NORTH-WESTERN SAHARA AQUIFER SYSTEM

Joint Management of a Transborder Basin

A STUDY ON SASS OBSERVATION NETWORKS

JUNE 2003

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SUMMARY

PRELUDE

This study was conducted by Professor Mustapha BESBES within the framework of the project TCP/RAB/0065, upon the joint request of the World Organisation for Agriculture and Food (FAO) and the Sahara and Sahel Observatory (OSS).

If fits perfectly into the framework of the assignments set out by the Concertation Mechanism as approved by Rome Regional Meeting – December 2002.

It makes up a tentative to work out the implementation of the SASS observation networks (Piezometry and quality).

The OSS strongly wishes to obtain the comments of the competent departments in the regional institutions, in the three countries, thus allowing a deeper approach into this important issue of the follow up networks during the ongoing works of the SASS project second phase.

The OSS and the FAO congratulate Professor BESBES for the quality of this study.

PART 1

SASS PIEZOMETRY NETWORK

SASS PIEZOMETRY NETWORK

The main follow up and evaluation indicators of the water resources are : the intake flows, the evolution of the piezometry levels, the evolution of the quality of the waters. Concerning the intake flows, their follow up goes through the gauging of all the exploited wells, the network includes several thousands of boreholes and it seems difficult to visit all of them on annual basis : a five year updating periodicity must be considered. In this report, the possibilities to implement quality and piezometry follow up networks are studied, with reference to the analysis of the information included in the SASS data base.

1- IDENTIFICATION of the SASS PIEZOMETRY NETWORK

1.1- Identification of the possible historic events

The source of information which was referred to is the data base « Sagesse » (Tables « Points » and « Piezometry »). The data base includes 8800 water points, 7500 of which are wells, which are the water points liable to provide an indication about the piezometry level. There exists 3001 points (namely 40%), representing (at least) a level value.

This number goes to **1163 water points** when we require, at least, two measurements of the level (taken on different dates) : this population, at the crude stage and before any checking, constitues a potential piezometry network since each of these points could provide some data about the evolution of the sheet during the **reference** history period which stretches from **1950** up to **2000.**

But this first population shall be subject to a series of checkings and filtrations, in order to eliminate all kinds of aberration data.

1.2- Successive filterings and reference pilot-wells

The **first filtering operation** consists in checking that all the measurements recorded on different dates, are not strictly identical (to the nearest cm, which is not possible or in any case represents an infinitesimal probability) ; which generally corresponds to a simple recording of an old value on the columns of a more recent inventory. If applied to the «altitude-np» and «level» fields of the data base, this filtering eliminates 405 points and brings the potential « network » population to **758 water points**.

The **second filtering** applies to the water points which represent only two measurement values, with the condition, in this case, that there will be no level rising : this particular case (rising) is not nevertheless impossible but it would correspond then to a purely local phenomenon caused by the pumping stoppage. But, generally speaking, the phenomenon corresponds to the failure to respect a signal convention about reporting the artesian levels (this reporting is marked with a positive or a negative signal according to the successive technical teams in charge of recording the measurements over interval years). This filtering eliminates 99 points, bringing down the « network » to **659 water points**.

The **third filtering** eliminates the points whose acquifer is not determined, and those whose coordinates do not exist or locate them outside the SASS domain. Thus 86 points are eliminated and there remains only **593 water points :**

- 237 at the IC : 71 in Algeria ; 98 in Libya and 68 in Tunisia
- 341 at the TC : 79 in Algeria ; 9 in Libya and 253 in Tunisia.
- 15 at the GS* in Tunisia

Up to this point, the selection of the water points was carried out in an entirely automatic manner, without any intervention from the experts. The **fourth filtering** will consist in visualizing each of the series previously identified (the two fileds : altitute np and the level of the DB are recorded in relation to time). The series whose evolution is judged unacceptable, after a first reading, are to be eliminated (rising over three measurements, abnormally high falling, but essentially and it is the most frequent case : a non parrallel evolution and sometimes even opposite evolution between the two variables, altitude np and level). This fourth filtering reduces the selected population to a network of **467 water points :**

- 203 at the IC : 46 in Algeria ; 94 in Libya ; 63 in Tunisia
- 249 at the TC : 60 in Algeria ; 8 in Libya ; 181 in Tunisia
- 15 au GS in Tunisia

1.3- Water points groups and reference history series

At this level of analysis, most of the anomalies have been detected and eliminated. There remains to identify the must representative series of the concerned aquifer and those that are liable to be integrated in the follow up network, to be implemented : these two criteria imply that the series at stake is rich enough, fairly long and that it covers, in one way or another, the last 30 or 20 years, during which the system witnessed the most significant perturbations. In order to do so, one has to proceed with **regroupings of the water points** in order to enrich [fill in and extend] the existing piezometry series : for each of the aquifers, the regrouping is done based on the proximity of the geographical locations and the similitude (the parrallelism) between the piezometric evolutions, these two conditions must be simultaneous. When the regrouping is not possible and not desirable, we will deal with isolated water points. The result gives a network of **135 water points or groups of water points** :

- **90 at the IC :**
  27 in Algeria : 14 isolated points and 13 groups
  38 in Tunisia : 28 isolated points and 10 groups
  25 in Libya : 9 isolated points and 16 groups

- **45 points at the TC :**
  18 in Algeria : 8 isolated points and 10 groups
  24 in Tunisia : 10 isolated points and 14 groups
  3 in Libya : 1 isolated point and 2 groups

1.4 The Reference Piezometric Network

Staring from this point, the network is subject to an **additional level of analysis** :

a) for the **isolated points**, we check that the piezometric values are of the same importance as the corresponding admitted values at the level of the considered sector (this is the criterium of regional likelihood, whether at the level of the overall piezometric map of the sheet, the reference map and the calculated map by the model in 1950 or 2000, or at the level of the drawdown map calculated by the model for the corresponding period). Localisation errors can then be detected : if they cannot be easily corrected, the point is eliminated. The points whose measurements ended in the seventies are also eliminated. Besides, the isolated points, relatively close and showing similar piezometric evolutions, can make up new groups.

b) b) for **the groups**, we start by predicting a « **group leader** » or a « **tutor** » : a water point which represents the longest, the most « recent » series, including the most recent measurements (generally from 1995 to 2000, in order to keep the possibility to follow up the series in the future), and the series whose general evolution is closer to that calculated by the SASS model (the latter is supposed, with the intermediate fixing, to have erased the big local disharmonies). Then we start to eliminate the water points, bringing in a strictly redundant information, and whose series look the least performant, as well as those whose evolution is far remote if compared to the tutor's, without being able to account for this difference. We then proceed with the construction of the longest and most representative series of the group, without information redundancy, which means that we keep a simple level value for a fixed date : we complete the series by adopting the values of the other points in the group, through an eventual vertical translation of the « adopted » curve, while respecting the general slope of the geometrical evolution which must be absolutely the same as, or very close to, the whole group.

In case of a heterogeneity of the piezometric variation, inside the group, we can make up again some sub-groups. The most typical examples of regroupings are shown in the fig. 1&2. On the same figure and opposite each other, are shown the synthetic series, obtained after the regrouping, which are attributed from now onwards, to the tutor.

The final result is a netwpork made up of **73 water points or groups of water points [** the group being represented by its tutor**], namely :**

- **46 at the IC** (25 isolated points and 21 groups) :
  12 in Algeria : 6 isolated points and 6 groups
  16 in Tunisia : 9 isolated points and 7 groups
  18 in Libya : 10 isolated points and 8 groups
- **27 at the TC** (4 isolated points and 23 groups) :
  8 in Algeria : 8 groups
  15 in Tunisia : 2 isolated points and 13 groups
  4 in Libya : 2 isolated points and 2 groups

Chart 1 : IC Reference Network

Reference Network of the INTERCALARY CONTINENTAL

	PAYS	NOCLAS	NAM	GROUPE		PAYS	NOCLAS	NOM	GROUPE
	A	G00900109	**SIDI KHALED 1**	Point	24	T	19450005	**Douz (CI 12)**	Chef de Gr
	A	H01200037	**BOU AROUA BAR 1**	Point	25	T	19452005	**Steftimi (CI 7)**	Chef de Gr
	A	I00700008	**OUED MEHAIGUENE AB 1**	Point	26	T	20109005	**S.Lahad (CI 17)**	Chef de Gr
	A	K01200001	**SINCLAIR MPC RB2**	Point	27	T	19009005	**Ksar Ghilane 3 bis**	Chef de Gr
	A	K00900004	**Daiet Rempt (DR 101)**	Point	28	T	X00700213	**Bir Zebbas (BZ1)**	Chef de Gr
	A	L00700062	**TIN BOUZID N°24 NOUV**	Point	29	L	WG10	**WG10 (1230) (MP.0.50)**	Point
	A	O00700044	**In Salah 1 (IS 101)**	Chef de Gr	30	L	T/2B/103/0/76	**Lawd Zamz**	Point
	A	J00800021	**NOUMERATE AERODROME**	Chef de Gr	31	L	SIQ1	**Fawar al Khadem**	Point
	A	O00400139	**ZAOUIET KOUNTA**	Chef de Gr	32	L	3.83	**Mardum**	Point
	A	I01100437	**SIDI SLIMANE**	Chef de Gr	33	L	T/2A/0043/0/84	**Taouargha**	Point
	A	L01100011	**GT 101 GASSI TOUIL**	Chef de Gr	34	L	T/2B/0060/0/77	**Wadi Zamzam**	Point
	A	N00400270	**GUERRARA 13**	Chef de Gr	35	L	WH 1	**Wadi Whashkah**	Point
	T	19484005	**Behaier (CI 9)**	Point	36	L	BAK-2	**B. Kabir**	Point
	T	X00700212	**Ben Sabeur (SB 1)**	Point	37	L	BAK-4	**B. Kabir**	Point
	T	19432005	**MAHBES 1**	Point	38	L	BAK-1	**B. Kabir**	Point
	T	SP 4 N	**SP 4 (1)**	Point	39	L	N4 (44/81)	**Niha**	Chef de Gr
	T	19998005	**Zemlet El bidha**	Point	40	L	T/2B/0010/0/85	**Nemwah**	Chef de Gr
18	T	19504005	**Bir Zar**	Point	41	L	JH6A	**(JH6A)**	Chef de Gr
19	T	06368005	**Oued Abdallah 2**	Point	42	L	K-8	**Wadi Bay Kabir**	Chef de Gr
20	T	07000005	**SP3(Trapsa)(*)**	Point	43	L	ZZ 1	**ZZ1**	Chef de Gr
21	T	06511005	**Lorzot**	Point	44	L	T/2B/0031/0/84	**Sadadah**	Chef de Gr
22	T	18781005	**EL BORMA 210**	Chef de Gr	45	L	B-5 (1/81)	**Bani walid (B-5 (1/81))**	Chef de Gr
23	T	19190005	**CF 1 bis**	Chef de Gr	46	L	MAR6	**(MAR6)**	Chef de Gr

