UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: May 2023

Module Number: CE7303 **Module Name: Construction Environmental Management**

[Answer **all questions**, questions carry **unequal** marks]

Q1. a) (i) Why do companies opt for end-of pipe solutions, rather than the clean technology?

[2.0 Marks]

(ii) Why should clean technologies be adopted in the construction industry?

[2.0 Marks]

(iii) Discuss how 'Life Cycle Assessment' can be applied in a multi-storey building construction work site to select the best environmental-friendly options.

[3.0 Marks]

b) Discuss an effective qualitative approach to prevent construction and demolition waste during the construction stage.

[2.0 Marks]

c) The following are the different stages of a building life cycle: Raw material extraction; Manufacturing; Construction; Operation and Maintenance; Demolition; and Disposal, reuse and recycling. Identify an environmental impact likely to arise in each stage and a mitigatory measure for each impact identified.

[3.0 Marks]

Q2. a) Municipality sewage treatment charges may be determined from (1) the volume of waste (quantity formula); (2) by applying a surcharge for parameters exceeding predetermined concentrations in addition to the charges based on the effluent volume (quantity-quality formula); and (3) by allowing all users to pay the same amount for an 'assessment rupee', after which a surcharge is applied (assessment/surcharge formula), i.e. every user has to pay a fixed amount of money annually to the municipality for sewage treatment (this amount which is called 'annual assessment' is set by the municipality based on an assessment of its wastewater characteristics).

(i) What is the best formula in the viewpoint of each of the following stakeholders: a polluter, regulatory agency and the people residing near the receiving water body.

[3.0 Marks]

(ii) Arrange the above three formula in the hierarchical order of preference in the viewpoint of pollution control, and give reasons for the arrangement.

[2.0 Marks]

b) "After setting the overall level of SO_2 emissions for a given region, the government regulators issued allotments (permits) to individual businesses which were free to trade them on the open market. The plan was to reduce total allotments over time, thereby improving the ambient air quality. Polluters with high treatment cost preferred to buy permits rather than invest in treatment. Polluters with low treatment cost sold permits and were encouraged to further reduce their pollution in order to sell more of their credits." Rationalize the foregoing paragraph, using the emission trading economic tool.

[3.0 Marks]

Q3. A mega-scale construction project discharges wastewater generated from its construction site into a stream flowing nearby. Table Q3 (a) gives measurements of the stream and the wastewater generated by the construction site. The saturation dissolved oxygen (DO) concentration at 15 ^0C is 10.07 *mg/L*. Assume that the downstream of the river immediately after the discharge of wastewater will be 80 % saturated.

Table Q3 (a): Measurements of the construction industry effluent and stream.

Parameter	Construction Site Effluent	Stream
Flow rate,	100 000 m^3/d	10 m^3/s
Velocity, *km/h*	-	14.0
Dissolved Oxygen (DO)	0	The upstream is 85 % saturated
BOD_5 at 20 ^0C, *mg/L*	200	-
BOD_5 at 20 ^0C, *mg/L*	-	2
Temperature, ^0C	20	15
'k' at 20 ^0C, d^{-1}	0.3	0.3
'k_2' at 20 ^0C, d^{-1}	-	0.6
Temperature coefficient (θ) for 'k'	1.1	1.1
Temperature coefficient (θ) for 'k_2'	-	1.05

The following equations are applicable:

$$D_c = \frac{k}{k_2} L_i e^{-k\theta_H^*} \quad ; \quad \theta_H^* = \frac{1}{(k_2 - k)} \ln \frac{k_2}{k}\left\{1 - \frac{D_i(k_2 - k)}{kL_i}\right\}; BOD_5 = BOD_U(1-e^{-kt});$$

$$k_T = k_{20}\theta(T - 20)$$

Where;

D_i = Initial dissolved oxygen deficit at the point of waste discharge, *mg/L*

D_c = Critical dissolved oxygen deficit, *mg/L*

θ_H^* = Critical hydraulic retention time, *d*

k_2 = Reaeration constant, d^{-1}

k = Carbonaceous organic matter degradation rate constant, d^{-1}

L_i = Ultimate *BOD* at the point of waste discharge, *mg/L*

θ = Temperature coefficient

k_T = Reaction rate constant at the temperature 'T', d^{-1}

a) Determine the critical time, critical oxygen deficit and its location.

