FASTER

Farmers' Adaptation and Sustainability in Tunisia through Excellence in Research

2nd FASTER SPECIALIZED TRAINING

on Climate change effects on water & land management in the Mediterranean

22-26 March 2021 (ONLINE)

AGENDA

Techniques for Estimating Groundwater Recharge in Data Poor Regions

March 25th, 2021
Specialized training course, FASTER project, Tunisia

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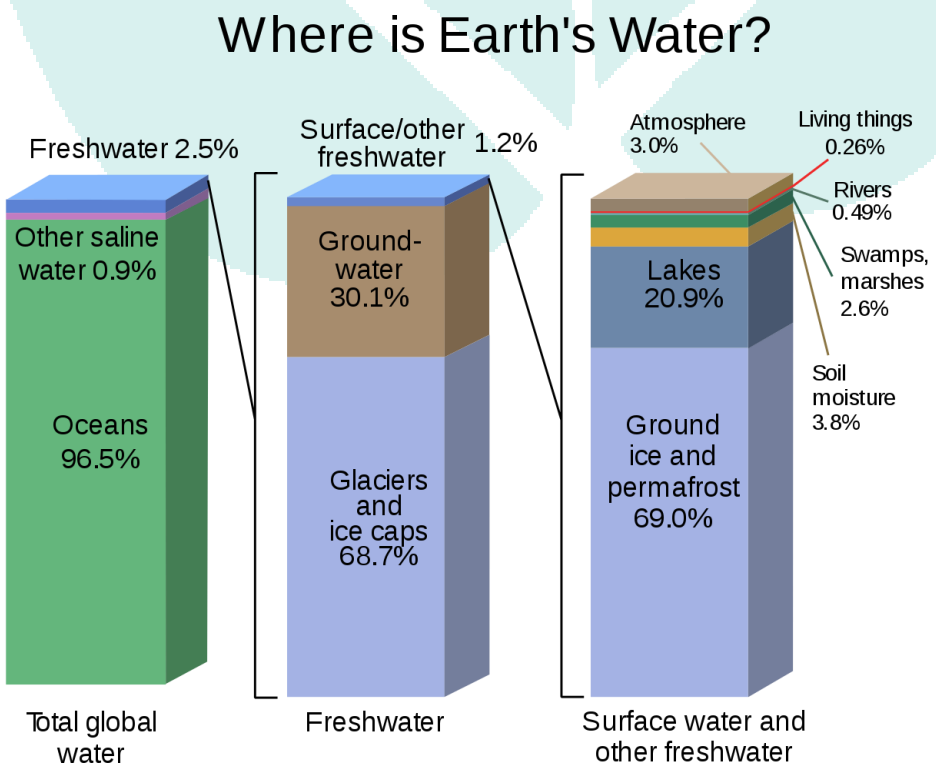
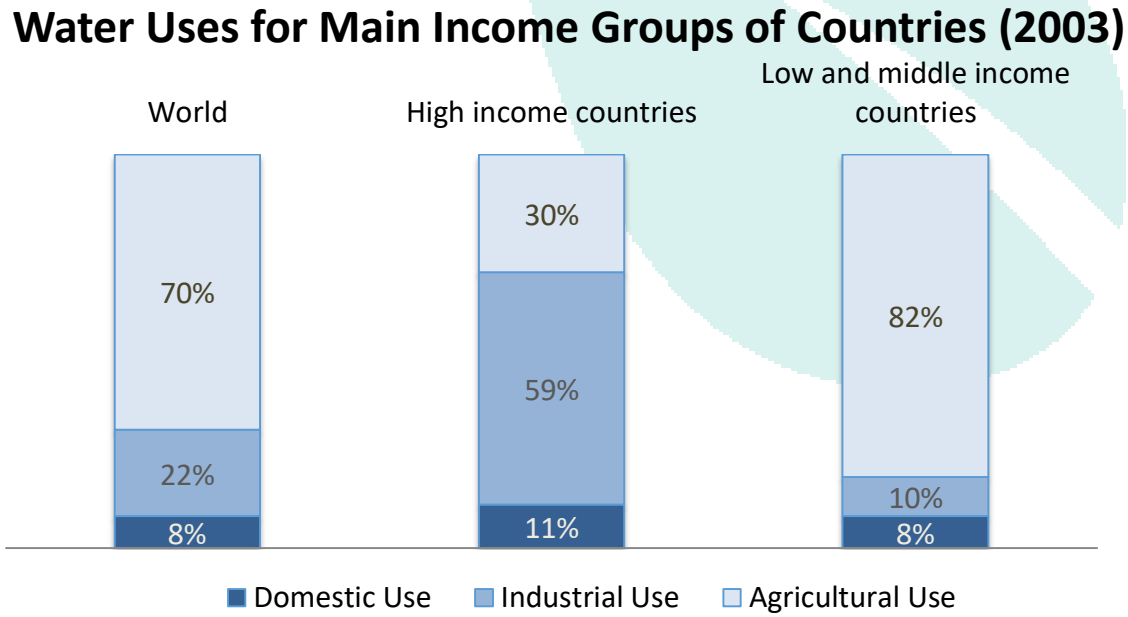
Available water

- 97% occurs as salt water in the oceans
- Of the 3%, two-thirds occur as snow and ice
- 1% available as global liquid freshwater
  - 97% occurs as groundwater (invisible)
  - 3% occurs as surface water (visible)



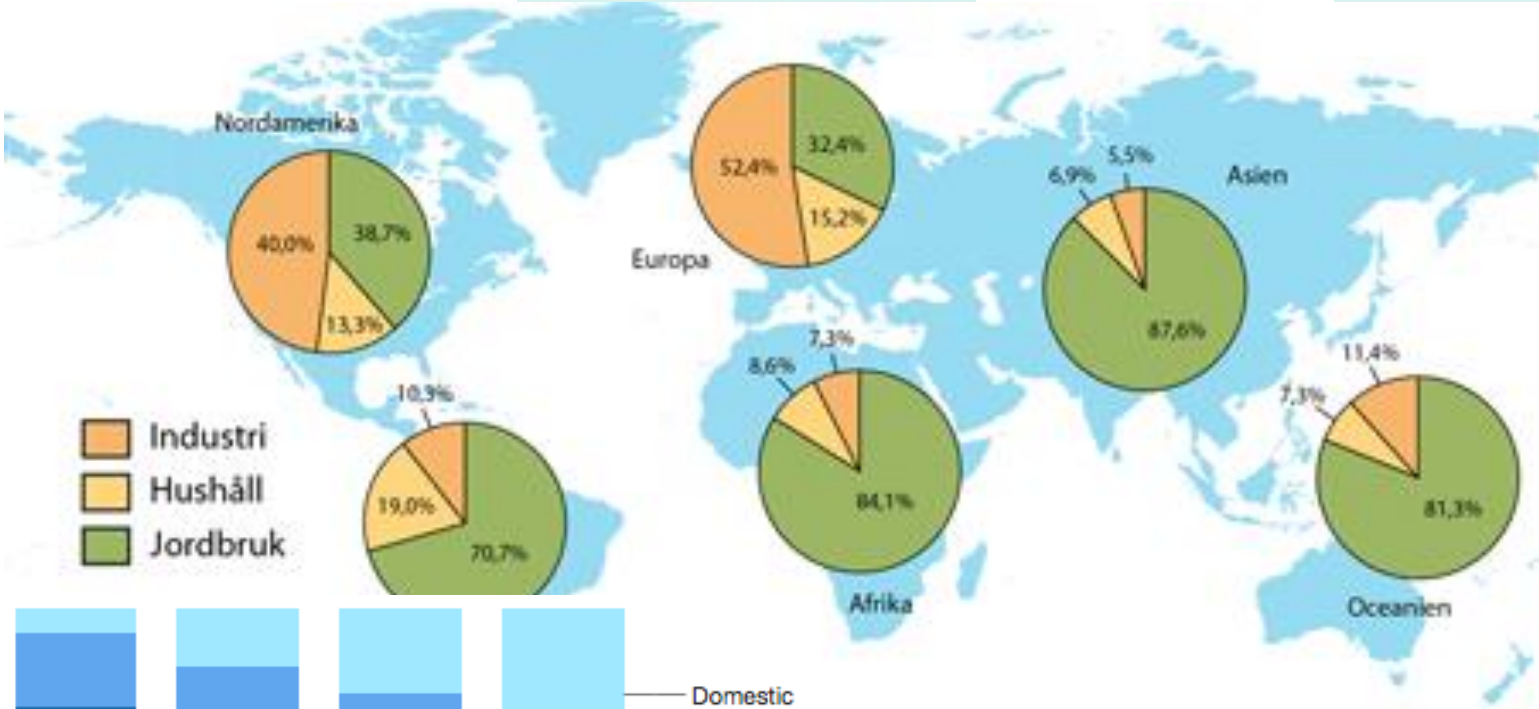
Bouwer, (2000)

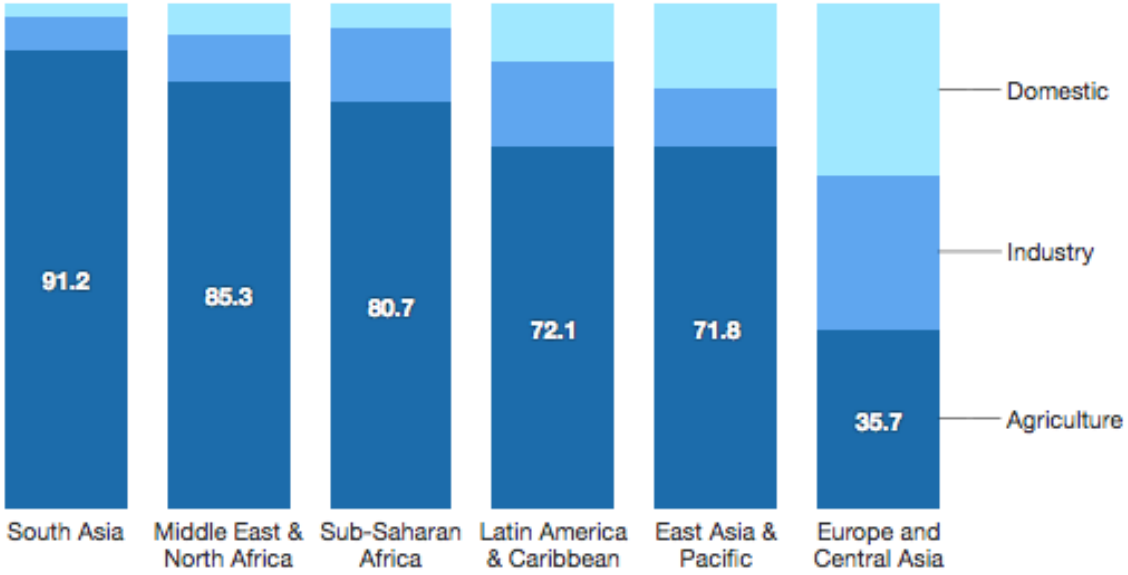
UNEQUAL WATER USAGE ON A GLOBAL LEVEL



There are geospatial and geopolitical differences in energy, water, and food policies, status quo resource management, environmental regulations, economic conditions, and resource (e.g., land and water) availability, all of which can provide opportunities or cause constraints across the nexus

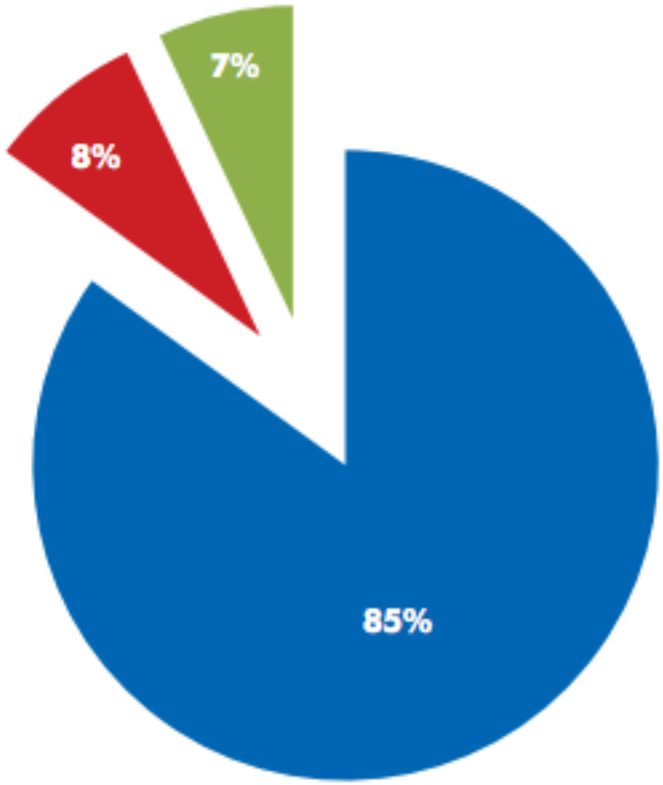
Sectoral Water Use





Source: Svenskt Vatten

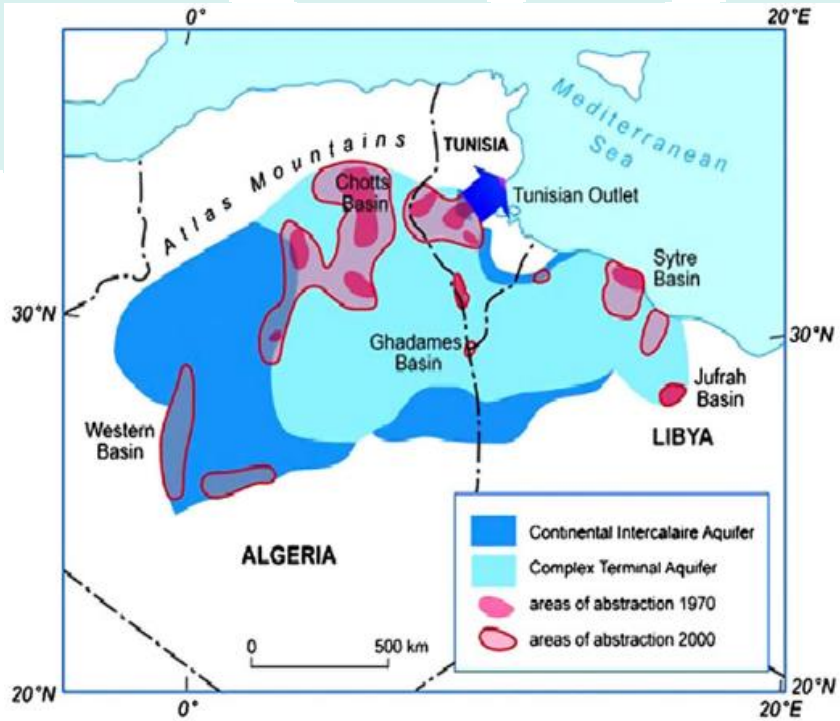
Water consumption (%) by sector in Arab Countries (1996-2006)



- Agricultural water withdrawal (% of total freshwater withdrawal)
- Domestic water withdrawal (% of total freshwater withdrawal)
- Industrial water withdrawal (% of total freshwater withdrawal)

