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# Engineering Hydrology

**Week-14**

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## **COURSE SUMMARY**

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# The Course Learning Outcomes

**Course Learning Outcomes:** After completion of this course, you will be able to:

- CLO-1:** Apply measurement techniques of the components of the hydrologic cycle, complete a water balance on a watershed and filling of missed Hydrological data;
- CLO-2:** Examine Rainfall-runoff relationship and use hydrologic data for hydrograph;
- CLO-3:** Examine the probability of occurrence of a particular hydrologic extreme event (e.g. rainfall, flood, drought, etc.) and determine the design flood for major hydraulic structures;
- CLO-4:** Analyze the physical processes involved using important statistical properties of time series;
- CLO-5:** Design capacity of reservoir from historical inflow records in the stream and assess the magnitude of sediment deposition in the reservoir;
- CLO-6:** Plan runoff volume and time of distribution of the runoff hydrograph from urbanization effect.



# Lecture contents of the last weeks (Week1-13)

Week	Topics
Week 1	<p><b>INTRODUCTION</b></p> <p>1 Pre-course assessment – past experiences and plan for this course.</p> <ul style="list-style-type: none"> <li>Experiences of the pre-requisite courses</li> <li>Present the course outline</li> </ul> <p>2 The hydrologic cycle and engineering hydrology</p> <ul style="list-style-type: none"> <li>Important concepts of hydrologic cycle at global and Ethiopian levels.</li> <li>The importance of engineering hydrology</li> </ul>
Week 2	<p><b>CHAPTER 1: HYDROLOGY AND ITS MEASUREMENT</b></p> <p>1.1 Meteorological data</p> <p>1.2 Principle of data analysis</p> <p>1.3 Hydrological data</p> <p>1.4 Missing data and comparison with the precipitation data</p>
Week 3	<p><b>CHAPTER -2 RAINFALL-RUNOFF RELATIONSHIPS</b></p> <p>2.1 Hydrological Models</p> <p>2.2 Rational Method</p> <p>2.3 Rainfall intensity and Time of Concentration</p> <p>2.4 SCS Curve Number and Time-Area Methods</p>

Week 4	<p>2.5 Stream Flow Hydrograph</p> <p>2.5.1 Hydrograph Analysis</p> <p>2.5.2 Factors Affecting Flood Hydrograph</p> <p>2.5.3 Effective Rainfall</p> <p>2.5.4 Separation of Base Flow and Runoff</p> <p>2.6 The Unit Hydrograph (UH)</p> <p>2.7 Applications of Unit Hydrograph</p>
Week 5	<p>2.8 Synthetic Unit Hydrographs</p> <p>2.8.1 Snyder's Method</p> <p>2.8.2 Dimensionless Unit Hydrograph</p> <p>2.9 Hydrology of Ungauged Catchment</p>
Week 6	<p><b>HAPTER -3 FLOOD ROUTING</b></p> <p>3.1 General</p> <p>3.2 Simple Non-Storage Routing</p> <p>3.3 Storage Routing</p> <p>3.4 Reservoir or Level Pool Routing</p>



# Lecture contents of the last weeks (Week1-13)

<b>Week 7</b>	3.5 Channel Routing 3.5.1 Muskingum Method of Routing 3.5.2 Application of The Muskingum Method 3.6 Hydraulic Routing
<b>Week 8</b>	<b>CHAPTER-4 FREQUENCY ANALYSIS</b> 4.2 Flow Frequency 4.3 Flood Probability 4.4 Methods of Peak flood determination 4.5 Regional Frequency Analysis
<b>Week 9</b>	4.6 Low Flow Analysis 4.6.1 Definitions and Basic Concepts 4.6.2 Low Flow Frequency Analysis 4.6.3 Drought Analysis 4.7 Precipitation Probability 4.8 Risk, Reliability and Safety Factor
<b>Week 10</b>	<b>CHAPTER-5 STOCHASTIC HYDROLOGY</b> 5.1 Introduction. 5.2 Time Series 5.3 Analysis of Hydrologic Time Series 5.4 Time Series Synthesis

