Question One

1ai. The IDF curves are a family of curves used to show the relationships between intensity, duration and frequency of occurrence of rainfall, for the design of stormwater drainage systems and detention ponds. IDF curves are usually developed by national meteorological agencies using local rainfall records and for specific localities within the country.

ii. The duration is typically specified in minutes. For drainage designs, an important factor is the time of concentration (t_c), which is the time for hydraulic flow from farthest point on the watershed to the outlet. It is used to find the corresponding intensity for largest peak discharge (i) in a particular storm. The rational method is then used to determine the runoff (Q) for drainage design, given the areas (A) and runoff coefficients (C).

LID is a new form of stormwater management that seeks to restore hydrological and ecological function of urbanised catchments to its “natural” state. It involves a paradigm shift that keeps stormwater on-site for longer periods and manages it as a valuable resource. Some steps in LID management include site preservation, runoff reduction and stormwater treatment. Hence, LID can increase the time of concentration, in turn lowering the peak discharge. This reduces the runoff, thus requiring a smaller drainage.

iii. Once in 100 years means that its return period is 100 years, hence there is a 0.01 probability that this rainfall will occur in a year.

P(100-year rainfall not occurring in 30 consecutive years) = $(1 - 0.01)^{30} = 0.74$

bi. Currently, the most common disposal method is landfill. There are several types of landfills, with semi-controlled dumps being the lowest quality and sanitary landfills being the best. Semi-controlled dumps have few controls in operation, minimal engineering measures, with some direct placement of waste, informal waste picking. Leachate management is poor due to unrestricted contaminate release, and lacks landfill gas management. In contrast, sanitary landfills necessitate registration, placement and compaction of waste, the use of daily cover, proper siting, infrastructure and post-closure plan. Containment and leachate treatment, coupled with flaring for landfill gas, are standards that have to be met. Thus, under the landfill umbrella, semi-controlled dumps are highly unsustainable, and the landfill method should only be continued using the most sustainable option, which is sanitary landfill.

ii. In 5 days of a week,
Mass of solid in a week = 900 / 50 = 18 tons = 18000 kg
Fill volume = 18000 / 400 = 45 m^3
Fill height per week= 0.3 x 5 = 1.5 m
Cross sectional area, A= 45 / 1.5 = 30 m^2

Assume a square, side length= 5.477 m
Cover volume= (0.15 x 4 + 0.3) x A = 0.9 x 30 = 27 m^3
Total height per week = 1.5 + 0.9 = 2.4 m
Side cover volume = 2.4 x 5.477 x 0.3 x 2 = 7.887 m^3
Fill volume = 45 m^3
Total volume = 79.887 m^3
E = Total Vol/ Fill Vol = 79.887 / 45 = 1.78

Question Two

2ai. The natural greenhouse effect refers to the heat balance mechanisms that moderates the earth’s temperature to support life. Solar radiation (mainly shortwave) passes through the clear atmosphere, mostly absorbed by the greenhouse gases such as water vapour and carbon dioxide. 30% of this radiation is reflected by clouds, snow, desert, forest and the ocean. Earth also emits infrared radiation (long-wave), some of which escapes into outer space, the rest absorbed and re-

emitted in all directions by the greenhouse gases. The stability of the mixture of these gases in the atmosphere would maintain earth's temperature to be conducive for life.

ii. The maximum capacity in the logistics growth model represents the maximum population that can be sustained with earth's current carrying capacity. Three factors that can change this capacity are: human innovation, extraterrestrial influence and natural calamities.

bi. DBPs refer to the toxic chlorinated by-products produced by the chlorination of water containing humic organic substances. These include volatile hydrophobic compounds, like Trihalomethanes (THMs), Haloacetic acids (HAAs), as well as non-volatile hydrophilic compounds like chlorinated and non-chlorinated aromatic and aliphatic compounds. Some examples are Trichloromethane and Bromodichloromethane.

Nano-materials are materials with at least one dimension ≤ 100 nm, such as nano-wires, buckminsterfullerene and quantum dot. Metal-containing nano-material may cause toxicity to cells, inducing different levels of cell injury and oxidative stress. They may generate reactive oxygen species that lead to cell membrane damage, stimulate or suppress immune responses.

Both DBPs and NMs are considered emerging contaminants in the aquatic environment due to the following properties.

1. Chemicals may already be present in the environment but are not routinely monitored.
2. There is a concern about possible health and other effects to wildlife and humans
3. No standardised biological test data available
4. Government Dept does not have approved methods to detect many of these chemicals
5. Environment fate & transport information is lacking
6. New tools are needed to help address this issue.
7. Potential candidates for future regulation,depending on their potential human health effects and toxicity.

ii. Caffeine is a kind of PPCP. Wastewater treatment currently does not target the removal of caffeine, so wetlands may remove caffeine via bioremediation like co-metabolism.

