
Addressing the Characteristics of Complex Engineering Problem Solving and Complex Engineering Activities in Civil Engineering

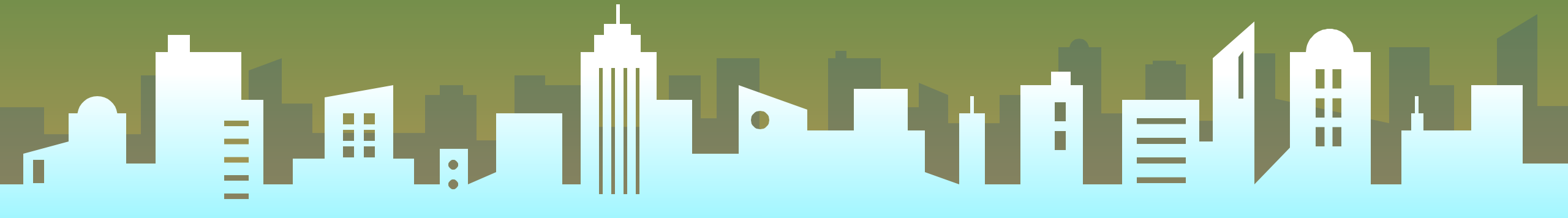
An Example of Integrated Design Project

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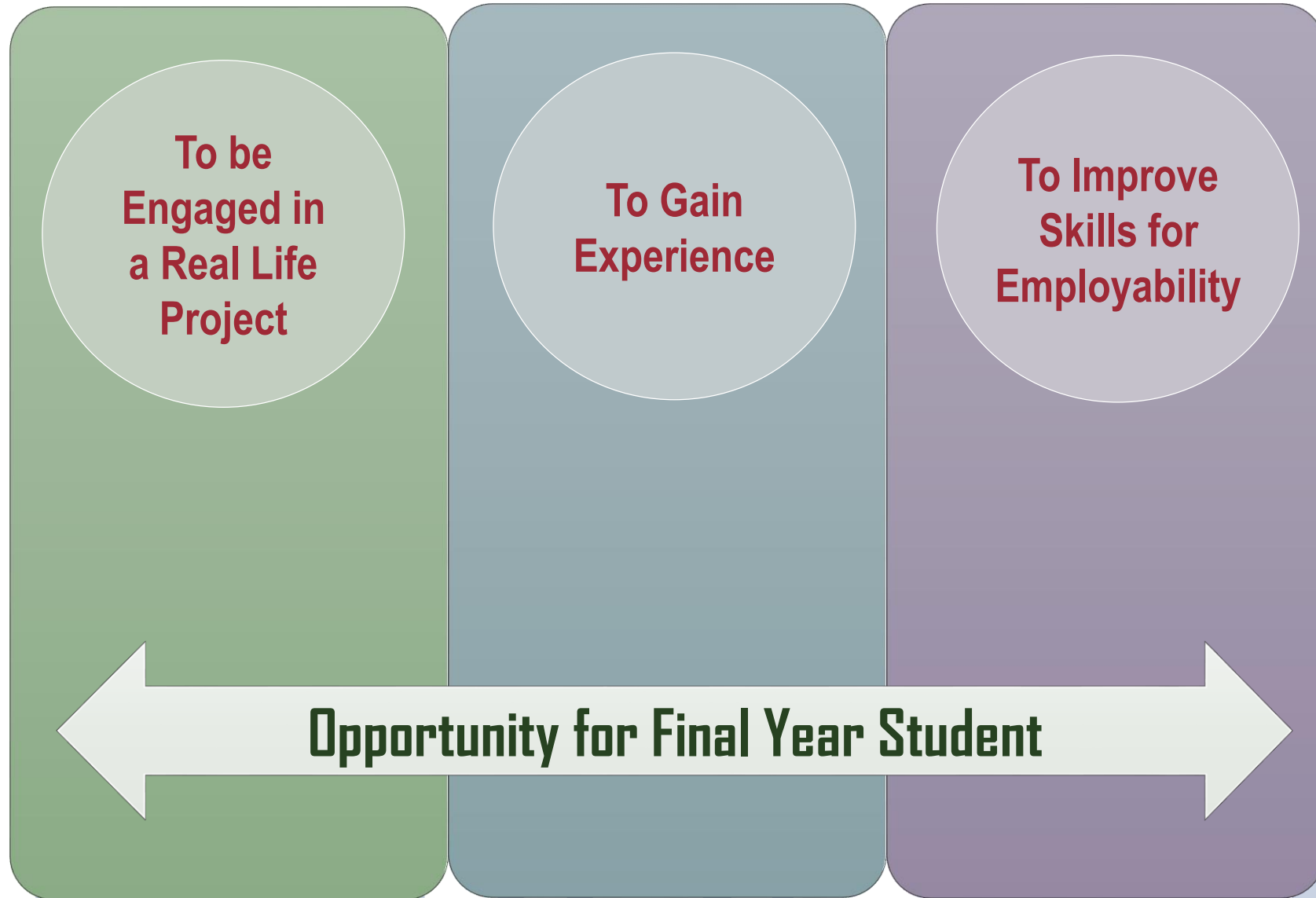
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&

