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Monitoring of Salinity Changes in Coastal Aquifer: Al Batinah Coast during 1984-2010, Oman

Tariq Helmi : Hydrogeologist Expert, Directorate General of Water Resources Assessment, MRMWR, Oman
E-mail: tariqhelmi@hotmail.com

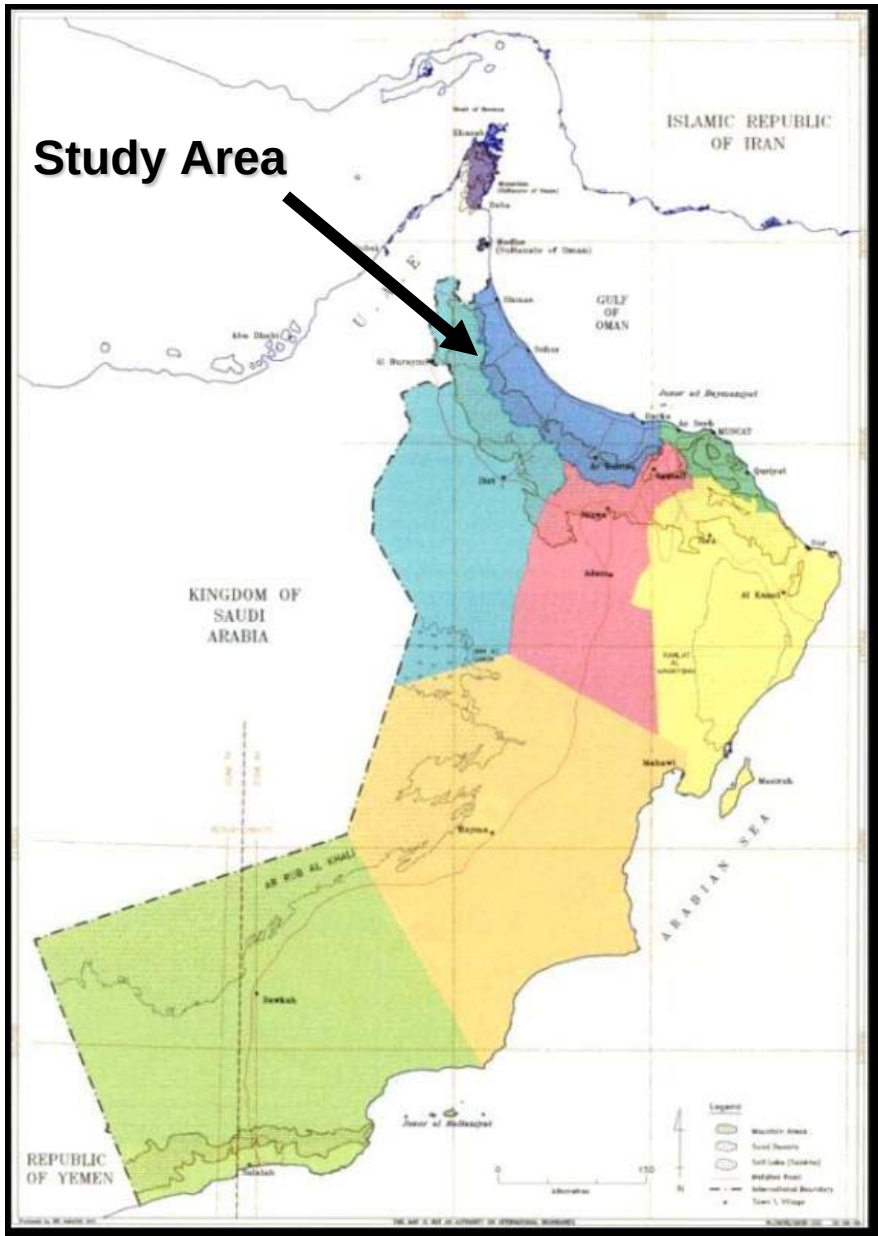
Ahmed bin Said Al Barwani : Water Resources Expert, Ministry of Regional Municipalities and Water Resources, Oman
E-mail: ahmed.albarwani@gmail.com

Agenda

- Introduction
- Study Area
- Hydrogeology
- Methodology
- Results
- Conclusion
- Recommendations

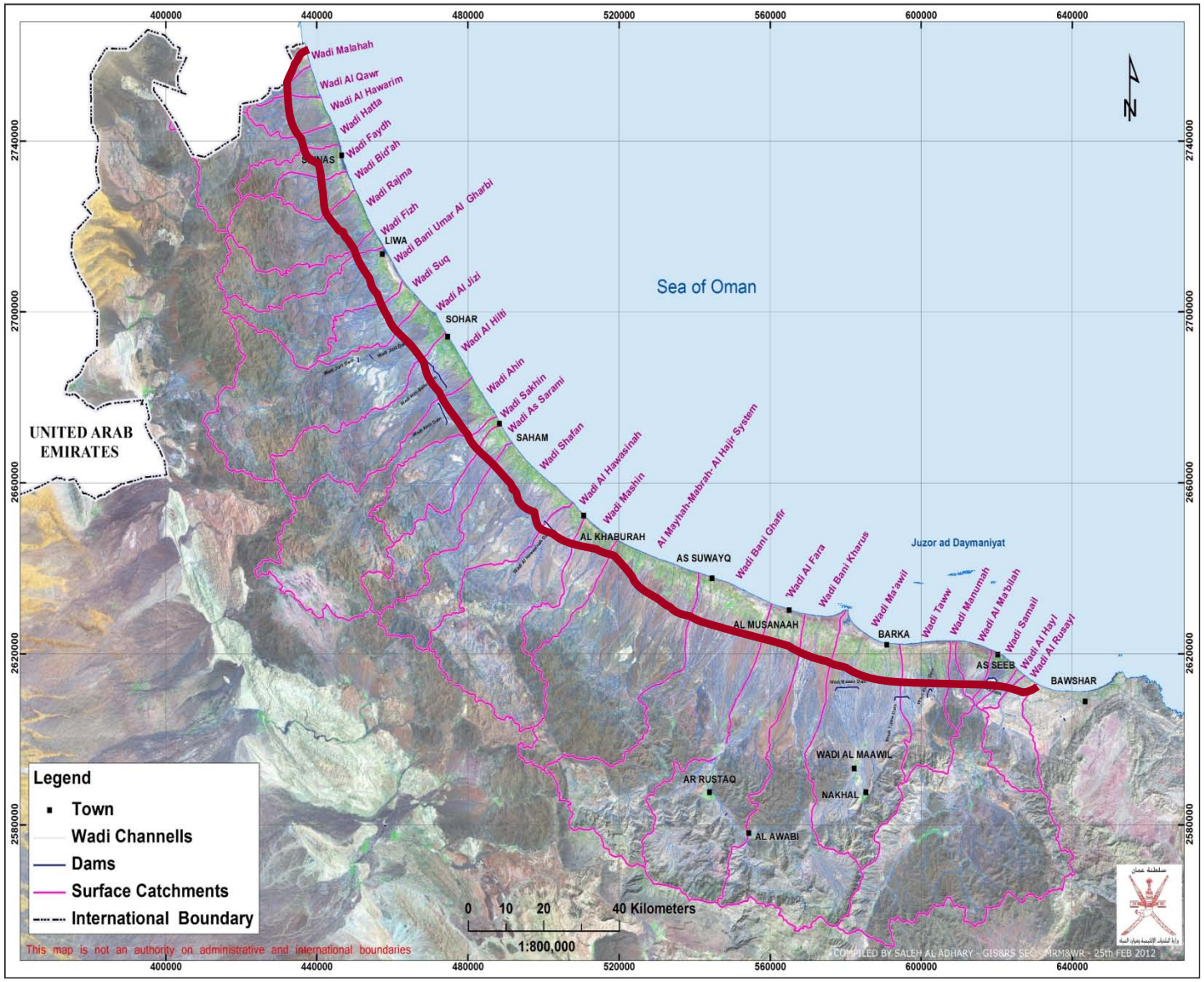
General

- Al Batinah located on the northern part of Al Hajar As Sharqi mountain.
- Total area **14,621** km^2 with the second ranked population density **52** p/km^2
- Groundwater is the main source of water uses.
- Agriculture demand represents more than **90%** of the total water demand.
- Highly cultivated area of the Sultanate as about **50%** of the total agriculture production is coming from Al Batinah.
- There is imbalance between water availability and water demand reaching (**348** Mm^3) which representing about 56% of the total water deficit of the Sultanate.



