TECHNICAL REPORT

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Artificial recharge to groundwater

Recharge artificielle des eaux souterraines

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Foreword

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 113, *Ground water*.

Introduction

Excessive extraction/use of ground water for various applications has resulted in marked lowering of ground water levels. Ground water levels are depleting very fast in various areas threatening ground water sustainability and causing adverse environmental impacts. Artificial recharge to ground water provides augmentation of ground water resources using surplus surface water available. Artificial recharge techniques can be applied to address the following issues:

a) enhance the sustainability of ground water resources in an area where over-development has depleted the aquifer;

b) conservation and storage of surplus water for future requirements;

c) improve the quality of existing ground water through dilution.

The following are basic requirements for recharging the ground water reservoir:

a) availability of surplus water of suitable quality in space and time;

b) suitable hydrogeological environment;

c) identification of sites for augmenting groundwater;

d) cost effective and appropriate artificial recharge techniques and structures.

Availability of source water of suitable quality is one of the prime requisites for ground water recharge. This can be assessed by analysing the water resources available as runoff and rainfall. The physical, chemical, and biological quality of the recharge water is important in planning and selection of recharge method. Age of water used for recharge is also considered important in certain cases.

The hydrogeological situation in each area needs to be appraised with a view to assess the recharge capabilities of the underlying geological formations. Detailed knowledge of geological and hydrological features of the area is necessary for proper selection of site and type of recharge structure. In particular, the input on geological boundaries, hydraulic boundaries, inflow and outflow of waters, storage capacity, porosity, hydraulic conductivity, transmissivity, natural discharge of springs, water resources available for recharge, natural recharge, water balance, lithology, depth of the aquifer, and tectonic boundaries features such as lineaments, shear zones, etc. are required for effective and efficient artificial recharge to ground water.

The aquifers best suited for artificial recharge are those that can hold large quantities of water and do not release them too quickly. The evaluation of the storage potential of sub-surface reservoirs (aquifers) is invariably based on the knowledge of dimensional data of permeable material in floodplain (alluvial), reservoir rock which includes their thickness and lateral extent. The availability of sub-surface storage space and its replenishment capacity further govern the extent of ground water recharge.

Artificial recharge techniques envisage integrating the surface water resources to ground water repositories resulting in changes in the ground water regime, like

a) rise in water level,

b) increment in the total volume of the ground water reservoir,

c) availability for extended period, and

d) quality of ground water.

The upper part of the unsaturated zone is not considered for recharging since it can cause adverse environmental impacts like water logging, soil salinity, dampness, etc.

Artificial recharge projects are site-specific and replication of the techniques even in similar areas is to be based on the local hydrogeological and hydrological environments. Artificial recharge to ground water is generally supported by the remote sensing studies, hydro-meteorological studies, hydrogeological studies, hydrological studies, soil infiltration testing, geophysical studies, hydro-chemical studies, etc. The studies bring out the potential of unsaturated zone in terms of total volume, which can be recharged.

Artificial recharge of ground water is normally undertaken in the following:

a) areas where ground water levels are continuously declining;

b) areas where substantial volume of aquifer has already been de-saturated;

c) areas where availability of ground water is inadequate in lean months;

d) areas where studies indicate scope for improvement of quality of ground water or areas where salinity ingress into fresh water aquifers has already taken place or is likely to happen in the near future.

Artificial recharge to groundwater

1 Scope

This Technical Report provides details of methods aimed at augmentation of ground water resources by modifying the natural movement of surface water as a general guide. This Technical Report does not cover the process of deciding and planning artificial recharge within an overall water resource management scheme.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 772, *Hydrometry — Vocabulary and symbols*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 772 apply.

