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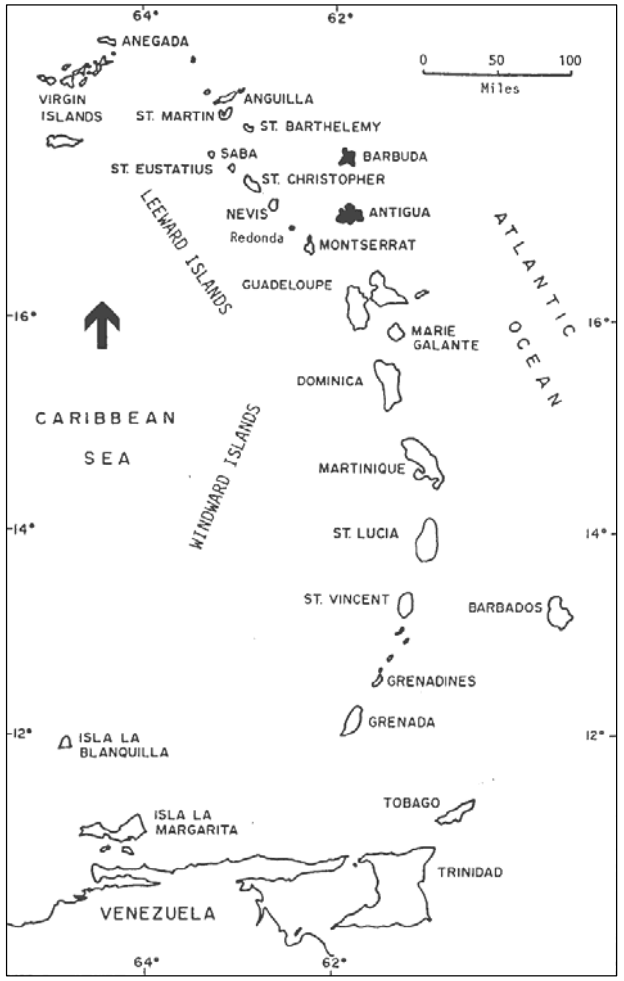
CARICOM

Managed Aquifer Recharge (MAR)

Practical Techniques for the Caribbean



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Scope of Presentation

- What is MAR?
- Antigua and Barbuda water resources issues
- Why promote MAR?
- MAR: Techniques
- MAR: Design criteria and considerations
- MAR: Strategy guidance

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What is MAR?

- Managed Aquifer Recharge
  - *'is the intentional diversion of surface water to the groundwater reservoir by modifying, through a variety of techniques, the natural movement of surface water' (UNESCO-IHP, 2005).*
  - Previously known as 'artificial recharge'
  - MAR is a useful mechanism in sustainable integrated water resources management.
    - Store freshwater for water supply underground, in aquifers
    - Restore ground water levels
    - Address water quality issues

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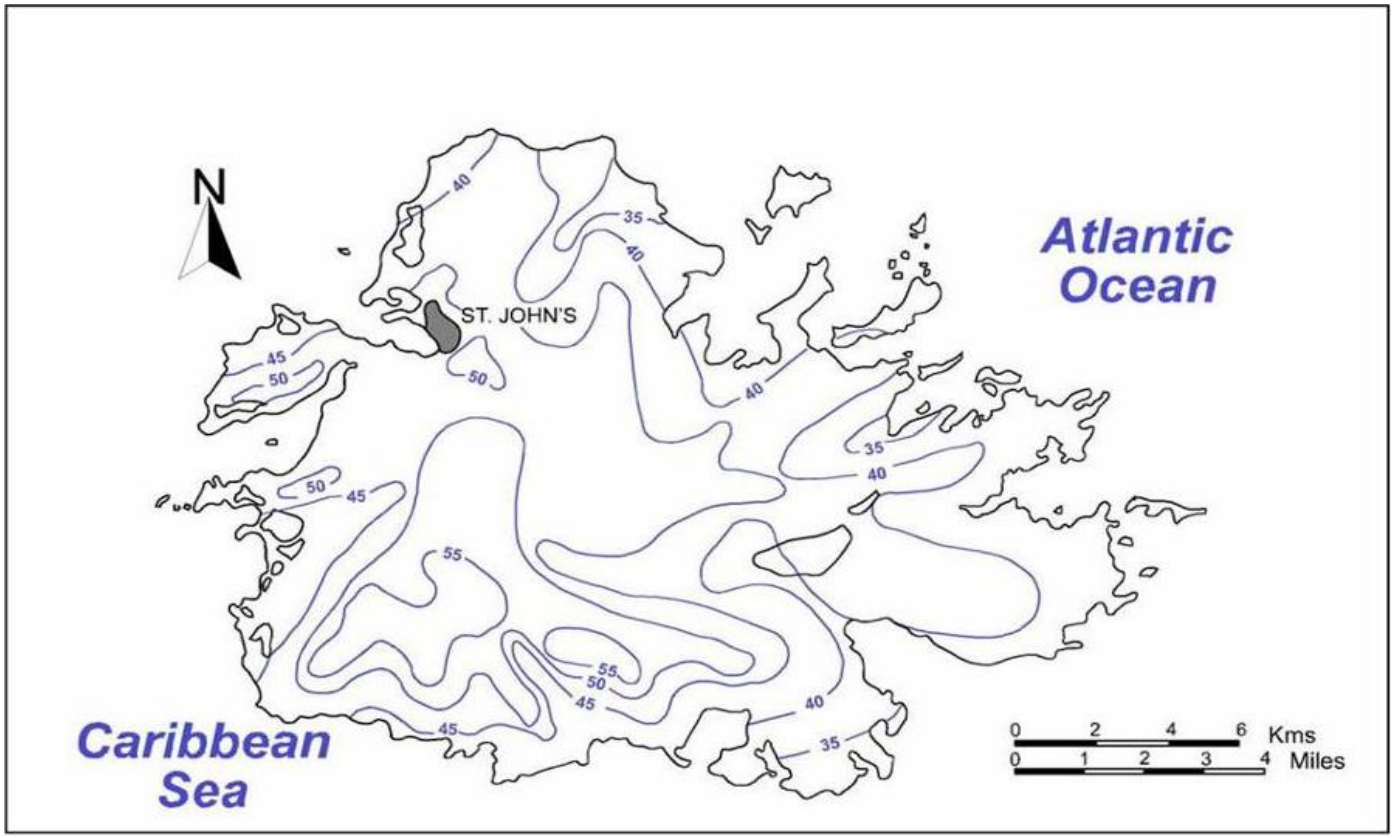
Antigua & Barbuda water resources issues

- High seasonal and interannual rainfall variability

Isohyetal distribution of rainfall in Antigua, *in inches.*

Source: Cooper and Bowen, 2001.



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Antigua & Barbuda water resources issues

- Antigua and Barbuda are prone to droughts and storms.
  - Less than 10% of annual rainfall falls in the dry season: January to April.
  - Hurricanes can produce 250-750mm of rain in a few days
  - The unreliability and variability in climate is predicted to worsen (Office of the Prime Minister, 2001)

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Antigua & Barbuda water resources issues

- Water Demand
  - Antigua and Barbuda has a combined population of 84,000
  - Tourism requires reliable water supply!!