Study Area

- Length = 270 km
- Width = 5-10 km
- Area = 3000 km^2 (21%)
- Coastal strip = 1000 km^2
- Plain area = 2000 km^2
- Population = 7772.59, 60%concentrated on 4 wilayats (Barka, Sohar, Saham and Swuaiq)
- 29 catchments

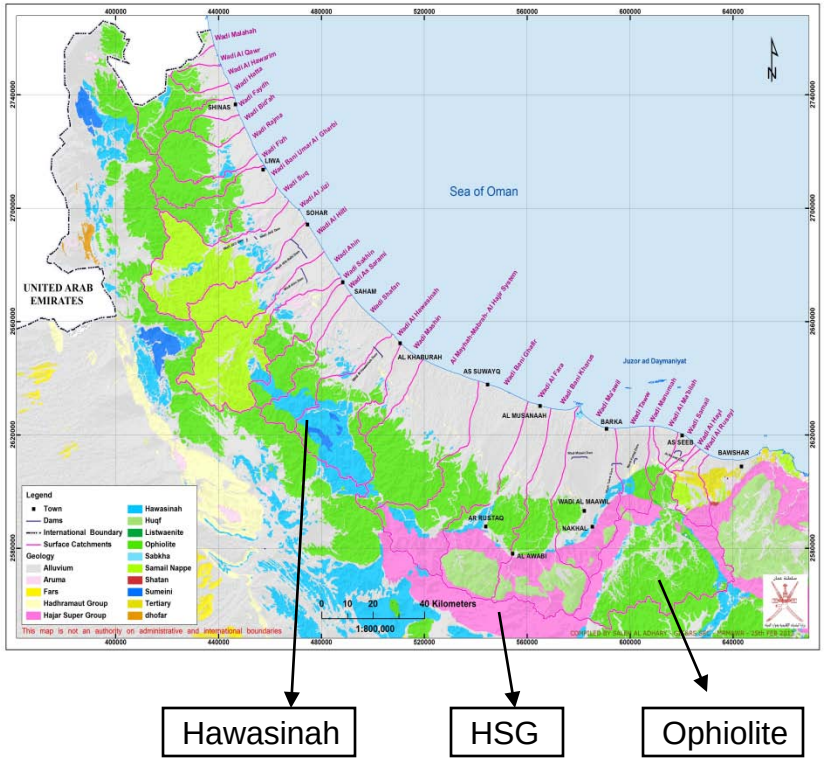


Study Area

Areas	Total Area km^2	Wadis	No. of Wells	No. Water samples
Seeb	196	Al Khoud, Rusayl, Manumah, Ma'bila	116	92
Barka	348	Taww, Al Maáwil, Bani Kharous	197	133
Suwaiq	491	Bani Ghafir, Fara, Mabrah - Al Hajer	190	163
Al Khabourah	306	Shafan, Mashin, Al Hawasinah	114	85
Sohar	500	Sarami, Sakhin, Hilti, Ahin, Al Jizzi, Suq, Bani Omar	182	133
Liwa-Shinas	326	Fizh, Rijma, Faydh, , Badiáh, Al Qawr, Hatta	127	94
TOTAL			**926**	**700**

Hydrogeology

- The coastal plain consist of coarse, gravels and boulders with occasional cemented beds. The later is the main aquifer with total depth more than 600 m in As Seeb - Barka area.
- Its storage and transmissivity are generally good with average transmissivity value of 550 m^2/day at Barka.
- Groundwater quality is extremely varied ; near recharge area TDS =1500mg/l.; Plain=1500 to 650mg/l. In the coastal zone the fresh water aquifer is underlain by a saltwater wedge.

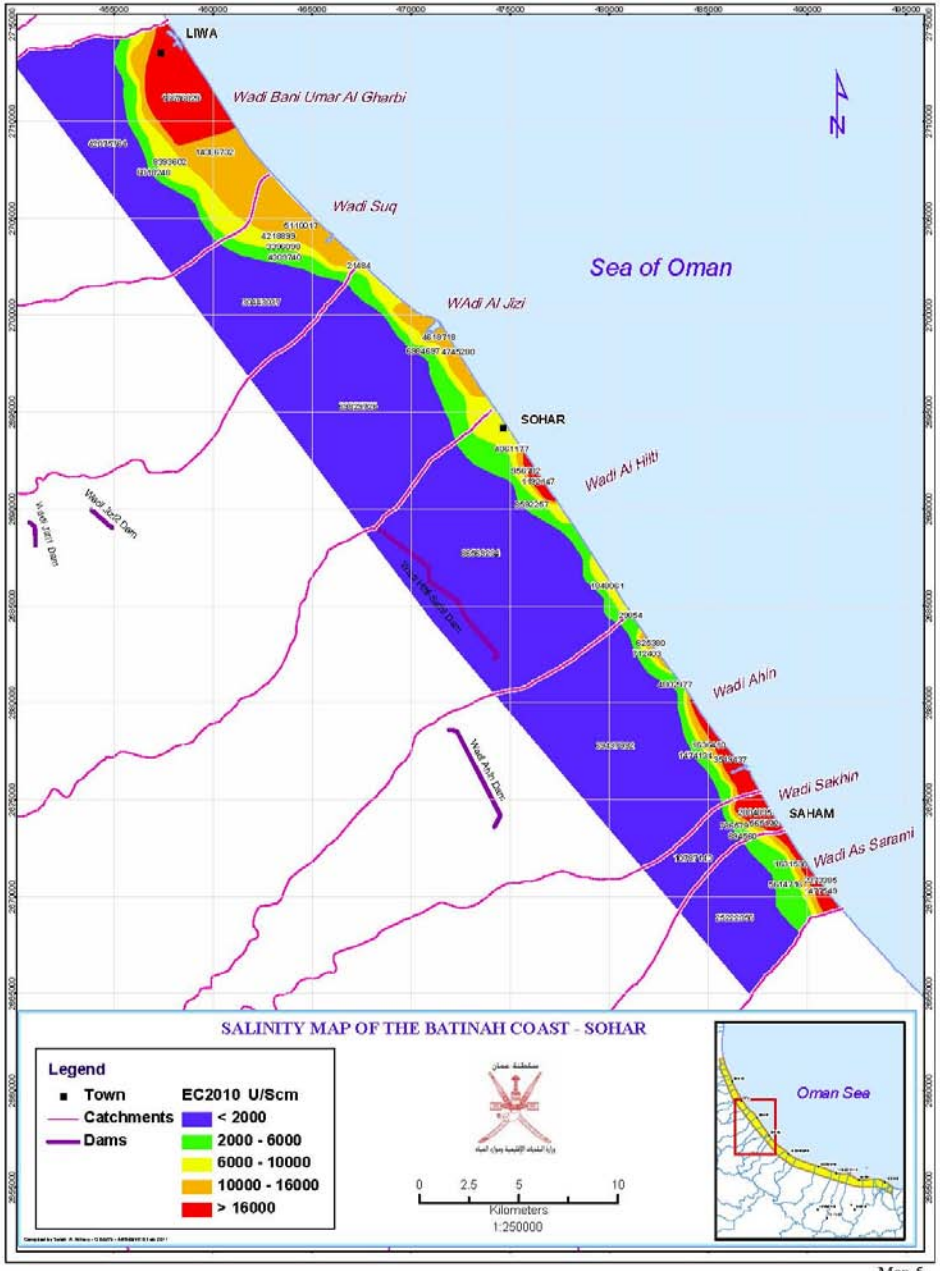


Methodology – Well Surveys

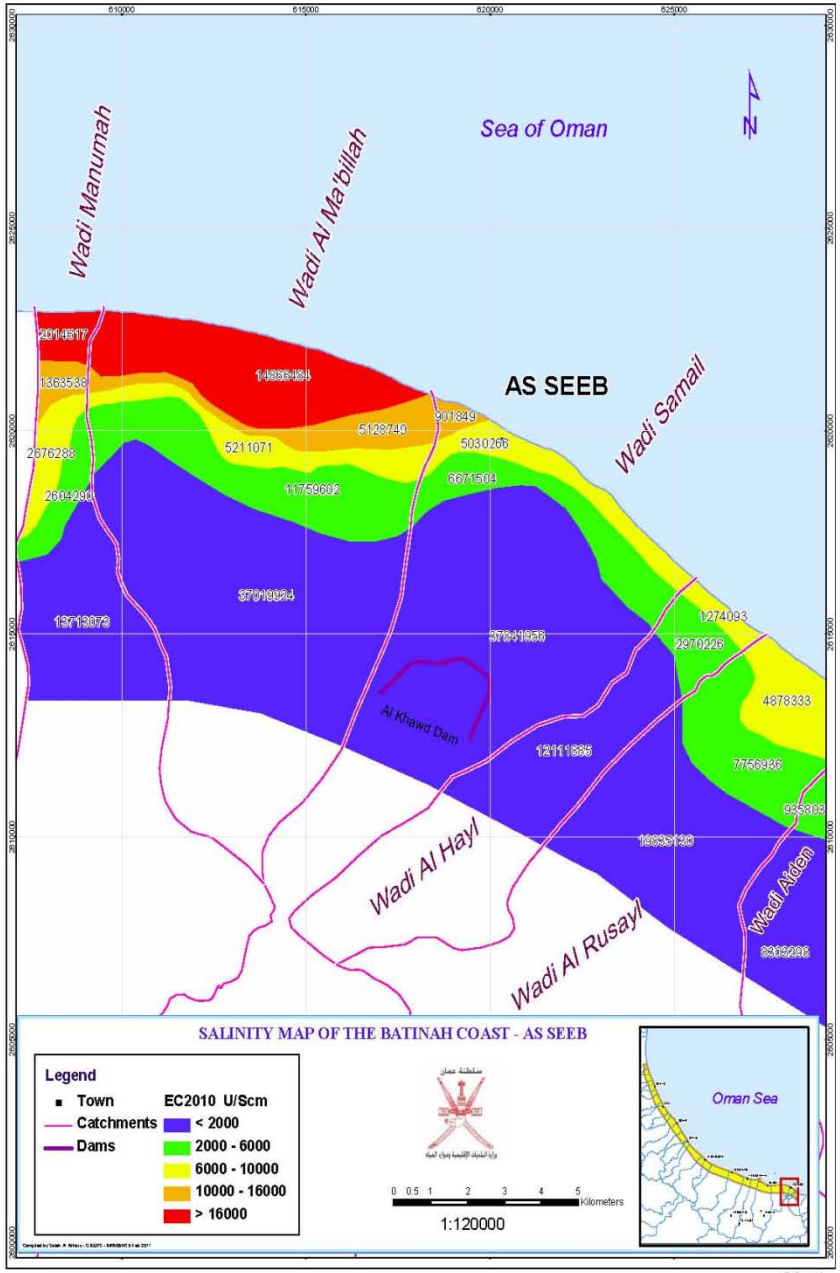
- Monitoring of salt-water intrusion beneath Batinah coastal plain is carried out through a mass sampling of (**1000**) from coastal boreholes and hand dug wells.
- **90%** of them are productive wells. However in 2010 all wells were productive.
- Since **1982** the surveying was repeated almost every **two** years.
- Since **2000** the surveying was repeated every **five** years.

