Mississippi State UNIVERSITY

Calculation of water surface elevation using HECRAS 4.1.0 for fixing tailrace elevation for powerhouse site in planned 37 MW Kabeli "A" Hydroelectric Project, Nepal

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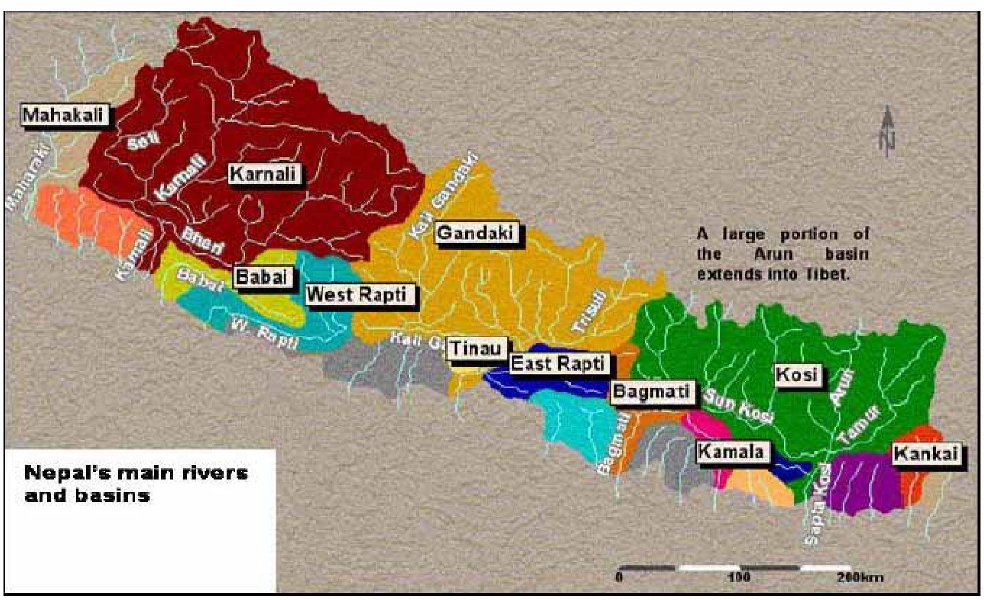
Why is the need for finding flood level elevations?

- To find out water surface elevations at different flood frequencies.
- To find out design water level to safeguard all costly engineering structures from flood damage which is probable sometime in future.
- To fix the tailwater elevation. As head (energy) relates to increase in revenue in hydroelectricity, small increment in head has a huge impact in overall project financial health in a long run. Earthwork excavation incurs huge part of powerhouse cost initially. There has to be optimized tailwater elevation by analyzing between increase in project revenue from head increment vs. initial earthwork excavation cost.