<b>Week 11</b>	5.5 Some Stochastic Models 5.6 The Uses of Stochastic Models
<b>Week 12</b>	<b>CHAPTE- 6 RESERVOIR CAPACITY DETERMINATION</b> 6.1 Mass Curve (Ripple's) Method: 6.2 Design Reservoir Capacity and Sediment Inflow 6.3 Sediment Load Prediction
<b>Week 13</b>	<b>CHAPTE- 7 URBAN HYDROLOGY</b> 7.1 Catchment Response Modifications 7.2 Urban Development Planning 7.3 Drainage Design
<b>Week 14</b>	<b>COURSE SUMMARY</b>



- **Explain** the important concepts of **hydrologic cycle** at **global** and **Ethiopian levels**.
- Hydrology, Engineering hydrology
- Hydrologic cycle,
- Ethiopian basins
- Elevation, rainfall, stream networks



# Week-1, Lecture -1 INTRODUCTION

1. Define the word “Hydrology” based on **occurrence, physical state , state of motion** of water and describe it with respect to **Ethiopian water**.
2. Define “**Engineering Hydrology**” and its importance for **Ethiopian water development**.
3. Sketch the systematic representation of **hydrologic or water balance**, **label the components** and describe what water balance mean for your sketch.
4. Describe the hydrology of Ethiopia (your country) based on topography, drainage basin, availability of surface water and irrigable land.
  1. How is the surface water distribution of Ethiopia with respect to **inland** and **transboundary** drainage basin?
  2. What does this distribution mean with respect to **water development** and **water diplomacy**?



## **Learning outcomes:**

- List components of the hydrologic cycle and their measurements.
- Compute water balance of the hydrologic cycle at watershed or catchment scale.
- Fill missing data.



**Make sure that you can write, and make comparison on the following topics:**

1.1 Water balance

- Control volume water balance

1.2 Meteorological data

1.3 Hydrological data

1.4 Principle of data analysis

- Missing data and comparison with the precipitation data
- Consistency check
- Areal rainfall



## **Contents covered:**

2.1 Hydrological Modeling

2.2 Rational Method

2.3 Rainfall intensity and Time of Concentration

2.4 SCS Curve Number and Time-Area Methods

2.5 Stream Flow Hydrograph

2.5.1 Hydrograph Analysis

2.5.2 Factors Affecting Flood Hydrograph

2.5.3 Effective Rainfall

2.5.4 Separation of Base Flow and Runoff



## **Contents covered:**

2.6 The **Unit Hydrograph** (UH)

2.7 **Applications** of Unit Hydrograph

2.8 **Synthetic** Unit Hydrographs

2.8.1 Snyder's Method

2.8.2 Dimensionless Unit Hydrograph

2.9 Hydrology of **Ungauged** Catchment



## Learning outcomes:

1. **Describe** different models for rainfall-runoff relationships.
2. **Compute** runoff from different surface conditions.
3. **Apply** hydrographs.
4. **Compute base-flow** separation
5. Describe the hydrology of **ungauged catchments**



## Make sure you can handle:

- **Hydrological modeling:** definition, importance and classification
- **Rainfall:** Intensity, duration, frequency, effective rainfall and time of concentration
- **Rational method:** symbols, units and problem analysis
- **SCS-CN methods:** symbols, units and problem analysis
  - Compare and contrast rainfall, effective rainfall and direct runoff.
    - Relate parameters under these methods
    - Try to solve mathematical expression and problem solving on these methods for effective rainfall



## Make sure you can handle:

- **Baseflow separation:** definitions and methods
  - What does baseflow mean?
  - Why it is important?
  - Compare and contrast baseflow separation methods graphically.
- **Hydrograph:** Factors affecting, UH., SUH
- **Data transfer for ungauged watersheds**



## **Contents covered:**

3.1 General

3.2 Simple **Non-Storage** Routing

3.3 Storage Routing

3.4 Reservoir or **Level Pool** Routing

3.5 Channel Routing

3.5.1 **Muskingum** Method of Routing

3.5.2 Application of The Muskingum Method

3.6 Hydraulic Routing



## **Make sure that you can:**

- Compute flood routing
- List importance of flood routing
- Describe types of flood routing
- Discuss techniques of flood routing
- Describe the mathematical representation of flood routing
- Calculation for  $K$ ,  $X$ ,  $Q$



## Contents covered:

- 4.1 Flow Frequency
- 4.2 Flood Probability
- 4.3 Methods of Peak flood determination
- 4.4 Regional Frequency Analysis
- 4.6 Low Flow Analysis
  - 4.6.1 Definitions and Basic Concepts
  - 4.6.2 Low Flow Frequency Analysis
  - 4.6.3 Drought Analysis
- 4.7 Precipitation Probability
- 4.8 Risk, Reliability and Safety Factor