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Integrated Design Project



Project Statement

“Accommodating the Growing Demand for Domestic Water Supply in a Town of Narayanganj District on the Bank of Shitalakkhya River”

Water Treatment Plant Project

- The Beneficiary of the Project**
 - **Population of the Town on the bank of Shitalakkhya River**

Multi-disciplinary Project within Civil Engineering Domain

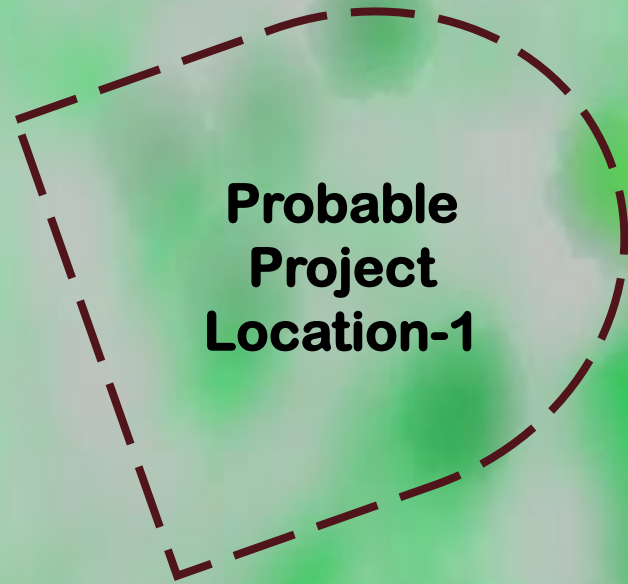
Course Outcomes: Integrated Design Project Course

- ❑ The students will be able to integrate the graduate attributes they have acquired during 4-years Engineering Education

- ❑ The students will be able to demonstrate
 - Depth of knowledge (P1)
 - Two or more attributes of complex engineering problems (P2 – P7) in addition to the “depth of knowledge (P1)”

- ❑ The students will be able to communicate effectively on complex engineering activities

Location: Narayanganj, Bangladesh



**Probable
Project
Location-1**

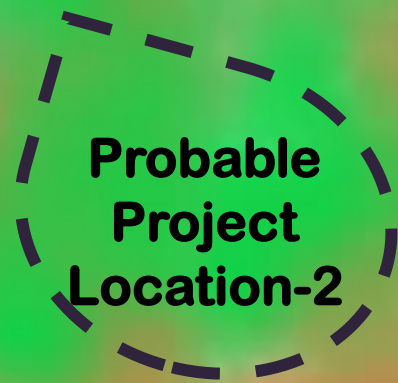
Starting Point
Selection of Intake Source
(Shitalakkhya River)

End Point
Distribution of the
Treated Water to the
End-users

Shitalakkhya River

Step-1

- Selection of Project Location
- Acquisition of Plant Location



**Probable
Project
Location-2**

Not in Scale

Expectations from PO Perspective

To be satisfied by the Students through Individual and Team Efforts

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Show-Case the Graduate Attributes