Location of Nepal on Globe

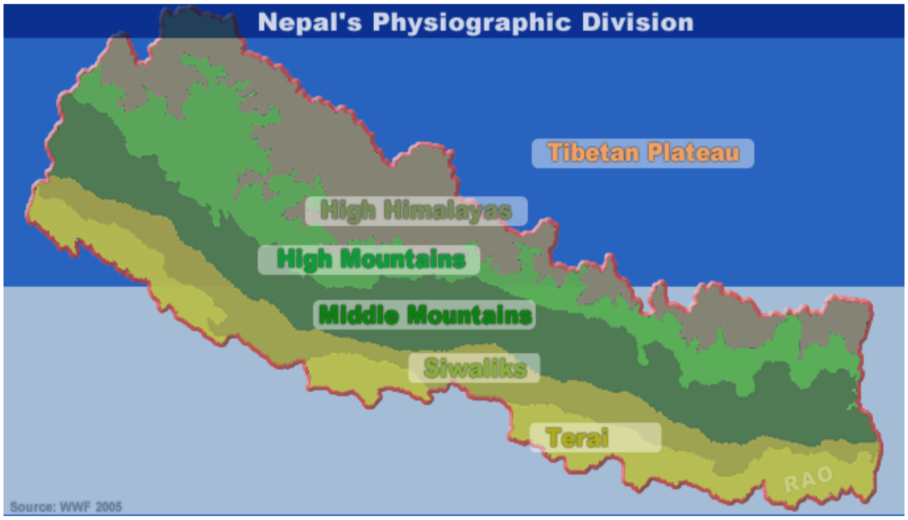
Source: WORLD ATLAS

Major Watersheds in Nepal



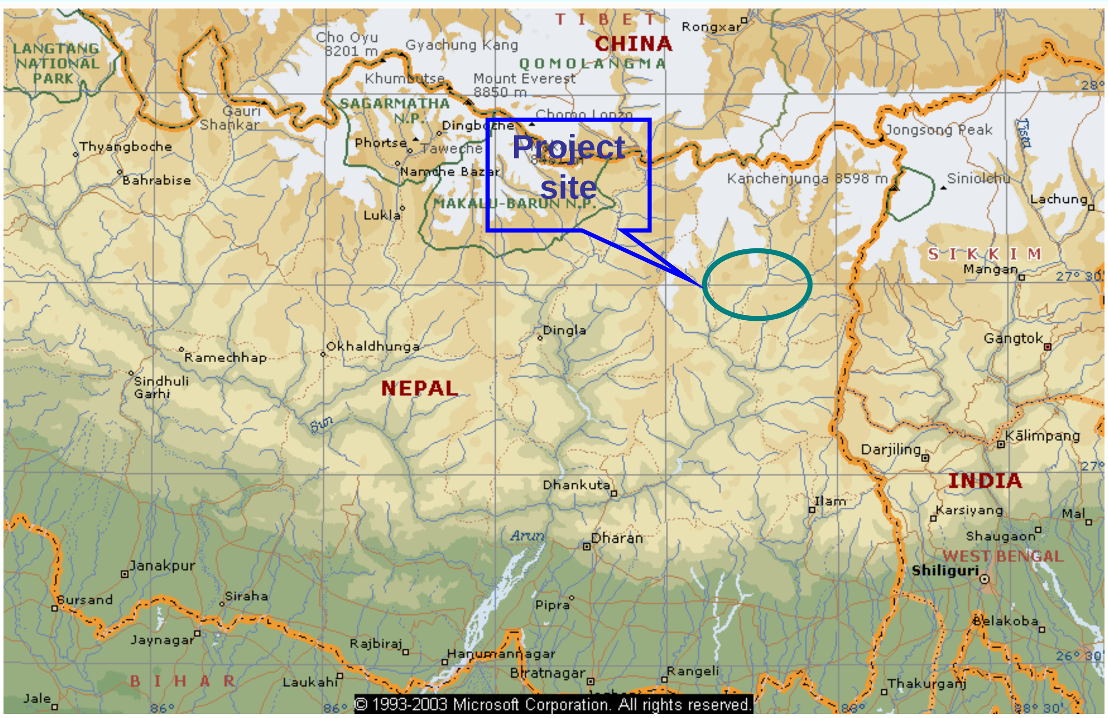
Source: Ministry of Energy, Nepal

Physiographic Divisions of Nepal

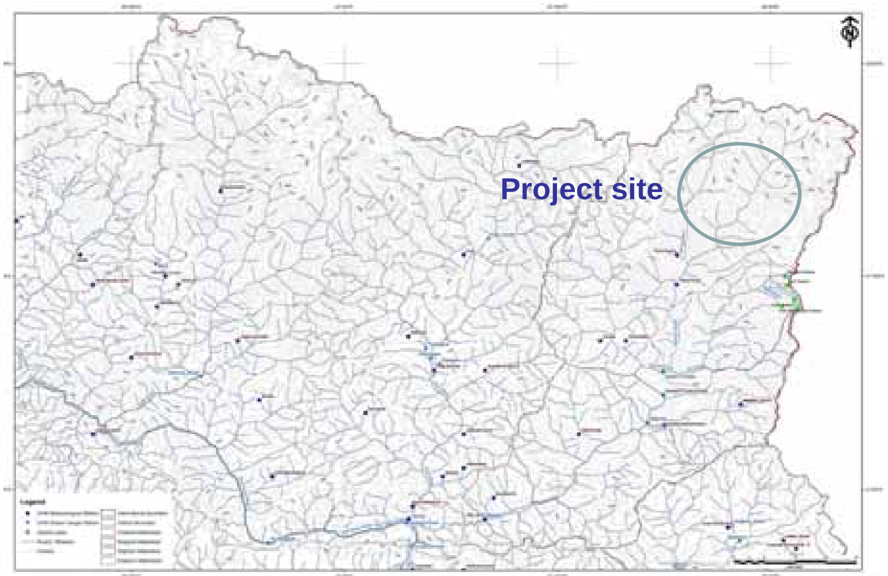


Source: WWF 2005

Kabeli "A" Hydroelectic Project Site

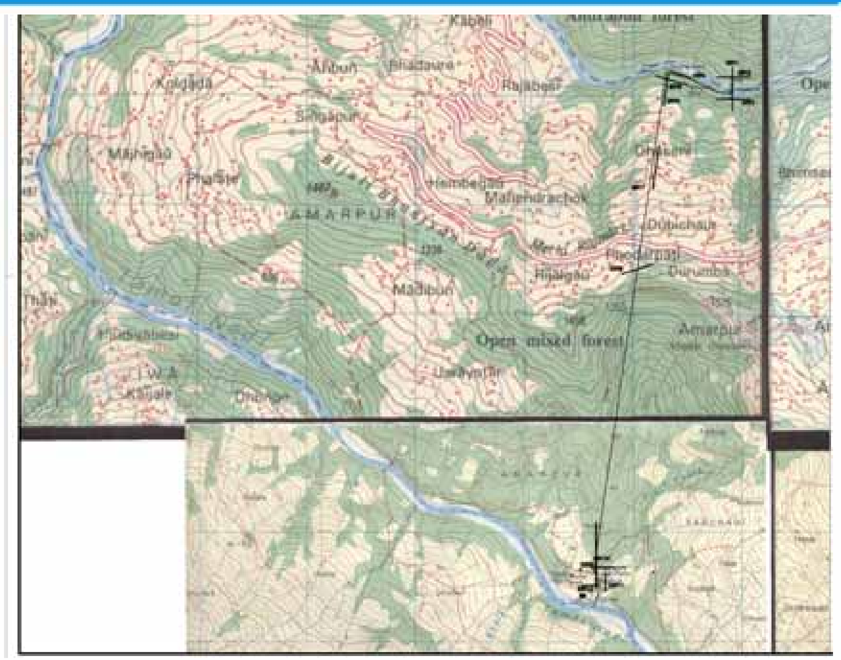


Kabeli “A” Hydroelectric Project Watershed Area



Source: Survey Department, Nepal

Kabeli “A” Hydroelectric Project Layout

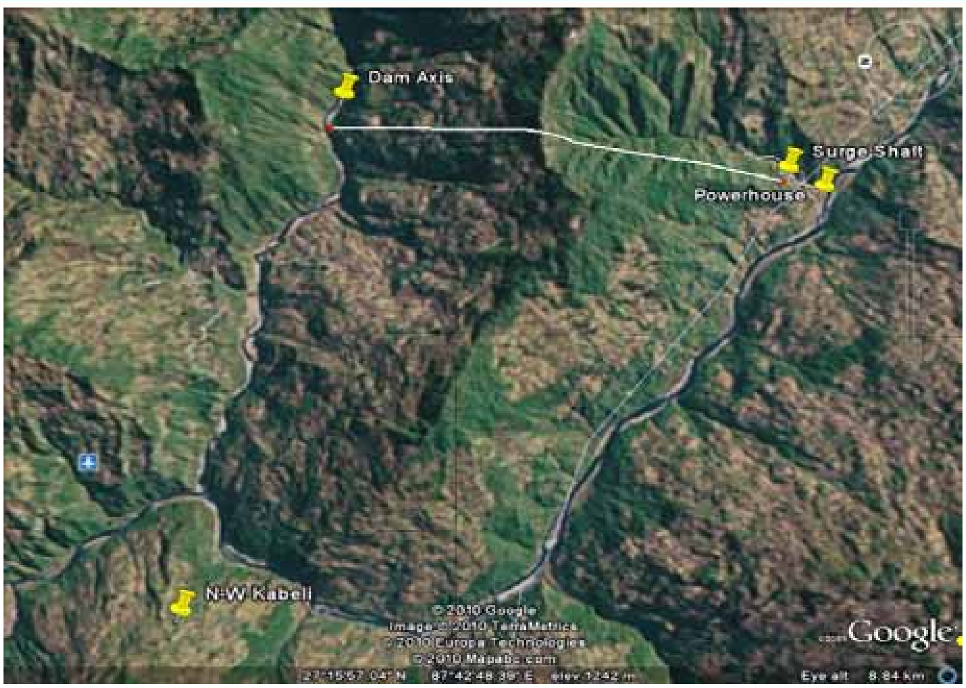


Source: Survey Department, Nepal

General Project Features

Items	Description
Project Name	Kabeli-A Hydroelectric Project
Location	Amarpur and Panchami VDCs of Panchthar District and Nangkholyang of Taplejung District
Project Boundaries	**Licensed Coordinates**
87° 45' 50'' E	Eastern Boundary
87° 40' 55'' E	Western Boundary