Methodology - Sampling

- Water samples were collected from all productive wells and non-pumped wells were pumped using MP1 pump with 2 inch diameter.
- The wells depths ranging from 20 – 100 meters taping the upper gravel layer of the Batinah aquifer.
- 700 samples collected, sent to the laboratory for complete physical and chemical analysis. Data were stored in access database.


LIWA
Wadi Bani Umar Al Gharbi
Wadi Suq
Sea of Oman
WAdi Al Jizi
SOHAR
Wadi Al Hilti
Wadi Ahin
Wadi Sakhin
SAHAM
Wadi As Sarami
SALINITY MAP OF THE BATINAH COAST - SOHAR
Legend
Town
Catchments
Dams
EC2010 U/Scm
< 2000
2000 - 6000
6000 - 10000
10000 - 16000
> 16000
0 2.5 5 10
Kilometers
1:250000
Oman Sea

Map 5


Wadi Manumah
Wadi Al Ma'billah
Sea of Oman
AS SEEB
Wadi Samail
Al Khawd Dam
Wadi Al Hayl
Wadi Al Rusayl
Wadi Aiden
SALINITY MAP OF THE BATINAH COAST - AS SEEB
Legend
Town
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EC2010 U/Scm
< 2000
2000 - 6000
6000 - 10000
10000 - 16000
> 16000
0 0.5 1 2 3 4 5
Kilometers
1:120000
Oman Sea

Map 1

Methodology – Salinity Ranges

- Fresh Water < 2000 µs/cm
- 2000 – 6000 µs/cm
- 6000 – 10000 µs/cm
- 10000 – 16000 µs/cm
- > 16000 µs/cm

Results – main findings

- 51 % of wells have EC less than 6000 µ/cm.
- Only 20% of wells have EC less than 2000 µ/cm.
- More than one third **33%** have EC more than 10.000 µ/cm.
- An increase in the No's of abandoned wells from 7% in 2005 to reach **20%** in 2010, i.e. from 70 to 299 wells.
- On 2010, the deterioration of cultivated area reached (9800 ha) which is equal to 5% of total area, compared to (13000 ha) during 2000-2005.

Results – areas of improvements

1) Seeb Area : Improvements

2) Barka Area : Deterioration, No improvements

3) Suwaiq Area : Improvements, Deterioration

4) Al Khabourah Area : Improvements

5) Sohar Area : Deterioration, No improvements

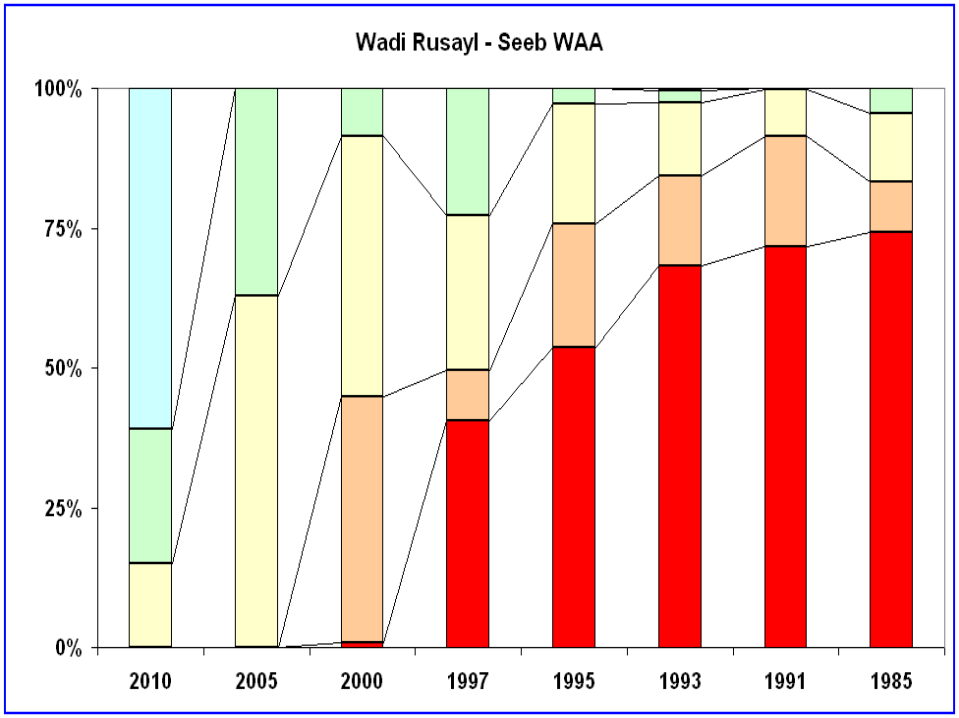
6) Shinas – Liwa Area : Improvements, Deterioration

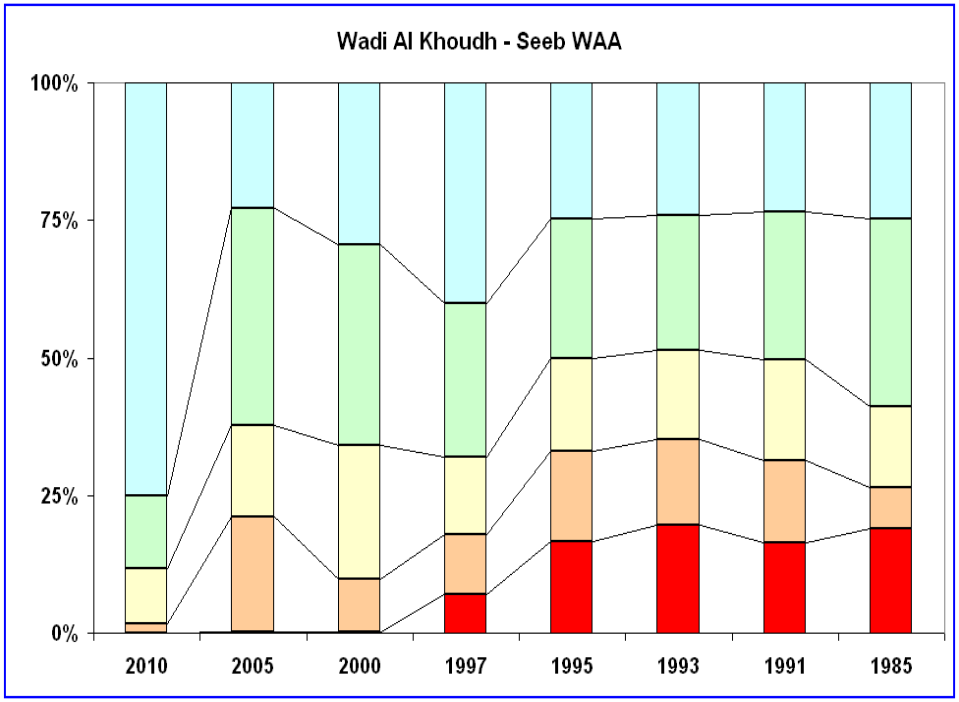
1) Seeb Area: (196 km^2, 116 wells, 92 samples)

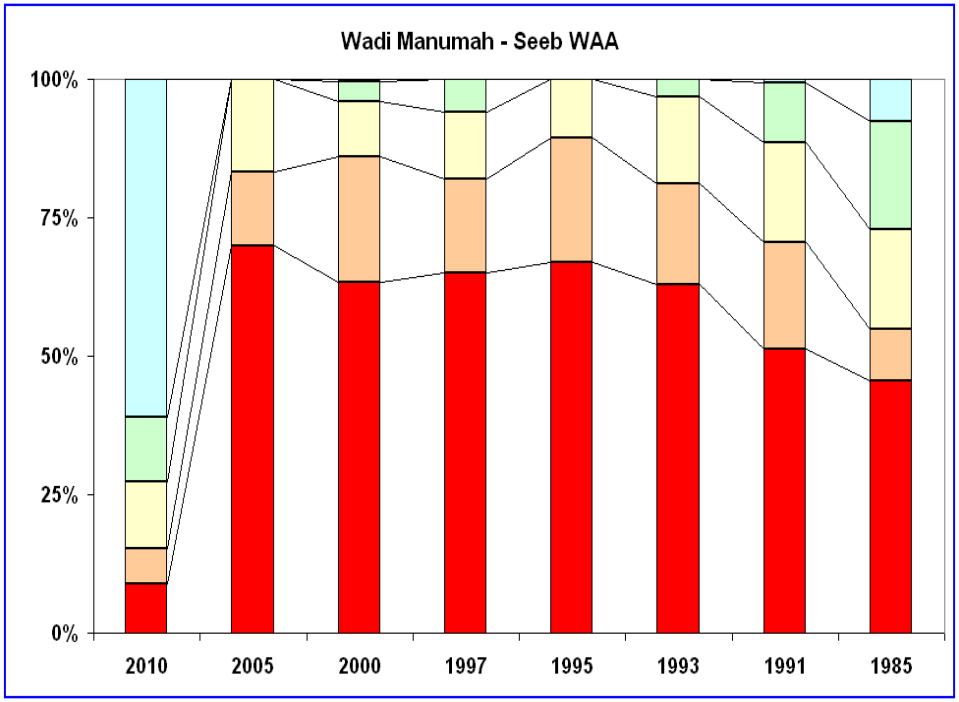
- Improvements at Wadi Al Khoud, Wadi Rusayl, Wadi Manumah

✓ All the area showing improvements as a result of exceptional recharge from rain during 2007, 2010.

