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Managed Aquifer Recharge (MAR)

Introduction and methods

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Objectives

At the end of this lecture, you will be able to answer

- What is Managed Aquifer Recharge (MAR)?
- Why do we need MAR?
- What are the various MAR methods?

References

- Dillon, P., et al. (2010) Managed Aquifer Recharge: rediscovering nature as a leading edge technology. Water science and technology, 62(10), 2338-2345. doi: 10.2166/wst.2010.444
- Managed Aquifer Recharge – An introduction
- Management of Aquifer Recharge and Subsurface Storage
- Strategies for MAR in semi-arid areas
- Managed Aquifer Recharge: Overview and Governance
- IGRAC (2007). Artificial Recharge of Groundwater in the World
- Australian guidelines on MAR implementation
- Indian manual on artificial groundwater recharge

What is Managed Aquifer Recharge?

- Managed aquifer recharge (MAR) is the purposeful recharge of water to aquifers for subsequent recovery or environmental benefit
- Aquifers are naturally replenished through two main processes:
  - **Rainwater Percolation:** Rainwater soaks through soil and rock, eventually reaching the aquifer.
  - **Stream Infiltration:** Water from streams seeps into the ground, recharging the aquifer.
- Includes nature-inspired solutions
- Chief characteristic is moving from centralised and conventional surface storage to decentralised storage in the sub-surface.