27° 17' 32'' N	Northern Boundary
27° 13' 41'' N	Southern Boundary
Type of development	Peaking Run-of-the-river (PROR)
Hydrology	
Catchment area at Intake	864 km^2
Catchment area at Powerhouse	3930 km^2
Mean monthly flow in Kabeli	51.75 m^3/s
40 percentile flow from Flow Duration Curve (FDC) in Kabeli River	37.73 m^3/s

General Project Layout Within Licensed Coordinates



Source: Google Earth

Change in Powerhouse Location

Catchment Area Characteristics

Elevation, masl	Intake Area		Powerhouse Area	
	Area in km²	% of total area	Area in km²	%
Above 5000	0.5	0.1%	717.0	18.2%
Between 5000 m and 3000 m	177.5	20.5%	1325.0	33.7%
Below 3000 m	686.0	79.4%	1888.0	48.1%
Total catchment area	864.0	100.0%	3930.0	100.0

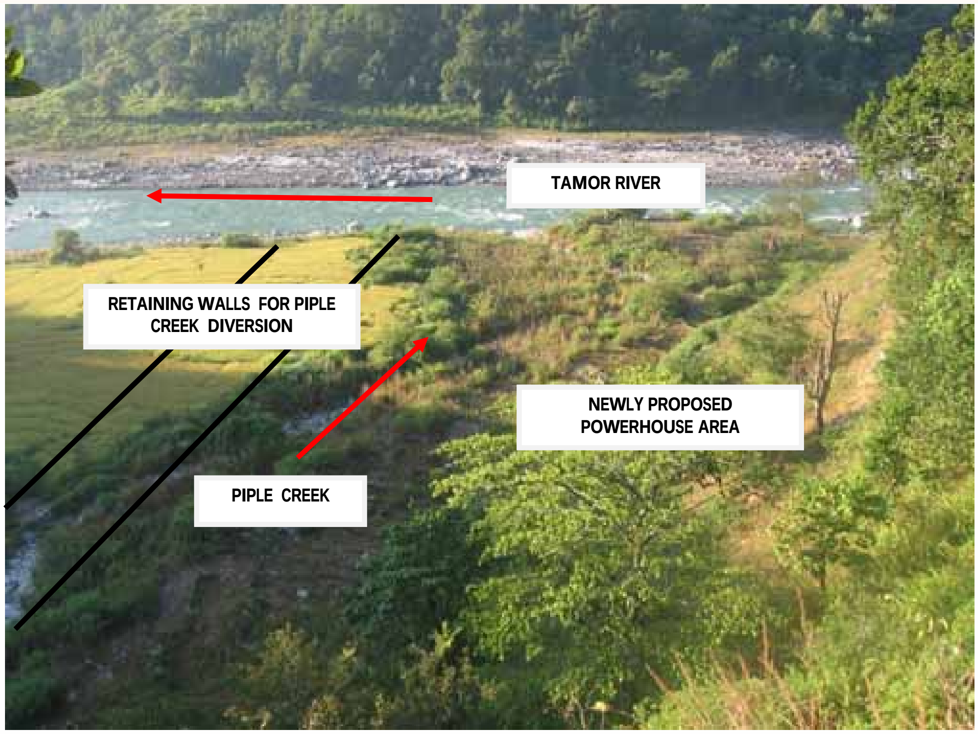
Newly Proposed Powerhouse Location on right side of Piple Creek (Picture taken during summer season)

