

Section A- 30 Marks

- 1. Origin, occurrence and movement of groundwater** **10%**
 - 1.1 Hydrologic cycle, groundwater storage, water table and artesian aquifers (unconfined and confined aquifers), influent and affluent streams, factors influencing infiltration, groundwater flow, lithology of aquifers, Darcy's Law, porosity, permeability, hydraulic gradient, safe yield, sea water intrusion
- 2. Testing Water wells for drawdown and yield and well hydraulics** **10%**
 - 2.1 Objective of tests, measuring pumping rates, water level measurements, aquifer tests, estimating well yield, estimating open pipe flow, Nature of converging flow, cone of depression, equilibrium well equation, yield vs. well size, yield vs. draw down, non-equilibrium well equation, modified non-equilibrium equation, time-drawdown relations, boundary effects, distance-drawdown relations, partial penetration of aquifers, water level recovery, well interference, radius of influence, well efficiency
- 3. Groundwater Quality and water treatment** **10%**
 - 3.1 Chemical components affecting groundwater quality (atmospheric, human and industrial waste, agricultural practices, disasters), processes affecting groundwater quality (soil type, human activities, and groundwater flow on contaminants), groundwater quality monitoring (selection of water quality parameters, sampling methods and density of observation networks, data processing and analysis, preventing measures and implementation), determining groundwater quality (hydrogeological, chemical, physical, and biological)
 - 3.2 Mineral analysis, units of measurements, hardness, electrical conductance, pH, dissolved minerals, water quality requirements, drinking water standards, aeration, iron and manganese removal, softening, demineralization, disinfecting wells - Use of hypochlorites, chlorination while drilling, filtration, disinfection by various methods
 - 3.3 Presence of arsenic in the groundwater of Nepal, source of arsenic and its remedy

Section B- 30 Marks

- 4. Groundwater exploration and Well drilling methods** **10%**
 - 4.1 Geologic and hydrologic studies, exploratory drilling, methods of sampling, electric logging, gamma-ray logging, electrical resistivity surveying, seismic refraction surveying. Basic principles of well drilling, cable-tool percussion method, direct rotary drilling, drilling fluid and drilling mud, reverse circulation drilling, jet drilling, air rotary drilling, driven wells, pipe casing selection, grouting and sealing casing, plumbness and alignment
- 5. Water well design screens selection** **10%**
 - 5.1 Grain-size analysis, plotting sand analysis curves, descriptive size classifications, types of grain-size curves
 - 5.2 Selection of housing and casing pipe, well screen design, selection of well screen (continuous slot type, shutter type, slotted pipe), casing diameter, casing material, well depth, well screen length, well screen diameter, well screen slot openings,

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- selection of well screen material, well screen design, pressure relief screens, formation stabilizer, open area, entrance velocity, screen transmitting capacity, gravel pack design, sanitary protection
- 5.3 *Installation of well screens*: Pull-back method, use of pilot hole, open bottom screens, wash-down method, well points, gravel packed screens, removing well screens for cleaning or reuse
- 5.4 *Well point system*: Multiple wells for water supply, installing well points, dewatering well point systems, design and layout, header and swing joints

6. Developing and completing water wells **10%**

- 6.1 Importance of development work, sand bridging, mechanical surging, surging with compressed air, over pumping, back washing, high velocity jetting, successful development procedures
- 6.2 *Water well Pumps*: Kinds of pumps, suction and cavitation, positive displacement pumps, variable displacement pumps, centrifugal pumps, jet pumps, air lift pumping, pump selection

Section C- 20 Marks

7. Conservation and management of groundwater **10%**

- 7.1 Conservation attitudes, optimum development of aquifers, subsurface water storage, artificial recharge, role and function of groundwater, conjunctive management of groundwater and surface water, pollution control, groundwater level control - structural measures, administrative measures, monitoring, implementation measures for groundwater management

8. Groundwater Resources of Nepal **10%**

- 8.1 History of groundwater study in Nepal, review of hydrological data, groundwater resources, groundwater use, groundwater recharge calculation, methods of groundwater estimate, groundwater balance

Section D- 20 Marks

9. Precipitation Infiltration and Water losses **10%**

- 9.1 Water vapour, measurement of humidity, variations in humidity, condensation, types of precipitation, thunderstorms, formation of raindrops, measurement of rainfall, use of radar, annual precipitation, variation in annual rainfall, mean rainfall in basin, testing and adjusting precipitation records, frequency of intense rainfalls, relation between storm frequency and mean annual rainfall, intensity duration curves, variation of average precipitation with area, maximum precipitation
- 9.2 *Soil moisture*: Definition of infiltration, factors affecting infiltration capacity, soil moisture, compaction due to rain, compaction due to man and animals, vegetative cover, temperature, annual and seasonal changes, methods of determining infiltration (f) infiltrometers, rain simulators, hydrograph analysis, determination of the 'f' curve
- 9.3 *Water losses*: Evaporation from free water surfaces, influence of depth, methods of determining evaporation, storage equation method, pan measurements, evaporation formulas, use of humidity and wind velocity gradients, transpiration ratio, measurement of transpiration, soil evaporation, influence of high or low water table, measurement of soil evaporation, total water loss, factors affecting total water loss

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10. Runoff and stream flow records

10%

- 10.1 *The hydrograph*: Terms and units, sources of runoff, the runoff process, soil moisture and groundwater, variability of stream flows, classification of streams, groundwater depletion curves, hydrograph analysis
- 10.2 *Runoff*: Surface runoff, relation between surface detention and discharge, synthesis of a hydrograph, unit hydrograph, prediction of runoff from rainfall, determination of unit hydrograph, duration curve
- 10.3 *Factors affecting runoff*: Type of precipitation, rain intensity, duration of rainfall, distribution of rainfall on basin, direction of storm movement, the drainage net, indirect drainage, artificial drainage
- 10.4 *Stream flow records*: Methods of obtaining discharge records, weir stations, control meters, velocity area stations, measurement of velocity, rating of current meter, type of current meters, methods of making discharge measurements, measurement of area, mean velocity in vertical, spacing of verticals, plotting and extending the stage discharge curve, measurement of peak flood flow

द्वितीय पत्रको एकाइहरूको प्रश्नसंख्या निम्नानुसार हुनेछ

द्वितीय पत्रका खण्ड	A			B			C		D	
द्वितीय पत्रका एकाई	1	2	3	4	5	6	7	8	9	10
प्रश्न संख्या	1	1	1	1	1	1	1	1	1	1

विषयगत नमूना प्रश्नहरू (Sample questions)

- Define the following terminologies:
(a) Darcy's Law (b) Confined and unconfined aquifers (c) Hydrologic cycle (d) Permeability (e) Influent and affluent streams. 5x 2=10
- Describe the process of conducting pumping test on a water well to determine the drawdown, yield, well efficiency and transmissivity.
- Describe the methods of treatment of groundwater, units of measurements and components affecting groundwater quality.
- Give the details of surface type and borehole type operations of geophysical methods applicable in groundwater exploration.
- Describe in detail the governing factors to be taken into consideration for an ideal water well design.
- Give the importance and steps of well development works.
- Describe the procedures and governing factors of groundwater conservation and management.
- Describe the hydrological conditions, methods applied for estimating groundwater reserve and groundwater balance of Kathmandu Valley.
- Give brief description of the following:
(a) Groundwater depletion curves
(b) Hydrograph analysis
(c) Variability of stream flow
(d) Methods of determining infiltration (f)
(e) Testing and adjusting precipitation records. 5x2=10
- Describe the different procedures and methods of obtaining stream flow and discharge records.