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SMVDU Small Hydropower Project-A Case Study

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Present Scenario

- By harnessing the potential of hydroelectricity, our project aims to significantly reduce the operational expenses associated with electricity consumption for pumping activities.
- Currently, the pumping station of SMVDU,katra incurs a monthly cost of around ₹**1,00,000.**
- This Mini Hydropower project is designed to generate **200 kW** of power, serving as an captive source of power for the pumping station.
- However, with the implementation of our mini hydro power project, we are poised to eliminate this recurring expense. Thus, making our solution economically advantageous**.**

Benefits of project:

1. Autonomy of operation.
2. Break even achieved in 18-19 years.
3. The project shall give better sustainability score to university.
4. Project shall be first of its type, to be developed by an educational organization.
5. Shall work as inspiration for other organization, operating pumping station.

Site condition:

- The project is proposed to be built on Jhajhar Nallah in J&K.
- There are cremation grounds at the site. Hence the tailrace of powerhouse shall open before cremation ground.

Typical arrangement of High Head Mini Hydro Power Project

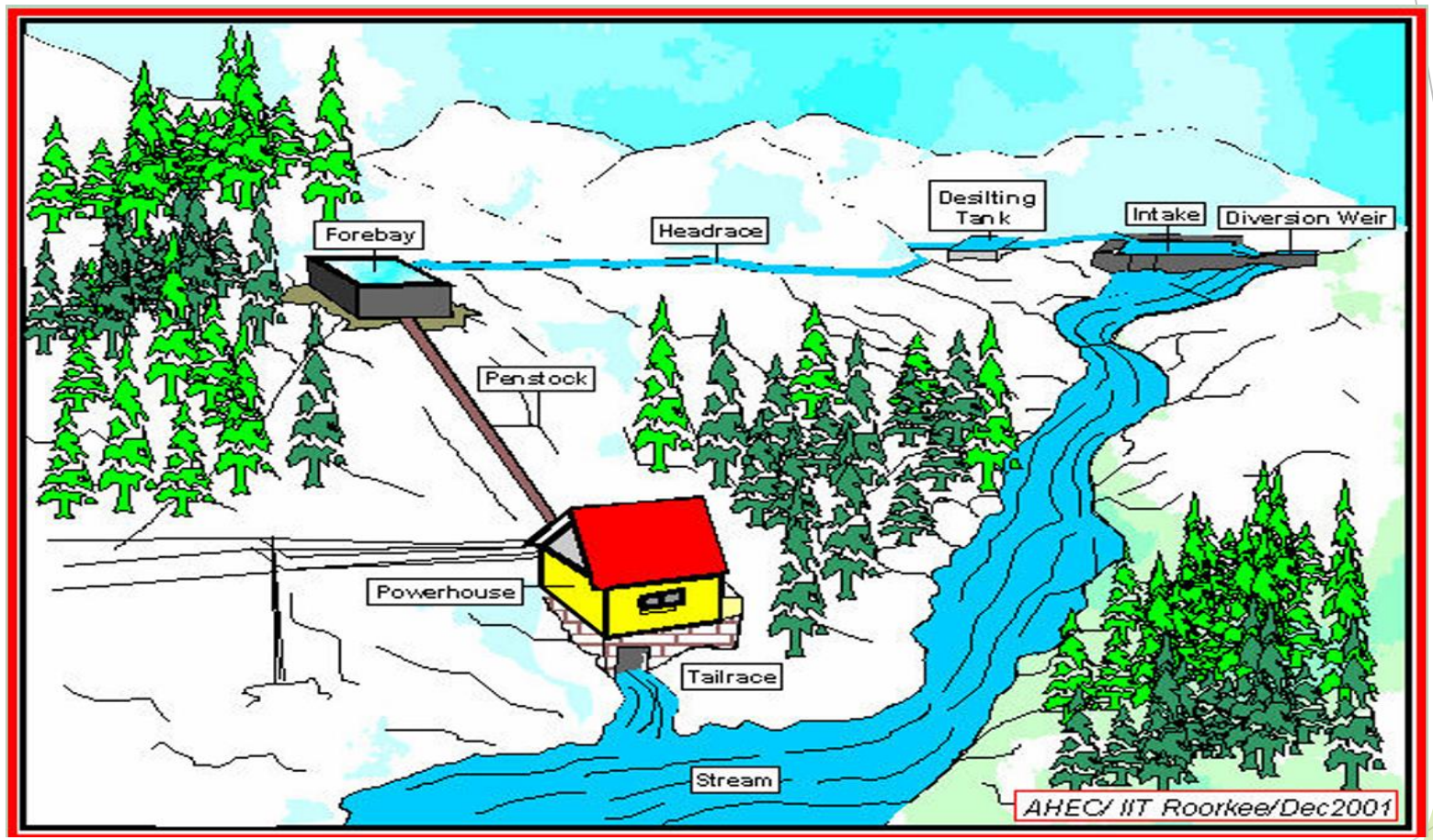


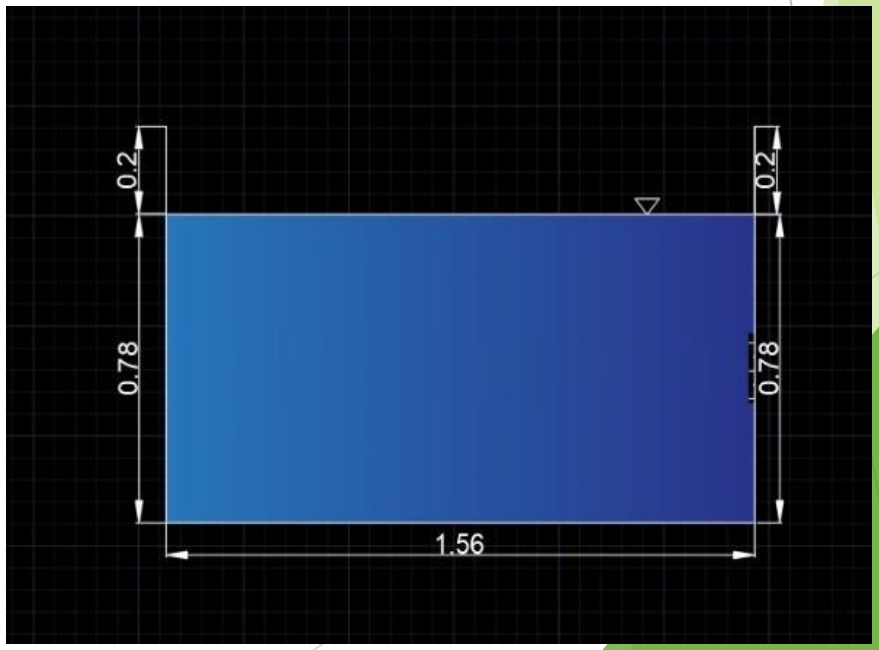
FIGURE : Typical Arrangement oF High Head Mini Hydro Power Project

(1)DESIGN OF POWER CHANNEL

- Power Channel:
  - Also known as **Headrace Channel.**
  - Shape: Rectangular
  - Material: Concrete.
  - Provide freeboard=0.2m
- **Design of power channel (Connecting Dam and Desilting Tank)**

Given Data:

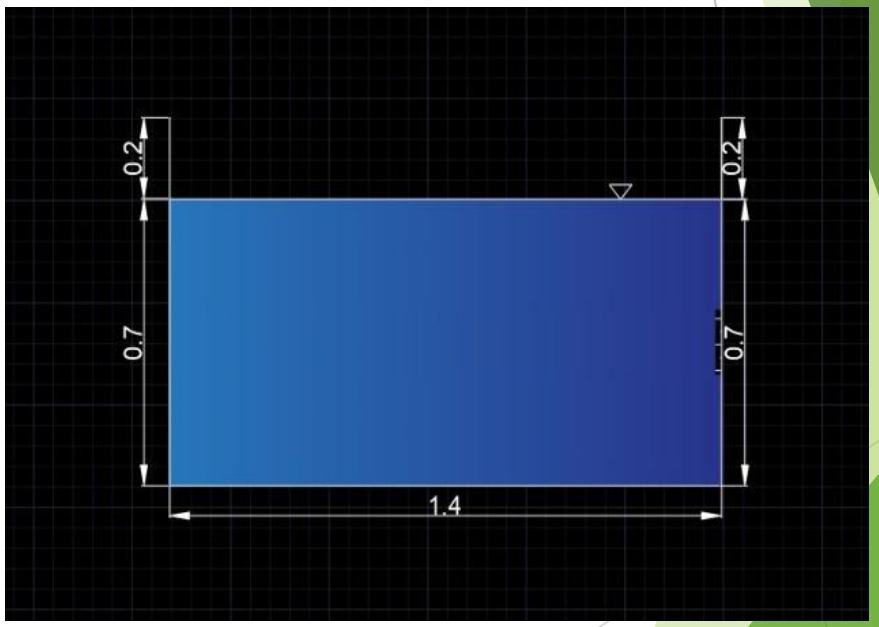
- Discharge in river in lean period(Q)= 0.72 m^3/sec
- **For Riparian Rights, 10% of the total discharge is released continuously.**
- V_{max} in power channel 1= 0.8m/sec
- Design discharge =1.5*(0.9*Q)=0.975 m^3/sec
- n=0.02(for concrete channel)
- The dimensions of channel are
  - A=1.22 m^2
  - y=0.78m
  - b=2y=2*0.78=1.56m
  - P= b+2y=3.12m
  - R=0.39m
  - S=1 in 1114



Design of power channel (Connecting Desilting Tank and Forebay)

Given Data:

- $Q_{entering}$ in Desilting Tank =0.65m^3/sec
- **25% of water is used for desilting tank for flushing**
- V_{max} in power channel 2= 0.8m/sec
- Design discharge=0.72 m^3/sec
- n=0.02 (for concrete open channel)
- The dimensions of channel are
  - A= 0.9m^2
  - y=0.7m
  - b=2y=2*0.7=1.4m
  - P= b+2y=2.8m
  - R=0.348
  - S=1 in 962



(2)Design of Desilting Tank

De – Silting Tank Definition

- A de-silting tank is a containment or settling basin where water is allowed to stand or move at a slow pace, allowing the sediment to settle to the bottom.

- The purpose of such a tank is to separate the solid particles from the water, helping to clarify the water and prevent the accumulation of sediment in downstream areas.

SILT ANALYSIS

- 2kg of soil sample collected
- The sample was dried for 24hrs.
- Sieve analysis was done and the particle size distribution curve was drawn.

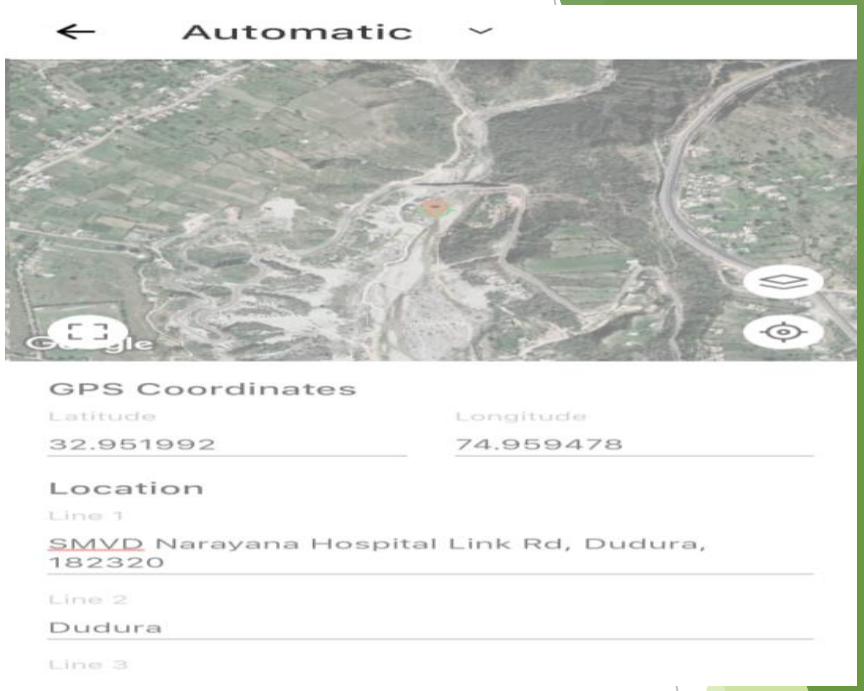


Fig. – Collection of Sample

Particle Size Distribution Curve

D_{10} = 0.1mm

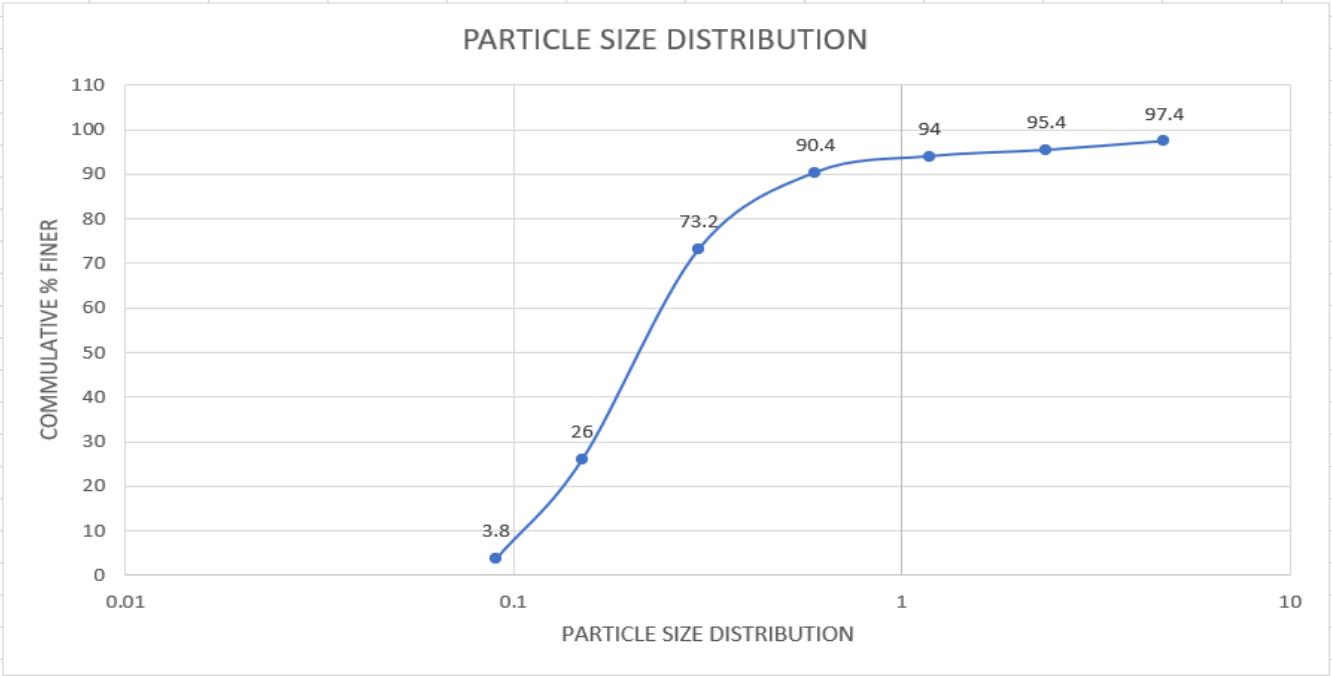
D_{30}= 0.3mm

D_{60}= 0.4mm

Cu = 4

Cc = 2.25

1	PARTICLE SIZE DISTRIBUTION	
2	CMM. %	PARTICLE SIZE IN MM
3	FINER	
4	97.4	4.75
5	95.4	2.36
6	94	1.18
7	90.4	0.6
8	73.2	0.3
9	26	0.15
10	3.8	0.09