Alluvial fan of Piple Creek and its confluence with Tamor River Downstream

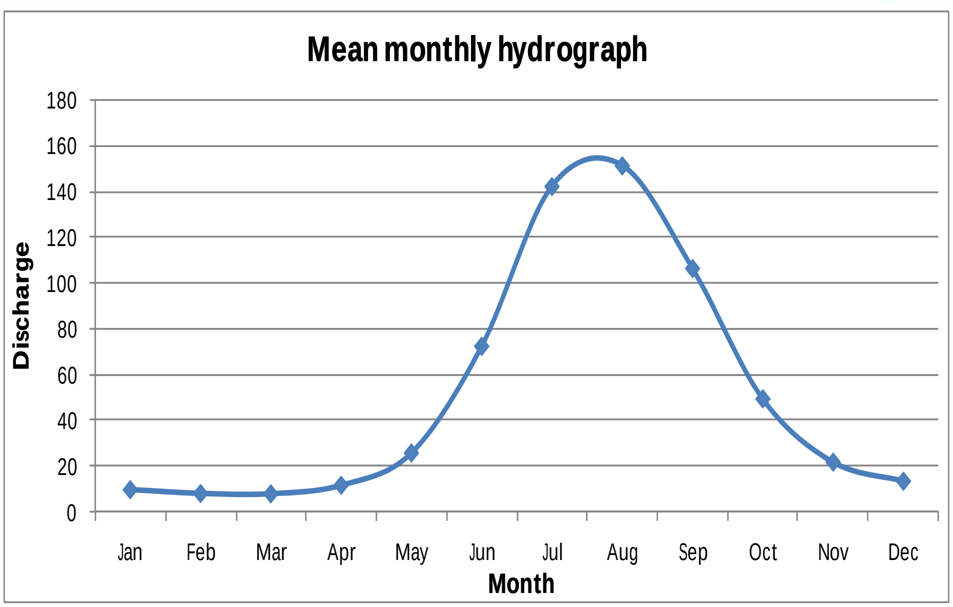
Regional Methodologies for Calculating Mean Monthly flows for un-gaged rivers

- **HYDEST:**developed by Water and Energy Commmission Secretariat (WECS) and Department of Hydrology & Metereology (DHM) in 1990. For complete analysis, catchment area and its distribution in altitude are essential along with monsoon wetness index (MWI)
- **MHSP (Medium Hydropower Study Project):**Nepal Electricity Authority (NEA) in 1997 developed a method to predict long-term flows, flood flows and flow duration curves at ungaged sites through regional regression technique. This approach uses both monsoon wetness index and average precipitation of the area along with catchment area of the river.
- **Catchment correlation:** an attempt was made to correlate the flows of gaged catchment with the ungaged catchment by using cathment area ratio. During the study, it was found that Tamor River at Majhitar (station no 684) has recorded data of 11 years only. Therefore, catchment characteristics of only two stations: station 690 (Tamor River at Mulghat) and station 795 (Kankai Mai at Mainachuli) are compared.

Newly Proposed Powerhouse Location during rainy season (Monsoon)