✓ Low water abstraction, limited cultivated area (deficit 27 mcm/yr).





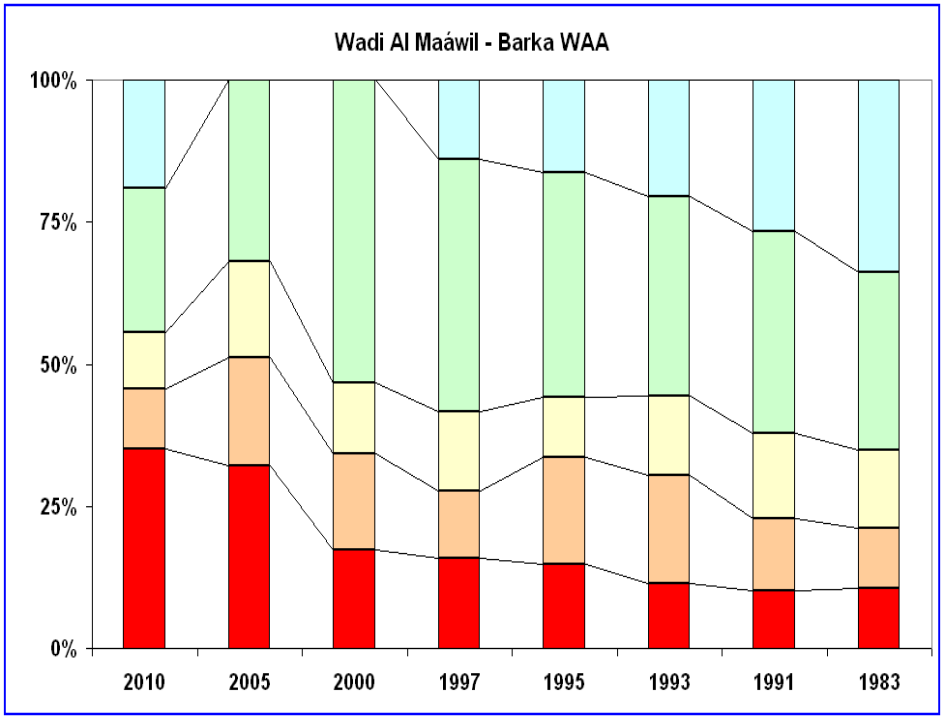


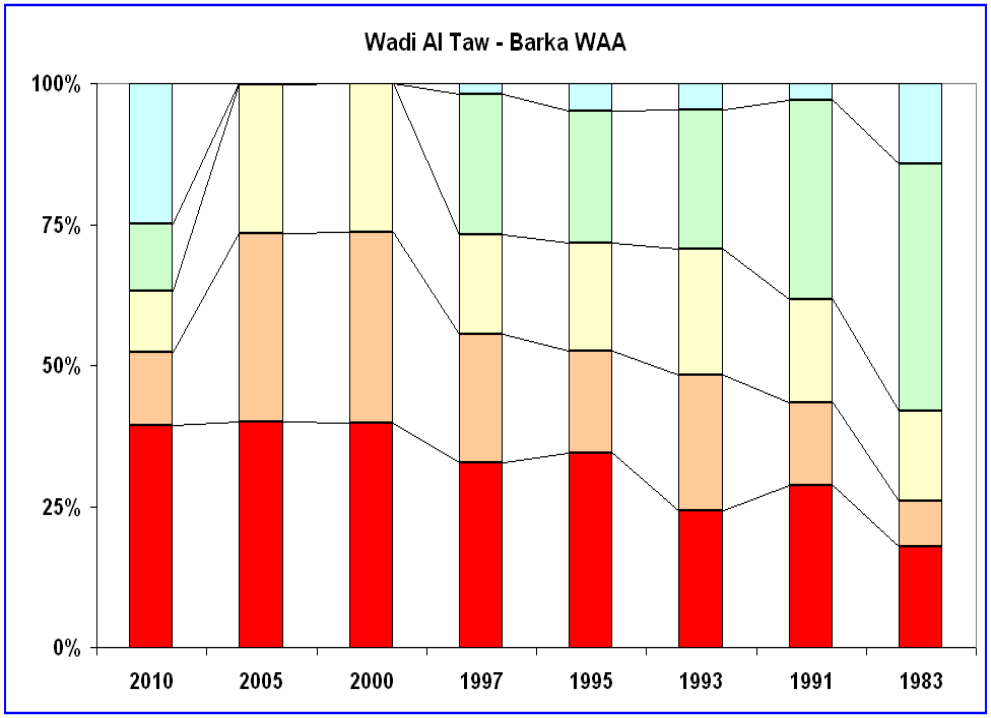
2) Barka Area: (348 km^2, 197 wells, 133 samples)

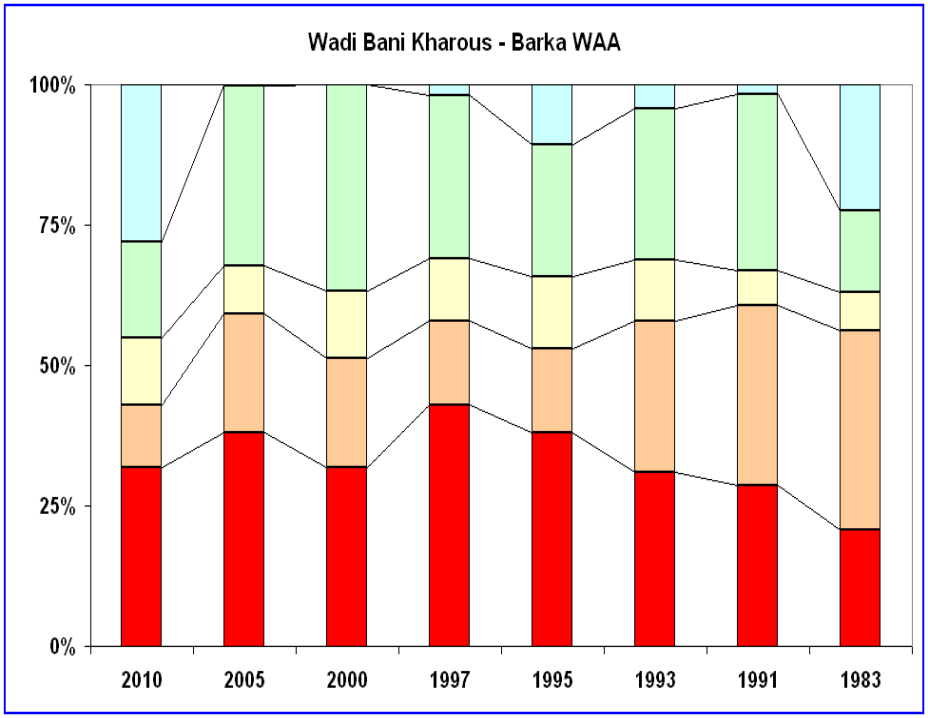
- Wadi Maáwil
- Wadi Taw
- Wadi Bani Kharous

✓ All catchments showing gradual deterioration in GW salinity and also during the last five years.

✓ High water abstraction rate (deficit 70 mcm/yr).