Chart 2 : TC Reference Network

Reseau de Reference du COMPLEXE TERMINAL									
PAYS		GROUPE	NOCLAS	NOM	PAYS		GROUPE	NOCLAS	NOM
1	A	Chef de Gr	L01100012	**ALLENDA NORD N 602**	14	T	Chef de Gr	06689005	**Guidma 1**
2	A	Chef de Gr	K01100022	**PUITS D'EAU NS I.H.I**	15	T	Chef de Gr	14021005	**MESSAID 3**
3	A	Chef de Gr	J01000518	**F SOVIET BOUROUBIA**	16	T	Chef de Gr	13995005	**Scast 5**
4	A	Chef de Gr	I01100076	**EL K'DA D36F63**	17	T	Chef de Gr	17675005	**El Faouar west**
5	A	Chef de Gr	H01100530	**KOUININE**	18	T	Chef de Gr	13116005	**PK 13**
6	A	Chef de Gr	H01100840	**MASRI**	19	T	Chef de Gr	09456025	**Sebaa Biar 2**
7	A	Chef de Gr	H01100356	**SIDI AHMED TIDJANI**	20	T	Chef de Gr	19181005	**Chouchet Negga 2**
8	A	Chef de Gr	I01000037	**AIN EL ARCHE**	21	T	Chef de Gr	06756005	**Ras El Aïn 1**
9	T	Point	20470005	**hezoua pz 1**	22	T	Chef de Gr	18826005	**GUETTAYA 4 bis**
10	T	Point	18755005	**Dergine El Ameur**	23	T	Chef de Gr	05692005	**RAHMAT 2**
11	T	Chef de Gr	19915005	**C2F1**	24	L	Point	MW-1287	**(1287) (MP.0.0)**
12	T	Chef de Gr	05713005	**Scast 4**	25	L	Point	T/2B/0022/0/8	**T/2B/0022/0/87**
13	T	Chef de Gr	18859005	**PZ Douz**	26	L	Chef de Gr	JF18A	**Ferjan**
					27	L	Chef de Gr	MW-2128	**2128 (P6)**