4 Artificial recharge techniques

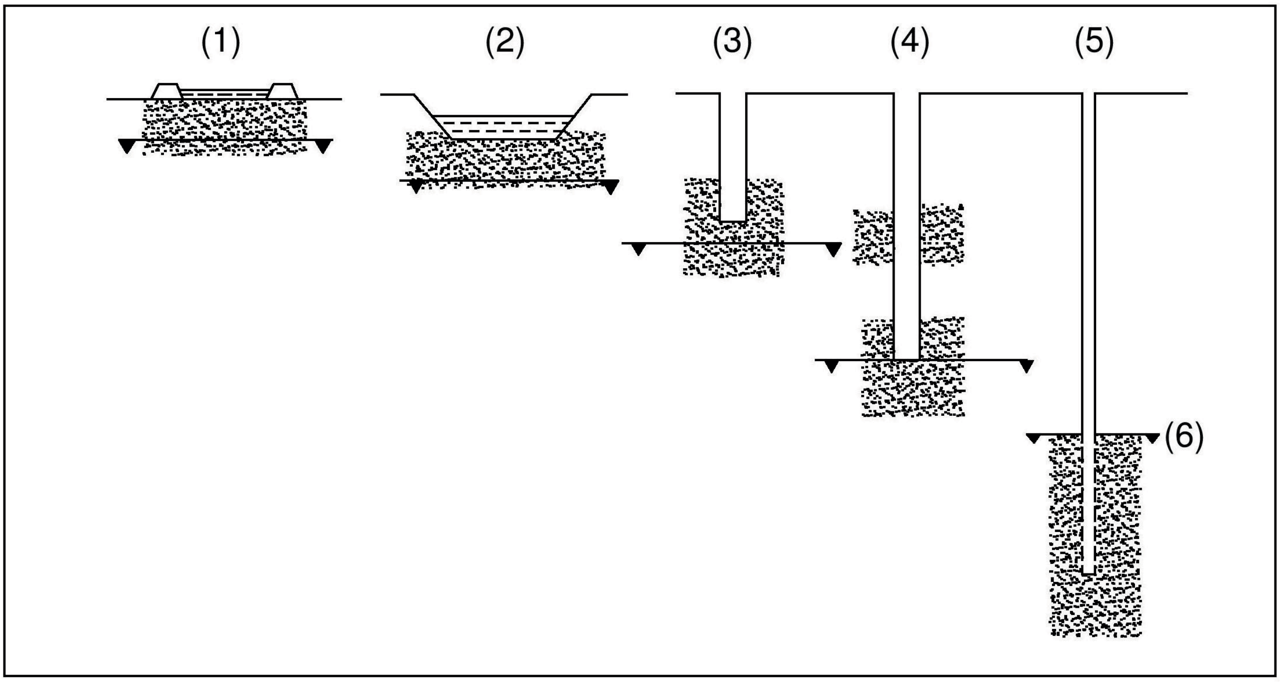
A wide spectrum of techniques are used to recharge ground water reservoirs. Artificial recharge techniques are broadly categorized as

a) surface spreading techniques,

b) sub-surface techniques, and

c) combination of surface and sub-surface techniques.

Aquifer disposition plays a decisive role in choosing the appropriate technique of artificial recharge of ground water as illustrated in Figure 1.



Key

1 and 2 surface spreading techniques

3, 4, and 5 sub-surface techniques

6 indication of water table/piezometeric head

NOTE Local regulations might exclude certain artificial recharge options, such as aquifer to aquifer interconnection, as shown in item 4.

Figure 1 — Recharge techniques for increasingly deep permeable materials.

4.1 Surface spreading techniques

These are aimed at increasing the contact area and residence time of surface water over the soil to enhance the infiltration and to augment the ground water storage in phreatic aquifers. The important considerations in the selection of sites for artificial recharge through surface spreading techniques include the following:

a) the aquifer being recharged should be unconfined, permeable, and sufficiently thick to provide storage space;

b) the surface soil should be permeable and have high infiltration rate;

c) vadose zone should be permeable and free from clay lenses;

d) ground water levels in the phreatic zone should be deep so as to accommodate the recharged water without water logging;

e) the aquifer material should have moderate hydraulic conductivity so that the recharged water is retained for sufficiently long periods in the aquifer and can be used when needed as natural repositories.

The most common surface spreading techniques used for artificial recharge to ground water are flooding, ditch and furrow, recharge basins, runoff conservation structures, and stream modifications.

4.1.1 Flooding

This technique is ideal for lands adjoining rivers or irrigation canals in which water levels remain deep even after monsoons and where sufficient non-committed surface water supplies are available. The schematics of a typical flooding system are shown in Figure 2. To ensure proper contact time and water spread, embankments are provided on two sides to guide the unutilized surface water to a return canal to carry the excess water to the stream or canal.

Flooding method helps reduce the evaporation losses from the surface water system, is the least expensive of all artificial recharge methods available, and has very low maintenance costs.