## **Make sure that you properly handle:**

- **Define** flood frequency, probability and recurrence interval
- **List** methods of flood frequency analysis
- **Analyze** design flood using Gumbel's and log-pearson methods
- **Describe** regional frequency and low flow analysis
- **Explain** risk, reliability and safety factor



## Contents covered:

5.1 Introduction.

5.2 Time Series

5.3 Analysis of Hydrologic Time Series

5.4 Time Series Synthesis

5.5 Some Stochastic Models



Make sure that you can :

- Discuss on analysis of hydrologic time series
- Describe time series synthesis
- List some stochastic models
- Analysis of hydrologic time series
- Compare some stochastic models



## 6.1 Mass Curve

(Ripple's) Method:

## 6.2 Design Reservoir

Capacity

## 6.3 Reservoir

sedimentation

**Make sure that you properly handle:**

- **Analyze** reservoir capacity
- **Explain** reservoir sedimentation



## 7.1 Catchment

Response

Modifications

## 7.2 Urban Development

Planning

## 7.3 Drainage Design

**Make sure that you properly handle:**

- **Explain** catchment modifications and urban water sensitive planning.
- **Analyze** runoff modification



## Consider the test exams: Test-1 [Mid-term Exam]

1) *The weather kit installed in AASTU reads 30 mm rainfall today within 3 hours.*

*Answer the following questions using **less than two lines**.*

*a. What does it mean with respect to **area** in AASTU? (1 pts)*

*b. How much rainfall amount is raining **in m<sup>3</sup>** today? (1 pts)*

*c. What **forms** of rainfall is it? (1 pts)*

*d. What **kinds** of rainfall is it? (1 pts)*

*e. How this rainfall is **measured** according to your field observation and class lecture? (1 pts)*



## Consider the test exams: Test-1 [Mid-term Exam]

### Answer:

1) A) It means 30 mm of rain water uniformly cover 246 ha a horizontal AASTU compound area.

B) **Given**  $RF=30 \text{ mm} \times 1\text{m}/1000\text{m} = \mathbf{0.003\text{m}}$ ,

$$A = 246 \text{ ha} = 246\text{ha} \times 10,000 \text{ m}^2/\text{ha} = 2,460,000 \text{ m}^2$$

**Required, V (m<sup>3</sup>)=?**

**Solution, V=Depth X Area= 0.003m X 2,460,000 m<sup>2</sup> = 738 m<sup>3</sup> -----#**

C) The real precipitation falling in that day was liquid **rainfall**. -----#

D) The rainfall coming to the area was due to moist air on the mountain *Yerer* and it is **orographic or relief rainfall**. -----#



## Consider the test exams: Test-1...

- 2) *The weather kit in AASTU has a one month missing rainfall data. The measurements of three weather stations around AASTU including Akaki stations were 40, 60 and 50 mm. The annual rainfall measurements of AASTU weather kit and the three weather stations were 1100, 1000, 1200 and 900 mm, respectively. Answer the following questions.*
- Which of rainfall missing data filling methods can be applied? Why? (2 pts)*
  - Calculate the missing data for AASTU weather kit for the given month. (3 pts)*



# Consider the test exams: Test-1.....

## Answer:

2) A) The **Normal Ratio Method** must be applied. Because,  $10\%$  of  $1100\text{ mm} = 0.10 \times 1100 = 110\text{ mm}$ .  $< 200\text{ mm}$  difference of the third station.

B) **Given:** Station | Monthly Rainfall ( $P_i$ ) | Normal Annual Rainfall ( $N_i$ ) |

Station 1	40 mm	1000 mm
Station 2	60 mm	1200 mm
Station 3	50 mm	900 mm

**Required:** Calculate the missing data for AASTU weather kit for the given month with normal annual rainfall of  $1100\text{ mm}$ .



# Consider the test exams: Test-1.....

**Answer:**

2) B) .....

**Solution,**  $P_x = (1/n) * \sum [ (N_x / N_i) * P_i ]$

Where:

$P_x$  = Missing rainfall at AASTU

$N_x$  = Normal annual rainfall at AASTU = 1100 mm

$n$  = Number of surrounding stations = 3

$P_i$  = Rainfall for the month at each surrounding station

$N_i$  = Normal annual rainfall at each surrounding station

$$P_x = (1/3) * [ (1100/1000 \times 40) + (1100/1200 \times 60) + (1100/900 \times 50) ] \approx \mathbf{53.37 \text{ mm}} \text{ -----\#}$$

The estimated missing rainfall data for the AASTU weather kit for the given month is **53.37 mm**.



