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SAT (Soil Aquifer Treatment) – The Long-Term Performance of the Dan Region Reclamation Project

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Why Wastewater Reuse ?

Domestic Wastewater

- **99.9% Water**
- **0.1% Solids (~1,000 mg/l)**

▪ **Even with successful urban demand management and increased irrigation efficiency, new water supplies will be needed in future**

▪ **Cost of supplying water from new sources is increasing due to: longer conveyance systems, higher pumping costs and higher treatment costs because of poorer water quality as a result of environmental pollution**

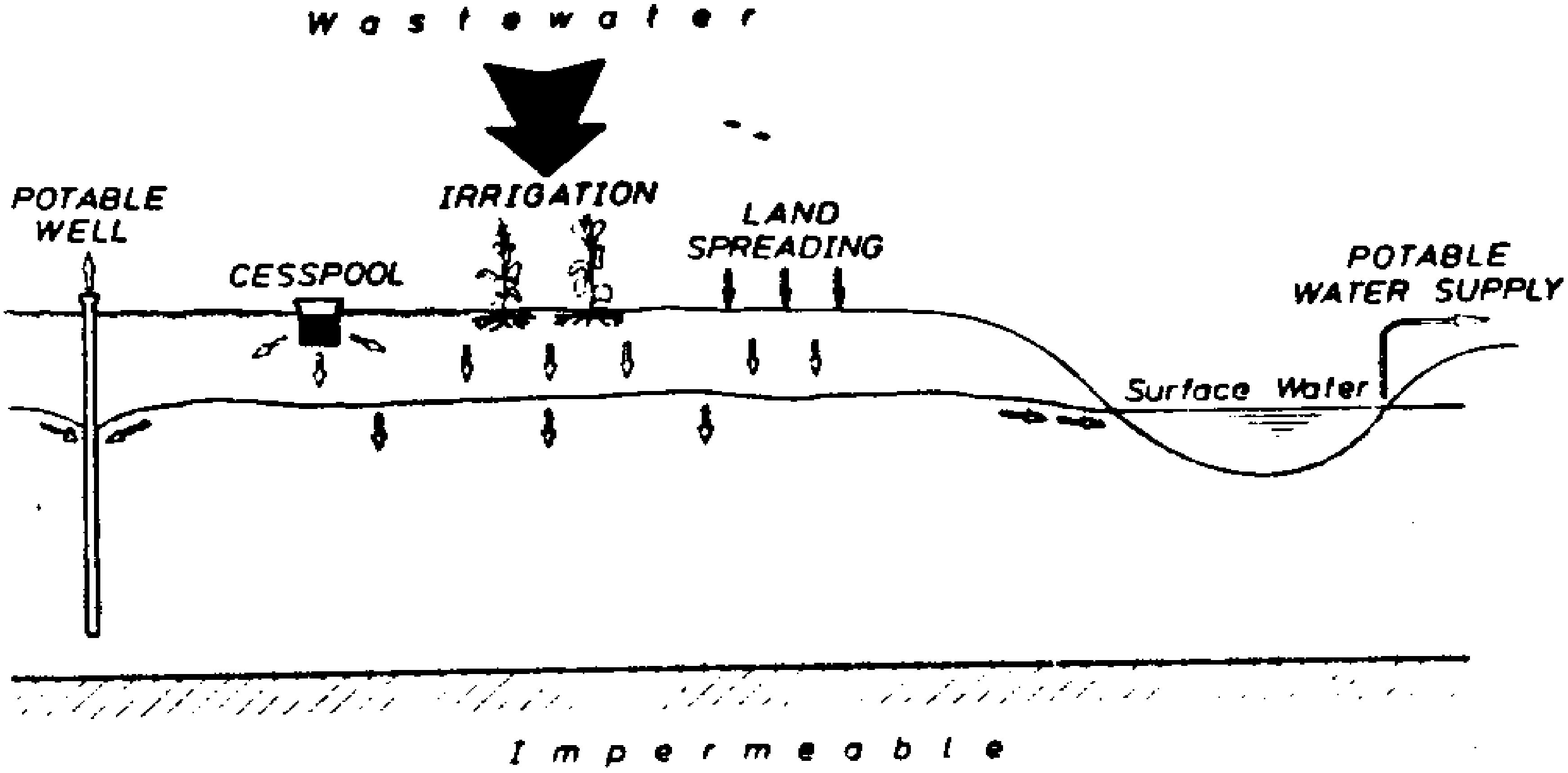
Approach to Wastewater Reuse in Israel

- **Reclaimed wastewater for irrigation in exchange of fresh water for potable supply**