Design of De-Silting Tank

- It is an important structure constructed on the head race canal for removal of sediment particles

Parameters of Settling Basin

1. %Fall Velocity or Settling Velocity (Vs):

90% settlement required;

i.e, upto D_{10} settle => Size ≥ 0.1 must settle

D_{10} = 0.1mm = 0.0001m

$V_s = 418\ (s-1)\ D^2\ [\frac{3T+70}{10}]$

s = specific gravity = 1.0009 (at T=15°C)

D = Particle size in 'm' = 0.0001m

T = temperature (°C) (of river stream as recorded by temperature probe)

$Vs = 418(1.0009 - 1)(0.0001)[\frac{3(15)+70}{100}]$

$Vs = 4.32*10^{-5}$ m/s

2.Surface Area of Settling Basin

- $A_s = \frac{K * Q}{Vs}$
- K = coefficient of turbulence(1.2 - 1.5)
- V_s = fall velocity
- $A_s = \frac{1.5 * 0.65}{0.039} = 25m^2$

3. Flow Velocity

- $V = a\sqrt{d}$
- d = particle size in mm
- a = 0.44 for 0.1 – 1mm
- $V = 0.44\sqrt{0.106} = 0.143m/s$

Therefore,

$A_s = 25m^2$

$A_{cs} = \frac{0.65}{0.143} = 4.5m^2$

$b*L = 25m^2$

$b*d = 4.5m^2$

$\frac{L}{d} = 5$

Say, d=0.7m

L=3.5m

b=6.5m

Therefore, Design Discharge = $0.65 m^3/s$

Flow Velocity, $V_f = 0.143 m/s$

Settling Velocity, $V_s = 4.32*10^{-5}$ m/s

Particle to be removed = 0.1mm & above size

Length of setting basin = 6m

Width = 7m

Depth = 0.7m

Hoppers:

Provided 1m diameter conical hoppers for silt flushing

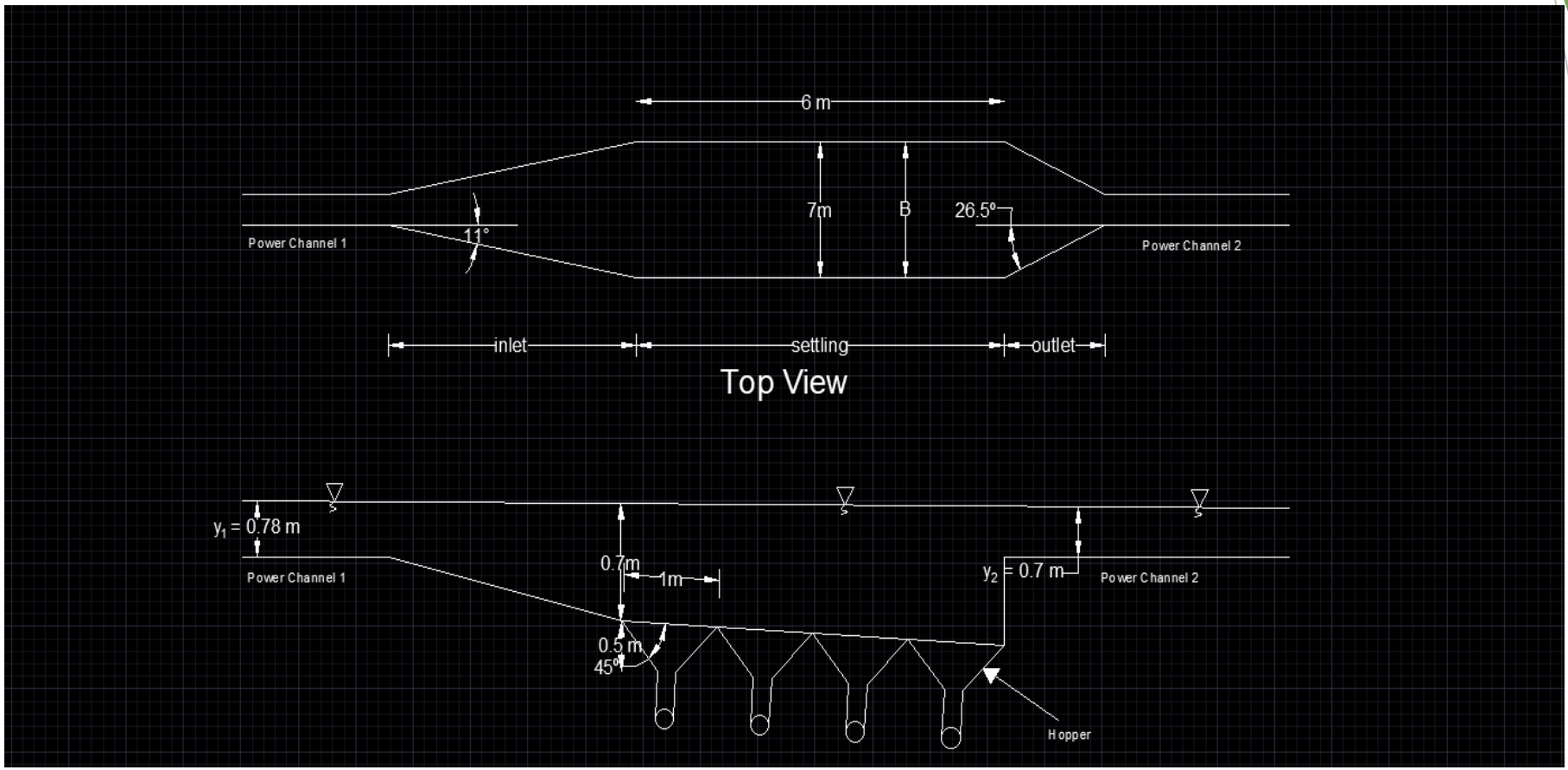
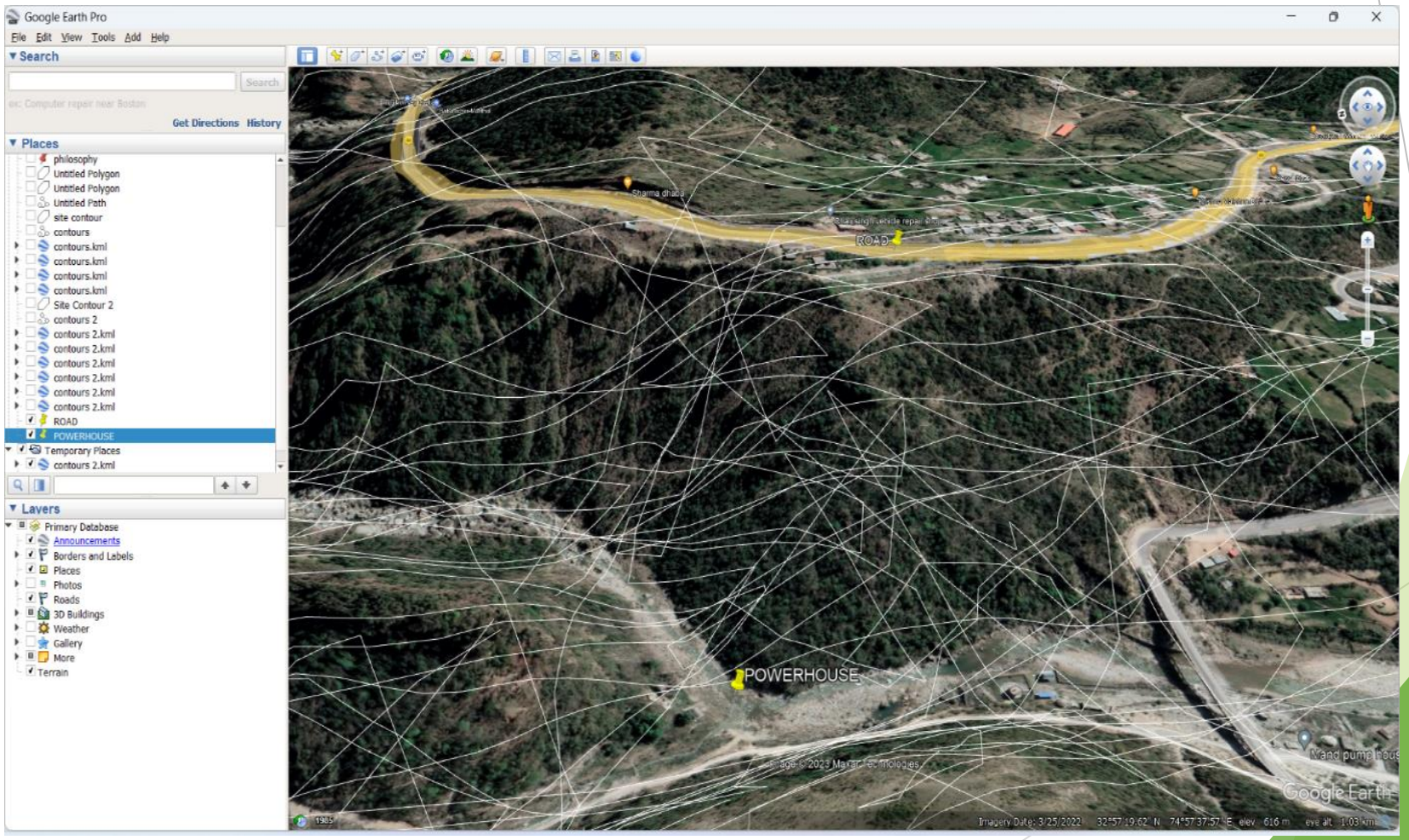