Diagram 1 : Groups of water points and reference historical series at the IC

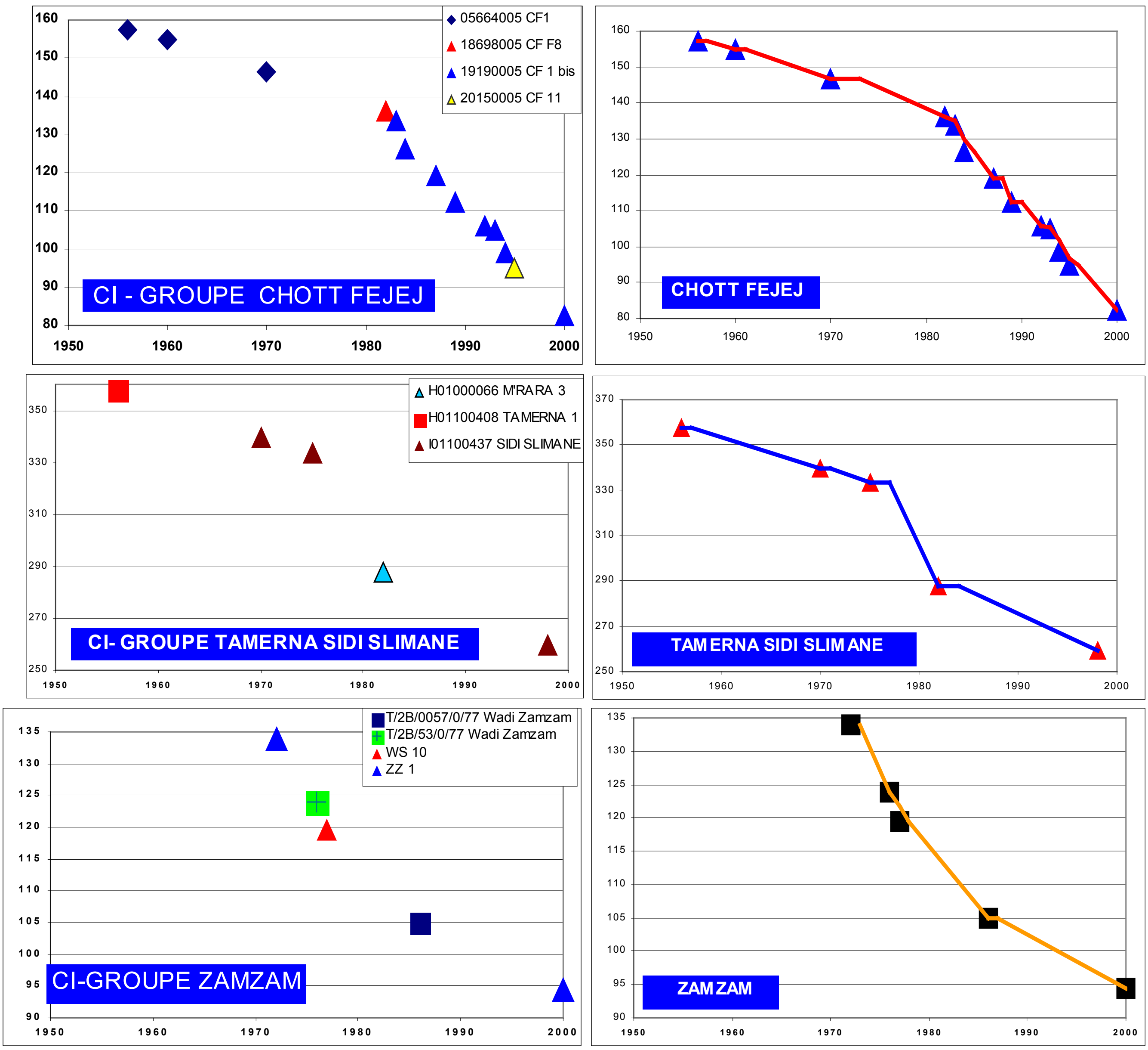


Diagram 2 : Groups of water points and reference historical series at the TC

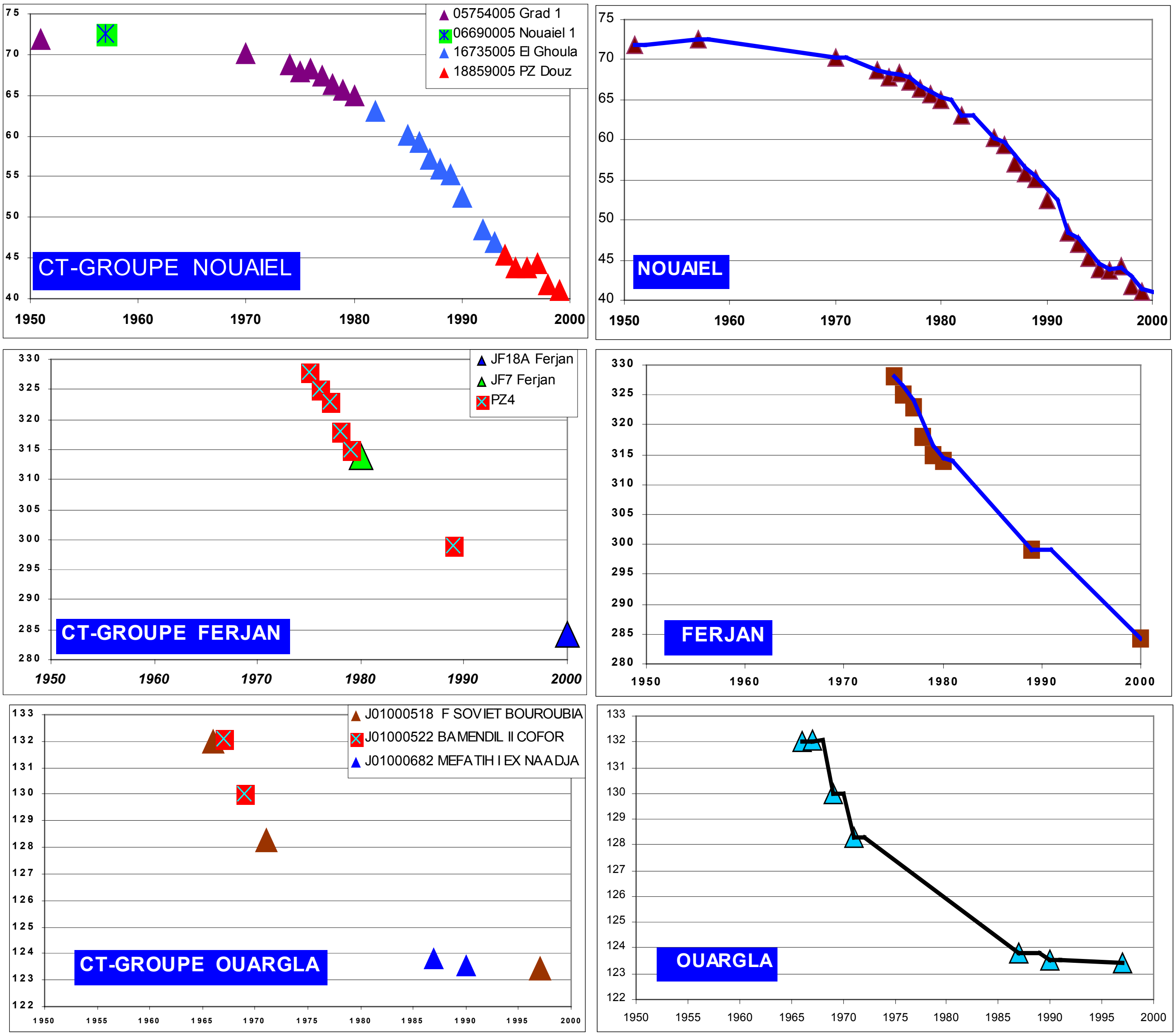
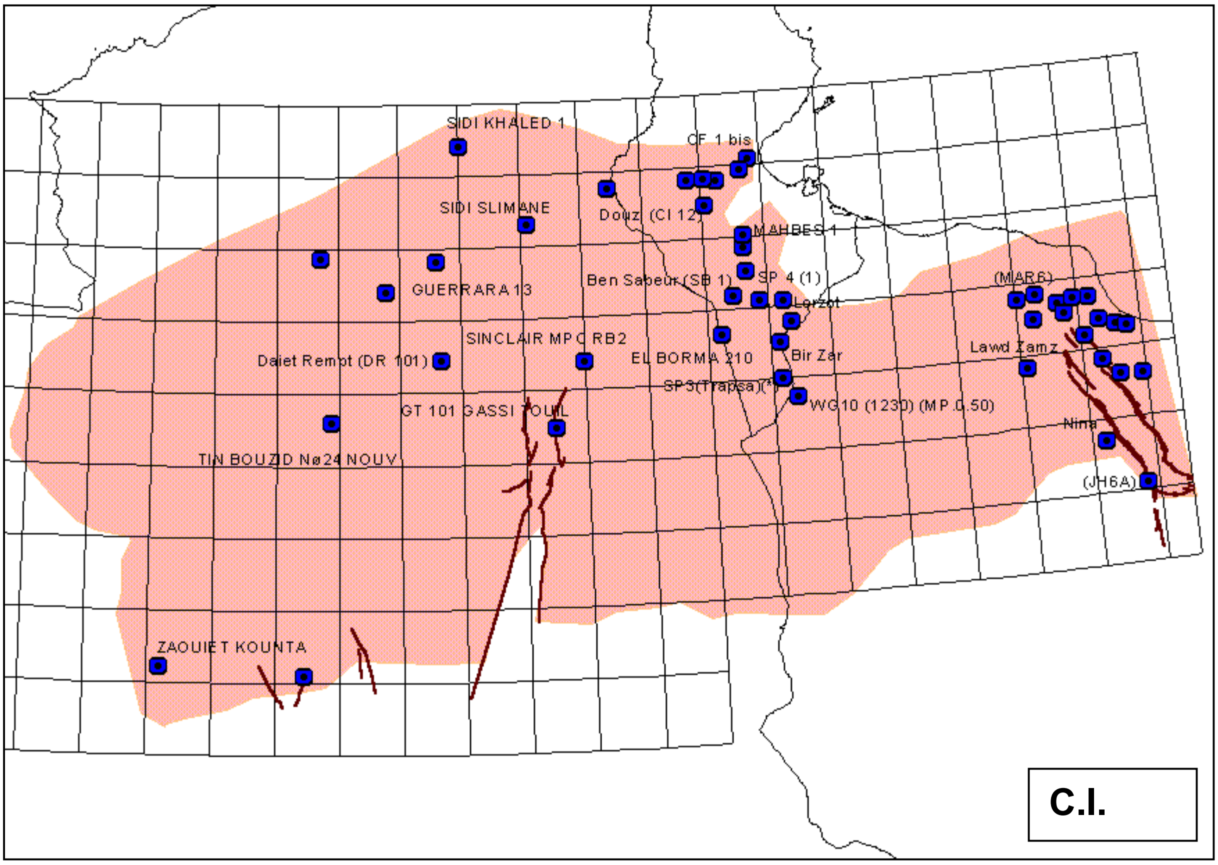
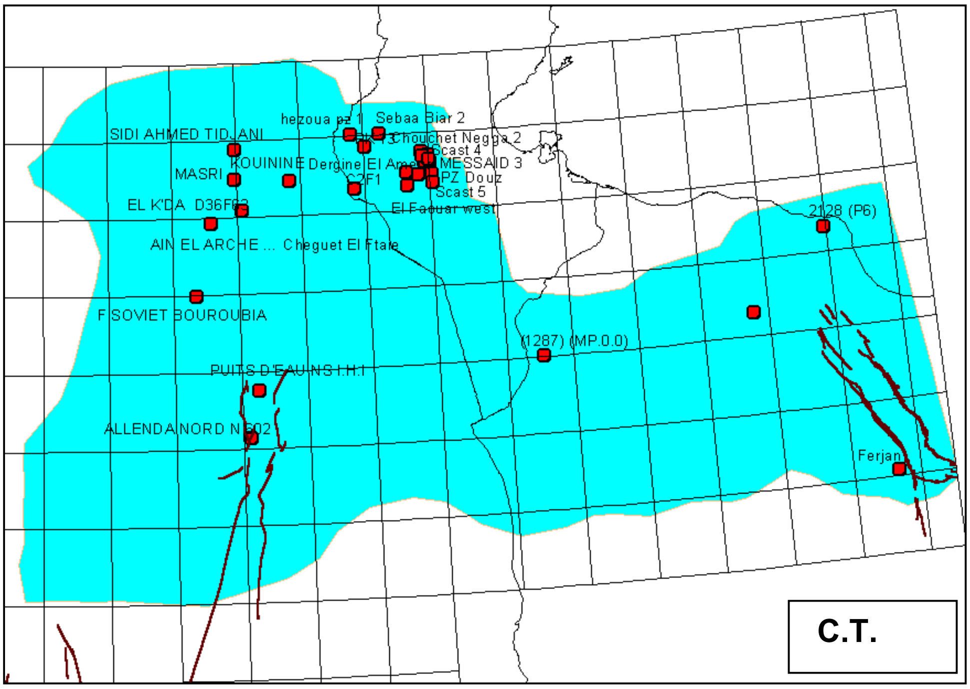


Diagram 3 : Location of the water points making up the reference networks at the IC and the TC





2- ANALYSIS OF THE REFERENCE NETWORK

The analysis of the network is carried out with reference to a certain number of indicators, by which it is possible to assign a qualification, a quality level to each of the reference points of the network. These indicators, which we will define hereafter, will concern the space distribution of the points, the temporal distribution of the measurements and the aptitude to represent a certain number of useful sizes for the management of the underground waters intake flows, regional level drops.

2.1- Space Coverage : the intrinsic presence rate

It is about measuring the space coverage density secured by the piezometric surveillance. We have to assign to each water point the domain it is supposed to control : in order to do so, the best way consists in deliminating the influence polygons of each point using the mediatrix method. The results for the IC and the TC is represented in Figures 4 and 5, respectively.

Figure 4 : The Influence Polygons of the pilot wells in the IC

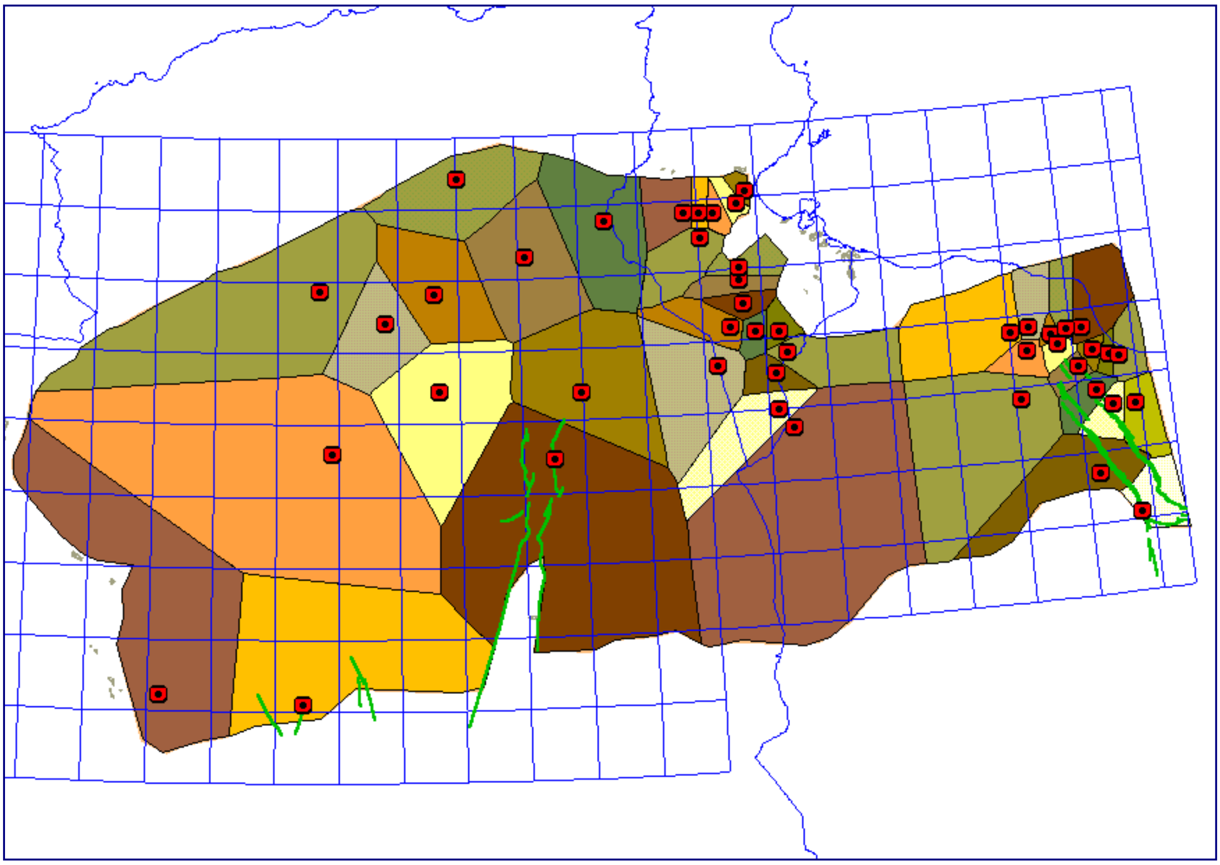
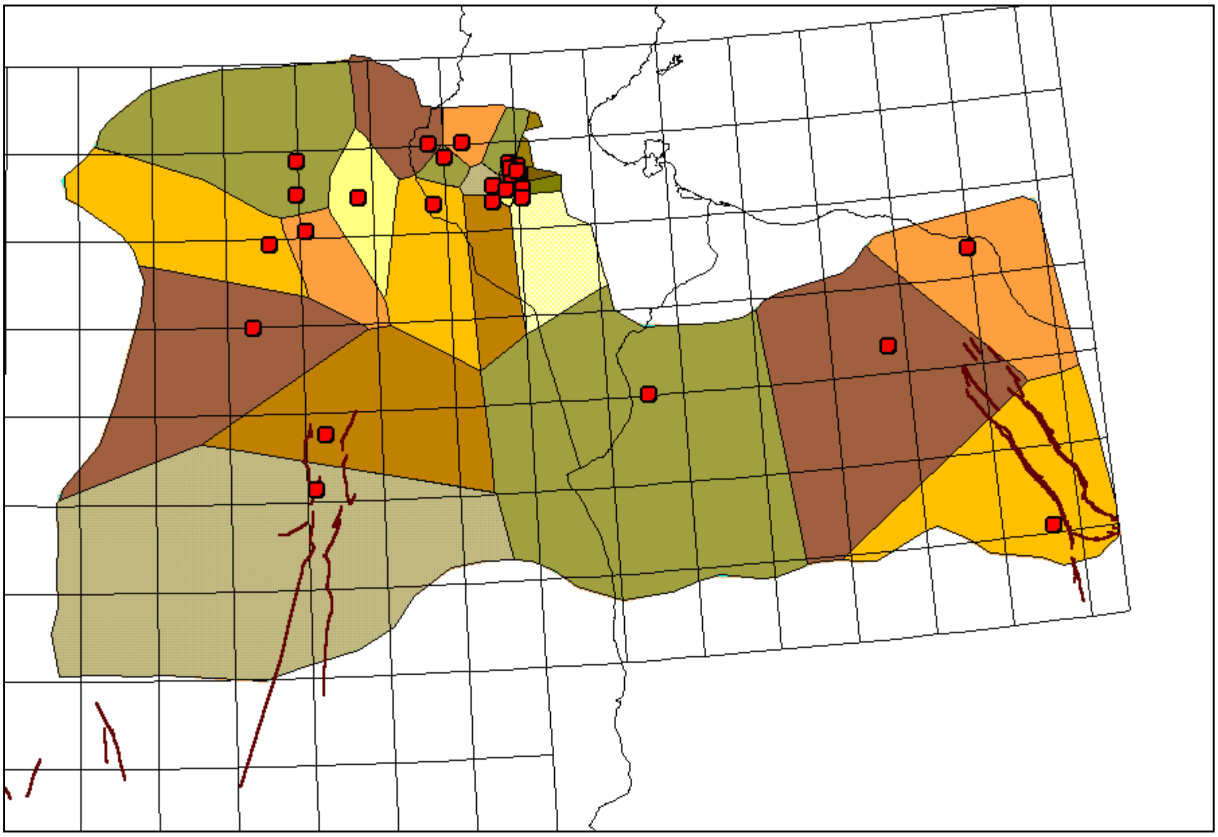