[7.0 Marks]

b) Estimate the 20 ^{0}C-BOD_5 of a sample taken at the critical point of the selected river.

[2.0 Marks]

c) Plot the DO sag curve.

[3.0 Marks]

Q4. Gin-Nilwala Diversion Project (GNDP) is a major development project aiming to divert excess water in the upper reaches of Gin and Nilwala River basins in the wet zone to Hambantota district. Hambantota district suffers from severe water shortage. The proposed infrastructure of the project includes two weirs, one reservoir, three tunnels and canals. There is a weir at Pitadeniya in Gin River, which will transfer water to Kotapola weir across Kotapola Oya in Nilwala River basin through a tunnel (Pitadeniya tunnel) of the length equal to 12 *km*. Water is then transferred from Kotapola weir through a second tunnel (Kotapola tunnel) of the length equal to 5.5 *km* to another reservoir at Ampanagala across Siyabalangoda Oya, which is also in the Nilwala Rver basin. From Amapanagala reservoir, the water will be transferred to Muruthewala reservoir across Urubokka Oya through a third tunnel (Ampanagala tunnel) of the length equal to 12.5 *km*. The balance water from Muruthawela reservoir after meeting its irrigation and drinking water demands, will be transferred to Chandrika Wewa in Walawe river basin through Muruthawela existing LB canal improved (13 *km*) and a new canal of the length equal to 17 *km*. It is planned to accompany the development as separate complexes as follows: Pitadeniya complex; Kotapola complex; Ampanagala complex; Muruthawela complex and Udawalawa-Mau Ara complex (Includes Chandrika wewa and its irrigable area). With this diversion, it is possible to provide drinking and industrial water requirement of the Greater Hambantota Development Area at different key locations in the Udawalawe and Liyangastota schemes. Figure Q4 illustrates the locations of the main components of the proposed GNDP. Following questions are based on the Environmental Impact Assessment (EIA) development for the proposed GNDP.

a) Given the complexity of the proposed project, the EIA studies are conducted by dividing the proposed project into different categories. Suggest a suitable categorization for the proposed GNDP.

[2.0 Marks]

b) Identify an environmental resource factor of each category, which is likely to be affected during the operational phase of the above project.

[1.0 Marks]

c) State an environmental impact, which will be imposed on each environmental resource factor identified in Q4 (b).

[2.0 Marks]

d) Construct a Leopold interaction matrix suitable for an EIA report for the above project to summarize the environmental impacts during the operational phase. Use only the environmental resource factors identified in Q4(b).
Assign an imaginary scale from 1 to 4 to indicate the magnitude and significance of the impact/s imposed on each resource factor. Complete and quantitatively summarize the Leopold matrix.

[4.0 Marks]

e) For the above project, construct an outline of a weighting-scaling checklist that could be used to compare the 'drill and blast' and 'tunnel boring' techniques in constructing the Ampanagala tunnel. The checklist should include at least 5 decision factors, an imaginary weight for each decision factor and an imaginary scale for each alternative. A composite index for each alternative must be obtained based on the imaginary weights and scales.

