1. What is groundwater and where does it come from?

- Groundwater is naturally occurring water found below the ground that is stored in fractured rock or alluvium based or sand aquifers. Groundwater is an integral part of the natural water cycle as rainfall and other types of surface water infiltrate below the ground to recharge existing aquifers.

2. What exactly is an aquifer?

- A rock formation capable of holding and transmitting water through its inter-connected pore spaces (or through joints and fractures) is called an aquifer.
- Unconfined aquifers are formed by formations which are exposed and pervious at the top surface but impervious at the bottom at some depth.
- An aquifer that occurs sandwiched between two impervious formations is a confined aquifer. In alluvial region, when a sand layer (aquifer) occurs in between two clay layers (impervious formations); the sand layer becomes a confined aquifer.
- Water in a confined aquifer enters from a far-away location where a part of the aquifer is exposed to the surface or to other sources of water for its recharge.
- Water in a confined aquifer occurs under hydrostatic pressure as the recharge area is essentially located at a higher elevation.

3. Which rock formations are good for transmitting groundwater?

- From the hydrogeology point of view, rock formations are categorized conveniently as unconsolidated (loose), consolidated (hard) and semi-consolidated.
- Recent and older alluviums are unconsolidated sedimentary formations yield moderate to good quantity of groundwater. Clay and shale on the other hand being impervious are natural barriers to groundwater flow.
- Semi-consolidated formations like sandstone and limestone yield moderate to good quantity of groundwater.
- Water is also unable to pass through compact rocks like granite, basalt, quartzite etc., which are usually devoid of any primary porosity. Weathered and fractured portions can transmit groundwater depending on degree of secondary porosity developed due to weathering.

4. We get so much water from underground rocks. Are there natural streams flowing underground?

- Not really! Groundwater moves through porous rock formations similar to the way water flows through a sponge with inter-connected pores. In nature, no space remains empty. Therefore, the pore space within the underground rock formations, remains filled either with air or water (sometimes oil and gas in deeper formations). Given a continuous supply, water enters a porous rock formation replacing the air and gradually saturates all the pore spaces. As the process continues, excess water tends to move through the saturated formation under gravitational force.

5. If rain water is the source of groundwater, how does it become brackish?

- As rain water percolates down the soil and the underlying formation(s), it keeps on dissolving the soluble chemicals from the formations. Furthermore, as general depth of water table has also gone down quite considerably, the percolated water has to travel a longer distance through the

formation before joining the water table and hence dissolves more salts than before. This is perhaps the reason why we get more brackish water in one well than in another in the vicinity.

6. Is it not true that wells showing shallower water level yield more water?

- It is not true that shallower the depth of water table more is the yield of the well. In other words, the depth of water table is not always a good indication of yield of the well.
- It is the property of the aquifer called permeability (ease of flow) that determines the yield of a well.
- Water table would tend to rise higher in that part of the aquifer where aquifer permeability is relatively low and vice versa.
- Shallow water table encountered in a dug well is not necessarily an indication of higher yield. Another well in the vicinity with deeper water table can yield higher quantity of water due to better permeability of the aquifer.

7. Which type of well yields more water: a dug well or a tube well?

- It is the nature of the aquifer tapped and not the type of well which is responsible for yield.
- A well is merely an extraction structure.
- Dug wells are ideal groundwater extraction structure for shallow unconfined aquifers.
- Tube wells are most ideal for tapping high yielding granular aquifers occurring at considerable depths.

8. What are the common options available for drilling water well in an alluvial area?

- The drilling rig used in an alluvial area is referred to as a “rotary rig”.

9. How is water wells drilled in hard rock formations?

- Most common type of drilling technique used in hard rock drilling is referred to as the “Down the Hole Hammer” (DTH) method.
- DTH rigs do not use mud circulation and hence are not suitable for drilling through soft formations beyond a certain depth as the bore hole would keep collapsing without the mud.
- The drilling machine used specifically to construct water wells in an area containing soft (loose) formation at the top to a considerable thickness followed by hard rocks below are known commonly as the “Combination Rig”.

10. Why are some bore wells fully cased while others hardly use any casing pipe?

- In alluvial area, the entire depth of a bore hole needs to be cased to prevent it from collapsing. In order to allow water to enter into the well from the aquifers, small openings usually in the shape of thin slots are provided at appropriate locations in the casing pipe. The annular space between the casing pipe and the bore is usually filled up with pea sized gravel of uniform size.
- In hard rock areas, a drilled bore hole on the contrary does not collapse. Hence there is no need to insert a casing pipe to keep the bore hole standing. However, as the top portion in hard rock areas usually becomes soft and loose due to weathering, only this weathered portion needs to be cased.

11. Why is it not advisable to construct too many wells too close to each other?

- When two wells too close to each other are pumped simultaneously, the two radiuses of influences get superimposed with each other resulting in a cumulative drawdown in each well. When a number of wells close to each other are pumped simultaneously, the fall of water level in all the pumping wells starts accelerating which may result in pumping failure due to shortage of water in some of the wells that are shallower than others.