## Consider the test exams: Test-1.....

3) The intensity of a rainfall event in AASTU was measures as 10 mm/hr. The land use and runoff coefficient data are given as indicated on Table. Answer the following using these data. Use the correct formula from:  $Q = CiA$ , or  $Q = 0.0028 CiA$ , or  $Q = 0.278 CiA$ .

- Which runoff estimation method can be applied from the event? (1 pt)
- Calculate the combined runoff coefficient of AASTU compound. (3 pts)
- Calculate the runoff amount ( $m^3/s$ ) from AASTU compound flowing to the downstream areas. (3 pts)

No.	Land use types	Area (ha)	C
1	Built-up area	100	0.9
2	Grass and lawn area	80	0.2
3	Forest land area	16	0.3
4	Agricultural area	50	0.4
	Total	246	



# Consider the test exams: Test-1.....

## Answer:

3) A) **Rational method** -----#

3)B) **Given:**  $C_i \times A_i$

- Built-up area:  $0.9 \times 100 \text{ ha} = 90 \text{ ha}$
- Agricultural area:  $0.4 \times 50 \text{ ha} = 20 \text{ ha}$
- Grass and lawn area:  $0.20 \times 80 \text{ ha} = 16 \text{ ha}$
- Forest land area:  $0.30 \times 16 \text{ ha} = 4.8 \text{ ha}$
- Total area: 246 ha

**Requires:** Combined  $C$ ,

**Solution:**  $C_{\text{weighted}} = (\sum [C_i \times A_i]) / A_{\text{total}}$   
 $= (90 + 20 + 16 + 4.8) / 246$   
 $= 130.8 / 246 \approx 0.532$

The combined (weighted) runoff coefficient for the AASTU compound is **0.532**. -----#



## Consider the test exams: Test-1.....

### Answer:

3)C) **Given:** C (Combined runoff coefficient) = 0.532 (dimensionless)

•I (Rainfall intensity) = 10 mm/hr

•A (Total area) = 246 ha

**Requires:** discharge **Q** in **m<sup>3</sup>/s**

**Solution:**  $Q = 0.0028 \times C \times i \times A$

$$Q = 0.0028 \times 0.532 \times 10 \times 246$$

$$Q = 0.0028 \times 1308.72$$

$$Q \approx \mathbf{3.664 \text{ m}^3/\text{s}} \text{ -----\#}$$

Answer: The runoff amount flowing from the AASTU compound is approximately **3.66 m<sup>3</sup>/s**. -----\#



# Consider the test exams: Test-2

## FLOOD ROUTING

1) *The inflow and outflow hydrographs for a reach of a river are given by Table 1.*

*A. Determine the **reduction** in peak and the time of peak of outflow. (2 pts)*

***B. Route the flood** through the reach at Muskingum coefficients of  $X=0.3$  and  $X=0.2$  and tabulate the outflow hydrograph. (3 pts)*

*C. How do you estimate the Muskingum coefficient  $K$  for the river reach? (1 pt)*

Time (hr)	Inflow (m <sup>3</sup> /s)	Outflow (m <sup>3</sup> /s)
0	35	39
24	125	52
48	575	287
72	740	624
96	456	638
120	245	394
144	144	235
168	95	142
192	67	93
216	50	60



## Consider the test exams: Test-2.....

### Answer:

1) A) **Given:**

**Peak Inflow:** Occurs at 72 hours with a discharge of  $740 \text{ m}^3/\text{s}$ .

**Peak Outflow:** Occurs at 96 hours with a discharge of  $638 \text{ m}^3/\text{s}$ .

**Required:** Attenuation and delay time to peak

### Solution:

**Attenuation of peak** =  $740 \text{ m}^3/\text{s} - 638 \text{ m}^3/\text{s} = 102 \text{ m}^3/\text{s}$  -----#

**Delay time to peak** =  $96 \text{ hr} - 72 \text{ hr} = 24 \text{ hr} = K$  -----#



# Consider the test exams: Test-2.....

## Answer:

1)B) **Given:** Time (hr), Inflow ( $m^3/s$ ) and Out flow ( $m^3/s$ ) as shown on the table