Mean Monthly Hydrograph for Kabeli River

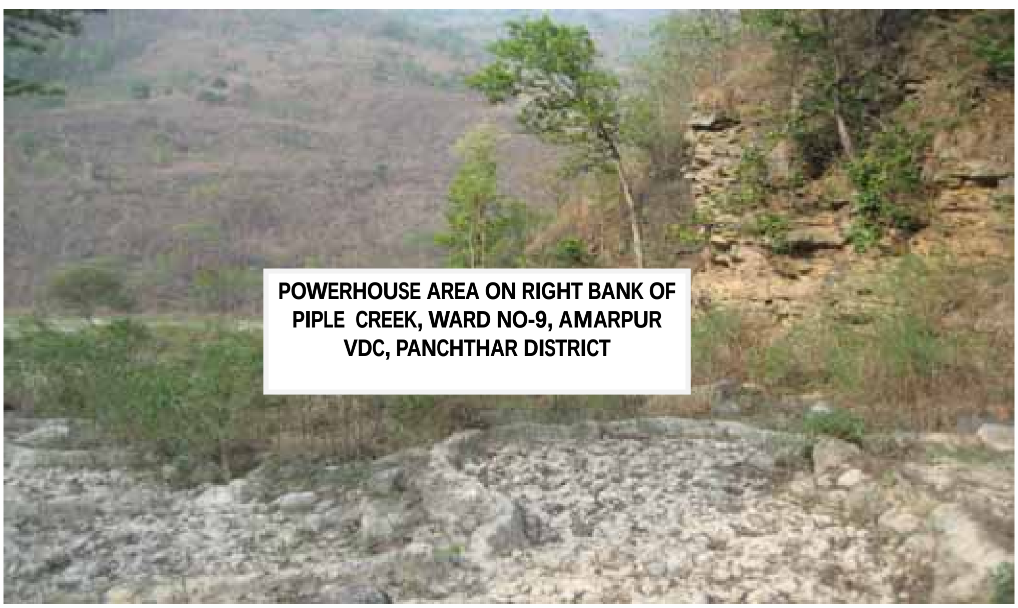


Extreme Hydrology (Flood Frequency Analysis) for Ungaged Catchment

- **Catchment Area Ratio (CAR) Method:** The maximum instantaneous flow data of Tamor River at Mulghat (station number 690) is available from the year 1965 to year 2006.Three distribution methods; Lognormal, Log Pearson III and Gumbel distribution methods were used to estimate the flow for different return periods. The Log pearson III method has given the best fit curve, therefore the result given by this method is taken
- **Regression analysis method:** Instantaneous maximum flow data from 15 gaging stations, all lying within Koshi basin was collected and their individual frequency analysis was carried out. Then, regression equations were developed between the catchment area below elevation 3000 m and T-year return period.
- **Regional flood frequency analysis method:** The same 15 gaging stations as mentioned in above method were selected for analysis in this method as well. The frequency analysis of maximum instantaneous floods was carried out for each of the station and regression equation between the mean flood discharge (Q2.33) and the catchment area was developed. The equation used is:

$$Y = 7.792X^{0.623}$$

Newly Proposed Powerhouse Location on Right Side of Piple Creek



What is Glacial Lake Outburst Flood (GLOF) ?

A glacial lake outburst flood (GLOF) is a type of outburst flood that occurs when the dam containing a glacial lake fails. The dam can consist of glacier ice or a terminal moraine. Failure can happen due to erosion, a buildup of water pressure, an avalanche of rock or heavy snow, an earthquake or cryoseism, volcanic eruptions under the ice, or if a large enough portion of a glacier breaks off and massively displaces the waters in a glacial lake at its base.

Source:http://en.wikipedia.org/wiki/Glacial_lake_outburst_flood

Glacial Lake Outburst Flood (GLOF) events are likely with high seismic events in Himalayas

Source: http://www.swisseduc.ch/glaciers/glossary/glof-2-en.html

Glacial Lakes in Kabeli Basin

S.N.	Glacial lake/pond	Elevation (m)	Surface area (ha)	Aerial distance from headworks (km)
1	Timbu Pokhari	4330	9.9	35
2	Hadi Pokhari	4220	8.7	36
3	Suke Pokhari	4350	3.0	36
4	Lam Pokhari	4360	3.5	36
5	Chhahare Pokhari	4440	4.8	36

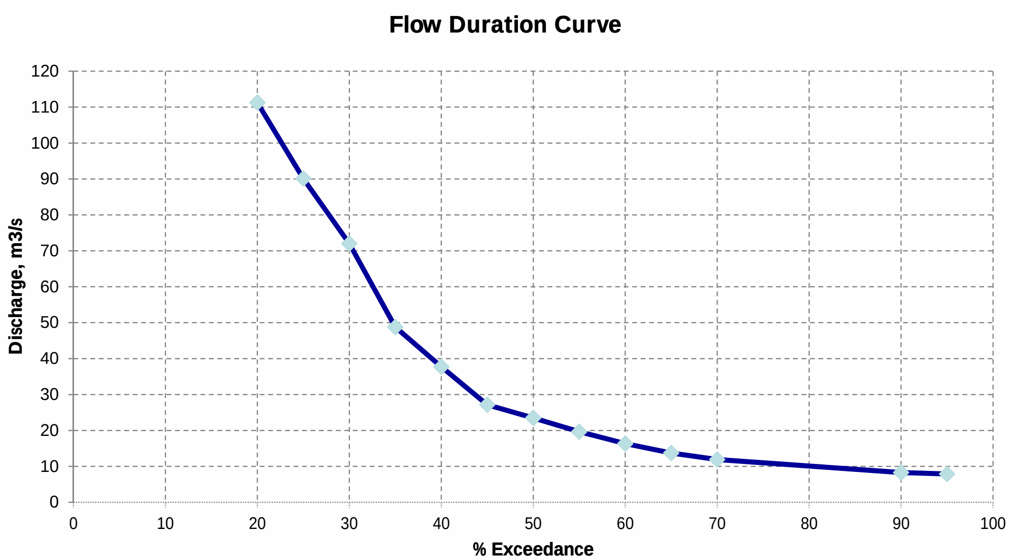
Calculation of flow data for Generating Hydrograph

Adopted mean monthly flow at Kabeli is derived by using gage data of Tamor at Mulghat (Station 690) and applying catchment area ratio (CAR) and precipitation index (PI). A multiplying factor of 0.14 (CAR=0.15 and Precipitation ratio=0.937) was applied in the daily flow of station 690 to derive long term daily flow of Kabeli River at the intake site. Tamor river at Mulghat is mother catchment for Kabeli river. Using CAR and PI, long term daily flow at Kabeli river is derived. The 40% exceedance of flow is 37.73 m3/s from flow duration curve (FDC) as shown in next slide.