*Latest values for all 22 Arab countries

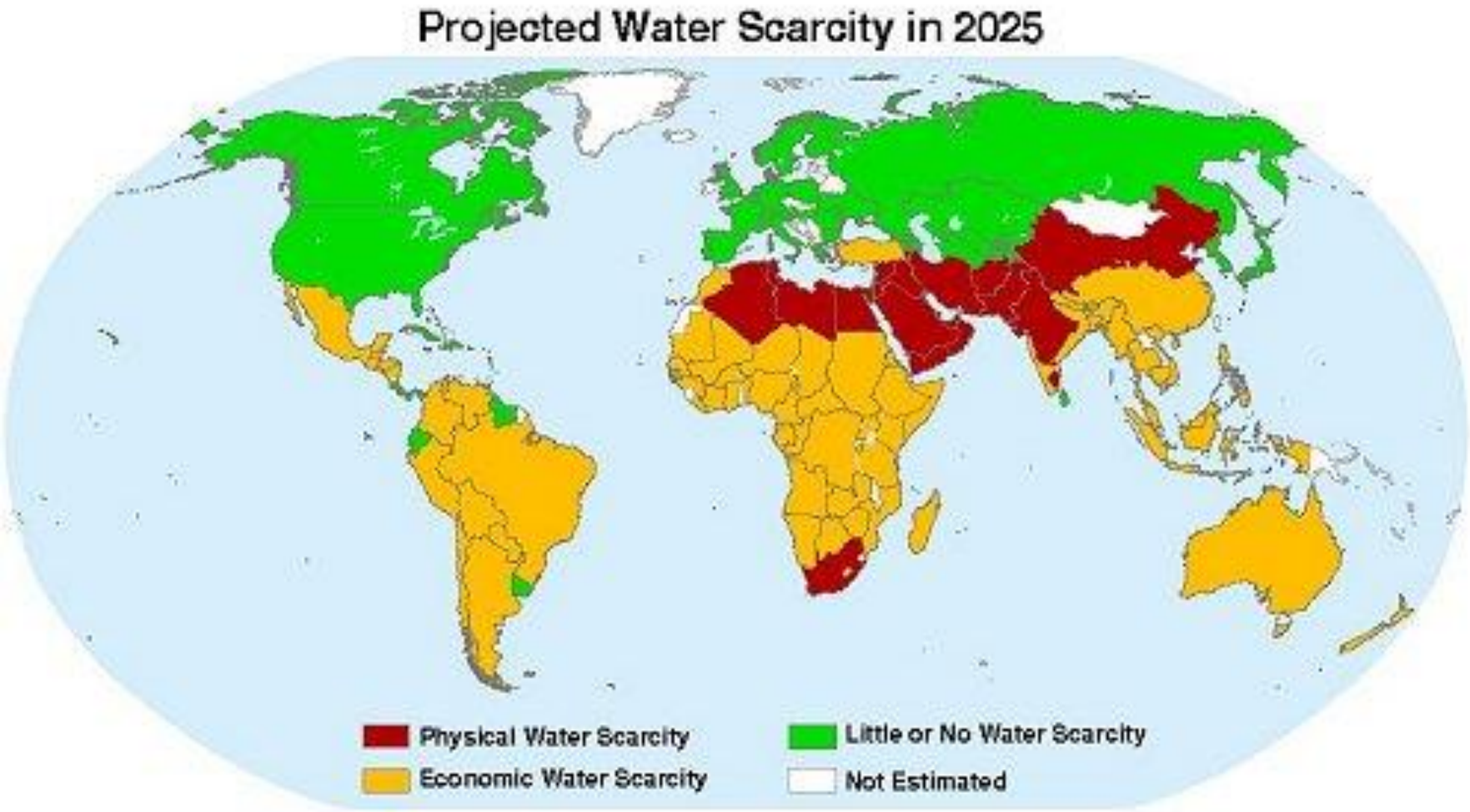
Source: UNDP, 2009



North-Western Saharan African Aquifer

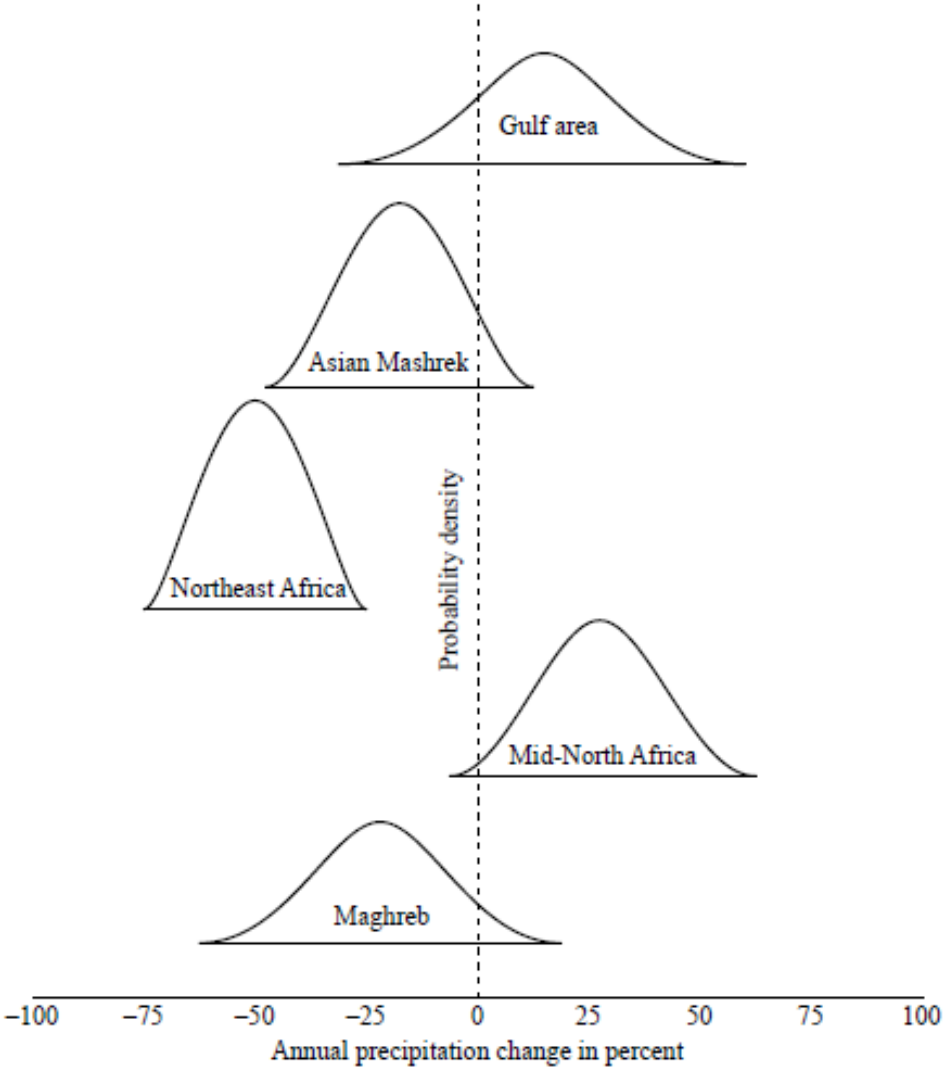
Hamed et al., (2013)

Water scarcity 2025



Source: International Water management Institute, *World water demand and supply, 1990 to 2025: Scenarios and Issues. Research Report 19* , based on map prepared for Vision of Water for Food and Development"

Precipitation change (MENA)



Climate change in the MENA region

313

Figure 5.
Probability distribution of annual precipitation from 1980 to 2080 for various regions of MENA using statistical predictions

Wasimi, 2010

Priorities/solutions

- Treat wastewater & reuse
- Increase efficiency (agriculture)
- Virtual water
- **Groundwater recharge**

Solution: Groundwater Recharge

Groundwater Recharge is considered a process of water movement downward through the saturated zone under the forces of gravity and is divided into:

I. Natural recharge (direct precipitation, riverbed, lakes…)

II. Artificial recharge (injection wells, water spreading…)

Time factor in natural groundwater recharge

I. Short-term recharge (heavy rainfall, ephemeral riverbed)

II. Seasonal recharge (occurs regularly, snowmelt season, seasonal river)

III. Perennial recharge (permanent river, i.e., in the humid tropics)

IV. Historical recharge (occurred long-time a go and contributed to the formation of the present GW resources)

Simmers, (1988)

Recharge Estimation Techniques

Unsaturated zone:

I. Lysimetric

II. Soil-water content

III. Pressure head

IV. Water-retention and hydraulic conductivity curves

V. Zero-flux plane

VI. Darcy method

VII. Unsaturated zone modeling (i.e., HYDRUS)

Recharge Estimation Techniques

Saturated zone:

I. Water Table Fluctuation (WTF) technique

II. Timeseries analysis

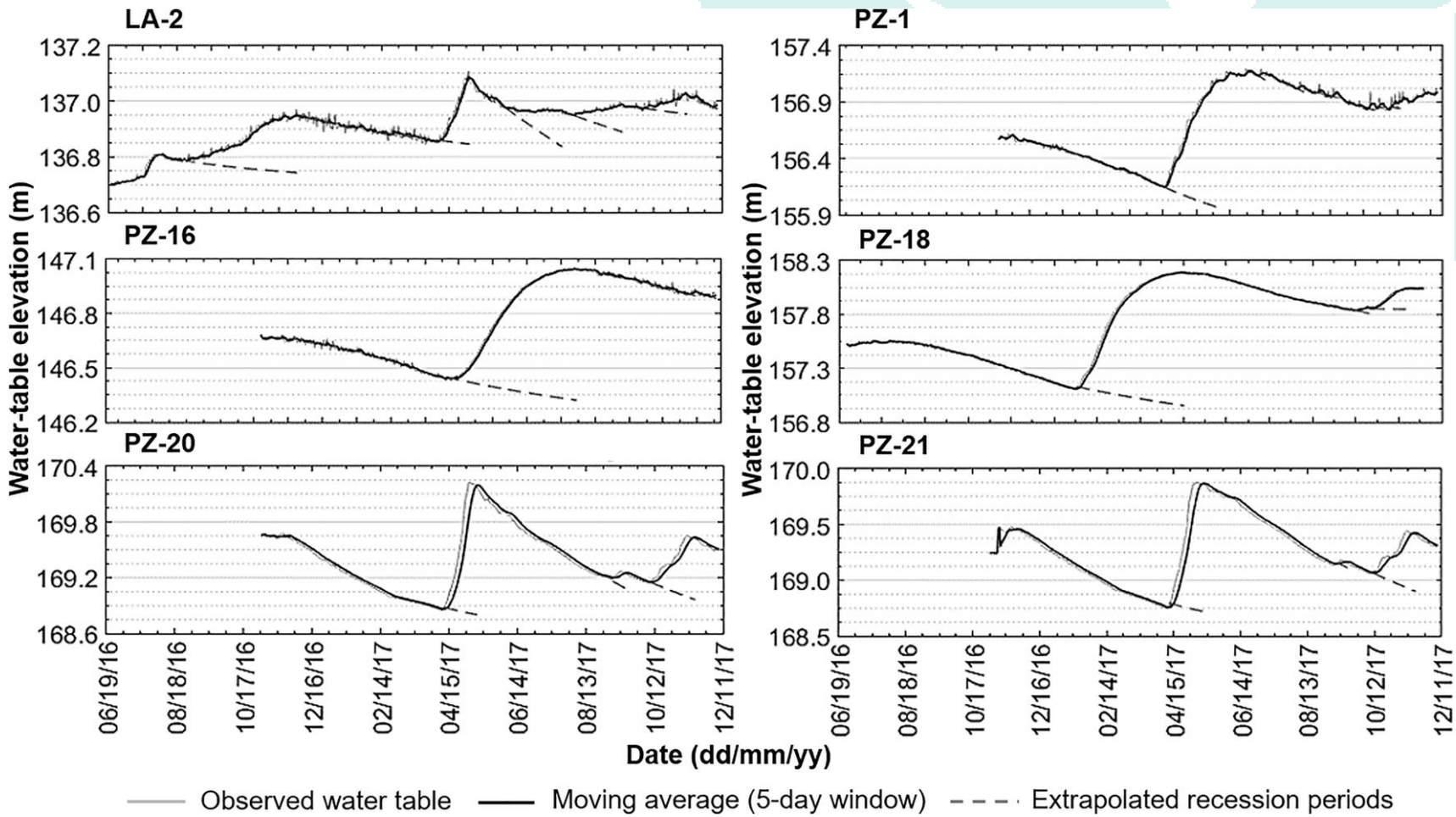
III. Darcy Flux method

IV. Tracer technique (chemical and heat tracers)

V. Groundwater Modeling

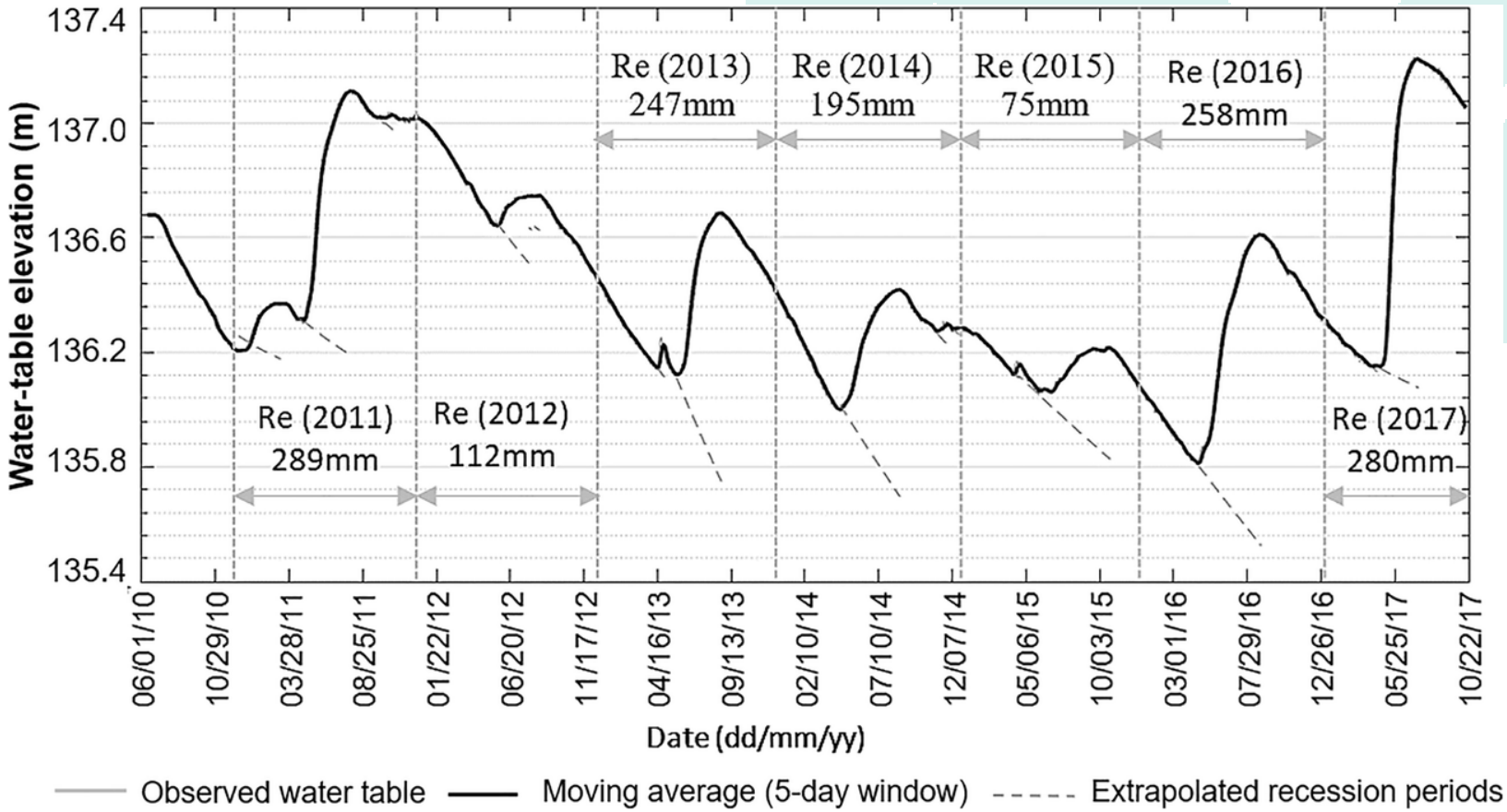
Healy and Scanlon, (2010)

Water table fluctuation method



Labrecque et al., (2020)