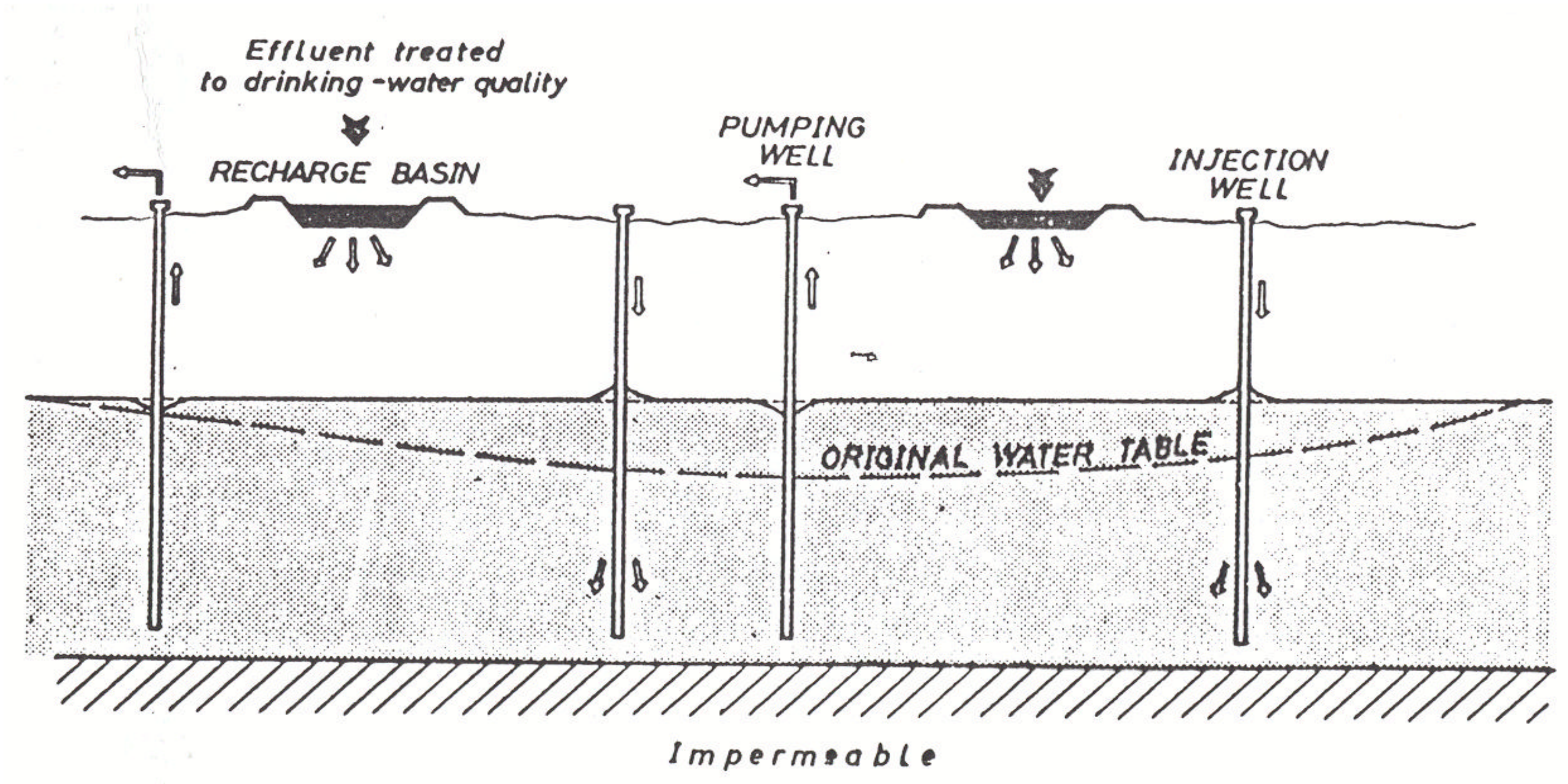
- **Groundwater recharge with effluent for soil-aquifer treatment (SAT) and integration of reclaimed water into national water supply system**

- **A dual supply network conveying separately potable water from natural sources and reclaimed water (after SAT) for unrestricted crop irrigation**

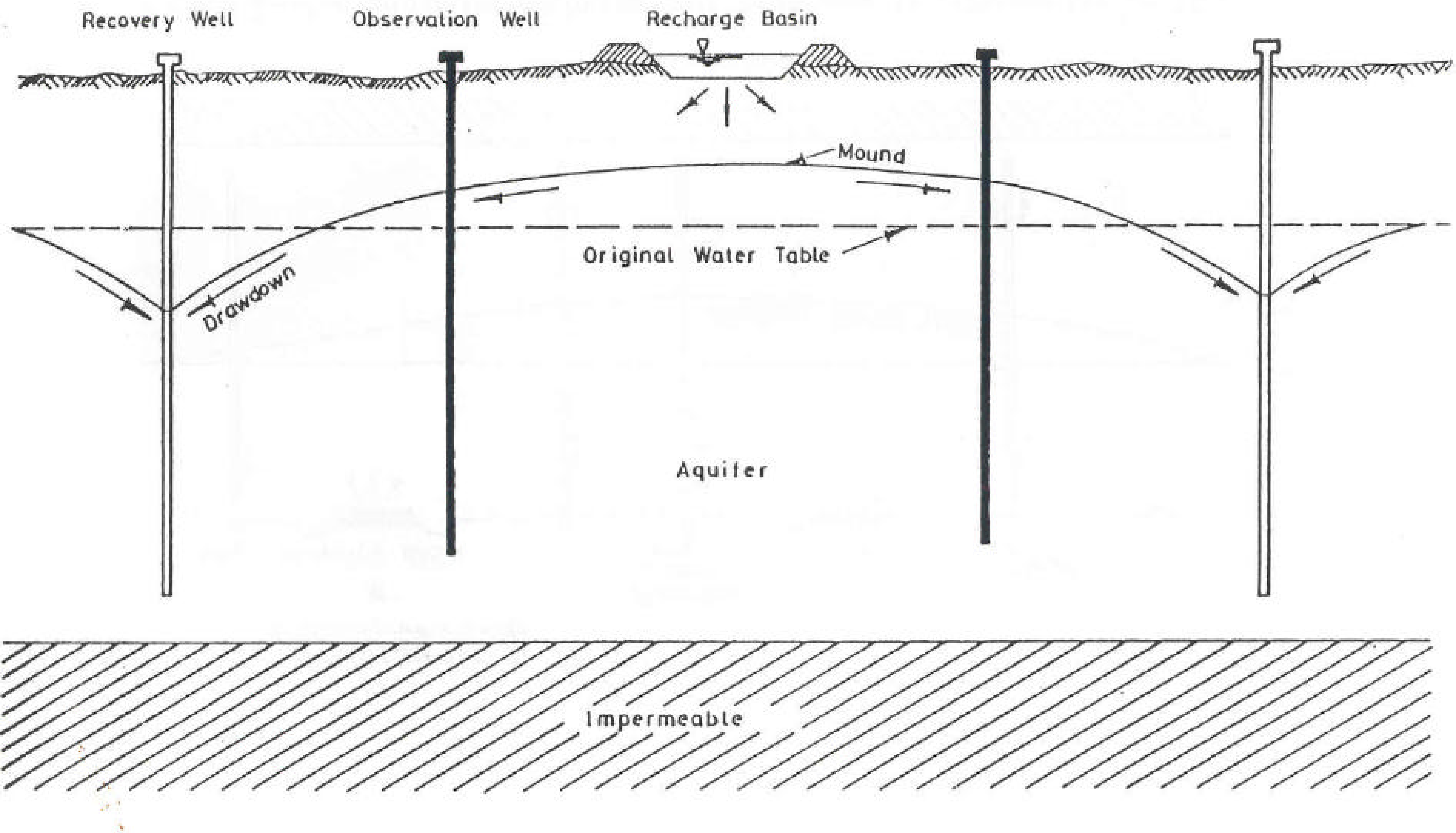
Old Method of Wastewater Reuse via Soil-Aquifer System