Problem Analysis

Investigation

Design

Focus on Environment and Sustainability

- Through Design / Problem Analysis/EIA

Demonstrate Attributes in one of the following two Disciplines

- Geotechnical Engineering
- Structural Engineering

Modern Tools Usage

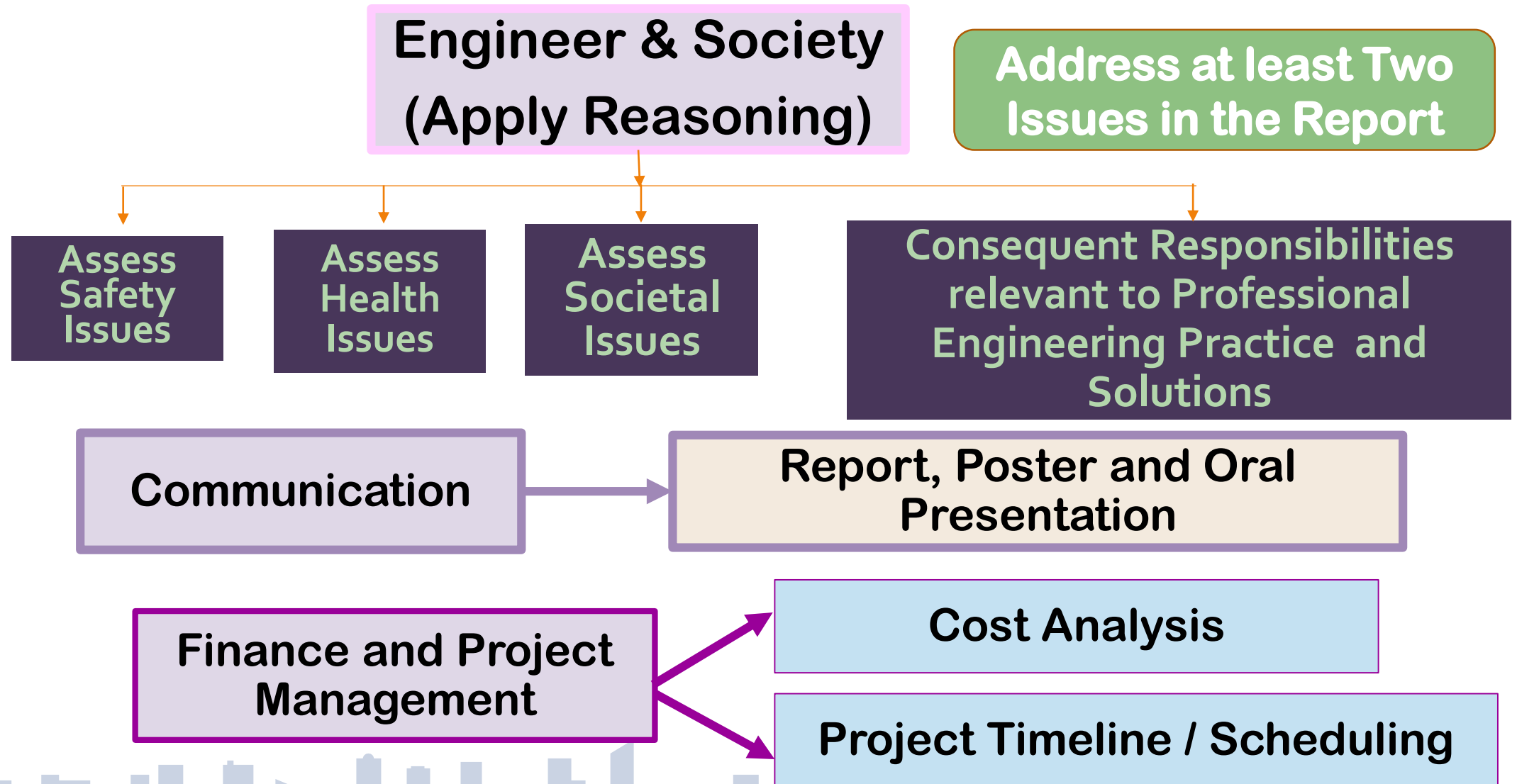
Problem Analysis

**Communication:
Report/Documentation**

Expectations from PO Perspective

To be satisfied by the Students through Individual and Team Efforts

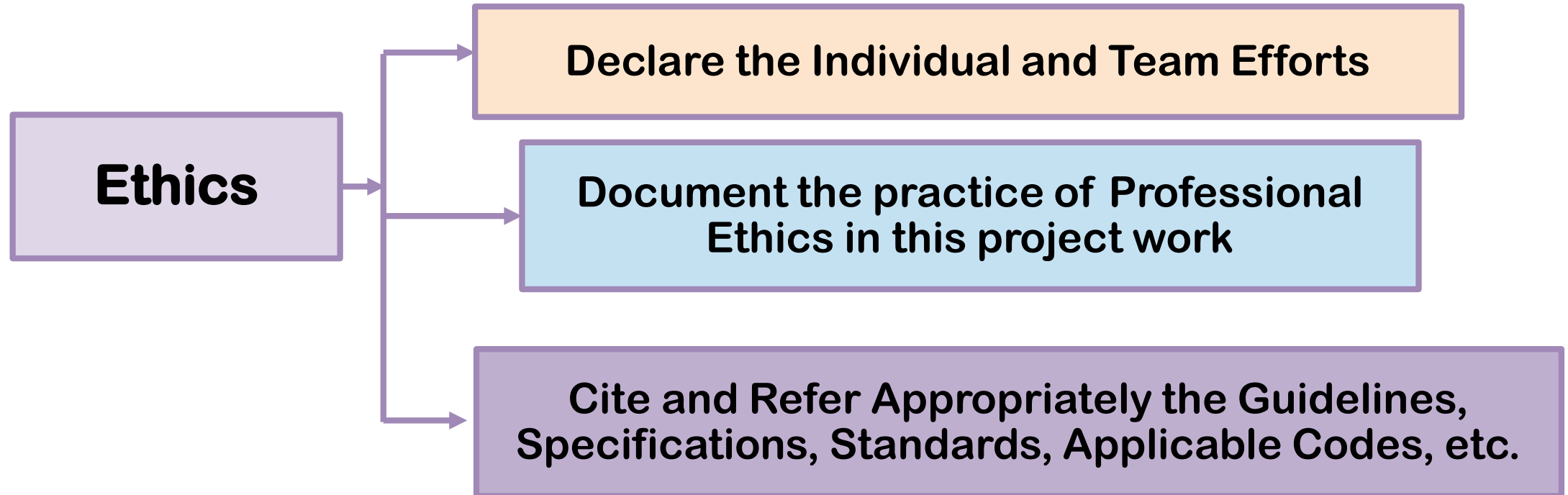
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Expectations from PO Perspective

To be satisfied by the Students through Individual and Team Efforts

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Summary: Opportunities for Attaining PO's (a-g)

	Program Outcomes		
a.	Engineering knowledge	✓	<ul style="list-style-type: none">• Environmental Engineering• Geotechnical Engineering• Engineering Materials• Structural Engineering
b.	Problem analysis	✓	<ul style="list-style-type: none">• Analysis of problems in different disciplines
c.	Design/development of solutions	✓	<ul style="list-style-type: none">• Design of Structures, Foundations, Distribution Network
d.	Investigation	✓	<ul style="list-style-type: none">• Site Investigation• Water Quality• Grit/Sludge