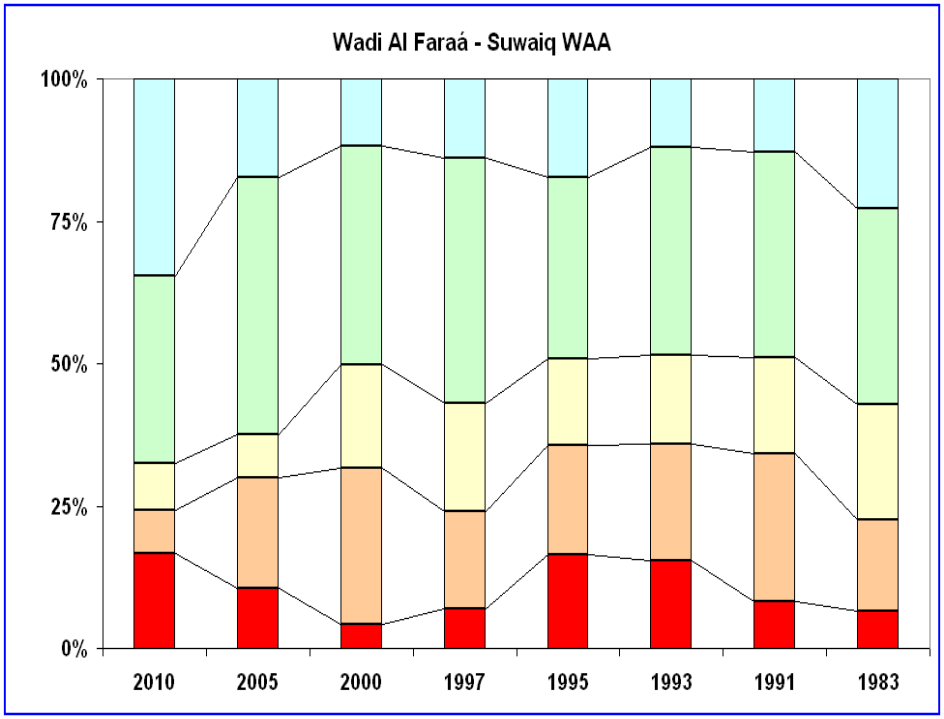


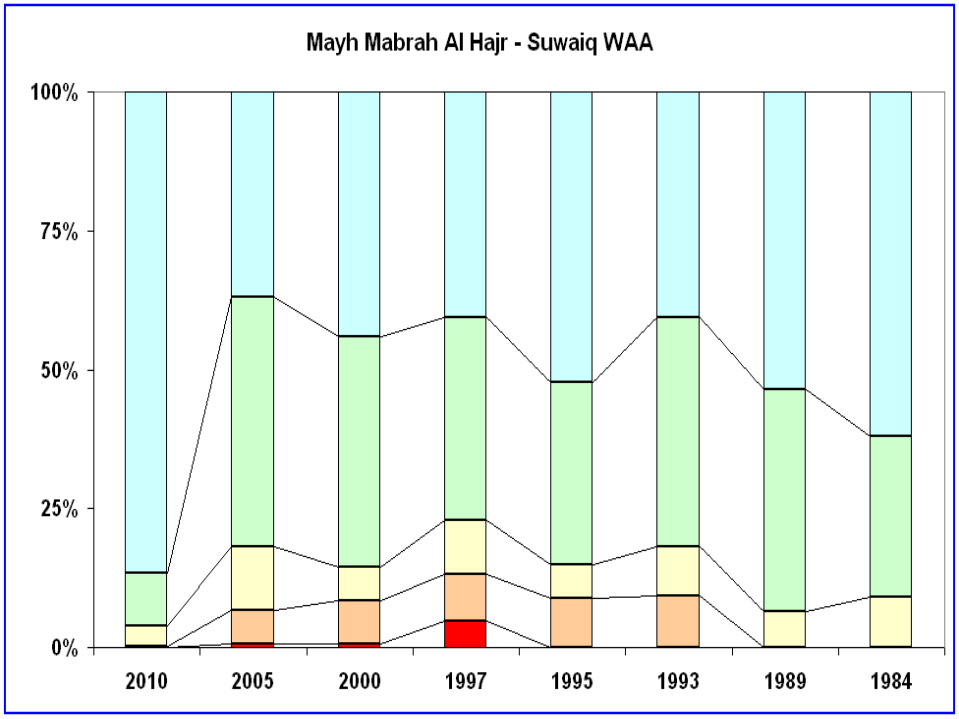


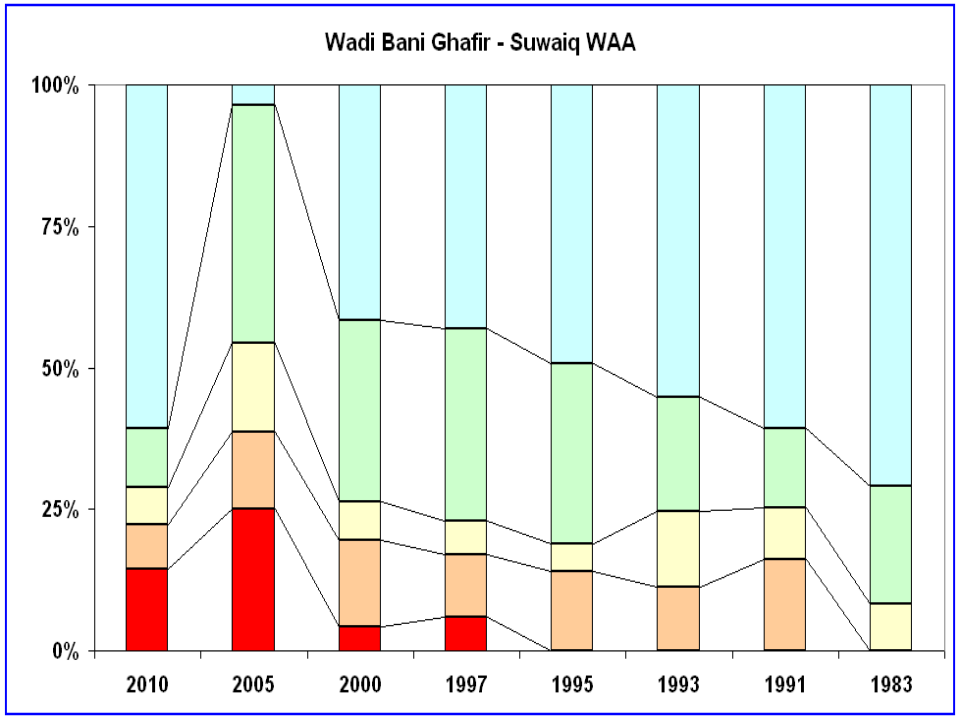


3) Suwaiq Area: (491 km², 190 wells, 163 samples)

- Improvements at Wadi Mayhah – Al Hajer and Wadi Bani Ghafir particularly during the last five years.
- Deterioration at Wadi Al Faraá, gradual increase in GW salinity since 2000 due to high abstraction.





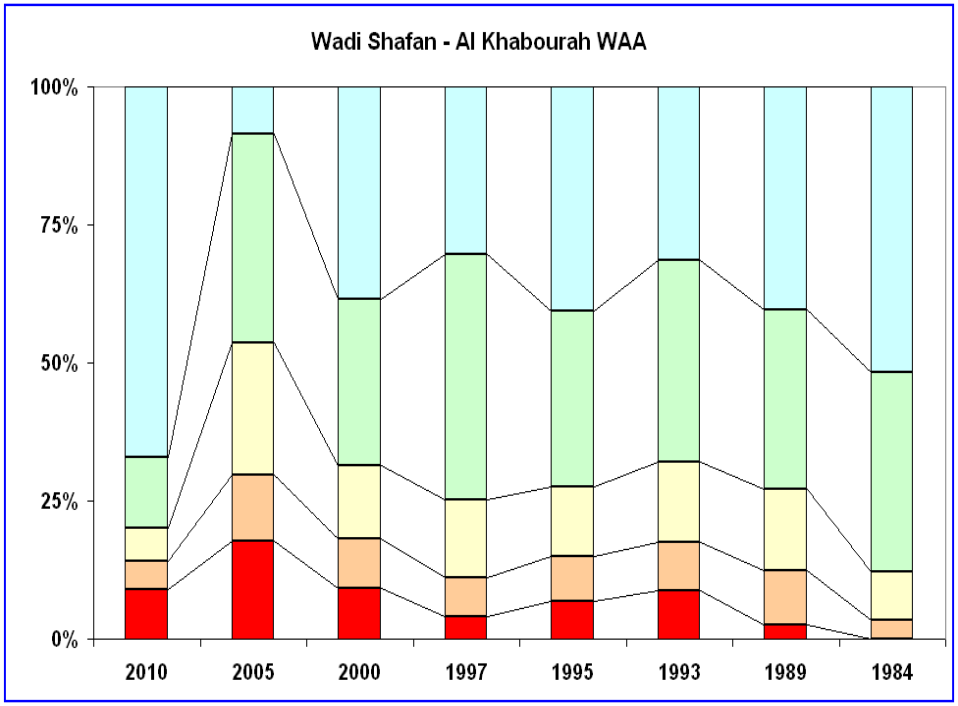


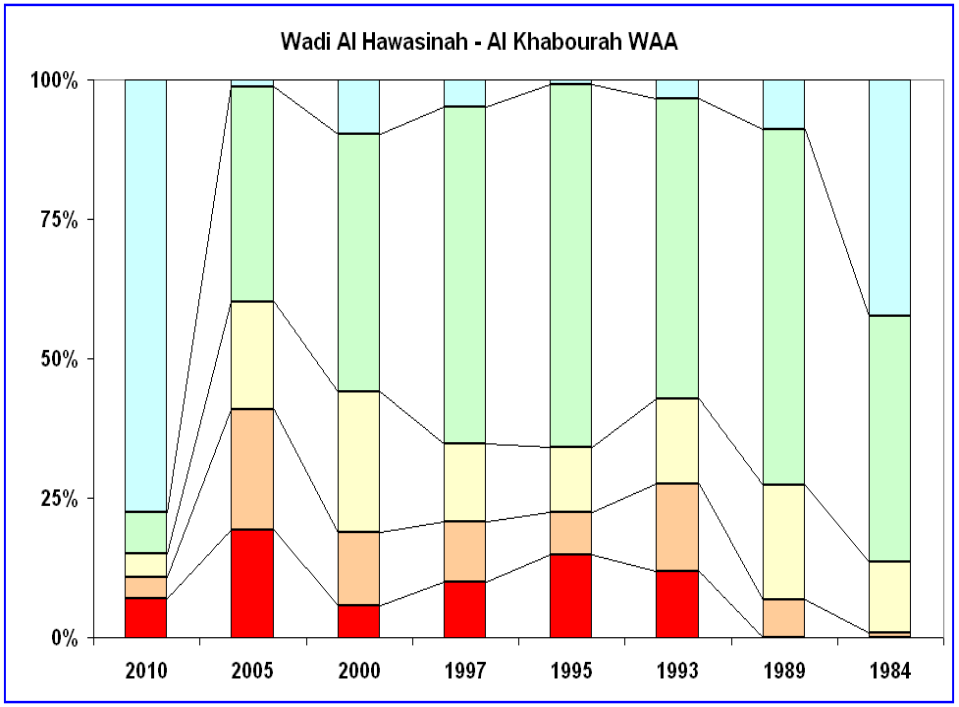
4) Al Khabourah Area: (306 km^2, 114 wells, 85 samples)

- Wadi Shafan
- Wadi Hawasinah

✓ There is a good improvement in GW quality during the last five years, as red % is back to it's values during 2000.