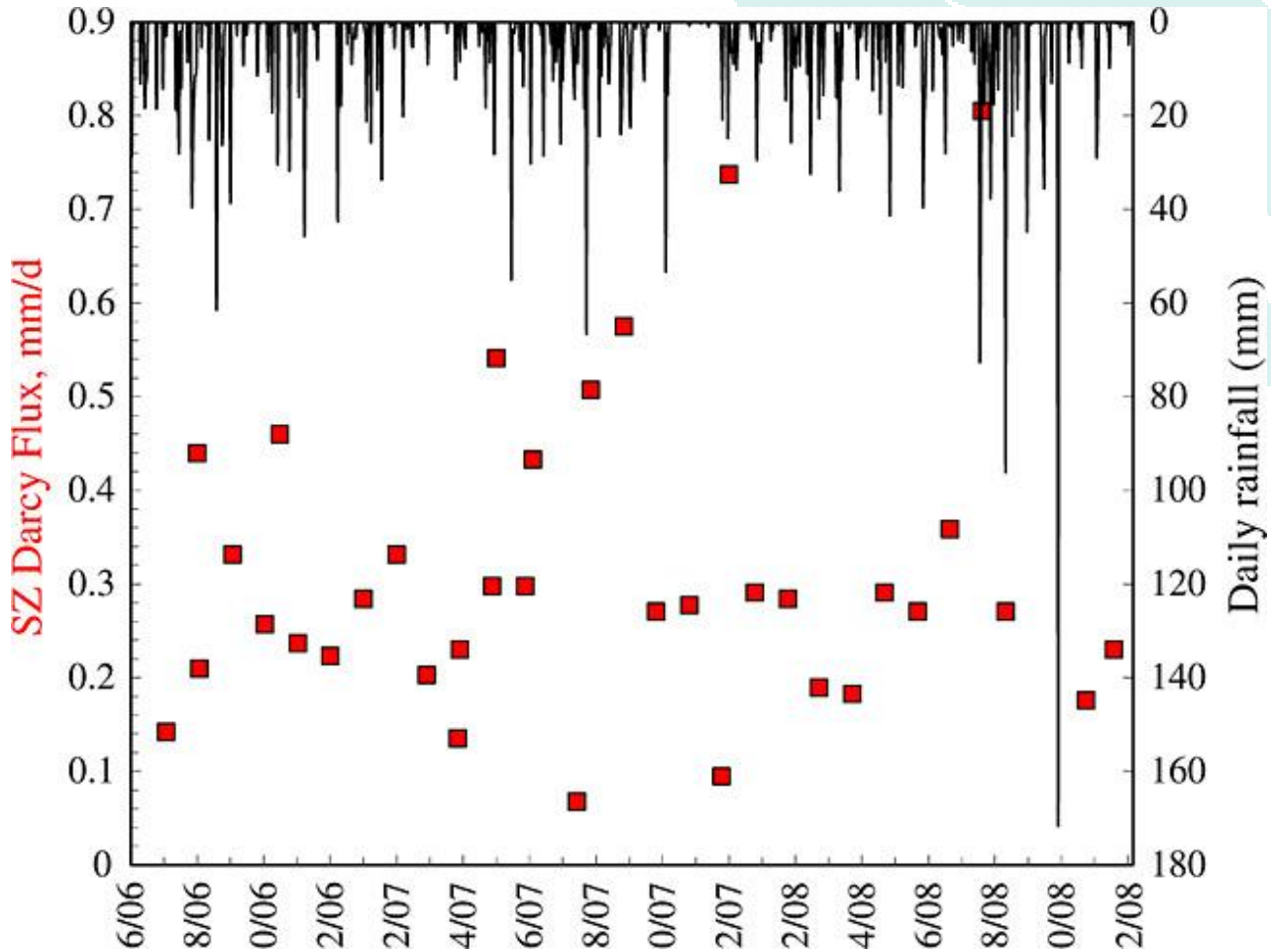
Water table fluctuation method



$$R = S_y \frac{h_m - h_a}{\Delta t}$$

Labrecque et al., (2020)

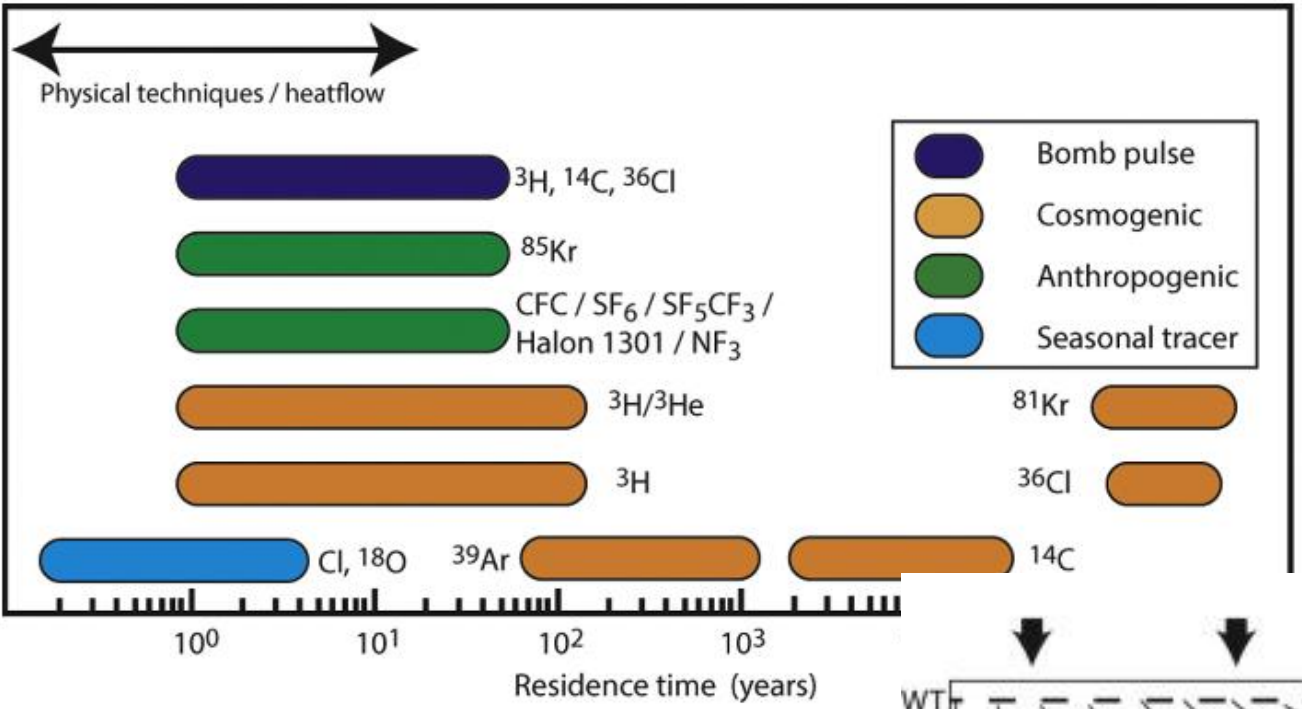
Darcy Flux method

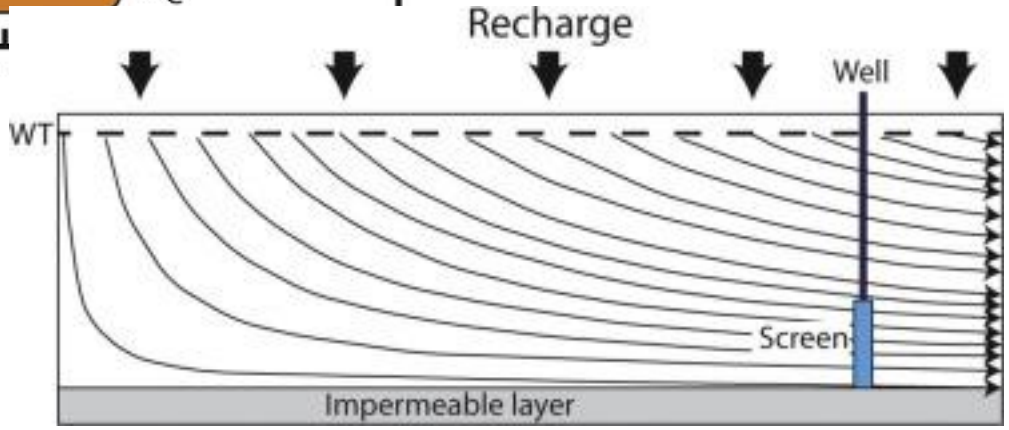


$$q_z = K_z \frac{h_{WT} - h_{P1}}{\Delta z}$$

Callahan et al., (2012)

Tracer technique





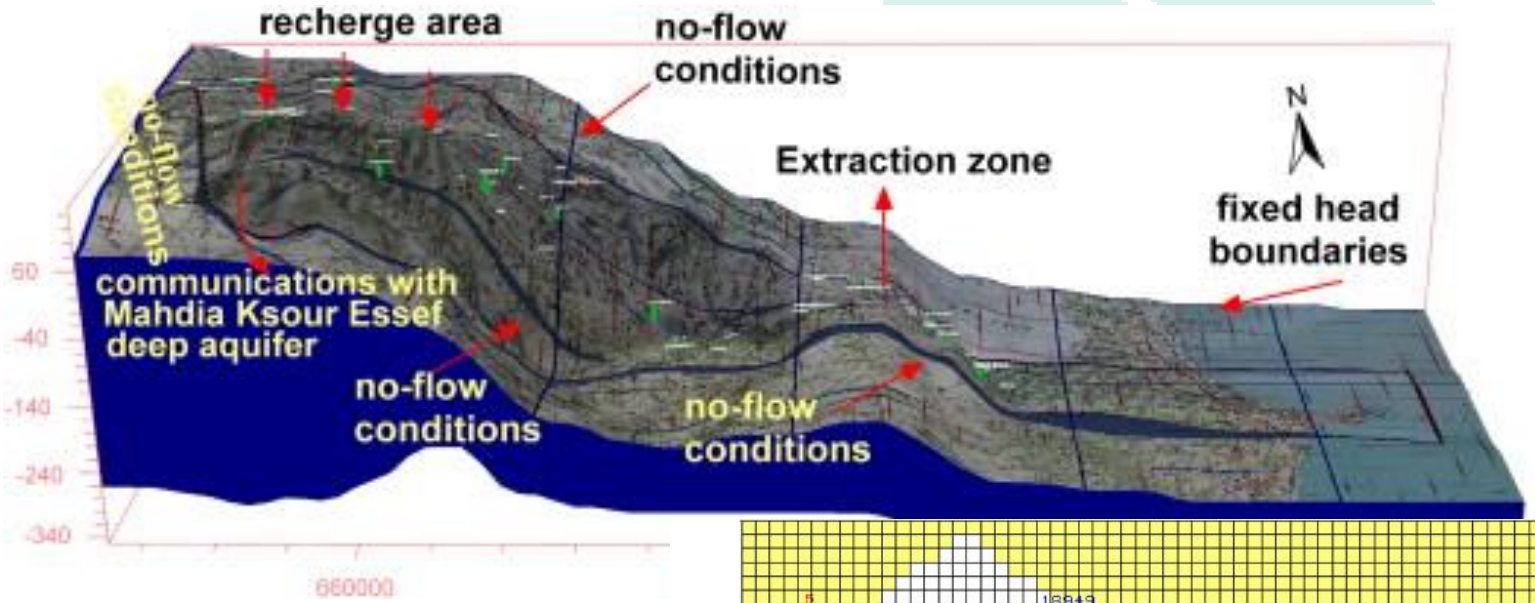
Approximate residence time range of tracers used in determining recharge rates

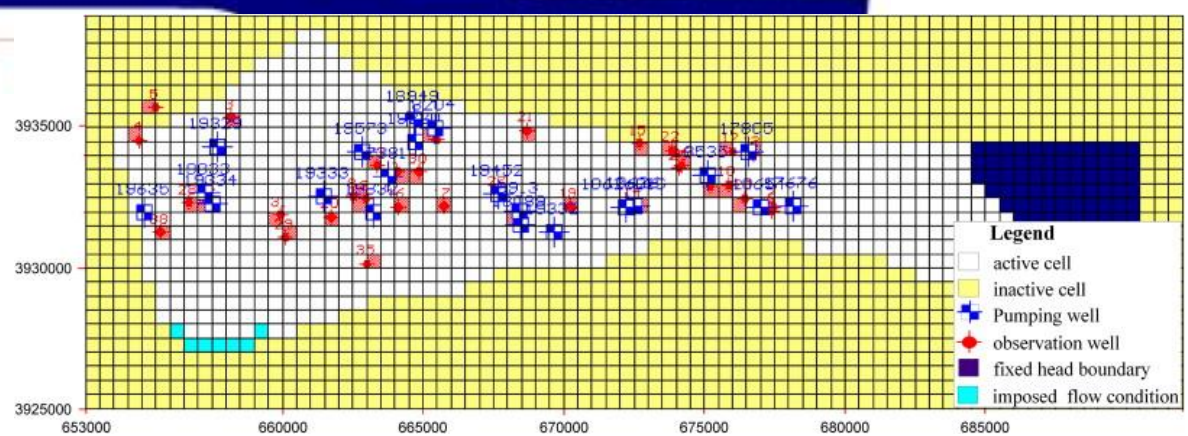
$$C_g(t) = \int_0^\infty C_i(t-\tau)g(\tau)e^{-\lambda\tau}d\tau$$

$$C_g(t) = (1-R_N)C_g(t-1)e^{-\lambda} + R_N C_i(t)$$

Cartwright et al., (2017)

Groundwater modeling



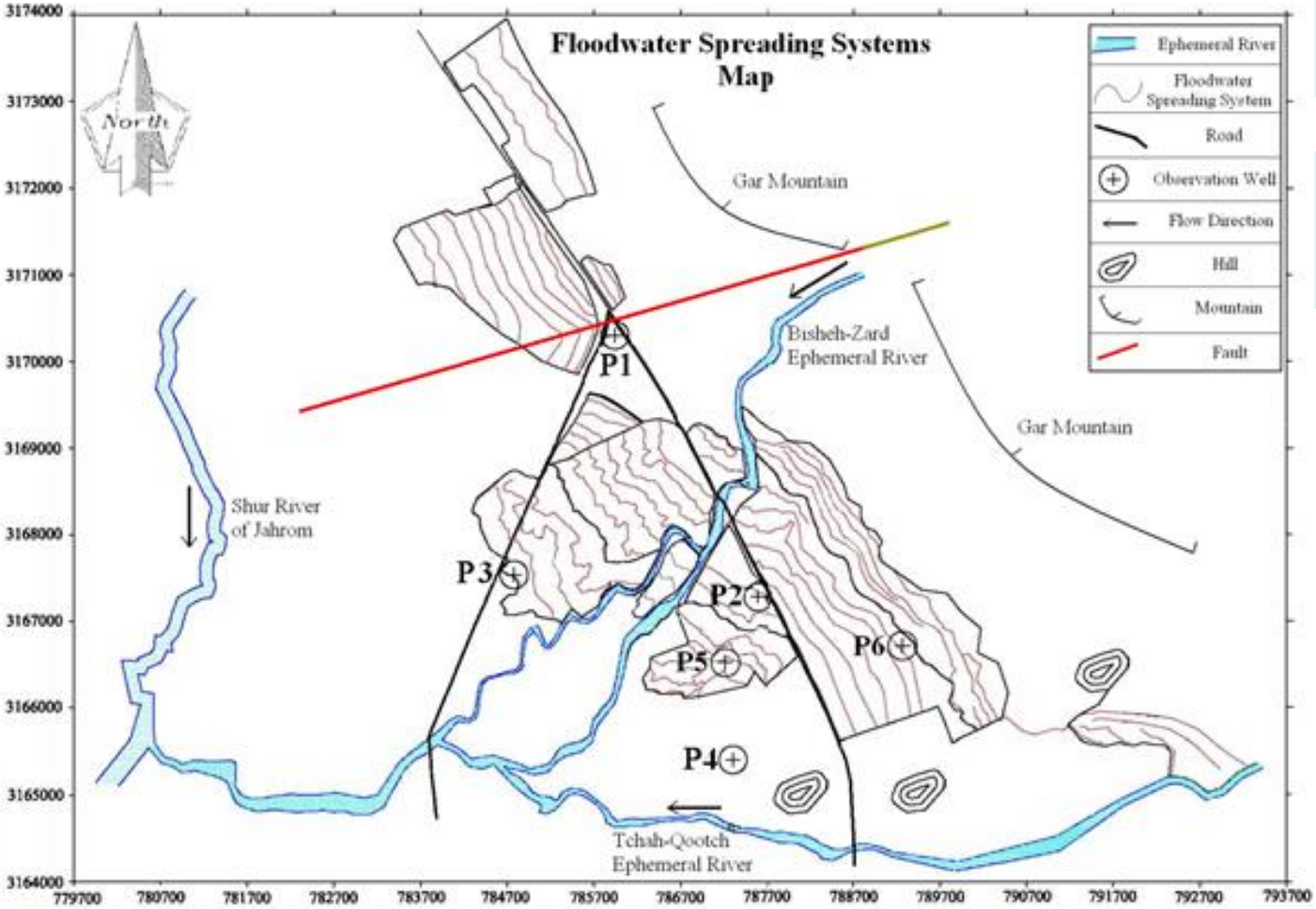


Jemmel, Zéramdine and Béni Hassen plains, Tunisia

Lachaal et al., (2012)