e.	Modern tool usage	✓	<ul style="list-style-type: none">• Design Drawing (AutoCAD)• Structural Analysis (ETABS, STADDPRO, etc.)
f.	The engineer and society	✓	<ul style="list-style-type: none">• Safety & Health Issues• Residual Management System
g.	Environment and Sustainability	✓	<ul style="list-style-type: none">• Analysis and Design• Quality Control Procedure

Opportunities for Attaining PO's (h-i)

	Program Outcomes		
h.	Ethics	✓	<ul style="list-style-type: none">▪ Document the application of Professional Ethics at different stages
i.	Individual work and teamwork	✓	<ul style="list-style-type: none">▪ Possible to divide the project for teamwork
j.	Communication	✓	<ul style="list-style-type: none">▪ Report writing and presentation
k.	Project Management and Finance	✓	<ul style="list-style-type: none">▪ Scheduling▪ Cost Analysis
l.	Life-long learning	✓	<ul style="list-style-type: none">▪ Review the Literature▪ Search for Appropriate Engineering Principles & Techniques▪ Find Alternatives & probable Design Solutions

Water Treatment Plant

**Time Duration to Complete IDP
1 Year**



- ❑ The students will have to identify different issues to be considered in different stages of this development project

The students will get opportunity to demonstrate 'Depth of knowledge' from the beginning.