**Required:** Route the flood through the reach at Muskingum coefficients of  $X=0.3$  and  $X=0.2$

**Solution:** The tabulated outflow hydrograph components are in the final columns of the table.

Time, t (hr)	Inflow, I ( $m^3/s$ )	Out flow, O ( $m^3/s$ )	XI+(1-X)O	
			At X=0.3	At X=0.2
0	25	39	11.2	8.6
24	125	52	38.2	11.2
48	575	287	173.2	58.2
72	<b>740</b>	624	222.7	125.6
96	456	<b>638</b>	137.5	128.4
120	245	394	74.2	79.6
144	144	235	43.9	47.8
168	95	142	29.2	29.2
192	67	93	2.08	19.4
216	50	60	15.7	12.8



## Consider the test exams: Test-2.....

### Answer:

- 1) C) The Muskingum coefficient  $K$ , the storage-time constant, represents the time lag of the flood wave as it moves through the reach. It can be

The procedure done on part B of the problem aims to estimate  $K$  and  $X$  values from the given hydrograph. The best estimations for the value of  $X$  at the relationship between out flow and  $XI+(1-X)O$  hydrographs approach a straight line. Then, the slope of this line is the best estimate for  $K$ . -----#

$$b = \sqrt{1 + 1.3K + 1.1K^2}, \frac{\sigma_{n-1}}{\sqrt{N}}$$



## Consider the test exams: Test-2

2) A certain river yielded the mean and standard deviation of the annual flood series as 6,437 and 2,951 m<sup>3</sup>/s, respectively for 100 years measured data. From Table for  $N = 100$  years,  $y_n = 0.56$ , and  $S_n = 1.2$ .

A. Using Gumbel's method, estimate the flood discharge with a return period of 500 years. (2 pts), and

B. Determine the: 95% and 80% confidence limits for this estimate for given confidence probabilities of 95% and 80% are  $f(95\%) = 1.96$  and  $f(80\%) = 1.282$ , respectively. (3 pts)

$y_T = -[\ln \cdot \ln \frac{T}{T-1}]$	$K = \frac{y_T - \bar{y}_n}{S_n}$	$x_T = \bar{x} + K\sigma_x$
$x_{1/2} = x_T \pm f(c) * S_e$	$S_e = \text{probable error} = b \frac{\sigma_{n-1}}{\sqrt{N}}$	$b = \sqrt{1 + 1.3K + 1.1K^2}$

$$b = \sqrt{1 + 1.3K + 1.1K^2}, \frac{\sigma_{n-1}}{\sqrt{N}}$$



## Consider the test exams: Test-2

### Answer:

2) A) **Given:**  $\bar{x}$  = Mean of the annual flood series = 6,437 m<sup>3</sup>/s

$\sigma$  = Standard deviation of the annual flood series = 2,951 m<sup>3</sup>/s

Reduced Mean ( $\bar{y}_n$ ) = 0.56

Reduced Standard Deviation ( $S_n$ ) = 1.2

**Requires:** *flood discharge with a return period of 500 years*  
discharge  $Q_{500}$  in m<sup>3</sup>/s

**Solution:** The main formula for Gumbel's method is:  $Q_T = \bar{x} + K_T * \sigma$

**Step 1:** Calculate the Reduced Variate ( $Y_T$ )

$Y_T = -\ln[-\ln(1 - 1/T)]$  For T = 500 years:

$Y_T = -\ln[-\ln(1 - 1/500)] = -\ln[-\ln(0.998)] = -\ln(0.002002) \approx 6.21$

$$b = \sqrt{1 + 1.3K + 1.1K^2}, \frac{\sigma_{n-1}}{\sqrt{N}}$$



## Consider the test exams: Test-2

### Answer:

2) A) **Step 2:** Calculate the Gumbel Frequency Factor ( $K_T$ )

The formula for  $K_T$  is:

$$K_T = (Y_T - \bar{y}_n) / S_n = (6.21 - 0.56) / 1.2 \approx \mathbf{4.71}$$

**Step 3:** Calculate the 500-Year Flood Discharge ( $Q_{500}$ )

$$Q_{500} = \bar{x} + K_T * \sigma = 6,437 + (4.71 * 2,951) = 6,437 + 13,900 = \mathbf{20,337 \text{ m}^3/\text{s}}$$

Answer for Part A: The estimated flood discharge for a 500-year return period is **20,337 m<sup>3</sup>/s. -----#**

$$b = \sqrt{1 + 1.3K + 1.1K^2}, \frac{\sigma_{n-1}}{\sqrt{N}}$$



## Consider the test exams: Test-2

### Answer:

2) B) **Given:**  $\sigma = 2,951$ ,  $K_T = 4.71$ ,  $N = 100$

$f(c)$  is the confidence probability factor (given).