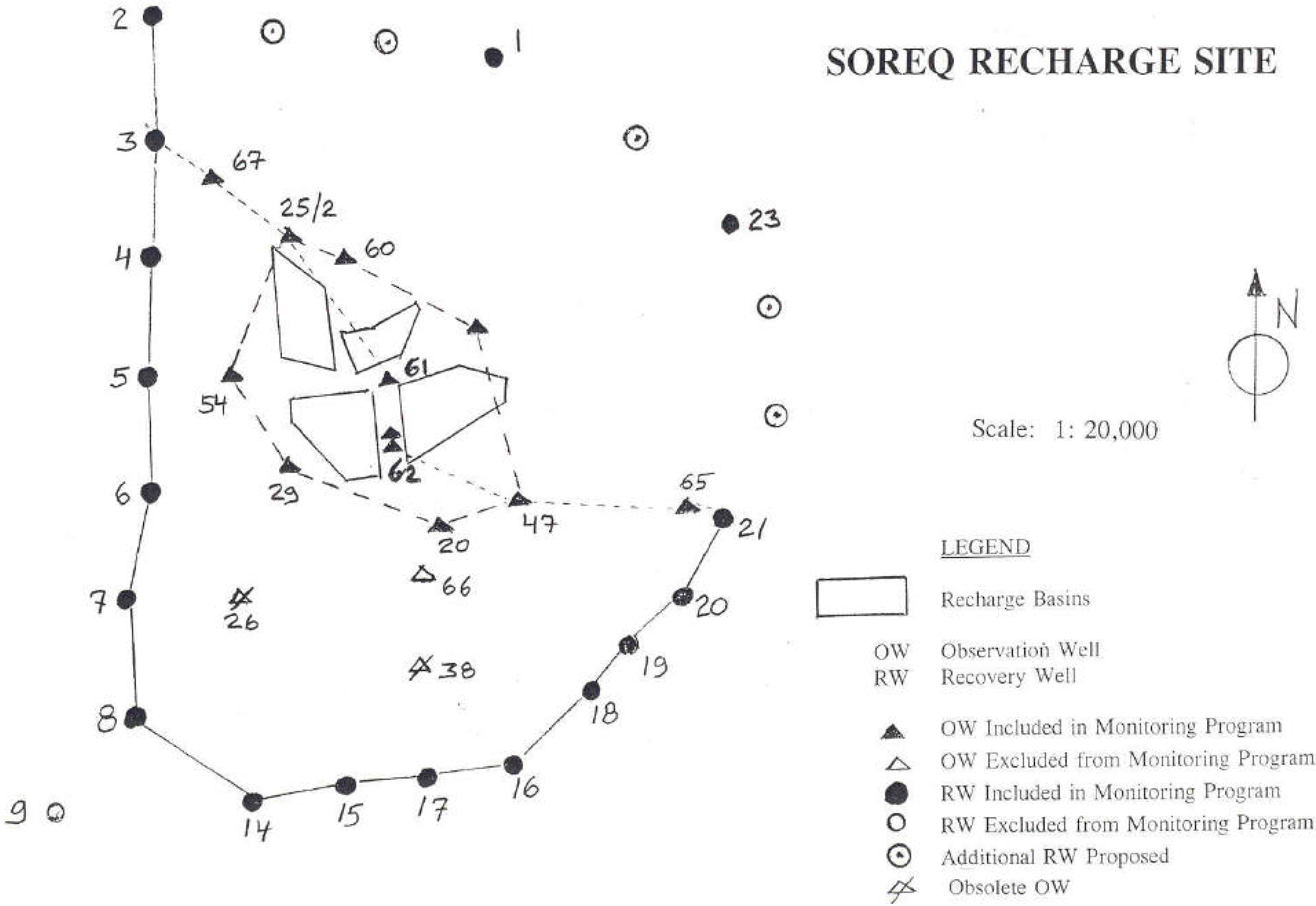
Groundwater Recharge with High-Quality Effluent for Aquifer Replenishment
(Southern California)