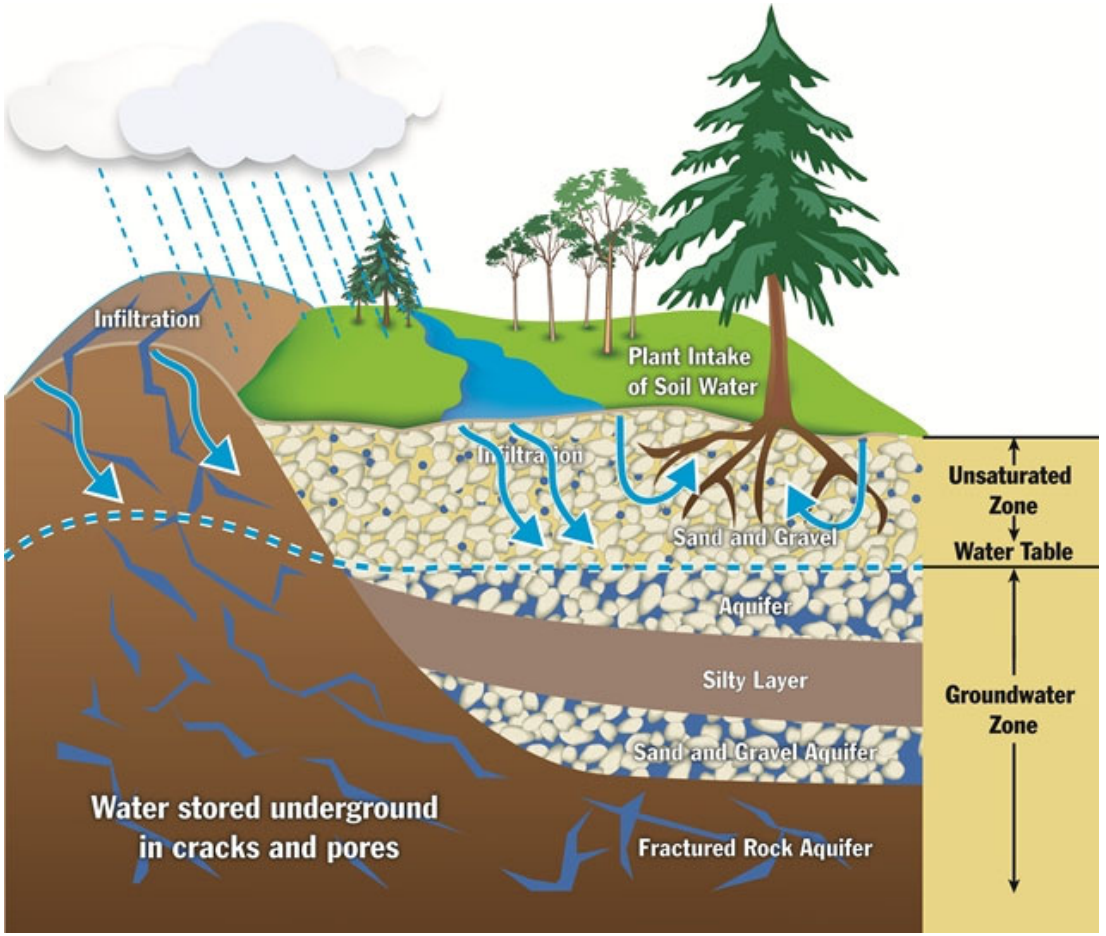


Image Credit: Govt. of Newfoundland and Labrador

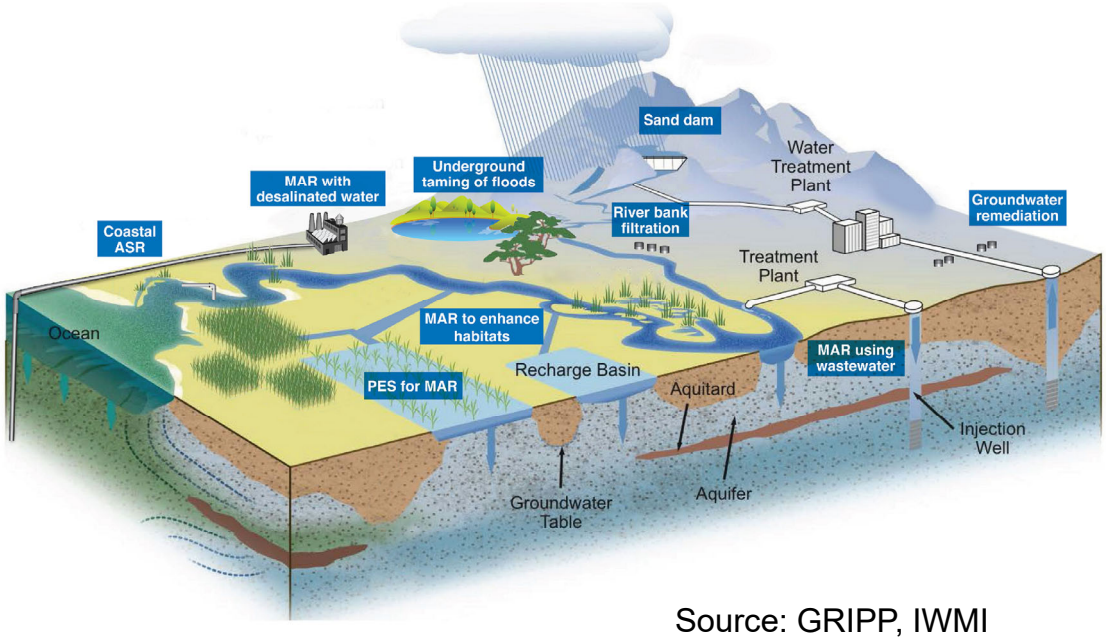
Increasing Aquifer Recharge

- Human activities that enhance aquifer recharge fall into three categories:
  - **Unintentional Recharge:**
    - Clearing of deep-rooted vegetation
    - Deep seepage under irrigation areas
    - Leaks from water pipes and sewers
  - **Unmanaged Recharge:**
    - Stormwater drainage wells and sumps
    - Septic tank leach fields
    - Typically used for disposing of unwanted water without considering reuse.
  - **Managed Recharge:**
    - Spreading methods
    - Injection wells
    - Infiltration basins and galleries
    - Utilized for various water sources including rainwater, stormwater, reclaimed water, mains water, and water from other aquifers
    - These methods ensure water is recovered for all types of uses

MAR methods

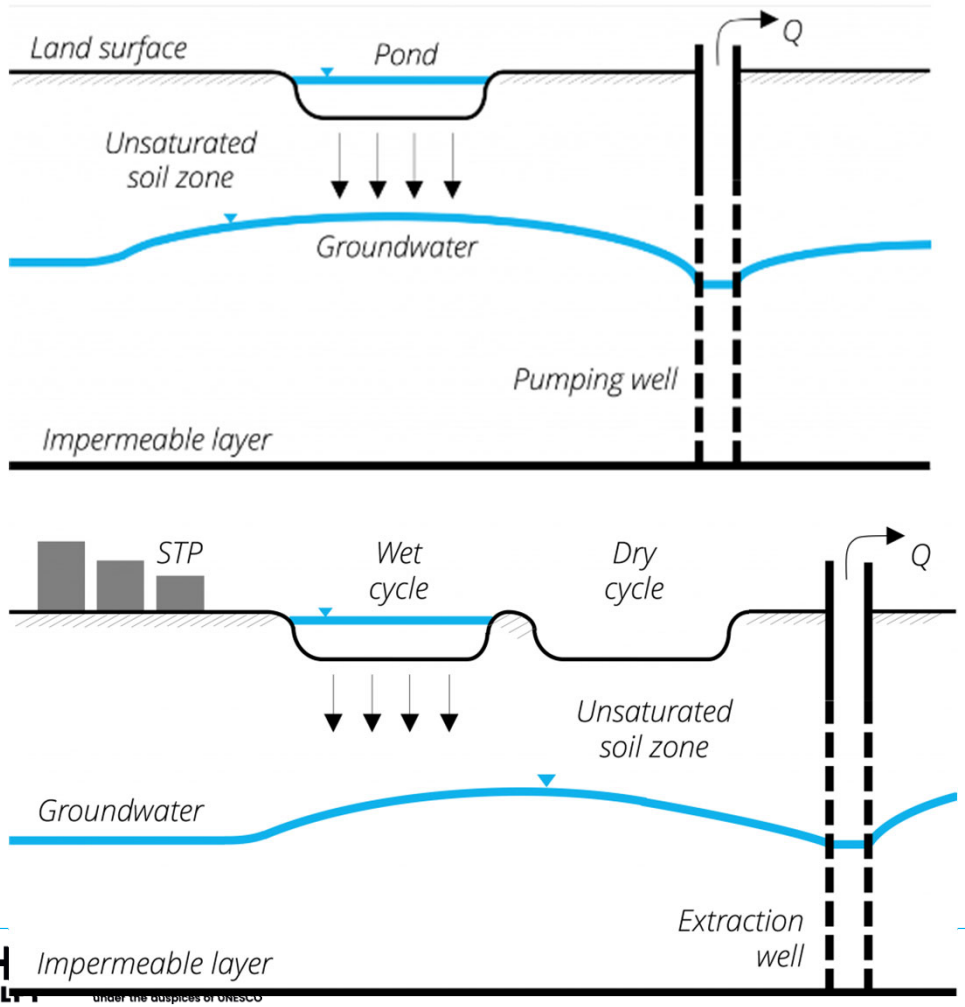
- Classification: 5 types and 15 sub-types (after IGRAC, 2007)