12. How to obtain sustainable/maximum yield from a bore well?

- The concept of sustainable yield applies to an aquifer only and not to a well.
- Sustainable yield of an aquifer refers to the total quantity of water it can yield i.e. total number of wells it can support without causing any unacceptable lowering of the regional water table over a long period.
- The yield of an aquifer eventually depends upon its size, permeability and annual recharge received by the same. Ideally, the quantity of water extracted annually from an aquifer should be less than or equal to the quantity of water received by the aquifer annually through recharge. If more water is extracted every year, naturally, the water table would start falling eventually turning the yield of the aquifer unsustainable and thus reducing the yields of the existing wells.
- The term 'maximum yield' applies to a particular well.
- How much water a well can yield depends on its location, size, extent and permeability of the aquifer tapped.
- The aquifer releases water equal to the pumping rate is the 'maximum yield' of the well.

13. What is stage of ground water development?

- The stage of ground water development is ratio of Annual Ground Water Draft to Net Annual Ground Water availability in percentage.

14. What are over-exploited, critical and semi critical blocks?

- The ground water resources are assessed in units i.e. Blocks These assessment units are categorized for ground water development based on two criteria:-

    a) Stage of ground water development, and
    b) Long-term of pre and post monsoon water levels. The long term ground water level trends are computed generally for the period of 10 years.

- The water level decline between 10 to 20 cm/year is taken as significant rate of water level decline, depending upon the local hydrogeological conditions.
- There are four categories, namely - **'Safe'** areas which have ground water potential for development; **'Semi-critical'** areas where cautious groundwater development is recommended; **'Critical'** areas; and **'Over-exploited'** areas, where there should be intensive monitoring and evaluation and future ground development be linked with water conservation measures.

15. What about water wells that are abandoned or not in use?

- Abandoned water wells (wells not in use) need to be properly plugged. Water wells that are not maintained or used may act as conduits for surface water and contaminants to enter the groundwater system. Plugging unused water wells alleviates the possibility of chemicals and other contaminants from entering the groundwater system.

- Large diameter wells (2 feet and larger) which are not used and not maintained may be hazards to small children and animals.

16. Which factors determine water quality?

- Water quality is determined by physical/chemical factors such as pH and conductivity, by the number / concentration of salts present.

17. What is hard water?

- When water is referred to as 'hard' this simply means, that it contains more minerals than ordinary water. These are especially the minerals calcium and magnesium. The degree of hardness of the water exceeds, when more calcium and magnesium dissolve.

18. What is Residual Sodium Carbonate (RSC)?

- [RSC = (CO_3^{-2} + HCO_3^{-}) - (Ca^{+2} + Mg^{+2})]; where all concentrations are expressed in mili-equivalents per liter (meq/l).
- Water with RSC values over 2.5 is generally not suitable for irrigation uses.

19. What is Sodium Absorption Ratio (SAR)?

- SAR is a mathematical relationship that expresses the relative activity of sodium ions in the exchange reactions with the soil. This ratio measures the relative concentration of Sodium to Calcium and Magnesium.
- SAR affects soil permeability.

20. How Can Our Ground Water Become Polluted?

- Ground Water is a natural solvent and dissolves any dissolvable material it comes in contact with. This results in pollution of ground water, polluted with every dissolved contaminant the water passed through on its path after leaving the atmosphere as rain, sleet, snow or hail.

21. What Are Some Natural Sources Of Ground Water Pollution?

- **Microorganisms -** Microorganisms (such as Parasites, Viruses and Bacteria) are most often found in water coming from a shallow well, especially in areas with a high water table. This results in a higher risk of an infested water supply. Symptoms of illnesses from microorganisms are similar to that of food poisoning. These include: Nausea, vomiting and diarrhea.
- **Nitrates and Nitrites** Nitrates and Nitrites are formed when nitrogen compounds break down into the soil. They are then transported by water into the water. Below the ground Nitrates and Nitrites are a threat to the health of infants.
- **Heavy Metals** – Heavy metals such as Arsenic, Cadmium, Chromium, Lead and Selenium may be found in underground rock and soil, but from natural sources, are usually only found in very low levels. They can pose numerous health effects, especially in infants and children.
- **Fluoride** - Fluoride is commonly used in dentistry for cavity prevention. So many water treatment plants add it to the water supply. However, too much fluoride can damage bone tissues and discolor teeth.

22. What Are Some Manmade Sources Of Ground Water Pollution?

- **Nitrates and Bacteria:**

  - come from human & animal waste
  - landfills
  - leaking septic tanks
  - large amount of animals in confined area
  - garbage dumps
  - fertilizers and pesticides

- **Heavy Metals**

  - can come from mining and construction
  - arsenic from outdated pesticides
  - industrial effluents

23. What is need for rain water harvesting and artificial recharge of ground Water?

- The need for adopting rain water harvesting is –
  - ✓ To overcome the inadequacy of surface water to meet our demands.
  - ✓ To arrest decline in ground water levels.
  - ✓ To enhance availability of ground water at specific place and time and utilize rain water for sustainable development.
  - ✓ To increase infiltration of rainwater in the subsoil which has decreased drastically in urban areas due to paving of open area?
  - ✓ To improve ground water quality by dilution.
  - ✓ To increase agriculture production.
  - ✓ To improve ecology of the area by increase in vegetation cover etc.

