SAFE (PERENNIAL, BASIN) YIELD

Safe yield: The safe yield of a ground water basin is the amount of water, which can be drawn annually without producing an undesired result.

Overdraft: Any draft in excess of safe yield is an overdraft. Overdraft area constitutes the largest ground water problem in the United States and in India as in parts of Hariyana and Punjab. Until this overdraft is reduced to safe yield in these basins, permanent damage or depletion of the ground water must be anticipated.

FACTORS GOVERNING SAFE YIELD The factors governing the safe yield are as follows-

Water supply: It should be apparent that the safe yield cann't exceed the long time annual mean water supply to the basin. Withdrawls exceeding these supplies must come from storage within the aquifer. This is often inferred as mining of ground water. There are certain cases in which recharge is many times more than the annual pumping of water. In this case more water can be discharged in any year. The water supply to a basin can be limited either by the physical size of the underground basin or by the rate at which water moves through the basin from the recharge area to withdrawl area.

Economics: Economic consideration may govern safe yield in basins where the cost a pumping ground water becomes excessive. Excessive pumping costs are generally in low ground water level areas or in the areas where aquifers are overlain by hard rocks.

Water quality: Safe yield can also be exceeded if draft on a basin produces a ground water of inferior quality. This inferior quality of water can be discharged in any of the cases like, pumping in coastal areas. Very deep pumping, which may produce connate water or intrusion of inferior water in pumping areas. Proper pumping of water can be helpful in maintaining safe yield.

Water rights: Legal considerations may limit safe yield if there is interference with prior water rights within a basin or in adjacent basins. Any legal restrictions on pumpage would have to be established before the safe yield could be determined.

COMPUTATION OF SAFE YIELD

----------In a confined aquifer safe yield can be defined in terms of gross annual pumpage. In unconfined aquifers safe yield can be defined as actual annual consumptive use of pumped ground water plus exported ground water. This is equivatent to gross annual pumpage minus return flow. Several methods have

been developed to compute safe yield where supply is general governing criterion.

Hill's method based on draft and change in ground water elevation: By this method the safe yield can be computed graphically. The average annual draft is plotted against average annual change in