Water infiltration techniques	Spreading methods	Infiltration ponds
		Flooding
		Diches, furrows, drains
		Excess irrigation
	Induced bank infiltration	River/lake bank filtration
		Dune filtration
	Well, shaft and borehole recharge	Deep well injection (ASR, ASTR)
		Shallow well/shaft/pit infiltration
Water intercepting techniques	In-channel modifications	Recharge dams
		Sub-surface dams
		Sand dams
		Channel spreading
	Runoff harvesting	Rainwater harvesting
		Barriers and bunds
		Trenches



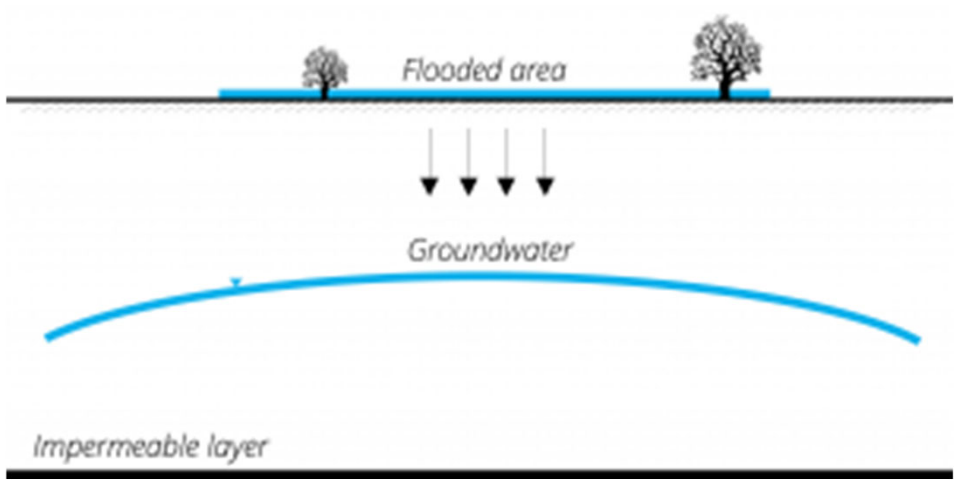
Source: GRIPP, IWMI

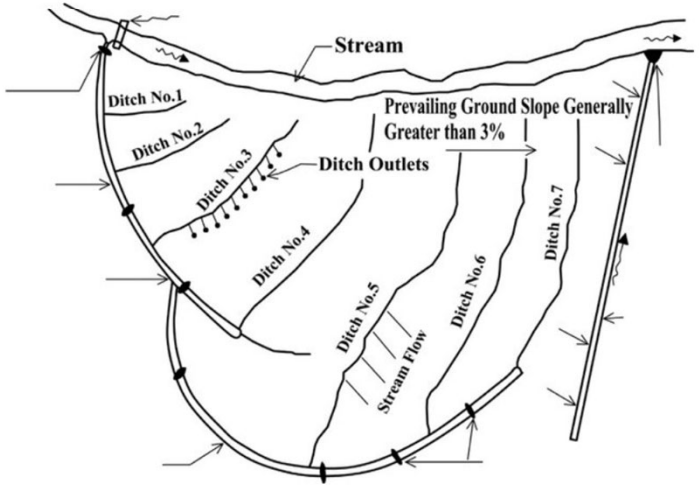
Spreading methods



- Enhance gravitational infiltration and percolation of water to unconfined aquifers
- **Surface spreading** – most applied MAR method
- Infiltration ponds is the common method for the retention and spreading of water
- **Soil aquifer treatment (SAT)** - quality of the feed water (stormwater or wastewater treatment plant effluent) is further improved during soil passage