✓ Annual recharge from rain is to the coastal aquifer effecting the GW quality

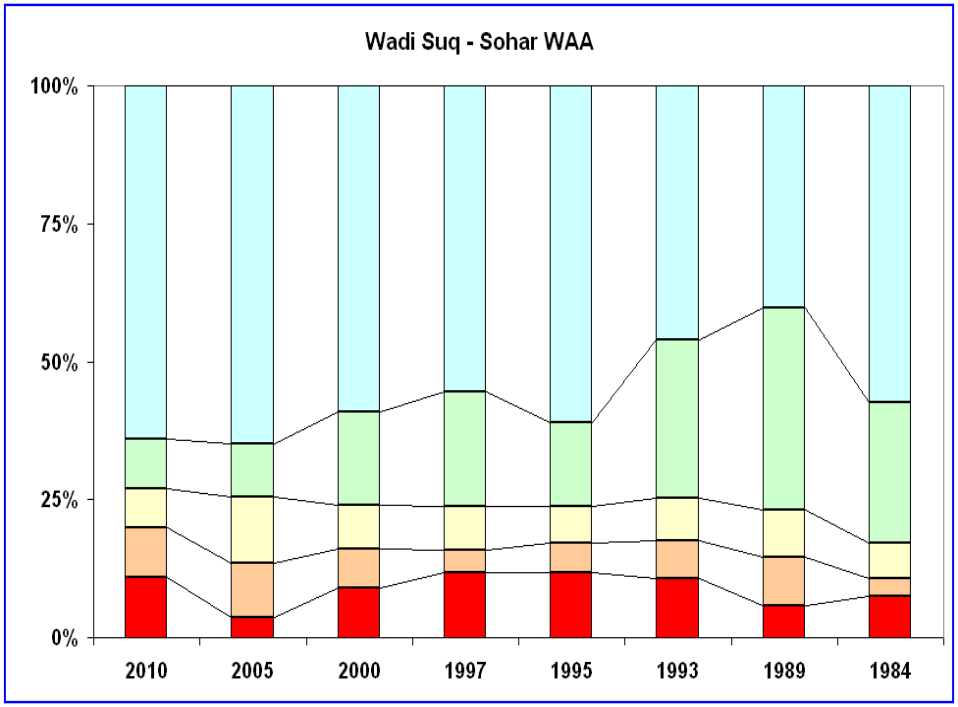


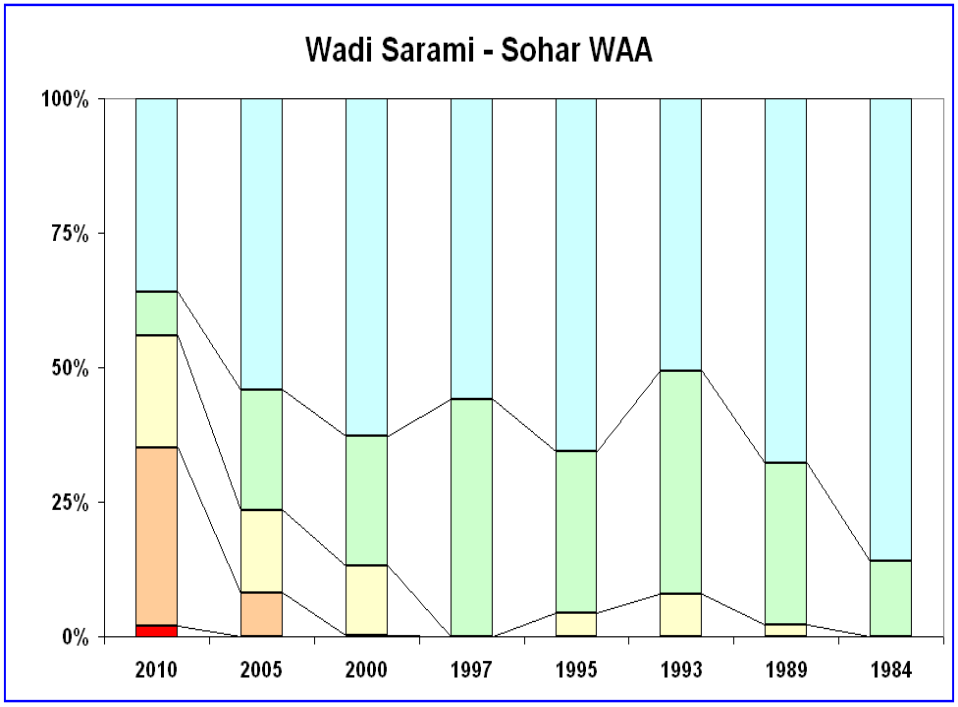


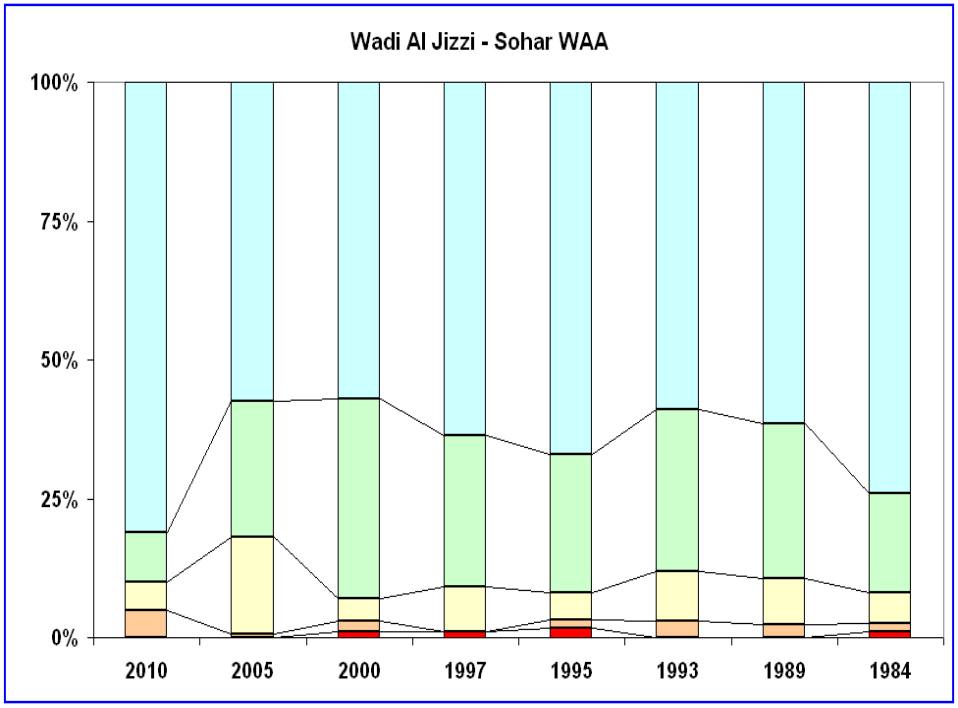
5) Sohar Area: (500 km², 182 wells, 133 samples)

- Deterioration at all Wadis; covering wilayats Sohar, Saham, southern Liwa on lower catchments.
- Wadi Sarami, Ahin, Hilti, Suq, Al Jizzi

✓ However upstream areas showing improvements as a result of exceptional recharge from rain during 2007, 2010.