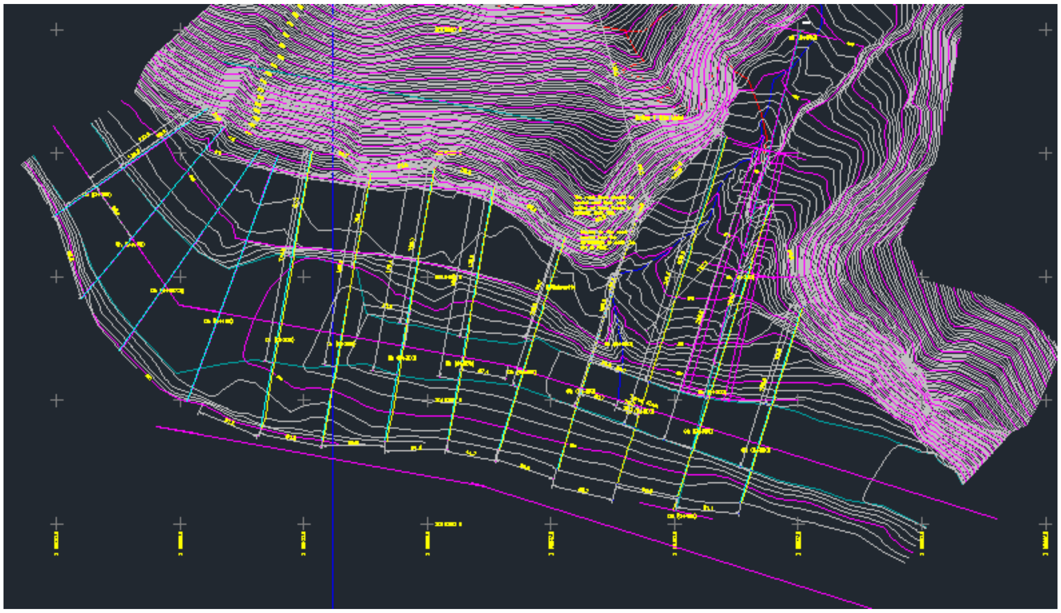
Flow Duration Curve for Kabeli River

% Exceedance	Discharge, m3/s
5	154.5
10	143.2
15	131.4
20	111.3
25	90.1
30	72.0
35	48.8
40	37.7
45	27.2
50	23.5
55	19.7
60	16.3
65	13.7
70	11.9
90	8.3
95	7.9

Flow Duration Curve for Kabeli River



13 Cross Sections Chosen for Input in Geometry Data for HECRAS Analysis



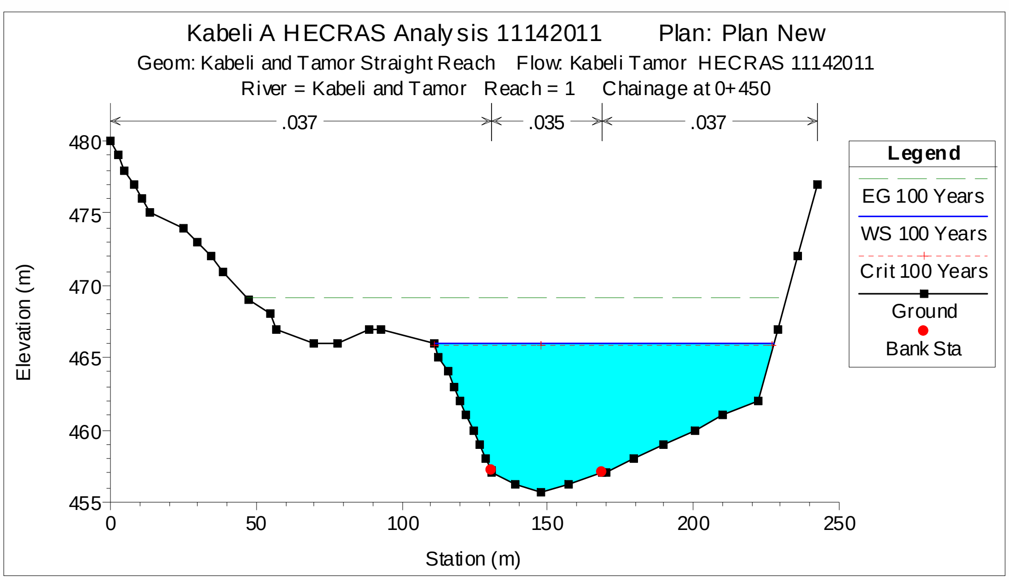
Input Cross Section of Geometry Data

	River Station 600 Chainage 0+000		River Station 550 Chainage 0+050	
3	Cumulative Distance (m)	Elevation (m)	Cumulative Distance (m)	Elevation (m)
4	0	481	0	475
5	1.41	480	2.57	474
6	2.86	479	5	473
7	5.49	478	7.33	472
8	8.91	477	9.67	471
9	11.9	476	17.57	470
10	14.36	475	21.91	469
11	16.32	474	24.4	468
12	18.62	473	28.56	467
13	21.03	472	41.47	466
14	23.36	471	45.8	465
15	25.3	470	65.49	464
16	27.09	469	77.75	463
17	28.88	468	81.3	462
18	30.69	467	84.91	461
19	37.78	466	85.5	461
20	43.59	465	104	459.3
21	61.98	464	120	458.18
22	76.14	463	138	459.3
23	79.59	462	157.7	461
24	82.96	461	158.98	461
25	83.2	461	164.6	462
26	100	459	167.8	463
27	110	458.5	170.08	464
28	120	459	175.33	465
29	138.3	461	179.06	466
30	139.13	461	185.94	471
31	142.09	462	192.82	476
32	144.28	463		