Spreading methods

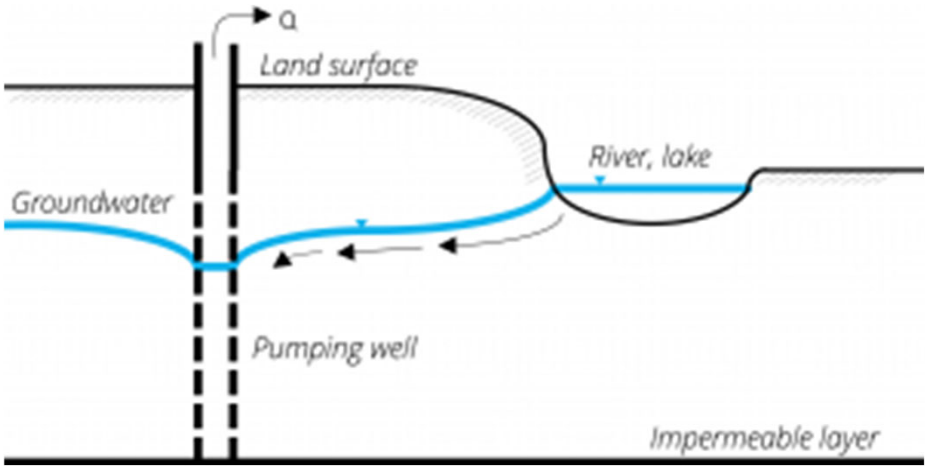


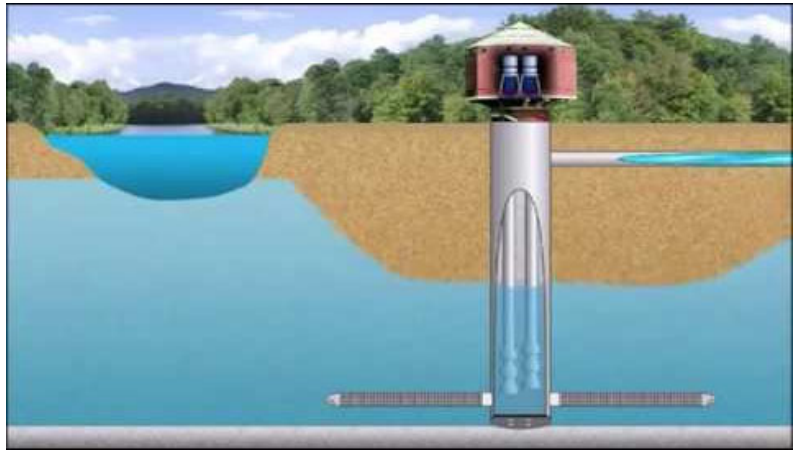


Patel & Shah, 2008

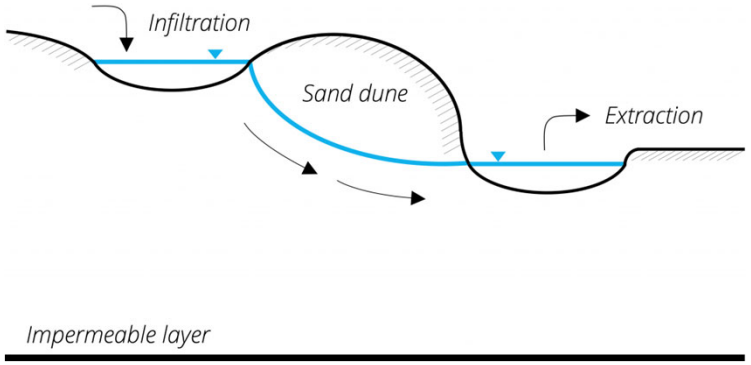
- **Flooding-** use of excess river flows during high flow season or to manage floods
- Passive infiltration through spreading and recharging of flood water/ excess runoff
- **Ditches, furrows and drains** – point or linear structures that allow slow infiltration of water
- Works also on irregular terrain
- **Excess irrigation** - excess water spread over agricultural land either during non-irrigated seasons
- Good use of the land area during non-use periods