Antigua & Barbuda water resources issues

- Water supply
  - Surface water reservoirs: Potworks reservoir is contaminated and has high evaporation rates
  - 50 active well fields (coastal aquifers affected by salt water intrusion)
  - 2 Desalination systems (table below describes the over-reliance on desalination)

Rainwater harvesting is an important source of safe drinking water at the household scale

Source	Dry season %	Wet season %
Surface water	5	25
Groundwater	20	15
Desalination	75	60

(After USACE, 2004)

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Antigua & Barbuda water resources issues

- Sanitation
  - Poor sanitation is a particular problem in St John's
  - Some properties discharge untreated effluent
  - The majority use septic tanks which vary in efficiency
  - Groundwater quality is affected

Why promote MAR?

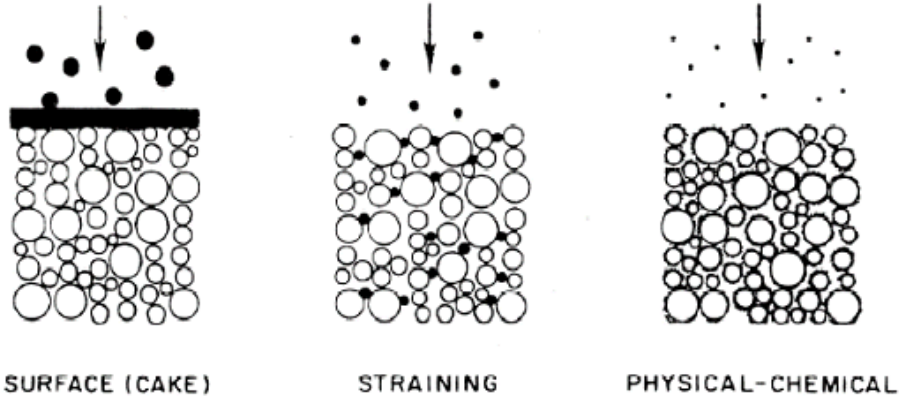
- The ability to store freshwater for later use
- Balancing out supply and demand fluctuations
- Stabilising or raising groundwater levels where currently over-exploited
- Freshening of brackish groundwater
- Reducing losses to evaporation and runoff
- Improving Groundwater quality
- An appropriate simple technology
- A reduced footprint to surface water storage
- Flood benefit: control of surface runoff
- Environmental benefit: control of land degradation and desertification and reduction in turbidity of surface water

Why promote MAR?

- However:
  - MAR is not always applicable
  - Poor water quality creates 'clogging' of systems →
  - Potential contamination of groundwater
  - Maintenance
  - Larger scale schemes require detailed investigation

Physical 'clogging' caused by suspended sediments

clogging is often the major limiting factor to recharge



...Biological and chemical process also cause clogging

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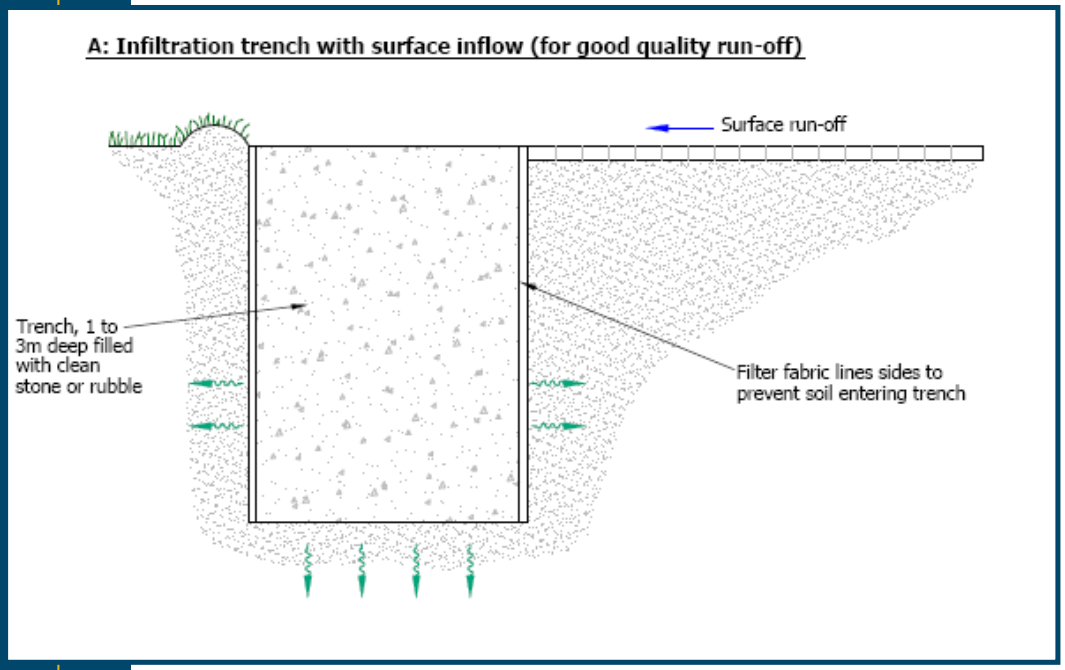
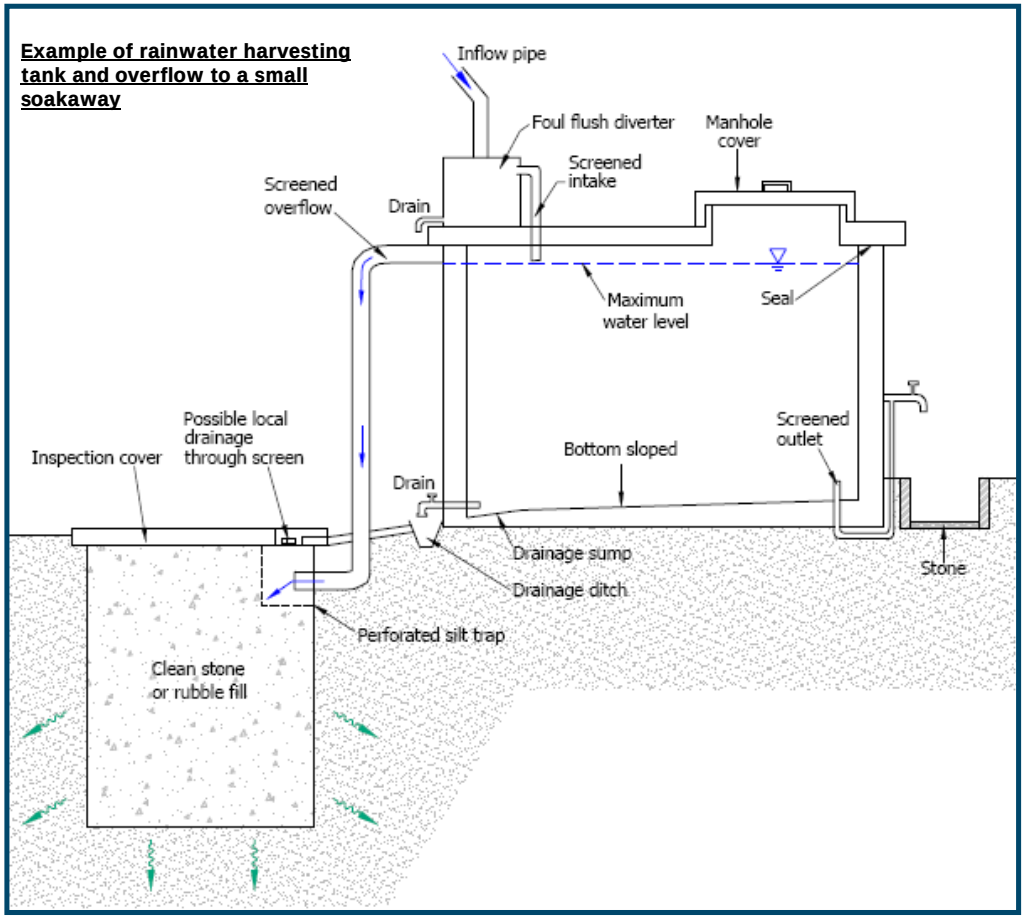
MAR: Techniques