Figure 5 : The Influence Polygons of the pilot wells in the TC



The curve of the influence polygons allows to quantify, in terms of surface, the importance of the domain controlled by each point of the network. The preceding diagrams indicate the number of transborder polygons, which is not obviously imaginable, including the case where the network is jointly managed. Indeed, it is up to **each country to proceed with the collection of the data about its own territory** ; it is only at a later stage that these data shall be grouped and analysed together. In this perspective, the drawing of the polygon is made again separately for each country, the assembly will be done then by aquifer system.

How to qualify the status of the space coverage by the points in the present network ?

In the absence of piezometric coverage standards, we can imagine that in the SASS regions, no matter their levels of knowledge, operation or even accessibility, we can no longer tolerate that there is not at least one pilot well per square degree, namely to put it in a simpler way, per 10,000 km². For each of the network points, we can therefore define a space coverage index as :

SPAT = 10,000 / surface ;

Surface : is the corresponding polygon surface in Km².

The results of the calculation is provided in the charts 3 and 4. The SPAT index varies from 10 down to values inferior to 0.1, which means that a single pilot well can control a territory covering a surface superior to 100,000 km², which is especially the case for :

Oued Mehiguene, Tin Bouzid, In Salah, Zaouiet Kounta, Gassi Touil, and Ghadames in the Intercalary Continental, as well as Allenda and Water Points (Gassi Touil), Mw1287 and TR/2B87 for the Terminal Complex facility.

If we keep the criterium of one point per 10,000 km² as a minimum coverage, we will notice that at the IC, 18 points over 46 do not comply with this criterium, which represents 90 % in terms of surface of the IC sheet. For the TC and according to the same criterium, these figures are respectively of 48 % of the points, corresponding to 96 % of the territory which is not enough covered by the piezometric surveillance.

2.2- Exploitation Surveillance and Drawdowns Control

In an aquifer system whose water resources are slightly renewable, the essential function assigned to a piezometric network is to give enough information about the exploitation level and to properly control the drawdowns evolution.

We can qualify or measure up the surveillance level of the intakes by the density of the flow of every influence polygon (recorded annual volume divided by the polygon surface). In terms of sizes, this indicator represents a water blade. It is the column EXP of the chart, expressed here in mm/year and divided by the exploitation of the year 2000. This value varies from zero for the non exploited polygons up to a maximum of 18 mm for the IC. For the Terminal Complex facility, this index reaches exceptionally high values : it varies from zero (Gassi Touil) up to 363 mm/year in Ras El Ain (1mm/day).

This indicator gives an idea about the exploitation status but does not allow the classification of the piezometers in relation to this criterium ; indeed, a piezometer is "good" if it is located in the core of a catching field because it gives the most significant drawdowns ; but a piezometer is not all that good if it is located far from the catching points because it gives then a non influenced drawdown and sometimes, in very remote areas, **a nil drawdown which makes up a very precious indication in order to provide information, on the influence radium of the catching fields.**

In terms of drawdowns, the column "Rabtot" of the table gives the total drawdown of the considered series, reconstitued according to the observations made on the series itself. But this drawdown does not relate always to all the reference period of 1950 – 2000, especially when the series is short or when it ends in a premature way. We reconstitute the additional drawdown by referring either to the neighbouring points, judged as being more reliable, or to the drawdown restored by the model ; the latter is supposed to soften the heterogeneities and provide an average or representative drawdown (there is of course a certain bias as long as a great number of water points have precisely served to the transient fixing of the model). The column RAB of the chart provides the ratio of rabtot to the drawdown value, at the same point, but it is integrated over all the period of 1950-2000.

This last indicator gives information on the capacity of the series to measure up the drawdown of the sheet. It varies from 0.3 to 1, with very numerous values equal to 1 or very close thereto : it is nothing else but the result of the regrouping of the series : the groups of water points aim precisely at extending the series in order to cover the maximum possible drawdown. (*The values above 1 make up anomalies ; there exists two of them at the TC*)

2.3- The Durability Index of the network water points

We are talking at present, about the assessment of the aptitute of every series for extension, in the future. Starting from the principle that the most recent series (in order to cover the eighties and the nineties when we witnessed the strongest flows) and the longest series, once critized, are always the best to chase, even if they were interrupted for some years. One has therefore to find a durability indicator which integrates several parameters at the same time :

- Longetivity
- Regularity
- Aptitude to continue the measurements

Longetivity is measured by the length of the series, in years : T.

The regularity can be measured by the rate of occurrence of the measurements : ratio of N number of the annual measurements[1] to the total length of the reference historical period which is 50 years.
Concerning the aptitude of a series to be continued in the future, it is stronger as the series is more recent. It will be reversibly proportional to the seniority A of the series. If the end is the year of the interruption of the observations, we will have :

$$A = 2001 - \text{end.}$$

The DURABILITY index is therefore :

$$DUR = (N/50) \times (T/A)$$

(DUR) can vary from 0.01 to 50 : the maximum would be for a 50 year series and including 50 level measurements. In fact, the recorded maximum reaches a DUR of 26 for the TC (Ras El Ain) and 11.7 for the IC (CF1bis). The minimum for the TC is for T/2B../87 with a DUR=0.005 for two measurements in 77-79, preceded by the Hazoua piezometer (DUR=0.04) with two measurements in 98-99. At the IC, the values drop very quickly : there exists only three points (or groups of points) for which DUR is higher than 3 ; although the seniority parameter is very penalizing to the denominator, the number of measurements for the IC is very low.