24. What are the Rain water harvesting initiatives?

- Efforts made in the direction of facilitating:-
  - ➢ Storage of rainwater on surface for future use.
  - ➢ Recharge to ground water

Urban Areas

Roof top rain water/storm runoff harvesting through

- Recharge Pit
- Recharge Trench
- Tube well
- Recharge Well

Rural Areas

Rain water harvesting through

- Gully Plug
- Contour Bund
- Gabion Structure
- Percolation tank
- Check Dam/Cement Plug/Nala Bund
- Recharge Shaft

- Dug well Recharge
- Ground water Dams/subsurface Dyke

25. What are the design considerations for an ideal artificial recharge structure?

- Any surface water body can contribute to groundwater recharge. However, quantum of recharge may become very insignificant when the bottom of the water body gets clogged due to siltation or when the water table is very deep. For this reason it is advisable to construct site specific structures suitable for accelerating groundwater recharge.
- The following criteria for construction of an artificial recharge structure are important.

  - The structure should be reasonably close to the source water to be used for recharge.
  - The quantity and quality of the source water should be of an acceptable level.
  - The structure should be constructed in such a way that it allows percolation of silt free water directly in to the aquifer.
  - The rate of percolation through the structure should be adequate to justify its construction.
  - The structure should preferably be constructed in areas where existing bore wells show a trend of falling water level.
  - The beneficiary communities are willing to take charge of the structure for regular maintenance.

26. Can abandoned dug wells be used for artificial groundwater recharge?

- An abandoned dug well can be used very conveniently as a makeshift artificial recharge structure.
- An abandoned dry dug well is just as good as a deep pit. When water from an external source is stored in a dry dug well, water starts percolating into the formation and contributes to recharge depending upon the permeability of the formation and depth to the water table.
- While using an abandoned dug well as a recharge structure certain precautions are necessary:

  - The abandoned dug well should be clean enough i.e. free from any dumping of undesirable materials like plastic, tree leaves, soil, bricks etc.
  - The water allowed to be stored in the dry well from an external source for recharge should be silt-free as far as possible.

27. Can ordinary farmers monitor groundwater recharge?

- Some educated farmers can become part geo-hydrologist after going through necessary orientation and training.
- The monitoring process would involve collecting rainfall data, measuring discharge from each well to obtain their cumulative extraction and measuring the depth of water table regularly throughout the year within an identified hydrological unit.
- The data collected can then be processed by more enlightened groups of farmers to assess annual recharge, extraction and groundwater balance available for crop production.
- The information can then be used by individual farmers to decide the type and acreage of crops to be grown in a given year based on water requirement of the selected crop(s) and groundwater balance available within the hydrological unit.

28. Who to be contacted for designing of recharge structures?

- The nearest Ground Water Department Office can be contacted for providing design of recharge structure.

29. Can RGWD provide any financial assistance for construction of recharge structures?

- The GWD does not provide any financial assistance for construction of Recharge Structures. The cost of construction has to be borne by the land owner.

30. Does RGWD also have trained masons etc. for construction of recharge structures?

- No, RGWD does not have any trained masons for construction of Recharge Structures. The general masons available in the market can easily take-up the work of construction of Recharge Structures as per design. No special masons are required for this purpose.

31. Which is the apex organization of the Ministry of Water Resources dealing with the ground related issues in India?

- Central Ground Water Board (CGWB) is the apex organization of the Ministry of Water Resources dealing with ground water and related issues.

32. What is the mandate of groundwater Department (GWD)?

- The Groundwater Department mandate :
  - Develop and disseminate technologies related to ground water.
  - Monitor sustainable development of ground water resources
  - Management of ground water resources,
  - Exploration, assessment, chemical quality analysis of ground water resources.
  - Conservation and artificial recharge of ground water resources.
  - IEC activities to develop awareness for conservation and management of ground water.
  - Active participation as a line department in preparation of IWRM plans (State Water Policy 2010).

33. What are the main activities of GWD?

- The main activities of GWD are :-
  - Ground Water Management Studies.
  - Artificial Recharge studies.
  - Ground Water Exploration.
  - Monitoring of Ground Water Observation Wells/Piezometers
  - Hydro-chemical Studies.
  - Geophysical studies.
  - Hydrological and Hydro-meteorological studies.
  - Data Storage and Retrieval.
  - Monitoring of Ground Water Development.
  - Periodic Assessment of Ground Water Resources.
  - Technical Documentation and Publication of Hydrogeological Atlases, Maps & Reports.
  - Organizing awareness Programs, Exhibitions, Seminars, and Work Shops etc.
  - Organizing Training of officers and staff of State Government organizations, institutes, NGO's, VO's etc.