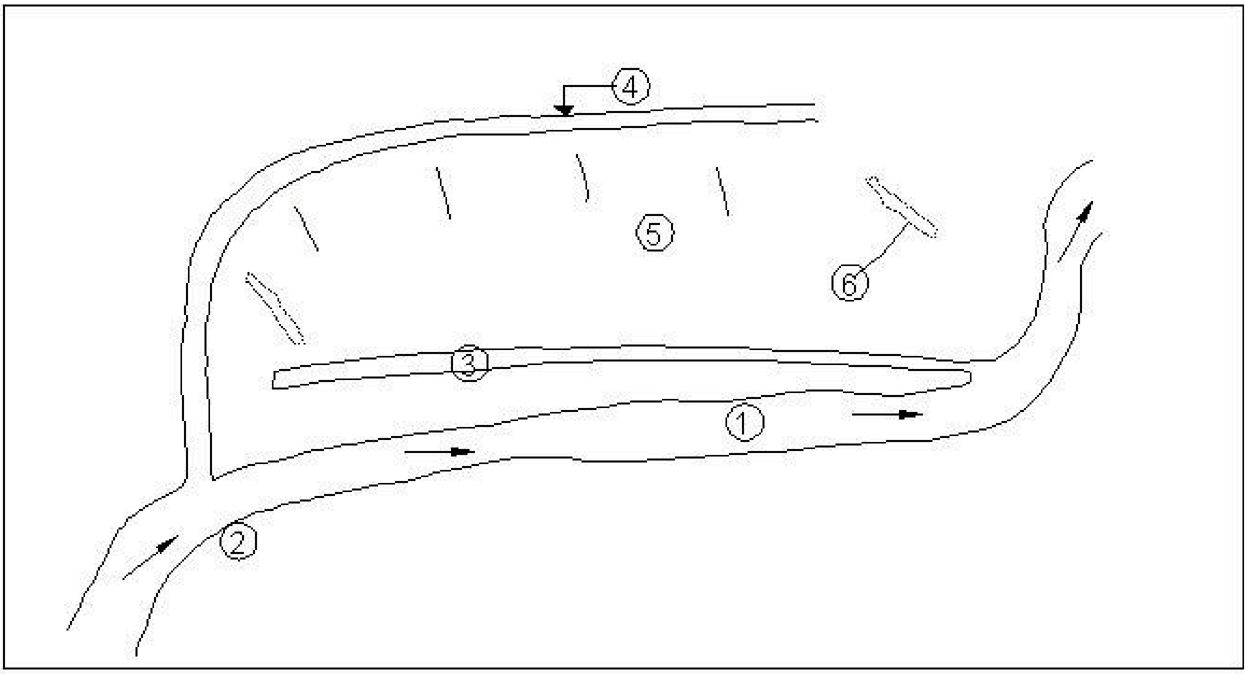
4.1.2 Ditch and furrows method

This method involves construction of shallow, flat-bottomed, and closely spaced ditches or furrows to provide maximum water contact area for recharge from source stream or canal. The ditches should have adequate slope to maintain flow velocity and minimum deposition of sediments. The widths of the ditches are typically in the range of 0,30 m to 1,80 m. A collecting channel to convey the excess water back to the source stream or canal should also be provided. Figure 3 shows a typical plan of a series of furrows originating from a supply ditch and trending down the topographic slope toward the stream. Though this technique involves less soil preparation when compared to recharge basins and is less sensitive to silting, the water contact area seldom exceeds 10 % of the total recharge area. Three common patterns *viz.* lateral ditch pattern, dendritic pattern, and contour pattern are detailed as follows and shown in Figure 4:

a) *Lateral ditch pattern*: the water from the stream is diverted to the feeder canal/ditch from which smaller ditches are taken out at right angles. The rate of flow of water from the feeder canal to these ditches is controlled by gate valves. The furrow depth is determined in accordance with the topography and to ensure that maximum wetted surface is available along with maintenance of uniform velocity. The excess water is routed to the main stream through a return canal along with the residual silt.

b) *Dendritic pattern*: water from the stream can be diverted from the main canal into a series of smaller ditches spread in a dendritic pattern. The bifurcation of ditches continues until practically all the water is infiltrated into the ground.