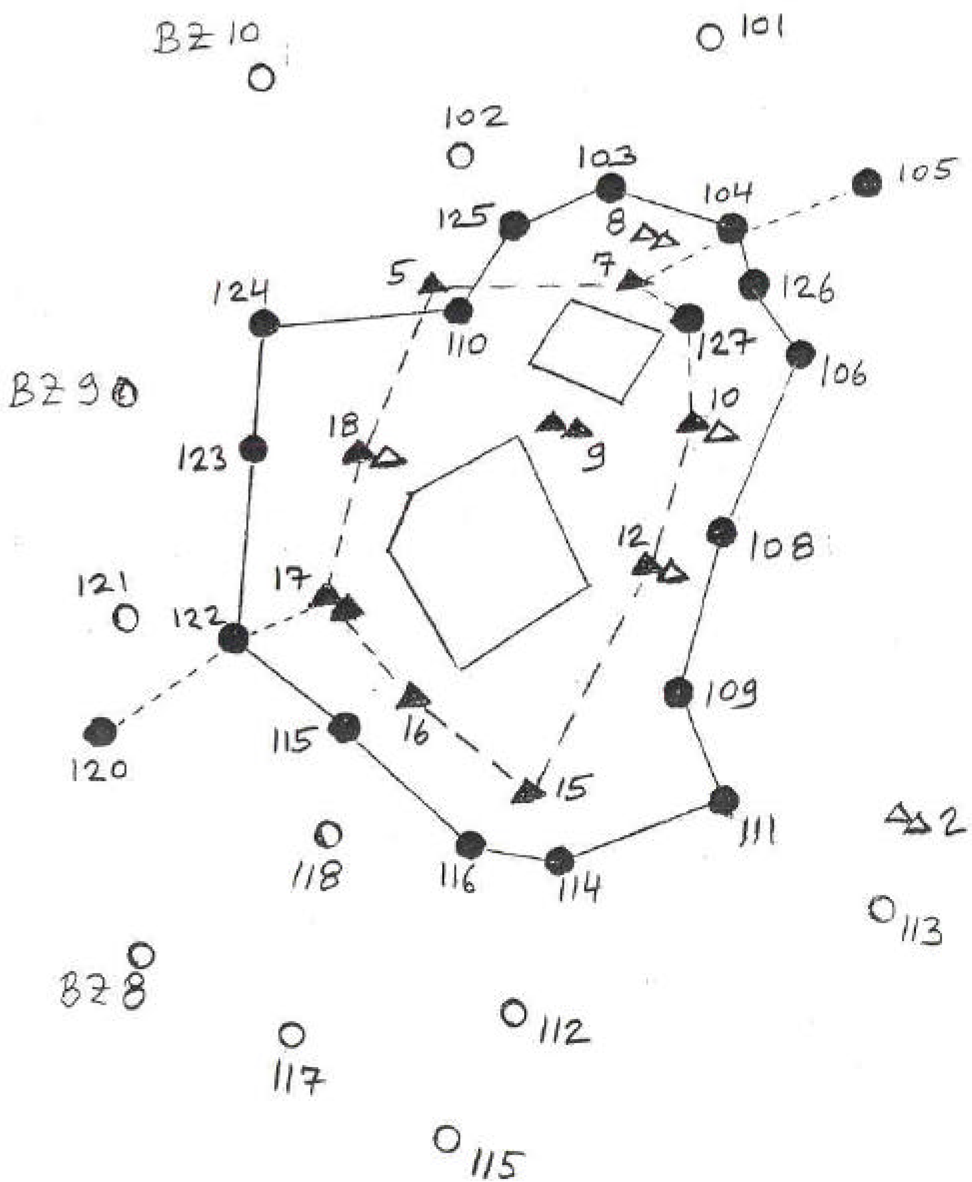


SAT Scheme – Dan Region Project in Israel

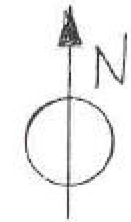


SOREQ RECHARGE SITE





YAVNE 1 RECHARGE SITE



Scale: 1: 20,000

LEGEND

Recharge Basins

OW Observation Well
RW Recovery Well

OW Included in Monitoring Program
OW Excluded from Monitoring Program
RW Included in Monitoring Program
RW Excluded from Monitoring Program

Data on Recharge Operation

Recharge Site	Soreq	Yavne
Area (ha)	25	60
First Recharge Year	1977	1987
Years of Operation	25	15
Total Volume Recharged (MCM)*	400	850
Cumulative Hydraulic Load (m)**	1,600	1,400

* **Volumes recharged are cumulative until 2001**
MCM – million cu.m

** **Load corresponds to ~2000 years of natural rainfall (700-800 mm per year)**

Recharge Basin during Flooding Period

Recharge Basin during Drying Period

Inlet Structure to Recharge Basin

Top Algae Layer

Top Layer before Cleaning

Cleaning of Basin

Extensive Monitoring Program

Before SAT:

- **Recharge Effluent - RE** (effluent pumped to recharge basins)