Chart 3 : Quality Indicators of the IC

Les INDICATEURS du CONTINENTAL INTERCALAIRE																	
PAYS	GROUP	NOCLAS	NOM	SUP	Qexp	Nexp	Rabtot	Nmes	Deb	Fin	Npdeb	Npfin	DensQ	SPAT	EXP	RAB	DUR
A	0	G00900109	SIDI KHALED 1	24624	70880940	34	80	2	1956	1970	381	351	2879	**0,4**	**3**	**0,4**	**0,0**
A	0	H01200037	BOU AROUA BAR 1	22630	946080	2	25	2	1970	1998	267,9	247,8	42	**0,4**	**0**	**0,8**	**0,4**
A	0	I00700008	OUED MEHAIGUENE AB 1	73347	1419120	1	5	2	1955	1990	481	477,7	19	**0,1**	**0**	**0,7**	**0,1**
A	0	K01200001	SINCLAIR MPC RB2	64605	34901207	31	23	3	1962	1998	333	312,8	540	**0,2**	**1**	**0,9**	**0,7**
A	0	K00900004	Daiet Rempt (DR 101)	36750	24125040	10	10	2	1960	1990	424,5	417,4	656	**0,3**	**1**	**0,7**	**0,1**
A	0	L00700062	TIN BOUZID N°24 NOUV	139138	61825620	81	8	3	1958	1994	401	395,3	444	**0,1**	**0**	**0,7**	**0,3**
A	100	O00700044	In Salah 1 (IS 101)	68185	51078708	76	10	5	1956	1991	281,3	272,05	749	**0,1**	**1**	**0,9**	**0,4**
A	101	J00800021	NOUMERATE AERODROME	17526	117159804	100	20	4	1956	1998	440,71	421,68	6685	**0,6**	**7**	**1,0**	**1,1**
A	200	O00400139	ZAOUIET KOUNTA	77219	181919046	372	5	5	1958	1996	218	214,6	2356	**0,1**	**2**	**0,7**	**0,8**
A	500	I01100437	SIDI SLIMANE	28857	63072000	18	100	5	1956	1998	357,93	259,5	2186	**0,3**	**2**	**1,0**	**1,4**
A	700	L01100011	GT 101 GASSI TOUIL	138698	20185248	15	10	4	1962	1998	350	341,77	146	**0,1**	**0**	**0,8**	**1,0**
A	900	N00400270	GUERRARA 13	22388	35126175	20	50	3	1954	1993	428,16	382,8	1569	**0,4**	**2**	**0,9**	**0,3**
T	0	19484005	Behaier (CI 9)	1976	2227342	5	60	5	1986	2000	190,6	155,8	1127	**5,1**	**1**	**0,6**	**1,5**
T	0	X00700212	Ben Sabeur (SB 1)	5219	210000	1	35	3	1956	2000	312	286,6	40	**1,9**	**0**	**0,7**	**2,7**
T	0	19432005	MAHBES 1	4151	174917	2	12	5	1985	1999	293,5	284,2	42	**2,4**	**0**	**0,8**	**0,8**
T	0	SP 4 N	SP 4 (1)	3185	567036	8	7	4	1963	2000	307,5	301,6	178	**3,1**	**0**	**0,8**	**3,0**
T	0	19998005	Zemlet El bidha	1792	0	0	40	3	1993	2000	84,2	73,8	0	**5,6**	**0**	**0,3**	**0,5**
T	0	19504005	Bir Zar	2865	0	0	8	2	1982	2000	306,1	303,4	0	**3,5**	**0**	**0,3**	**0,8**
T	0	06368005	Oued Abdallah 2	2754	580955	17	12	4	1964	2000	306,2	295,4	211	**3,6**	**0**	**0,9**	**3,0**
T	0	07000005	SP3(Trapsa)(*)	6516	202953	4	7	3	1956	2000	325,1	318,2	31	**1,5**	**0**	**1,0**	**2,7**
T	0	06511005	Lorzot	978	23396	3	15	4	1955	1982	316,8	312,6	24	**10,2**	**0**	**0,3**	**0,1**
T	100	18781005	EL BORMA 210	3395	7236768	11	40	6	1963	2000	311,3	270	2132	**2,9**	**2**	**1,0**	**4,6**
T	200	19190005	CF 1 bis	1537	27428131	12	80	13	1956	2000	157,39	82,4	17845	**6,5**	**18**	**0,9**	**11,7**
T	300	19450005	Douz (CI 12)	8567	9199689	5	60	6	1986	2000	261,88	223	1074	**1,2**	**1**	**0,6**	**1,8**
T	400	19452005	Steftimi (CI 7)	1829	6116601	4	60	7	1986	2000	234,88	212,8	3344	**5,5**	**3**	**0,4**	**2,1**
T	500	20109005	S.Lahad (CI 17)	13893	10424722	7	50	5	1986	2000	234,88	212,8	750	**0,7**	**1**	**0,4**	**1,5**
T	800	19009005	Ksar Ghilane 3 bis	4421	4770912	16	35	9	1951	2000	297	262,8	1079	**2,3**	**1**	**1,0**	**9,0**
T	900	X00700213	Bir Zebbas (BZ1)	2376	331568	2	12	4	1966	2000	306,8	295,75	140	**4,2**	**0**	**0,9**	**2,8**
L	0	WG10	WG10 (1230) (MP.0.50)	94325	19537200	7	9	11	1975	1995	296,9	288,7	207	**0,1**	**0**	**0,9**	**0,8**
L	0	T/2B/103/0/76	Lawd Zamz	47392	0	1	35	2	1979	2000	265,7	230,5	0	**0,2**	**0**	**1,0**	**0,9**
L	0	SIQ1	Fawar al Khadem	3571	5000000	2	60	2	1978	2000	199,7	138	1400	**2,8**	**1**	**1,0**	**0,9**
L	0	3.83	Mardum	1122	2000000	1	37	2	1978	2000	140,4	103,5	1783	**8,9**	**2**	**1,0**	**0,9**
L	0	T/2A/0043/0/84	Taouargha	2790	6000000	1	40	2	1987	2000	72,5	48,4	2151	**3,6**	**2**	**0,6**	**0,6**
L	0	T/2B/0060/0/77	Wadi Zamzam	1303	8000000	1	60	3	1977	2000	114,5	61,6	6140	**7,7**	**6**	**0,9**	**1,4**
L	0	WH 1	Wadi Whashkah	1202	3000000	1	40	2	1976	2000	98,4	58,1	2496	**8,3**	**2**	**1,0**	**1,0**
L	0	BAK-2	B. Kabir	4015	2000000	1	40	2	1977	2000	154,3	114,3	498	**2,5**	**0**	**1,0**	**1,0**
L	0	BAK-4	B. Kabir	2456	3500000	2	40	2	1976	2000	157	117	1425	**4,1**	**1**	**1,0**	**1,0**
L	0	BAK-1	B. Kabir	6716	0	0	40	2	1978	2000	159	119	0	**1,5**	**0**	**1,0**	**0,9**
L	100	N4 (44/81)	Nina	19735	9700000	2	35	4	1981	2000	371	336	492	**0,5**	**0**	**1,0**	**1,6**
L	101	T/2B/0010/0/85	Nemwah	2940	0	0	60	3	1977	2000	154,7	94,4	0	**3,4**	**0**	**1,0**	**1,4**
L	110	JH6A	(JH6A)	7424	14016000	1	35	5	1975	2000	327,5	292,92	1888	**1,3**	**2**	**1,0**	**2,6**
L	200	K-8	Wadi Bay Kabir	4389	5000000	1	50	3	1975	2000	162	115,07	1139	**2,3**	**1**	**0,9**	**1,6**
L	400	ZZ 1	ZZ 1	3199	7500000	1	40	5	1972	2000	134	94,36	2344	**3,1**	**2**	**1,0**	**2,9**
L	600	T/2B/0031/0/84	Sadadah	1606	0	0	35	3	1985	2000	161,64	136,4	0	**6,2**	**0**	**0,7**	**1,0**
L	700	B-5 (1/81)	Bani walid (B-5 (1/81))	23400	16193000	5	35	4	1982	2000	238,2	204	692	**0,4**	**1**	**1,0**	**1,5**
L	800	MAR6	(MAR6)	5263	7000000	4	50	4	1978	2000	185,68	139,15	1330	**1,9**	**1**	**0,9**	**1,8**

[1] During the elaboration of the SASS data Base, it was agreed to keep a piezometric value per year.

Chart 4 : TC Network Quality Indicators

Les INDICATEURS du COMPLEXE TERMINAL																	
PAYS	GROUP	NOCLAS	NOM	SUP	Qexp	Nexp	Rabtot	N_mes	Deb	Fin	Npdeb	Npfin	DensQ	SPAT	EXP	RAB	DUR
A	100	L01100012	**ALLENDA NORD N 602**	137876	5059951	20	1	4	1957	1990	169	168	37	**0,1**	**0**	**1,0**	**0,2**
A	200	K01100022	**PUITS D'EAU(G.Touil)**	67122	0	0	0,5	3	1960	1990	145,21	144,8	0	**0,1**	**0**	**0,8**	**0,2**
A	430	J01000518	**F SOVIET BOUROUBIA**	49420	97165283	263	10	7	1966	1997	131	123,42	1966	**0,2**	**2**	**0,8**	**1,1**
A	500	I01100076	**EL K'DA D36F63**	10913	155987228	266	35	4	1970	1995	88,59	55,2	14294	**0,9**	**14**	**1,0**	**0,3**
A	600	H01100530	**KOUININE**	45792	84309981	142	35	5	1961	1995	77,97	51,95	1841	**0,2**	**2**	**0,7**	**0,6**
A	700	H01100840	**MASRI**	34652	292250958	371	40	5	1953	1991	41,35	12,7	8434	**0,3**	**8**	**0,7**	**0,4**
A	800	H01100356	**SIDI AHMED TIDJANI**	34652	292250958	371	35	7	1955	1995	31,94	-0,2	8434	**0,3**	**8**	**0,9**	**1,0**
A	900	I01000037	**AIN EL ARCHE**	34071	25699302	40	1	4	1957	1990	98,09	97,17	754	**0,3**	**1**	**0,9**	**0,2**
T	0	20470005	**hezoua pz 1**	2704	26598147	39	20	2	1998	1999	38,8	37,3	9837	**3,7**	**10**	**0,1**	**0,0**
T	0	18755005	**Dergine El Ameur**	1451	3990046	8	30	20	1979	2000	68,7	48,5	2750	**6,9**	**3**	**0,7**	**8,8**
T	100	19915005	**C2F1**	2516	22850838	28	20	16	1977	1999	80	63,51	9082	**4,0**	**9**	**0,8**	**3,7**
T	101	05713005	**Scast 4**	641	21933633	39	35	16	1951	2000	66,4	31,58	34218	**15,6**	**34**	**1,0**	**16,0**
T	111	18859005	**PZ Douz**	461	86227483	50	32	25	1951	1999	71,9	40,99	187044	**21,7**	**187**	**1,0**	**12,3**
T	120	06689005	**Guidma 1**	365	17190755	18	22	26	1957	2000	70,68	48,68	47098	**27,4**	**47**	**1,0**	**22,9**
T	130	14021005	**MESSAID 3**	307	62046236	39	42	15	1952	1999	62,49	21,74	202105	**32,6**	**202**	**1,0**	**7,2**
T	140	13995005	**Scast 5**	30480	1886979	8	40	14	1972	1994	76,28	44,1	62	**0,3**	**0**	**0,8**	**0,9**
T	300	17675005	**El Faouar west**	6701	11682580	22	25	20	1969	1997	70,49	53,53	1743	**1,5**	**2**	**0,7**	**2,9**
T	400	13116005	**PK 13**	1842	36406228	36	30	9	1965	1999	53,2	26,5	19765	**5,4**	**20**	**0,9**	**3,2**
T	500	09456025	**Sebaa Biar 2**	3923	73094223	89	25	28	1954	1995	53,3	34,46	18632	**2,5**	**19**	**0,8**	**3,9**
T	600	19181005	**Chouchet Negga 2**	3173	50087809	78	35	17	1950	2000	55,3	20,01	15786	**3,2**	**16**	**1,0**	**17,3**
T	700	06756005	**Ras El Aïn 1**	80	29004092	28	30	26	1951	2000	49,96	18,64	362551	**125,0**	**363**	**1,0**	**26,0**
T	800	18826005	**GUETTAYA 4 bis**	200	9497574	16	35	21	1972	1999	58,96	29,91	47488	**50,0**	**47**	**0,8**	**5,9**
T	900	05692005	**RAHMAT 2**	658	4111956	10	40	21	1951	2000	62,35	25,33	6249	**15,2**	**6**	**0,9**	**21,0**
L	0	MW-1287	**(1287) (MP.0.0)**	74649	0	0	0,2	14	1974	2000	4	3,08	0	**0,1**	**0**	**4,6**	**7,6**
L	0	T/2B/0022/0/87	**T/2B/0022/0/87**	76748	12000000	5	0,2	2	1977	1979	278,1	249,5	156	**0,1**	**0**	**143,0**	**0,0**
L	100	JF18A	**Ferjan**	44643	107914586	5	50	8	1975	2000	328	284,3	2417	**0,2**	**2**	**0,9**	**4,2**
L	300	MW-2128	**Zamzam-2128 (P6)**	21095	112600000	19	18	20	1974	2000	-2,77	-18,4	5338	**0,5**	**5**	**0,9**	**10,8**

