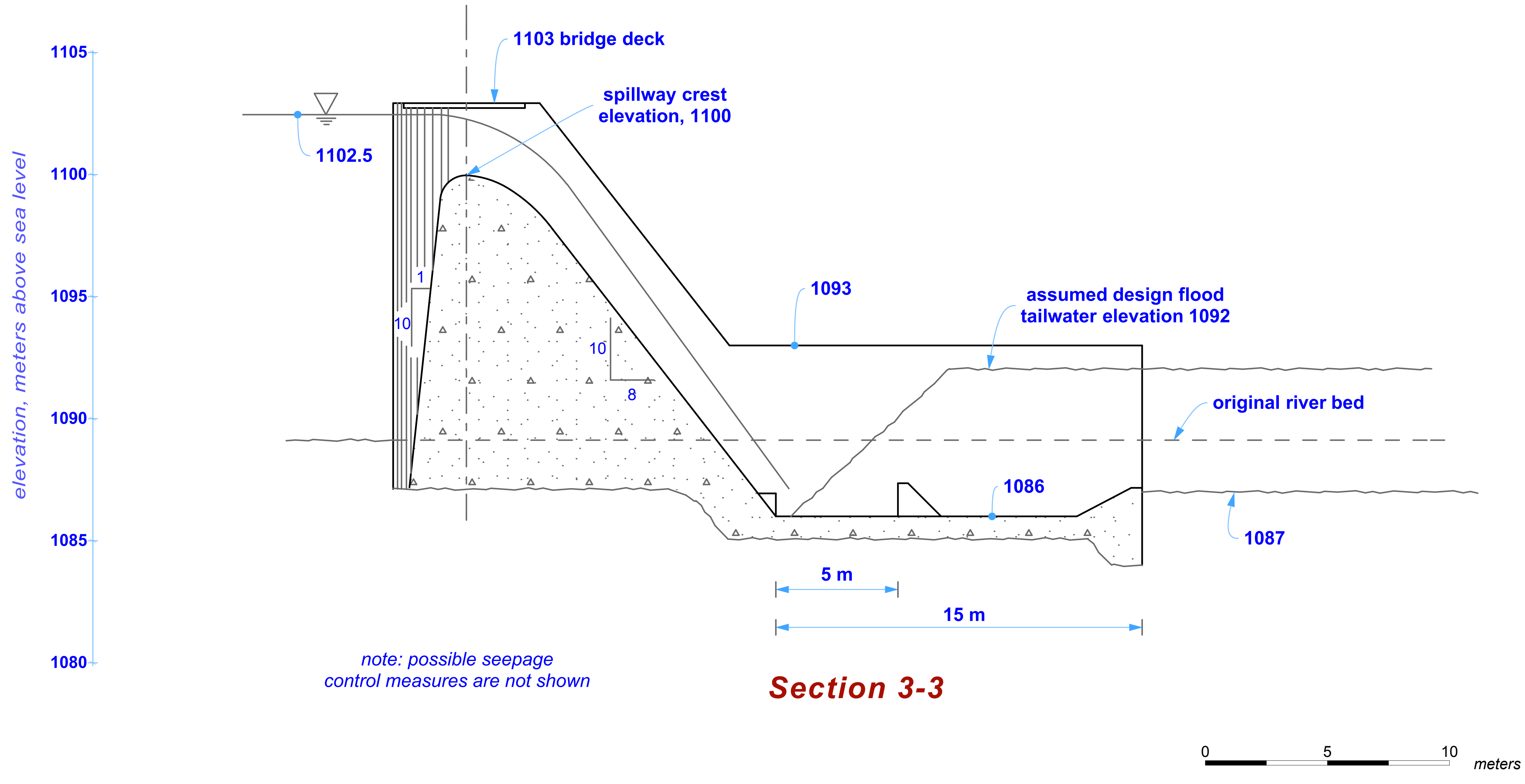
Section 2-2

BLACK & VEATCH
Building a world of difference.

Pre-Feasibility Study
Kheledula 2

Diversion Structure
Section 2-2

Drawing Scale	1:200	September 2011

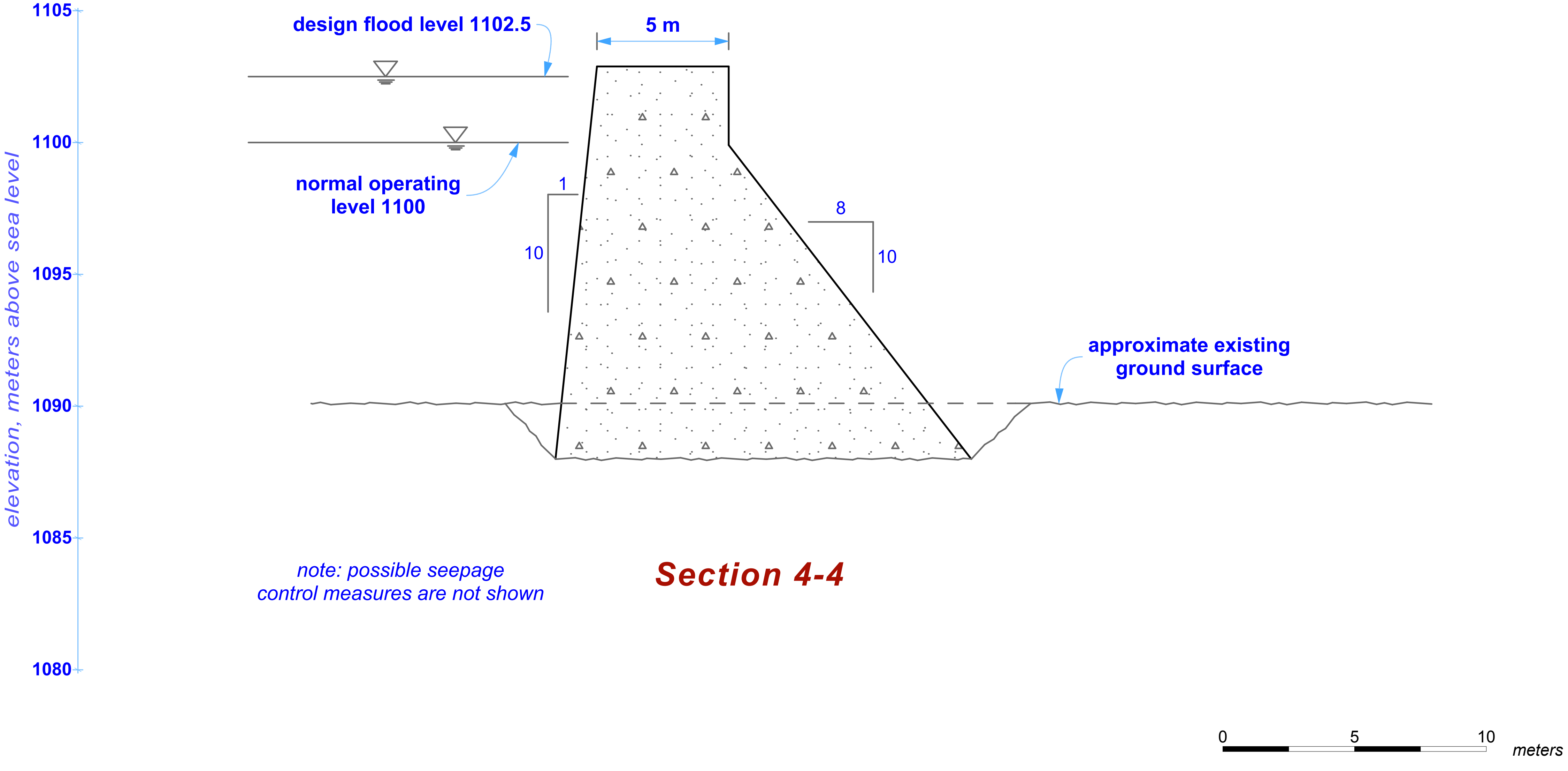


note: possible seepage control measures are not shown

Section 3-3

BLACK & VEATCH
Building a world of difference.

Pre-Feasibility Study Kheledula 2	
Diversion Structure Section 3-3	
Drawing Scale 1:200	September 2011



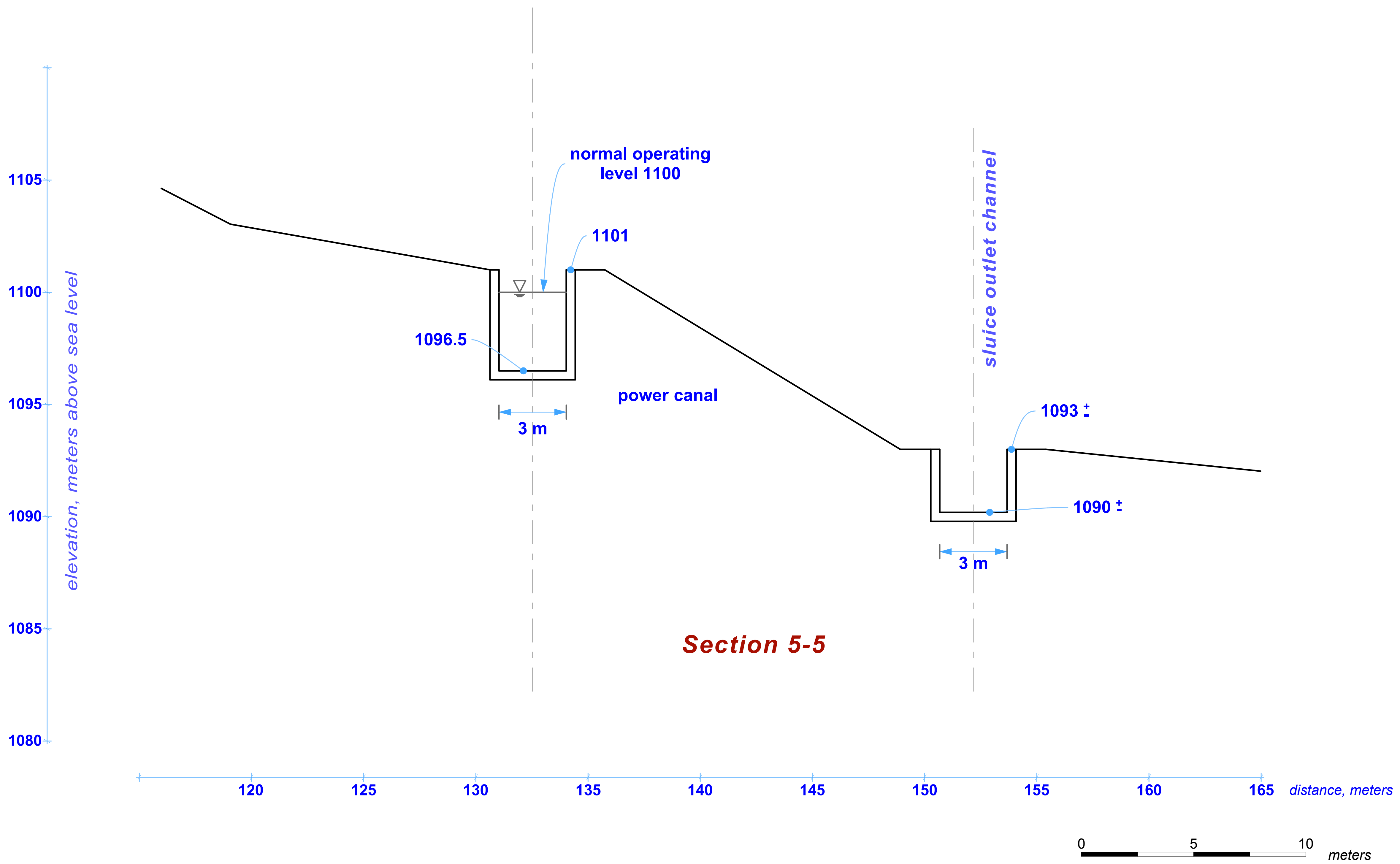
Section 4-4

BLACK & VEATCH
Building a world of difference.

Pre-Feasibility Study
Kheledula 2

Diversion Structure
Section 4-4

Drawing Scale	1:200	September 2011



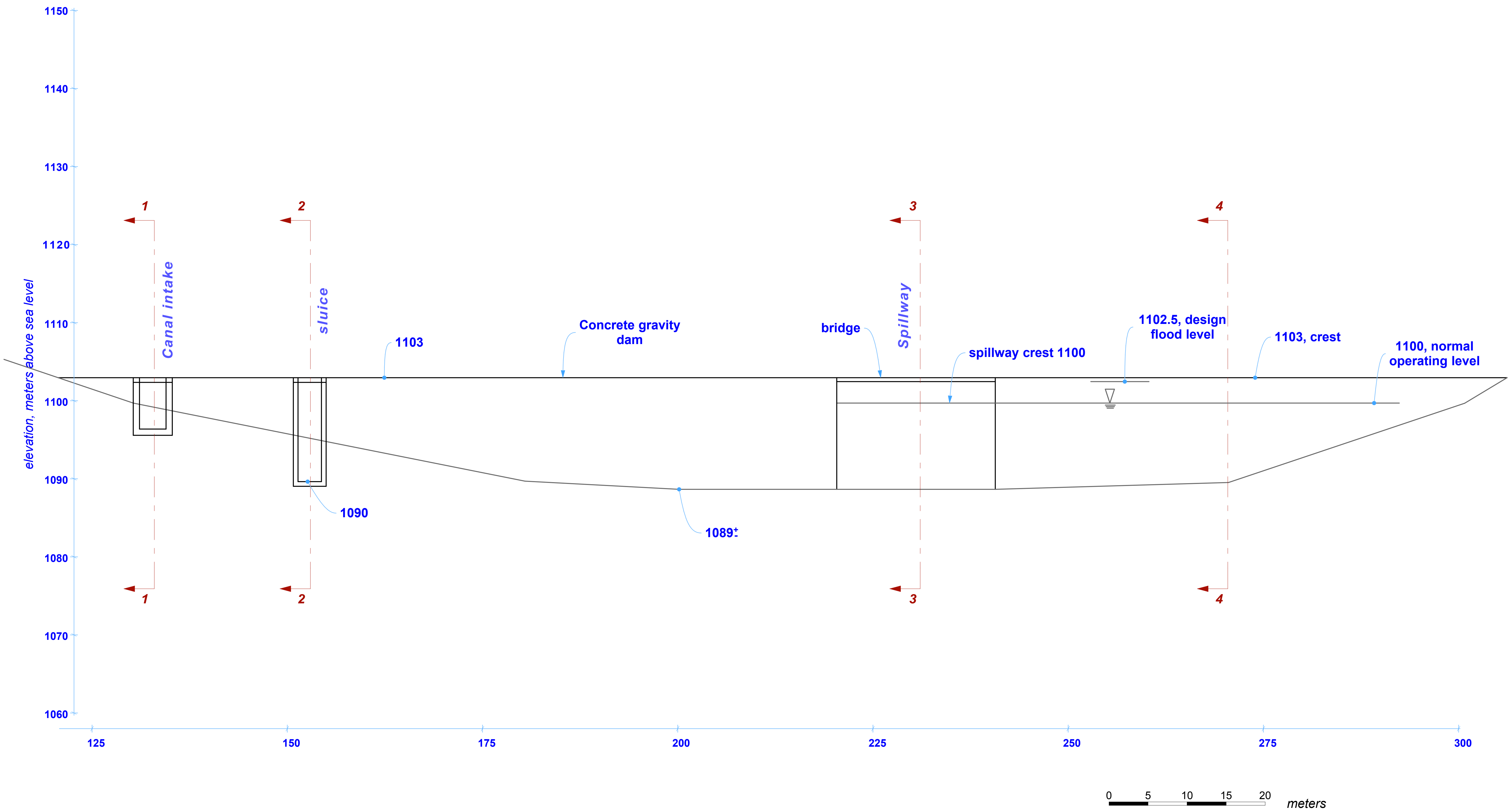
Section 5-5

BLACK & VEATCH
Building a world of difference.

Pre-Feasibility Study
Kheledula 2

Diversion Structure
Section 5-5

Drawing Scale	1:200	September 2011

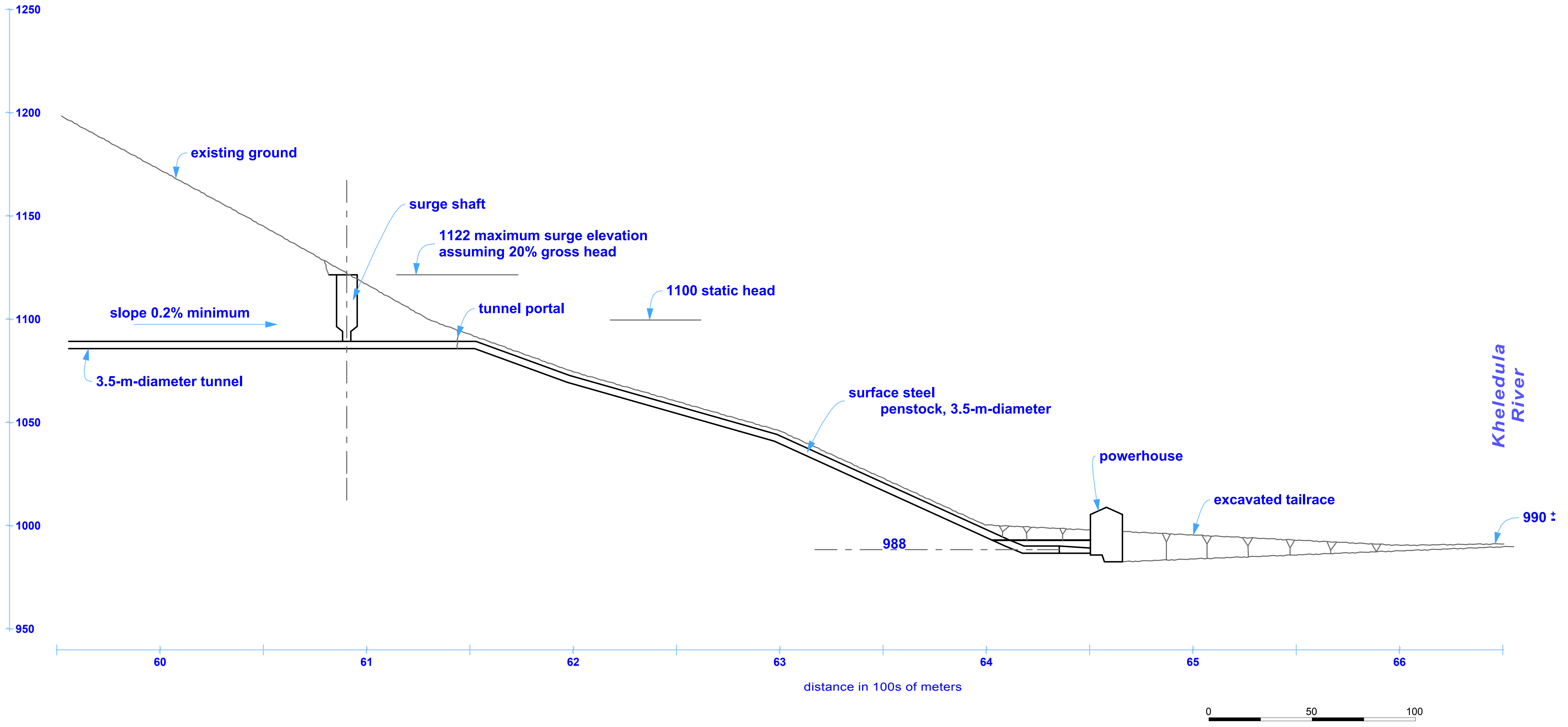


BLACK & VEATCH
Building a world of difference.

Pre-Feasibility Study
kheledula 2

Diversion Structure
Upstream Elevation

Drawing Scale 1:500 | September 2011

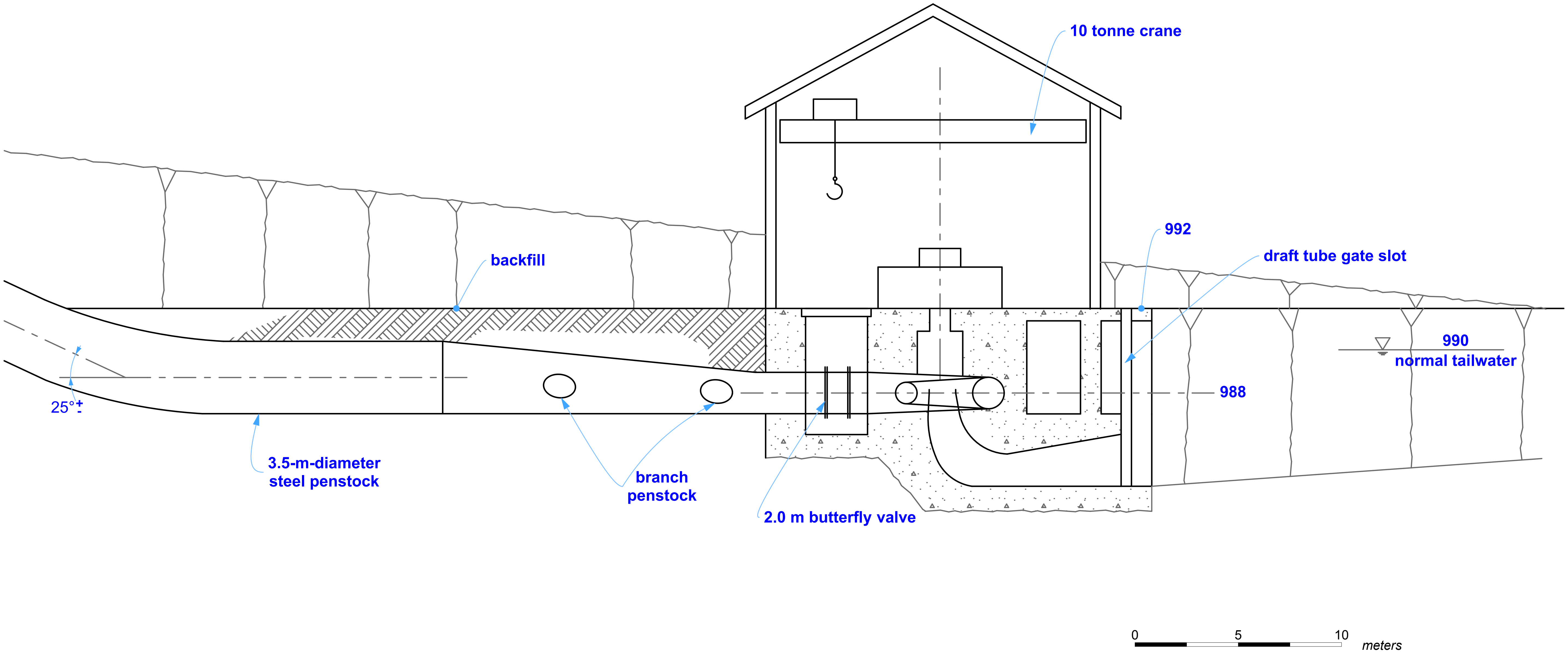


BLACK & VEATCH
Building a world of difference.