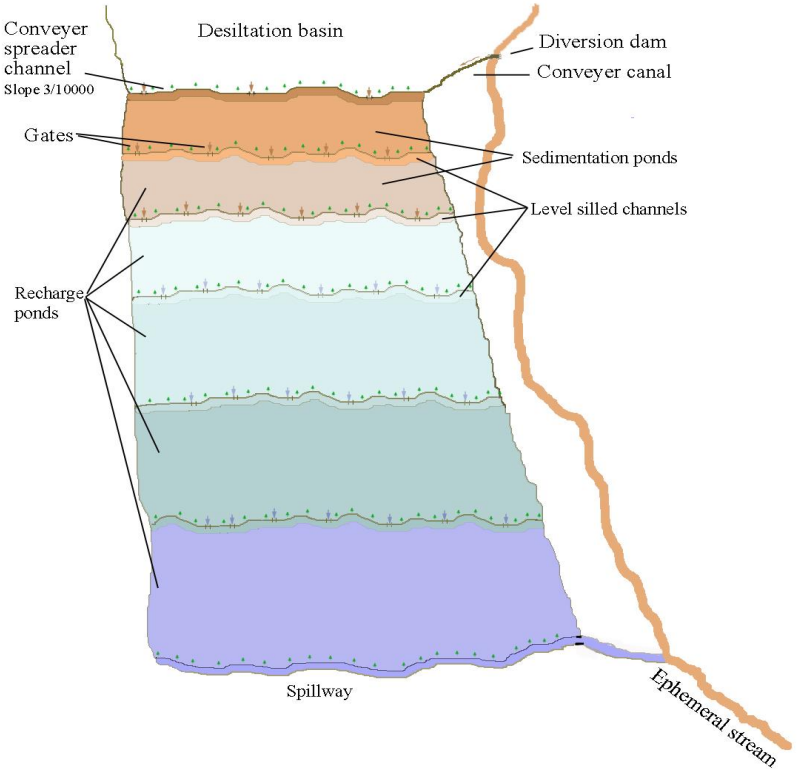
EXAMPLE

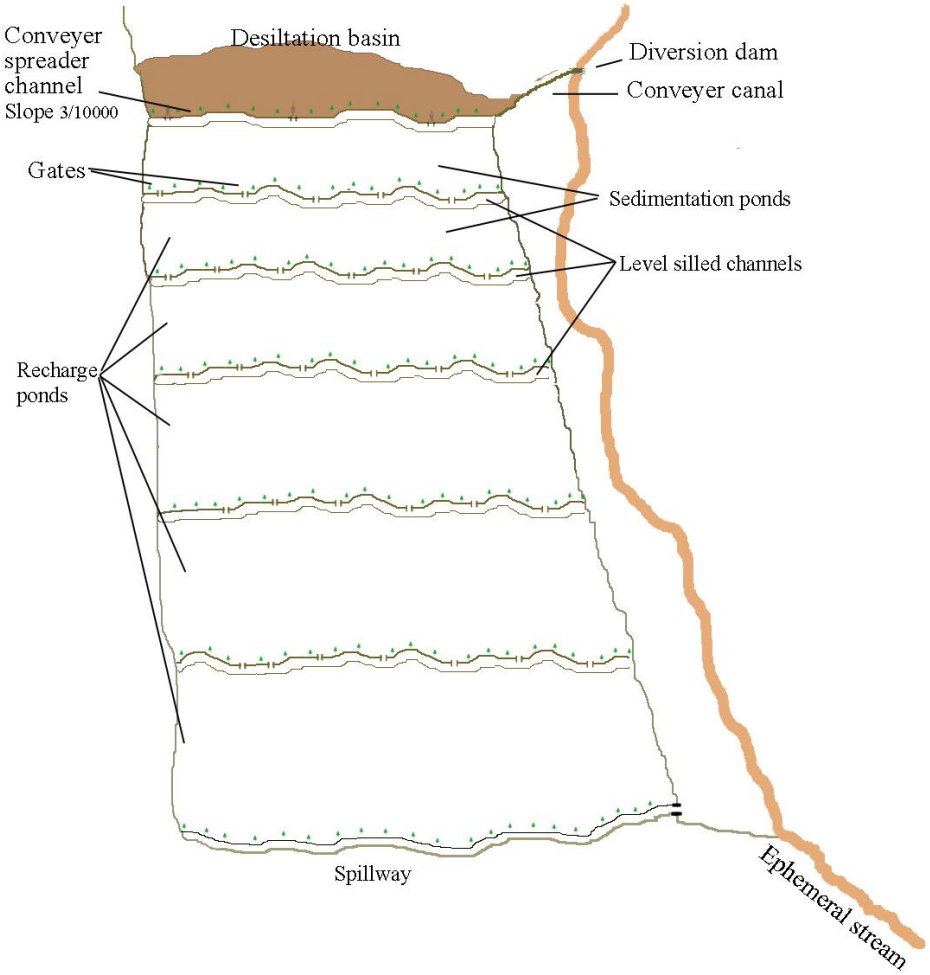
Floodwater spreading system



Hashemi et al., (2012)