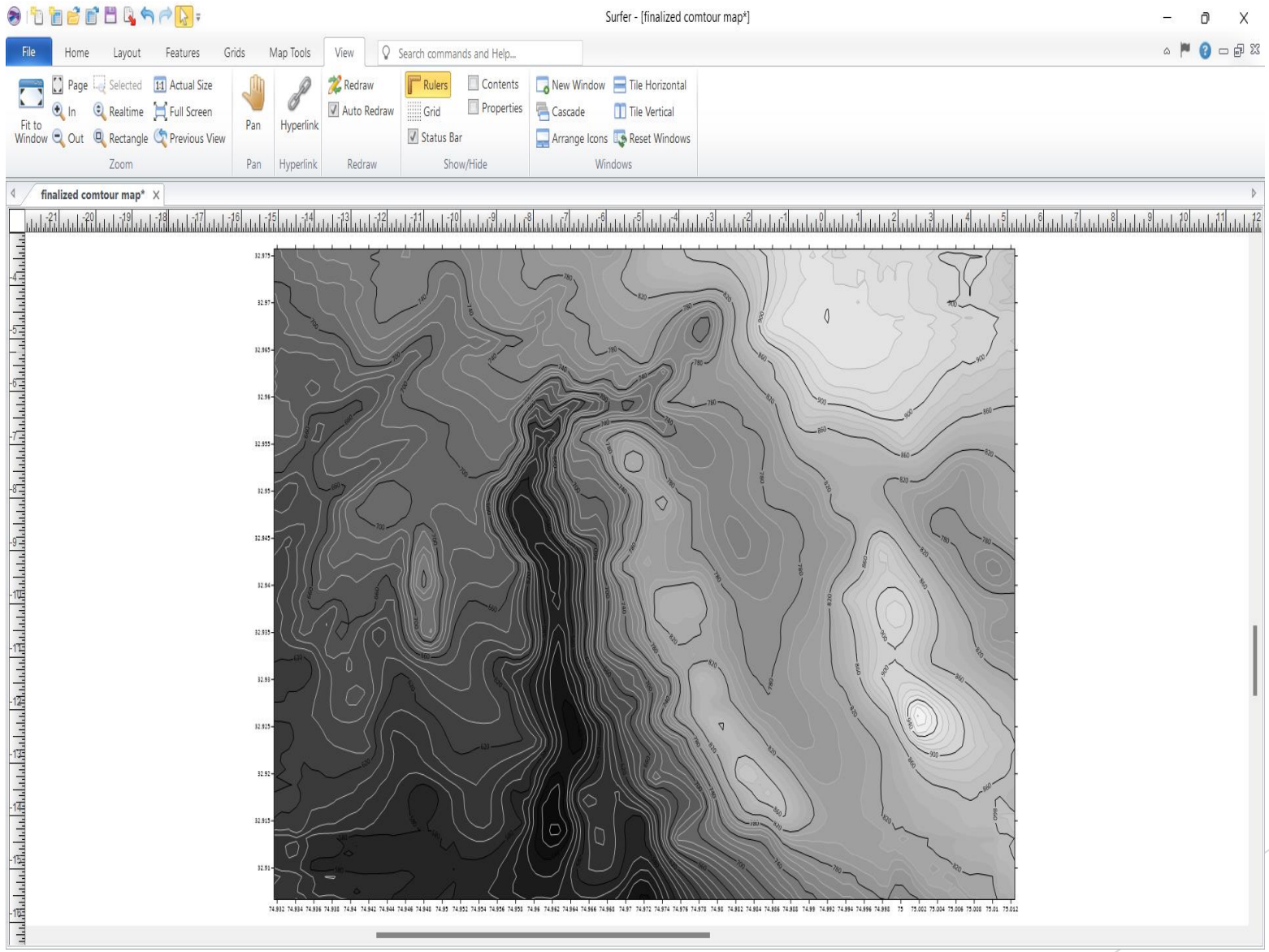
Fig: Desilting Tank

Steps involved to find out location of forebay with the help of contour map:

- **Step 1: Locating powerhouse at the desired position in Google Earth pro followed by grid lines.**