Pre-Feasibility Study
Kheledula 2

Power Plant Area
Profile

Drawing Scale 1:2,000	September 2011

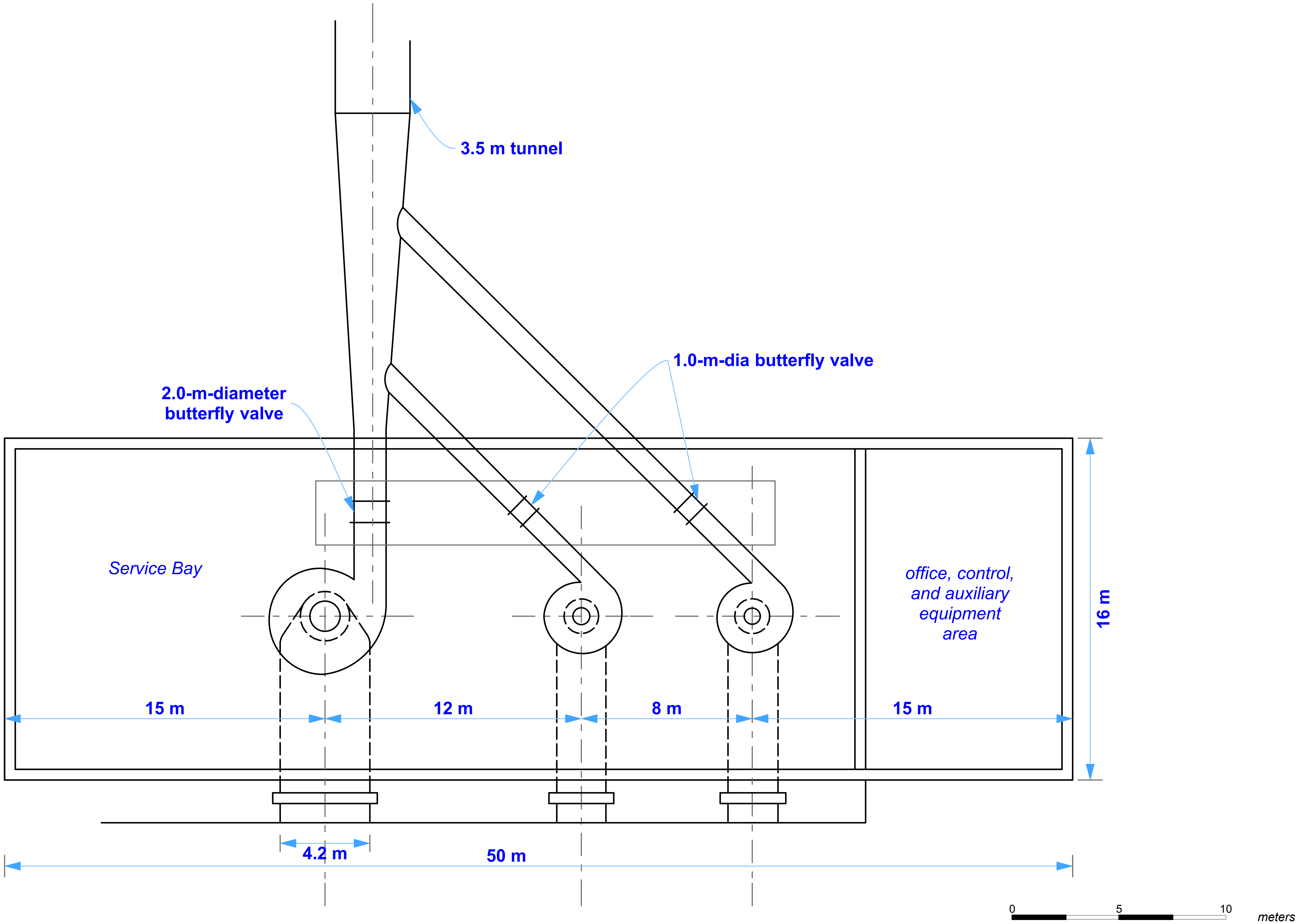


BLACK & VEATCH
Building a world of difference.

Pre-Feasibility Study
Kheledula 2

Powerhouse
Cross Section

Drawing Scale	1:200	September 2011



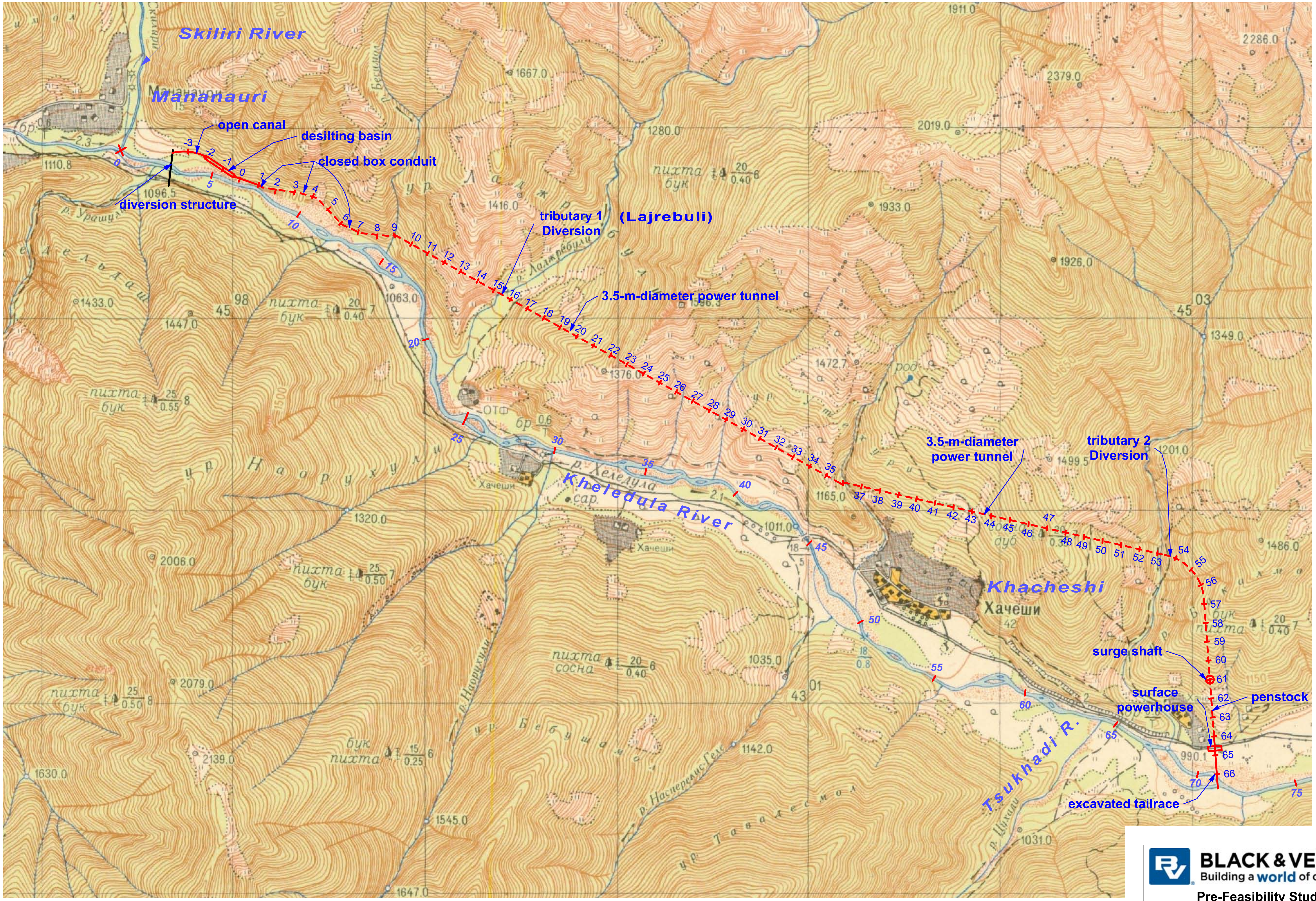
BLACK & VEATCH
Building a world of difference.

Pre-Feasibility Study
Kheledula 2

Powerhouse Plan

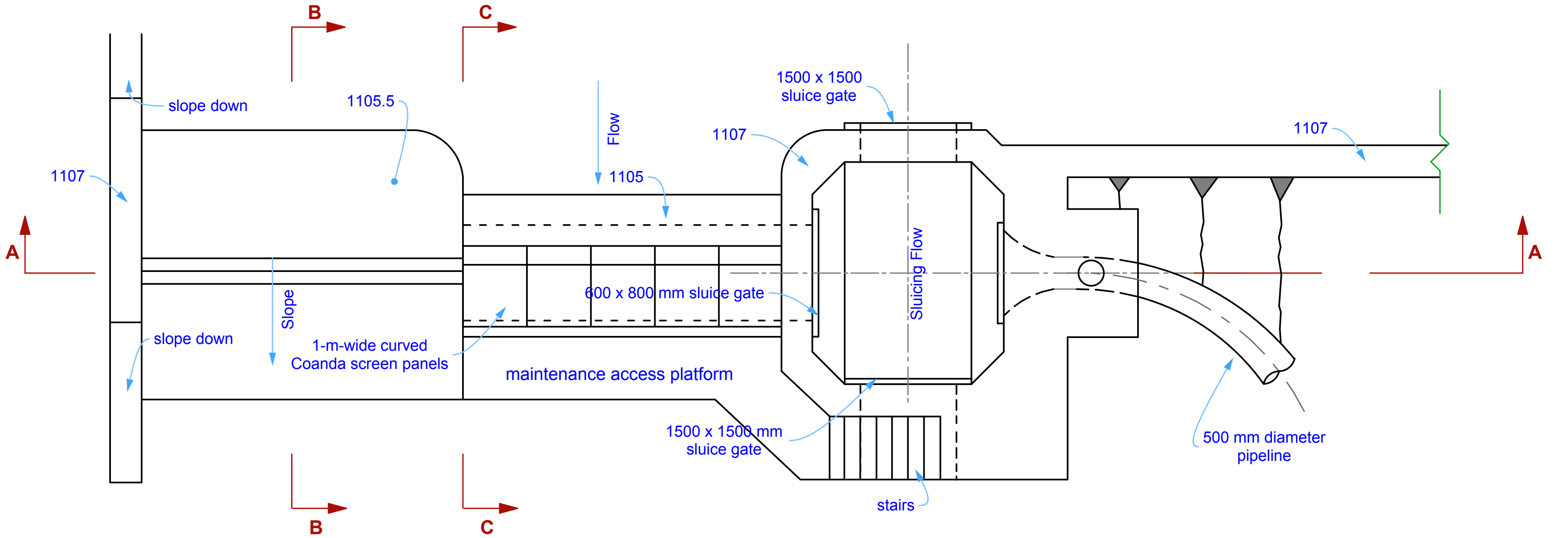
Drawing Scale 1:200

September 2011

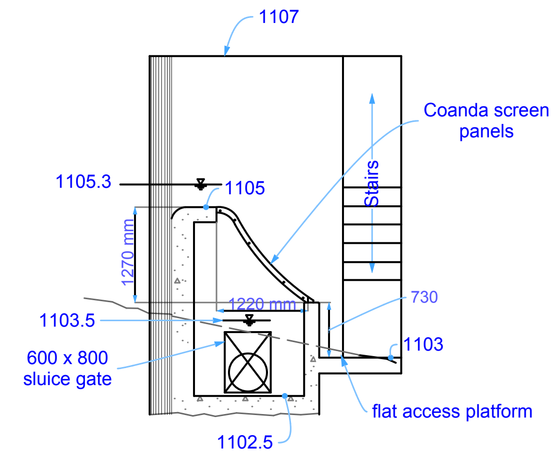


BLACK & VEATCH
Building a world of difference.

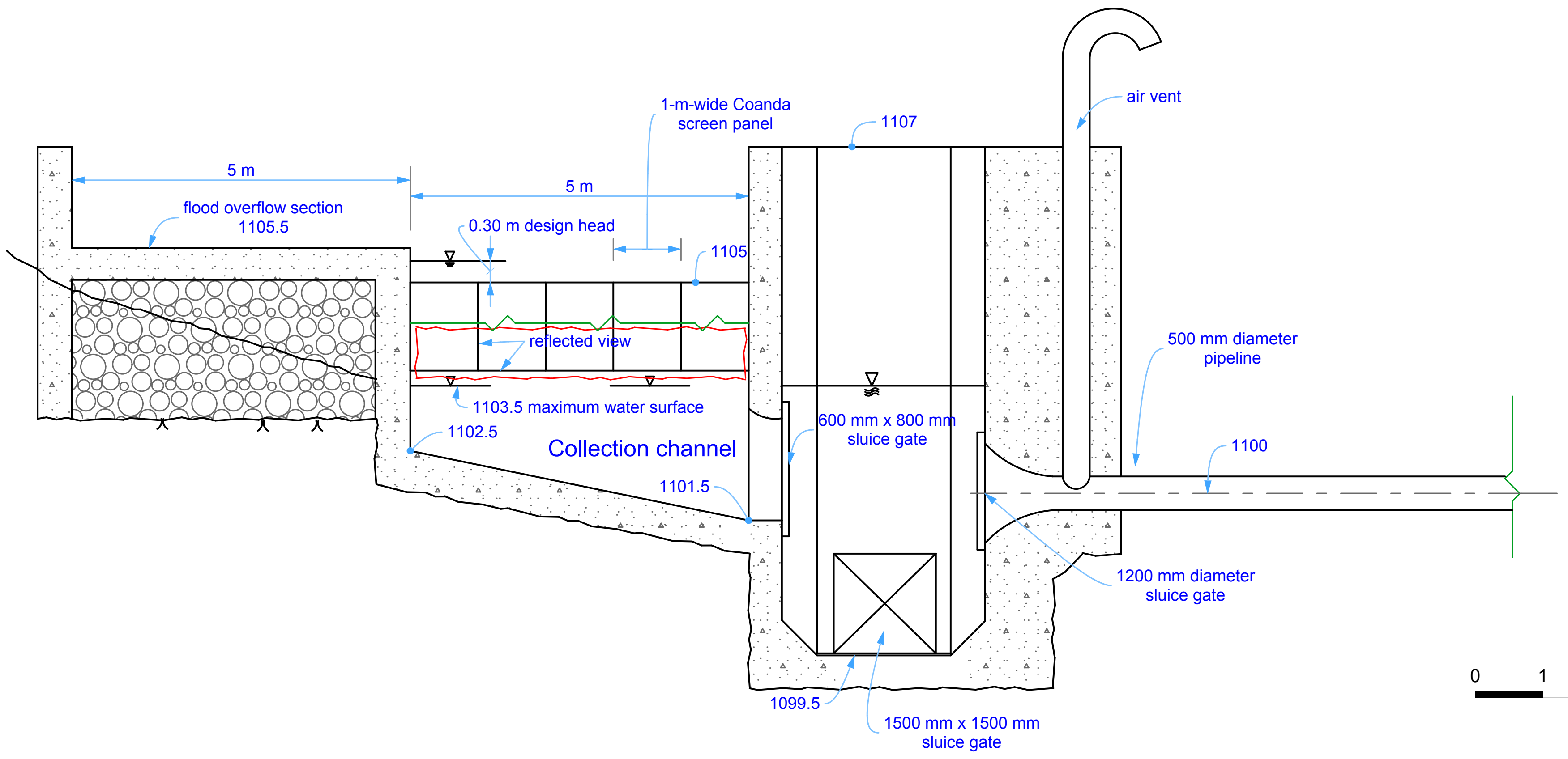
Pre-Feasibility Study Kheledula 2	
Project Arrangement	
Drawing Scale 1:20,000	September 2011



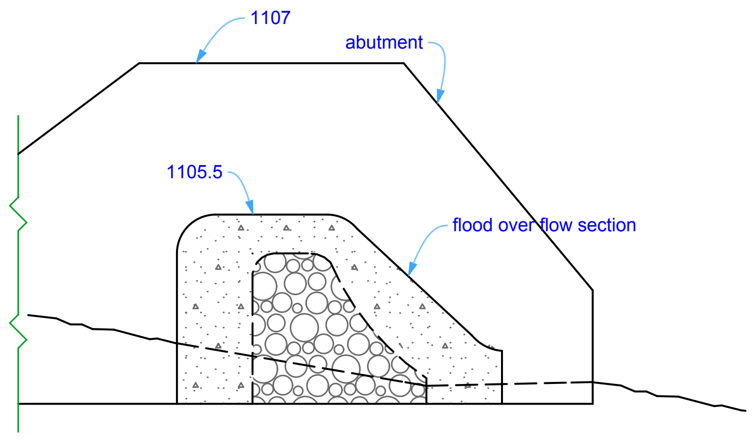
Plan



Section C-C



Section A-A



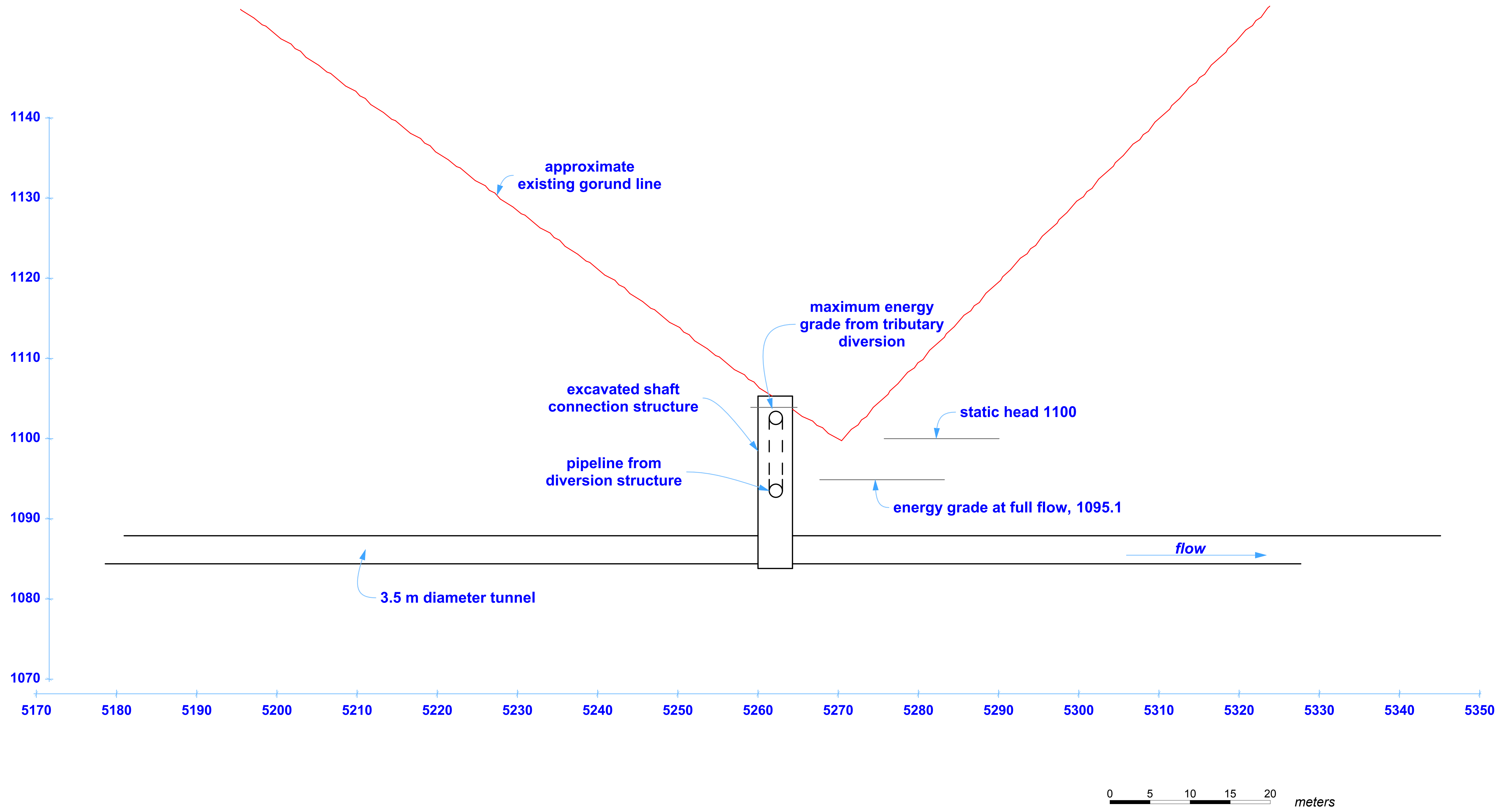
Section B-B

BLACK & VEATCH
Building a world of difference.

Pre-Feasibility Study
Kheledula 2

Tributary 2 Diversion
Plan and Sections

Drawing Scale	
1:100	**September 2011**



BLACK & VEATCH
Building a world of difference.