3- CONSOLIDATION OF THE REFERENCE NETWORK :

3.1- Spatial Densification

90% of the SASS domain, both for the IC and the TC, was either ill covered or not covered at all by the piezometric network. The first measurement aiming at consolidating the network must therefore target the improvement of the density of the spatial coverage. It would be therefore useless to contemplate real proposals in this respect, on a purely documentary basis, but we can reasonably allow that a coverage of one point for 10,000 Km² must constitute a short term plausible target, all the more so as (cf. §3.3 « risk coverage ») the least covered areas are precisely those for which the SASS study proposes to direct the biggest portion of the intakes to come and mainly the investigations to be conducted.

3.2- Adequacy to the SASS Model Wedging :

A more developped spatial density will allow undoubtedly, in the future, when the need arises, to take up again the fixing of the model, as a transition, on a new historical sequence, to obtain a better representation of the model and therefore a bigger viability of the results in simulation cases.

Besides, one of the main results of the SASS study was to prove that observing the drawdowns in the **free surface zones of the sheet,** even if they were remote from the pumping fields, constituted one of the main keys for a better viability of the forecasts.

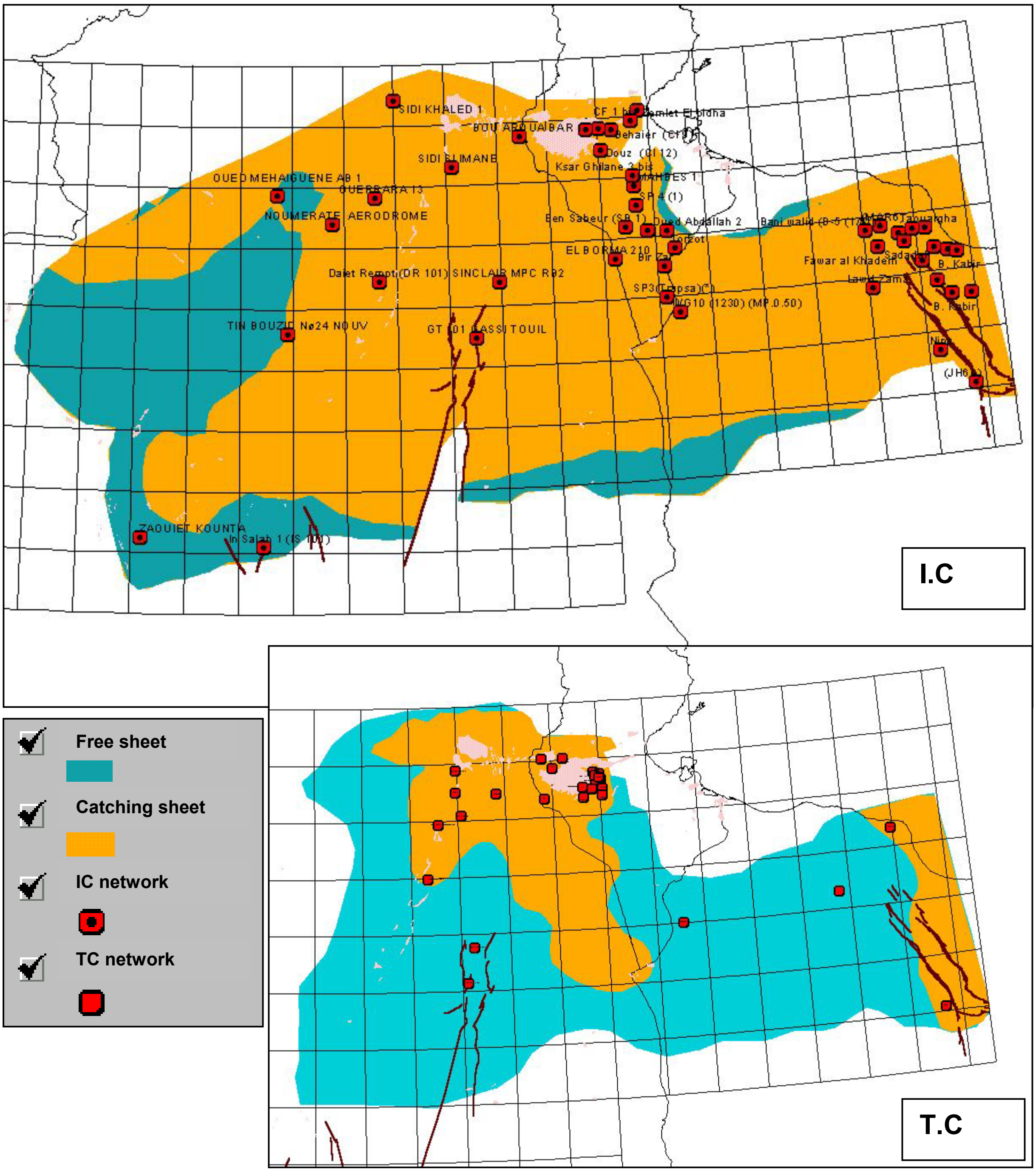
How do the points of the present reference network behave in relation to these free surface regions ? The diagram 6 allows to have a precise idea thereon.

The IC water, besides the two Adrar points (Zaouiet Kounta ; In Salah) which control the Touat-Tidikelt, the big free surface reservoir of the Intercalary Continental of the Western Erg, a real water castle in the making of the SASS, is controlled only by two pilot wells : Oued Meheguene and Tin BouZid, the two points which, as we mentioned before, had the worst spatial coverage coefficients. The control of all this region in the IC is to be considerably reinforced.

Concerning the TC free sheet which represents the huge stretches, mainly in the Tunisian South and particularly in the Algerian South (whereas the existence of a free surface under the Hamada El Hamra is still to be confirmed) is controlled only by two water points (Gassi Touil and Alenda North wells) which both of them indicate drawdowns that are however lower to 1 m in 50 years (0.45 m and 1m respectively), but which need to be reconfirmed by a more regular follow up.

In the chapter called Model improvements, another domain where the piezometric surveillance must bring in a contribution, is the follow up of the reloading. Indeed, one of the weak points of all the built models in the region, including that of SASS, is to shift too quickly to the reloading solution. Furthermore, none of the piezometric network points is located on the reloading surfaces of the sheet, whether for the IC or for the TC. In the selection of the location of new pilot wells, the objective of following up the reloading must be taken into consideration.

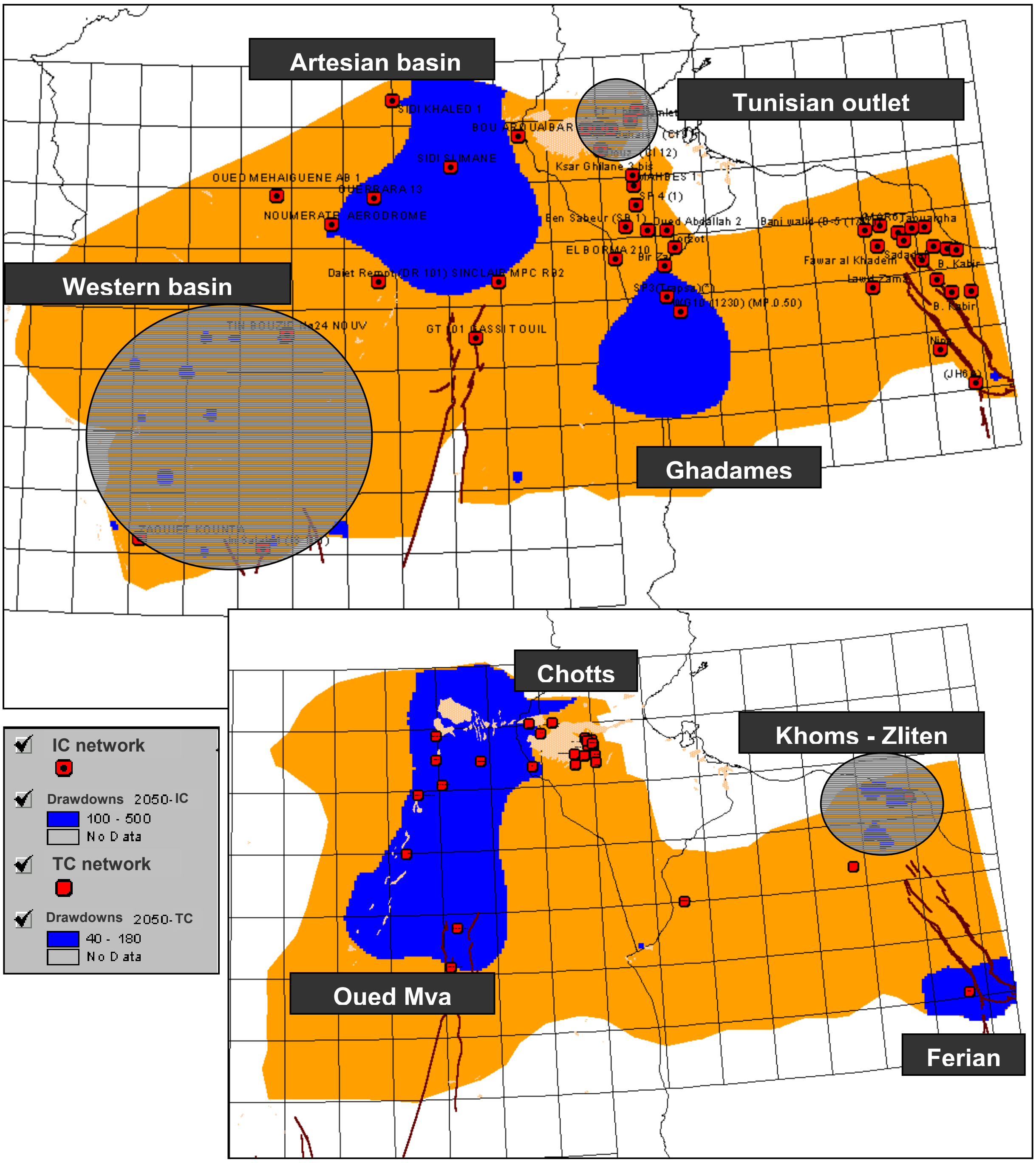
Diagram 6 : Location of the pilot-wells and limits of the free sheet – catching sheet In the IC and the TC