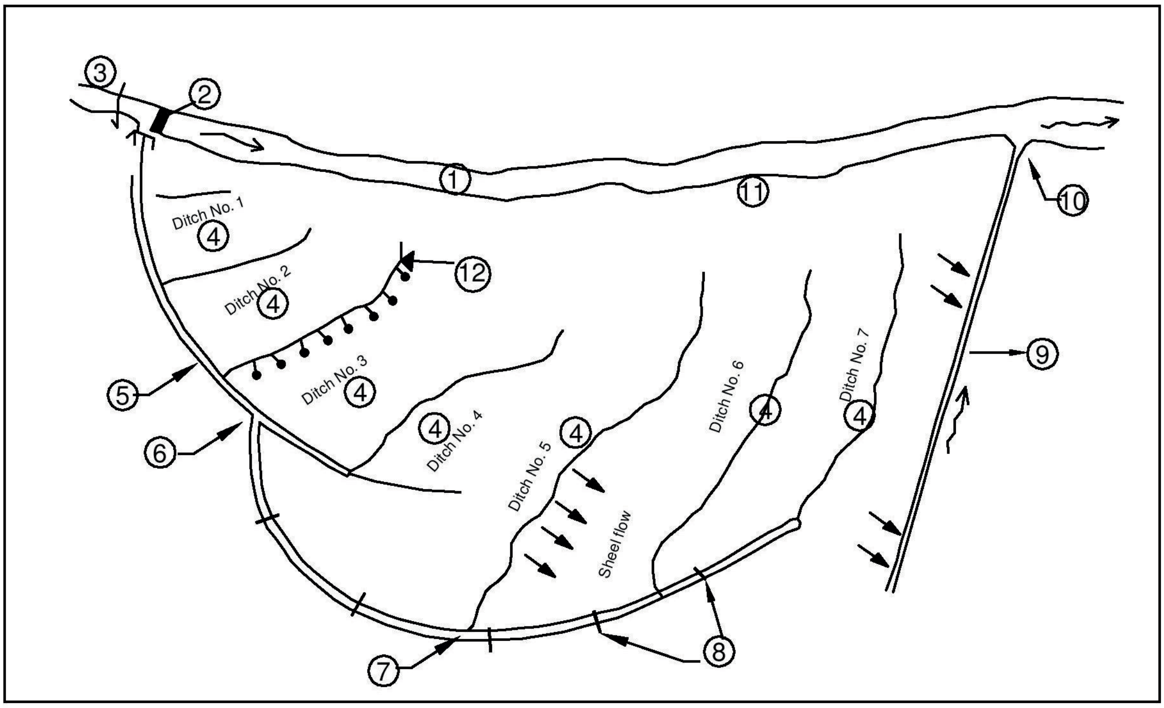
c) *Contour pattern*: ditches are excavated following the ground surface contour of the area. When a ditch comes close to the stream, a switch back is made to meander back and forth to traverse the spread repeatedly. At the lowest point downstream, the ditch joins the main stream, returning the excess water to it.



Key

1 stream
2 direction of flow
3 return flow
4 delivery canal
5 sheet flow
6 embankment

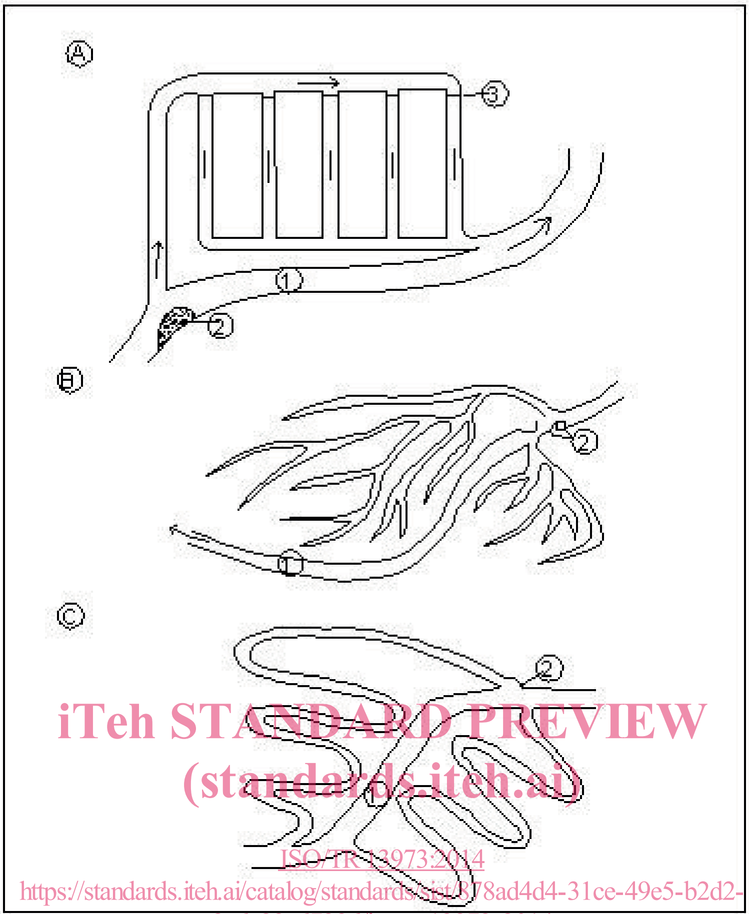
Figure 2 — Schematics of a typical flood recharge system