Pre-Feasibility Study
kheledula 2

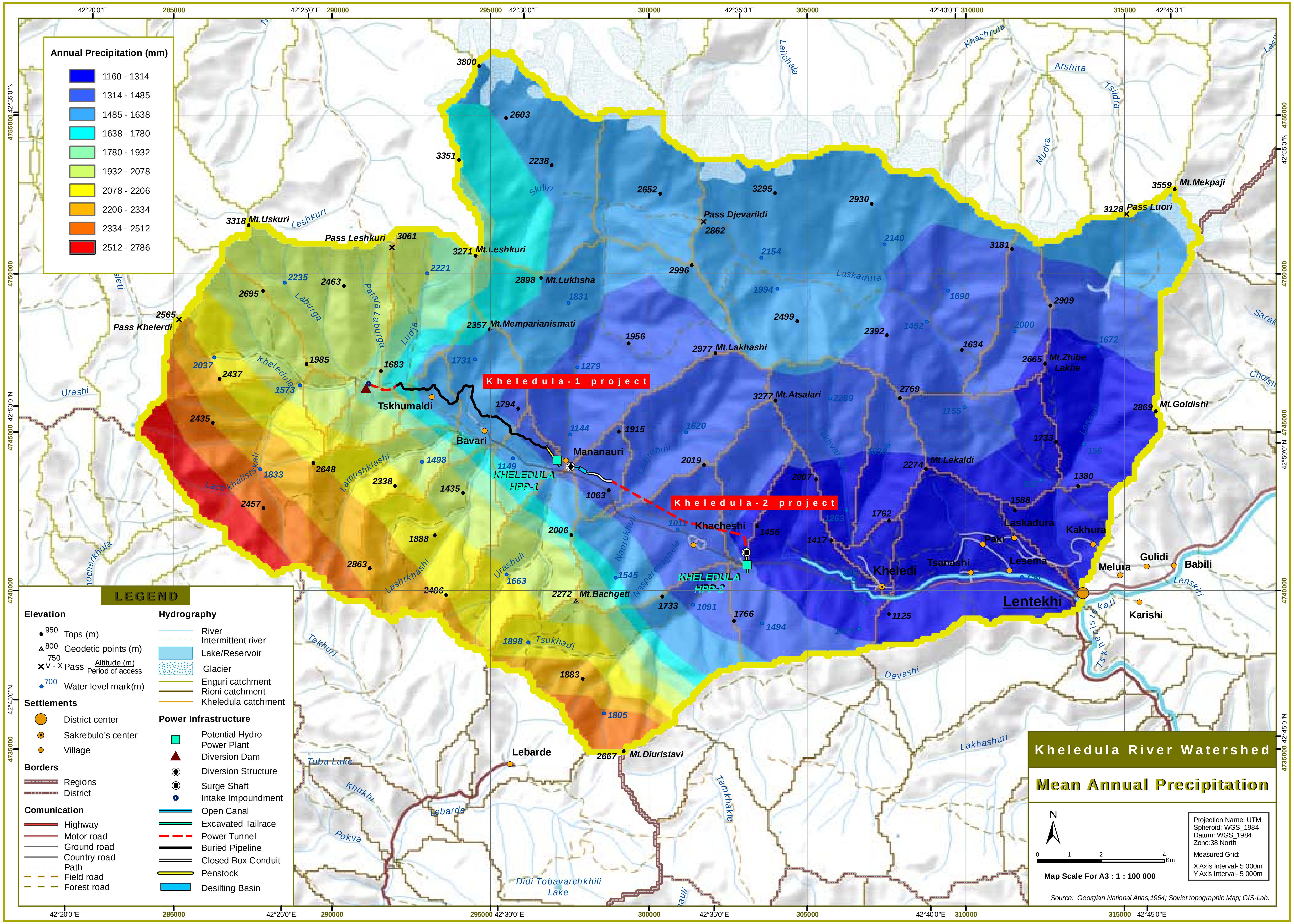
Tributary 2
Tunnel Connection

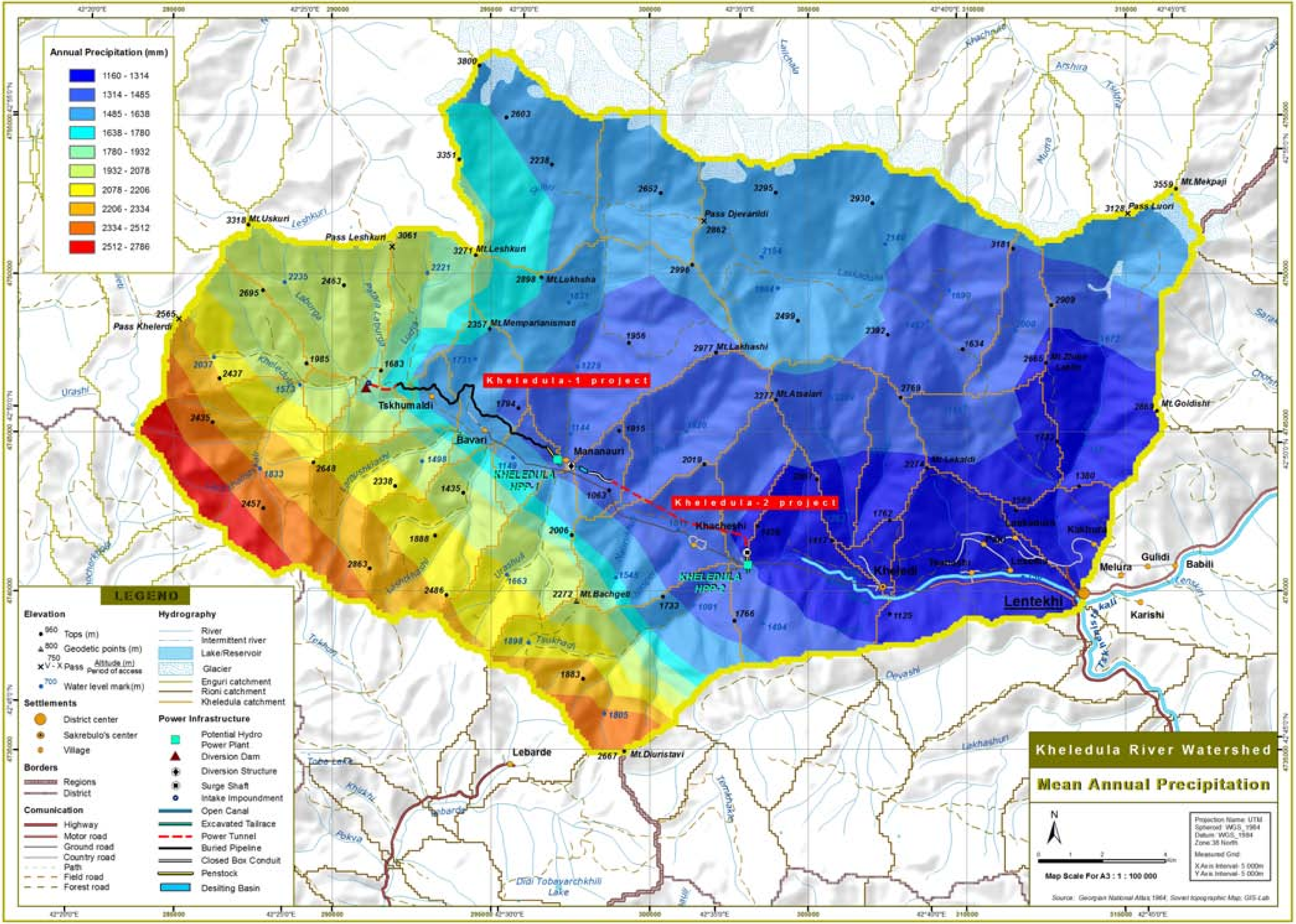
Drawing Scale 1:500

September 2011

Appendix 6

Annual Precipitation Map

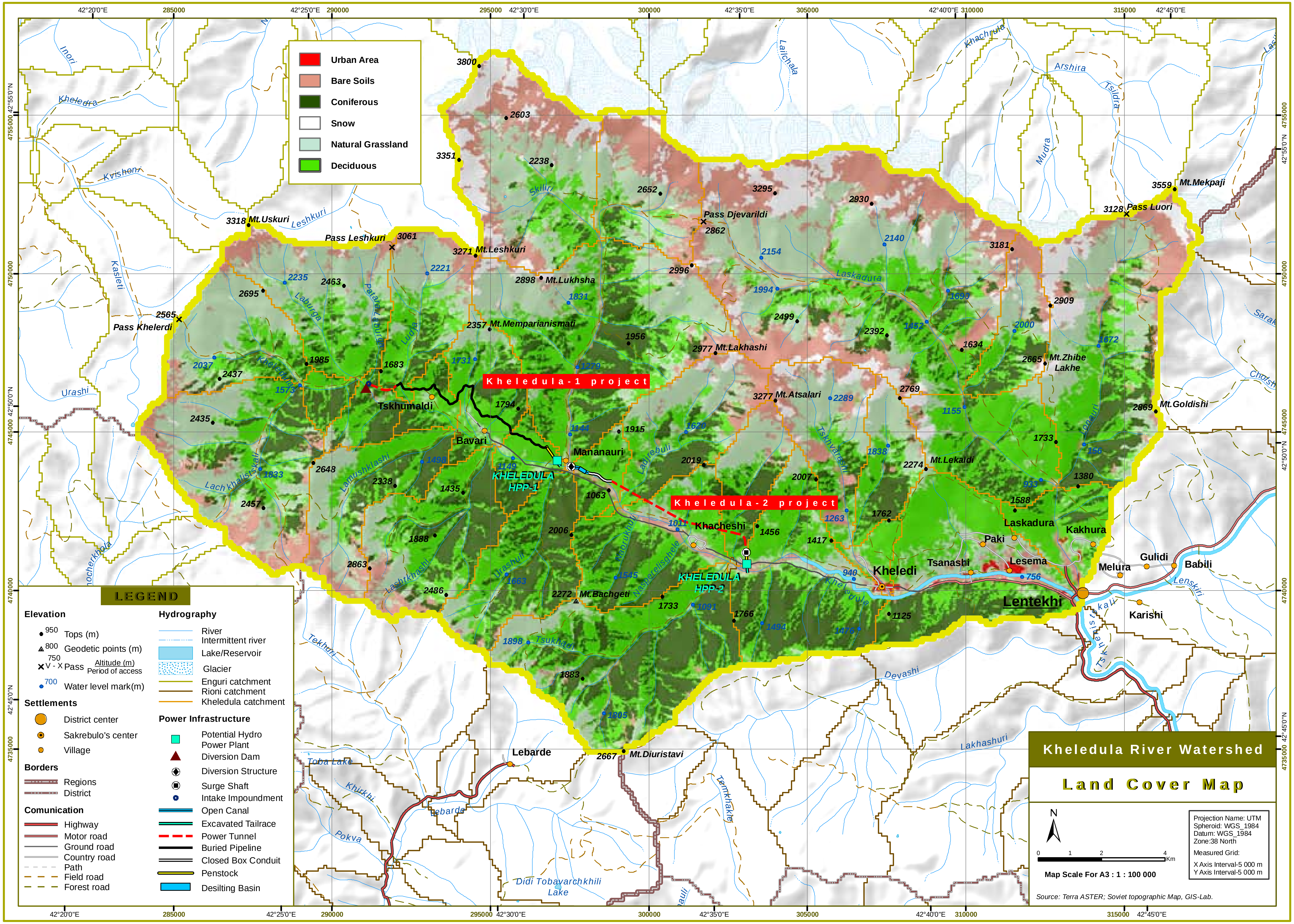

Kheledula River Watershed
Mean Annual Precipitation
Annual Precipitation (mm)
1160 - 1314
1314 - 1485
1485 - 1638
1638 - 1780
1780 - 1932
1932 - 2078
2078 - 2206
2206 - 2334
2334 - 2512
2512 - 2786
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
District center
Sakrebulo's center
Village
Borders
Regions
District
Comunication
Highway
Motor road
Ground road
Country road
Path
Field road
Forest road
Hydrography
River
Intermittent river
Lake/Reservoir
Glacier
Enguri catchment
Rioni catchment
Kheledula catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Diversion Structure
Surge Shaft
Intake Impoundment
Open Canal
Excavated Tailrace
Power Tunnel
Buried Pipeline
Closed Box Conduit
Penstock
Desilting Basin
Kheledula-1 project
Kheledula-2 project
KHELEDULA HPP-1
KHELEDULA HPP-2
Lentekhi
Kheledi
Tskhumaldi
Bavari
Mananauri
Khacheshi
Tsanashi
Lesema
Paki
Laskadura
Kakhura
Melura
Gulidi
Babili
Karishi
Lebarde
Mt.Uskuri
Pass Leshkuri
Mt.Leshkuri
Mt.Lukhsha
Mt.Memparianismati
Pass Khelerdi
Pass Djevarildi
Mt.Lakhashi
Mt.Atsalari
Mt.Lekaldi
Mt.Zhibe Lakhe
Mt.Goldishi
Mt.Mekpaji
Pass Luori
Mt.Bachgeti
Mt.Diuristavi
Toba Lake
Didi Tobavarchkhili Lake
N
Map Scale For A3 : 1 : 100 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval- 5 000m
Y Axis Interval- 5 000m
Source: Georgian National Atlas,1964; Soviet topographic Map; GIS-Lab.



Kheledula River Watershed
Mean Annual Precipitation
Annual Precipitation (mm)
1160 - 1314
1314 - 1485
1485 - 1638
1638 - 1780
1780 - 1932
1932 - 2078
2078 - 2206
2206 - 2334
2334 - 2512
2512 - 2786
Kheledula-1 project
Kheledula-2 project
KHELEDULA HPP-1
KHELEDULA HPP-2
Tskhumaldi
Bavari
Mananauri
Khacheshi
Kheledi
Lentekhi
Melura
Gulidi
Babili
Karishi
Lebarde
Mt.Uskuri
Pass Leshkuri
Mt.Leshkuri
Mt.Lakhsha
Mt.Memparianismati
Pass Kheledi
Pass Djevaridi
Mt.Lakhashi
Mt.Atsaari
Mt.Mekpaji
Pass Luori
Mt.Goldishi
Mt.Bachgeli
Mt.Diuristavi
LEGEND
Elevation
Tops (m)
Geodetic points (m)
Pass Altitude (m) Period of access
Water level mark(m)
Settlements
District center
Sakrebulo's center
Village
Borders
Regions
District
Comunication
Highway
Motor road
Ground road
Country road
Path
Field road
Forest road
Hydrography
River
Intermittent river
Lake/Reservoir
Glacier
Enguri catchment
Rioni catchment
Kheledula catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Diversion Structure
Surge Shaft
Intake Impoundment
Open Canal
Excavated Tailrace
Power Tunnel
Buried Pipeline
Closed Box Conduit
Penstock
Desilting Basin
Map Scale For A3 : 1 : 100 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval: 5 000m
Y Axis Interval: 5 000m
Source: Georgian National Atlas 1964; Soviet topographic Map; GIS-Lab

Appendix 7

Land Cover Map



Kheledula River Watershed
Land Cover Map
Urban Area
Bare Soils
Coniferous
Snow
Natural Grassland
Deciduous
LEGEND
Elevation
Tops (m)
Geodetic points (m)
V - X Pass
Altitude (m)
Period of access
Water level mark(m)
Settlements
District center
Sakrebulo's center
Village
Borders
Regions
District
Comunication
Highway
Motor road
Ground road
Country road
Path
Field road
Forest road
Hydrography
River
Intermittent river
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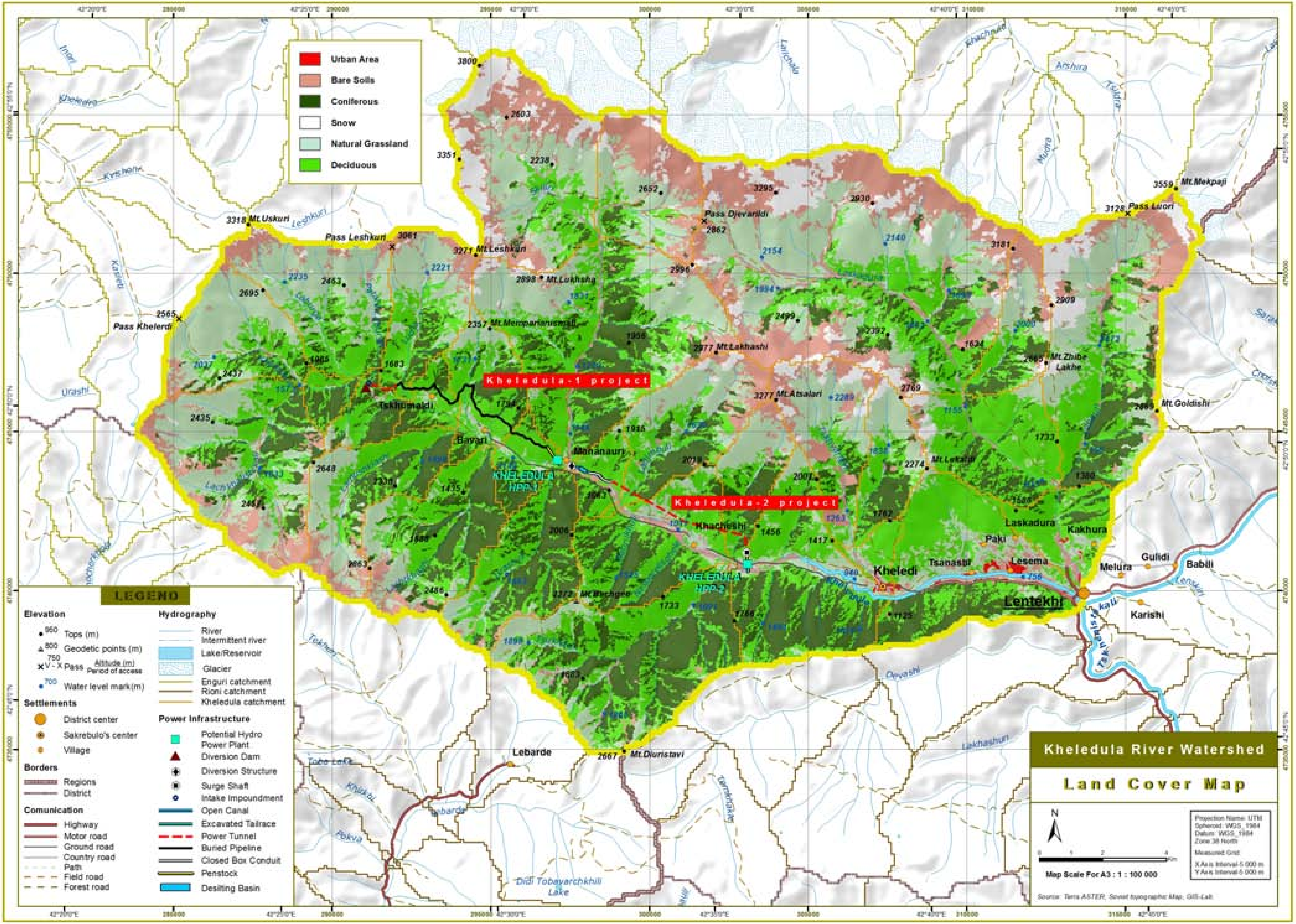
Glacier
Enguri catchment
Rioni catchment
Kheledula catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Diversion Structure
Surge Shaft
Intake Impoundment
Open Canal
Excavated Tailrace
Power Tunnel
Buried Pipeline
Closed Box Conduit
Penstock
Desilting Basin
Kheledula-1 project
Kheledula-2 project
KHELEDULA HPP-1
KHELEDULA HPP-2
Lentekhi
Kheledi
Tskhumaldi
Bavari
Mananauri
Khacheshi
Tsanashi
Paki
Lesema
Laskadura
Kakhura
Melura
Gulidi
Babili
Karishi
Lebarde
Mt.Uskuri
Pass Leshkuri
Mt.Leshkuri
Mt.Lukhsha
Mt.Memparianismati
Pass Khelerdi
Pass Djevarildi
Mt.Lakhashi
Mt.Atsalari
Mt.Lekaldi
Mt.Zhibe Lakhe
Mt.Goldishi
Mt.Mekpaji
Pass Luori
Mt.Bachgeti
Mt.Diuristavi
Toba Lake
Didi Tobavarchkhili Lake
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-5 000 m
Y Axis Interval-5 000 m
Map Scale For A3 : 1 : 100 000
Source: Terra ASTER; Soviet topographic Map, GIS-Lab.


Kheledula River Watershed
Land Cover Map
Urban Area
Bare Soils
Coniferous
Snow
Natural Grassland
Deciduous
Kheledula-1 project
Kheledula-2 project
KHELEDULA HPP-1
KHELEDULA HPP-2
Lentekhi
Kheledi
Tsanashi
Lesema
Paki
Laskadura
Kakhura
Melura
Gulidi
Babili
Karishi
Khacheshi
Mananauri
Bavari
Tskhumaldi
Lebarde
Pass Khelerdi
Pass Leshkuri
Mt.Uskuri
Mt.Leshkan
Mt.Lukhsha
Pass Djevaridi
Mt.Lakhashi
Mt.Atsalari
Mt.Lekadi
Mt.Zhibe Lakhe
Mt.Goldishi
Pass Luori
Mt.Mekpaji
Mt.Diuristavi
Didi Tobavarchkhili Lake
LEGEND
Elevation
Tops (m)
Geodetic points (m)
Pass Altitude (m) Period of access
Water level mark(m)
Settlements
District center
Sakrebulo's center
Village
Borders
Regions
District
Comunication
Highway
Motor road
Ground road
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Field road
Forest road
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River
Intermittent river
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Glacier
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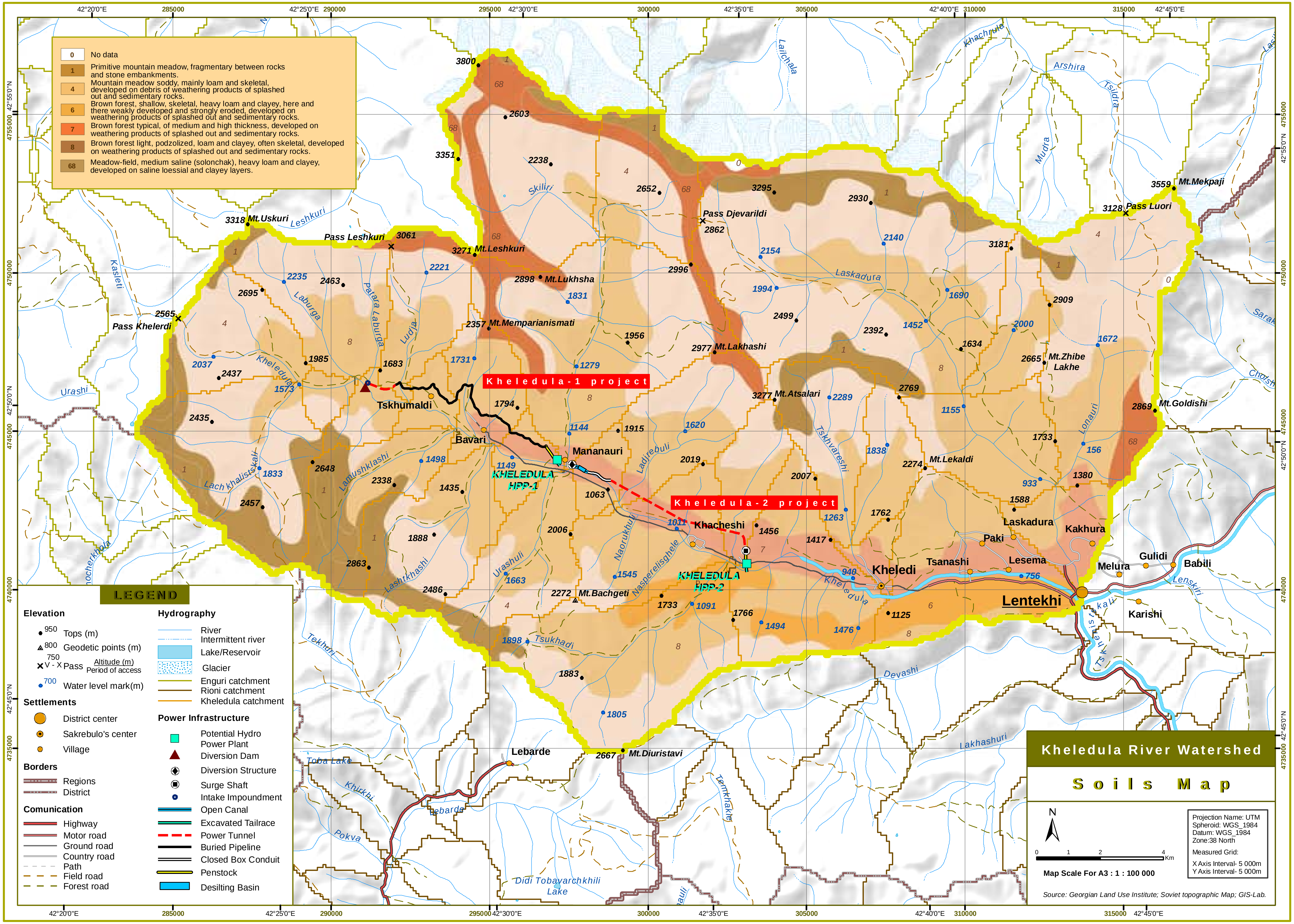
Rioni catchment
Kheledula catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Diversion Structure
Surge Shaft
Intake Impoundment
Open Canal
Excavated Tailrace
Power Tunnel
Buried Pipeline
Closed Box Conduit
Penstock
Desilting Basin
Map Scale For A3 : 1 : 100 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Source: Terra ASTER, Soviet topographic Map, GIS-Lab

Appendix 8

Soils Map


Kheledula 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.
68 Meadow-field, medium saline (solonchak), heavy loam and clayey, developed on saline loessial and clayey layers.
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
District center
Sakrebulo's center
Village
Borders
Regions
District
Comunication
Highway
Motor road
Ground road
Country road
Path
Field road
Forest road
Hydrography
River
Intermittent river
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Glacier
Enguri catchment
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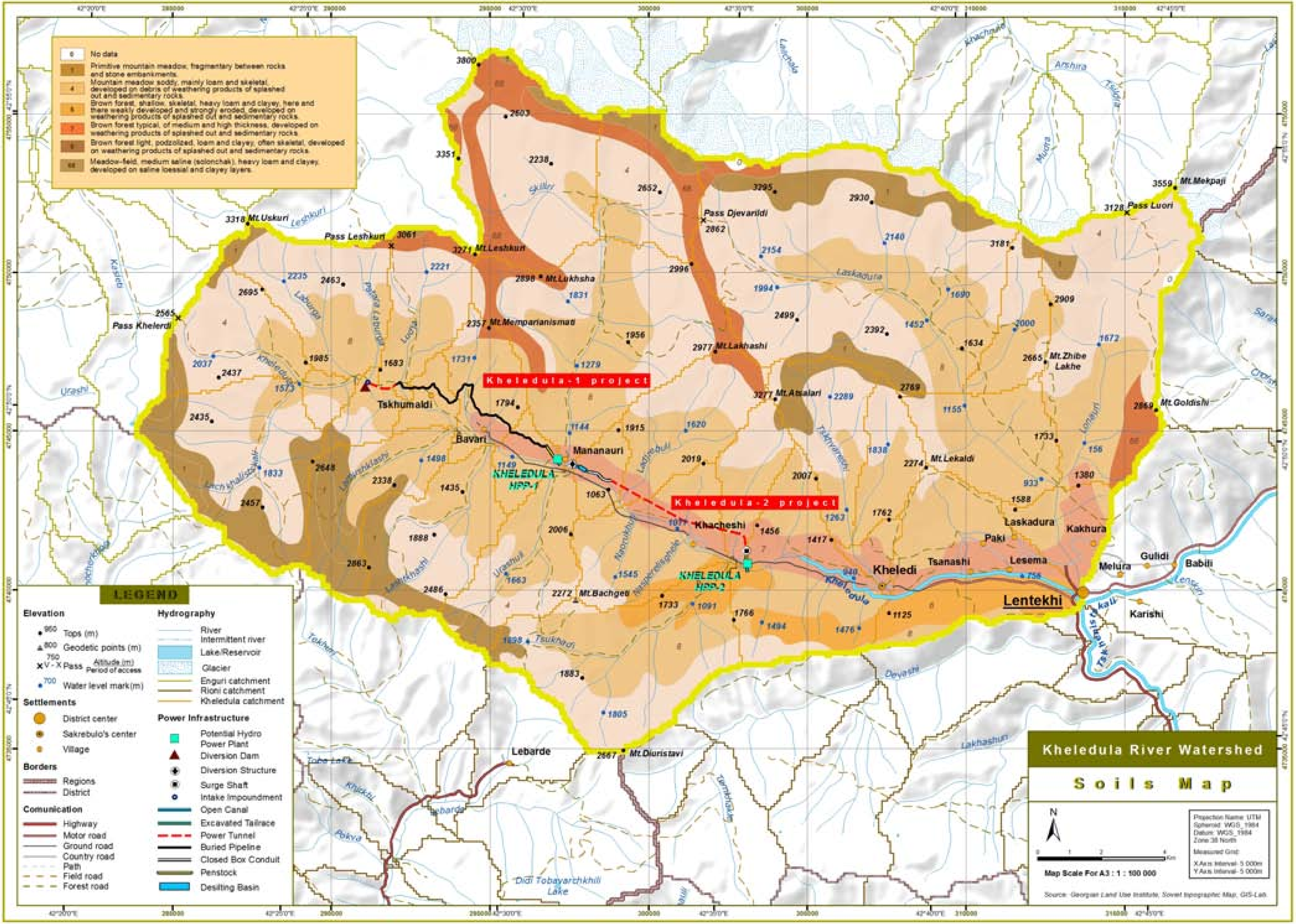
Potential Hydro Power Plant
Diversion Dam
Diversion Structure
Surge Shaft
Intake Impoundment
Open Canal
Excavated Tailrace
Power Tunnel
Buried Pipeline
Closed Box Conduit
Penstock
Desilting Basin
Kheledula-1 project
Kheledula-2 project
KHELEDULA HPP-1
KHELEDULA HPP-2
Lentekhi
Kheledi
Khacheshi
Mananauri
Bavari
Tskhumaldi
Tsanashi
Lesema
Paki
Laskadura
Kakhura
Melura
Gulidi
Babili
Karishi
Lebarde
Mt.Uskuri
Pass Leshkuri
Mt.Leshkuri
Mt.Lukhsha
Mt.Memparianismati
Pass Djevarildi
Mt.Lakhashi
Mt.Atsalari
Mt.Lekaldi
Mt.Zhibe Lakhe
Mt.Goldishi
Mt.Mekpaji
Pass Luori
Pass Khelerdi
Mt.Bachgeti
Mt.Diuristavi
Toba Lake
Didi Tobavarchkhili Lake
N
0 1 2 4 Km
Map Scale For A3 : 1 : 100 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval- 5 000m
Y Axis Interval- 5 000m
Source: Georgian Land Use Institute; Soviet topographic Map; GIS-Lab.