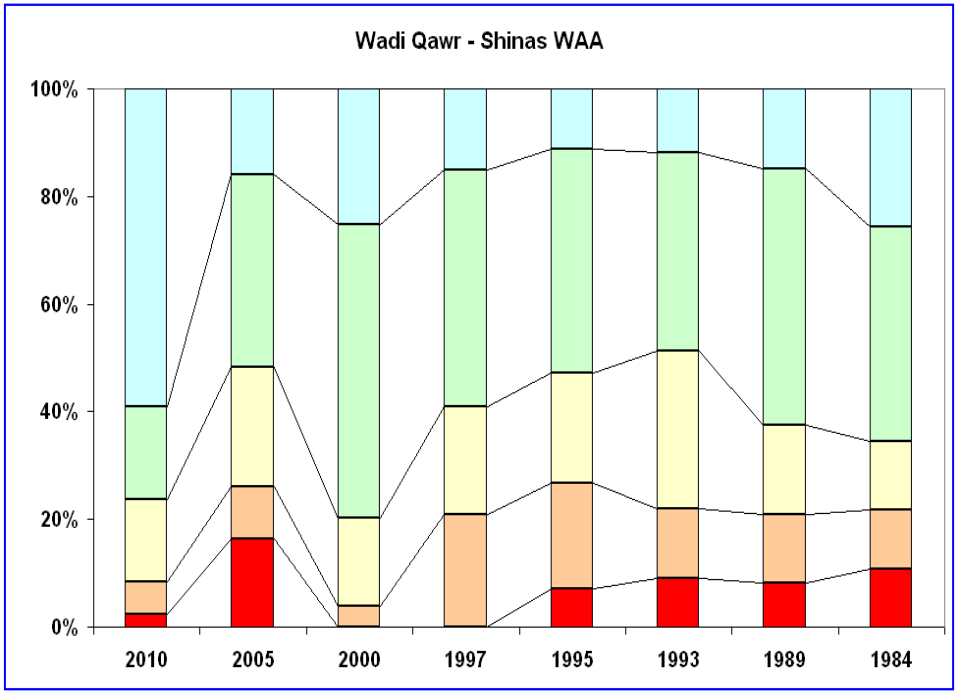


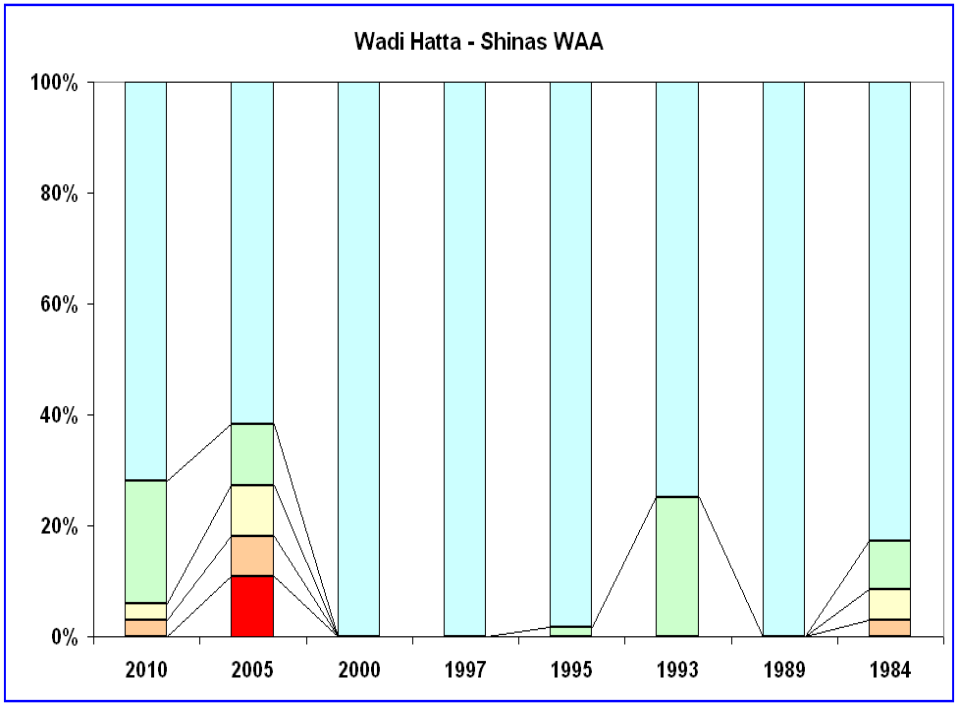
6) Liwa - Shinas: (326 km^2, 127 wells, 93 samples)

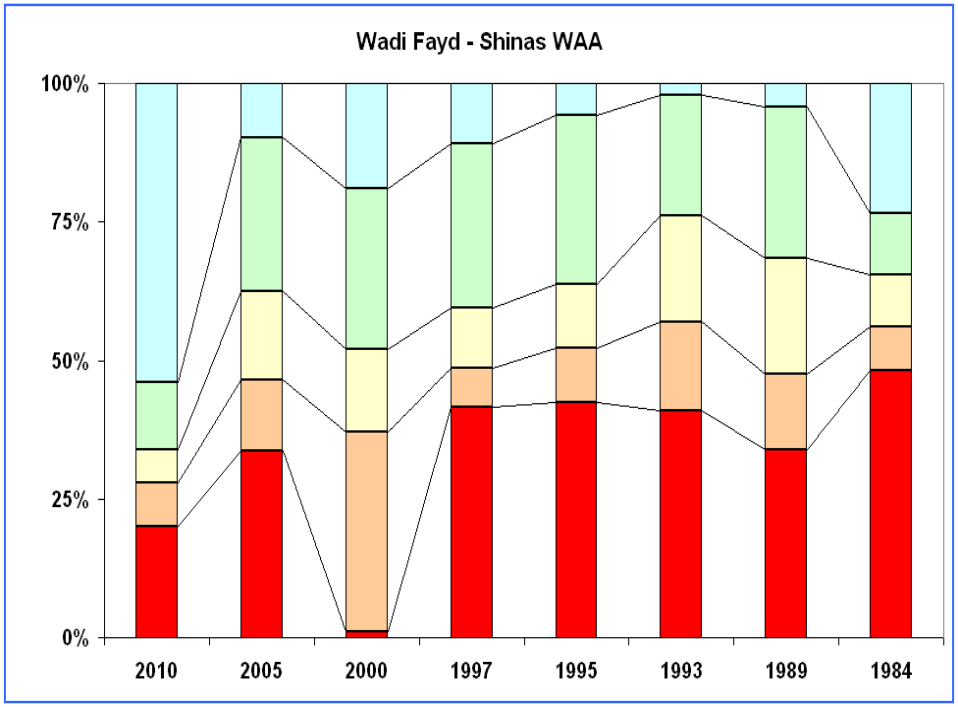
- Improvements at Wadi Al Qawr, Hatta, Faydh

✓ All the area showing improvements as a result of exceptional recharge from rain during 2007, 2010.