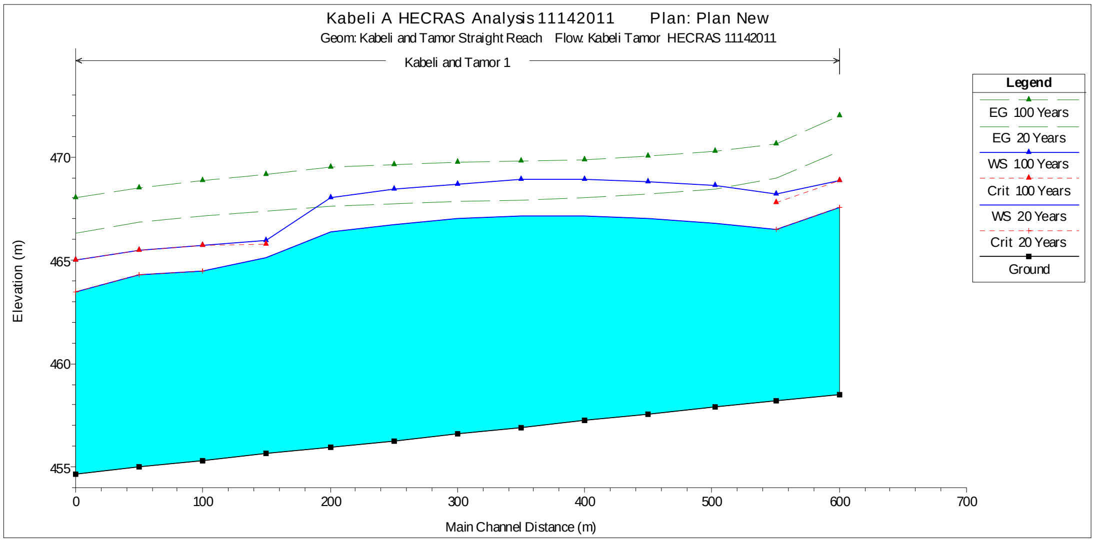
Flow Data for HECRAS Analysis

	At Normal Flow	
River	Kabeli and Tamor	Kabeli and Tamor After adding Q from Powerhouse
Reach	**1**	**1**
RS	**600**	**100**
Jan	48.75	86.48
Feb	40.25	77.98
Mar	39.55	77.28
Apr	57.90	95.63
May	127.52	165.25
June	345.29	383.02
July	682.56	720.29
Aug	734.02	771.75
Sept	512.06	549.79
Oct	241.09	278.82
Nov	106.79	144.52
Dec	68.10	105.83
2 Years	2212.00	2250.00
20 Years	4414.00	4452.00
50 Years	5292.00	5329.00
100 Years	5984.00	6022.00
1000 Years	8523.00	8561.00

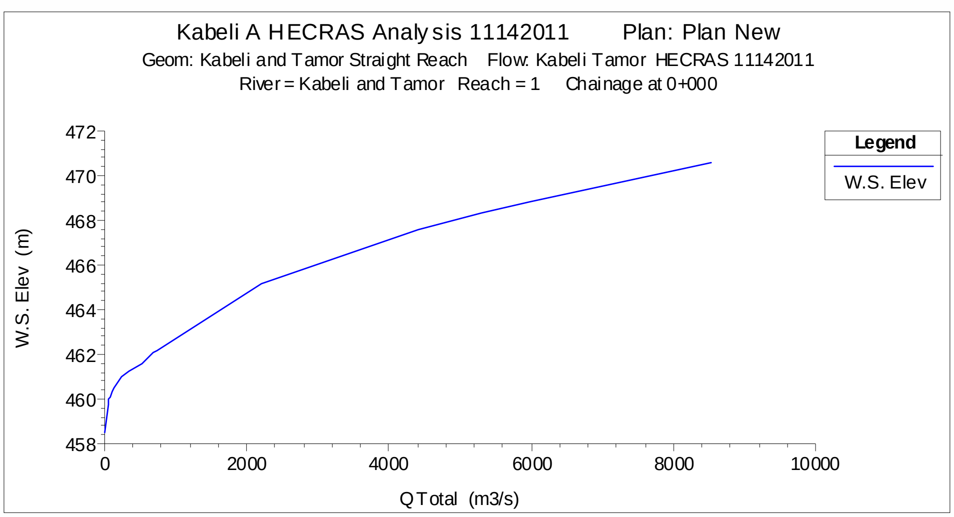
Cross Section Profile 30m upstream where tailwater release meets Tamor River



20 and 100 Years Return Period Flood Elevations Under Steady State Analysis Conditions



Rating Curve at first upstream cross section in Powerhouse Area taken for HECRAS analysis



Cross Section Output Table

Cross Section Output

File Type Options Help

River: Kabeli and Tamor Profile: 100 Years

Reach 1 RS: 600 Plan: Plan New

Plan: Plan New Kabeli and Tamor 1 RS: 600 Profile: 100 Years

E.G. Elev (m)	472.02
Vel Head (m)	3.18
W.S. Elev (m)	468.83
Crit W.S. (m)	468.83
E.G. Slope (m/m)	0.004785
Q Total (m3/s)	5984.00
Top Width (m)	125.90
Vel Total (m/s)	7.26
Max Chl Dpth (m)	10.33
Conv. Total (m3/s)	86505.3
Length Wtd. (m)	46.29
Min Ch El (m)	458.50
Alpha	1.19
Frctn Loss (m)	0.20
C & E Loss (m)	0.24