Kheledula 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.
68 Meadow-field, medium saline (solonchak), heavy loam and clayey, developed on saline loessial and clayey layers.
Kheledula-1 project
Kheledula-2 project
KHELEDULA HPP-1
KHELEDULA HPP-2
Tskhumaldi
Bavari
Mananauri
Khacheshi
Kheledi
Tsanashi
Paki
Laskadura
Kakhura
Lesema
Melura
Gulidi
Babili
Lentekhi
Karishi
Lebarde
Mt.Uskuri
Pass Leshkuri
Mt.Leshkuri
Mt.Lukhsha
Pass Djevarildi
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Pass Luori
Pass Khelerdi
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Mt.Lakhashi
Mt.Atsalari
Mt.Zhibe Lakhe
Mt.Goldishi
Mt.Lekaldi
Mt.Bachgeti
Mt.Diuristavi
LEGEND
Elevation
Tops (m)
Geodetic points (m)
Pass Altitude (m) Period of access
Water level mark(m)
Settlements
District center
Sakrebulo's center
Village
Borders
Regions
District
Comunication
Highway
Motor road
Ground road
Country road
Path
Field road
Forest road
Hydrography
River
Intermittent river
Lake/Reservoir
Glacier
Enguri catchment
Rioni catchment
Kheledula catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Diversion Structure
Surge Shaft
Intake Impoundment
Open Canal
Excavated Tailrace
Power Tunnel
Buried Pipeline
Closed Box Conduit
Penstock
Desilting Basin
Map Scale For A3 : 1 : 100 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval: 5 000m
Y Axis Interval: 5 000m
Source: Georgian Land Use Institute, Soviet topographic Map, GIS-Lab.

Appendix 9

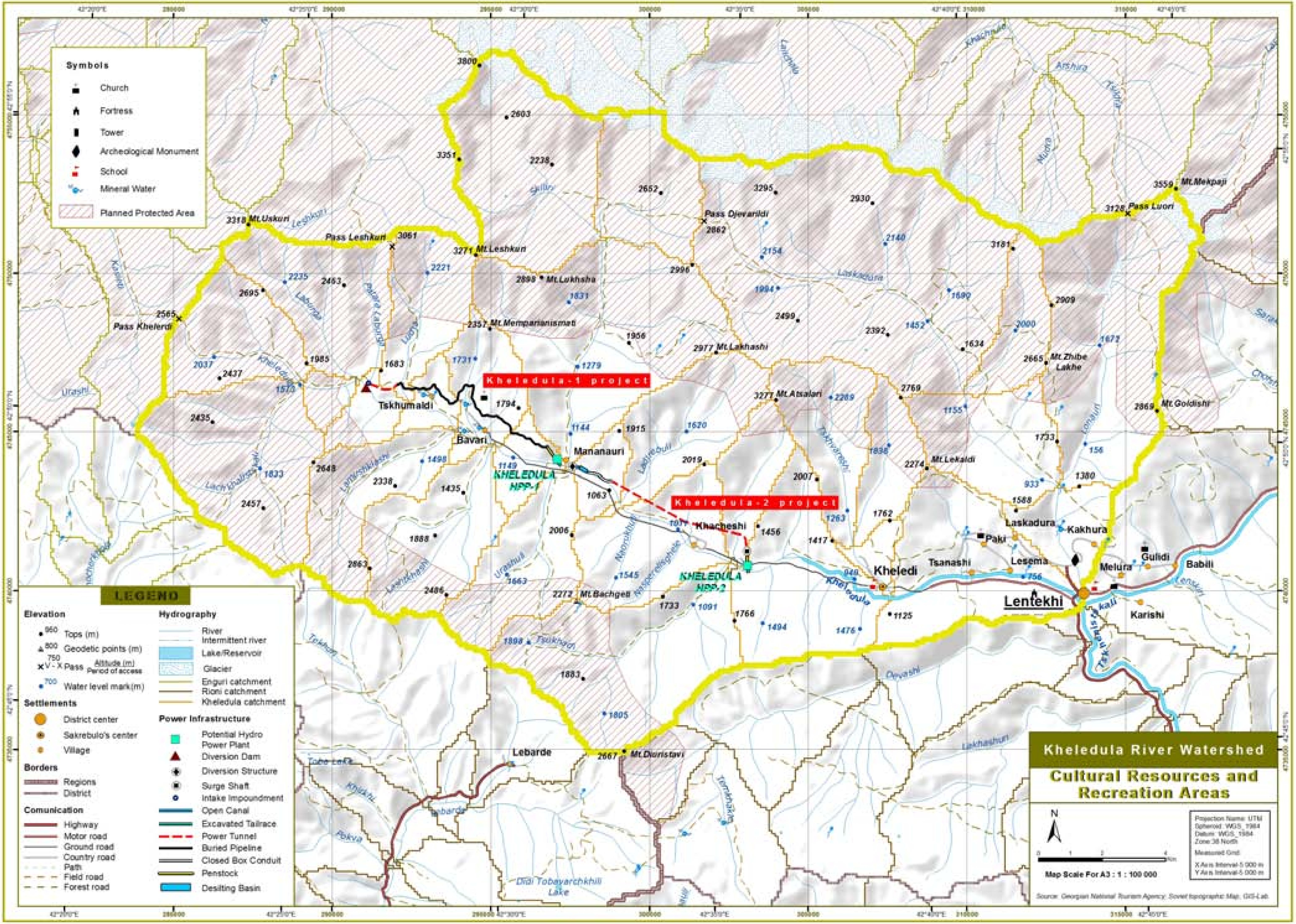
Cultural Resources & Recreation Areas

Historical, Cultural and Archeological Resources in the Lentekhi District

#	Name	Location	Dated
1	Church "Matskhovari"	Village Bavari, (3 km north-west from the village)	Late Medieval
2	St. George's Church	Village Kheledi	XIX-XX A.D.
3	Complex of the ruins of "Dzughareshi"	Village Kheledi	Medieval
4	Church	Village Kheledi	XX A.D.
5	Tower building	Village Buleshi	Late Medieval
6	Gardapkhadze's Tower building and House	Village Tekali	-
7	Zagoleti Church	Village Tekali, surroundings	XI-XII A.D.
8	Tower	Lentekhi	Early Medieval
9	Charkviani's Tower	Village Leushera	Late Medieval
10	Larashi – Dadiani's Castle and Tower	Village Leksura	Medieval
11	St. George's Church (Jgragi)	Village Ludji (on the territory of the cemetery)	X-XI A.D.
12	Tower Building	Village Mami	Late Medieval
13	Church "Matskhovari"	Village Mami	X-XI A.D.
14	St. George's Church (Jgragi)	Village Margvishi	Medieval
15	Machubebi Complex	Village Makhashi	Late Medieval
16	Tower "Moroldirad"	Village Makhashi (1 km west from the village)	Late Medieval
17	Oniani's Tower	Village Mebetsi	Late Medieval
18	Church	Village Mele(on the territory of the cemetery)	Late Medieval
19	Oniani's Tower	Village Mele	Late Medieval
20	Church Tarigzeli (Church for Archangel)	Village Mutsdi	Late Medieval
21	Church Tarigzeli (Church for Archangel)	Village Natsuli	Late Medieval
22	Church Tarigzeli (Church for Archangel)	"Sandy" Surroundings of Village Sasa	Late Medieval
23	St. George's Church (Jgragi)	Village Sakdari	Late Medieval
24	Tower	Village Tvibi (0,5 km north from the village)	Late Medieval

25	Church Tarigzeli (Church for Archangel)	Village Tvibi surroundings	X-XI A.D.
26	Church Tarigzeli (Church for Archangel)	Village Paki	Medieval
27	St. Mary Church	Village Ghobi	
28	Church "Matskhovari"	Village Ghobi	Late Medieval
29	Tower Building	Village Shvitili	Late Medieval
30	Lamaria Church	Village Chikhareshi (on the territory of the cemetery)	XIX A.D.
31	Lamaria Church	Village Chikhareshi (Dabishi)	Medieval
32	Church Tarigzeli (Church for Archangel)	Village Chukuli	Medieval
33	"Sianebis" Tower	Village Chukuli, "Nakisheri"	Medieval
34	Church	Village Chukuli (1 km north from the village)	Medieval
35	Church "Muchpa"	Village Chukuli surroundings	XII-XIII A.D.
36	Church Tarigzeli (Church for Archangel)	Village Chukuli surroundings	X-XII A.D.
37	Church	Village Kheria, Lamzagora	IX-X A.D.
38	St. George's Church (Jgragi)	Village Zhakhunderi	XI-XII A.D.

Source: Ministry of Culture of Georgia(2006)
Management Plan for Racha-Lechkhumi-Lower Svaneti Planned Protected Areas (2008)


Kheledula River Watershed
Cultural Resources and Recreation Areas
Symbols
Church
Fortress
Tower
Archeological Monument
School
Mineral Water
Planned Protected Area
LEGEND
Elevation
Tops (m)
Geodetic points (m)
Pass Altitude (m) Period of access
Water level mark(m)
Settlements
District center
Sakrebulo's center
Village
Borders
Regions
District
Comunication
Highway
Motor road
Ground road
Country road
Path
Field road
Forest road
Hydrography
River
Intermittent river
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Glacier
Enguri catchment
Rioni catchment
Kheledula catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Diversion Structure
Surge Shaft
Intake Impoundment
Open Canal
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Buried Pipeline
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Penstock
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Kheledula-1 project
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KHELEDULA HPP-1
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Tskhumaldi
Bavari
Mananauri
Khacheshi
Kheledi
Tsanashi
Paki
Laskadura
Kakhura
Lesema
Melura
Gulidi
Babili
Lentekhi
Karishi
Lebarde
Mt.Uskuri
Pass Leshkuri
Mt.Leshkuri
Mt.Lukhsha
Mt.Mempanianismati
Pass Kheledi
Pass Djevanildi
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Mt.Atsalari
Mt.Lekaldi
Mt.Zhibe Lakhe
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Projection Name: UTM
Spheroid: WGS_1984
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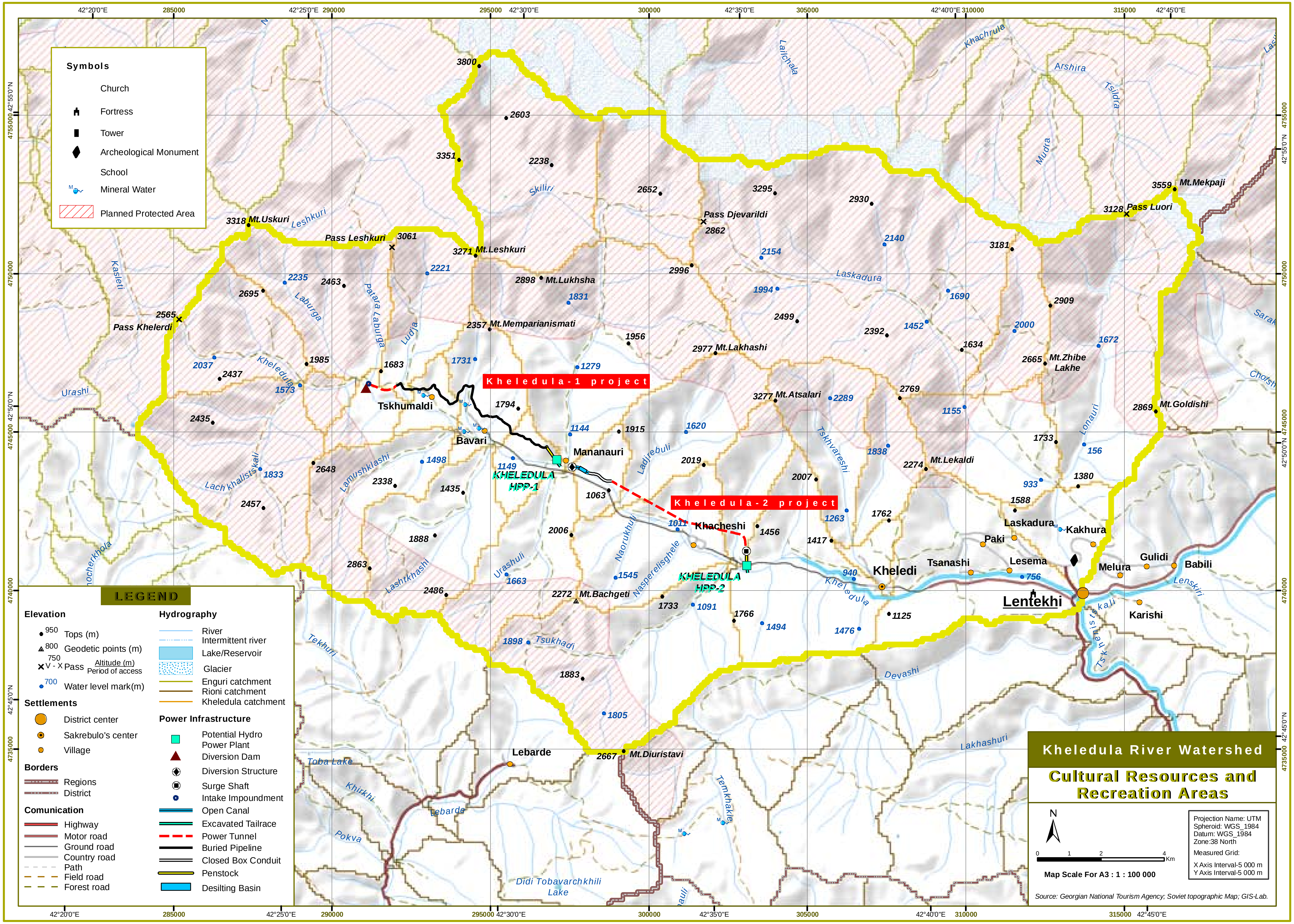
Kheledula River Watershed
Cultural Resources and Recreation Areas
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Fortress
Tower
Archeological Monument
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Mineral Water
Planned Protected Area
LEGEND
Elevation
950 Tops (m)
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700 Water level mark(m)
Settlements
District center
Sakrebulo's center
Village
Borders
Regions
District
Comunication
Highway
Motor road
Ground road
Country road
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Lentekhi
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Bavari
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Tsanashi
Lesema
Laskadura
Kakhura
Paki
Melura
Gulidi
Babili
Karishi
Lebarde
Mt.Uskuri
Mt.Leshkuri
Mt.Lukhsha
Mt.Memparianismati
Mt.Lakhashi
Mt.Atsalari
Mt.Lekaldi
Mt.Zhibe Lakhe
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Mt.Mekpaji
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X Axis Interval-5 000 m
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Map Scale For A3 : 1 : 100 000
Source: Georgian National Tourism Agency; Soviet topographic Map; GIS-Lab.

Appendix 10

Environmental and social impacts Significant Data

Public Awareness Workshop Report

TITLE: Public Awareness Workshop in Tsageri Community

DATE: 05.13.2011

VENUE: Tsageri Municipality (Gamgeoba) Building

Speakers:

Dennis McCandless, HIPP Project, Black&Veatch, Professional Engineer
Mariam Bakhtadze, Environmental Specialist, Deloitte, HIPP Project
Avtandil Lomiashvili, Engineer, Deloitte, HIPP Project

Background:

The United States Agency for International Development (USAID) through the Hydropower Investment Promotion Project (HIPP) supports development of a minimum 400 MW in new, run-of-the-river hydropower stations in Georgia. This project is managed by Deloitte Consulting. As part of this program, HIPP has identified a cluster of project sites along the Tskhenistskali River. HIPP is now conducting pre-feasibility studies for two projects with a total capacity of 230 MW. These two HPP sites are on the River Tskhenistskali in Racha-Lechkhumi-Kvemo Svaneti Region, near Lentekhi and Tsageri.

The HIPP team is preparing basic technical studies to evaluate the technical and economical feasibility of the projects. As part of this process, public awareness workshop was held in Tsageri community to ensure community involvement at the early planning stage, identify areas of community concern, and gather feedback from local residents.

The project profiles, HIPP information leaflets and USAID energy map was used as supportive documentation. Meeting agenda, advertisement, list of participants and photos are attached to this document as illustrative materials.

Aim of the Workshop:

- To increase awareness of local communities on small and medium run-of-the-river hydro power plans and promote their support to such activities;
- To inform local community the goal of the project and ensure their involvement at the early planning stage;
- Identify community concerns regarding the possible development of the project and gain their feedback; ensure positive attitude towards the project and increase cooperation perspectives between public and project developers.

Workshop Process:

The purpose of the meetings was to provide information and get the opinions of the locals related to the project. The date, place and the scope of these meeting was preliminary informed and agreed with Tsageri and Lentekhi Municipalities during HIPP team field visits. Meeting date and venue were agreed with local Municipalities; Public workshop was announced through advertisements and distributed to the both municipalities as well as distributed through electronic media sources (CENN mailing list).

The primary stakeholders (landowners, vendors, hawkers, and local authorities) were identified by HIPP team and informal meetings were conducted beforehand during field trips. During those preliminary meetings stakeholders were informed about the planned public awareness workshop and were asked their attendance. Besides, HIPP team facilitated attendance of both municipality members on the workshop. Totally 45 community members were attending the workshop (attached see list of participants).

During the workshop HIPP team members provide information about project in general, and discussed technical characteristics of the proposed HPP project as well as possible environmental and social impact. Issue that project will not create significant impoundment causing displacement of adjacent population was stressed during the workshop.

The HIPP team stressed the importance of public participation in early project design phase. Participants have been asked to express their opinion/attitude towards the project in general as well as impact on environment and socio-economic conditions of their household.

The municipality representatives mentioned a few considerations about the project impacts both environmental and socio-economic point of view.

Key issues/concerns rose by community members were as follows:

- Few questions were asked about the landslide risks and previous experiences with similar types of projects such as laganuri HPP; Lajanuri reservoir is 25.0 million m^3 on overall, useful volume is 17.0 million m^3 and surface area is 1.6 km^2. The Lajanuri reservoir operates the Lajanuri HPP with installed capacity of 112 MW; reservoir entered into operation in 1960. Currently reservoir is full with sediments. Frequent uninformed release of the water from reservoir cause impact on downstream population and land users (water floods their agricultural lands and homes);
- Local benefits of project; Community members were interested whether they could benefit from the low electricity tariffs;
- Community members think they would benefit from employment during the project implementation;

Certain fear of local population relates to possible change of ecological conditions within the project impact area resulting in negative outcomes for agricultural, historical-cultural objects as well as increase of landslide risks; Laganuri hadro is already operating in Tsageri community and the development of two more hydro's (Namakhvani and Tsageri-Lentekhi) has been planned. This issue triggered community members to questioning the cumulative impact on Tskhenistskali watershed from operating three hydro power plants.

CONCLUSIONS:

The Tsageri public awareness workshop outcome is as follows:

- Generally, community's attitude towards the project development is positive; Community members think they could benefit from development of project in case the project developers properly consider their concerns/suggestions and watershed characteristics. On the other hand, community members are willing to cooperate with HPP project developers. From operation of the HPP local population expects to receive new job opportunities;
- It was agreed that further development of the project would be further discussed with the community members.

Other Needs and Suggestions

- For ensuring participatory attitudes and practices in HPP community it would be reasonable to develop informative leaflet covering issues associated with the project development, including environmental implications and distribute to the communities during organizing the meetings.

The table below shows the public awareness meeting in Tsageri municipality.

Table 1. ***Pictures of the public awareness workshop***

PREPARED BY: Mariam Bakhtadze, Irina Iremashvili

APPROVED BY: Michael Jake Delphia, CoP

Attachment A: Public Awareness Workshop Agenda

Public Awareness Meeting for Tskhenistskali HPP Cascade Project

Agenda

13 May, 2011, Lentekhi Municipality Gamgeoba Building

11:00–11:15	Registration		
	Introductions	**Moderator :**	Duration
11.15–11.20	Opening Remarks	HIPP/D. McCandless, Local Municipality	5 min
11:20–11:30	HIPP Project Descriptions	HIPP/A. Lomiashvili/G. Chikovani	10 min
11:30–12:00	HPP Project Outline	HIPP/A. Lomiashvili	30 min
12:00–12:20	Presentation of Identified Environmental/Social Issues	HIPP/M. Bakhtadze	20 min
	Questions and Discussion		
12:20–13.45	Filling Out of Meeting Questionnaire Discussion • Socioeconomic Issues • Environmental Issues • Public Health & Safety Issues • Construction Issues	Facilitated by HIPP/I.Iremashvili Facilitated by HIPP/I.Iremashvili	1 hour and 25 min
13:45–14:00	**Concluding Remarks**	HIPP/D.McCandless, Local Municipality	15 min

Attachment B: Public Awareness Advertisement (distributed in Georgian and English languages)

Announcement:

Subject: Public Awareness Meeting in Tsageri and Lentekhi Communities

Project: Hydropower Investment Promotion Project

Dear Sir/Madam,

The United States Agency for International Development (USAID) through the Hydropower Investment Promotion Project (HIPP) supports development of a minimum 400 MW in new, run-of-the-river hydropower stations in Georgia. This project is managed by Deloitte Consulting. As part of this program, HIPP has identified a cluster of project sites along the Tskhenistskali River. HIPP is now conducting pre-feasibility studies for two projects with a total capacity of 230 MW. These two HPP sites are on the River Tskhenistskali in Racha-Lechkhumi-Kvemo Svaneti Region, near Lentekhi and Tsageri.

The HIPP team is preparing basic technical studies to evaluate the technical and economical feasibility of the projects. As part of this process a public awareness workshop will be held to ensure community involvement at the early planning stage, identify areas of community concern, and gather feedback from local residents.

Therefore, we are pleased to invite you to participate in this public meeting, which will be held on **May 13 2011** in Tsageri Municipality, Gamgeoba Building, #64 Rustaveli Street, Tsageri, Georgia; at a time of 11:00.

For additional information, please contact Ms. Mariam Bakhtadze by telephone (+995 32) 23 45 70/71 or e-mail: mbakhtadze@dcop-hipp.ge. Enclosed please find a copy of the workshop's agenda.

Please be advised the workshop will be conducted in Georgian.

Sincerely,

Michael James Delphia

Deloitte Consulting LLP
Chief of Party
USAID-funded Hydropower Investment Promotion Project (HIPP)
I. Chavchavadze Avenue 17b, Suite 1
Tbilisi, 0179, Georgia
Tel: [+995 32]-22 45 70/71

განცხადება ცაგერის და ლენტეხის თემებთან შეხვედრის შესახებ

ჰიდროენერგეტიკაში ინვესტიციების ხელშეწყობის პროექტი

ბატონებო და ქალბატონებო,

გაცნობებთ, რომ ამერიკის შეერთებული შტატების სააგენტო (USAID) ახორციელებს ჰიდროენერგეტიკაში ინვესტიციების ხელშეწყობის პროექტს, რომლის მიზანია მინიმუმ 400 მეგავატის ჯამური სიმძლავრის ახალი სადერივაციო ტიპის ჰესების შექმნის ხელშეწყობა. ამ ინიციატივის ფარგლებში, პროექტმა იდენტიფიცირება მოახდინა 230 მეგავატ ჯამური სიმძლავრის ჰიდროელექტროსადგურის კასკადისა მდინარე ცხენისწყალზე, რაჭა-ლეჩხუმი-ქვემო სვანეთის რეგიონში.

ამ მიზნით, HIPP პროექტი გეგმავს ჩაატაროს პროექტის საბაზისო შეფასება, რომელიც დაადგენს მის ტექნიკურ-ეკონომიკურ მიზანშეწონილობას. ამ საქმიანობის ფარგლებში ჩატარდება საჯარო შეხვედრა, რომლის მიზანია საზოგადოების პროცესში ჩართვა პროექტის დაგეგმვის სტადიაზე და მათგან მოსაზრებების/შენიშვნების მიღება.

ცხენისწყალის ჰიდროელექტროსადგურების კასკადის პროექტის განხილვები გაიმართება 2011 წლის 13 მაისს, ცაგერის მუნიციპალიტეტის გამგეობის შენობაში. მის: ცაგერი, რუსთაველის ქ. 64, 11 საათზე. დამატებითი ინფორმაციისათვის გთხოვთ დაუკავშირდეთ მარიამ ბახტაძეს ტელ: (+995 32) 24 45 70/71 ელ.ფოსტა: mbakhtadze@dcop-hipp.ge. აქვე იხილეთ შეხვედრის დღის წესრიგი.