- Main groups:
  - Infiltration techniques
  - Direct recharge
  - Channel modification (infiltration)
  - Catchment management
  - Indirect recharge
    - Over-irrigation
    - Leaking supply pipes
    - Sewage disposal via septic tank

MAR: Techniques
Infiltration techniques

Soakaway/trench





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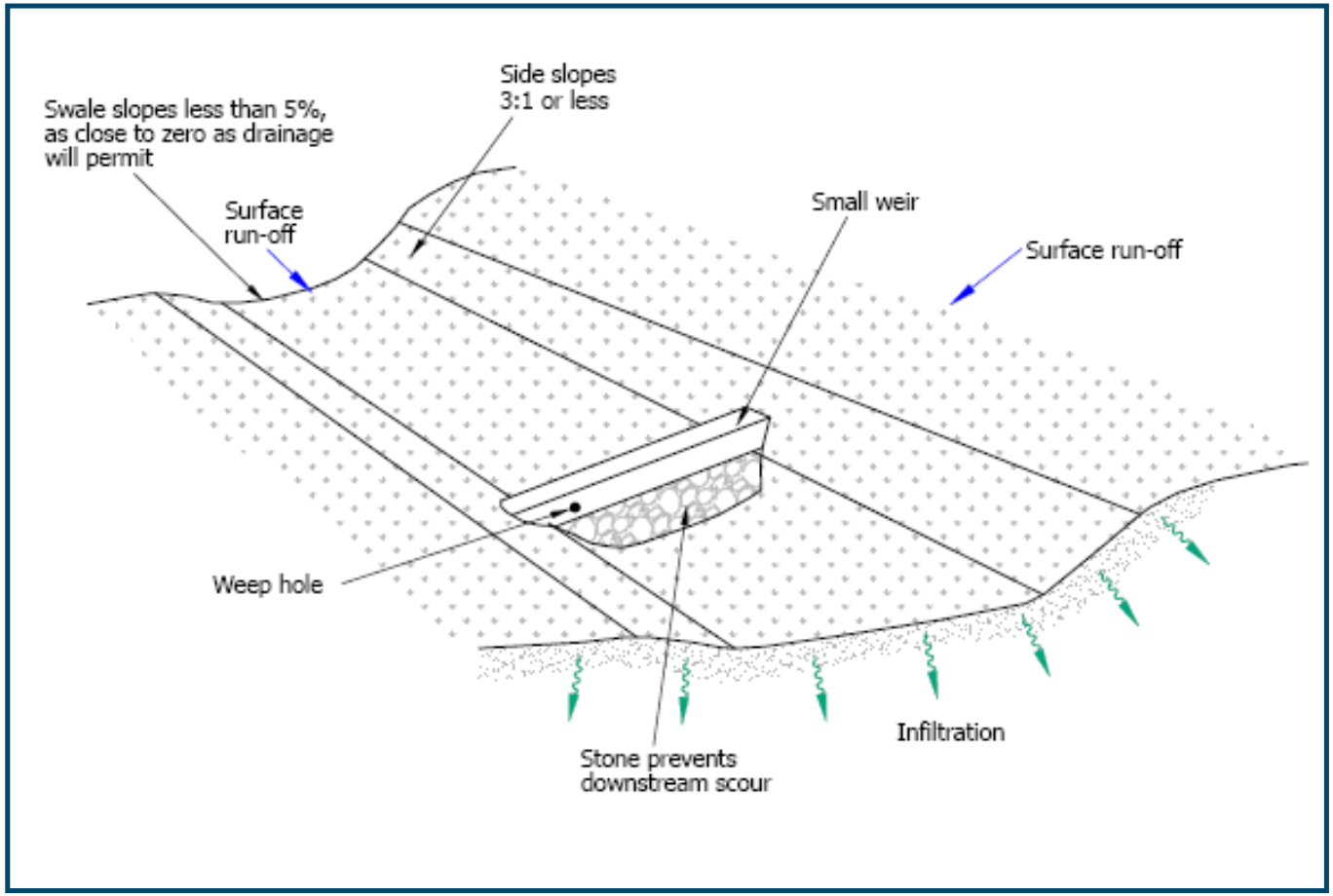
MAR: Techniques
Infiltration techniques