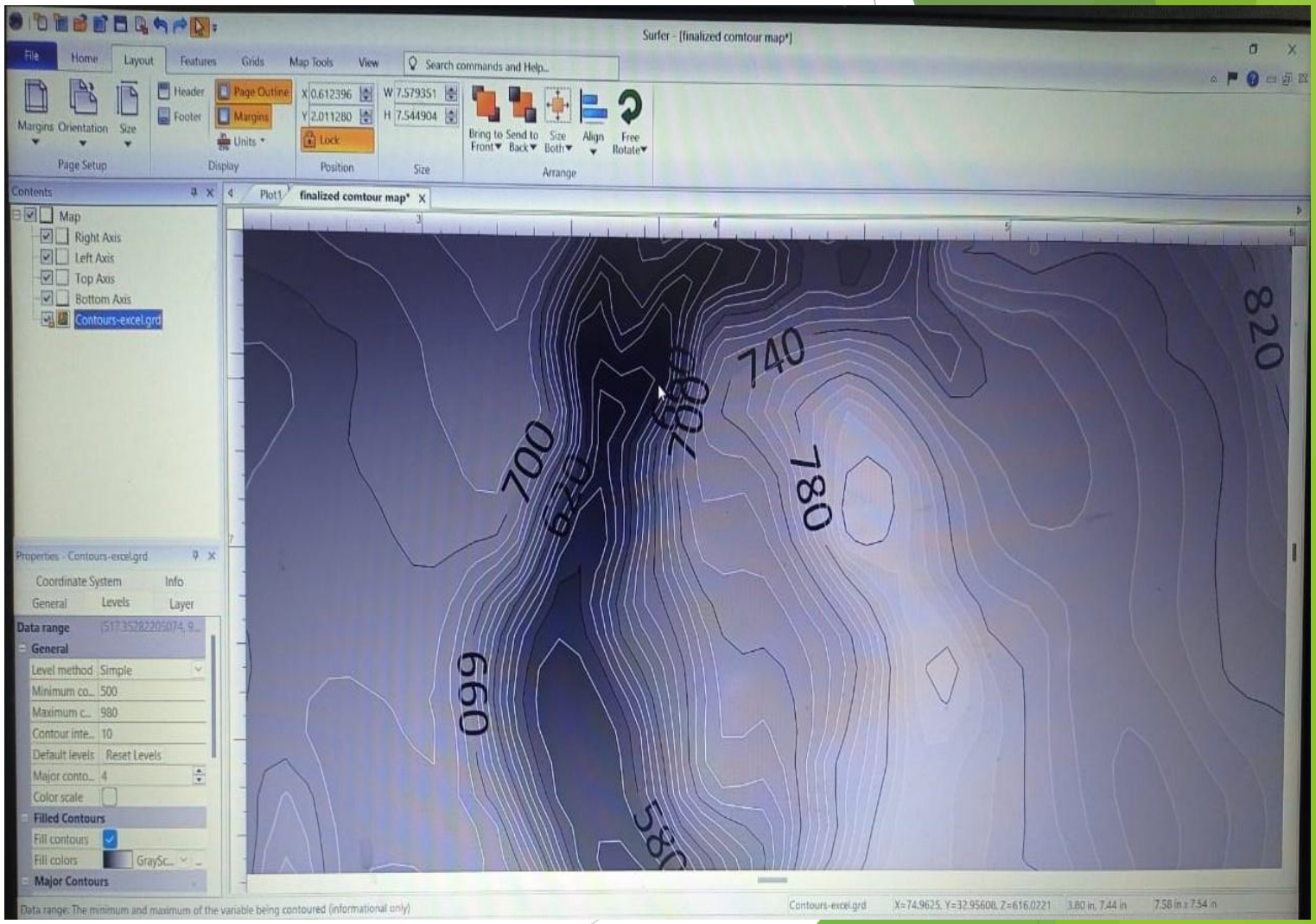


❑ Step 2: Making the contour map with the help of surfer software.

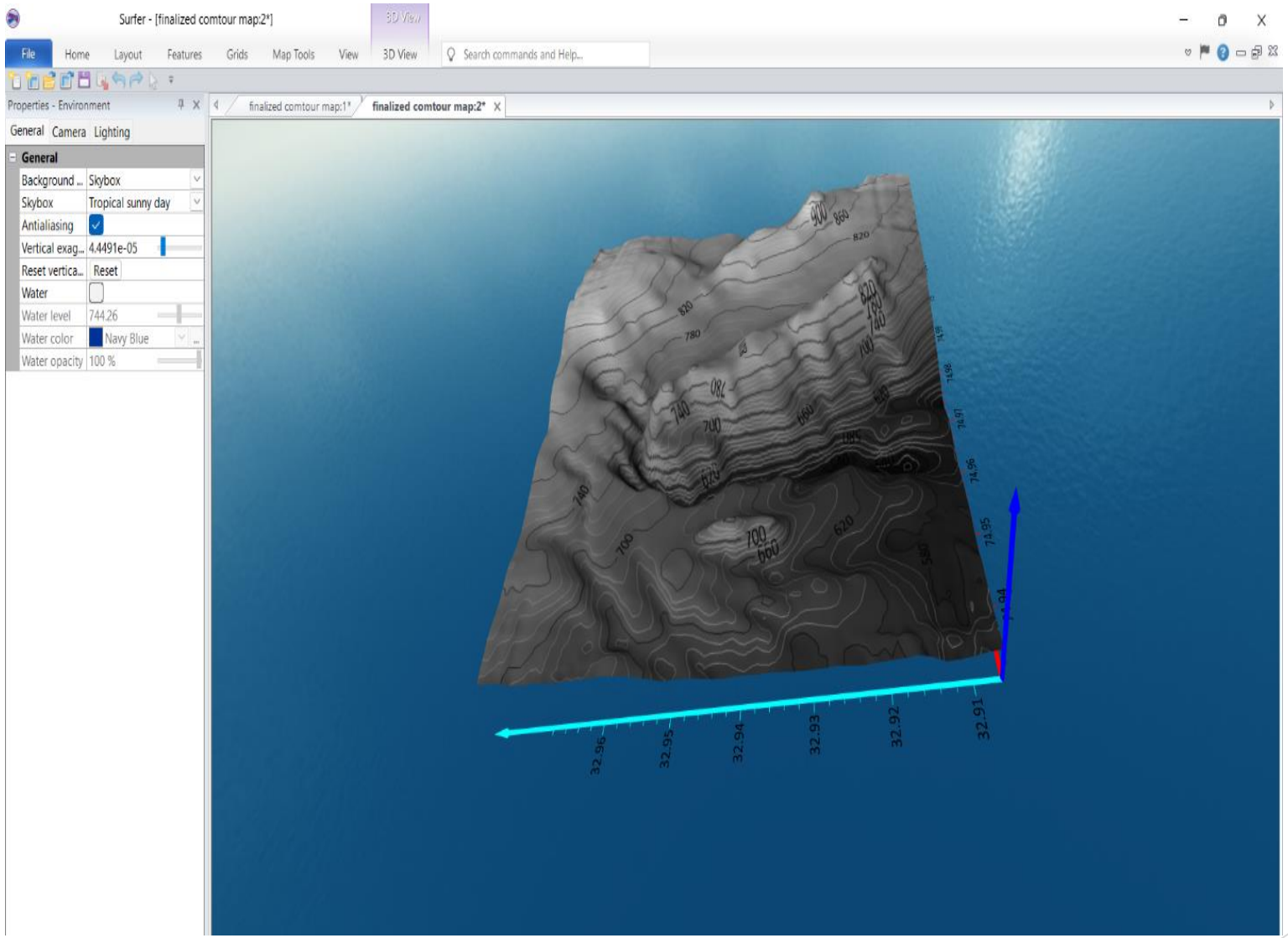


❑ Step 3: Locating the powerhouse according to latitude,longitude and elevation(MSL)