Floodwater Harvesting (Spreading) System




Conveyer spreader channel
Slope 3/10000
Desiltation basin
Diversion dam
Conveyer canal
Gates
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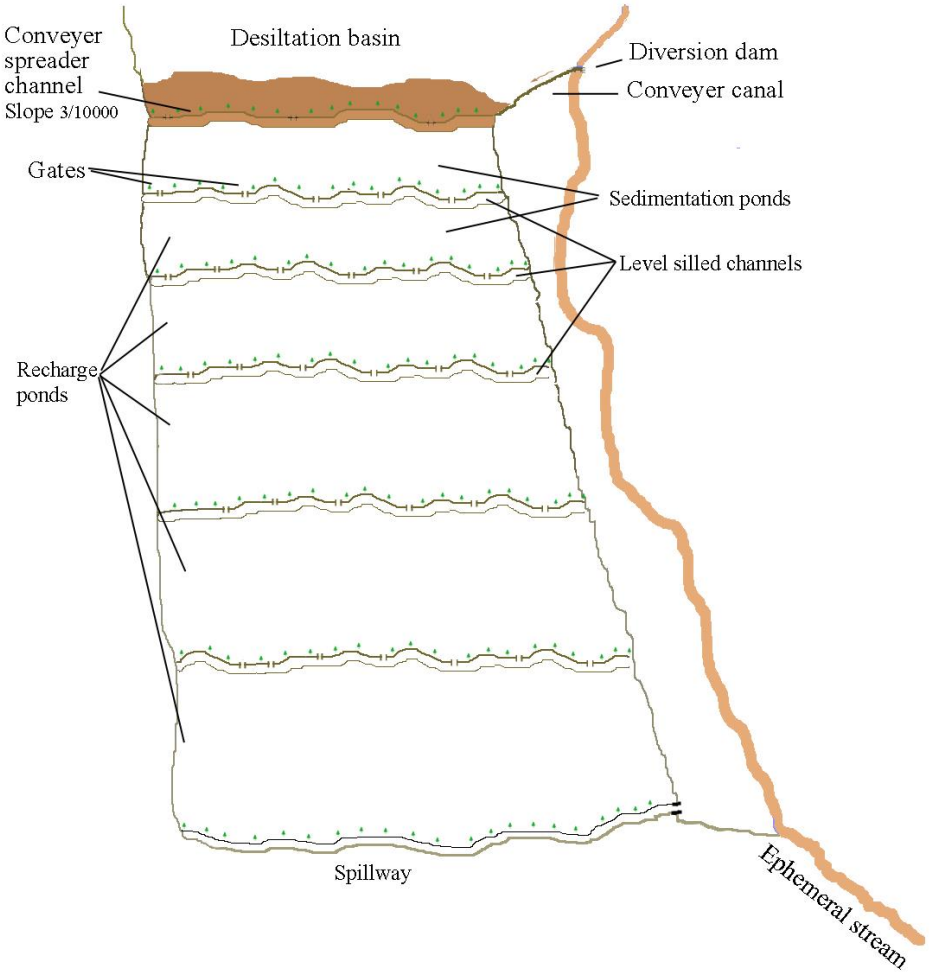
Level silled channels
Recharge ponds
Spillway
Ephemeral stream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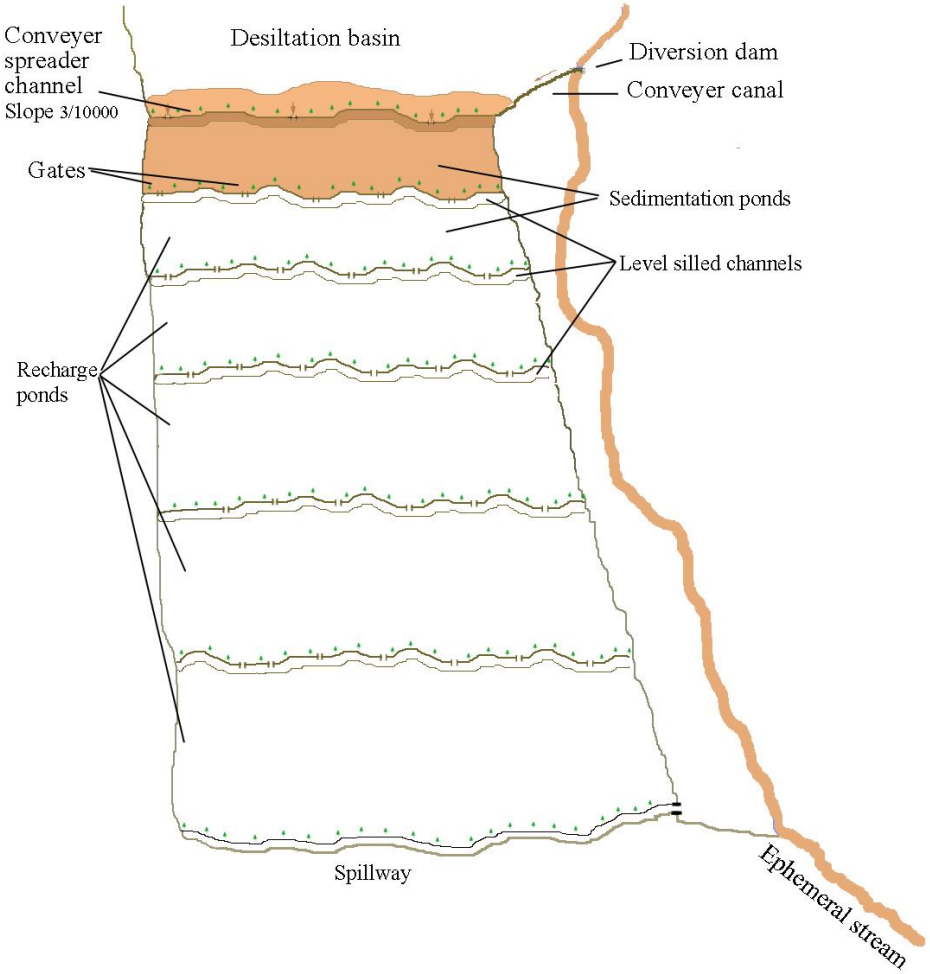
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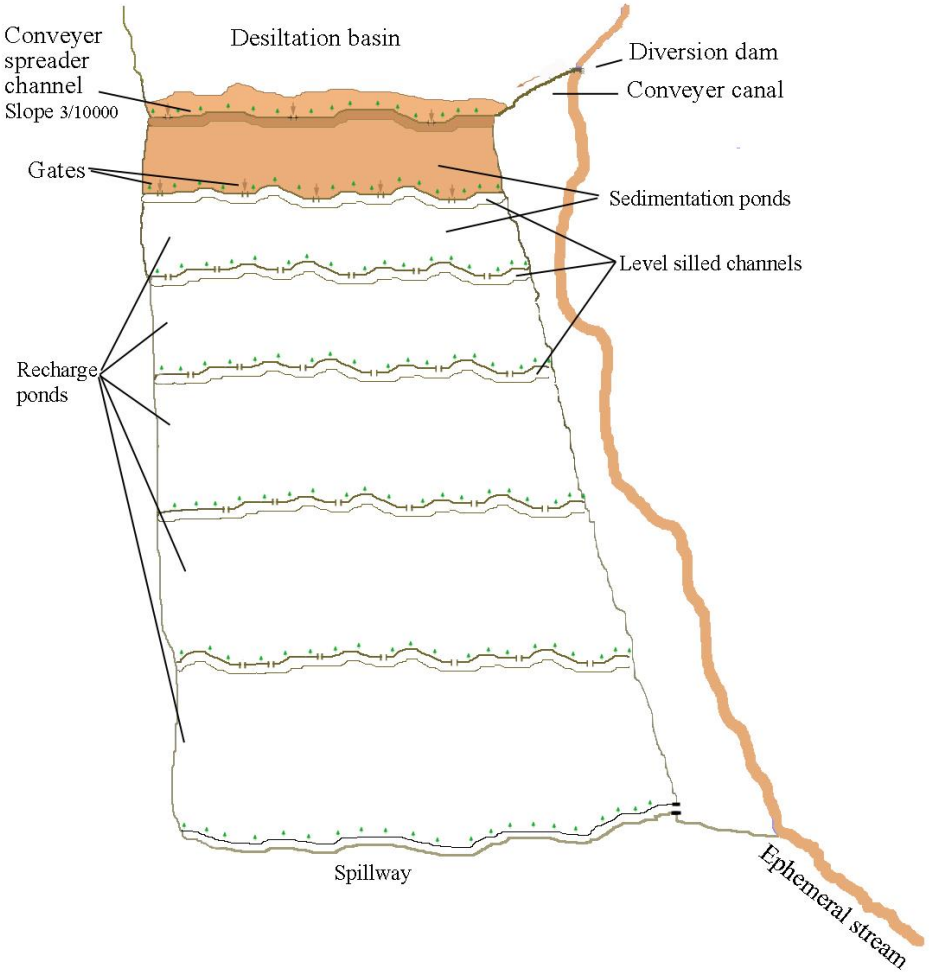
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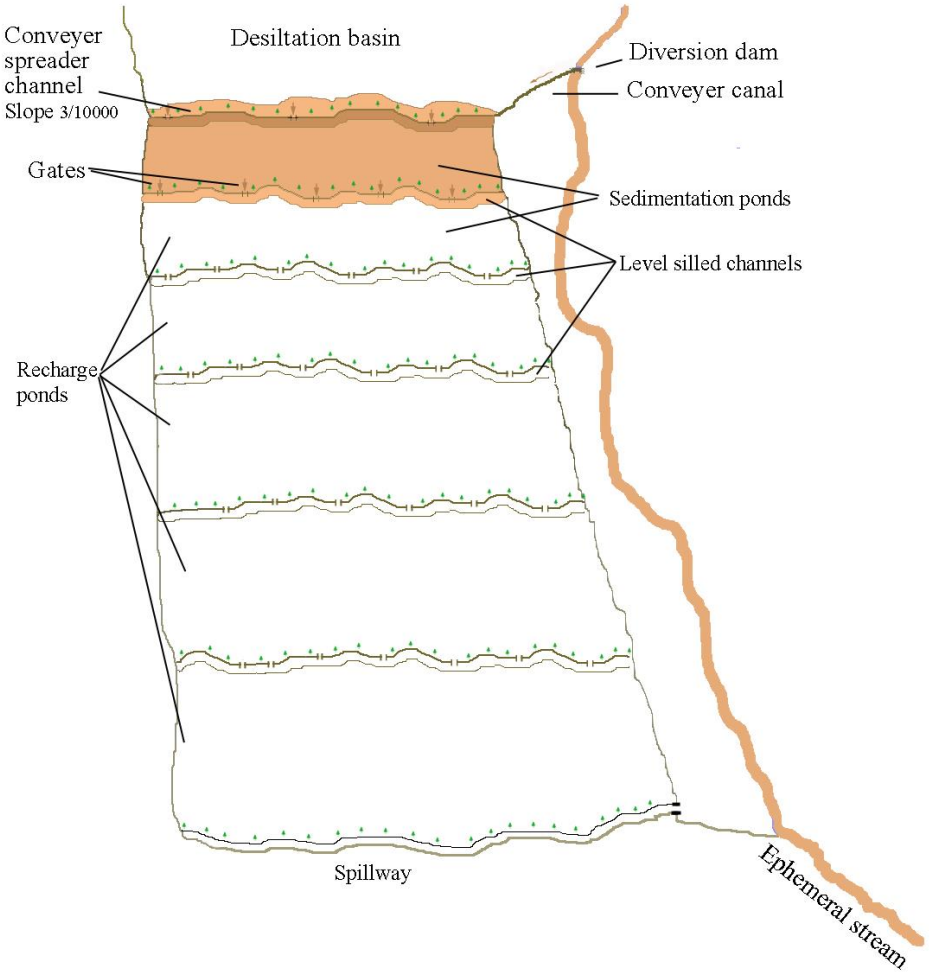
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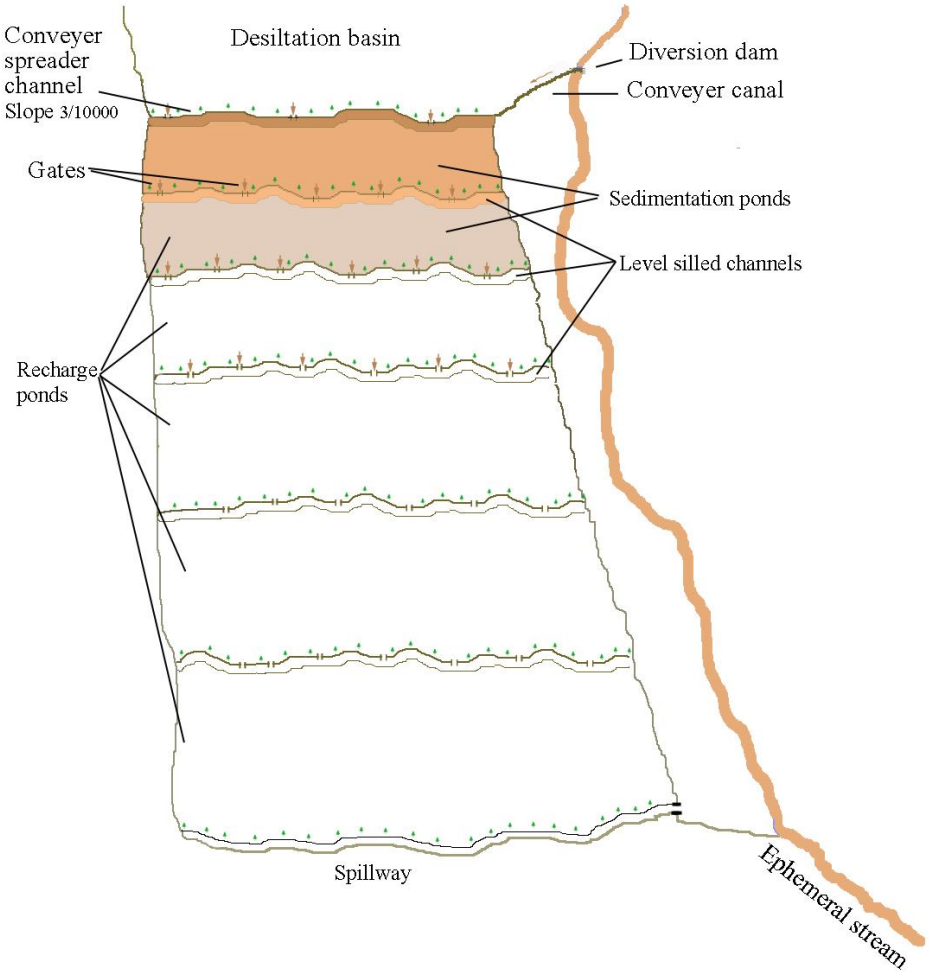
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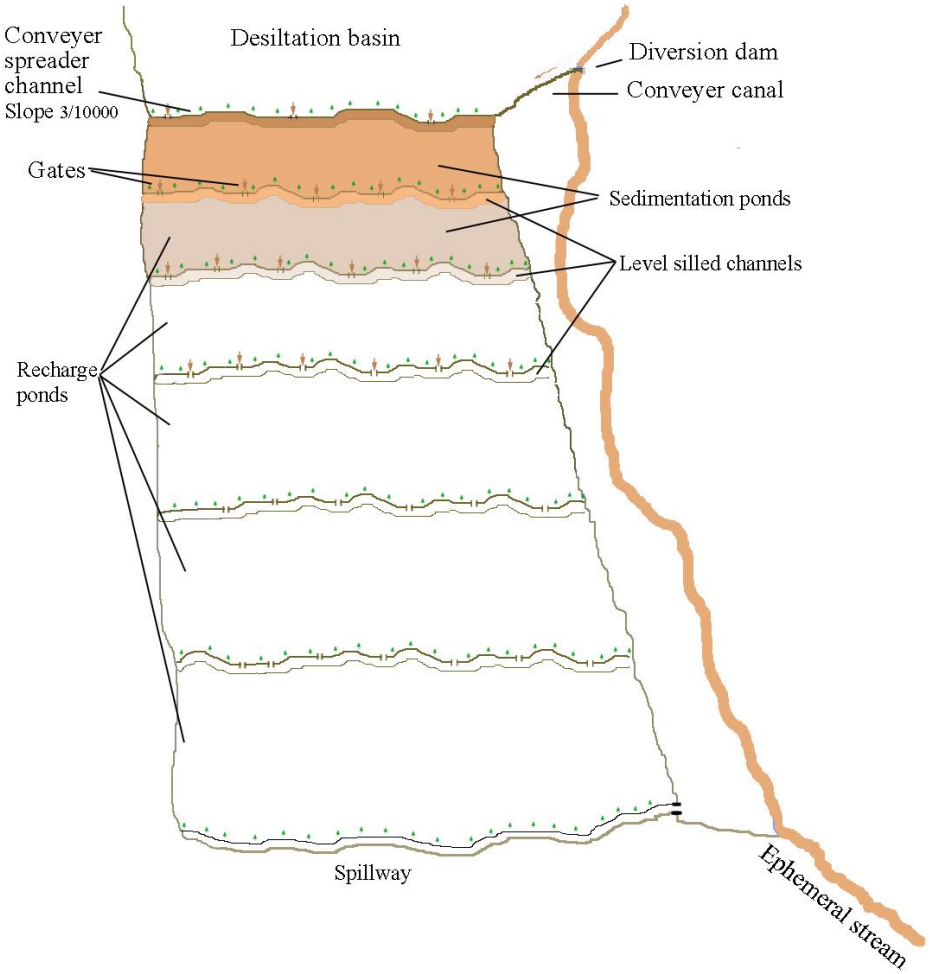
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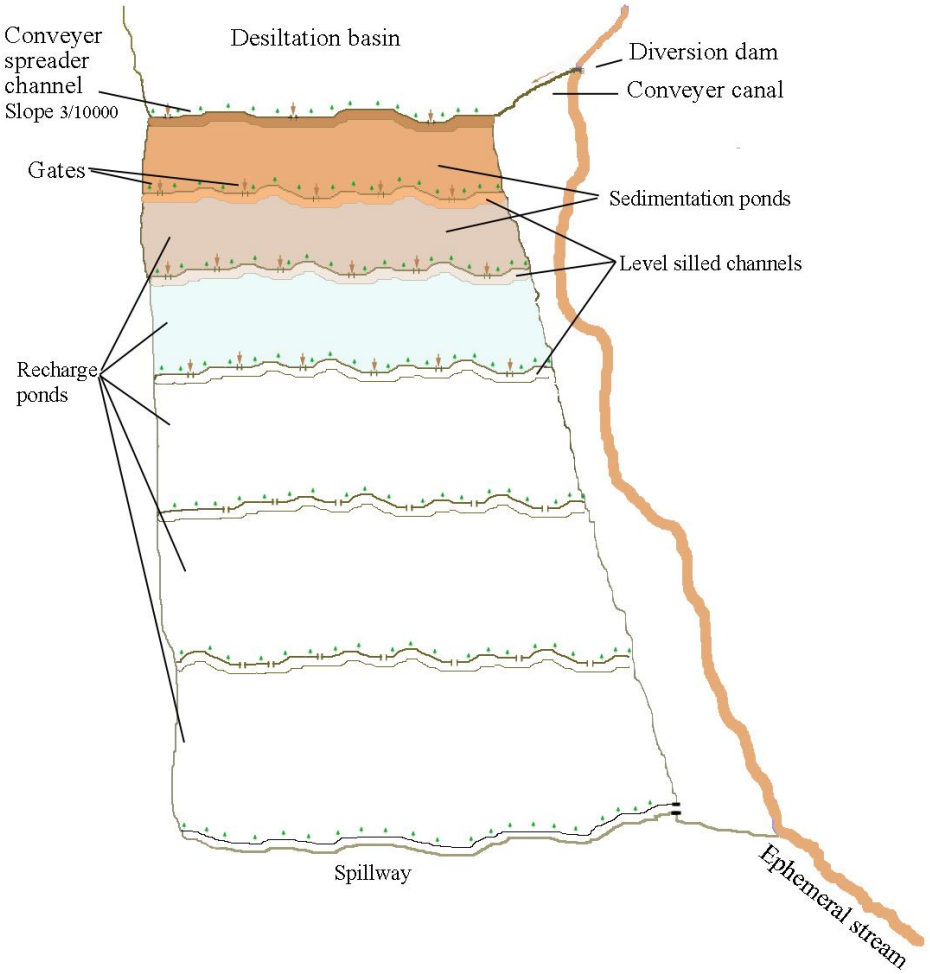
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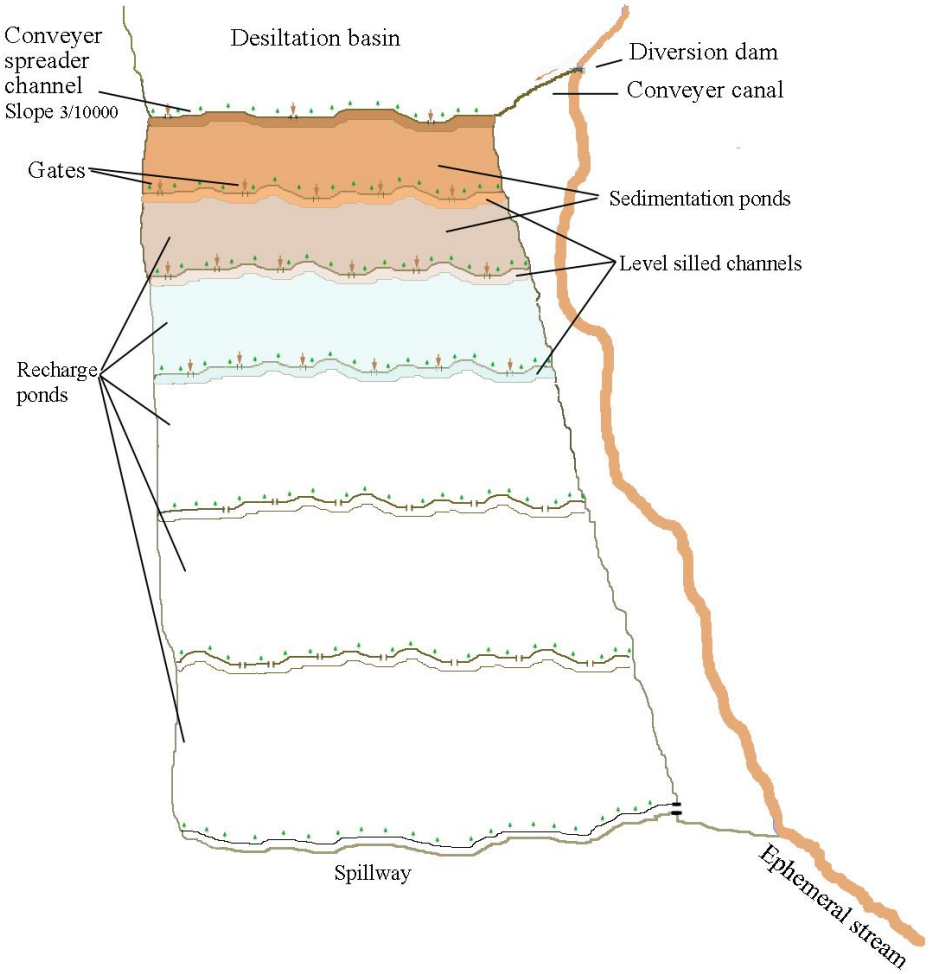
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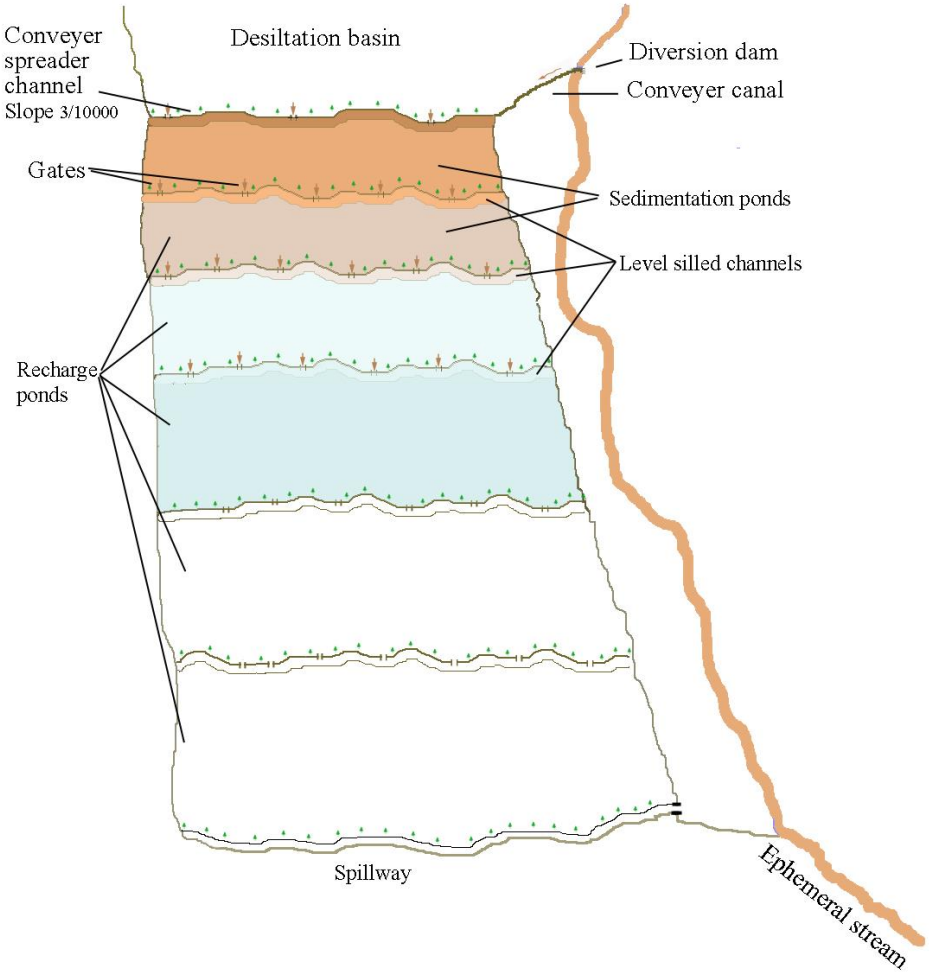
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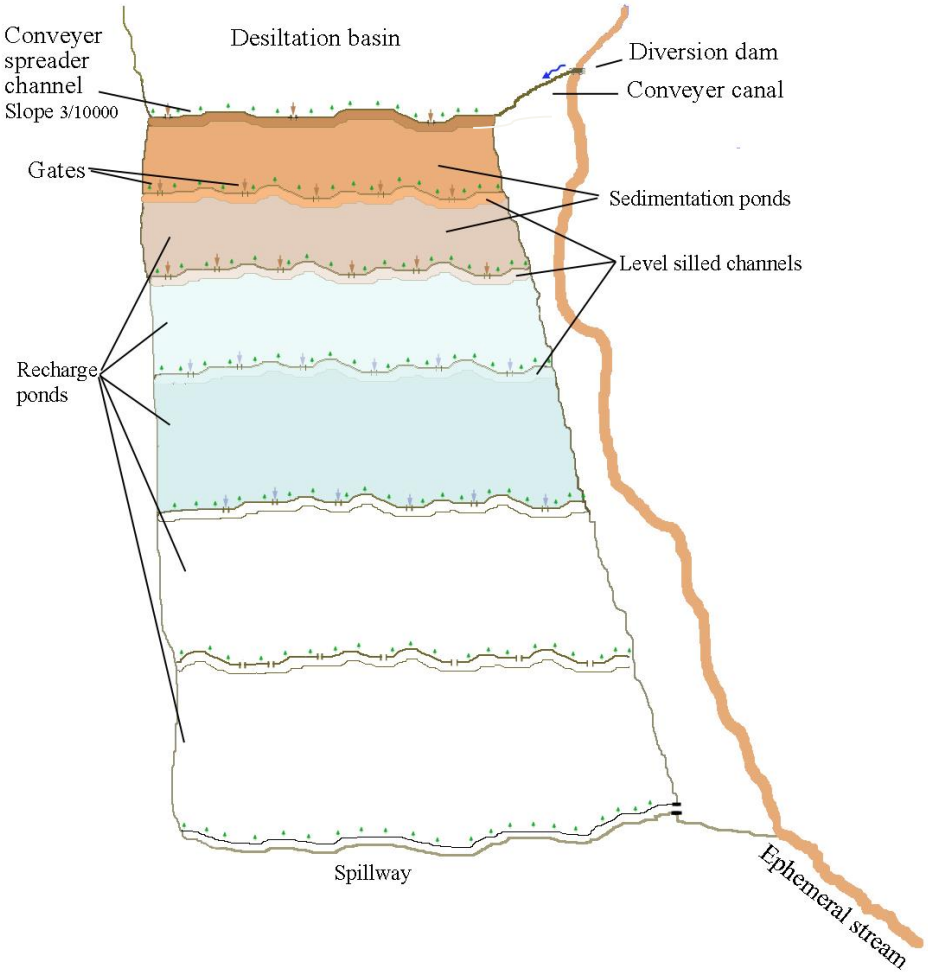
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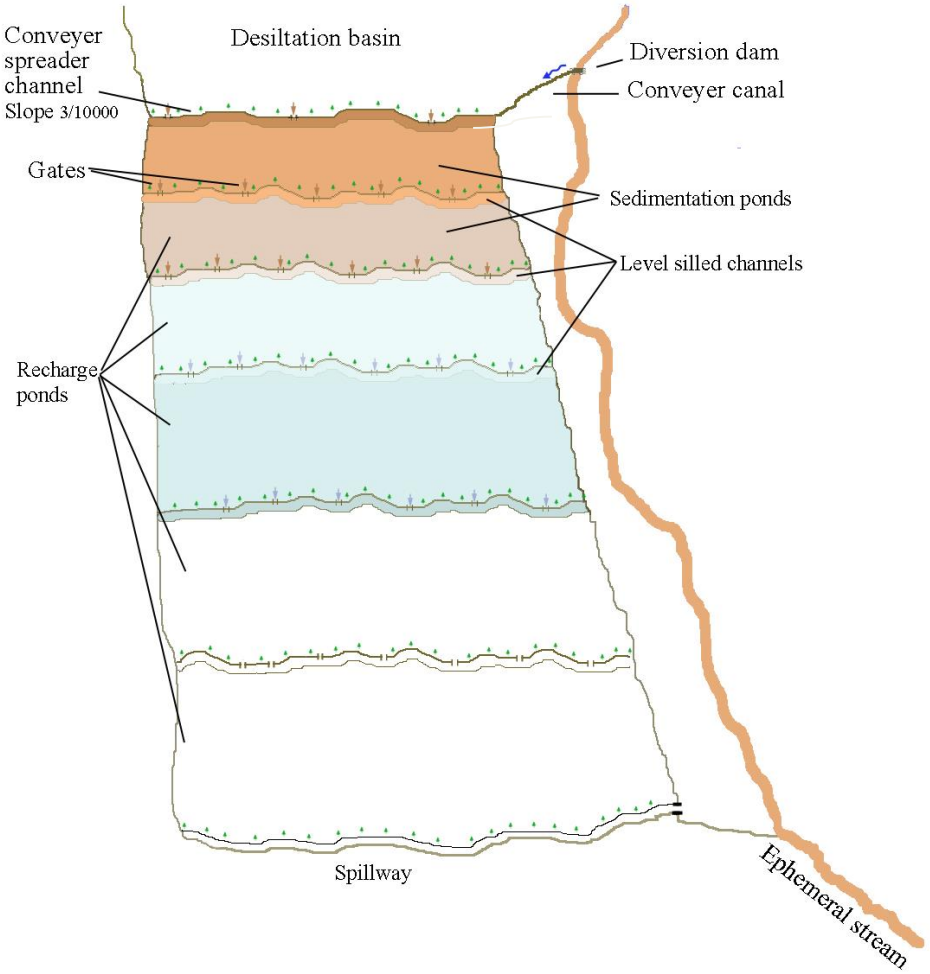
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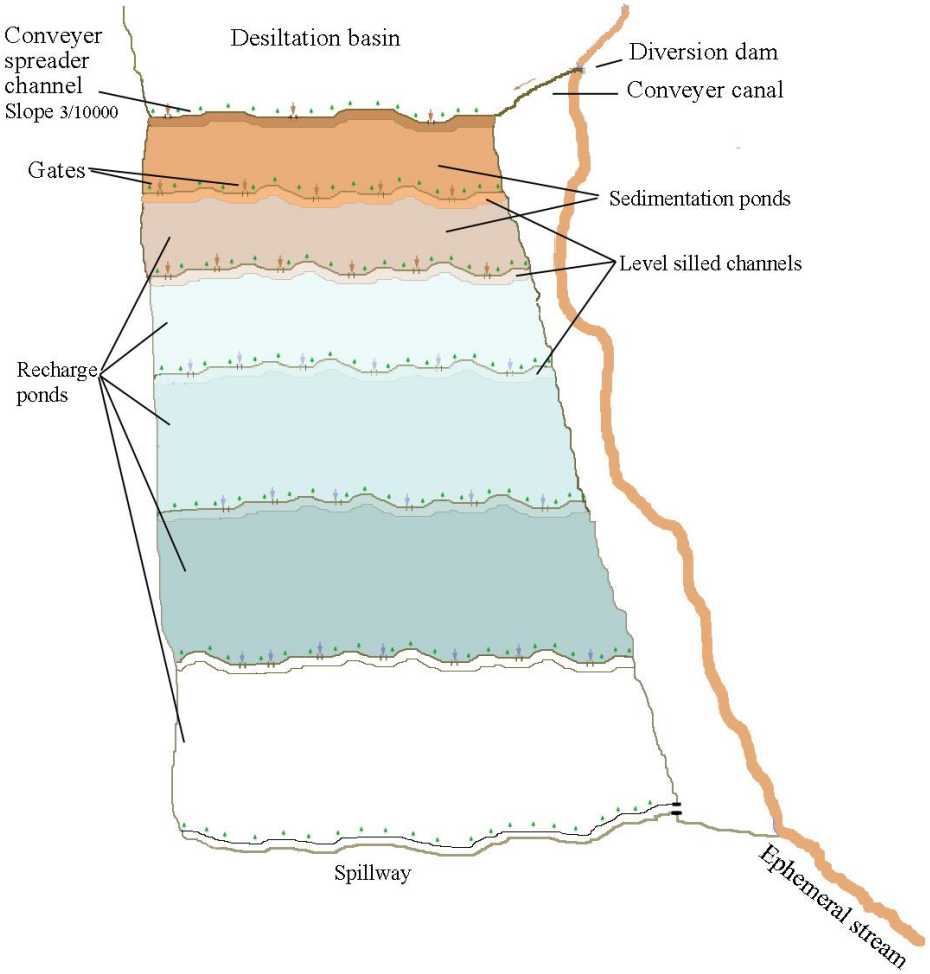
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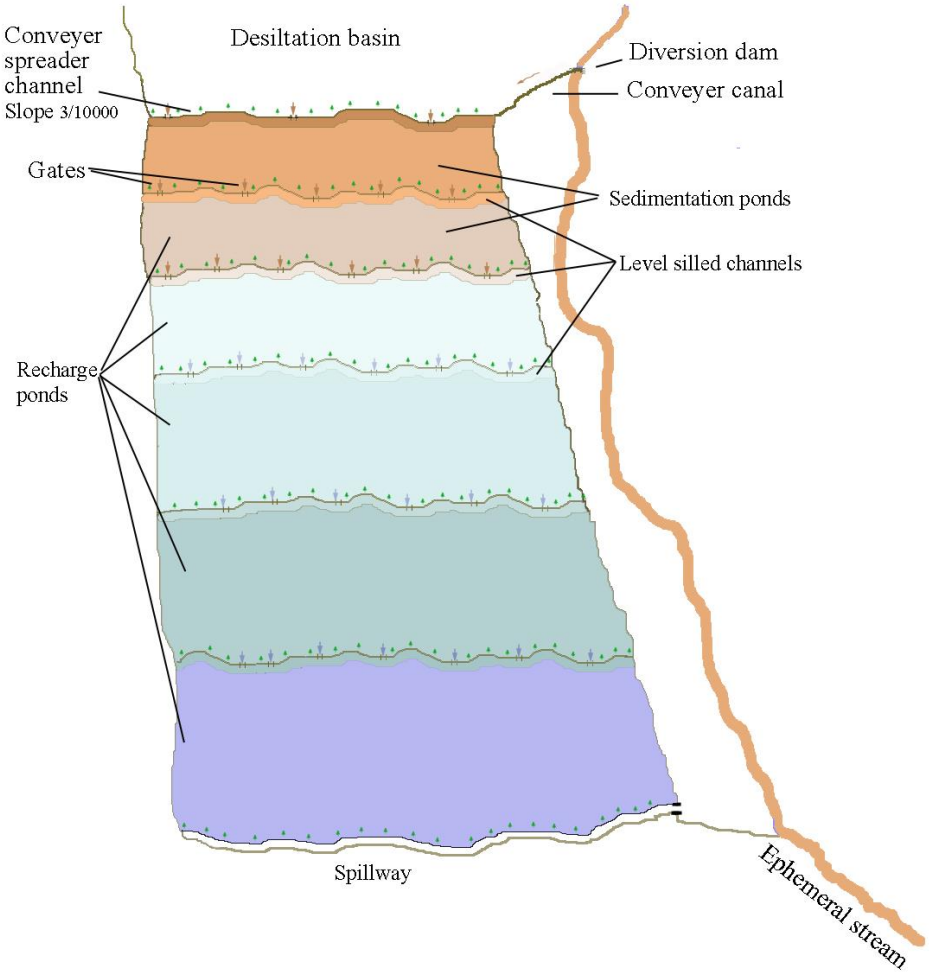
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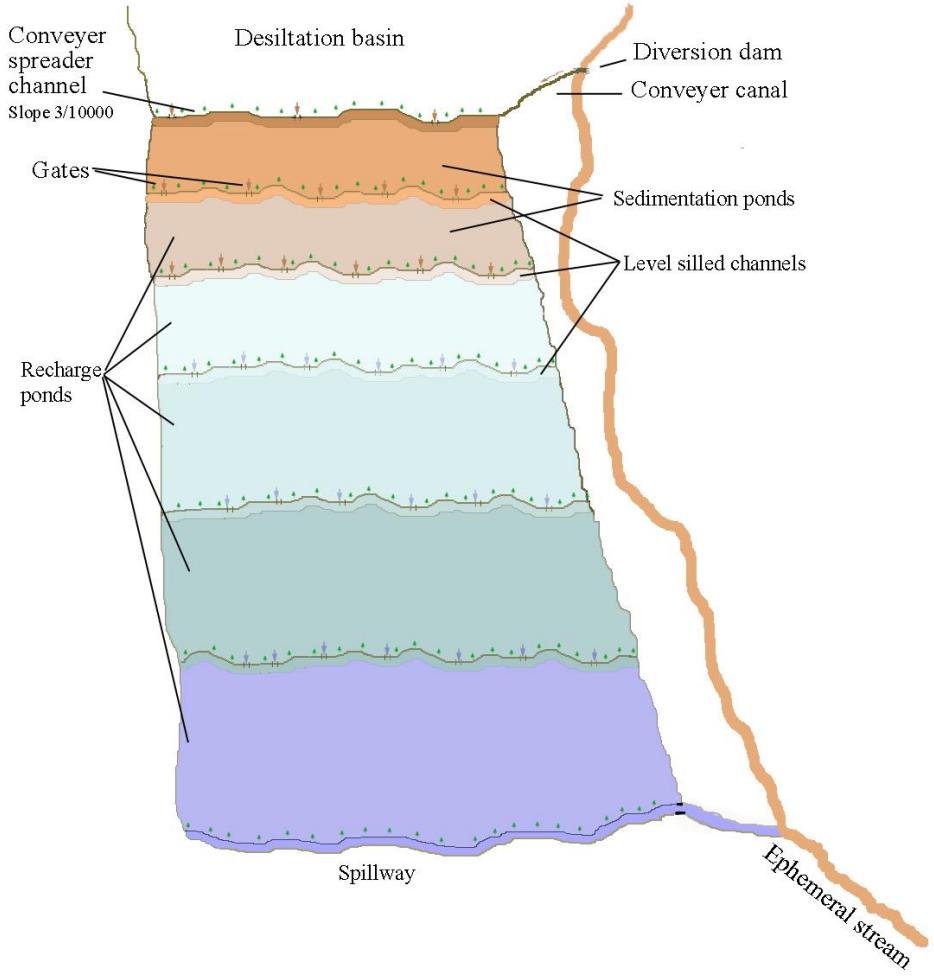
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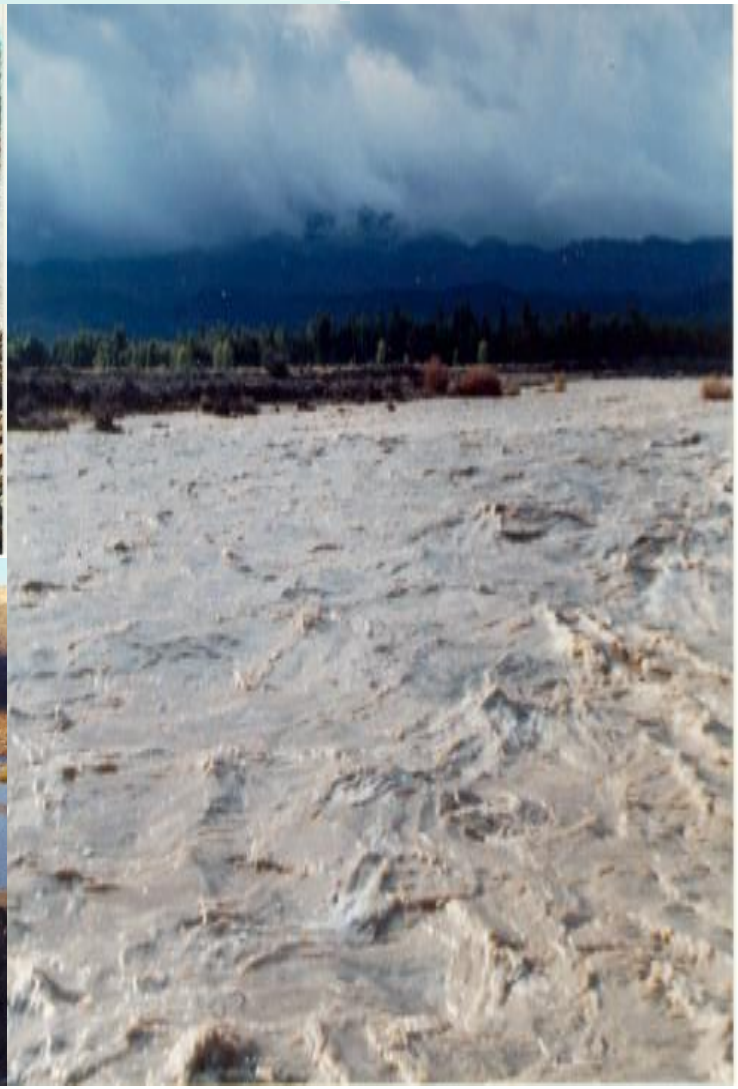
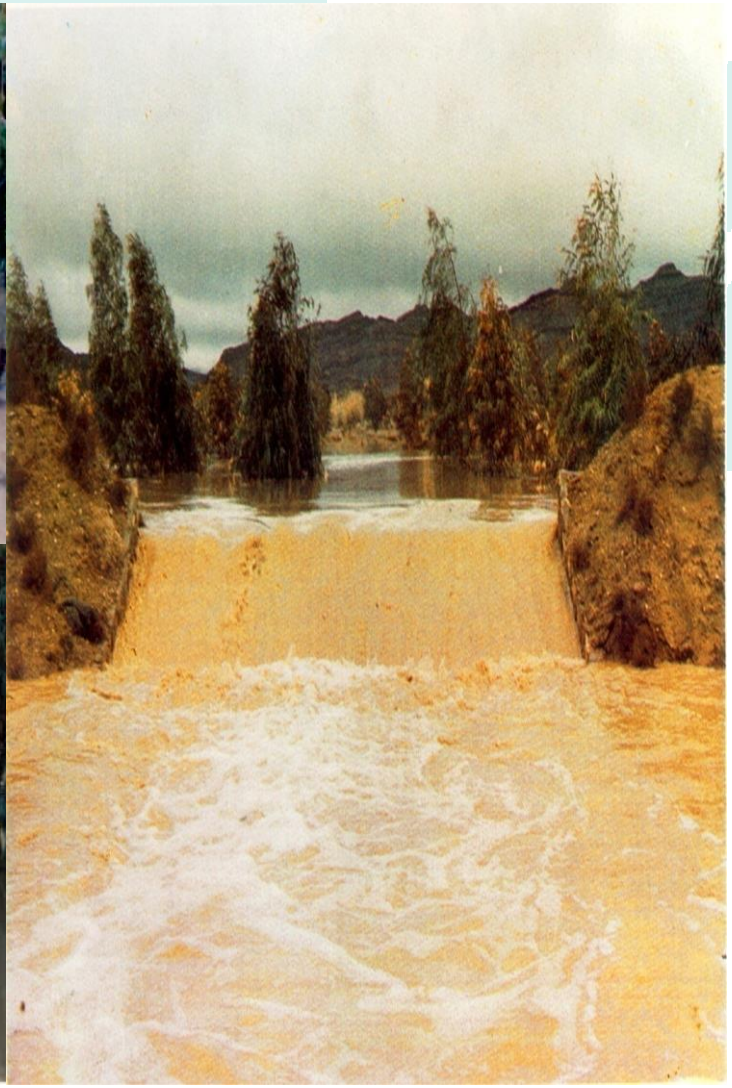
(a)
(b)
(c)
(d)