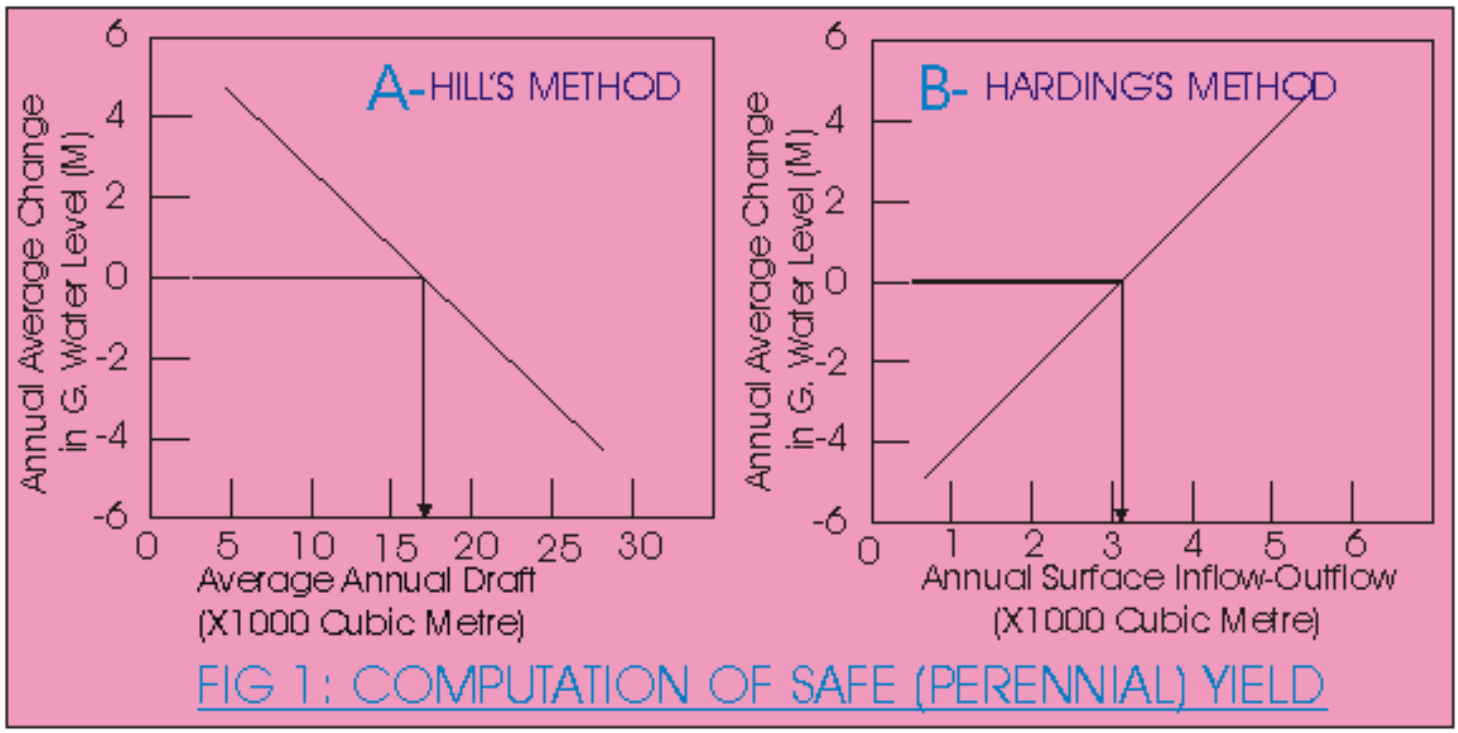

FIG 1: COMPUTATION OF SAFE (PERENNIAL) YIELD

ground water level. If the water supply to the basins is reasonably constant a straight line can fit the points. The draft corresponding to zero change in the elevation equals the safe yield. The method has the advantage that the draft during the entire period of record may be an overdraft, yet the prolongation of the fitted straight line defines the safe yield at the intercept of the zero change in elevation line (figure 1A).

Harding's method based on annual retained inflow and change in water table elevation: The annual retained inflow is the difference between total inflow and total outflow. Here also both the above mentioned quantities are plotted against each other and the point corresponding to zero change in water table elevation is the safe yield. An important limitation of this method is that they can only be applied to unconfined aquifers, where there is always a direct contact between aquifer and the surface (figure 1B).

Method based on **zero net ground water level fluctuation:** If the ground water elevation at the beginning and end of a period of time, amounting to at least several years is the same, the average annual net draft of the basin in a measure of the safe yield. The average annual supply should approximate the long time mean and the draft before and after the period should approach overdraft condition.

Method based on **Darcy 's law:** If the inflow into a basin is lateral and the direction is known the safe yield can be obtained from the average long time inflow by Darcy's law. The average hydraulic gradient, aquifer permeability and cross sectional area perpendicular to flow must be known. Ground water levels, pumping tests and geological data respectively, can determine these. The method is most advantageous for confined aquifers having unidirectional flows. In Geological Survey of India these methods are being applied since long.

Simpson method based on a pumping through in a coastal aquifer: Overdrafts in coastal aquifers