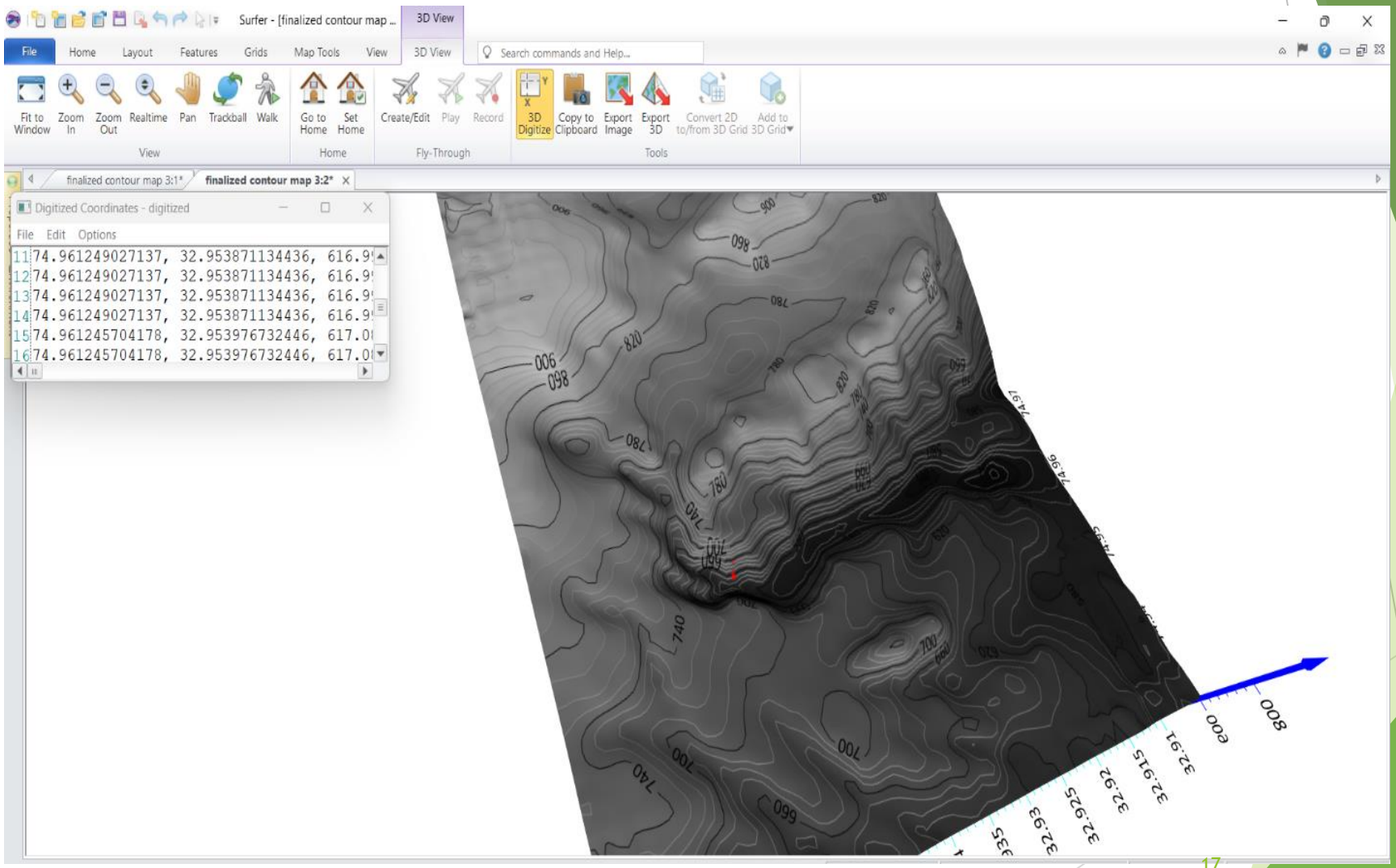
- Powerhouse location:
  - Latitude: $32^0 57'19.62'' = 32.95608^0$
  - Longitude: $74^0 57'37.57'' = 74.9625^0$
  - Elevation: 616m



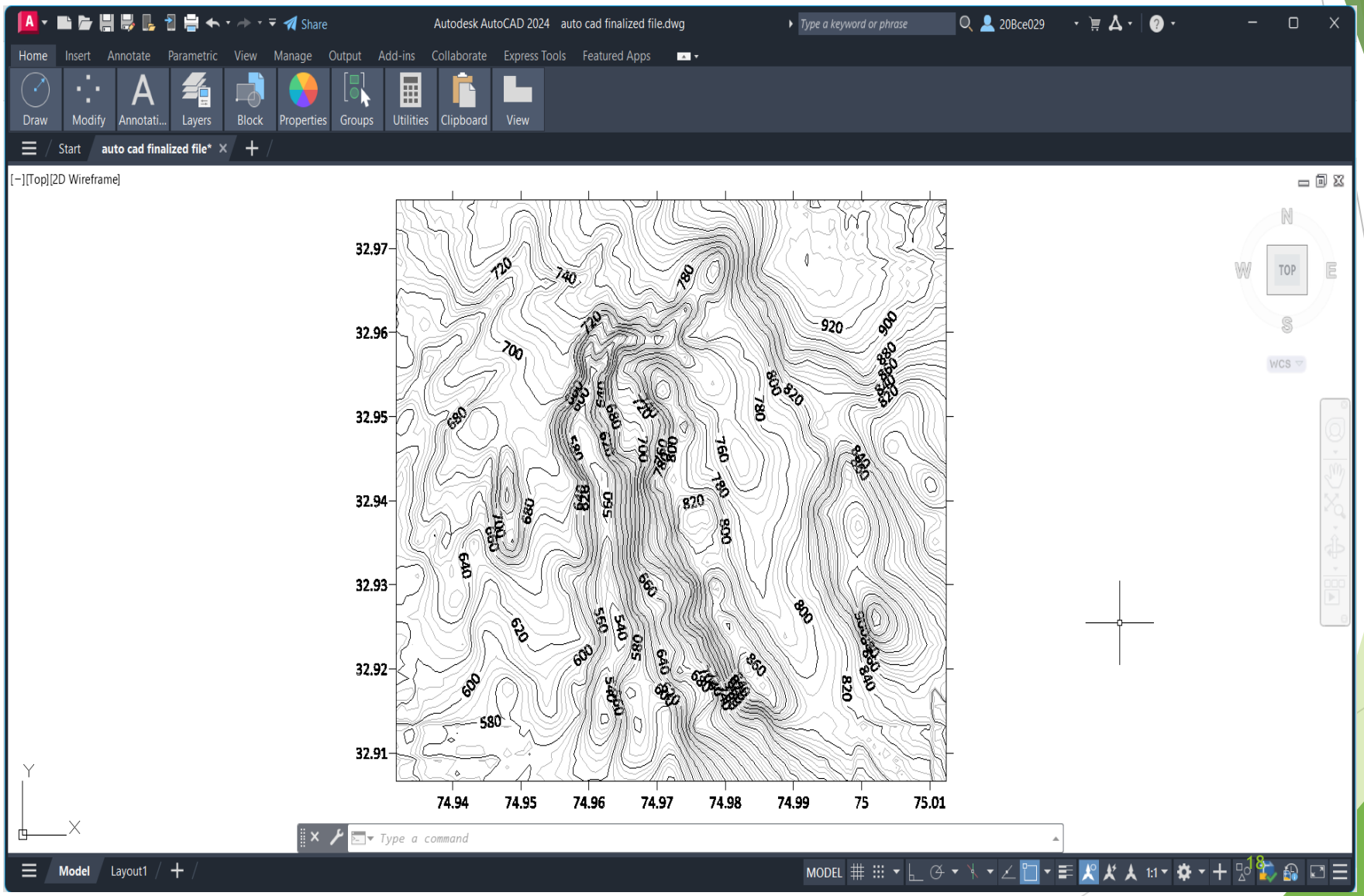
❑Step 4: Showing 3D view of contour map for more clarity.