Swale



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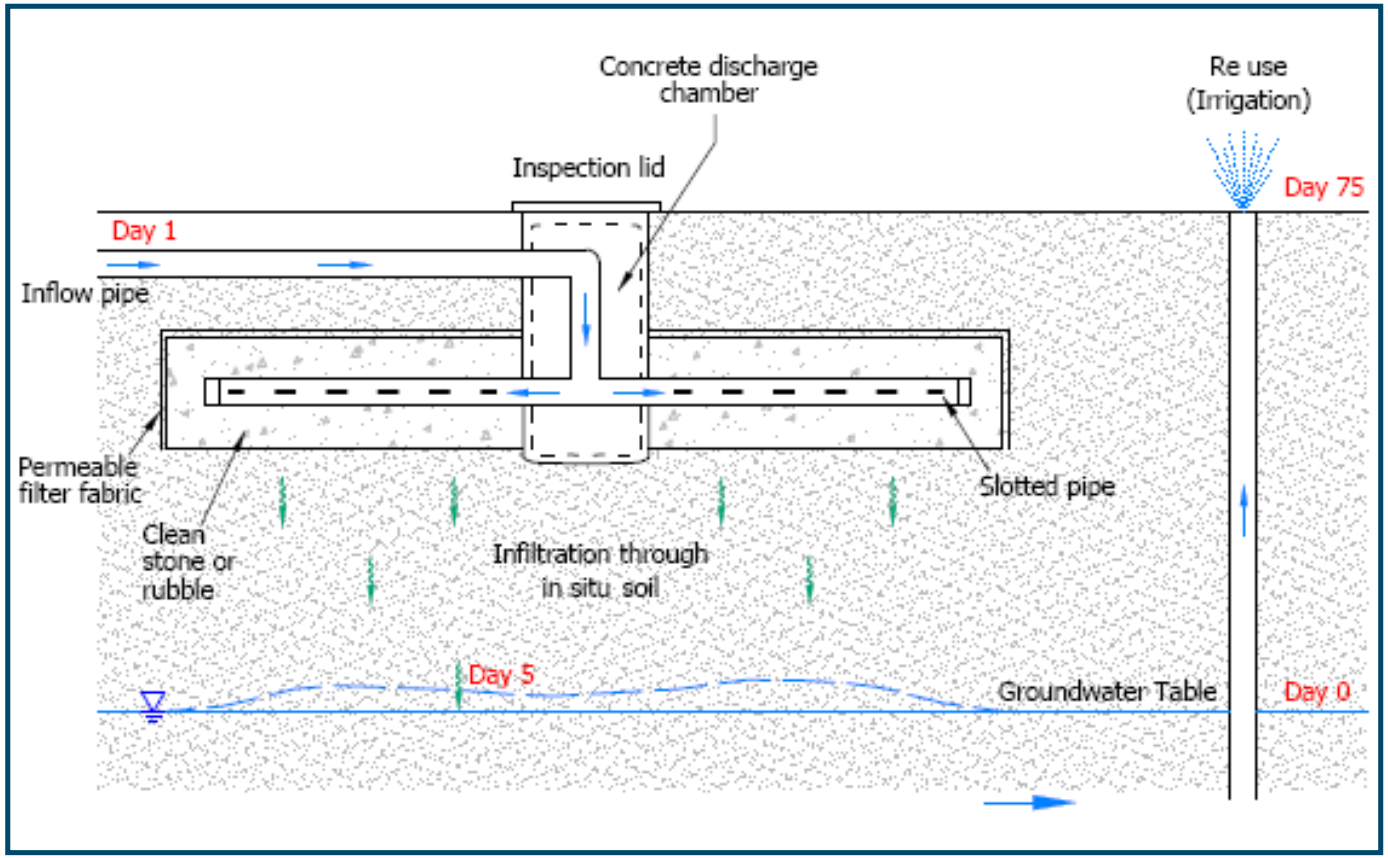
MAR: Techniques
Infiltration techniques

Infiltration gallery



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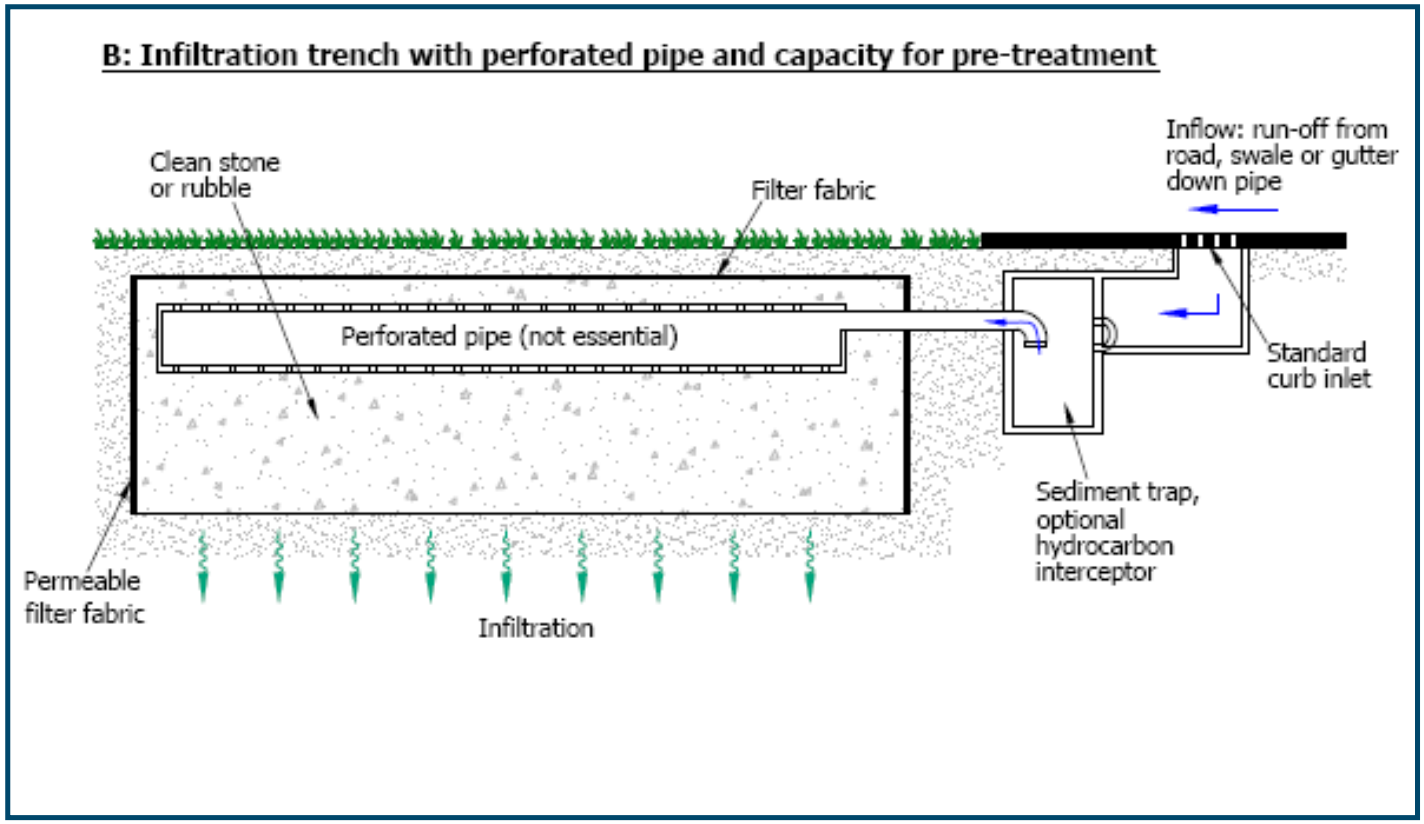
MAR: Techniques
Infiltration techniques