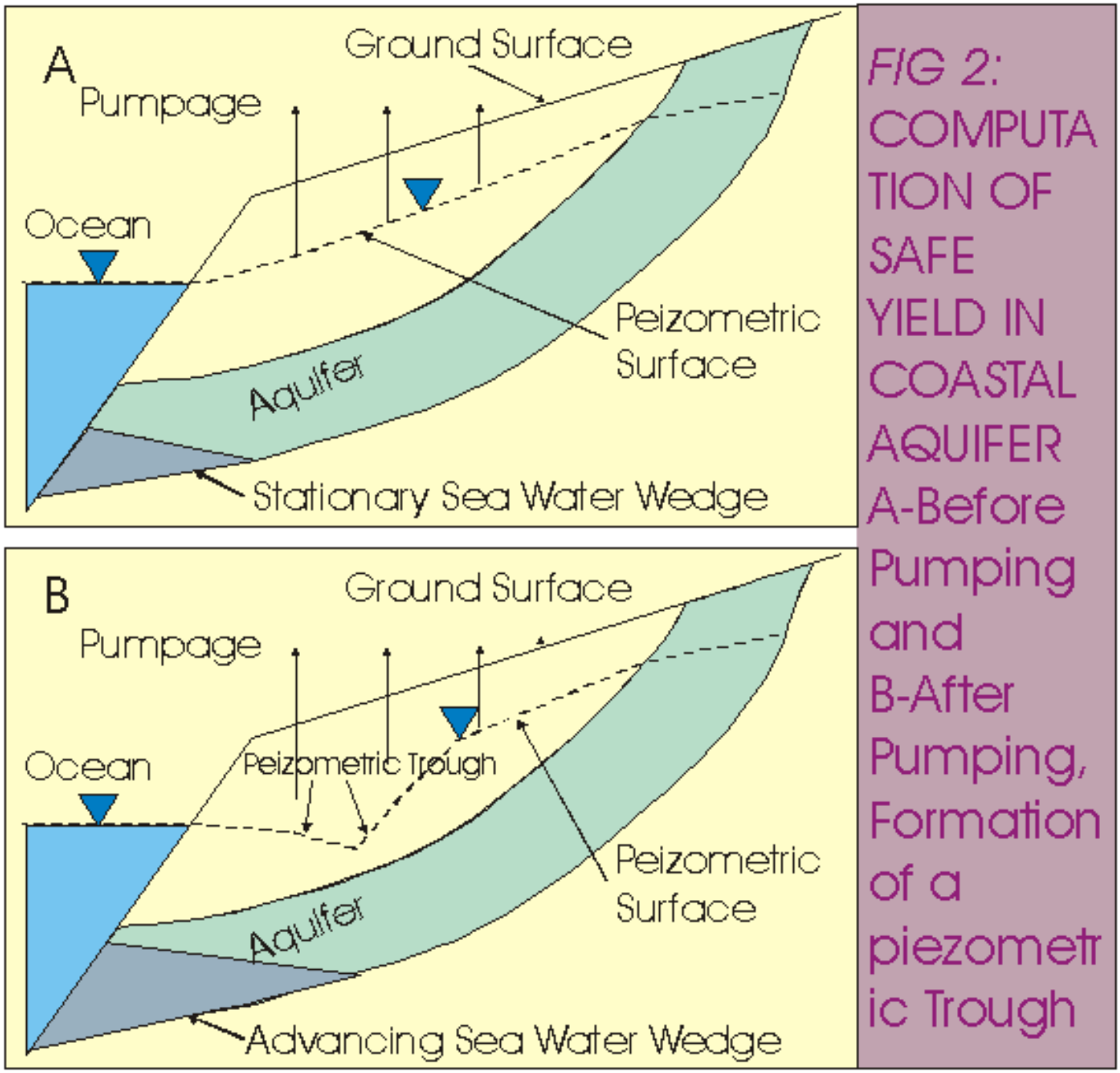

FIG 2: COMPUTATION OF SAFE YIELD IN COASTAL AQUIFER A-Before Pumping and B-After Pumping, Formation of a piezometric Trough

extending to the ocean lead to seawater intrusion when water table and peizometric levels fall below sea level. Simpson developed a method for computing safe yield during investigation of a river valley in California. Let us amume that a confined aquifer intersects the coast, as shown in figure 2A. When the basin draft equals safe yield the peizometric surface slopes down ward towards the ocean and a small amount of fresh water in wasted into the ocean in order to stabilize the position of the wedge of seawater. Uunder overdraft condition, however, the down valley flow is less than the draft causing the peizometric surface to fall. A pumping trough is formed (figure 2B). From the hydraulic gradients it is clear that draft on the seaward side of the trough comes from ground water moving inland from the sea. The latter action extends the seawater wedge further into the aquifer. Wells near the coast begin to pump highly saline water from the aquifer and must be abandoned. It follows that basin draft just prior to the appearance of the trough or immediately after its disappearance is the safe yield.

Method based on **specific yield and average annual rise** in water table: In unconfined aquifers the annual recharge can be expressed as the product of specific yield, annual rise in the water table and area of aquifer. Water table changes can be measured in observation wells and the aerial extent of an aquifer can be found from geological data. The average annual rise should approximate the long time mean.

HYDROLOGIC EQUILIBRIUM EQUATION:

[Surface inflow + subsurface inflow + precipitation + imported water + decrease in surface storage + decrease in ground water storage] = [Surface out flow +subsurface out flow + consumptive use + exported water + increase in surface storage + increase in ground water storage.]