[4.0 Marks]

Q5. 12.2% of the population in a town does not have proper sanitation facilities. The drainage system in the city is polluted with domestic wastewater. During the wet season, the cesspools and soakage pits saturate and the wastewater overflows freely into the drainage lines. High population density, poor drainage system, frequent sewage overflows into drains etc. have caused health hazards in the area. Therefore, a proper sewage disposal system is a necessity for this town to minimize the spreading of water borne diseases. In order to improve this situation, a project of constructing a wastewater collection, treatment and disposal system, which will comprise a collection network, treatment system, effluent and sludge disposal systems and operation and maintenance facilities, has been proposed.
The wastewater treatment plant (WWTP) will consist of a waste stabilization pond system, which can accommodate 10,000 m^3/d of wastewater including ground water infiltration. The sludge accumulated in anaerobic stabilization ponds will be composted and sun dried. The collection network will be laid along the main roads in the town. The treated effluent will be released into an abandoned irrigation tank (tank 1), which will be rehabilitated before using for the said purpose. The discharge of the treated effluent into the tank 1 may augment the volume of water in another irrigation tank (tank 2), which the overflow water from the former tank drains into. Other than agricultural purposes, the tank 2 is widely used for bathing and washing purposes, particularly by the neighboring residents.

Because there is no piped sewerage system in the town, all grey water is discharged into surface water drains ending up at the tank 1. The collection network and the WWTP will be designed to cater for a total design period until 2047. Table Q5 (a) depicts the average number of new domestic sewer connections per 5-year period. The value is the same for all the years within each five-year period. Table Q5 (b) shows the wastewater data of 4 drainage lines ending up at the tank 1.

Table Q5 (a): No. of new domestic sewer connections.

Year	No. of new domestic sewer connections per year	No. of total population
2022	100	8,000
2027	200	9,000
2032	300	10,000
2037	400	11,000
2042	500	11,500
2047	600	12,400

Table Q5 (b) Average wastewater data of 4 drainage lines.

Drainage No	Cross Sectional Area (m^2)	Velocity (ms^{-1})	BOD_5 (mg/L)
C1	0.3	0.4	300
C2	0.2	0.1	400
C3	0.3	0.3	500
C4	0.8	0.1	800

a) Discuss environmental impacts due to 'no action alternative' for the above project.

[2.0 Marks]

b) Develop a methodology to estimate the ambient water quality in the tank 1 surrounding the treated effluent discharge point, upon the discharge of treated effluent during the operational phase of the above project. Clearly state the parameters and factors to be considered.

[3.0 Marks]

c) It is expected that the water-borne diseases will totally be eliminated from this area once the proposed project is in operation. In conducting an extended cost-benefit analysis, the avoided cost of medication and gain in productivity as a result of the elimination of the water-borne diseases is one beneficial aspect of this proposed project. Health statistics from the nearby base hospital indicate that the hospitalization rates for acute and non-acute water-borne diseases are 40 and 80 per 1,000 population, respectively. It takes an average of 4 days and 1 day for a patient suffering from acute and non-acute water-borne diseases to fully recovered, respectively. The cost of medication is about Rs. 700/*d*. Although most patients are children, about 20 % of the patients are adults. The average labor wage in the area is Rs. 400/*d*. The medication cost and wages will increase by 30 % every five-year period. Estimate the avoided cost of medication and gain in productivity as a result of the elimination of the water-borne diseases.

[4.0 Marks]

d) The implementation of the proposed project is expected to improve the water quality of the tank 1 by gradually eliminating the pollution load carried by the 4 drainage lines given in Table Q5 (b), as the people will not incline to release untreated wastewater into surface drainage. It is expected that the total pollution load carried by these lines will entirely disappear by the design year, 2047. Estimate the net economic benefit gained through the improvement of the water quality due to the implementation of the proposed project in the year 2047. The effluent BOD_5 is 15 *mg/L*. The shadow price for BOD_5 is Rs. 3.0 per 1 *kg* of the pollutant load.

[4.0 Marks]

e) Name **three** economic cost aspects and **six** economic benefit aspects associated with the above project that can be monetized to estimate a benefit-cost ratio for the project. Exclude the economic benefits described in parts 'c' and 'd' above.