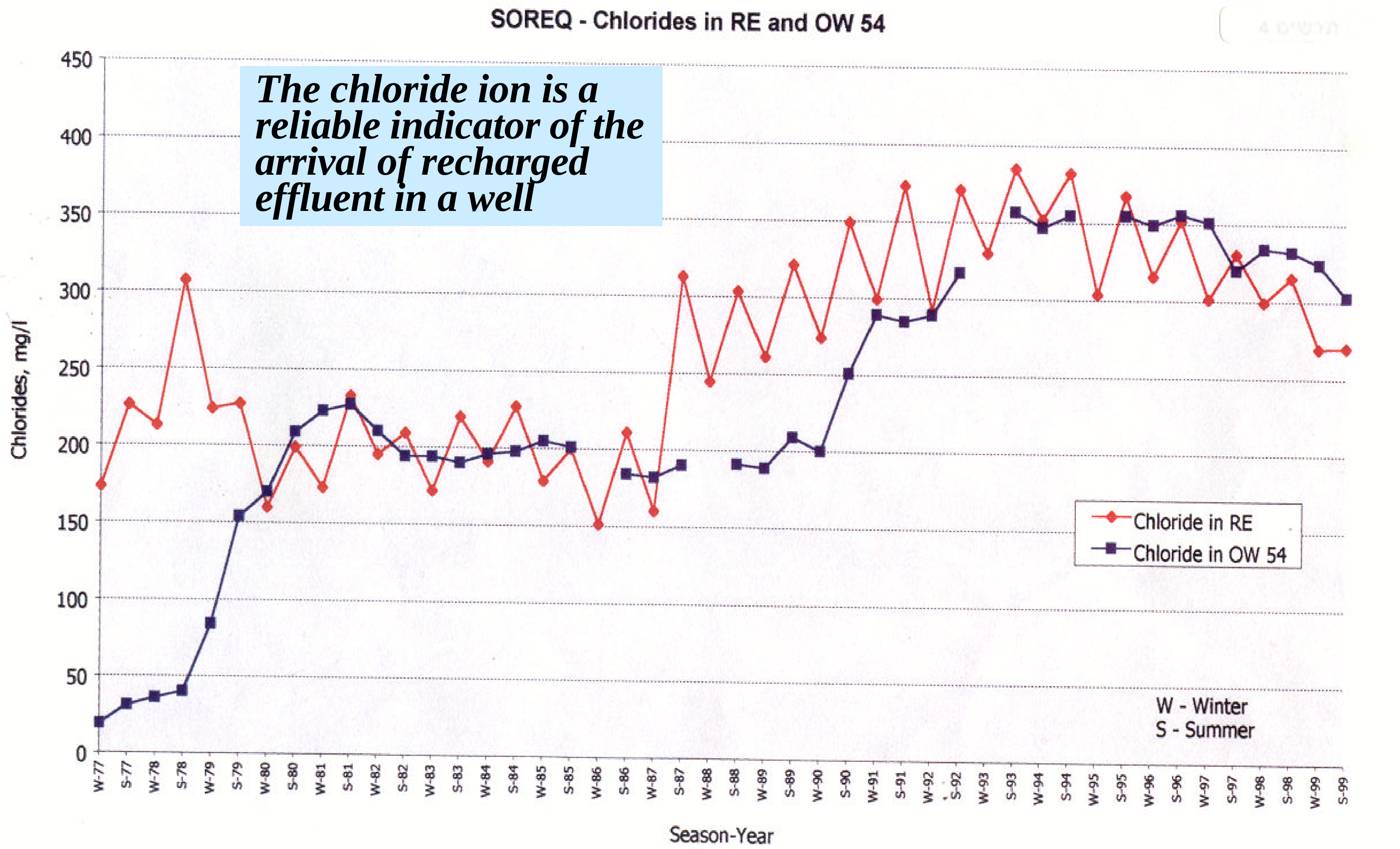
After SAT:

- Some 50 **Observation Wells - OW**
  - Close to recharge basin (50-100 m)
  - Far from recharge basin (2 0- 00 m)
- Some 100 **Recovery Wells - RW**
  - 50- 00 m from recharge basin

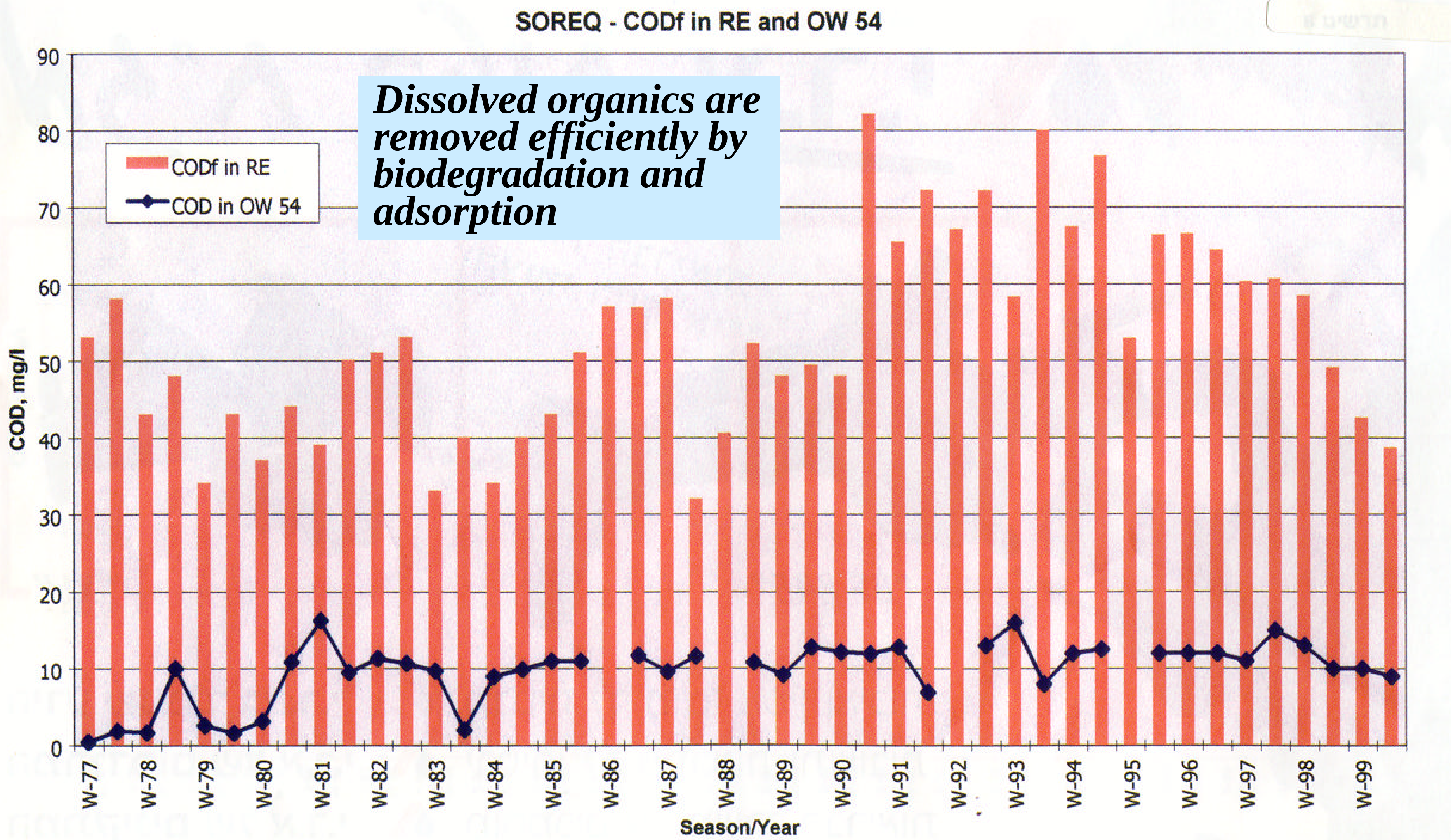
- Several **Potable Wells** - **PW** pumping from the same aquifer and located outside the ring of recovery wells to ascertain that the recharge-recovery operation does not affect the water quality of these wells