პატივისცემით,

მაიკლ ჯეიკ დელფია
ჰიდროენერგეტიკაში ინვესტიციების ხელშეწყობის პროექტის ხელმძღვანელი
ი.ჭავჭავაძის გამზირი. 17, ბ.1;
ტელ: (+995 32) 22 45 70/71

Attachment C: Attendance list

Event Name		
Dates	05.13.2001	12.00-03.00 pm

#	First Name, Last Name	Position	Contact Details	Comment
1	Miranda Saghinadze	Deputy “Gamgebeli” (Governor), Tsageri Municipality “Gamgeoba” (Governor’s Office)	877 95 25 35	*Interested in other similar practices, Concerned about the implications of Ladjanuri HPP, tried to discuss the measures to avoid negative impact.*
2	Tsito Partsuliani	Chief Specialist, Tsageri Municipality	899 74 58 56	*Negative attitude towards constructions of HPPs due to their influence on Tsageri agricultural lands and flooding.*
3	Venera Goletiani	Chief Specialist, Tsageri Municipality	899 90 57 37	
4	Mamuka Letodiani	Chairman, Tsageri Municipality “Sakrebulo” (Council)	899 29 56 13	*More constructive and eager to cooperate to avoid possible complications on social and environmental issues in the region*
5	Lela Bakhsoliani	Chief Specialist, Administration, Tsageri Municipality “Gamgeoba”	898 20 98 22	
6	Inga Burdjaliani	Chief Specialist, Tsageri Municipality	895 56 98 47	
7	Mzekala Leshkali	Chief Specialist, Tsageri Municipality	895 50 99 98	
8	Mevlud Meshveliani	Chief Specialist, Tsageri Municipality	851 27 58 27	
9	Mirza Khometiani	Head of Administration, Tsageri Municipality	851 40 31 40	*Very active, aware of anticipated results and concerned about negative implications of project implementation; requiring certain compensation measures*
10	Mirian Saghinadze	Chief Specialist, Economy and Property Management Department, Tsageri Municipality	891 13 49 13	
11	Bondo Melitauri	Specialist, Economy and Property Management Department, Tsageri	895 26 84 68	

		Municipality		
12	Temur Silagadze	Chief Specialist, Economic Service, Tsageri Municipality	899 90 987 10	
13	Avto Epadze	Head of Community, Village Chkhuneti	895 49 18 01	
14	Badri Chokhonelidze	Specialist, Infrastructure and Logistics Service, Tsageri Municipality	898 22 07 85	
15	Zaur Benidze	Leading Specialist in Tourism Issues, Tsageri Municipality	899 25 50 04	
16	Kakha Tskhvediani	Head of Financial and Budgeting Department , Tsageri Municipality		
17	Giorgi Kopaliani	Tsageri Municipality	899 13 70 73	
18	Giorgi Gugava	Tsageri Municipality Cultural Center	898 10 65 72	
19	Giorgi Omanidze	Tsageri Municipality	890 34 43 21	
20	Vakhtang Benidze	Village Zubi Community Member	899 35 79 42	
21	Nugzar Esvaldiani	Tsageri Municipality	839 14 03 52	
22	Malvina Silagadze	Tsageri Municipality	899 26 69 31	
23	Sopho Gvishiani	Head of Architecture and Supervisory Department, Tsageri Municipality "Gamgeoba	899 27 58 08	
24	Rostom Burjaliani	Tsageri Municipality	899 78 47 02	
25	Nani Shengelia	Tsageri Municipality	890 34 43 70	
26	Khatia Akhvlediani	Administrative Assistant to "Gamgebeli", Tsageri Municipality	891 66 26 94	
27	Diana Tsvariani	Administrative Service, Tsageri Municipality	898 51 43 58	
28	Takhu Chankseliani	Chief Specialist, Lentekhi Municipilaty "Gamgeoba"	895 97 80 96	
29	Tornike Gugava	Lentekhi Municipality "Sakrebulo"	851 97 80 96	
30	Tornike Mukbaniani	Lentekhi Municipality "Sakrebulo"	851 32 32 15	
31	Mamuka Liparteliani	Lentekhi Municipality "Sakrebulo"	899 69 92 38	*Interested in other similar practices, cooperative and concerned about environmental issues*
32	Bezhan Chumburidze	Vice-Chairman, " Sakrebulo", Tsageri Municipality	899 55 50 52	*More positive expectations and ready for constructive cooperation with the project team and the authorities*
33	Tamar Davituliani	Chief Specialist, Public Relations department, Lentekhi Municipality	899 95 16 78	
34	Tsitsino Pandjaradze	Chief Specialist, Tsageri Municipality	890 15 58 01	
35	Irine Liparteliani	Chairman of Commission, Lentekhi "Sakrebulo"	899 24 39 54	
36	Boris Liparteliani	Head of Architecture and Constructions Department, Lentekhi Municipality	899 69 43 32	
37	Marika Kopaliani	Chief Specialist, "Gamgeoba", Tsageri Municipality	898 18 64 24	

38	Iuzi Mindadze	Specialist, “Sakrebulo”, Tsageri Municipality	851 16 10 98	
39	Gocha Gurguchiani	“Sakrebulo”, Tsageri Municipality	899 23 80 67	
40	Ghiorgie Murtskhvaladze	Specialist, “Sakrebulo”, Tsageri Municipality		
41	Davit Mamardashvili	Specialist, “Sakrebulo”, Tsageri Municipality	899 22 42 17	
42	Ghela Mamardashvili	Specialist, “Sakrebulo”, Tsageri Municipality	895 17 99 07	
43	Maya Gughava	Specialist, “Gamgeoba”, Tsageri Municipality	877 95 25 22	
44	Ladie Kacharava	Specialist, “Gamgeoba”, Tsageri Municipality		
45	German Khurasbediani	Head of Department, “Gamgeoba” Lentekhi Municipality	899 51 34 20	

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

 ------------------------ M/L	disturbance • Temporary Diversion of River away from Dam and intake structure -- **Operation Phase:** effects on surface water resources during facility operations	SH --------------------------- LG	VL/R/T ----------------------------------- L/R/T	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/H ----------------------------- H/H	**Seismic Risk** **Construction Phase (HPP and Transmission Facility)**: Impacts on infrastructure and public due to seismic activity --- **Operation Phase**: Impacts on infrastructure and public due to seismic activity that causes HPP to fail	VSH --------------------------------- VSH	M/R and IR/T and P depending on seismic characteristics --------------------------------------- M/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/H	**Landslides and Mudslides** **Construction Phase (HPP and Transmission Facility)**: Improper stockpiling of materials, poor sitting, of storage and lay down areas, blasting activities and/or destruction of vegetation cover could increase receptor impacts if land slide or mud slide occurs at HPP site or upstream.	VSH	M/R/T	Erosion and sediment control plan (includes issues like: proper site sitting and engineering design based on best management practices, accumulated sediment disposal plan, grading and smoothing steep slopes, re-vegetation activities etc) at national and international standards should be developed. Emergency shut down and Evacuation plans should be developed to protect receptors, property, and human life. Early Warning Monitoring to include Weather and watershed and upslope areas from HPP site and

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

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

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

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

Biodiversity				
Receptor s	**IMPACT (Description of effect)**	**Duration LG/MD/SH/VSH term)**	**Risk Level (VL, L, M, H, and Irreversible/ reversible; temporary/ permanent**	**Mitigation Practices**
Terrestrial flora **(Vulnerability (H, M, L, None) and Value (H, L)** L/H ---------------------------- L/H	**Construction Phase (HPP and Transmission Facility)**: Project might have following primary and secondary impacts on the terrestrial flora: • Construction of HPP, new roads and/or Transmission lines may cause removal of vegetation (forests, topsoil); • Alien species invading the existing ecosystem; -- **Operation Phase:** There would be minor or no impact on flora during the operation phase	SH -------------------------------- MD	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/H	**Construction Phase (HPP and Transmission Facility)**: Project might have following primary and secondary impacts on the terrestrial fauna: • Disruption of sites of breeding and sheltering; • Animal mortality due to construction activities (e.g. accidents and/or mortality of birds due to Transmission lines) • Alien species invading the existing ecosystem;	SH	M/R/T	Wildlife management plan should be developed. Noise management plan. Proper scheduling of construction activities; Monitoring of vibration and blasting activities from construction equipment

	• number of equipments and/or possible blasting activities may cause the increase the noise/vibration level during the construction process, which may disturb wildlife (affect species behaviour)			
L/H	**Operation Phase:** Impacts affecting fauna elements during operation are: • Ecological barrier effect (movement is disabled or hindered • Mortality of animals on roads; • Mortality of birds on power lines	LG	VL/R/P	Implementing and monitoring the wildlife management plan.
Fishery **(Vulnerability (H, M, L, None) and Value (H, L)** L/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.	MD	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
L/L	**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	M/R/T	Well understood process. Permanent monitoring of sanitary water flow; compliance with environmental and in-stream flow requirements with monitoring.

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

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

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

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

	building, it will have not any considerable nuisance.			
Recreation (Vulnerability (H, M, L, None) and Value (H, L) 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	SH	VL/R/T	Proper scheduling of construction activities. Develop construction management plan. Development appropriate waste management plan which includes management of solid, liquid, hazardous waste management and are in line with national and international environmental regulations. Provide construction schedules and coordinate with recreational locations to minimize access issues for visitors.
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M/H	**Operation Phase:** New reservoir and new infrastructure (e.g. better roads) may positively impact on recreational activities	LG	VL/R/P	Operations practice should coordinate with recreational activities so as to assure safe access (fishing), adequate water in bypass channels to support in-stream activities, and provide access to river for such activities if project limits access.
Roads, Infrastructure, and Communities **(Vulnerability (H, M, L, None) and Value (H, L)** L/H	**Construction Phase (HPP and Transmission Facility)**: It is expected that during construction new access roads will be built. Loads on the existing roads will increase due to construction machinery. Traffic increase will affect Noise, Air Quality, community safety, and Public Health Receptors. Construction provides jobs and economic benefits to community	SH	L/R/T	Develop construction management plan that addresses materials delivery, storage, noise, and air quality issues that are sensitive to local communities and meet all Georgian environmental and legal requirements. Include job training for local population where appropriate.
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L/H	**Operation Phase:** It is expected that during operational phase vehicular movement will be increased for maintenance, etc purposes. Consider community health, safety and security issues, as well as Noise and Air Quality Receptors.	LG	VL/R/P	Develop traffic management plan with limited vehicular movement during operational phase. Ensure compliance with local and regional laws that effect the community

Public Health **(Vulnerability (H, M, L, None) and Value (H, L)** L/H ----------------------------- L/H	**Construction Phase (HPP and Transmission Facility)**: Construction activities might cause health impact to the workers (e.g. construction related accidents). Also see Air Quality, Population Receptors --- **Operation Phase:** Operational activities might cause health impact to the workers and/or local population.	SH --------------------------------- LG	VL/R/T --------------------------------------- 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 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: No File Name

TURBINE SIZING CRITERIA

Rated Discharge:	211.9	cfs	/	6.0	m3/s
Net Head at Rated Discharge:	360.9	feet	/	110.0	meters
Gross Head:	377.3	feet	/	115.0	meters
Site Elevation:	3281	feet	/	1000	meters
Water Temperature:	68	Degrees F	/	20	Degrees C
Setting to Tailwater:	-3.3	feet	/	-1.0	meters
Efficiency Priority:			5		
System Frequency:			50 Hz		
Minimum Net Head:	344.5	feet	/	105.0	meters
Maximum Net Head:	370.7	feet	/	113.0	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 / 1013 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:	28.4	108.4
At Peak Efficiency Condition:	27.2	103.7

SOLUTION PERFORMANCE DATA

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At Rated Net Head of: 360.9 feet / 110.0 meters

% of Rated Discharge	Output (KW)	Efficiency (%)	cfs	m3/s
** 109.1	6417	90.8	231.2	6.5
100	5970	92.2	211.9	6.0
* 90.9	5455	92.7	192.6	5.5
75	4450	91.6	158.9	4.5
50	2731	84.3	105.9	3.0
25	1037	64.0	53.0	1.5
+ 48.8	2645	83.7	103.4	2.9

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

....

At Maximum Net Head of: 370.7 feet / 113.0 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.061	6658	90.8	233.5	6.6

....

At Minimum Net Head of: 344.5 feet / 105.0 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.062	5905	90.6	223.3	6.3

....

Solution File Name: No File Name

MISCELLANEOUS DATA

Maximum Runaway Speed (at Max. Net Head):	830 rpm	
Turbine Discharge at:		
Runaway Speed (at Rated Net Head & 100% gate):	99 cfs	2.8 m3/s
Synchronous Speed-No-Load (at Rated Net Head):	17 cfs	0.5 m3/s
Site's Atmospheric Pressure minus Vapor Pressure:	29.3 feet	8.9 meters
Sigma Allowable (at 100% Output & Rated Net Head):	0.046	
Sigma Plant (at 100% Output & Rated Net Head):	0.090	
Maximum Hydraulic Thrust (at Max. Net Head):	30102 lbs	13683 kg
Approximate Runner and Shaft Weight:	5211 lbs	2368 kg
Vel. at Draft Tube Exit (at Rated Head & Discharge):	3.6 fps	1.1 m/s

DIMENSIONAL DATA

Intake Type: SPIRAL CASE

	inches	mm
Inlet Diameter:	42.0	1067
Inlet Offset:	63.0	1600
Centerline to Inlet:	73.6	1869
Outside Radius A:	84.0	2134
Outside Radius B:	79.6	2023
Outside Radius C:	73.7	1872
Outside Radius D:	67.3	1708

Draft Tube Type: ELBOW

	inches	mm
Centerline to Invert:	127.6	3240
Shaft Axis to Exit Length:	191.4	4862
Exit Width:	119.6	3039
Exit Height:	71.8	1823

Shafting Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT

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

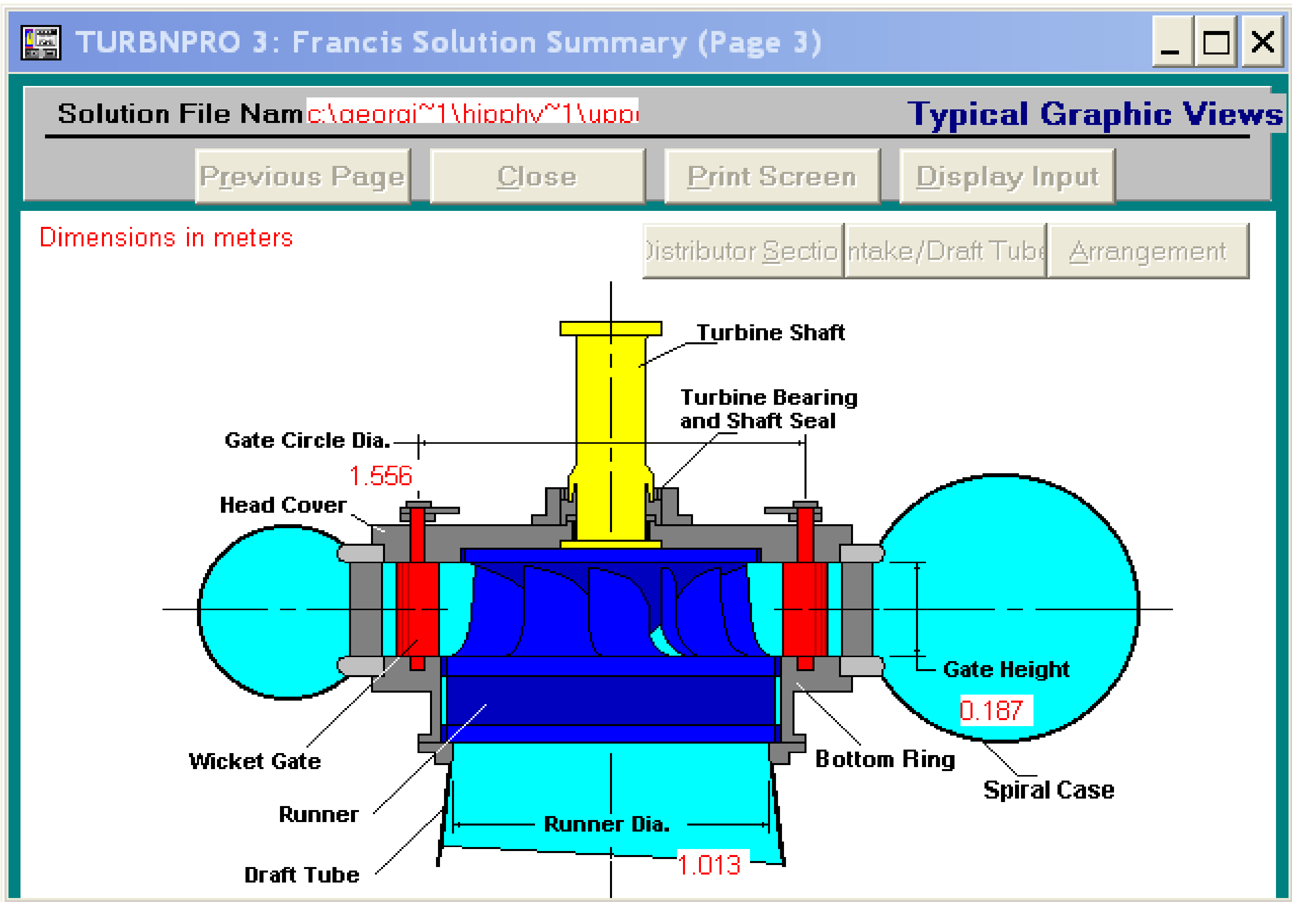
Miscellaneous:

	inches	mm
Wicket Gate Height:	7.3	187
Wicket Gate Circle Diameter:	61.3	1556

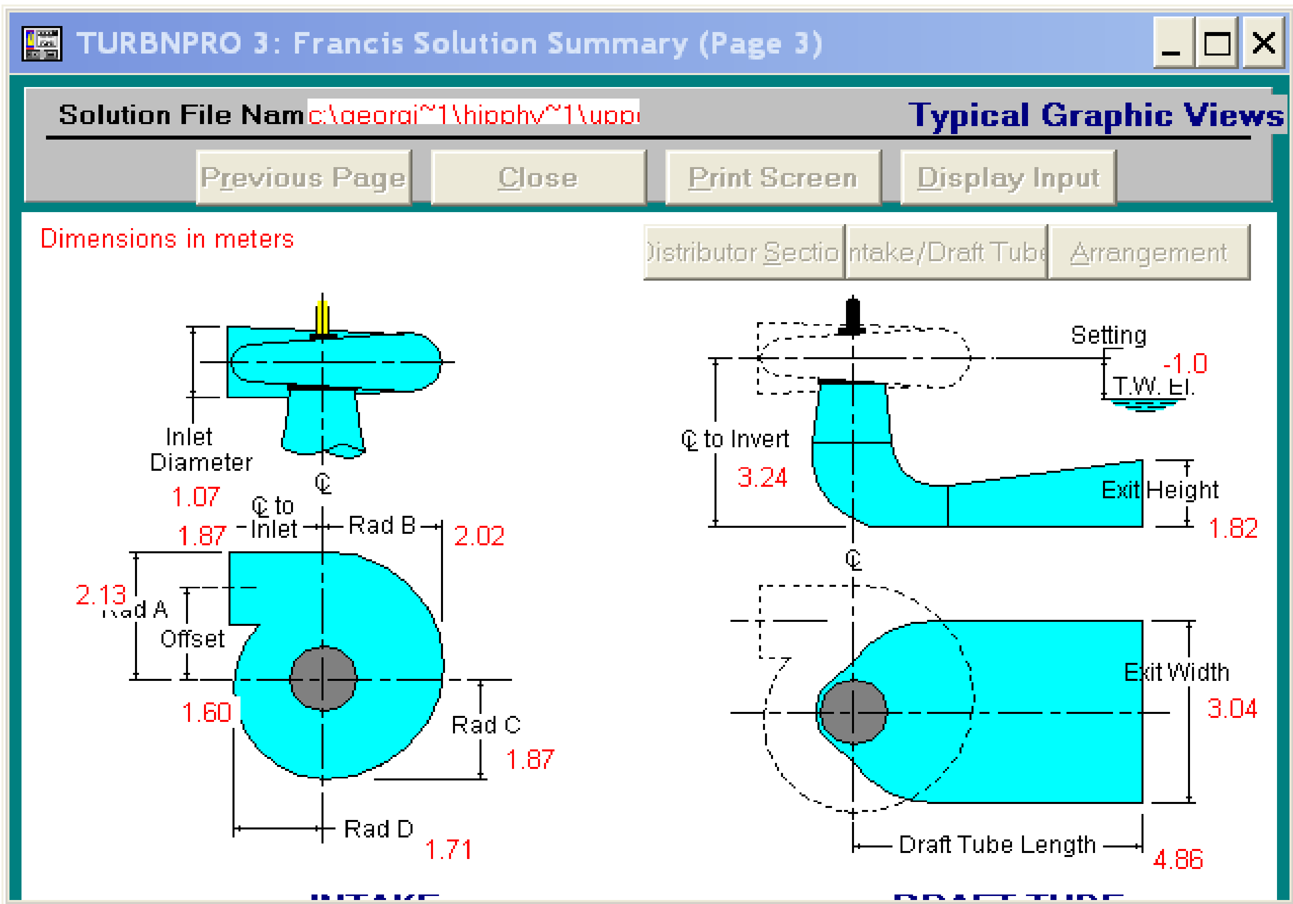
**** All information listed above is typical only. Detailed characteristics will vary based on turbine manufacturer's actual designs.

TURBNPRO Version 3.0 - FRANCIS TURBINE SOLUTION GRAPHICS

Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khel2-sf.pdf
Runner Diameter: 1013 mm
Net Head at Rated Discharge: 110.00 meters
Unit Speed: 500.0 rpm



Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khel2-sf.pdf
Runner Diameter: 1013 mm
Net Head at Rated Discharge: 110.00 meters
Unit Speed: 500.0 rpm



TURBNPRO Version 3.0 - FRANCIS TURBINE SOLUTION GRAPHICS

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Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khel2-sf.pdf
Runner Diameter:                  1013   mm
Net Head at Rated Discharge:      110.00   meters
Unit Speed:                       500.0   rpm
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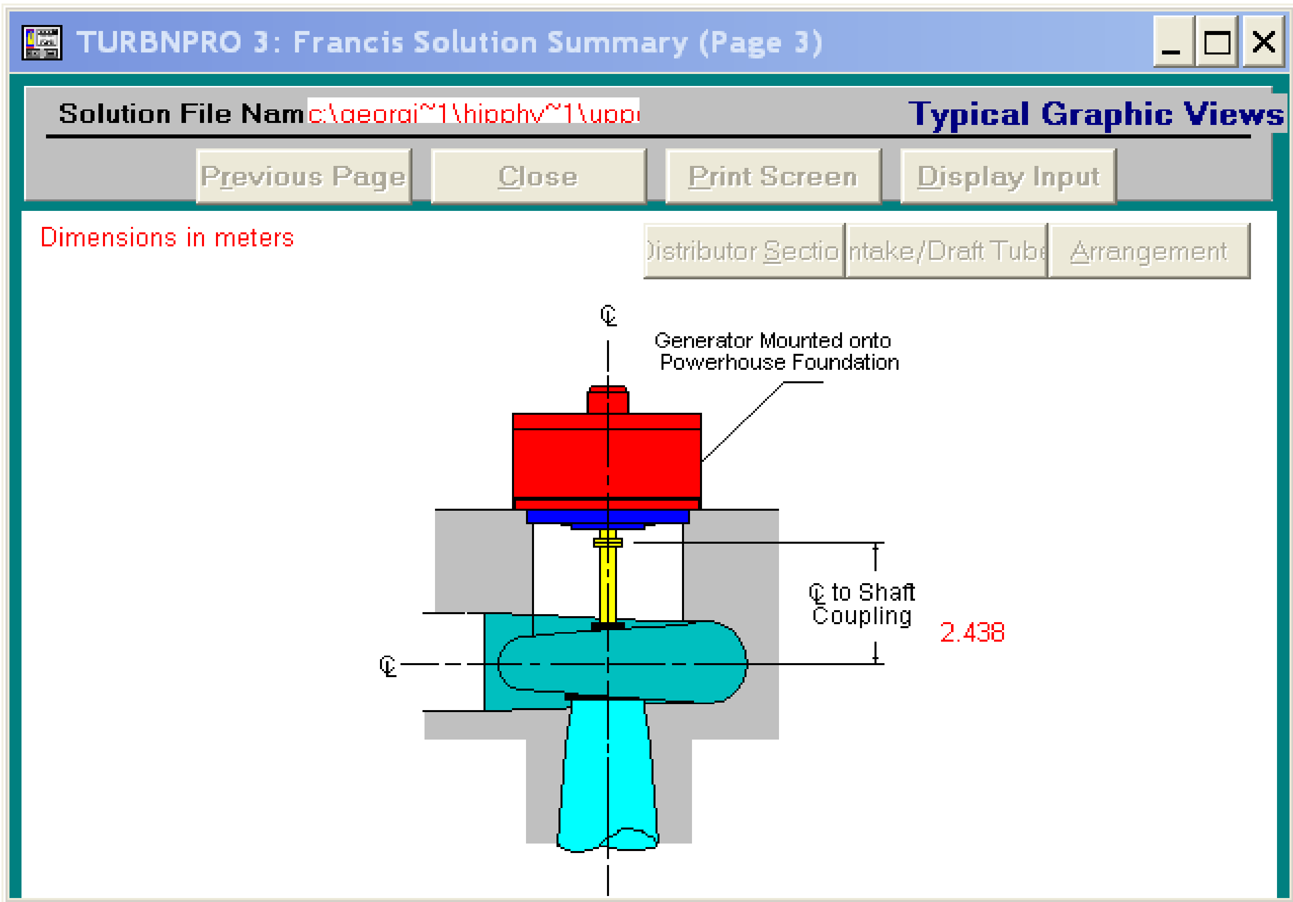
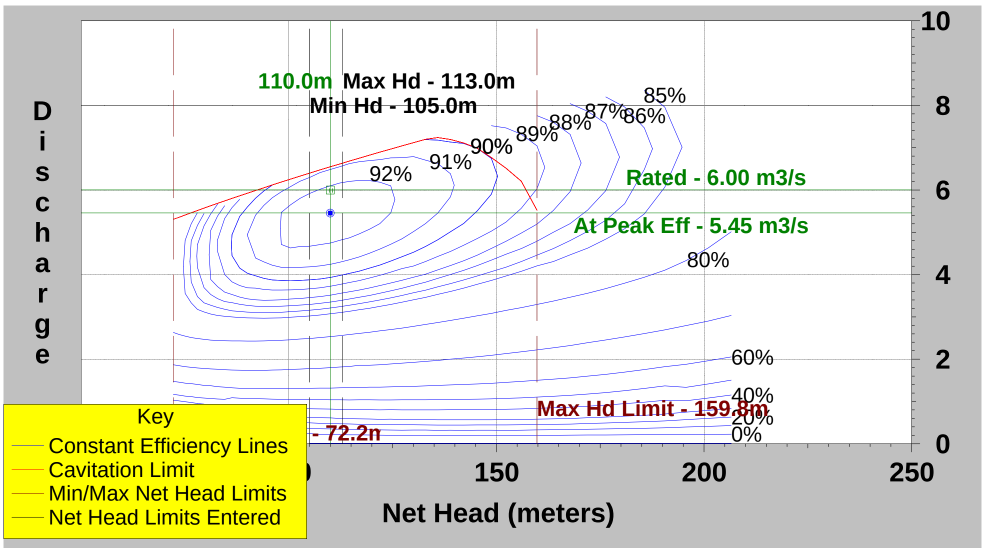