[2.0 Marks]

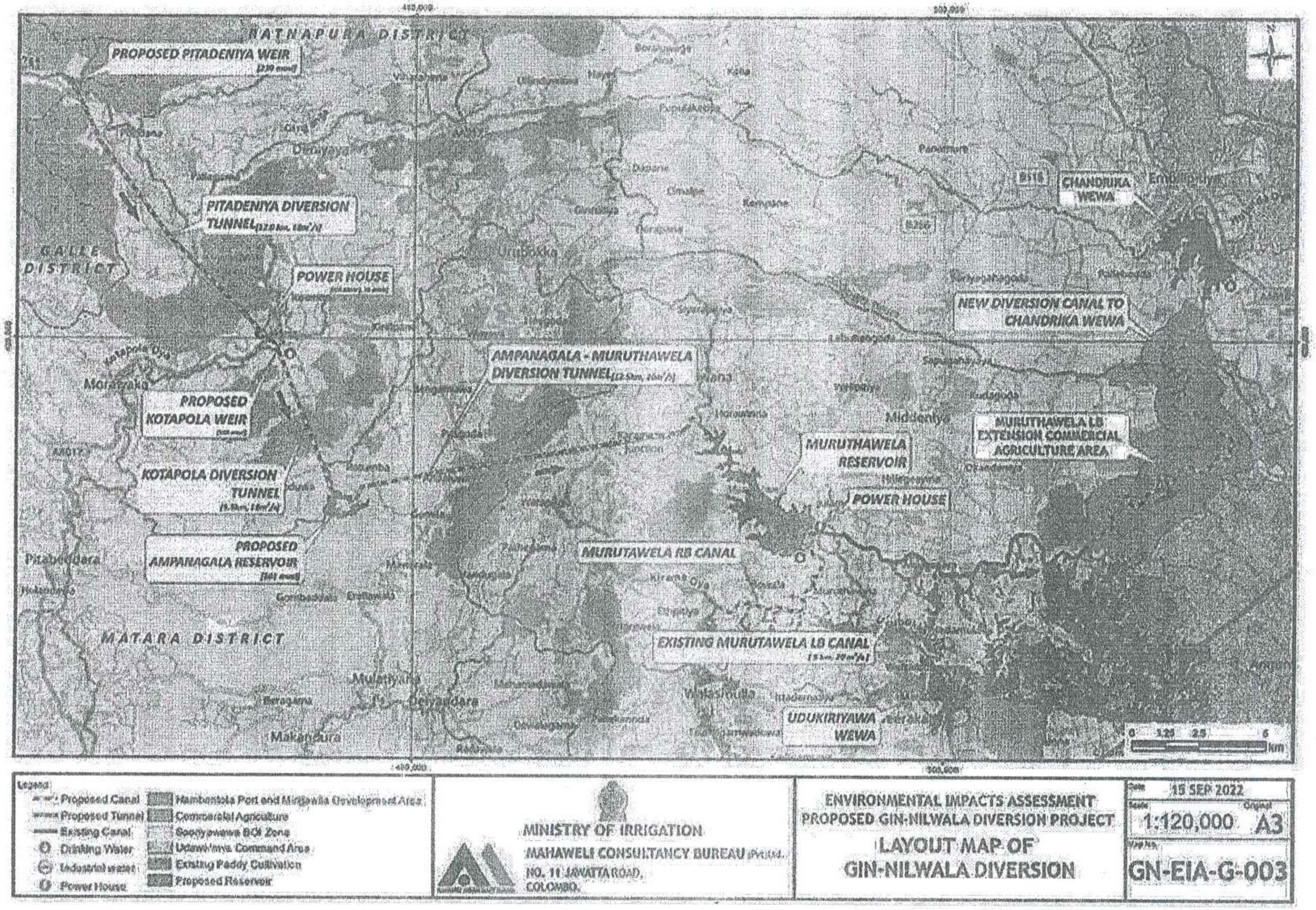

Figure Q4: Locations of the proposed project