Induced bank infiltration

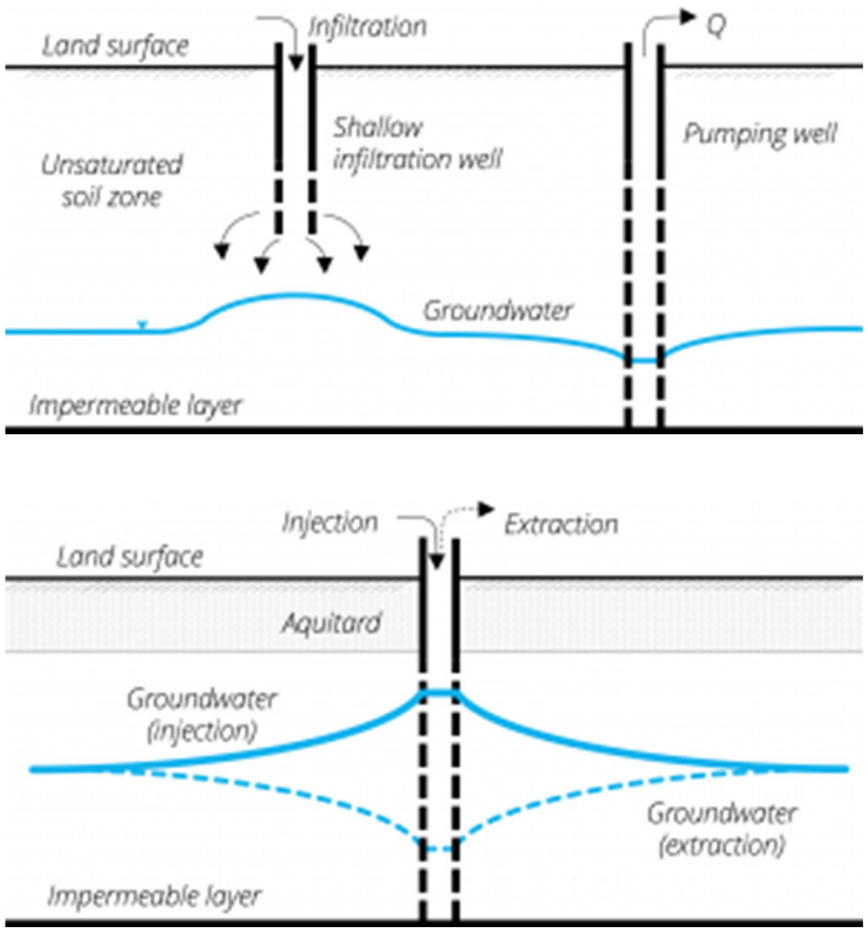




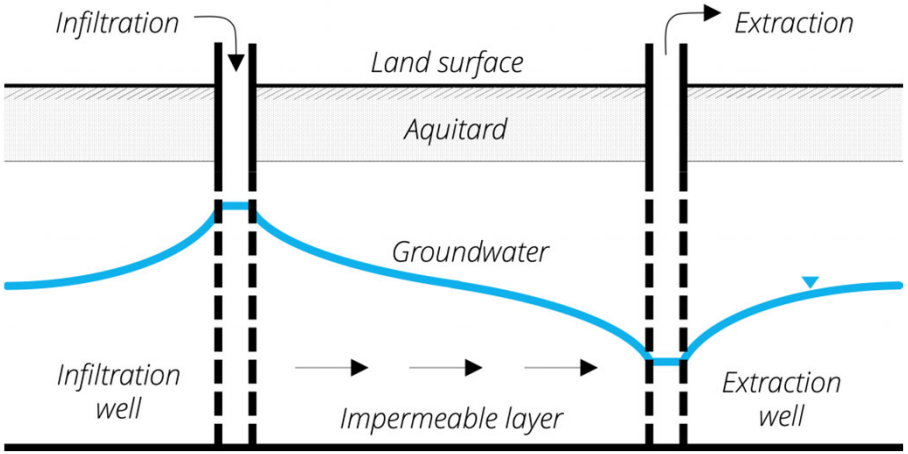
- Surface water is induced to infiltrate from a river or lake
- Pumping is carried out through well galleries or a number of wells constructed parallel to the river/ lake banks
- Extracting groundwater will induce more water to infiltrate to the aquifer
- Also serves as a treatment process improving the quality of the infiltered water