Infiltration gallery with pre-treatment



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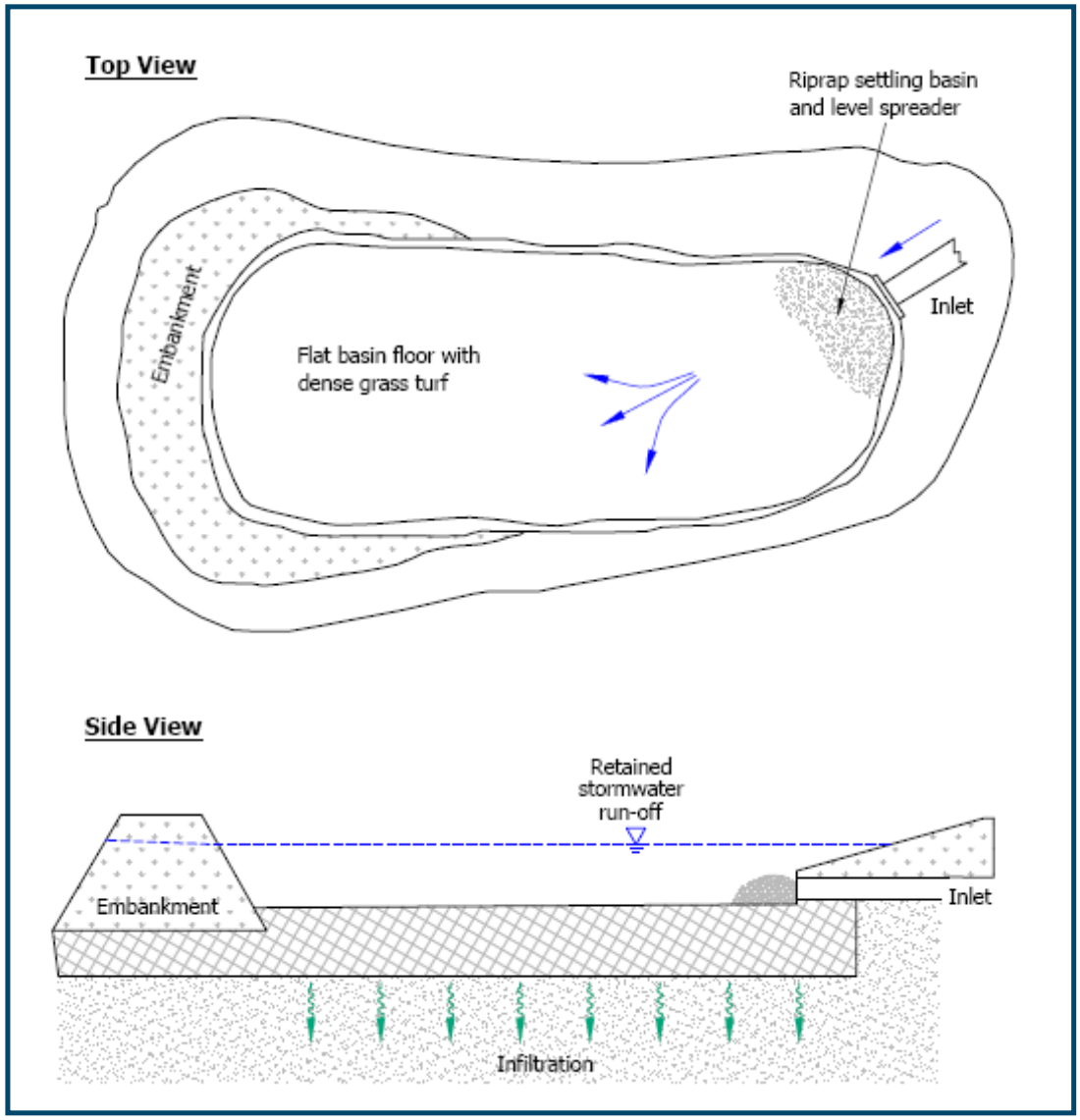
MAR: Techniques Infiltration techniques

Infiltration basin for storm (or diverted river) water



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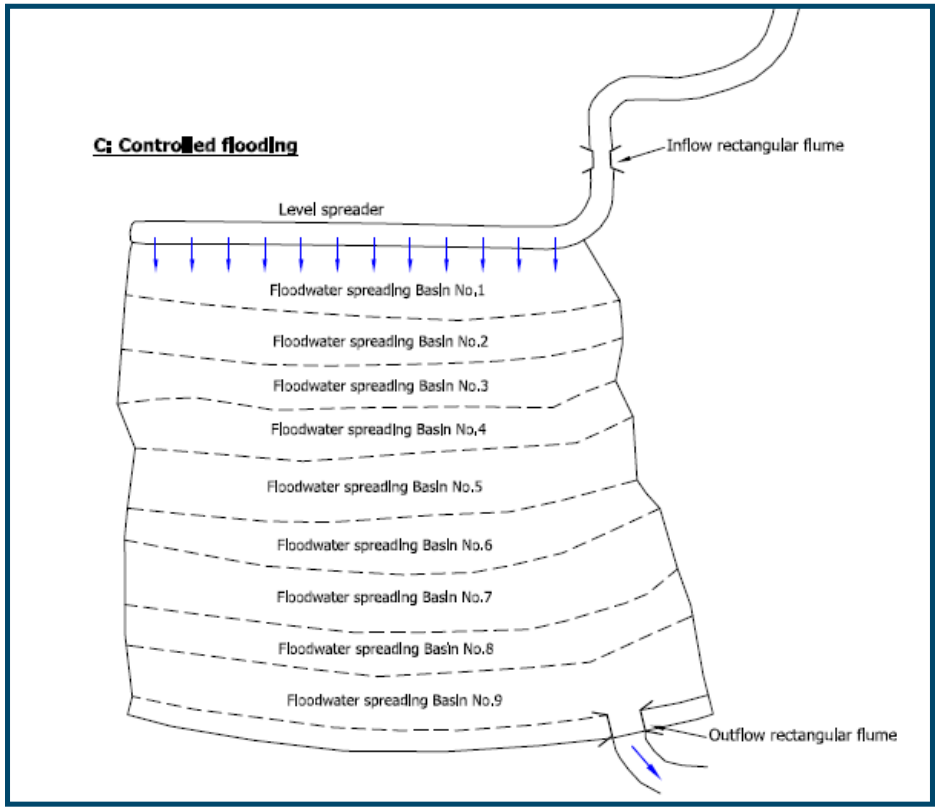
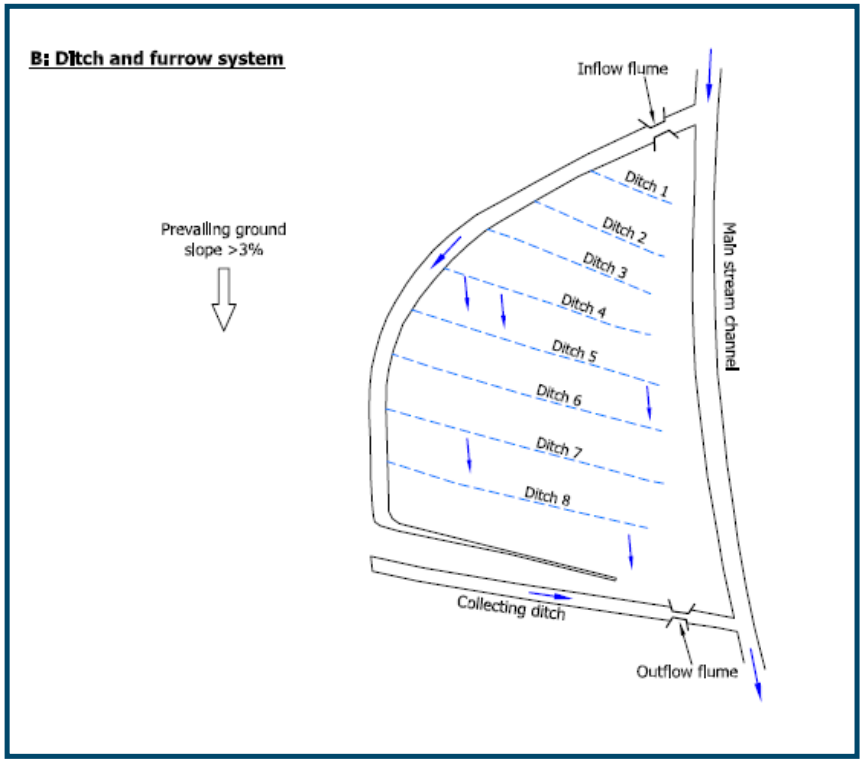
MAR: Techniques
Infiltration techniques