Question Three

3a. Weather describes the state of the atmosphere over a short term while climate refers to the weather conditions over longer period of time (30 years) in a region.

b. Measurable/Observable change to weather pattern: Increasing temperature, lower humidity, higher frequency of floods/droughts/cyclones/heat waves, more extreme rainfall events, more violent weather

c. Vulnerability is the extent to which a natural or social system is susceptible to sustaining damage from climate change. It is a function of [choose one] the magnitude of climate change, the sensitivity of the system to changes in climate and the ability to adapt the system to changes in climate

Sensitivity of system: In tropics and subtropics, crops are very sensitive to high temperature. This leads to an increased risk of hunger and low food security. Many areas are susceptible to reduced agricultural productivity due to water shortage and weather extremes. Many watersheds are sensitive to shrinkage of water availability, increasing water stress to hundreds of millions of people. As for health, many countries are facing higher risk of heat stress. In many developing countries, there could be changing patterns in the occurrence of disease vectors (e.g. malaria, cholera, & diarrhoea). Many low-lying areas, coastal cities & coastal infrastructure, and ecosystems are sensitive to sea-level rise and other coastal hazards.

Question Four

4a. Energy is the work done when a force moves the object in the direction of the force and is given by the product of the force and the distance moved in the direction. 1 Joule is equal to the energy transferred (or work done) to an object when a force of one newton acts on that object in the direction of its motion through a distance of one metre.

$J = N \cdot m = [kg \cdot m \cdot s^{-2}] \cdot m = kg \cdot m^2 \cdot s^{-2}$

b. Energy can be changed from one form to another, but it cannot be created or destroyed. The total amount of energy and matter in the Universe remains constant, merely changing from one form to another.

c. An electric power generator converts mechanical energy into electrical energy. Based on Faraday's law of electromagnetic induction, the induced electromotive force is equal to the rate of change of magnetic flux. The flow of electric charges is induced by moving an electrical conductor, such as a copper wire that contains electric charges, in a magnetic field. As the copper coil rotates, cutting the magnetic field, this change in magnetic flux creates a voltage difference between the two ends of the wire, which in turn causes the electric charges to flow, thus generating electric current for usage.

Alternating current.

d. Renewable energy refers to energy that can be replenished within short period of time or is obtained from inexhaustible source. Example: Biomass, Solar, Wind, Geothermal, Ocean& Water.

e. Carbon monoxide, Methane, Ethene (=Ethylene, but ethylene ruled out in 1993 IUPAC naming), Methanol

Question Five

5a. First, a resource is discovered, where there is discovery and development. In the second phase, it is widely used, wherein lies the Peak-rate Year of Resources. Finally, supply becomes limited, limited accessibility means that a substitute is needed.

b. Changes in temperature, amount of carbon dioxide and the frequency and intensity of extreme weather could have significant impacts on crop yields. On one hand, Higher carbon dioxide levels can increase yields. On the other hand, more extreme temperature and precipitation can prevent crops from growing. Worse still, Many weeds/pests/fungi thrive under warmer temperatures, wetter climates and increased carbon dioxide levels.

Moreover, changes in climate could affect animals both directly and indirectly. Heat waves could directly threaten livestock, by increasing vulnerability to disease and reducing fertility. Drought may threaten pasture and feed supplies**.** Climate change may increase the prevalence of parasites and diseases that affect livestock. Increases in carbon dioxide levels may increase the productivity of pastures, but may also decrease their quality. The ranges of many fish and shellfish species may change as many aquatic species can find colder areas of streams and lakes or move northward along the coast or in the ocean. Changes in temperature and seasons could affect the timing of reproduction and migration.

c. From Figure 5, it can be seen the the shares of renewable energy has risen, and is projected to increase up to 10% by 2035. Gas is also increasing, from 15% in 1965 to 25% in 2035. In contrast, the shares of oil and coal have a general decrease, from 42% to 28% and 37% to 24% (estimate) respectively.

Given the aforementioned variation, there are several positive effects on the land, air and water. With less oil and coal mining, there will be reduced scarring and disruption of the land surface. The chances of wastewater and toxic sludge, stored behind dams, overflowing and releasing toxic substances are lowered. Biodiversity in both forests and marine habitats are better conserved. In addition, coal mining operations produce large amounts of solid waste and cause major water and air pollution. Hence, a shift towards gas and renewable energy would mean less waste is produced, and pollution is curtailed. Air pollution from burning of coal and oil is also reduced by using gas and other cleaner energy sources.