Key

1 stream
2 diversion structure
3 gate and measuring device
4 various recharge ditches
5 supply ditch
6 alternate diversion
7 supply ditch
8 wire bound check dam
9 collecting ditch
10 measuring device
11 prevailing ground slope
12 ditch

Figure 3 — Schematics of a typical ditch and furrows recharge system



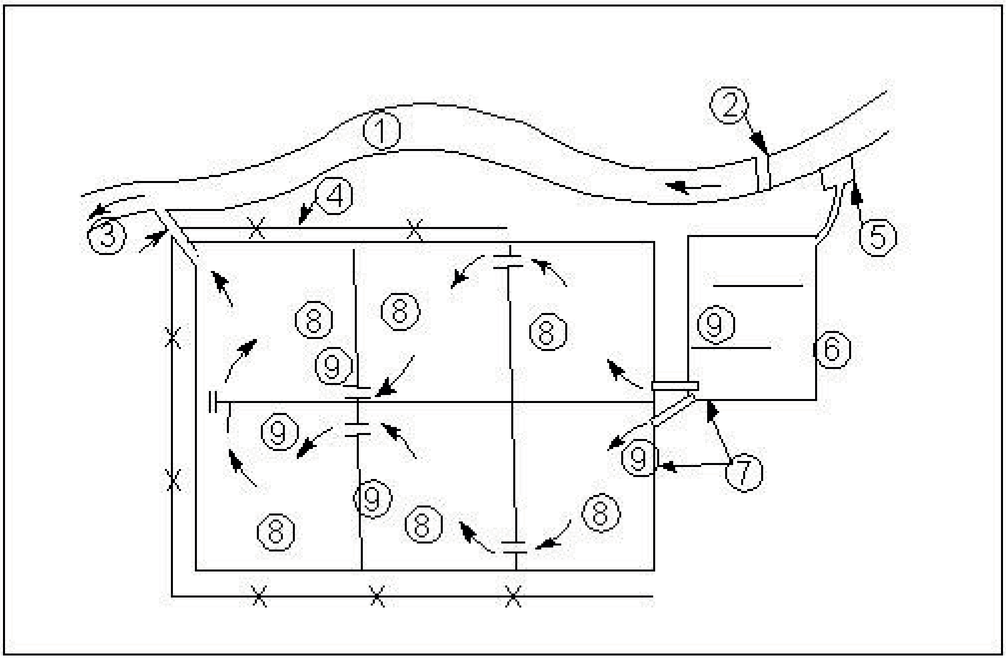
Key

1 stream
2 diversion structure
3 control ditch
A lateral ditch pattern
B dendritic ditch pattern
C contour ditch pattern

Figure 4 — Common patterns of ditch and furrow recharge systems

4.1.3 Recharge basins

Artificially recharged basins are commonly constructed parallel to ephemeral or intermittent stream channels and are either excavated or are enclosed by dykes and levees. They can also be constructed parallel to canals or surface water sources. In alluvial areas, multiple recharge basins can be constructed parallel to the streams (see Figure 5), with a view to increase the water contact time, reduce suspended material as water flows from one basin to another, and to facilitate periodic maintenance such as scraping of silt, etc. to restore the infiltration rates by bypassing the basin under restoration.



Key

1 stream

2 diversion structure

3 cut fall

4 fence as required

5 intake structure

6 sediment retention basin

7 main entrance road on levees as required

8 recharge basin

9 interbasin control structure

Figure 5 — Schematics of a typical recharge basin

In addition to the general design guidelines mentioned, other factors to be considered while constructing recharge basins include the following:

a) area selected for recharge should have gentle ground slope;

b) the entry and exit points for water should be diagonally opposite to facilitate adequate water circulation in individual basins;

c) water released into the basins should be as sediment-free as possible;

d) rate of inflow into the basin should be slightly more than the infiltration capacity of all the basins.

The water contact area in recharge basin is normally high and may range from 75 % to 90 % of the total recharge area. It is also possible to make efficient use of space by making basins of different shapes to suit the terrain conditions and available space.

4.1.4 Runoff conservation structures

These are normally multi-purpose measures, mutually complementary, and conducive to soil and water conservation, afforestation, and increased agricultural productivity. They are suitable in areas