- **Step 5: Locating Powerhouse with red mark in 3D view of contour map for more clarity.**



❑ Step 6: Export surfer file to the AutoCAD and selecting the scale of autocad 1:1

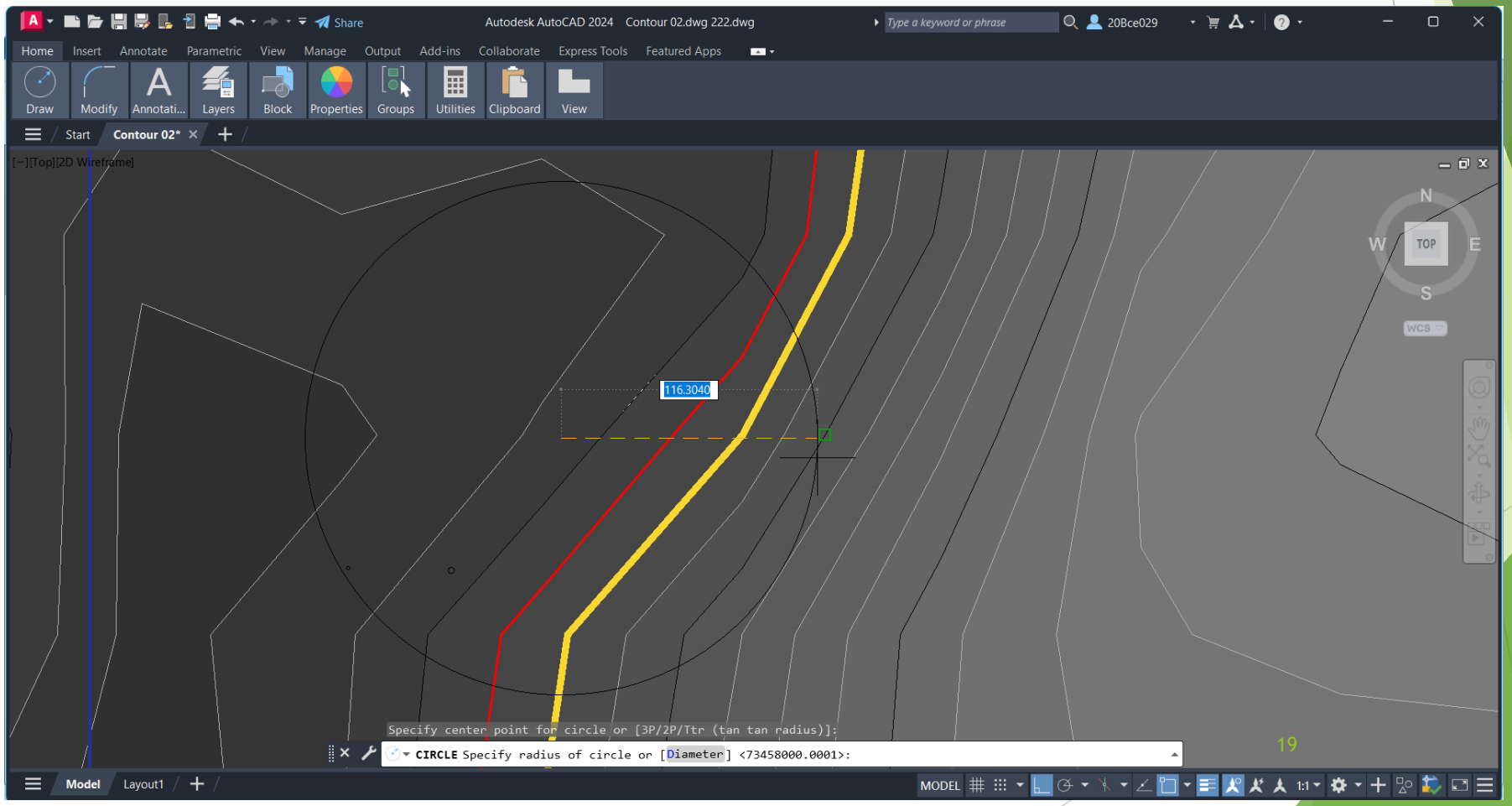


❑ Step 7:

MSL Of Powerhouse= 616 m

Vertical distance between powerhouse and forebay is 50 metre

Cut contour line of 616 + 50 =666 (Nearly 670m)



- **After Cutting Contour Line Of 670m,**
- **Got Horizontal Distance Between Forebay And Powerhouse (Horizontal Equivalent) Nearly 115 Metre.**

(3)Penstock

- Penstock is a steel or reinforced concrete conduit that supplies water from forebay or a reservoir to the turbines.

The penstocks shall carry water to the turbines with the least possible loss of head.

Therefore,

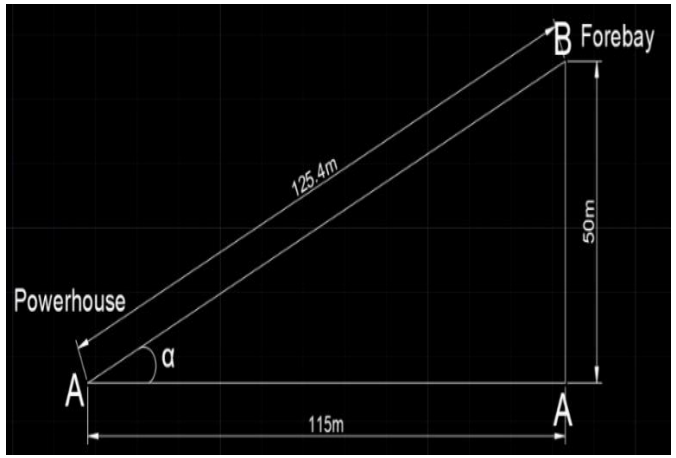
Economical diameter of penstock pipe is given by :