✓ Low water abstraction, limited cultivated area

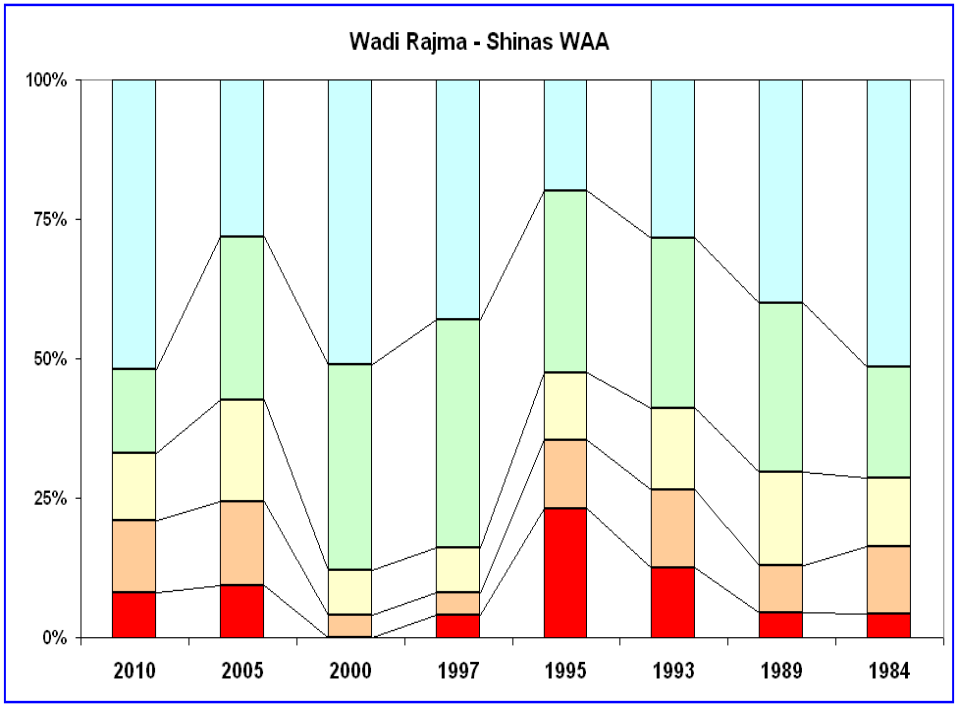


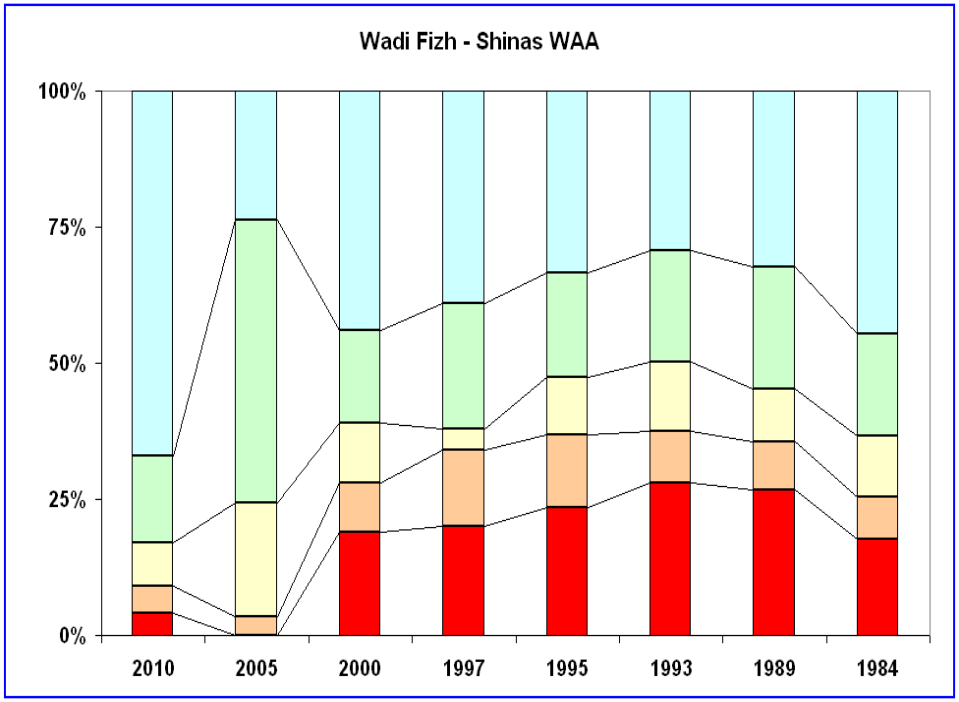


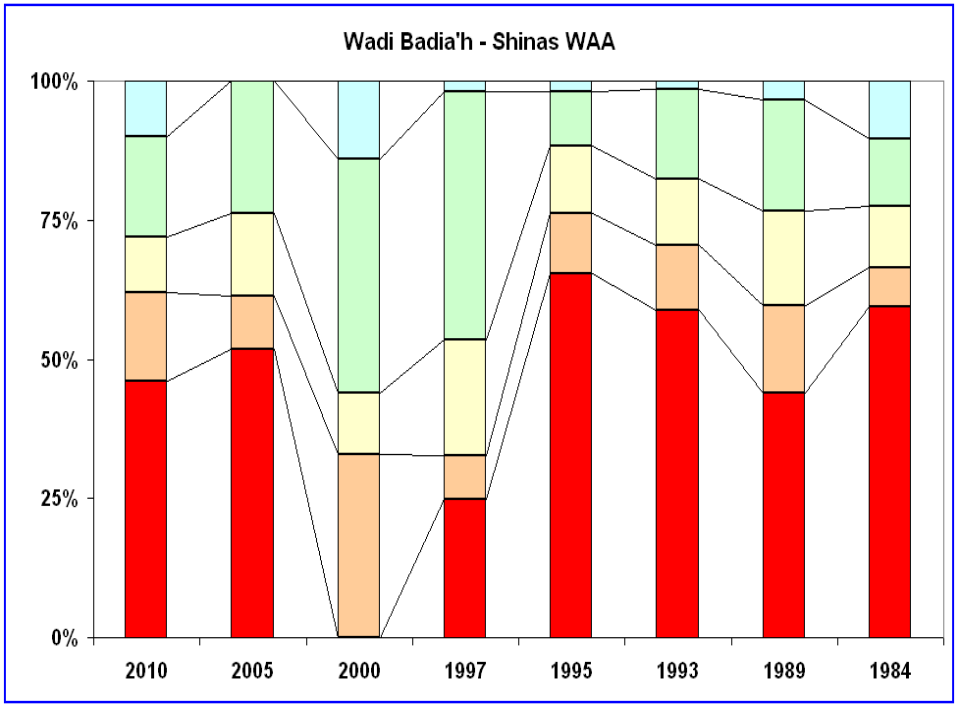


6) Liwa - Shinas: (326 km^2, 127 wells, 93 samples)

- Deterioration at Fizh, Rijma, Badiáh



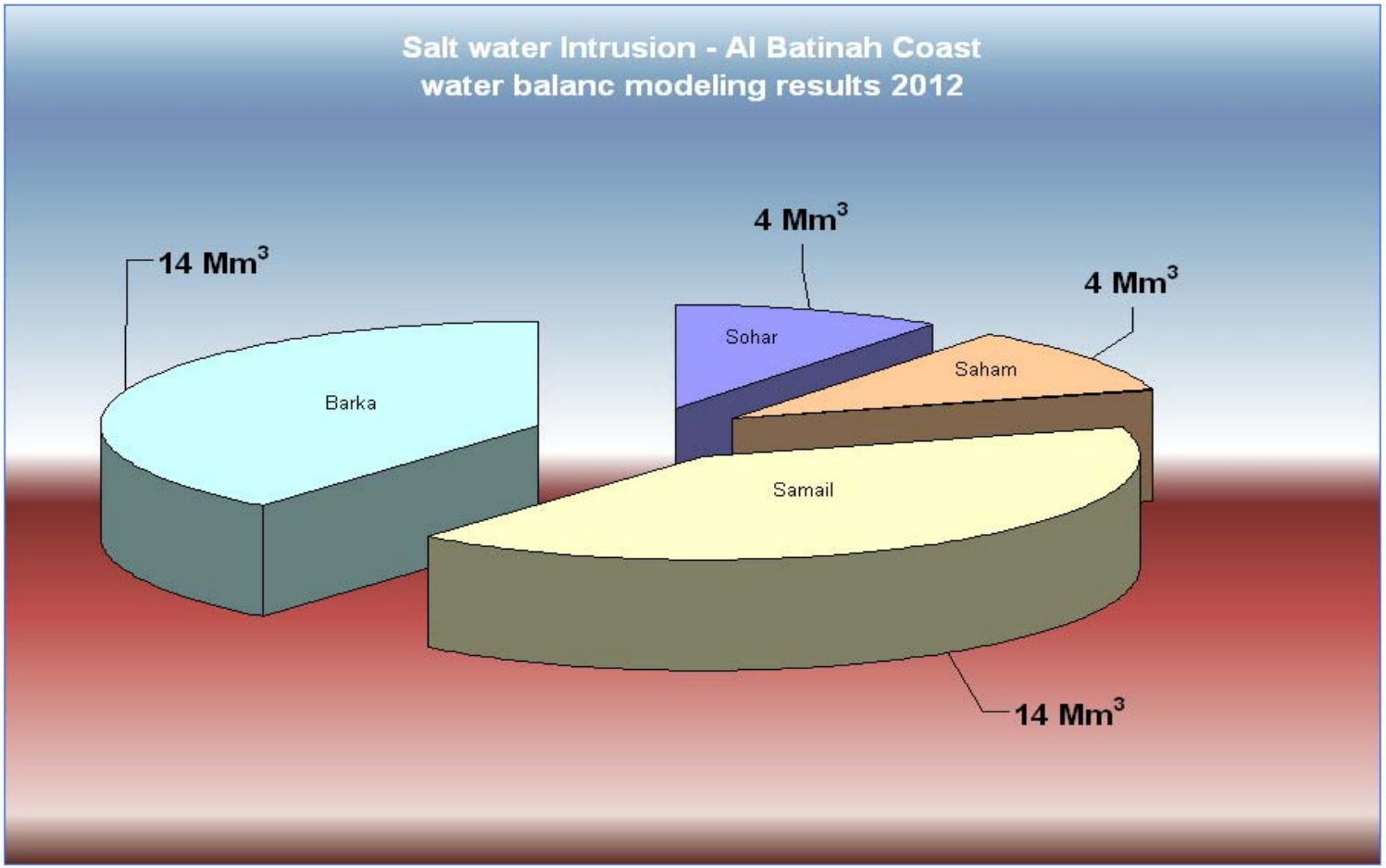




Water Balance Results, 2012

Water balance Model results for salt water intrusion:

- Seeb area = 14 Mm^3
- Barka area = 14 Mm^3
- Saham and Sohar area = 8 Mm^3



Conclusion

- Annual recharge from rainfall is greatly affecting the GW quality at Al Batinah coast.
- Groundwater quality improvements at some parts and/or deterioration of others along Al Batinah coast on 2010 survey is controlled by both hydrological and socio-economical conditions prevailing during the last five years. These conditions could be summarized as on the following:
  - Groundwater deterioration/increasing sea water intrusion is directly related to areas of high agriculture intensity such as Barka and Al Khabourah.
  - Recharge from natural resource (exceptional recharge from two cyclones Guno 2007 and Phet 2010 at Wadis Al Khoud, Rusayl and Manumah). These cyclones hit Seeb area as part of Al Batinah coast.
  - Recharge from retained dams (Al Khoud, Al Jizzi, Al Hawasinah).
  - Rapid economic development and increase of urbanization rate.
  - Changing land use
  - Changing source of water supply system from conventional source (groundwater) to non-conventional source (desalination).
- Preventing the saline water intrusion along the Batinah coast depend on the following factors; continuous recharge events from rainfall and wadi flows which maintaining high water levels and, controlling the over pumping from wells along the Batinah coast

Recommendations

In order to, manage, prevent salinity changes of coastal aquifers (salt water intrusion) and to ensure a sustainable source of coastal aquifers for the future many actions should be taken simultaneously. These actions can be summarised as follows:

1) Monitoring and assessment approaches:
   - traditional monitoring approaches,
   - innovative approaches (EM Logs),
   - numerical modeling

2) Engineering and Regulatory approaches:
   - reduce the rate of pumping from coastal aquifers (transfer Rhodgrass farms to Nejd area; saving approximately (**100** Mm^3/yr, **reduce deficit by 38%**)
   - artificially recharge freshwater into coastal aquifer; recharge dams,
   - injection wells, reuse of treated recycled wastewater,
   - blending of water of different quality
   - implementation of water-conservation, **changing crop type**, tolerant crop types,
   - improve water efficiency; **modern irrigation systems** (**saving ~ 20-40% of the current water use**),
   - monitoring of abstraction rate through water meters (**saving ~ 18% of the total water use**, reported by Dr. Slim Zekri),
   - Cloud seeding to increase natural recharge of coastal aquifers.

Thank you
Q & A