- Lists the items to be performed at these stages

Initial Demonstration of Depth of Knowledge in Planning Stage

The team lists the Items to be considered and also elaborates-

Selection of Plant Location

- Population size to be served (Present and Future)
- Extent of geotechnical investigation (Inside and outside the 'plant complex')
- Finance and budget allocation

Processes of Water Treatment

Design of Water Treatment Units

Residual Management System

Quality Control of Treatment Processes

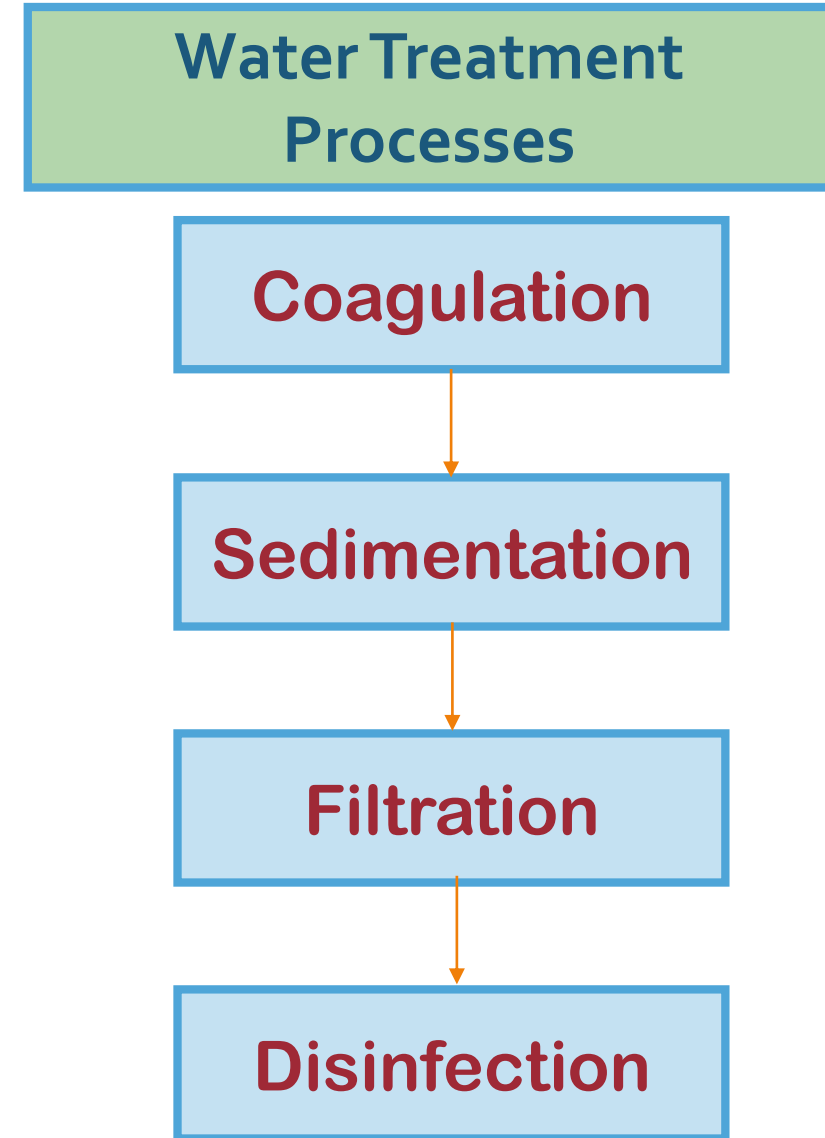
Planning of Space Allocation for Different Units of Water Treatment Units inside the 'Plant Complex' Area

Design

- ❑ **Outside the Plant Complex**
 - Intake water pipeline design
 - Pumping system
 - Water distribution network

- ❑ **Inside the Plant Complex**
 - Design of structures and plant units
 - Design of Foundation
 - Design of water treatment processes

- ❑ **Storage Tank of Treated Water**



Evaluation Criteria for P1 ('Depth of Knowledge')

Expectations from Complex Engineering 'Problem Solving' Perspective

Attributes of Complex Engg. Problem: P1 "Depth of knowledge required"

- **Cannot be resolved without in-depth engineering knowledge**

Construct Design-specific Problem Statements

Review the Literature

Identify and apply Engineering Principles and Techniques

Select Appropriate Engineering Tools from Various Alternatives

Select Robust Method for Conducting, Analyzing, Testing and Interpreting Experimental Results

Conclusions and Recommendations based on Important Design Features and Test Results

Quality Distinctions: Performance Level Descriptors

[Liew, Puteh and Hamzah, 2020]

The Quality of Student's Performance needs to be assessed

- Evaluation is performed in terms of Performance Level Descriptors for each Evaluation Criteria