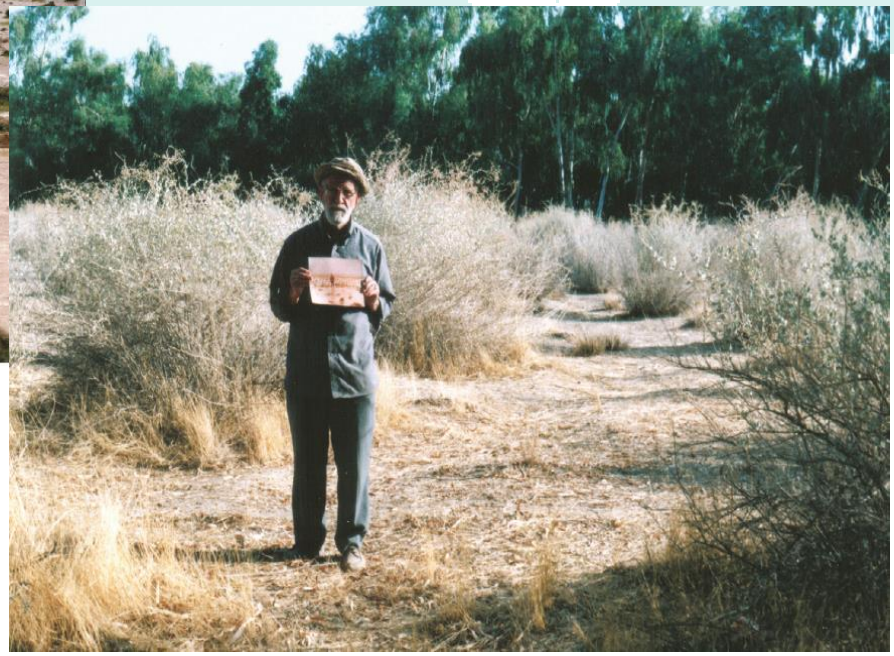




Before FWS (1983)