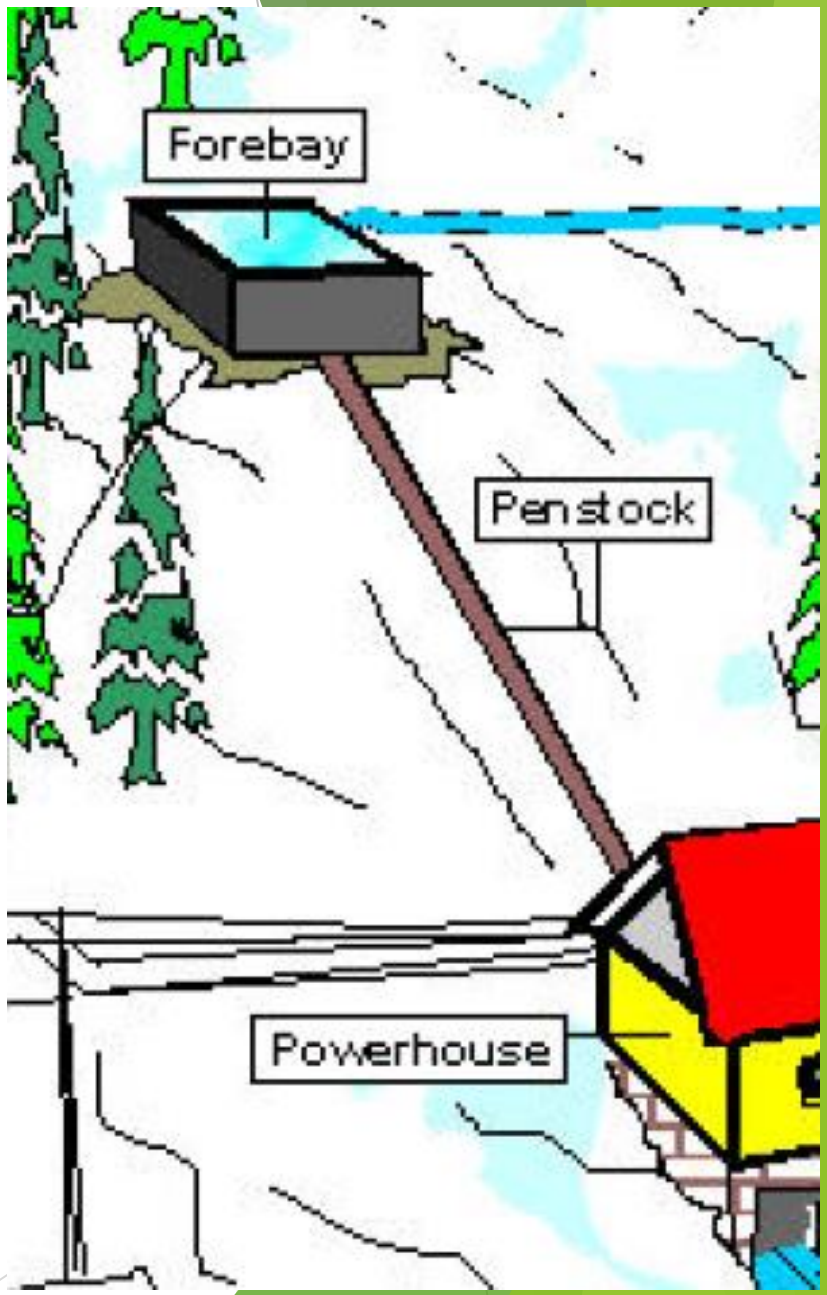
$\boldsymbol{D_e = 0.72\ Q^{0.5}}$ **= (**0.49m**)**

&Velocity = $\frac{Q}{A} = 2.5$ m/sec

Head Loss = $\frac{\boldsymbol{fLV^2}}{\boldsymbol{2gD}}$ **=** 0.89m

α = 23.26 degree





(4)Forebay Design

- Available discharge = 0.472 cum/sec
- Storage required = 2 minutes
- Capacity of tank = 0.472* 2* 60
  = 56.7 m^3
- After considering safety factor = 90m^3

- Taking water depth = 2 m
- Area = $\frac{90}{2}$ = 45 m^2
- L * B = 45 m^2
- Assuming length = 9m
- Width (B) = $\frac{45}{9}$ = 5 m
- Depth = 5 m

SPILLWAY DESIGN

$Q = CLH^{\frac{3}{2}}$

$$L = \frac{0.472}{2*(0.2)^{\frac{3}{2}}}$$

L = 4.15 = 4.5m (assume)

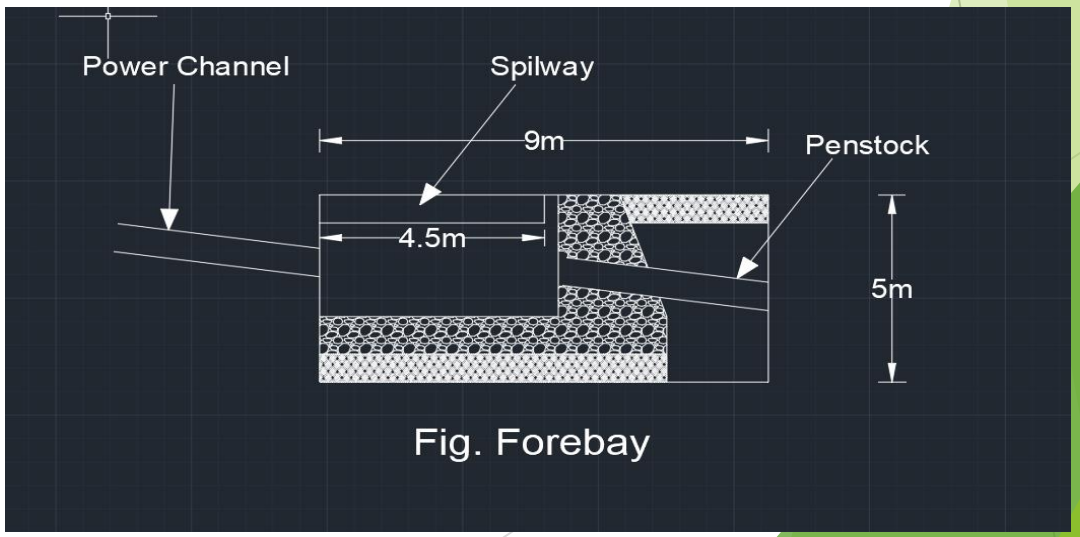


Fig. Forebay

(5)DESIGN OF TURBINE TO GENERATE A POWER OF 200 KW

DESIGN: LET US DESIGN 4 TURBINES OF 50KW EACH

AVAILABLE DISCHARGE = (0.7*0.9) * 0.75 (CONSIDERED 35% LOSSES)
= 0.4725cum/s

Loss 1 (Riparian rights) = 10%

Loss 2 (Desilting tank) = 25%

- Net Available Head = 48m
- Efficiency = 0.90
- Power = 9.81*η *Q*H = 50KW
- Design 4 Turbines of 50KW each.

- **Since the project is high head and low discharge, pelton turbine is chosen.**

DESIGN OF PELTON TURBINE

Wp = 200kw
H = 48m
Q = 0.47cum/s

- Velocity of jet(V) = Cv*$\sqrt{2gH}$

  Cv = co-efficient of velocity i.e 0.98
  =30.7m/s

- Velocity of wheel (u) = $\phi \sqrt{2gH}$

  ϕ = Speed ratio i.e 0.43
  =13.19m/s

- Pitch diameter (D) = $\frac{u \times 60}{\pi N}$
  = 0.428 m

- Jet ratio m = $\frac{D}{d}$

  d = D/m (m=6)

  d = 0.071m

- Number of buckets on runner(Z) = 15+$\frac{D}{2d}$

  =**18 buckets**

- Width of bucket = 5d

  = 0.35 m

- Depth of bucket = 1.2 d

  = 0.085 m

- No. of jets = $\frac{Q}{AV}$

  = 4 jets

1 jet for each turbine

Work done by jet

From velocity turbine of impulse turbine
$\rho aV (Vw_1 + Vw_2) \times u = \rho . Q (Vw_1 + Vw_2) \times u$

- Vr_1 = V - U
  = 30.07-13.19
  =16.883m/s

- $Vr_2 = Vr_1$ =16.88
  Vw_1= V = 30.07 m/s
  Vw_2 =3.11m/s

- Work done = 1000 x 0.47(30.07+3.11) x 13.19
  =206568.062 m/s

- Power given by water to runner in Kw = $\frac{\text{WORKDONE}}{1000}$
  = 206 Kw

- **Size of casing** = 1m
- **Spacing between turbines** = 1.5 m

❑ Results and learnings:

1. The proposed project shall provide a captive use mini hydropower project for university.
2. It was observed that there is heavy silt movement.The desilting tank shell be required and is thus designed.
3. The software like surfer can vary effectively be used to define position of various components of hydropower project.
4. The project once commissioned shall be a great example to the society for accepting the small hydro as alternative to grid electricity.

❑ Future Scope:

- The components like power channel and penstock are though designed but alignment is required to be checked as per site condition.
- The powerhouse and hydromechanical equipments are still to be designed.

Thanks.....