Exceeds Expectations	Excellent
Adequately Meets Expectations	Good
Minimally Meets Expectations	Fair
Fails to Meet Expectations	Not provided/ Not Correct

Quality Distinctions: Attributes of Complex Problem-P1

Evaluation Criteria-1

Constructing Problem Statements/ Problem Identification related to

- Site Selection
- Identification of Cutting-Edge Technologies for Geotechnical Survey
- Analysis, Testing and Interpretations in Core Content Areas
 - Geotechnical Survey Report
 - Processes for Water Treatment and Quality Control Procedure
 - Process for Residual Management and Quality Control Procedure

Exceeds Expectations

Complete with **Thorough Discussions**;
Consistent with available Info

Minimally Meets Expectations

Provides Problem Statement **w/o any Discussion**; Haven't considered All the Available Info

Adequately Meets Expectations

Complete with **Light Discussions**;
Consistent with available Info

Fails to Meet Expectations

Not Consistent with Available Information

Quality Distinctions: Attributes of Complex Problem-P1

Review of Research Literature

- **Expectations: Summarizes, Compares and Evaluates**
- **Should include various Concepts, and Current Theories and Models in Core Content Areas**

Exceeds Expectations

Summarizes, Compares & Evaluates Concepts, Current Theories and Models

Minimally Meets Expectations

Provides only Summary of Concepts, Theories and Models (Or Not Up To Date)

Adequately Meets Expectations

Summarizes and Compares Concepts, Current Theories and Models

Fails to Meet Expectations

No Literature Review Provided

Quality Distinctions: Attributes of Complex Problem-P1

Selects Engineering Tools from Alternatives

Exceeds Expectations

The Selection of modern tools is Justified through critical discussions

Minimally Meets Expectations

Provides some Documentation related to the Justification behind the selection

Adequately Meets Expectations

Some discussion is provided to support the tool selection

Fails to Meet Expectations

Justification behind the selection is Missing

Quality Distinctions: Attributes of Complex Problem-P1

Expectation: Selects Appropriate Engineering Principles and Techniques

❑ Analysis:

- Liquefaction Analysis
- Settlement Analysis
- Structural Analysis
- Water Quality Analysis

❑ Design:

- Units of water treatment processes
- Structures and Foundations
- Intake-water pipelines and water distribution network

Exceeds Expectations

Establishes **excellent** connection between the Project & the core content area of specific Engineering Domain. Relevant Engineering Principles and Techniques are Correctly applied.

Minimally Meets Expectations

Fails to provide a complete framework; Though provides Basic Principles and Techniques but **some are missing**

Adequately Meets Expectations

Provides a **good** engineering framework for the project. Relevant Engineering Principles and Techniques are Correctly applied.

Fails to Meet Expectations

Provides Basic Understanding about the Principles and Techniques, but **Fails to apply**

Quality Distinctions: Attributes of Complex Problem-P1

Conclusions and Recommendations

Expectations about Conclusions: **Summarizing Important Design Features and Test Results**
Expectations about Recommendations: **Relevant & describes**

Exceeds Expectations

- **Clearly summarizes**
- **Recommendations: Relevant & Described in Detail**

Minimally Meets Expectations

- **Missed Important Points in Summary**
- **Recommendations: Relevant but Unsatisfactory**

Adequately Meets Expectations

- **Summarizes Satisfactorily**
- **Recommendations: Relevant but Described not in Detail**

Fails to Meet Expectations

- **Provides no Summary**
- **Recommendations: Irrelevant and Significant Lackings**

Attributes of Complex Problem-P2

P2 : Range of Conflicting Requirements

Conflicting Factors in deciding the Capacity of the Plant (Volume of water can be treated per day)

- Constraints: Maximum Volume of Water may be withdrawn from the Shitalakkhya river per day;.....
- Criteria: Demand (For current population and projected population for 20 years);
- Assumption:

Expectations/ Evaluation Criteria: Identifies and Discusses Constraints, Criteria, and Assumptions

Exceeds Expectations

- Complete Identification
- Clear and Detail Discussion

Minimally Meets Expectations

- Unsatisfactory Identification
- Light Discussion

Adequately Meets Expectations

- Satisfactory Identification
- Discussion not in Detail

Fails to Meet Expectations

- No Identification
- No Discussion

Attributes of Complex Problem-P3

P3 : Depth of Analysis Required

- Have no obvious solution and require abstract thinking

Expectations: Discusses the possible Approach to Investigate, Identifies some possible Solutions, recognizing available Resources

Issue: The pipelines will be installed underground

Require Thinking

Requires Investigation & need to Select Appropriate Technologies

Corrosion of Pipe Material??