More examples...





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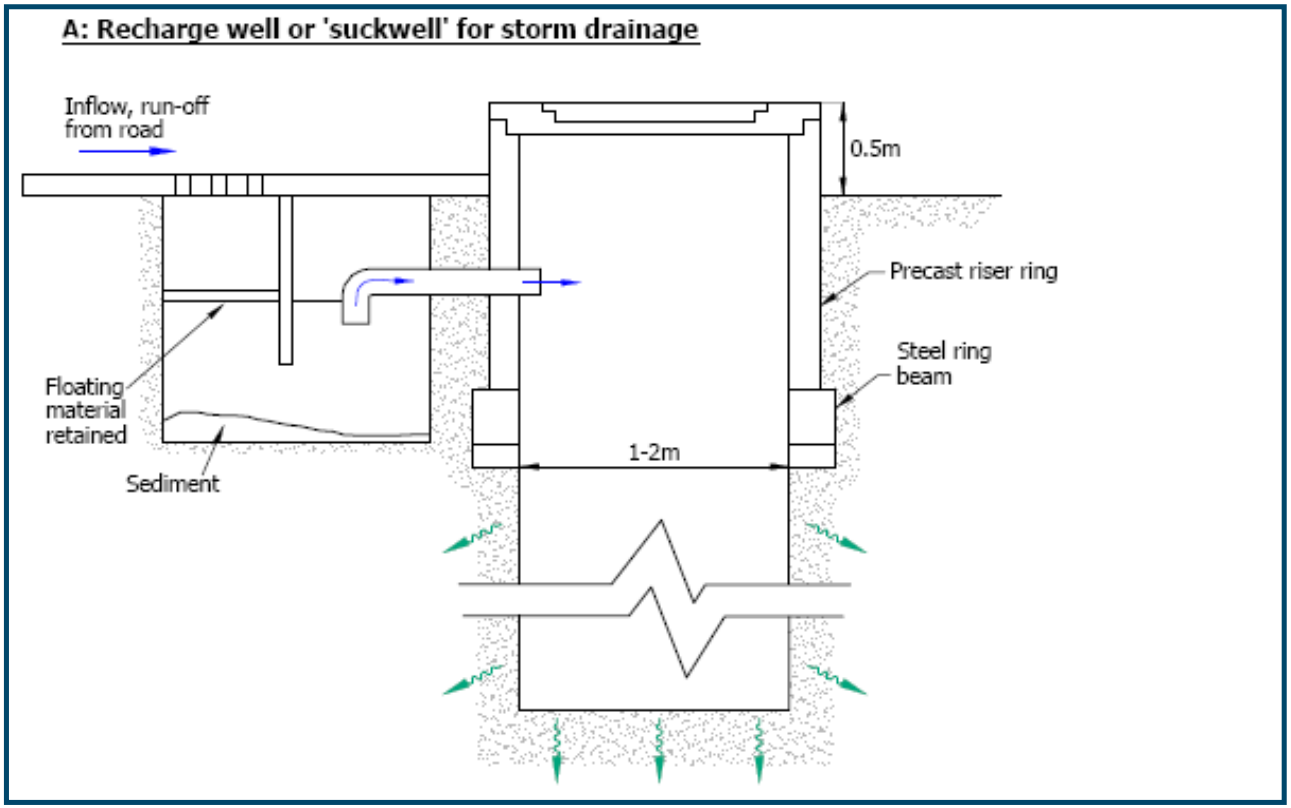
MAR: Techniques
Direct recharge

Recharge well



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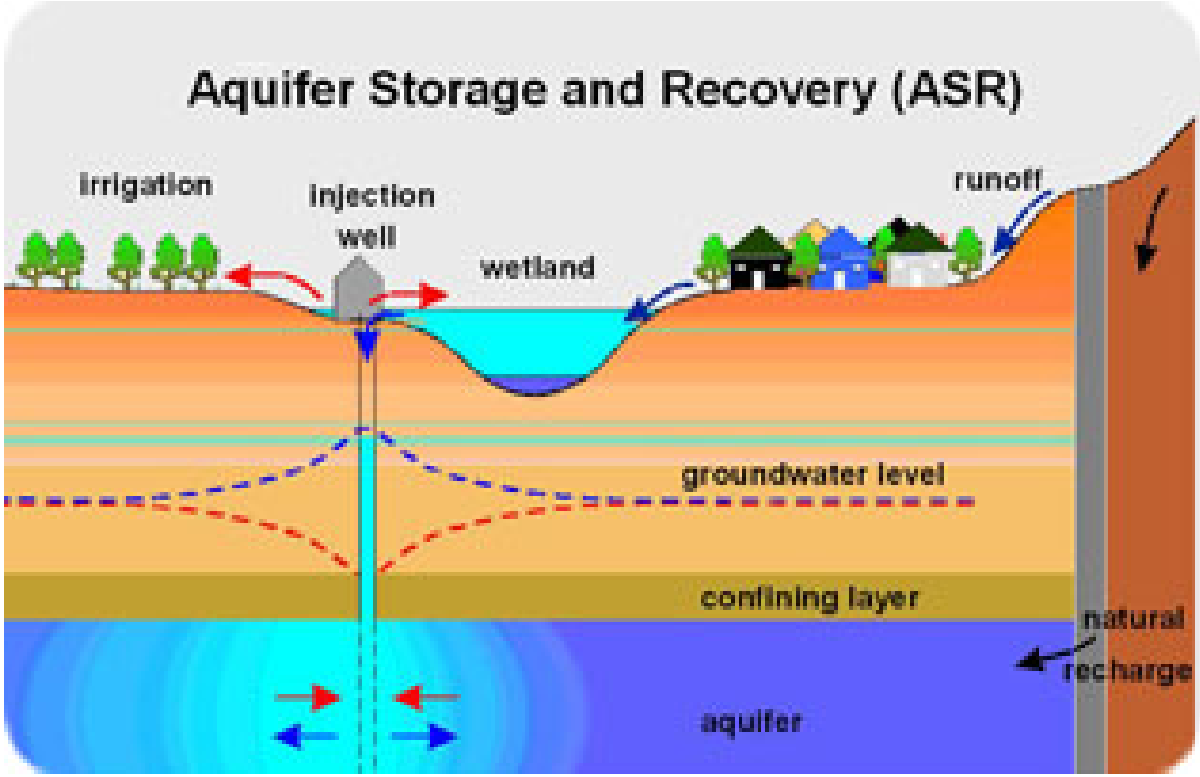
MAR: Techniques
Direct recharge