Well, shaft and borehole recharge

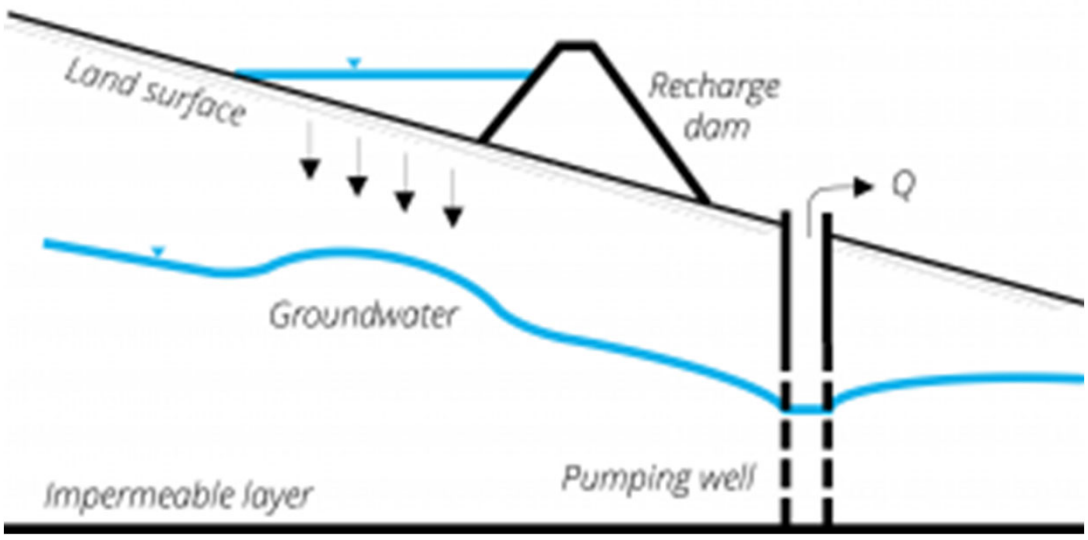


- Gravitational recharge through shallow or deep structures such as wells, shafts, boreholes or pits.
- **Deep well injection**:
  - Aquifer Storage & Recovery (ASR)
  - Aquifer Storage, Treatment & Recovery (ASTR)
- **Shallow infiltration**: wells/ shafts/ pits



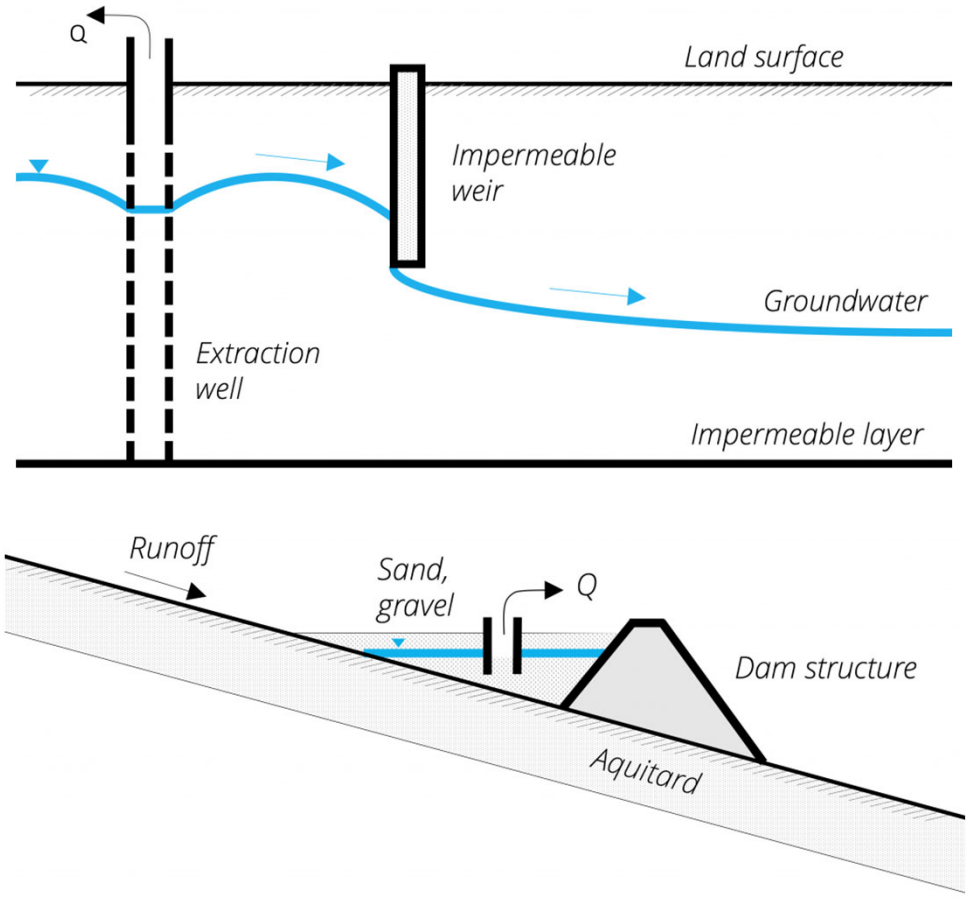
In-channel modifications

- Structures built in drainage channels that intercept or delay run-off
- Mainly built in intermittent or ephemeral streams with distinct monsoon periods



- **Recharge dams** are impermeable structures built in stream channels to store runoff water by creating surface reservoirs.
- These dams enhance groundwater recharge by allowing water to infiltrate the ground behind the dam
- Alternatively, they can control water release to promote downstream infiltration through the riverbed
- Little interference with other land use
- Storage of flash floods