Requires decision in Testing, whether Priority should be given to Soil-Water Extracts or Borehole Water

Possible Approach & Possible Solutions

This issue will be the deciding Factor behind the selection of appropriate type of Pipe Material

A Suitable Model needs to be Formulated

Available Resources

Metallic Pipes: Steel, galvanized steel, alloy steels, copper alloy, nickel alloy

Non-Metallic Pipes: HDPE, PVC and FRP

Attributes of Complex Problem-P4

P4: Familiarity Issues

- ❑ Infrequently encountered issues, associated to this project, are common in general.

■ Problem Analysis:

- Liquefaction Analysis
- Structural Analysis of WT Units

■ Investigation:

- Chemical Tests of Soil
- Soil Corrosivity Test
- Water Quality Tests

■ In Material Selection

Exceeds Expectations

- Addresses **3 or more Infrequently Encountered Issues**; adequately in detail

Minimally Meets Expectations

- Addresses at least **1 Infrequently Encountered Issue** in detail

Adequately Meets Expectations

- Addresses **3 Infrequently Encountered Issues**; All are not in detail

Fails to Meet Expectations

- **No Infrequently Encountered Issue** is addressed

Attributes of Complex Problem-P5

P5: Extent of applicable Codes

- Different codes will be used to perform the following tasks
- Liquefaction Analysis (geotechnical)
- Evaluate the quality of treated water (environmental)
- Recommendations for Design of Structures (structural)
- Recommendations for Design of Building Foundations (foundation)
- Evaluation of Soil Corrosivity (geotechnical)
-

Exceeds Expectations

- Followed the applicable Codes **in all sorts** of Analysis & Designs; **also Identifies if there are any Limitations**

Minimally Meets Expectations

- Applicable Codes are **randomly followed** in Analysis & Designs

Adequately Meets Expectations

- Followed the applicable Codes in **all sorts** of Analysis & Designs

Fails to Meet Expectations

- Performing Analysis & Design **w/o consulting the Codes**

Attributes of Complex Problem-P6

P6: Extent of stakeholder involvement and conflicting requirements

- Involve diverse groups of stakeholders with widely varying needs

Public
Engineers
Workers
Contractors
Suppliers

Expectations: Anticipates and explains needs and impacts in social, environmental, and economic, health, and safety terms beyond the immediate client and users

Exceeds Expectations

- Discusses the anticipations about **Safety and 2 more issues** (3 or more groups of stakeholders)

Minimally Meets Expectations

- Discusses the Impact of the Project
- Addresses **only Safety** for 1 group of stakeholder

Adequately Meets Expectations

- Discusses the Impact of the Project in terms of **Safety (detail) and 2 more** (2 groups of stakeholders)

Fails to Meet Expectations

- **Not** addressed **Safety** Terms

Attributes of Complex Problem-P7

P7: Interdependence

- Are high level problems including many component parts or sub-problems

- Can be divided into sub-problems/components
 - Environmental Engineering
 - Geotechnical Engineering
 - Engineering Materials
 - Structural Engineering

Exceeds Expectations

- Performs Analysis/Design/Investigation, etc. in **3** or more Disciplines

Minimally Meets Expectations

- Performs Analysis/Design/Investigation, etc. in **1** Discipline only

Adequately Meets Expectations

- Performs Analysis/Design/Investigation, etc. in **2** Disciplines

Fails to Meet Expectations

- Provides **inappropriate or incomplete** Analysis/Design/Investigation, etc.

Attributes of Complex Problem A-1

A1: Range of resources

Issue: Project Scheduling

Involve the use of diverse resources

- People
- Finance
- Equipment
- Materials
- Technologies

Accomplished

- Constructs and Critically Analyzes the Project Timeline by giving considerations to 3 or more resources

Developing

- Constructs and Critically Analyzes the Project Timeline by giving considerations to 1 resource

Competent

- Constructs and Critically Analyzes the Project Timeline by giving considerations to 2 resources

Beginner

- Constructs but not critically analyzed

Thank You