**Required:** Determine the 95% and 80% confidence limits for this estimate.

### Solution:

**Step 1:** Calculate the Standard Error ( $S_e$ )

The formula for  $S_e$  is:  $S_e = \sigma * \sqrt{[(1 + 1.3K_T + 1.1K_T^2) / N]}$

$$S_e = 2,951 * \sqrt{[(1 + (1.3 * 4.71) + (1.1 * (4.71)^2)) / 100]}$$

$$= 2,951 * \sqrt{[(1 + 6.123 + (1.1 * 22.184)) / 100]}$$

$$= 2,951 * \sqrt{[(1 + 6.123 + 24.402) / 100]}$$

$$= 2,951 * \sqrt{[31.525 / 100]} = 2,951 * \sqrt{[0.31525]} = 2,951 * 0.5615 \approx \mathbf{1,657 \text{ m}^3/\text{s}} \text{ -----\#}$$

$$b = \sqrt{1 + 1.3K + 1.1K^2}, \frac{\sigma_{n-1}}{\sqrt{N}}$$



## Consider the test exams: Test-2

**Answer:**

2) B) **Solution:**

**Step 2:** Calculate the Confidence Limits

For the 95% Confidence Limit,  $f(95\%) = 1.96$

Margin of Error =  $1.96 * 1,657 = 3,248 \text{ m}^3/\text{s}$

Upper Limit =  $20,337 + 3,248 = 23,585 \text{ m}^3/\text{s}$

Lower Limit =  $20,337 - 3,248 = 17,089 \text{ m}^3/\text{s}$

For the 80% Confidence Limit,  $f(80\%) = 1.282$

Margin of Error =  $1.282 * 1,657 = 2,124 \text{ m}^3/\text{s}$

Upper Limit =  $20,337 + 2,124 = 22,461 \text{ m}^3/\text{s}$

Lower Limit =  $20,337 - 2,124 = 18,213 \text{ m}^3/\text{s}$

Answer for Part B:

The 95% confidence limits are from **17,089 m<sup>3</sup>/s to 23,585 m<sup>3</sup>/s.**

The 80% confidence limits are from **18,213 m<sup>3</sup>/s to 22,461 m<sup>3</sup>/s.**-----#



# Final course mini-project

Let you consider weather station data from:

- a) **AASTU weather kit**, and
- b) **Akaki stations** in Addis (Meteorological and hydrological data given by separate spreadsheet data for this assignment).

Then,

1. **Analyze** monthly meteorological and hydrological data (sum, mean, standard deviations).
  - Refer the videos:
    - i. How to change daily data (Rainfall) to monthly and annual data using Excel  
<https://youtu.be/aykF6ZzXlxA?si=rwNx7S3AVS3Y3jty>
    - ii. Mass-curve and hyetograph: <https://youtu.be/tr55QHsr0Zc?si=dquDLu4uXXhVYL1T>
2. **Compute** statistics of the river flow at daily, monthly, annual hydrographs. Do maximum, minimum, mean values for each time level.
  - Fill missing data: [https://youtu.be/\\_TU8uRK-0NI?si=y30dDE8Lt-zuP6EB](https://youtu.be/_TU8uRK-0NI?si=y30dDE8Lt-zuP6EB)
3. **Develop** design IDF curves



## Final course project

2. Use *Akaki* River flow data
  - Analyze monthly and daily hydrographs
  - Determine return periods of the flow quantities.
  - Draw hydrographs for the peak values
3. Propose water sensitive urban planning for Addis Ababa using a one-page text writings considering your analyzed data and WSUD principles.

Project paper outline will be given for you.



# Thank you very much for your active attendance!!

**Prepared By:** Sisay Demeku Derib (PhD, Practicing Hydraulics Engineer, Assistant Prof.)

**Affiliated to:** Addis Ababa Science and Technology University –AASTU, Department of Civil Engineering

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