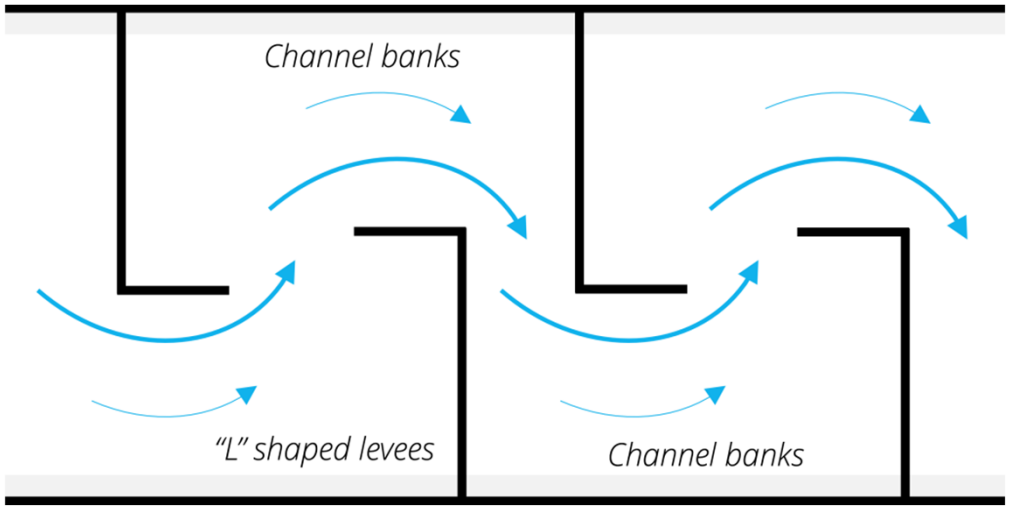
In-channel modifications



- **Subsurface dams** are underground barriers with low permeability designed to store water and elevate the groundwater table by reducing lateral flow
- An impervious or low-permeability wall is built within the trench, which is then filled with the excavated material

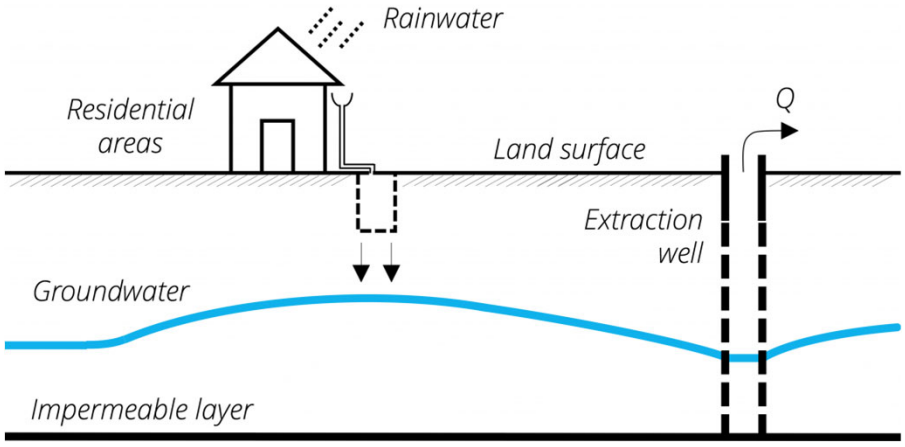
- **Sand dams** are impounding structures constructed above ground within intermittent river channels
- This creates an artificial aquifer upstream of the dam that can store the storm water runoff
- Increases water availability during dry seasons, prevents water evaporation, and protects water from contamination