TURBNPRO Version 3 - FRANCIS TURBINE HILL CURVE

Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khel2-sf.pdf

Runner Diameter:	1013	mm
Net Head at Rated Discharge:	110.00	meters
Unit Speed:	500.0	rpm
Peak Efficiency:	92.7	%
Multiplier Efficiency Modifier:	1.000	
Flow Squared Efficiency Modifier:	0.0000	



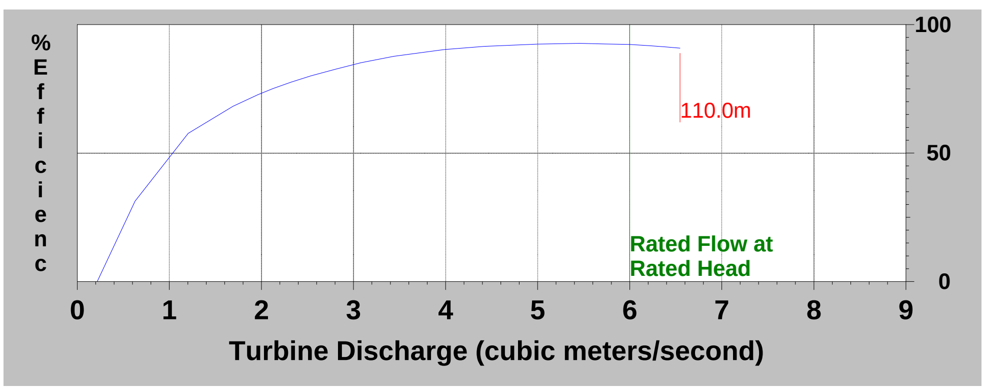
NOTE: Discharge is in cubic meters per second

TURBNPRO Version 3 - FRANCIS TURBINE CROSS PLOT

Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khel2-sf.pdf
Runner Diameter: 1013 mm
Net Head at Rated Discharge: 110.00 meters
Unit Speed: 500.0 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

Performance Data Shown is for a Net Head of: 110

Power (KW)	Efficiency (%)	Discharge (m3/s)	Notes
6417	90.8	6.55	Additional Output Capability
6158	91.7	6.22	Additional Output Capability
5970	92.2	6.00	Rated Flow/Head Condition
5869	92.3	5.89	-
5560	92.6	5.57	-
5456	92.7	5.46	Best Efficiency Condition
5230	92.5	5.24	-
4888	92.2	4.91	-
4538	91.8	4.58	-
4181	91.0	4.26	-
3815	90.0	3.93	-
3436	88.4	3.60	-
3055	86.5	3.27	-
2666	83.9	2.95	-
2284	80.8	2.62	-
1909	77.2	2.29	-
1542	72.8	1.96	-
1184	67.0	1.64	-
846	59.9	1.31	Low efficiency; not used in energy calculation
503	47.4	0.98	Low efficiency; not used in energy calculation
230	32.5	0.65	Low efficiency; not used in energy calculation
29	8.3	0.33	Low efficiency; not used in energy calculation



TURBNPRO Version 3 - PELTON TURBINE SOLUTION SUMMARY

Solution File Name: No File Name

TURBINE SIZING CRITERIA

Rated Discharge:	317.8	cfs	/	9.00	m3/s
Net Head at Rated Discharge:	344.5	feet	/	105.0	meters
Gross Head:	377.3	feet	/	115.0	meters
Efficiency Priority:			5		
System Frequency:			50 Hz		
Minimum Net Head:	302.9	feet	/	92.3	meters
Maximum Net Head:	366.1	feet	/	111.6	meters

PELTON TURBINE SOLUTION DATA

Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT
Intake Type: 4 - JET
Runner Pitch Diameter: 103.0 inches / 2617 mm
Unit Speed: 157.9 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

	(US Cust.)	(SI Units)
Specific Speed at Rated Net Head (turbine) -		
At 100% Turbine Output:	11.2	42.8
At Peak Efficiency Condition:	10.3	39.1
Specific Speed at Rated Net Head (per jet) -		
At 100% Turbine Output:	5.6	21.4
At Peak Efficiency Condition:	5.1	19.6

SOLUTION PERFORMANCE DATA

At Rated Net Head of: 344.5 feet / 105.0 meters

% of Rated Discharge	Output (KW)	Efficiency (%)	cfs	m3/s
** 116.7	9628	89.0	370.8	10.50
100	8308	89.6	317.8	9.00
* 83.3	6935	89.8	264.8	7.50
75	6231	89.6	238.3	6.75
50	4105	88.6	158.9	4.50
25	2015	86.9	79.4	2.25

** - Overcapacity
* - Peak Efficiency Condition

At Maximum Net Head of: 366.1 feet / 111.6 meters

Max. Output (KW)	Efficiency (%)	cfs	m3/s
10517	88.7	382.2	10.82

At Minimum Net Head of: 302.9 feet / 92.3 meters

Max. Output (KW)	Efficiency (%)	cfs	m3/s
7935	89.0	347.7	9.85

Solution File Name: No File Name

MISCELLANEOUS DATA

Maximum Runaway Speed (at Max. Net Head):	283 rpm
D/B Ratio (Runner Pitch Dia./Bucket Width):	2.88
Maximum Hydraulic Thrust (at Max. Net Head):	17948 lbs / 8158 kg
Hydraulic Thrust per Jet (at Max. Net Head):	12693 lbs / 5770 kg
Estimated Axial Thrust:	64693 lbs / 29406 kg
Approximate Runner and Shaft Weight:	62719 lbs / 28508 kg

DIMENSIONAL DATA

Intake Type: 4 - JET

	inches	mm
Inlet Diameter:	57.1	1450
Nozzle Diameter:	33.8	858
Jet Orifice Diameter:	10.8	274
Needle Stroke:	10.3	260
Inlet Piping Spiral Radius:	230.1	5846
Jet to Jet Included Angle:	90 Degrees	

Housing/Discharge Geometry:

	inches	mm
Centerline to Housing Top:	72.5	1843
Housing Diameter:	343.5	8725
Discharge Width:	257.6	6544
Tailwater Depth:	36.1	917
Discharge Ceiling to T.W.:	61.8	1570
Centerline to Tailwater:	169.0	4293

Shafting Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT

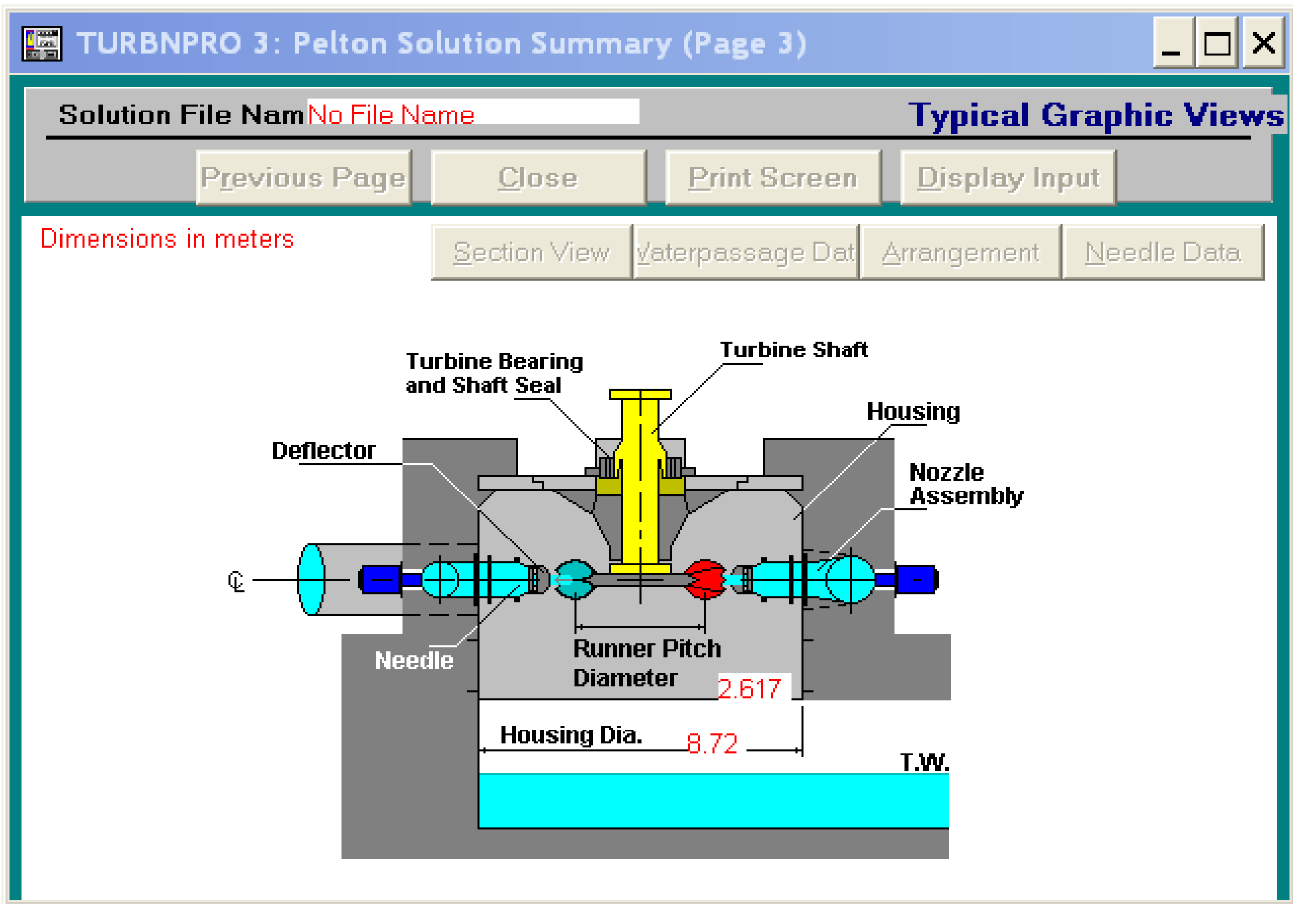
	inches	mm
Centerline to Shaft Coupling:	145.1	3685
Turbine Shaft Diameter:	22.6	573

Miscellaneous:

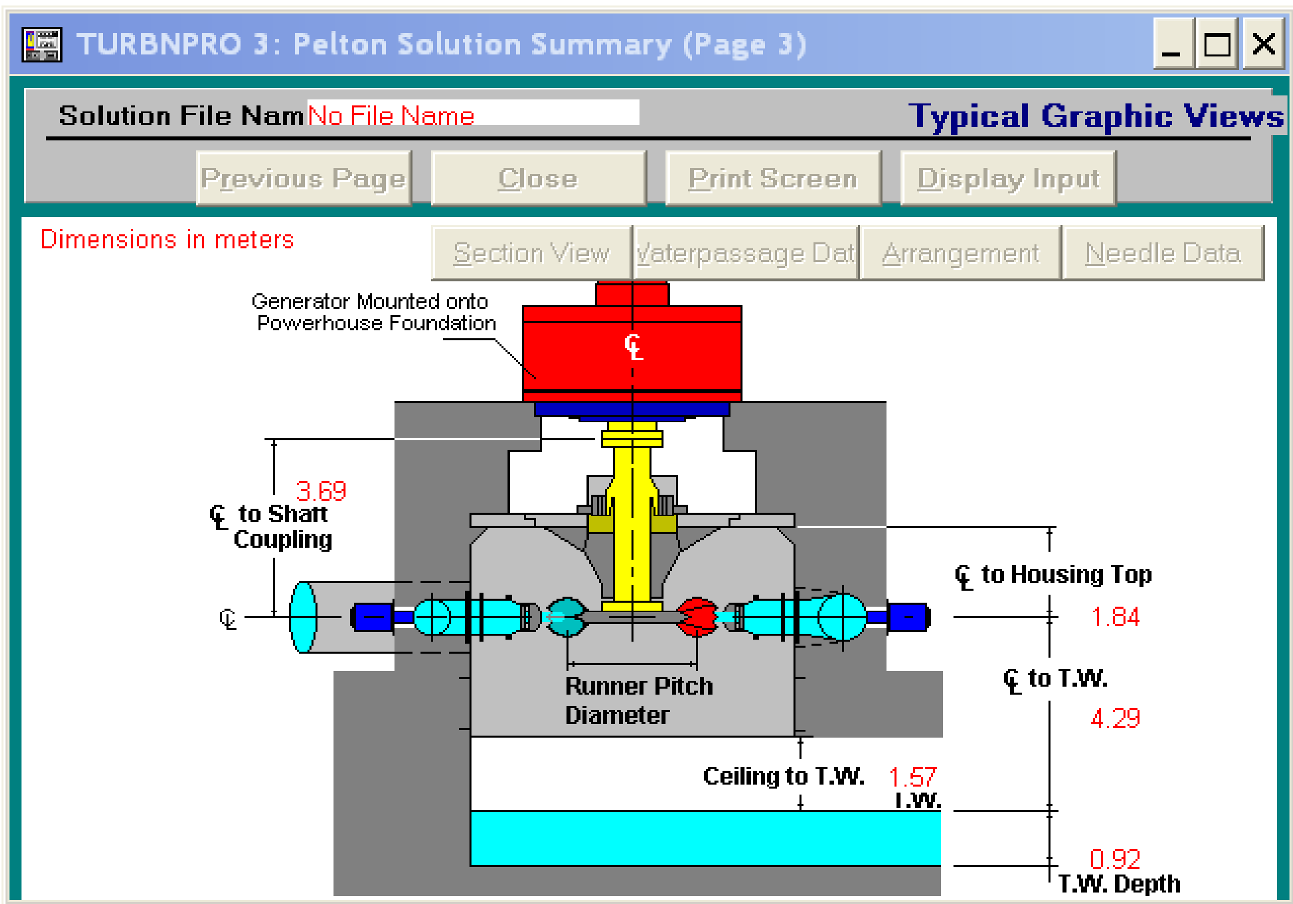
	inches	mm
Runner Outside Diameter:	138.8	3525
Runner Bucket Width:	35.7	908

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

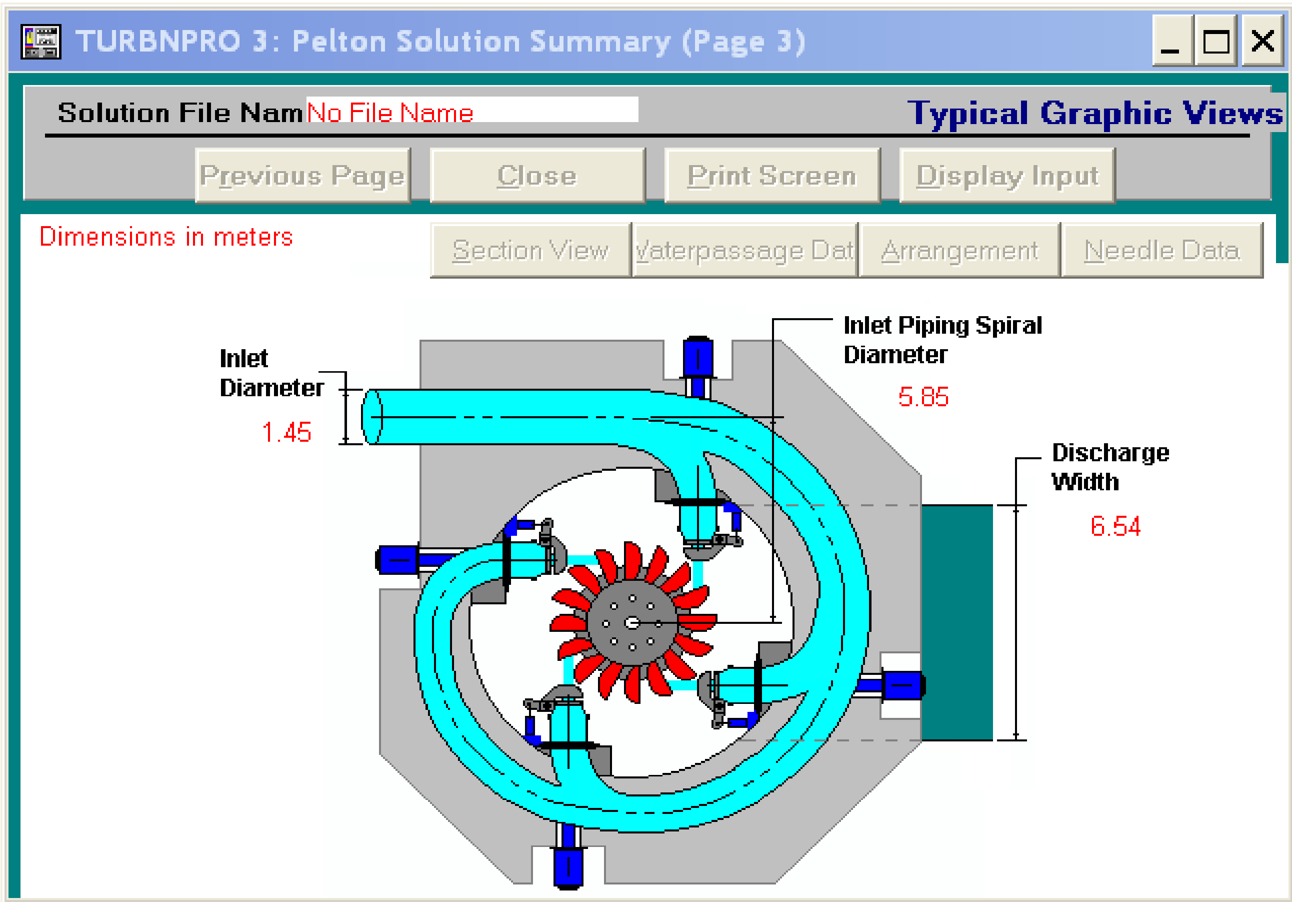
Solution File Name: No File Name	
Intake Type:	4 - JET
Runner Diameter:	2617 mm
Net Head at Rated Discharge:	105.00 meters
Unit Speed:	157.9 rpm



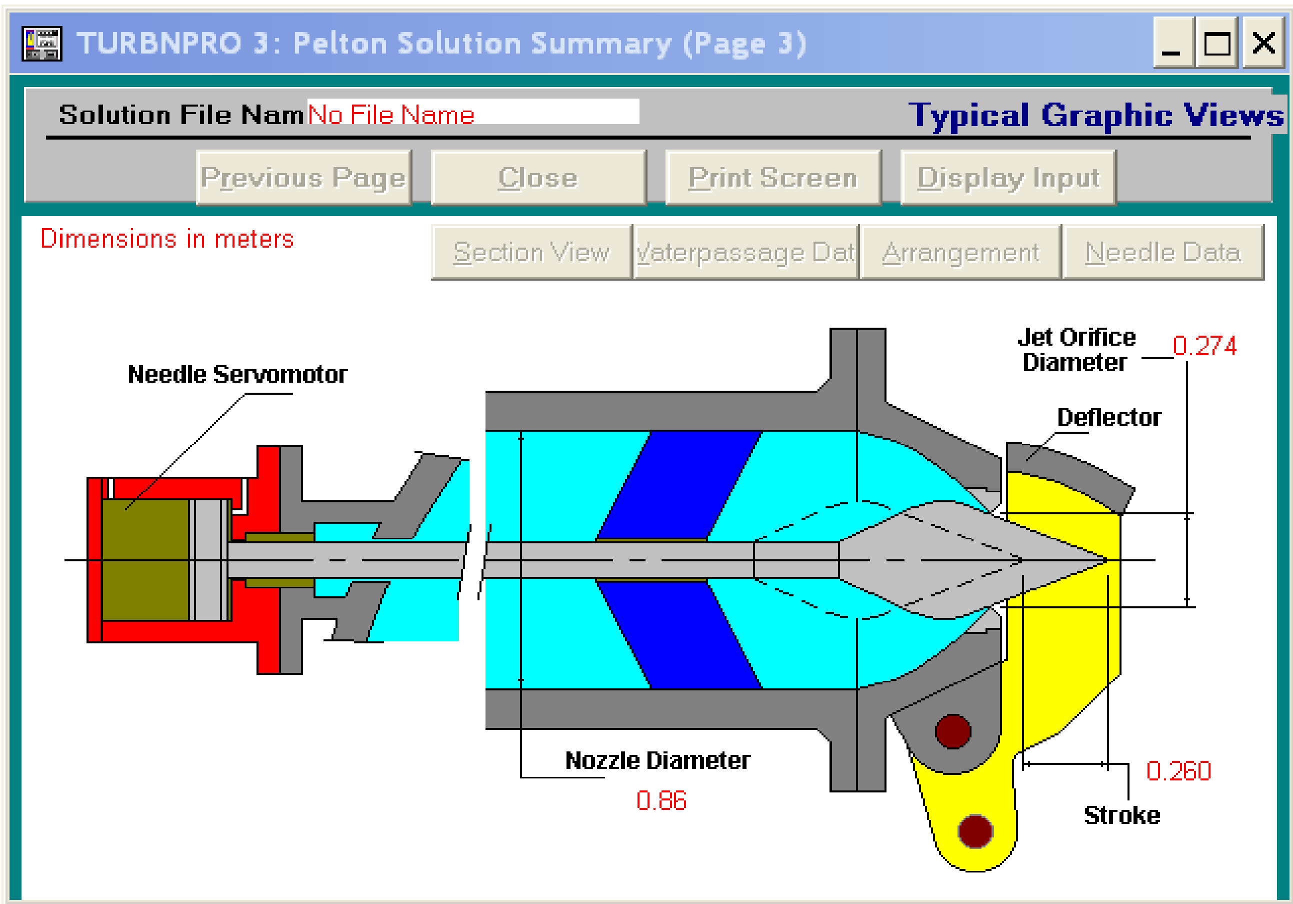
Solution File Name: No File Name	
Intake Type:	4 - JET
Runner Diameter:	2617 mm
Net Head at Rated Discharge:	105.00 meters
Unit Speed:	157.9 rpm



Solution File Name: No File Name
Intake Type: 4 - JET
Runner Diameter: 2617 mm
Net Head at Rated Discharge: 105.00 meters
Unit Speed: 157.9 rpm

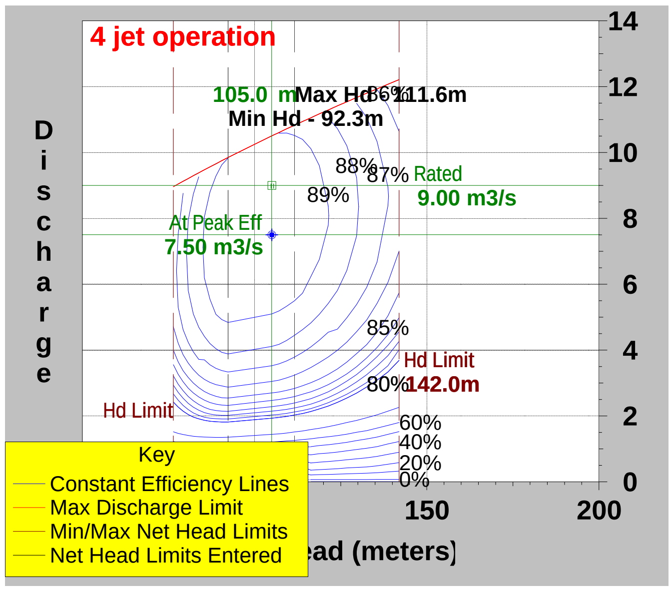


Solution File Name: No File Name
Intake Type: 4 - JET
Runner Diameter: 2617 mm
Net Head at Rated Discharge: 105.00 meters
Unit Speed: 157.9 rpm