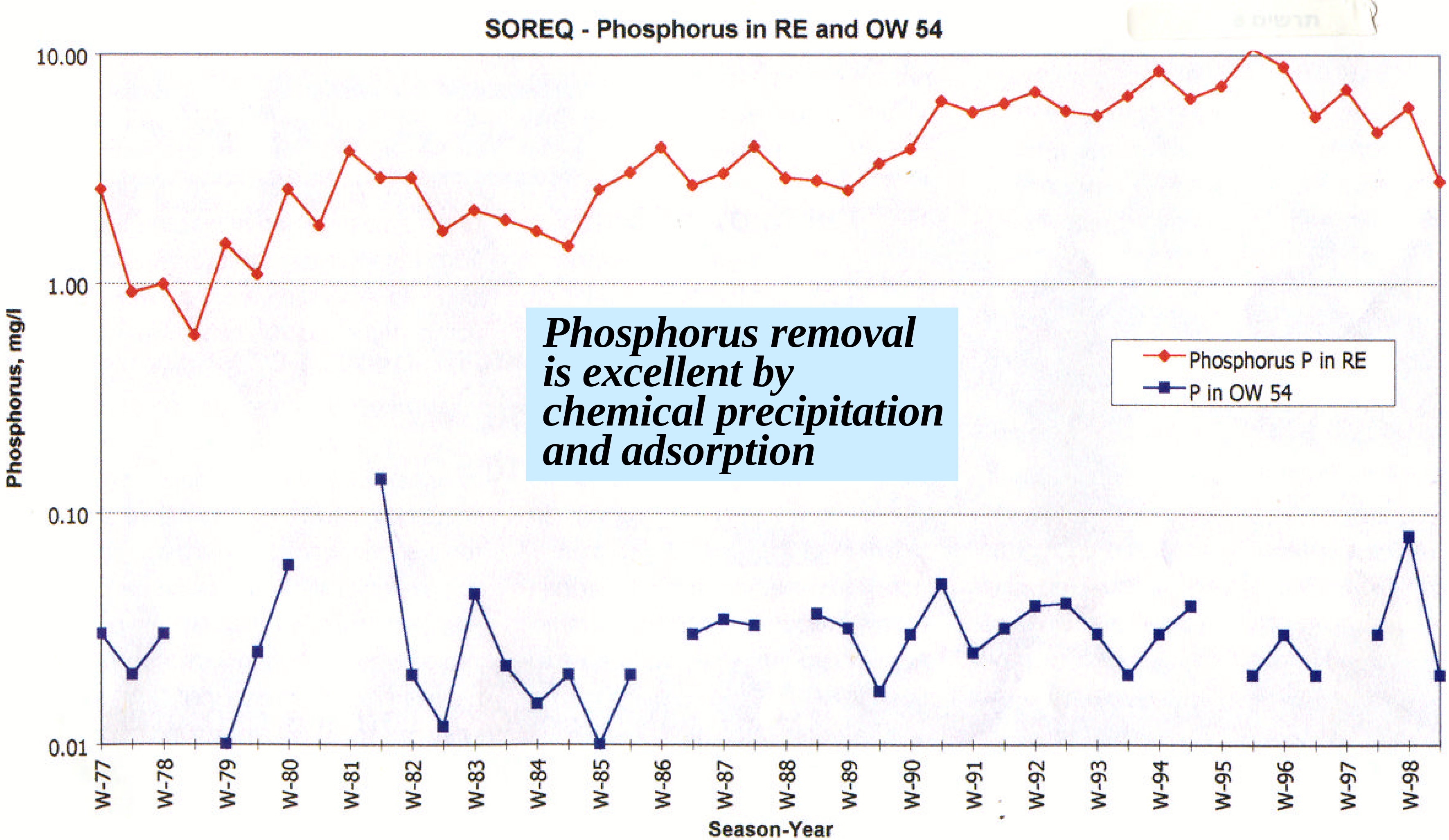
Observation Well

The chloride ion is a reliable indicator of the arrival of recharged effluent in a well