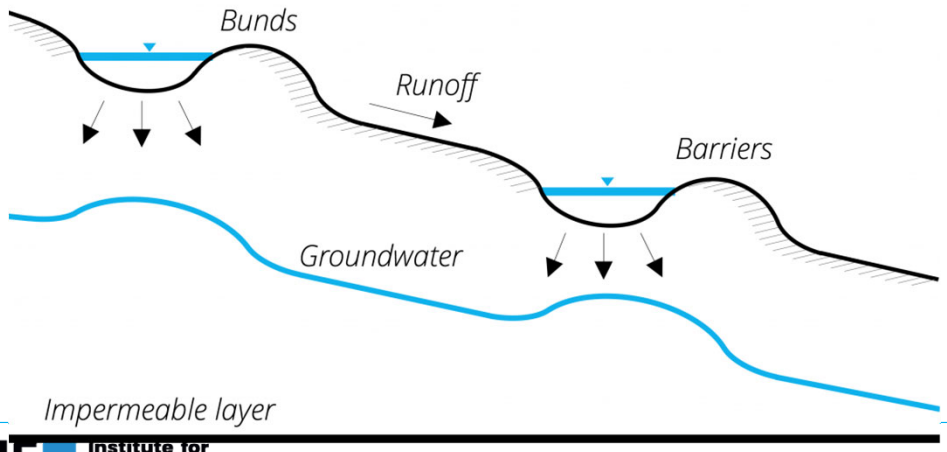
In-channel modifications



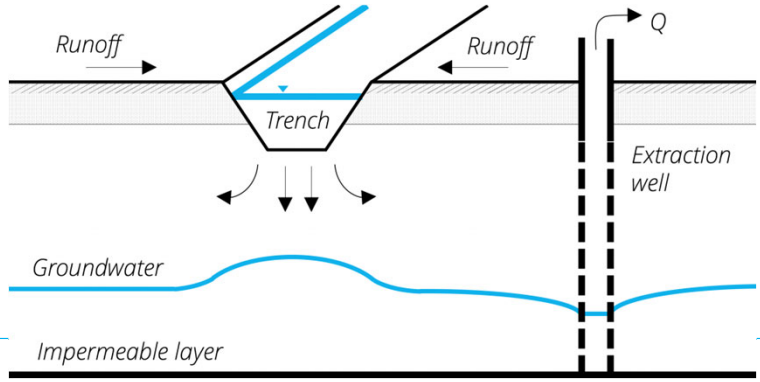
- The area of a drainage structure is increased to enhance the time for recharge
- This is done by widening, levelling or dredging
- 'L-shaped' levees may also be installed
- Low costs technique.
- Simple design, operation and maintenance.

Runoff harvesting





- **Rainwater harvesting**: roof runoff is diverted into a well, sump or caisson filled with sand or gravel and allowed to percolate to the water-table where it is collected by pumping from a well
- As urban areas are characterized by sealed surfaces, harvesting and recharge can help to sustain groundwater levels
- **Barriers and bunds** obstruct surface runoff from catchments and prohibit flow of the water to be infiltrated
- They can also be used in combination with **trenches**



https://www.inowas.com/mar/

MAR purposes

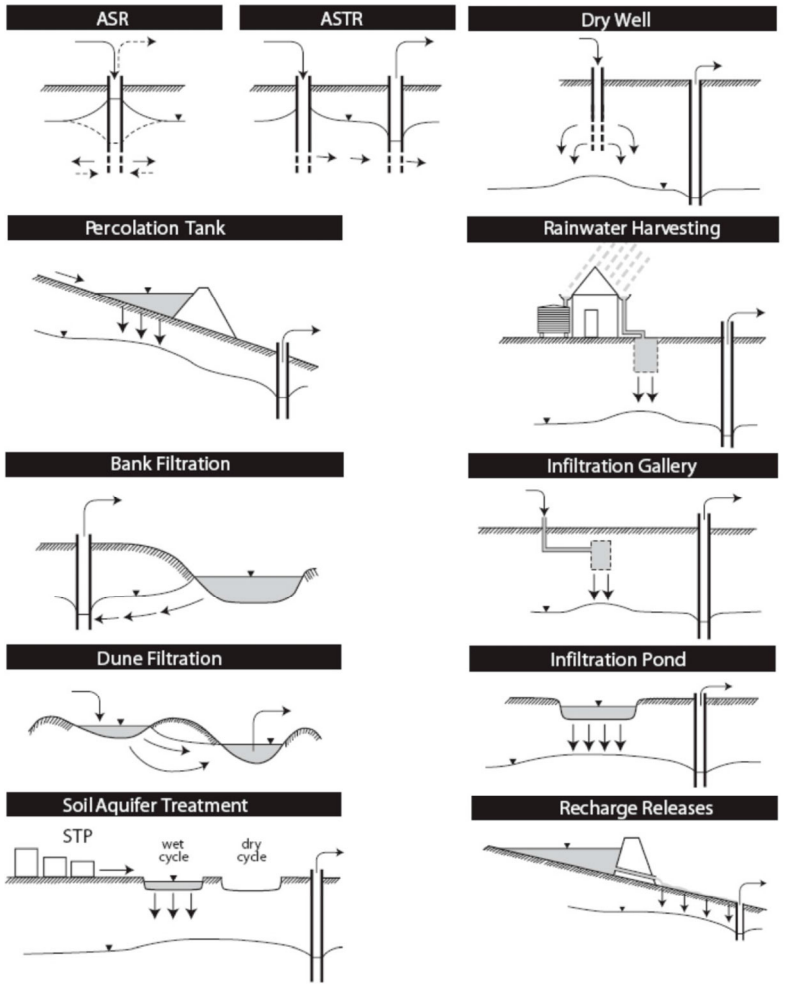
- Managing water supply
- Meeting legal obligations
- Restoring/protecting aquifers
- Maintaining minimum flows and levels
- Flood mitigation
- Water quality enhancement and protection
- Water reuse
- Ecosystem restoration and protection


Source: Central Arizona Project


Source: LOFTUS (2011)

Summary

- **Define MAR**: Understand it as a method to intentionally recharge aquifers for sustainable water resource management.
- **Recognize its Importance**: Learn why MAR is essential for addressing over-extraction, water quality issues, and climate resilience.
- **Identify MAR Methods**: Explore key approaches like recharge basins, percolation tanks, injection wells, and check dams.



Source: Dillon (2005)

Aerial view of Upo Wetland near Changnyeong-gun, Korea.

Thank you

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