Solution File Name: No File Name

Intake Type:	4 - JET
Runner Pitch Diameter:	2617 mm
Net Head at Rated Discharge:	105.00 meters
Unit Speed:	157.9 rpm
Peak Efficiency:	89.8 %
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

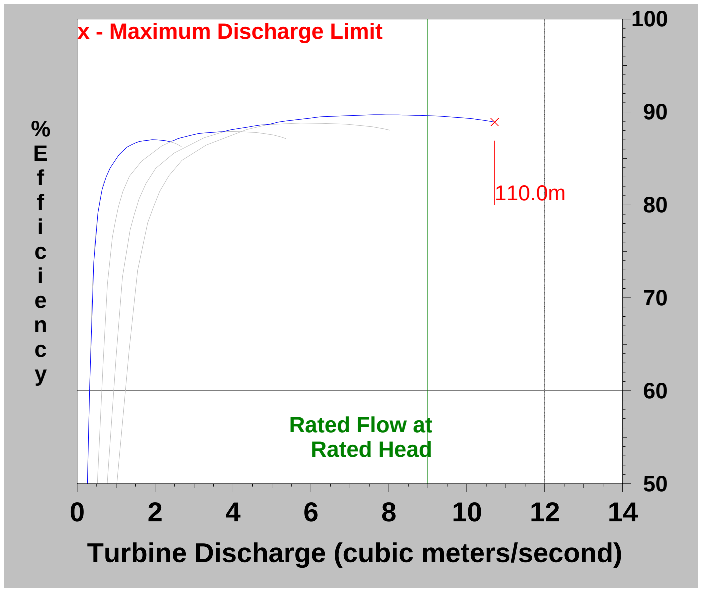
Solution File Name: No File Name
Intake Type: 4 - JET
Runner Pitch Diameter: 2617 mm
Net Head at Rated Discharge: 105.00 meters
Unit Speed: 157.9 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

Performance Data Shown is for a Net Head of: 110

Power (KW)	Efficiency (%)	Discharge (m3/s)	Operating Jets	Notes
10280	88.91	10.71	4	Max Discharge Limit
10092	89.07	10.50	4	-
9899	89.19	10.29	4	-
9705	89.30	10.07	4	-
9506	89.37	9.86	4	-
9307	89.44	9.64	4	-
9106	89.50	9.43	4	-
8906	89.56	9.21	4	-
8701	89.59	9.00	4	-
8496	89.62	8.79	4	-
8292	89.64	8.57	4	-
8086	89.67	8.36	4	-
7880	89.68	8.14	4	-
7673	89.68	7.93	4	-
7466	89.69	7.71	4	-
7407	89.69	7.65	4	Best Efficiency at Net Head
7257	89.67	7.50	4	-
7047	89.64	7.29	4	-
6838	89.60	7.07	4	-
6628	89.57	6.86	4	-
6418	89.54	6.64	4	-
6209	89.51	6.43	4	-
5998	89.45	6.21	4	-
5785	89.34	6.00	4	-
5571	89.23	5.79	4	-
5500	88.80	5.74	3	Best Efficiency for 3 Jet Operation
5358	89.12	5.57	4	-
5146	89.02	5.36	4	-
4932	88.88	5.14	4	-
4716	88.67	4.93	4	-
4507	88.59	4.71	3	-
4295	88.45	4.50	3	-
4084	88.30	4.29	3	-
3873	88.16	4.07	3	-
3662	87.99	3.86	3	-
3630	87.90	3.83	2	Best Efficiency for 2 Jet Operation
3453	87.84	3.64	2	-
3248	87.78	3.43	2	-
3042	87.72	3.21	2	-
2834	87.55	3.00	2	-
2626	87.34	2.79	2	-
2417	87.10	2.57	2	-
2208	86.82	2.36	1	-
2011	86.95	2.14	1	-
1811	87.00	1.93	1	-
1796	87.00	1.91	1	Best Efficiency for 1 Jet Operation
1607	86.88	1.71	1	-
1403	86.66	1.50	1	-
1196	86.21	1.29	1	-
987	85.36	1.07	1	-
777	84.01	0.86	1	-
566	81.65	0.64	1	-
341	73.83	0.43	1	-

TURBNPRO Version 3 - PELTON TURBINE HILL CURVE

Power (KW)	Efficiency (%)	Discharge (m3/s)	Operating Jets	Notes
94	40.72	0.21	1	Low efficiency; not used in energy calculation



TURBNPRO Version 3 - FRANCIS TURBINE SOLUTION SUMMARY

Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khe

TURBINE SIZING CRITERIA

Rated Discharge:	423.7	cfs	/	12.0	m3/s
Net Head at Rated Discharge:	360.9	feet	/	110.0	meters
Gross Head:	377.3	feet	/	115.0	meters
Site Elevation:	3281	feet	/	1000	meters
Water Temperature:	68	Degrees F	/	20	Degrees C
Setting to Tailwater:	-3.3	feet	/	-1.0	meters
Efficiency Priority:			5		
System Frequency:			50 Hz		
Minimum Net Head:	344.5	feet	/	105.0	meters
Maximum Net Head:	370.7	feet	/	113.0	meters

FRANCIS TURBINE SOLUTION DATA

Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT
Intake Type: SPIRAL CASE
Draft Tube Type: ELBOW
Runner Diameter: 55.1 inches / 1400 mm
Unit Speed: 375.0 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:	30.2	115.2
At Peak Efficiency Condition:	28.9	110.1

SOLUTION PERFORMANCE DATA

....

At Rated Net Head of: 360.9 feet / 110.0 meters

% of Rated Discharge	Output (KW)	Efficiency (%)	cfs	m3/s
** 109.1	12875	91.1	462.2	13.1
100	11983	92.5	423.7	12.0
* 90.9	10949	93.0	385.2	10.9
75	8930	91.9	317.8	9.0
50	5465	84.4	211.9	6.0
25	2056	63.5	105.9	3.0
+ 49.5	5396	84.1	209.9	5.9

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

....

At Maximum Net Head of: 370.7 feet / 113.0 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.067	13360	91.1	466.9	13.2

....

At Minimum Net Head of: 344.5 feet / 105.0 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.067	11992	91.1	451.5	12.8

....

Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khe

MISCELLANEOUS DATA

Maximum Runaway Speed (at Max. Net Head):	626 rpm	
Turbine Discharge at:		
Runaway Speed (at Rated Net Head & 100% gate):	204 cfs	5.8 m3/s
Synchronous Speed-No-Load (at Rated Net Head):	34 cfs	1.0 m3/s
Site's Atmospheric Pressure minus Vapor Pressure:	29.3 feet	8.9 meters
Sigma Allowable (at 100% Output & Rated Net Head):	0.050	
Sigma Plant (at 100% Output & Rated Net Head):	0.090	
Maximum Hydraulic Thrust (at Max. Net Head):	56498 lbs	25681 kg
Approximate Runner and Shaft Weight:	10736 lbs	4880 kg
Vel. at Draft Tube Exit (at Rated Head & Discharge):	3.7 fps	1.1 m/s

DIMENSIONAL DATA

Intake Type: SPIRAL CASE

	inches	mm
Inlet Diameter:	60.0	1524
Inlet Offset:	84.4	2143
Centerline to Inlet:	105.4	2677
Outside Radius A:	114.4	2905
Outside Radius B:	108.5	2757
Outside Radius C:	100.3	2548
Outside Radius D:	91.2	2317

Draft Tube Type: ELBOW

	inches	mm
Centerline to Invert:	175.6	4461
Shaft Axis to Exit Length:	264.6	6720
Exit Width:	165.4	4200
Exit Height:	99.2	2520

Shafting Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT

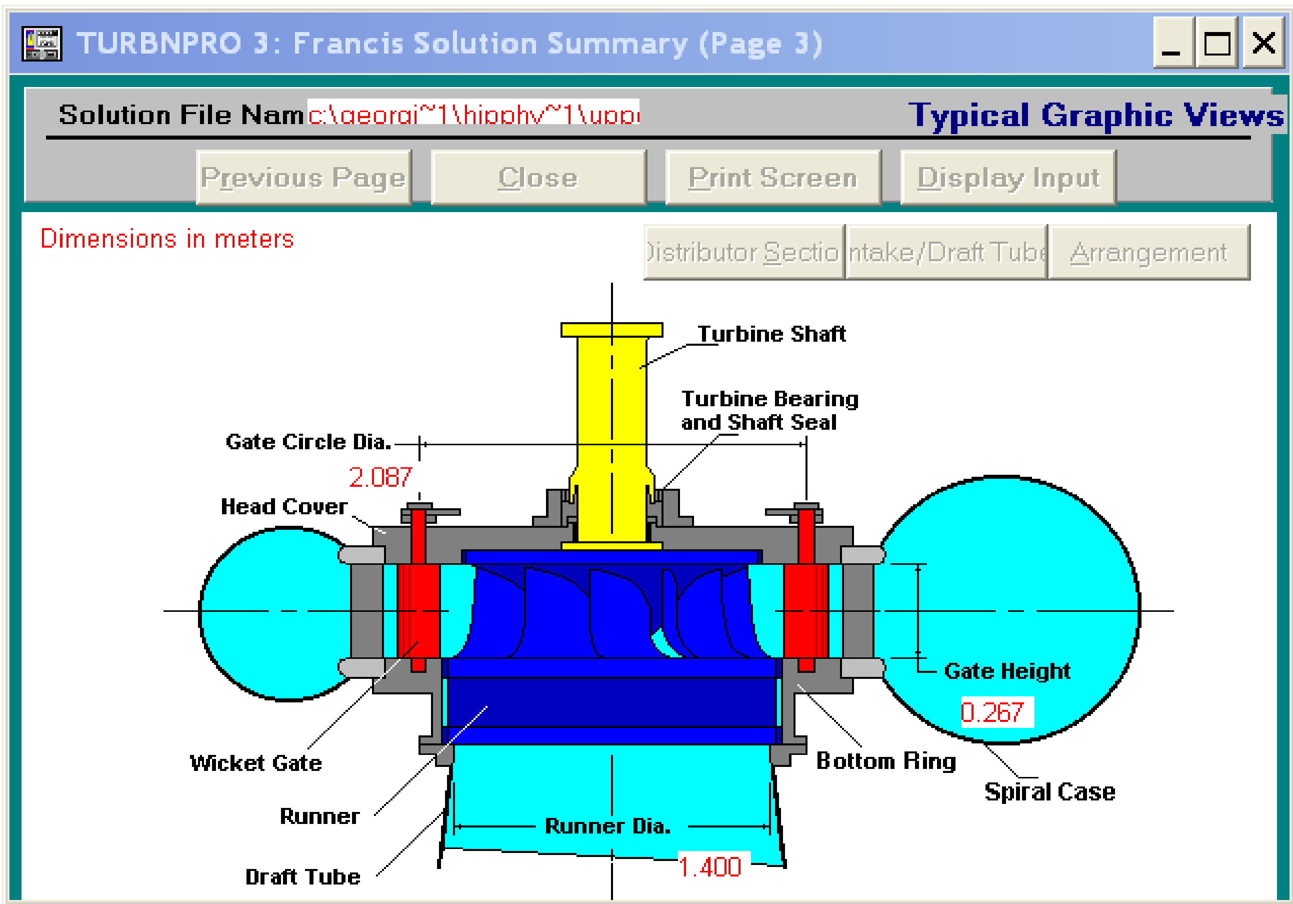
	inches	mm
Centerline to Shaft Coupling:	96.0	2438
Turbine Shaft Diameter:	15.3	388

Miscellaneous:

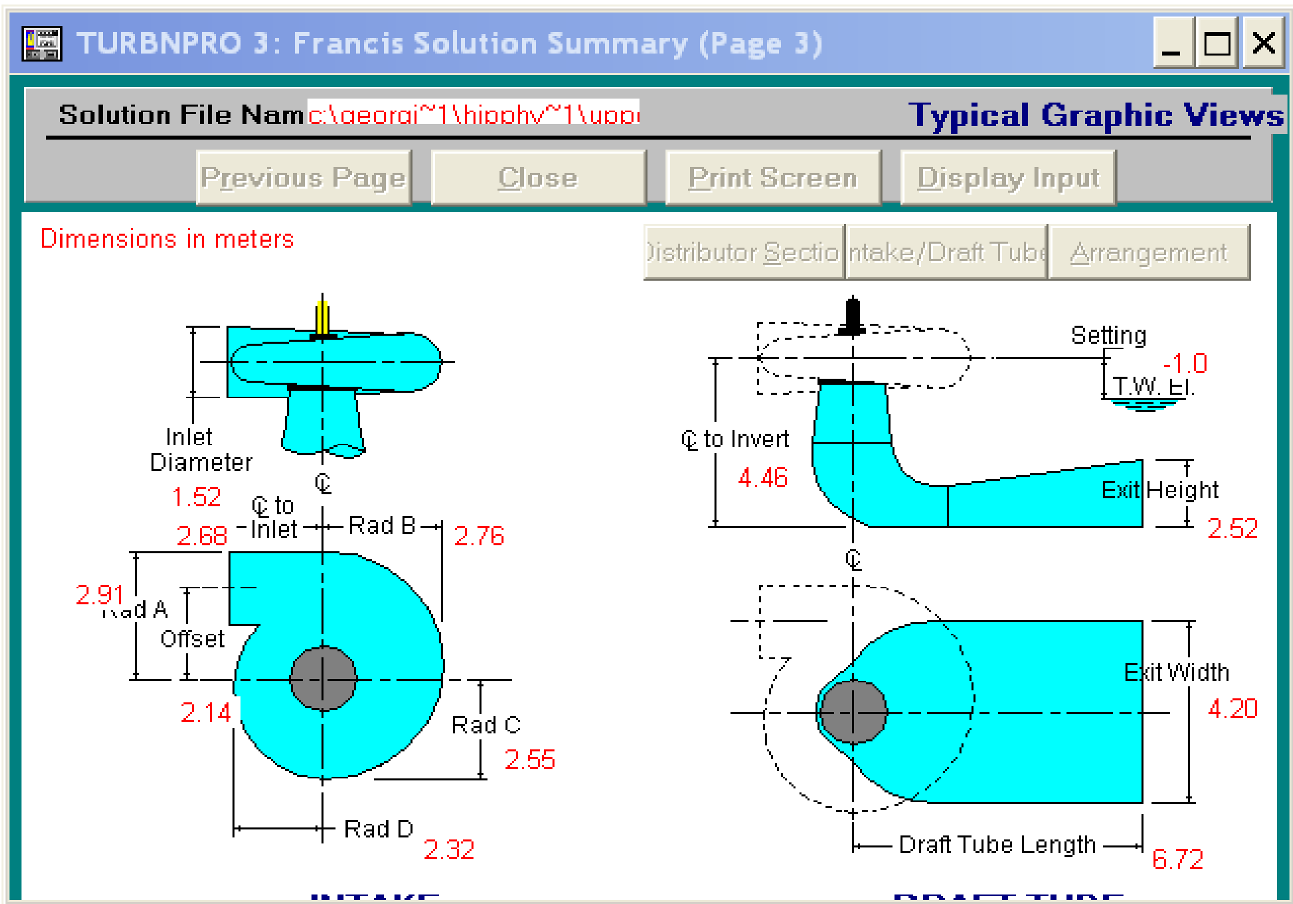
	inches	mm
Wicket Gate Height:	10.5	267
Wicket Gate Circle Diameter:	82.2	2087

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

Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khe2-lf.dat
Runner Diameter: 1400 mm
Net Head at Rated Discharge: 110.00 meters
Unit Speed: 375.0 rpm

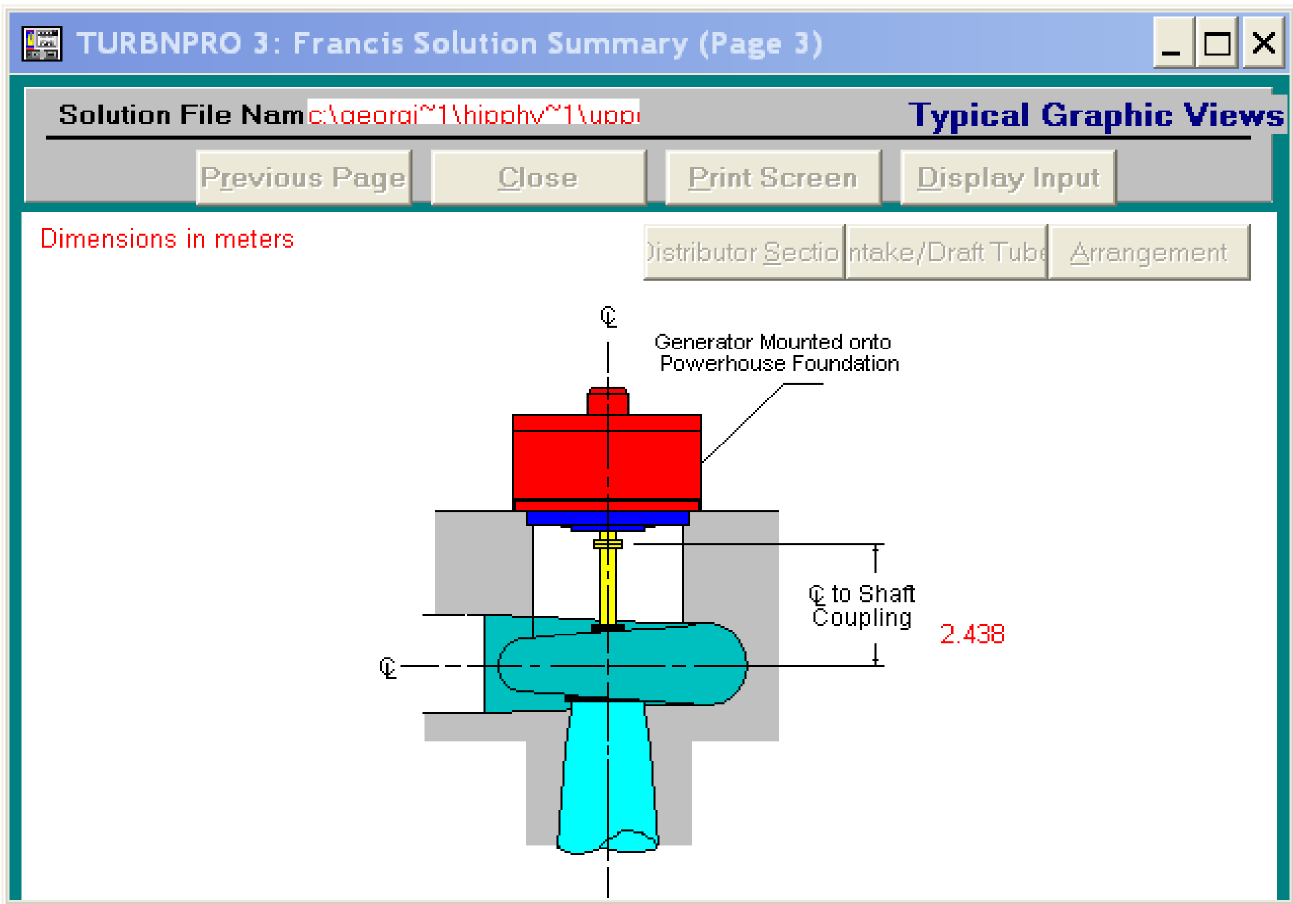


Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khe2-lf.dat
Runner Diameter: 1400 mm
Net Head at Rated Discharge: 110.00 meters
Unit Speed: 375.0 rpm



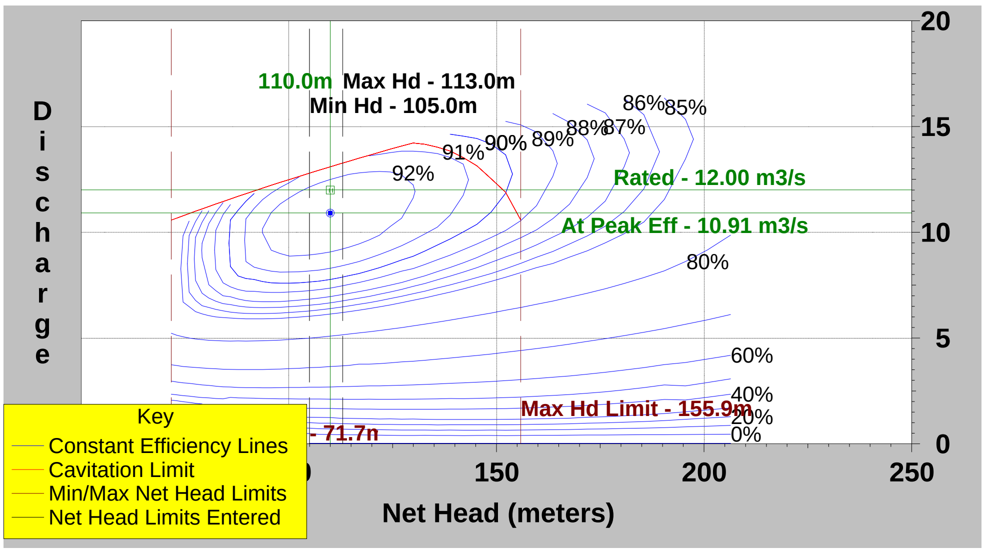
TURBNPRO Version 3.0 - FRANCIS TURBINE SOLUTION GRAPHICS

Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khe2-lf.dat
Runner Diameter: 1400 mm
Net Head at Rated Discharge: 110.00 meters
Unit Speed: 375.0 rpm



Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khe2-1f.dat

Runner Diameter:	1400 mm
Net Head at Rated Discharge:	110.00 meters
Unit Speed:	375.0 rpm
Peak Efficiency:	93.0 %
Multiplier Efficiency Modifier:	1.000
Flow Squared Efficiency Modifier:	0.0000



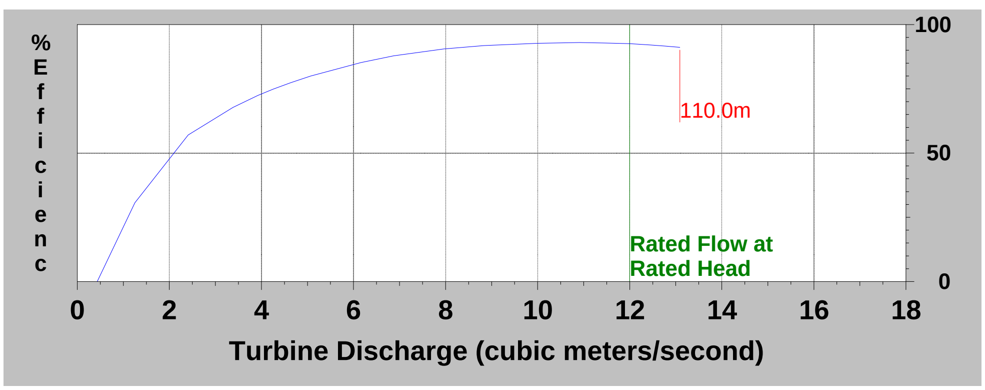
NOTE: Discharge is in cubic meters per second

TURBNPRO Version 3 - FRANCIS TURBINE CROSS PLOT

Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khe2-lf.dat
Runner Diameter: 1400 mm
Net Head at Rated Discharge: 110.00 meters
Unit Speed: 375.0 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

Performance Data Shown is for a Net Head of: 110

Power (KW)	Efficiency (%)	Discharge (m3/s)	Notes
13007	92.1	13.09	Cavitating Operation !
12356	92.1	12.44	Additional Output Capability
11983	92.5	12.00	Rated Flow/Head Condition
11777	92.6	11.78	-
11156	92.9	11.13	-
10948	93.0	10.91	Best Efficiency Condition
10494	92.9	10.47	-
9808	92.6	9.82	-
9104	92.1	9.16	-
8385	91.3	8.51	-
7647	90.2	7.85	-
6884	88.6	7.20	-
6116	86.6	6.55	-
5333	83.9	5.89	-
4562	80.7	5.24	-
3807	77.0	4.58	-
3069	72.4	3.93	-
2349	66.5	3.27	-
1675	59.3	2.62	Low efficiency; not used in energy calculation
992	46.8	1.96	Low efficiency; not used in energy calculation
451	31.9	1.31	Low efficiency; not used in energy calculation
58	8.2	0.65	Low efficiency; not used in energy calculation