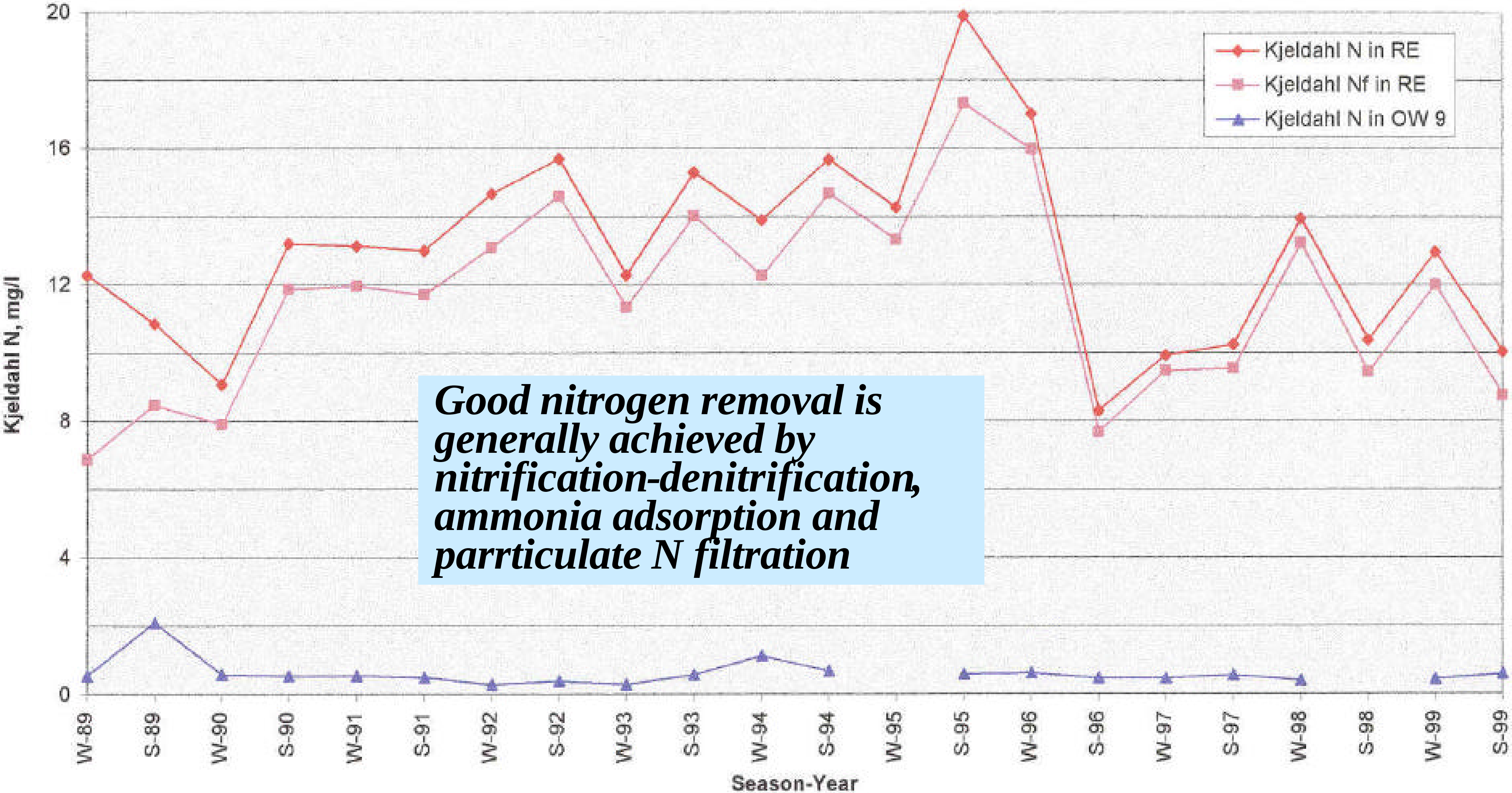
Dissolved organics are removed efficiently by biodegradation and adsorption