Direct Injection:

(Aquifer Storage and Recovery)



Source: *Smartwater.com.au*

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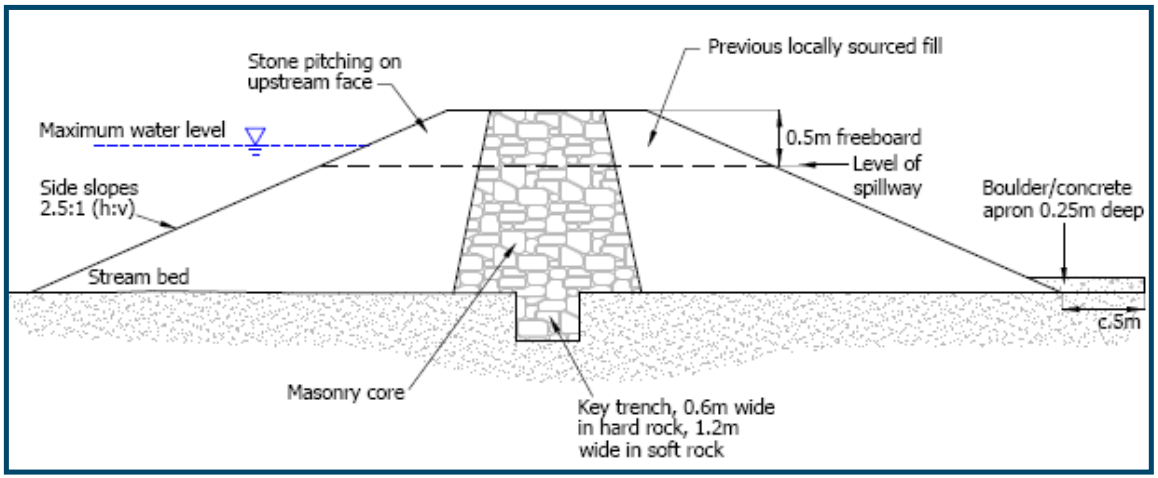
MAR: Techniques
Channel modification

Check Dams

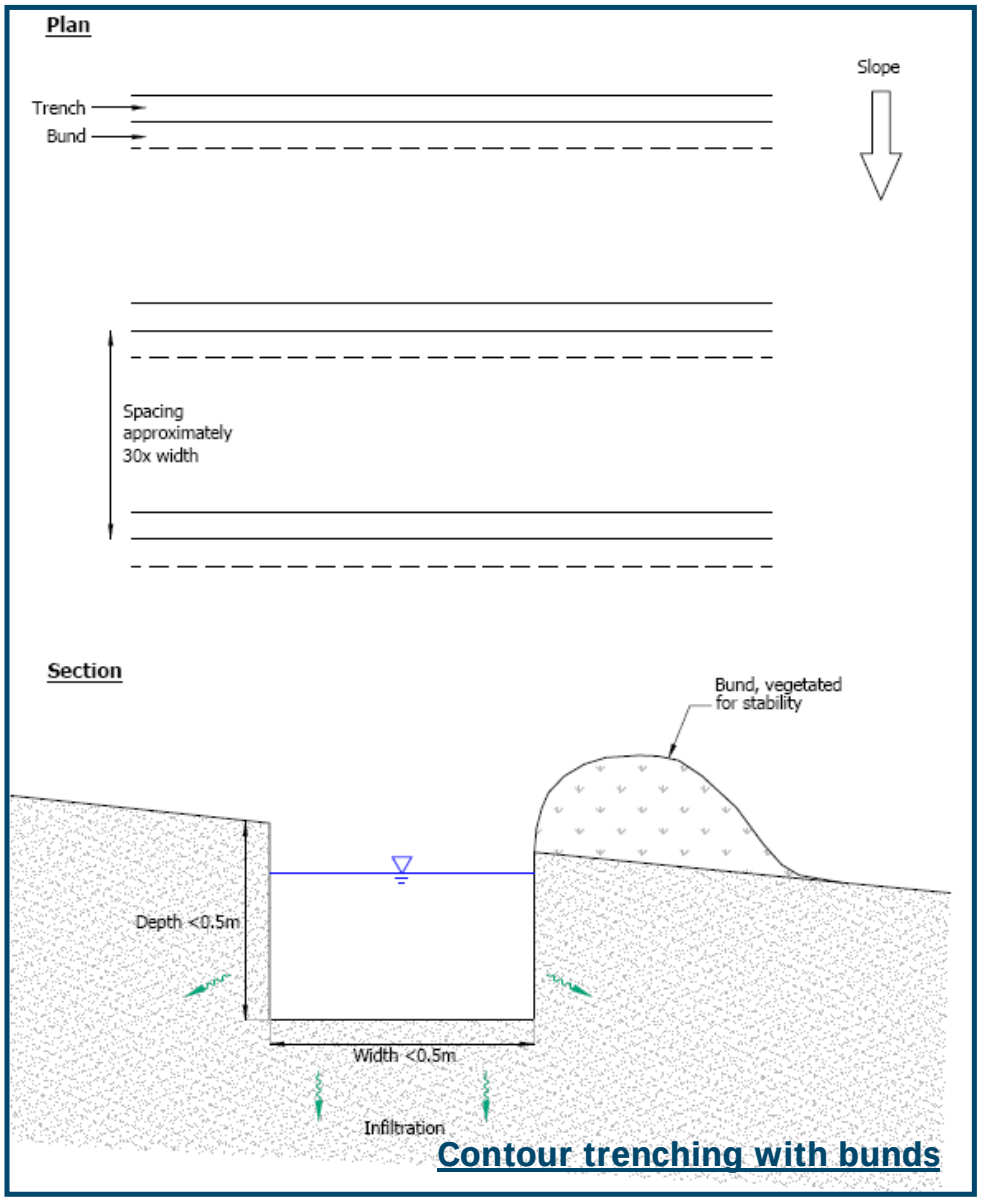
Recharge dams

Examples...