After FWS (2003)

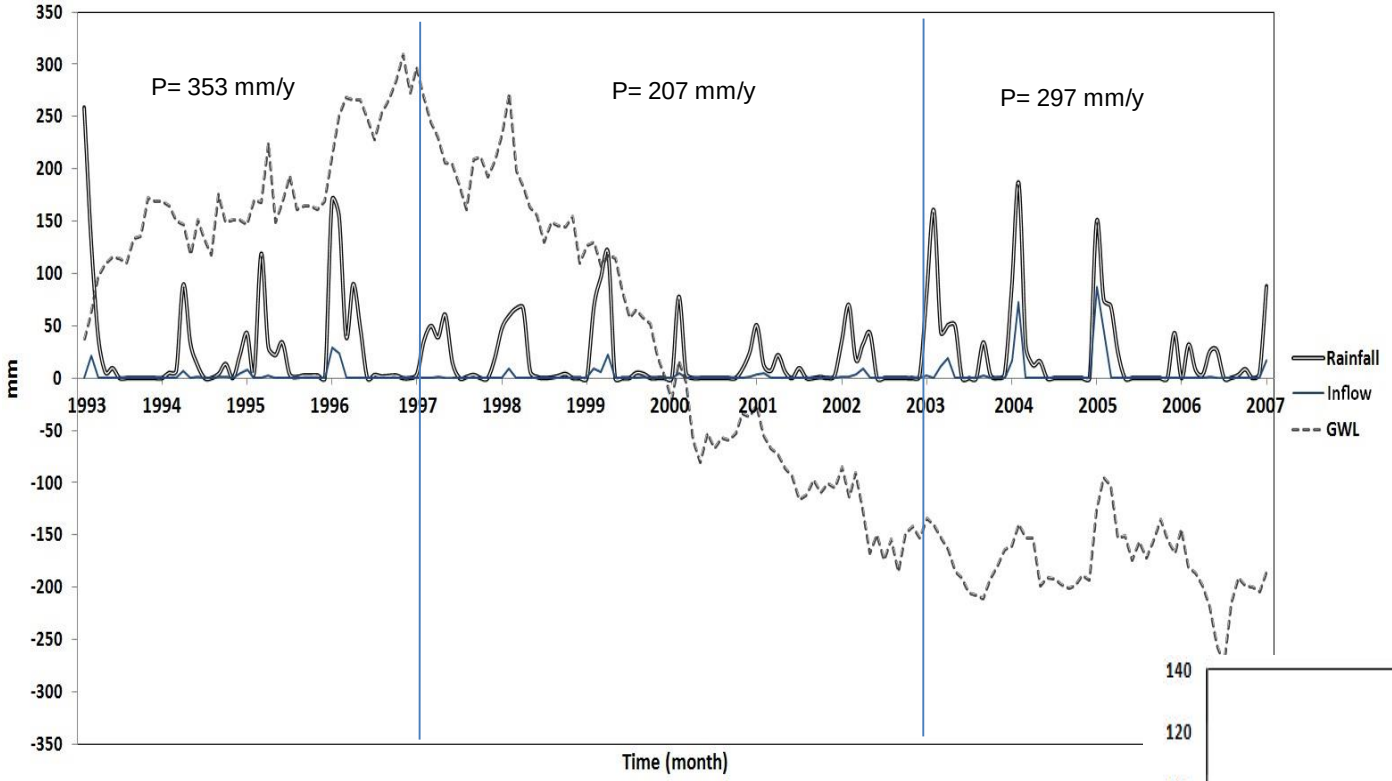
Before FWS (1983)

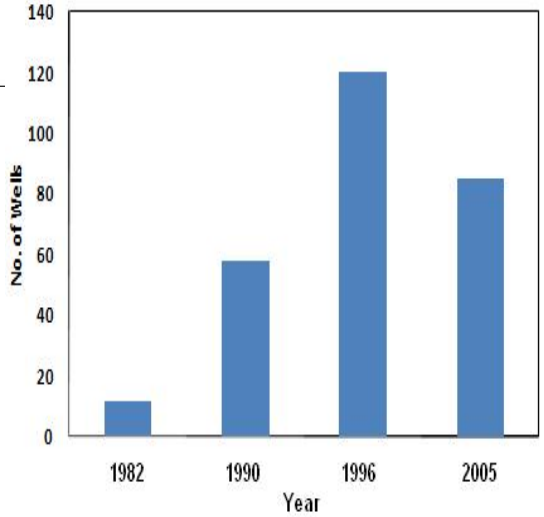


After FWS (2003)

Project locations

Floodwater spreading (FWS) project locations across Iran country.

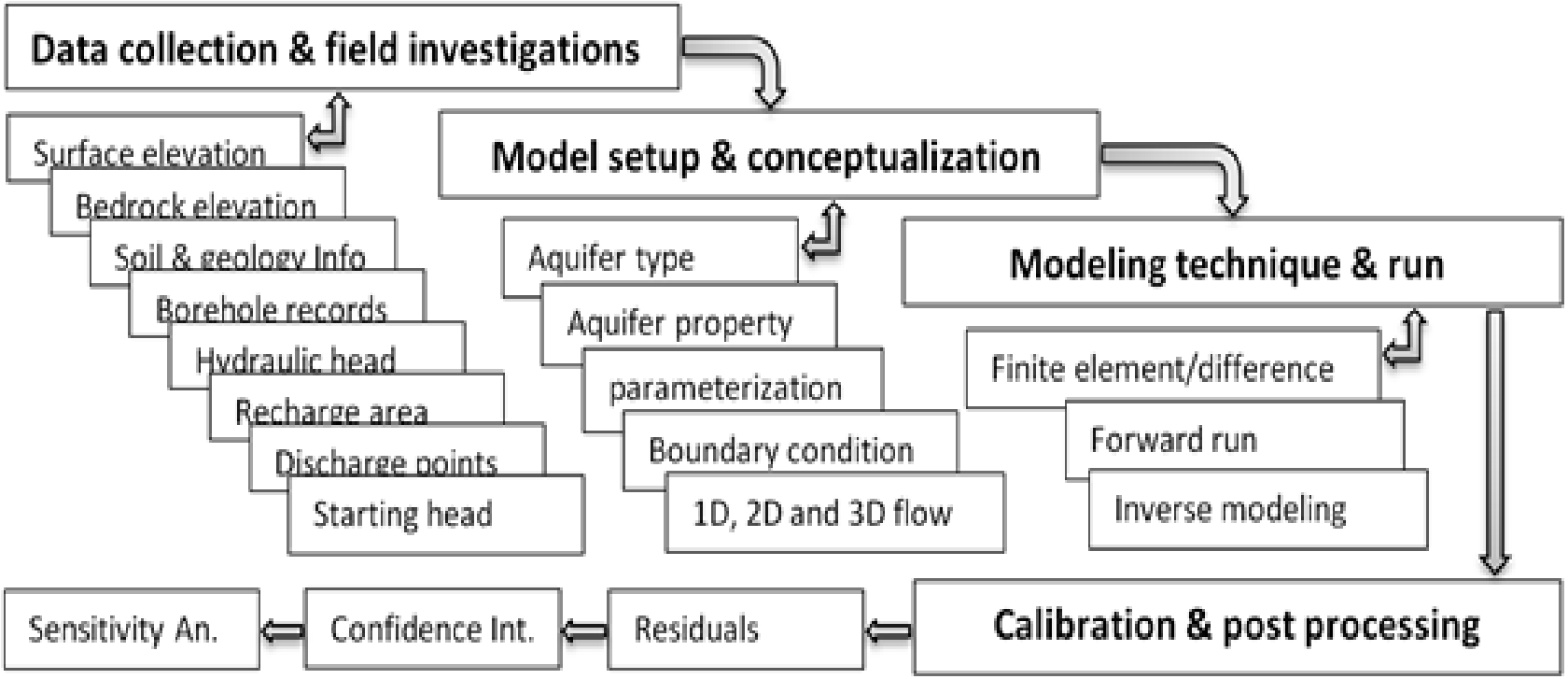

P= 353 mm/y
P= 207 mm/y
P= 297 mm/y
mm
Time (month)
Rainfall
Inflow
GWL


No. of Wells
Year

Groundwater model

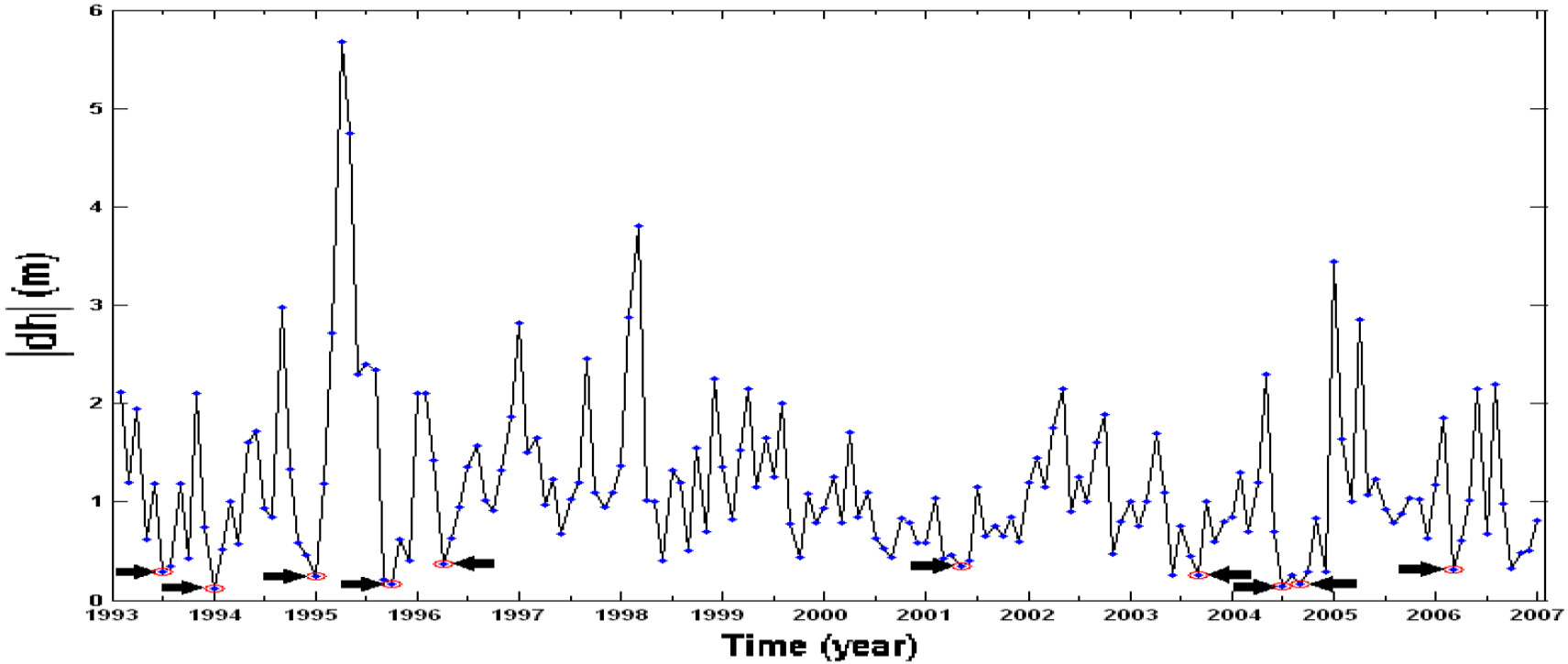
MODFLOW-2000

1) Steady-state 2) Transient

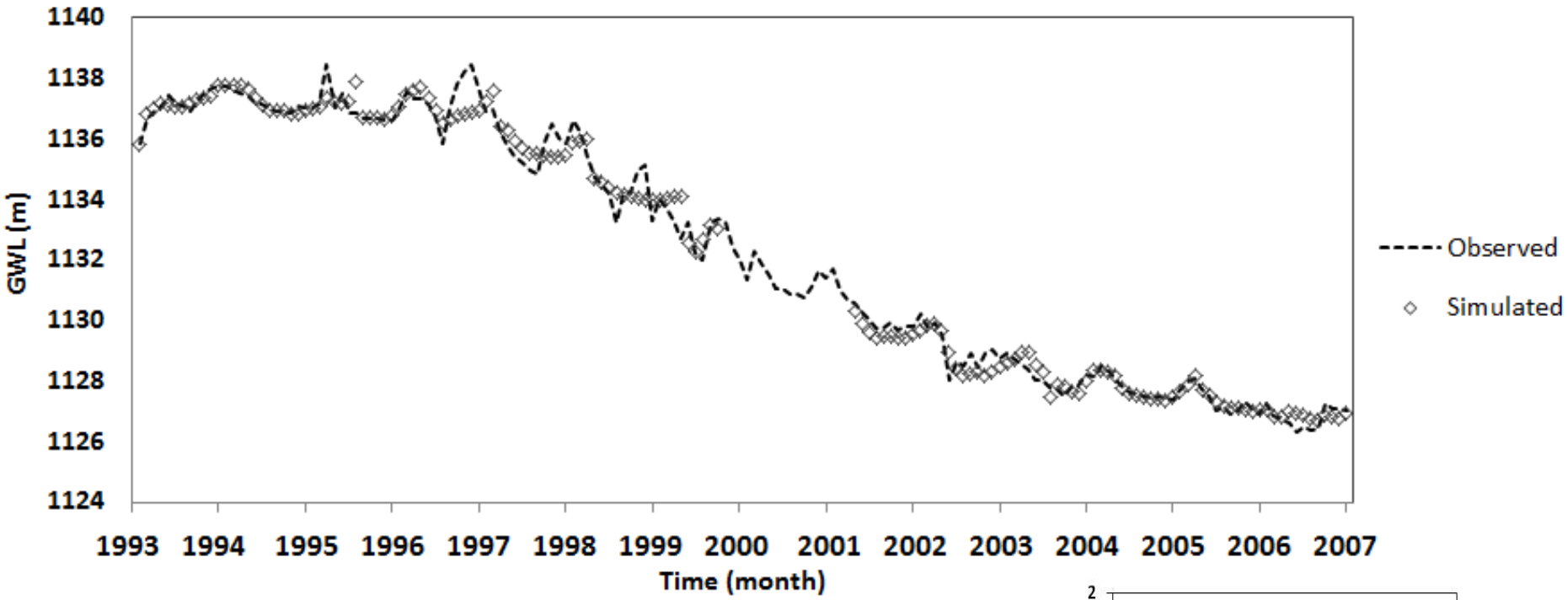


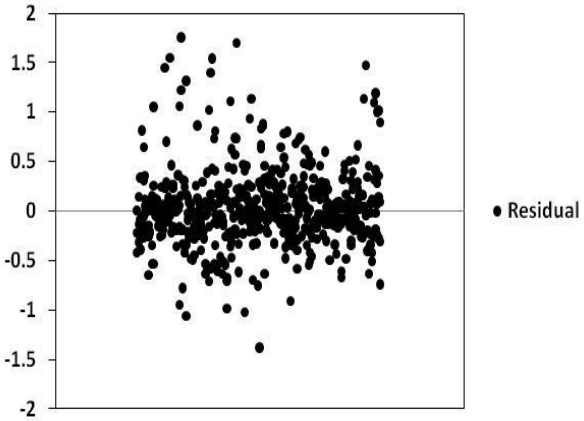
Steady and unsteady state condition

- One way to simplify the model calibration is to choose steady-state time intervals when aquifer parameters such as storativity and storage coefficient can be ignored.
- In steady-state intervals the heads in observation wells are almost constant over time.
- The estimated parameters can then be transferred to transient or unsteady models.