Element	Left OB	Channel	Right OB
Wt. n-Val.	0.037	0.035	0.037
Reach Len. (m)	20.20	50.00	69.60
Flow Area (m2)	242.50	511.62	70.32
Area (m2)	242.50	511.62	70.32
Flow (m3/s)	1193.34	4453.49	337.17
Top Width (m)	55.81	55.10	14.99
Avg. Vel. (m/s)	4.92	8.70	4.79
Hydr. Depth (m)	4.35	9.29	4.69
Conv. (m3/s)	17251.0	64380.1	4874.2
Wetted Per. (m)	56.79	55.35	17.12
Shear (N/m2)	200.39	433.73	192.74
Stream Power (N/m s)	7877.35	0.00	0.00
Cum Volume (1000 m3)	156.16	352.26	197.87
Cum SA (1000 m2)	39.80	35.09	29.91

Errors, Warnings and Notes

Warning: The energy equation could not be balanced within the specified number of iterations. The program used critical depth for the water surface and continued on with the calculations.

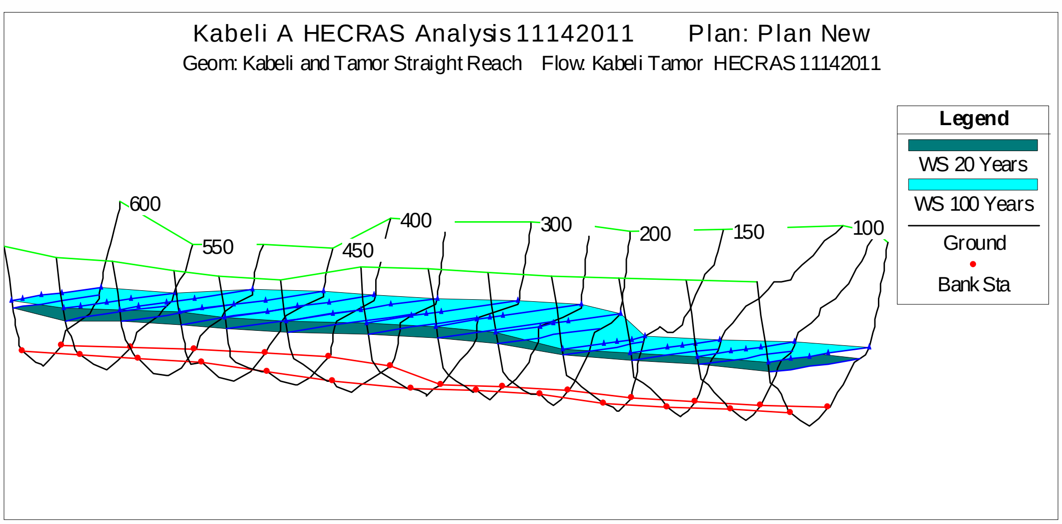
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.

Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.

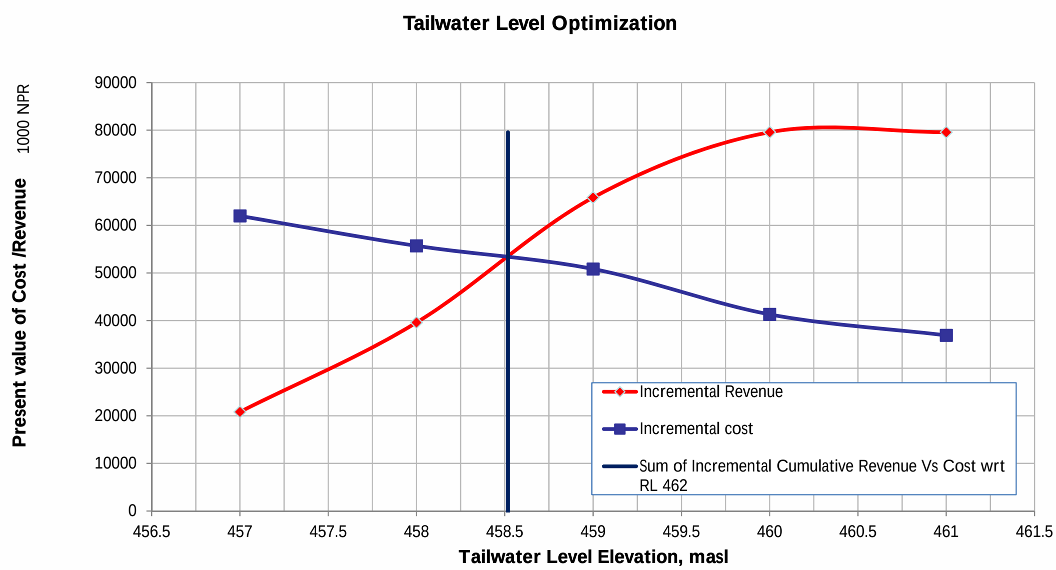
Warning: During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated

Select River Station

X-Y-Z Perspective View of 20 and 100 Years Return Period Flood Frequency



Tail water Level Optimization: Optimum Tailwater level comes out as 458.5m



ANY QUESTIONS?

THANK YOU