MAR: Techniques Catchment management

- Contour bunding
- Contour trenching
- Gully plugging
- Afforestation
- Controlled grazing



Contour trenching with bunds

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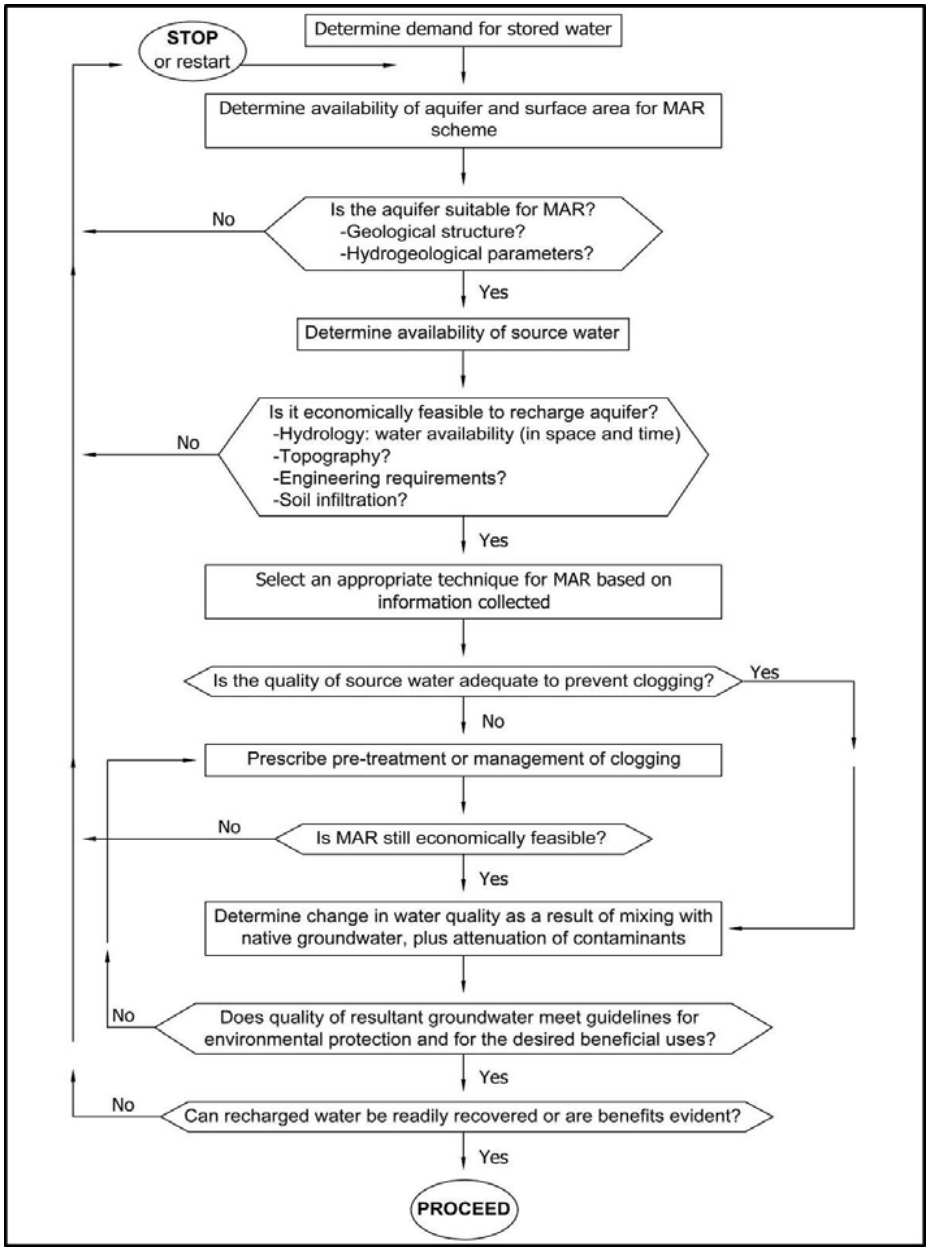
MAR: Design criteria and considerations

Conceptual flow/decision diagram for MAR implementation



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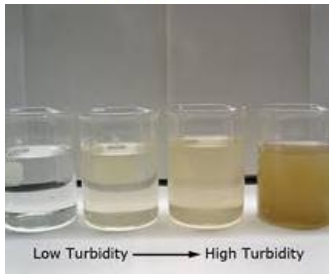
MAR: Design criteria and considerations

- Geology and Hydrogeology:
  - Physical character of the subsurface deposits namely the depth, porosity and permeability
  - Depth to the water table
  - Maximum permitted water table fluctuation;
  - Transmissivity and hydraulic gradient of the water table;
  - Chemistry of the subsurface deposit and the native groundwater.

MAR: Design criteria and considerations

- Hydrology:
  - Quantity of water available for recharge
  - Timing of flows and the seasonal availability of water
  - Location (within the catchment) of available water
  - Current demand and water use
  - Local topography
  - Engineering designs required to convey water to the recharge site

MAR: Design criteria and considerations



- Water quality and clogging:
  - MAR can effectively treat water: physically, through filtration, and chemically and biologically in the soil and rock matrix (e.g. septic tanks).
  - **Physical** clogging generally occurs at or near the surface when water has a high turbidity (suspended solids load)
  - **Biological** clogging occurs as a result of microbial growth usually when water has a high nutrient content
  - **Chemical** clogging occurs through the precipitation of minerals in the soil, aquifer or the infiltration surface
  - Clogging is best controlled through prevention (via pre-treatment), and thus knowledge of the quality of the available water is crucial

MAR: Design criteria and considerations

- Soil infiltration capacity:
  - Where possible and land is available infiltration systems are preferable
    - Clogging can be affectively managed by scraping of sediment
    - Water is naturally treated in the vadose (unsaturated) zone
    - Less pre-treatment is required
  - Soil infiltration capacity must be high enough to allow infiltration
  - Soil type maps can inform areas with opportunity for surface infiltration MAR schemes
  - On-site testing must be undertaken to verify infiltration rate

MAR: Strategy guidance

Strategic Planning

- Achieved using GIS and mapping techniques
- Decision making and planning tool
- Consider all relevant design criteria
- Planning for further study (feasibility/ site investigation)

i	Topographic map	Including detailed land relief contours
ii	Hydrographic map	Including drainage pattern, catchment boundaries and other surface water features
iii	Climatic Map	Including average annual rainfall, or effective rainfall distribution
iv	Geological map	Including underlying strata and dimensions, for locating aquifers
v	Hydrogeological map	Including groundwater table contours (inferred from baseline information collected)
vi	Soil map	Including infiltration capacity
vii	Land use map	To identify potential pollution hot-spots, or sub-catchments
viii	Population density map	To identify areas of high public water demand
ix	Water Infrastructure map	To identify where schemes can be located to assimilate best with current water supply infrastructure (thus reducing cost)

MAR: Strategy guidance

<u>The role of MAR in Integrated Water Resources Management (IWRM) and policy:</u>

- MAR exploits natural processes and the connectivity within the hydrological system
- Has multiple, cross-sector benefits
  - Improved, more resilient water resources,
  - Reducing water loss, and promoting water re-use
  - Adaptation to climate change
  - Benefits to public health, agriculture, tourism etc
- MAR implementation requires coordination of the government and civil society stakeholders
- And... it MUST be implemented alongside demand management and water conservation strategies, watershed management, and public education and awareness strategies

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