TURBNPRO Version 3 - FRANCIS TURBINE SOLUTION SUMMARY

Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khe

TURBINE SIZING CRITERIA

Rated Discharge:	105.9	cfs	/	3.0	m3/s
Net Head at Rated Discharge:	360.9	feet	/	110.0	meters
Gross Head:	377.3	feet	/	115.0	meters
Site Elevation:	3281	feet	/	1000	meters
Water Temperature:	68	Degrees F	/	20	Degrees C
Setting to Tailwater:	-3.3	feet	/	-1.0	meters
Efficiency Priority:			5		
System Frequency:			50 Hz		
Minimum Net Head:	344.5	feet	/	105.0	meters
Maximum Net Head:	370.7	feet	/	113.0	meters

FRANCIS TURBINE SOLUTION DATA

Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT
Intake Type: SPIRAL CASE
Draft Tube Type: ELBOW
Runner Diameter: 31.6 inches / 802 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:	19.9	76.1
At Peak Efficiency Condition:	19.1	72.7

SOLUTION PERFORMANCE DATA

At Rated Net Head of: 360.9 feet / 110.0 meters

% of Rated Discharge	Output (KW)	Efficiency (%)	cfs	m3/s
** 109.1	3155	89.3	115.5	3.3
100	2936	90.7	105.9	3.0
* 90.9	2683	91.2	96.3	2.7
75	2192	90.3	79.4	2.3
50	1363	84.2	53.0	1.5
25	539	66.6	26.5	0.8
+ 45.3	1205	82.1	48.0	1.4

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

At Maximum Net Head of: 370.7 feet / 113.0 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.044	3274	89.3	116.7	3.3

At Minimum Net Head of: 344.5 feet / 105.0 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.045	2912	89.2	111.9	3.2

Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khe

MISCELLANEOUS DATA

Maximum Runaway Speed (at Max. Net Head):	804 rpm	
Turbine Discharge at:		
Runaway Speed (at Rated Net Head & 100% gate):	44 cfs	1.2 m3/s
Synchronous Speed-No-Load (at Rated Net Head):	8 cfs	0.2 m3/s
Site's Atmospheric Pressure minus Vapor Pressure:	29.3 feet	8.9 meters
Sigma Allowable (at 100% Output & Rated Net Head):	0.033	
Sigma Plant (at 100% Output & Rated Net Head):	0.090	
Maximum Hydraulic Thrust (at Max. Net Head):	16526 lbs	7512 kg
Approximate Runner and Shaft Weight:	3397 lbs	1544 kg
Vel. at Draft Tube Exit (at Rated Head & Discharge):	2.8 fps	0.9 m/s

DIMENSIONAL DATA

Intake Type: SPIRAL CASE

	inches	mm
Inlet Diameter:	36.0	914
Inlet Offset:	56.9	1445
Centerline to Inlet:	81.8	2078
Outside Radius A:	74.9	1902
Outside Radius B:	71.5	1817
Outside Radius C:	67.7	1719
Outside Radius D:	62.2	1580

Draft Tube Type: ELBOW

	inches	mm
Centerline to Invert:	102.8	2612
Shaft Axis to Exit Length:	151.6	3850
Exit Width:	94.7	2406
Exit Height:	56.8	1444

Shafting Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT

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

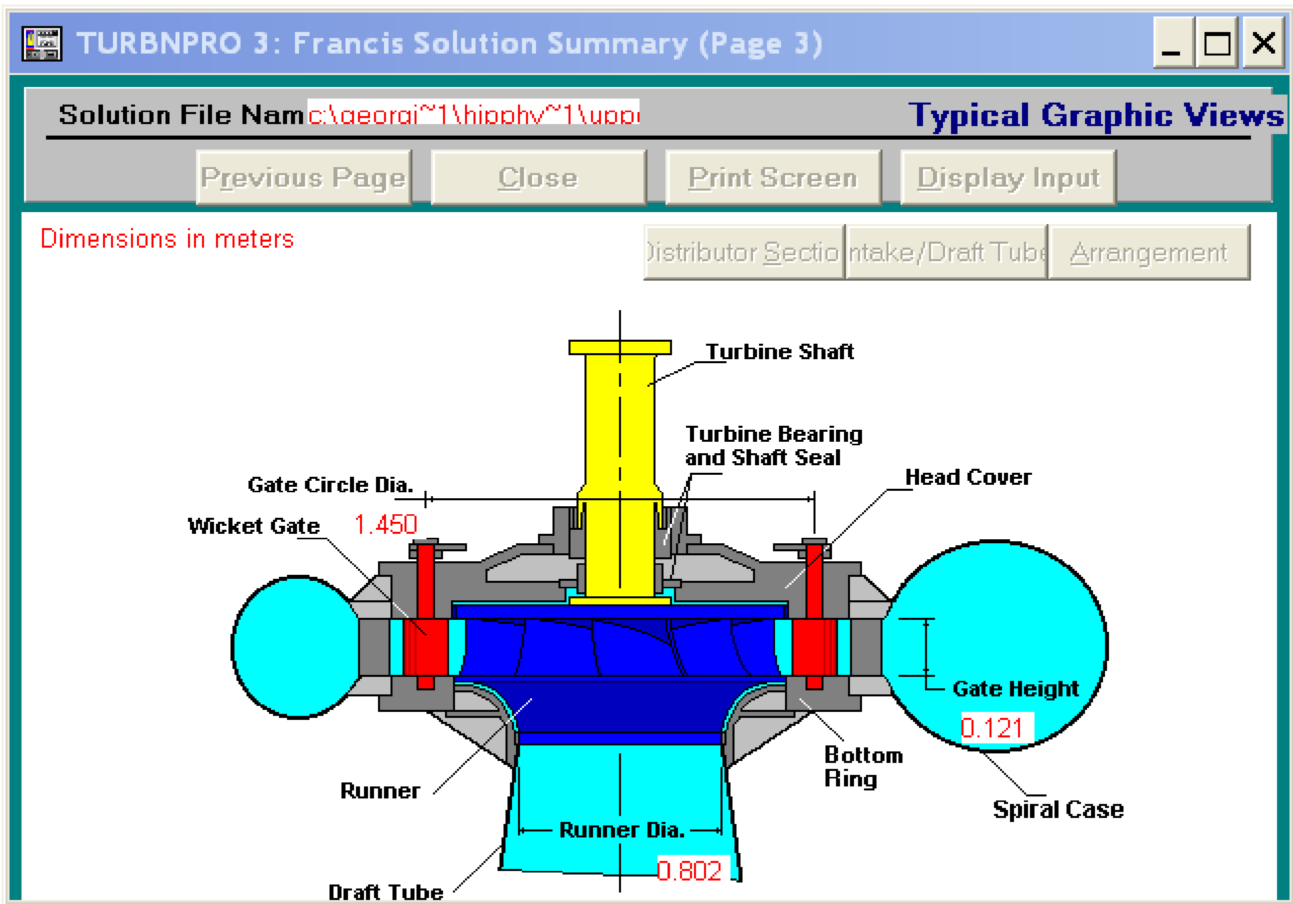
Miscellaneous:

	inches	mm
Wicket Gate Height:	4.8	121
Wicket Gate Circle Diameter:	57.1	1450

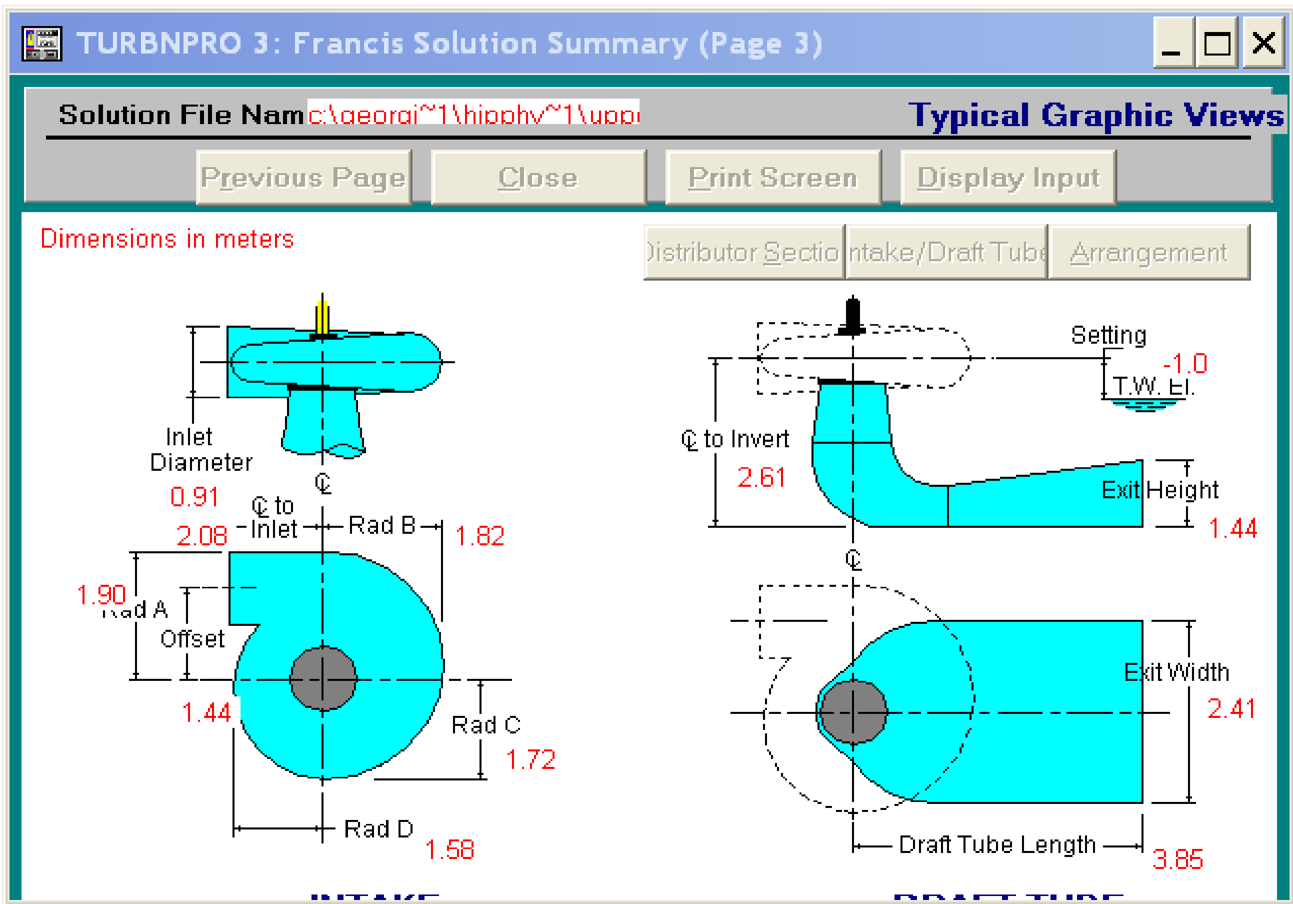
**** All information listed above is typical only. Detailed characteristics will vary based on turbine manufacturer's actual designs.

TURBNPRO Version 3.0 - FRANCIS TURBINE SOLUTION GRAPHICS

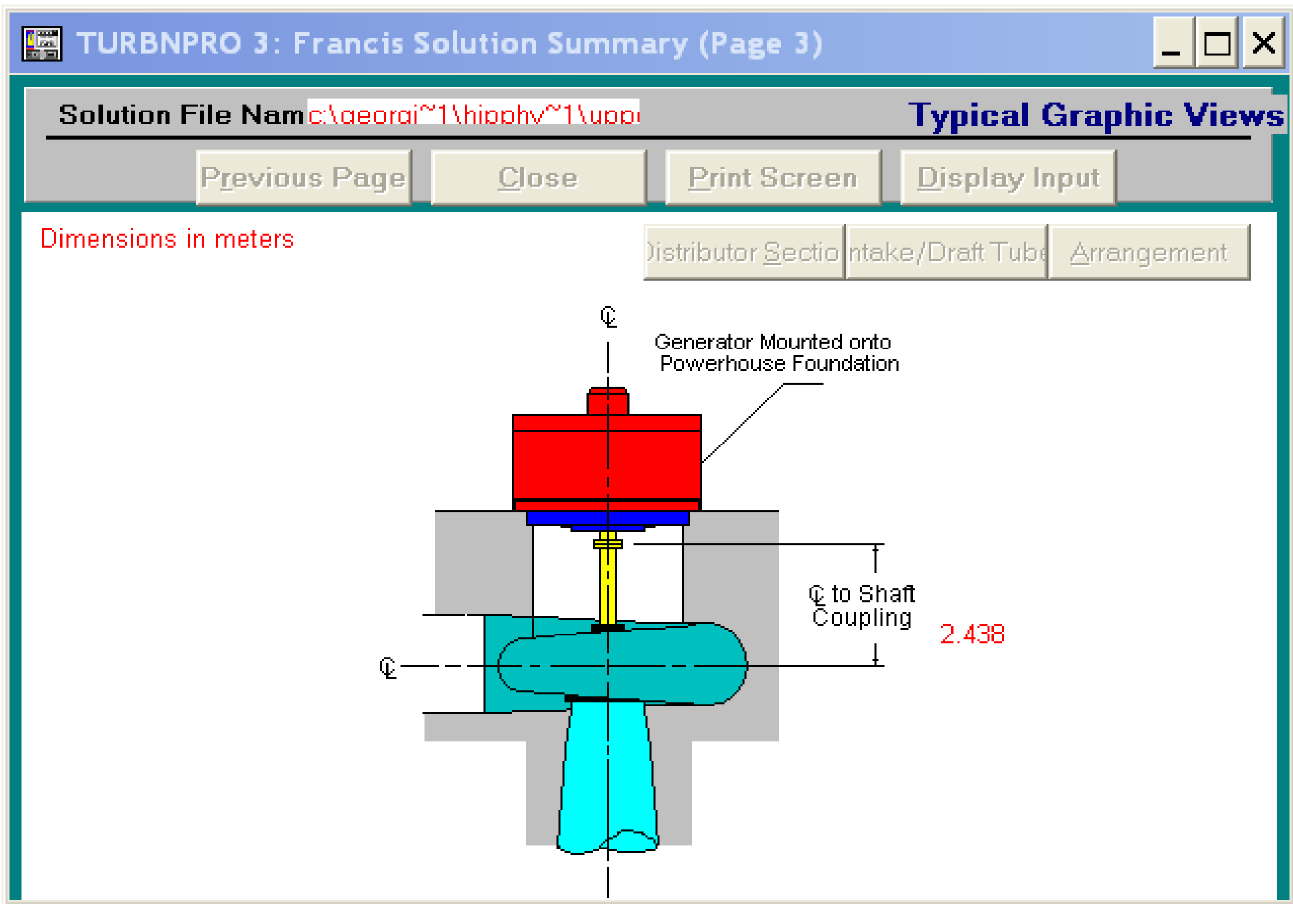
Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khe2-vsf.dat
Runner Diameter: 802 mm
Net Head at Rated Discharge: 110.00 meters
Unit Speed: 500.0 rpm



Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khe2-vsf.dat
Runner Diameter: 802 mm
Net Head at Rated Discharge: 110.00 meters
Unit Speed: 500.0 rpm

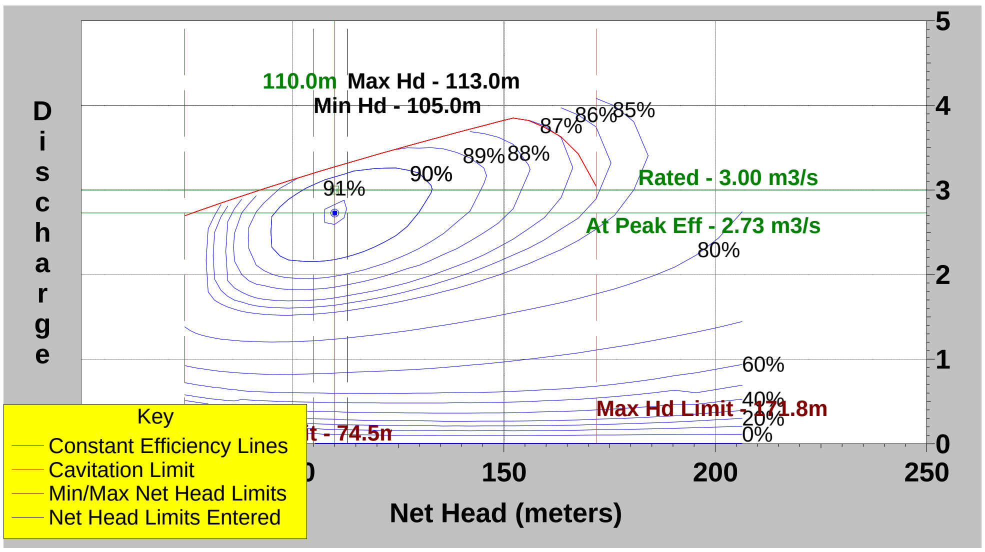


Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khe2-vsf.dat
Runner Diameter: 802 mm
Net Head at Rated Discharge: 110.00 meters
Unit Speed: 500.0 rpm



Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khe2-vsf.dat

Runner Diameter:	802 mm
Net Head at Rated Discharge:	110.00 meters
Unit Speed:	500.0 rpm
Peak Efficiency:	91.2 %
Multiplier Efficiency Modifier:	1.000
Flow Squared Efficiency Modifier:	0.0000



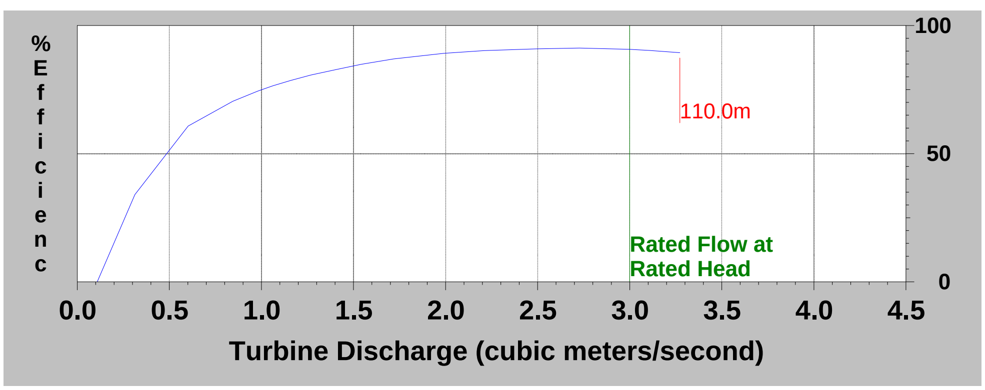
NOTE: Discharge is in cubic meters per second

TURBNPRO Version 3 - FRANCIS TURBINE CROSS PLOT

Solution File Name: c:\georgi~1\hipphy~1\uppert~1\kheled~2\turbin~1\khe2-vsf.dat
Runner Diameter: 802 mm
Net Head at Rated Discharge: 110.00 meters
Unit Speed: 500.0 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

Performance Data Shown is for a Net Head of: 110

Power (KW)	Efficiency (%)	Discharge (m3/s)	Notes
3155	89.3	3.27	Additional Output Capability
3028	90.3	3.11	Additional Output Capability
2936	90.7	3.00	Rated Flow/Head Condition
2886	90.8	2.95	-
2734	91.1	2.78	-
2683	91.2	2.73	Best Efficiency Condition
2572	91.0	2.62	-
2404	90.8	2.45	-
2234	90.4	2.29	-
2060	89.8	2.13	-
1883	88.9	1.96	-
1701	87.6	1.80	-
1518	86.0	1.64	-
1332	83.8	1.47	-
1148	81.3	1.31	-
967	78.2	1.15	-
788	74.4	0.98	-
612	69.3	0.82	-
444	62.8	0.65	-
267	50.4	0.49	Low efficiency; not used in energy calculation
125	35.3	0.33	Low efficiency; not used in energy calculation
16	9.1	0.16	Low efficiency; not used in energy calculation



Appendix 12

Forecasted Energy Sales Price

Forecasted Energy Sales Price for Power Produced by New Georgian HPPs

Contact: Jake Delphia, CoP

HydroPower Investment Promotion Project

August 2011

Forecasted Energy Sales Price for Power Produced by New Georgian HPPs

A. Initial Regional Market Analysis

Newly constructed Georgian hydropower plants have various options for sale of their energy production. This is an initial analysis of the regional power markets – further analysis will be completed in the near future.

1) **Direct energy sales** – for plants less than 13 MW, power sales contracts can be consummated with retail consumers. From our discussions with Alliance Energy Group, we know that the tariff is between USc 5.5 and USc 6.0. The cost of power for large consumers is about USc8.0 cents/kwh, so there is room for the tariff to grow over time.

2) **The sale of power to eligible consumers** also provides an opportunity for future sales. Beside the largest 8 retail consumers, there are several other entities that can purchase power from the plants – 3 distribution (and retail supply) companies, 3 transmission companies, and thermal power producers. In fact, Enguri HPP is an eligible consumer that could purchase power in the lower price time periods and sell in the high priced power periods by using the reservoir for storage of energy. As the price in the Southern Region of Russia increases, then this option will be increasing more viable. The short term energy sales price for energy from Ukraine to the Russian Southern Region in 2010 grew to as high as USc 7.0 cents.

3) **ESCO –** The MoUs and IAs signed by the developers of Georgian HPPs agree to sell energy in Georgia for at least the 3 winter months (December through February). The sales can be to any entity within Georgia. In the worst case, ESCO agrees to pay for energy produced in the winter months for 10 years. The energy sales price is determined by the price paid by ESCO in the previous month for gas-fired generation. This price recently ranged from 8.0 Tetri/kwh to 11.0 Tetri/kwh (or USc 5.0/kwh to USc 6.5/kwh.)

4) **Turkey** – There are several options for sale of power in Turkey.
    a. The spot market was recently created, but volumes have been low so price swings can be significant.
    b. The wholesale power market has been active for many and the prices seem to (but not always) follow the price of natural gas. The prices on the wholesale market range from USc 7.0 cents/kwh to 9.0 USc/kwh. With the growing demand in Turkey and the shrinking reserve margin, the prices are forecasted to increase significantly. Deutch Bank has forecasted the current wholesale power price in Turkey to increase 100% by 2020.
    c. Energy sales to large energy consumers.

d. Energy sales to distribution companies/retail supply companies. This option will be explored on HIPP's September mission to Turkey.

5) **Europe** – Southeast Europe is in an increasing tighter reserve capacity position. Several of the countries are in fact are in capacity deficit. The daily on-peak price of energy ranges from USc 11.0/kwh to USc 16.0/kwh. For this option (Georgia is currently selling to Serbia for spot sales), Georgian HPPs will have to pay the CBT (no more than USc 1.0/kwh as transit fee). For these sales, Georgian HPPs most likely could receive CERs.

6) **Iraq** – Energy sales to Iraq may be limited a few hundred MWs due to the limited interconnection between Turkey and Kurdistan. Iraq has a large deficit of electrical capacity and has a huge program of constructing new gas and oil-fired power plants near oil rigs. New g thermal power plant energy production costs will range in the USc 8.0/kwh to USc 10.0/kwh while the spare oil and gas are available. As the spare gas and oil is used up, then the price of energy will greatly increase as the plants will have to purchase fuel at market prices.

7) **Southern Neighbors** – Georgian and Armenia have agreed to analyze a new double circuit 400 KV line from Gardebani Station to Hrazdan Station for the sole purpose of exporting power from Georgia to Armenia and south and east. There are too many issues to resolve at this time but the option may happen through swap transactions that are not exactly transparent.

B. Estimated Price for Sale of Electricity from HPPs

Attachment 1 provides a review of some viable options. HIPP has decided to use two options for energy sales from future HPPs:

a) Sales to ESCO during the period December through February (winter months)
b) Sales to the Turkish wholesale power market during the remaining nine months.

Both of these options provide a floor for the energy sales price. It is anticipated that the actual energy prices will be higher as other competitive power market options become available.

Sales Price Forecast to ESCO

2011 price - USc 5/kwh (paid at HPP busbar according to Market Rules)

<u>Forecasted Price</u> – 2011 price escalated at 5%/year.

Sales Price Forecast to the Turkish Wholesale Power Market

2011 price – USc 8.5/kwh (paid at the delivery point assumed to be in Western Turkey.)

Forecasted Price – 2011 price escalated at 5%/year.

Attachment 1

Calculation of Net Sales Price/kwh (In USc/kwh) for New Georgian HPP Power Production

	ESCO	Turkish Wholesale Power Market	European Wholesale Power Market	Eligible Consumer (for HPPs less than 13 MW)
Price For Energy	5.0	8.5	11.0	5.5
Georgian Transmission Tariff		0.50	0.50	
Georgian Dispatch Fee		0.15	0.15	
EnergoTrans Estimated Tariff		1.20	1.20	
Turkish Transmission Fee		0.80	0.80	
European CBT			1.00	
Net Price Paid	5.0	5.85	7.35	5.5

USAID Hydropower Investment Promotion Project (USAID-HIPP)

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