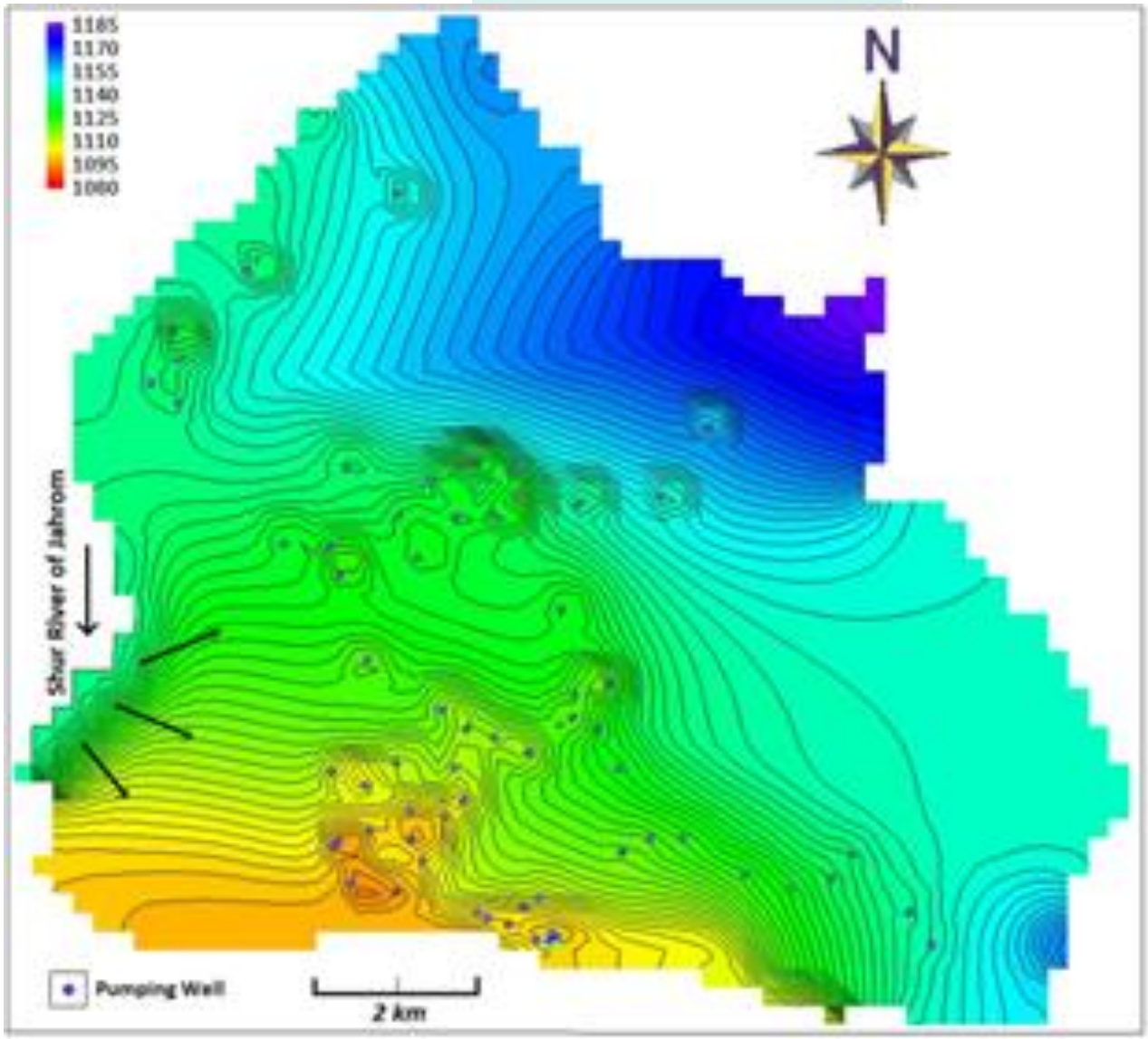


Unsteady-state modeling

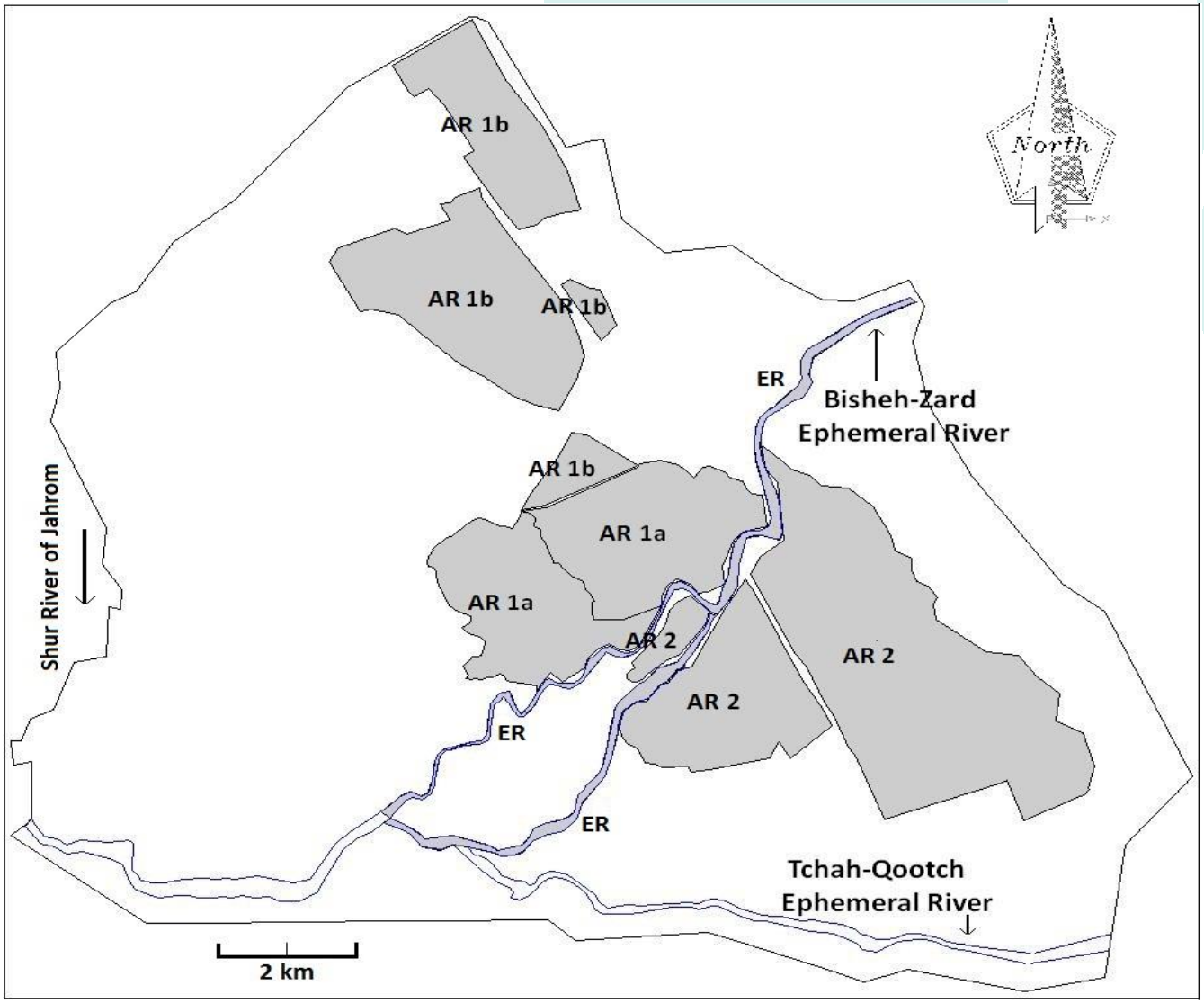




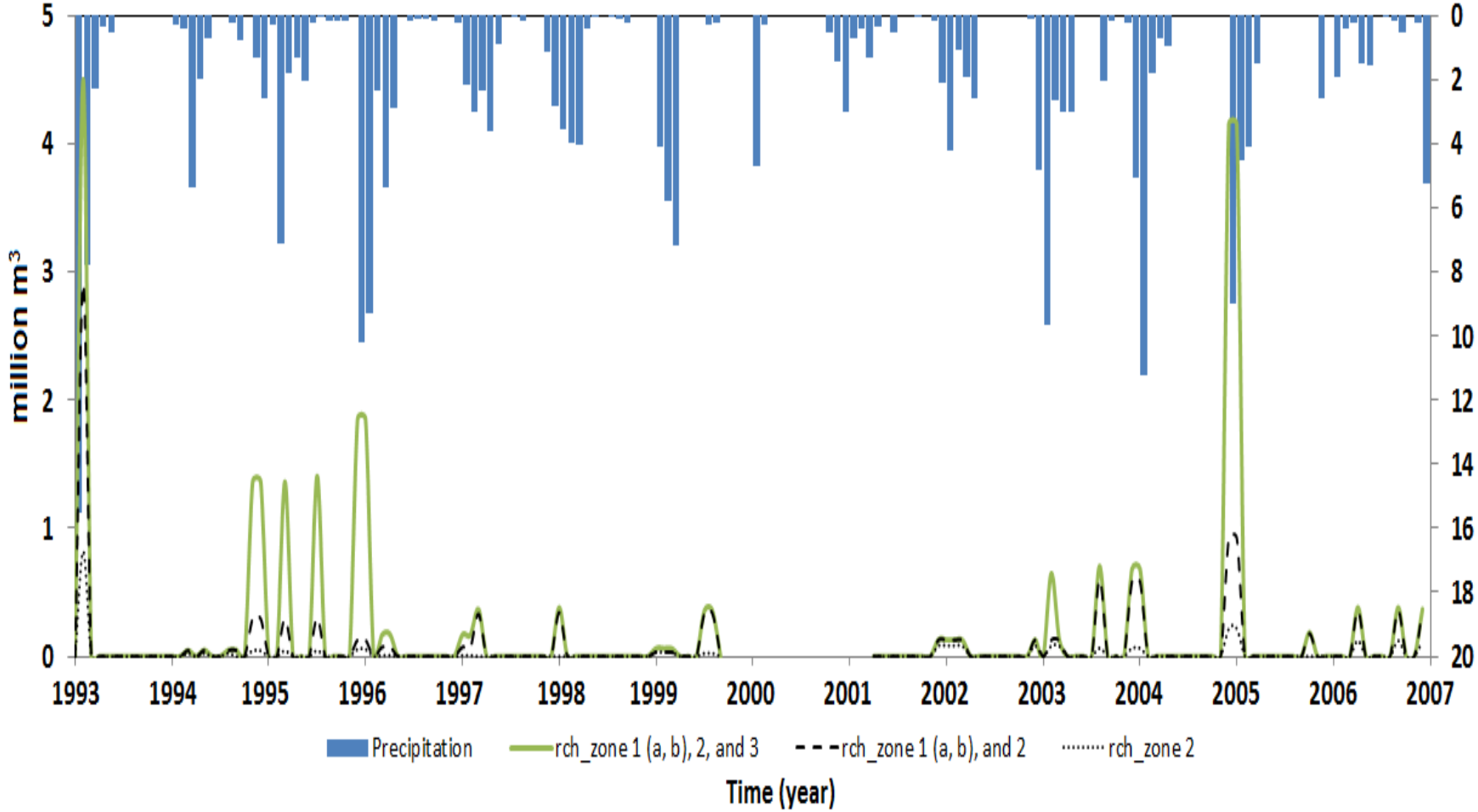
Groundwater flow



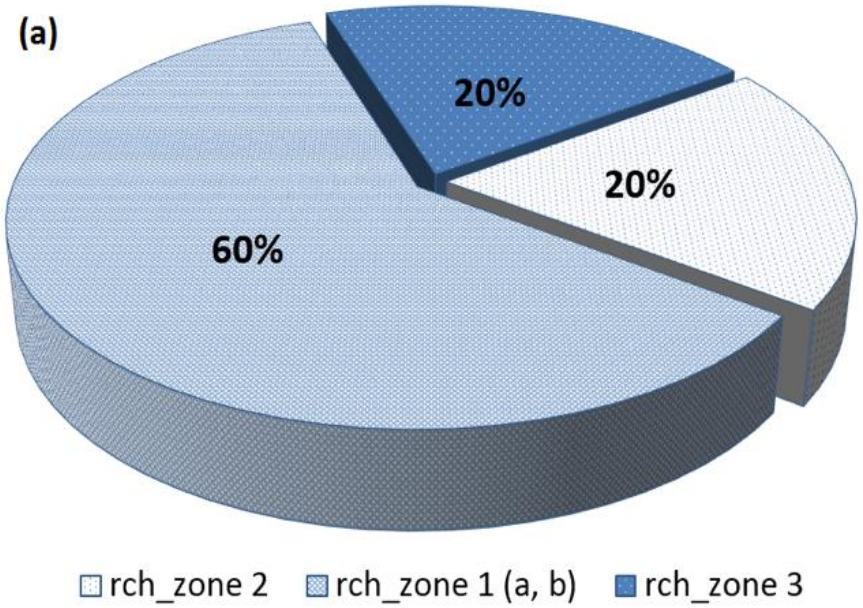
Recharge zones

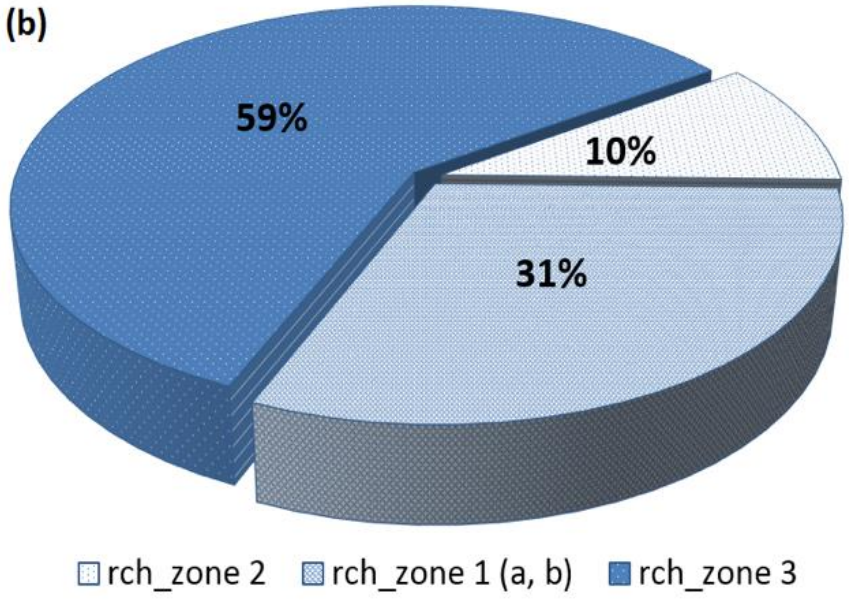


Recharge estimation



Artificial vs. Natural recharge





Conclusion

- The WH techniques are indigenous, parsimonious, and well adapted to the social, economic, and environmental properties of the arid world. The technique is multi-purpose and multi-functional to overcome basic problems associated with water availability in rural areas.
- The results also showed that the estimated total recharge varied between about several hundred thousand to 4.5 million m^3 per month for the rainy season.
- Results also show that extraction has a substantial effect on GWL drawdown that needs to be taken into account in the water resources management plan.

Questions for discussion!

- Can you give examples of groundwater recharge estimation in Tunisia?
- Groundwater usage in Tunisia (urban, industry, and agriculture)
- Artificial recharge projects in Tunisia?
- Water harvesting system for Artificial Recharge of Groundwater?
- Irrigation efficiency, and groundwater use in Tunisia.

That´s all for now!

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Assignment

- Collect rainfall and groundwater level timeseries (at least 5 years)
- Simple analysis of rainfall event and groundwater level fluctuation (correlation)
- Discuss the groundwater condition in your target aquifer during the study period
- Discuss whether the groundwater is influenced by rainfall or consequent runoff in your target basin