3.3- Risk Coverage

the diagram 7, taking up the total drawdowns (the SUM of zero scenario and the simulated last scenario, respectively IC8 for the IC and TC5 for the TC) are represented in blue (above 100 m for the IC and 40 m for the TC) shows the SASS risk map. The forecast risks in the region include namely :

Diagram 7 : The SASS risk map and the Reference Piezometric Network



3.3.1- The Tunisian Outlet (IC)

One can consider, as a first analysis, that the Tunisian outlet is properly covered in terms of piezometric surveillance. Indeed, its perimeter (diagram 7) is already controlled by six pilot wells in the present reference network. The unique measurement which would allow to increase the efficiency of the control would consist in totally dedicating one of the wells of the CF group to the piezometric surveillance while fitting it out with a permanent measuring equipment.

3.3.2- The Artesian Basin (IC)

Sidi Slimane, Guerrara and Noumerate : these are the present network water points which would allow to continue tracking the artesianism evolution in the region of Oued Rhir and El Oued. It is not enough for a perimeter whose additional expected drawdowns (with respect to 2000) will exceed 100 m over more than 80,000 km². A consolidation of the network in this sector seems necessary.

3.3.3- The Ghadames Basin (IC)

The expected drawdown in this sector would exceed 100 m over more than 50,000 km². Here also, the surveillance is presently negligeable ; it is secured only by two points : WG10 and SP3. The consolidation of the network is also mandatory.

3.3.4- The Western Basin (IC)

Here, the seriousness of the problem is summarized by three figures :
-Three hundred thousand Km² of sheet surface governing this basin
-Three billion m3/year of additional intakes in 50 years have been simulated by the Model
-Three pilot wells, composing the surveillance present network (Tin Bouzid, Zaouiet Kounta, In Salah)

3.3.5- The Algerian-Tunisian Chotts (TC)

With respect to the « chotts » risk, the piezometric surveillance level seems by far satisfactory in the Nefzaoua with 11 pilot wells over less than 2000 Km². This level is not all that high in the Djerid (North of Chott Djerid) with only 3 pilot wells, and still less high in the Oued Rhir Valley and around the Merouane and Melghir chotts with a total of six wells for all this région.

3.3.6- The Oued Mya

This new catching field to be developped, simulated by the model at 600 Million m3/year, is not controlled yet by any piezometric surveillance : the nearest pilot well, today (Russian drilling in Gassi Touil) is located at more than 100 Km from the site.

3.3.7- Ferjan

The expected additional drawdowns exceed 50 m. One must reinforce the surveillance, presently secured by a single group of wells.

3.3.8 – Khoms –Zliten

We expect that this coastal zone will suffer very important drawdowns if the simulated scenarii on the model (absorbing the deficits) were executed : in 2050, the sheet level would be more than 50 m below the sea level. A very close monitoring must be conducted as of today.

4- THE FUTURE OF THE REFERENCE NETWORK

How must we proceed, today, in order to secure the continuation of the piezometric observations under the best possible conditions ? How must we select the water points which will make up the SASS surveillance network ? What are the present network points that we have to keep and what are those which we should consider to replace ? In which locations must we replace the wells by piezometers in order to secure a greater "autonomy" as far as the measurements are concerned, with respect to the exploitation regime ? What are the new points to be implemented ? At the end of the analysis, which is drafted hereabove, an adequate answer to all these questions requires a case by case handling. One can nevertheless try to bring up some answers after examining some of the network characteristics.

4.1- Continuing the series using the most recent points :

Since the service life of boreholes is limited, it seems reasonable to select the youngest points in the present network in order to secure the perenniality of the historical series. Unfortunately, the examination of the creation dates indicates generally old ages, both at the level of IC and TC (Diagram 5). Despite the missing information, we can deduct that about 4 or 5 boreholes are more than 20 year old and one borehole out of three is more than 40 year old. Many of the old tutors of the network must therefore be replaced : one should get ready for the necessary arrangement and already select the water points to which this function is to be assigned. We can consider, besides that, except for contrary checking on the site, the 30 year old boreholes can continue to fulfil this function.

Chart 5 : Execution dates of the network water points ; IC and TC respectively

N°	Country	Name	Completion date		N°	Country	Name	Completion date
1	A	GUERRARA 13	19/12/93		12	L	(JH6A)	
2	A	BOU AROUA BAR 1	11/08/70		13	L	(MAR6)	
3	A	GT 101 GASSI TOUIL	01/01/62		14	L	Lawd Zamz	
4	A	SINCLAIR MPC RB2	01/01/62		15	L	Taouargha	
5	A	Daiet Rempt (DR 101)	02/10/60		16	L	Wadi Zamzam	
6	A	SIDI SLIMANE	05/07/60		17	L	Nemwah	
7	A	ZAOUIET KOUNTA	01/01/60		18	L	Sadadah	
8	A	TIN BOUZID No24 NOUV	21/04/58		1	T	Zemlet El bidha	04/10/93
9	A	NOUMERATE AERODROME	01/01/56		2	T	Bir Zar	31/12/87
10	A	SIDI KHALED 1	01/01/56		3	T	Behaier (CI 9)	03/11/86
11	A	OUED MEHAIGUENE AB 1	01/01/55		4	T	Steftimi (CI 7)	05/09/86
12	A	In Salah 1 (IS 101)			5	T	Douz (CI 12)	22/07/86
1	L	Mardum	01/01/83		6	T	CF 1 bis	06/02/84
2	L	Bani walid (B-5 (1/81))	01/01/82		7	T	Ksar Ghilane 3 bis	01/04/81
3	L	Nina	01/01/81		8	T	EL BORMA 210	01/01/78
4	L	Fawar al Khadem	01/01/78		9	T	SP3(Trapsa)(*)	31/12/60
5	L	B. Kabir	01/01/78		10	T	MAHBES 1	
6	L	B. Kabir	01/01/77		11	T	S.Lahad (CI 17)	
7	L	Wadi Bay Kabir	01/01/77		12	T	Ben Sabeur (SB 1)	
8	L	Wadi Whashkah	01/05/76		13	T	SP 4 (1)	
9	L	B. Kabir	01/01/76		14	T	Oued Abdallah 2	
10	L	ZZ1	01/01/72		15	T	Lorzot	
11	L	WG10 (1230) (MP.0.50)			16	T	Bir Zebbas (BZ1)	

N°	Countr	Name	Completion date		N°	Country	Name	Completion date
1	A	KOUININE	25/11/77		2	T	Chouchet Negga 2	10/12/83
2	A	MASRI	01/01/69		3	T	Dergine El Ameur	09/11/77
3	A	F SOVIET BOUROUBIA	24/04/66		4	T	El Faouar west	19/01/77
4	A	AIN EL ARCHE . Cheguet El Ftaie	01/01/66		5	T	MESSAID 3	06/01/73
5	A	PUITS D'EAU NS I.H.I	27/08/60		6	T	Scast 5	31/08/72
6	A	ALLENDA NORD N 602	18/12/57		7	T	PK 13	02/07/71
7	A	EL K'DA D36F63	26/04/53		8	T	Ras El A<n 1	13/02/59
8	A	SIDI AHMED TIDJANI	10/07/52		9	T	Guidma 1	06/04/57
1	L	Ferjan	01/01/76		10	T	RAHMAT 2	09/03/51
2	L	(1287) (MP.0.0)			11	T	Scast 4	17/01/49
3	L	T/2B/0022/0/87			12	T	hezoua pz 1	
4	L	2128 (P6)			13	T	C2F1	
1	T	PZ Douz	05/02/92		14	T	Sebaa Biar 2	
					15	T	GUETTAYA 4 bis	

4.2-Transforming into Piezometers the most shallow boreholes :

The replacement of the boreholes by piezometers is easier when the catchment is shallow. At the Terminal Complex, this operation should not encounter special difficulties (chart 6) ; however, at the IC, the catchments are generally very deep, except in the Western Basin.