Phosphorus removal is excellent by chemical precipitation and adsorption

Figure 55
YAVNE - Kjeldahl N in RE and OW 9



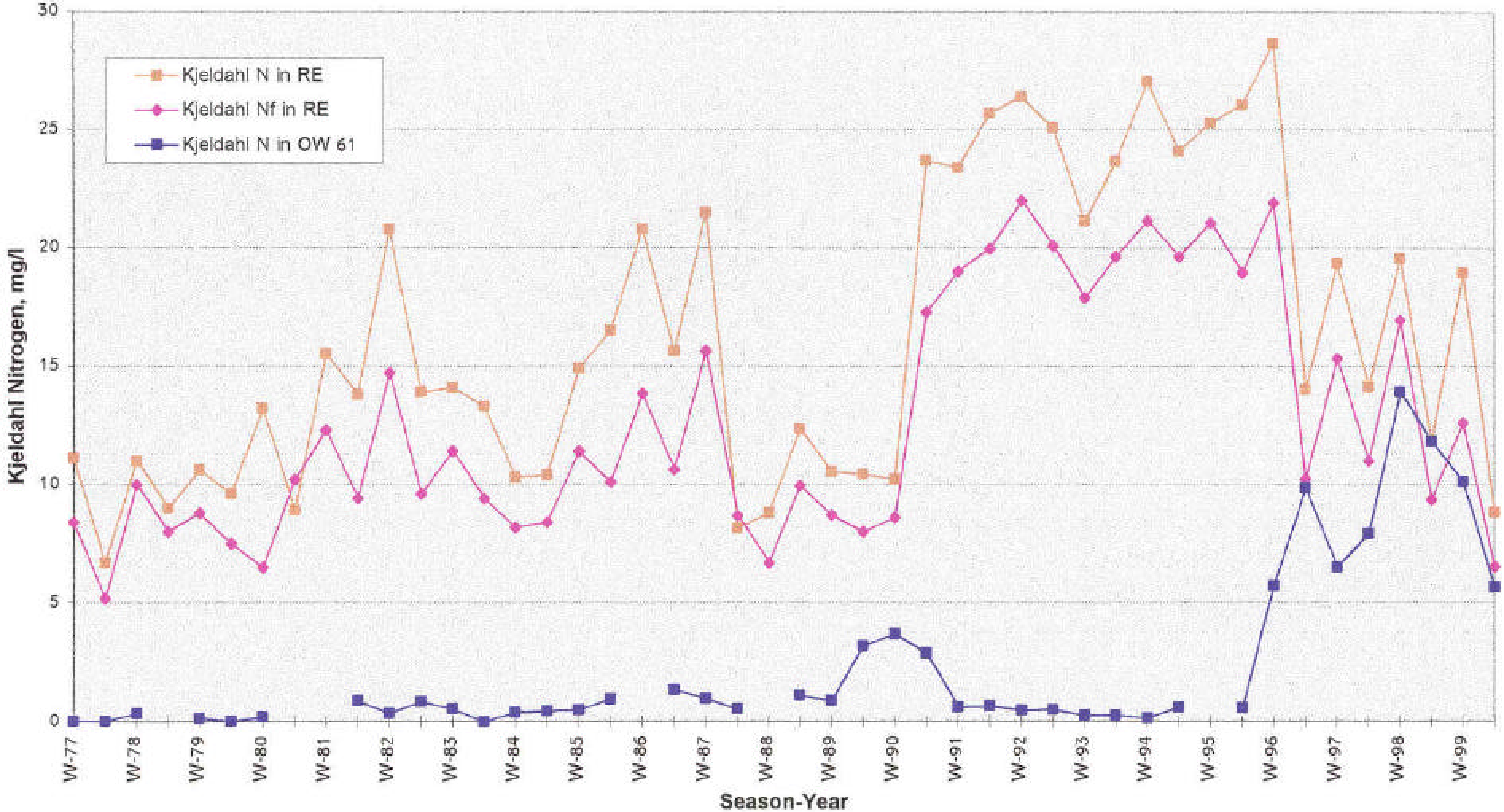
Good nitrogen removal is generally achieved by nitrification-denitrification, ammonia adsorption and parrticulate N filtration

PROBLEMS

During the period 1996-2000, the removal efficiency of nitrogen (and organics, to a lesser extent) was considerably reduced at one of the recharge sites (Soreq)

The reason was the formation of predominantly anaerobic conditions in the soil-aquifer system, as a result of the reduction in the infiltration capacity of some basins (Soreq) and the difficulty of ensuring drying periods for oxygen penetration into the soil

Figure 33
SOREQ - Kjeldhal Nitrogen in RE and OW 61



SAT Removal Efficiency
Organics and Nutrients

Parameter	Concentration before SAT	Concentration after SAT	Average RRE (Relative Removal Efficiency)
SS	10-80	0	100%
BOD	5-40	0.5	98%
COD	40-160	10-20	85%
CODf	40-80	10-20	75%
DOC	15-20	3-6	74%
UV Abs.	150-400	30-80	80%
Detergents	0.4-1.0	0.05-0.2	82%
Total N	5-30	5-10	57%
Total P	3-10	0.01-0.03	99%

All concentrations are in mg/l

Heavy Metals and Pathogens

SAT removes efficiently a variety of heavy metals and toxic elements by chemical precipitation and adsorption

The soil-aquifer system removes efficiently pathogenic bacteria and viruses as a result of sand filtration and die-off resulting from the long detention time in the unsaturated zone and the aquifer

The Long-Term Performance of SAT Removal Processes

Contaminants Removed	Process	Duration
Suspended solids	Filtration	Forever
Dissolved organics	Biodegradation	Forever
	Adsorption	Limited time
Nitrogen	Filtration	Forever
	Nitrification	Forever
	Denitrification	Forever
	Adsorption	Limited time
Phosphorus	Chemical Precipitation	Limited, long time
	Adsorption	Limited, long time

Cost of Water from Various Sources

	US cents per m^3
Conventional Water Sources	**25-30**
Wastewater Reuse	
a) Secondary Biological Treatment	5-15
b) Tertiary Chemical Treatment	10
c) Deep Reservoir Treatment (DRT)	7-15
d) Soil Aquifer Treatment (SAT)	17
Total DRT (a+c)	**12-30**
Total SAT (a+d or a+b+d)	**22- 42**
Desalination of brackish water	**40-60**
Desalination of sea water	**60-100**
Dan Region Project	
Treatment prior to SAT (a or a+b)	15
SAT (d)	17
Conveyance and Distribution after SAT	13
Total Dan Region Project at point of use	**45**

SAT includes: recharge, monitoring and pumping

CONCLUSIONS

- **SAT has an excellent capacity for removing from the effluent a wide range of contaminants by a variety of processes**
- **The soil-aquifer system should be viewed as a huge reactor where both biological and physico-chemical processes occur**
- **The biological and physico-chemical processes perform in conjunction with one another. Consequently, the purification capacity has not been affected by time**
- **With proper operation and maintenance and adequate monitoring, the SAT system should be considered an extremely attractive and reliable method for effluent reclamation and reuse in areas where suitable conditions exist for groundwater recharge via spreading basins**