Chart 6 : Total depths of the network water points ; IC and TC, respectively

N°	Country	Name	PROINV		N°	Country	Name	PROINV
1	**A**	ZAOUIET KOUNTA	102		12	**L**	(JH6A)	
2	**A**	TIN BOUZID No24 NOUV	145		13	**L**	(MAR6)	
3	**A**	GUERRARA 13	180		14	**L**	Lawd Zamz	
4	**A**	NOUMERATE AERODROME	400		15	**L**	Taouargha	
5	**A**	Daiet Rempt (DR 101)	605		16	**L**	Wadi Zamzam	
6	**A**	GT 101 GASSI TOUIL	942		17	**L**	Nemwah	
7	**A**	SINCLAIR MPC RB2	1363		18	**L**	Sadadah	
8	**A**	OUED MEHAIGUENE AB 1	1640		1	**T**	Ksar Ghilane 3 bis	680
9	**A**	SIDI SLIMANE	1776		2	**T**	EL BORMA 210	750
10	**A**	SIDI KHALED 1	2600		3	**T**	SP3(Trapsa)(*)	819
11	**A**	BOU AROUA BAR 1	2780		4	**T**	CF 1 bis	824
12	**A**	In Salah 1 (IS 101)			5	**T**	Bir Zar	963
1	**L**	Nina	836		6	**T**	MAHBES 1	978
2	**L**	Bani walid (B-5 (1/81))	975		7	**T**	Zemlet El bidha	1500
3	**L**		1003		8	**T**	Behaier (CI 9)	1621
4	**L**	Fawar al Khadem	1102		9	**T**	Steftimi (CI 7)	1987
5	**L**	Wadi Whashkah	1196		10	**T**	Douz (CI 12)	2080
6	**L**	Mardum	1210		11	**T**	S.Lahad (CI 17)	2500
7	**L**	B. Kabir	1220		12	**T**	Ben Sabeur (SB 1)	
8	**L**	B. Kabir	1225		13	**T**	SP 4 (1)	
9	**L**	B. Kabir	1234		14	**T**	Oued Abdallah 2	
10	**L**	Wadi Bay Kabir	1278		15	**T**	Lorzot	
11	**L**	WG10 (1230) (MP.0.50)			16	**T**	Bir Zebbas (BZ1)	

N°	Country	Name	PROINV		N°	Country	Name	PROINV
1	A	PUITS D'EAU NS I.H.I	90		2	T	RAHMAT 2	88
2	A	F SOVIET BOUROUBIA	94		3	T	Guidma 1	98
3	A	AIN EL ARCHE . Cheguet El Ftaie	97		4	T	Ras El A<n 1	98
4	A	MASRI	132		5	T	Chouchet Negga 2	99
5	A	EL K'DA D36F63	195		6	T	Scast 4	103
6	A	ALLENDA NORD N 602	210		7	T	Scast 5	150
7	A	SIDI AHMED TIDJANI	210		8	T	GUETTAYA 4 bis	156
8	A	KOUININE	314		9	T	El Faouar west	172
1	L	Ferjan	194		10	T	Dergine El Ameur	200
2	L	(1287) (MP.0.0)			11	T	MESSAID 3	208
3	L	T/2B/0022/0/87			12	T	C2F1	343
4	L	2128 (P6)			13	T	PK 13	605
1	T	PZ Douz	80		14	T	hezoua pz 1	
					15	T	Sebaa Biar 2	

5- CONCLUSION

At the end of the first analysis of the whole recorded piezometer observations in the SASS data base, it was possible, thanks to some groupings of the boreholes, based on proximity and behaviour similitude criteria, to identify a **Historical Reference Network**, composed of 73 water points, 46 at the IC and 27 at the TC. The distribution per country, which was not included in the selection criteria, is, generally speaking, fairly balanced : 20 points in Algeria, 22 in Libya, 31 in Tunisia. On the contrary, the distribution of the pilot wells within the SASS area is very uneven: it is very weak, in average, about 1 point per 22,000 km² and more than 90 % of the SASS has under 1 point per 10,000 Km^2.

Besides, the examination of the risk zones has allowed the identification of the sectors where a densification of the network seems necessary in the short term. These are the sectors where the water quality is likely to deteriorate (chotts, Syrte Gulf), the zones exposed to exhaustion and to be monitored (Tunisian outlet, Artesianism) as well as the new extension regions of the catchment fields (Ghadames, Oued Mya, Western Basin) where important modifications in the flowdowns are predicted. The future management of the reference network points must be conducted, on a case by case basis, on the field, whether for the implementation of the new points in the non covered sectors or for the selection of the existing water points which will be called to secure the perenniality of SASS piezometric series.

PART 2

SASS QUALITY SYSTEM

Although all the SASS regions are concerned by the water salinity risk, it is the chotts regions at the TC which seems to be more exposed than others. A first analysis of the available salinity historical sequences, about this sector, in the SASS data base, allows the following remarks :

- The « Quality » table of the DB includes 4600 entries : 800 at the IC and 3800 at the TC. Countrywise, these entries are distributed as follows : 1600 in Algeria, 200 in Libya, 2800 in Tunisia.
- If we throw a closer look at the salinity histories (Dry residue), mainly at the Terminal Complex, the examination of the DB allows the identification of a total of 269 water points showing at least two DR (dry residue) values on different dates : 39 in Algeria, 230 in Tunisia and none in Libya.
- In Algeria, the historical series are not numerous and dispose of little information : the frequency of the measurements, in the series, is not all that high. We cannot really talk about a pre-existing backbone of the quality system, although all the carried out measurements converge towards a general tendency of a progressive increase of the salinity rates, more or less high, unfortunately. The quality network remains to be designed.
- In Tunisia, the measurements density, both in time and space, is fairly comfortable and the quality measurement network can be considered as being already implemented in the chotts region. Over the recorded historical sequences, we can notice that the tendency for an increase of the salinity rates is general. However, a certain number of boreholes, although small, depart from this rule. But the most unexpected result seems that the water points whose salinity rate is most stable, are precisely those which are closer to Chott Djerid, those which seem precisely most exposed to the risk of salinity. The diagnosis of the origin of the salt and the evolution of the salinity rates in the TC sheet remains to be undertaken. The implementation, the rationalization and the exploitation of the permanent follow up quality network will contribute to the improvement of our knowledge which is, in this field, still in the making : this is the right time to invest in the procurement of information.

Diagram 8 : Evolution of the salinity rates at the TC in Algeria

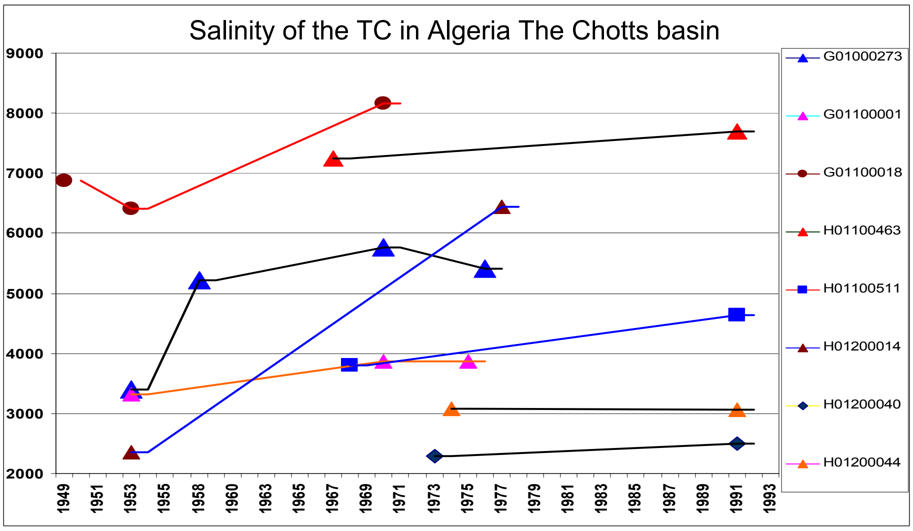
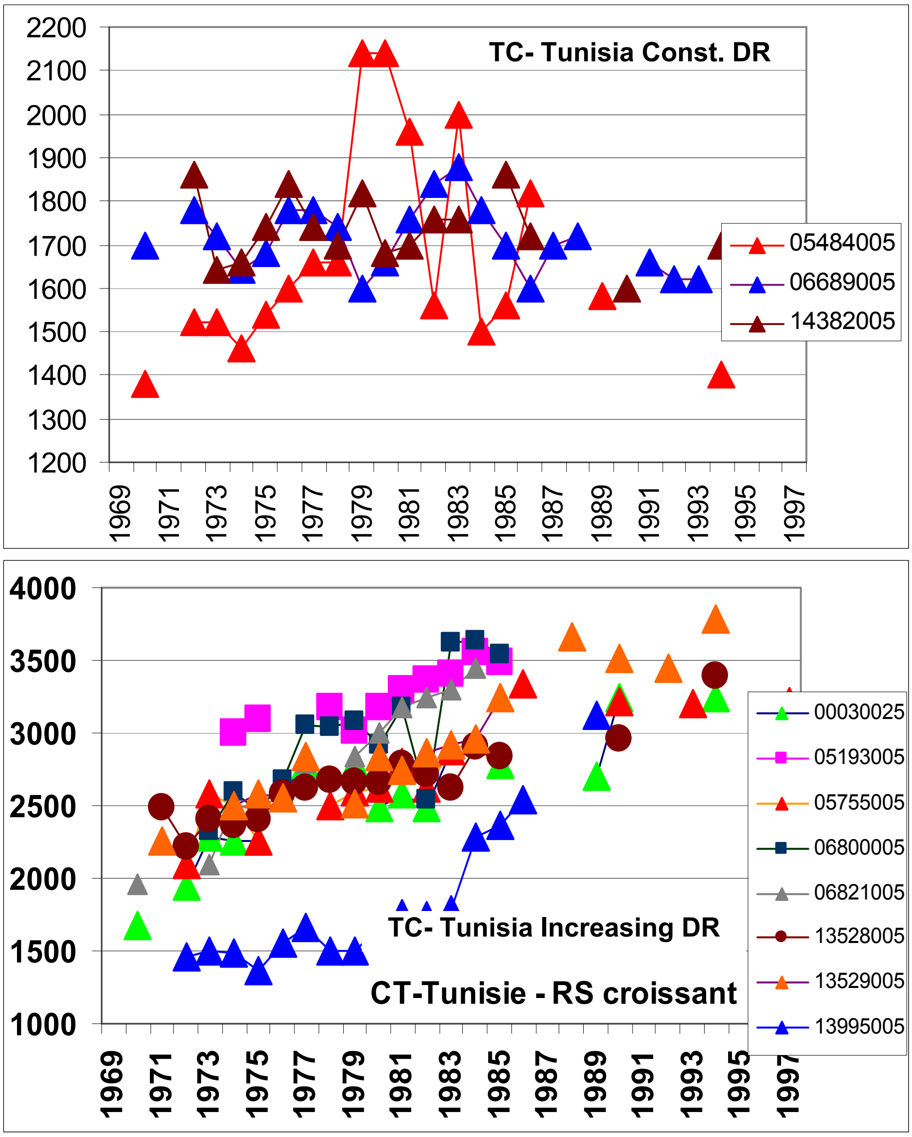
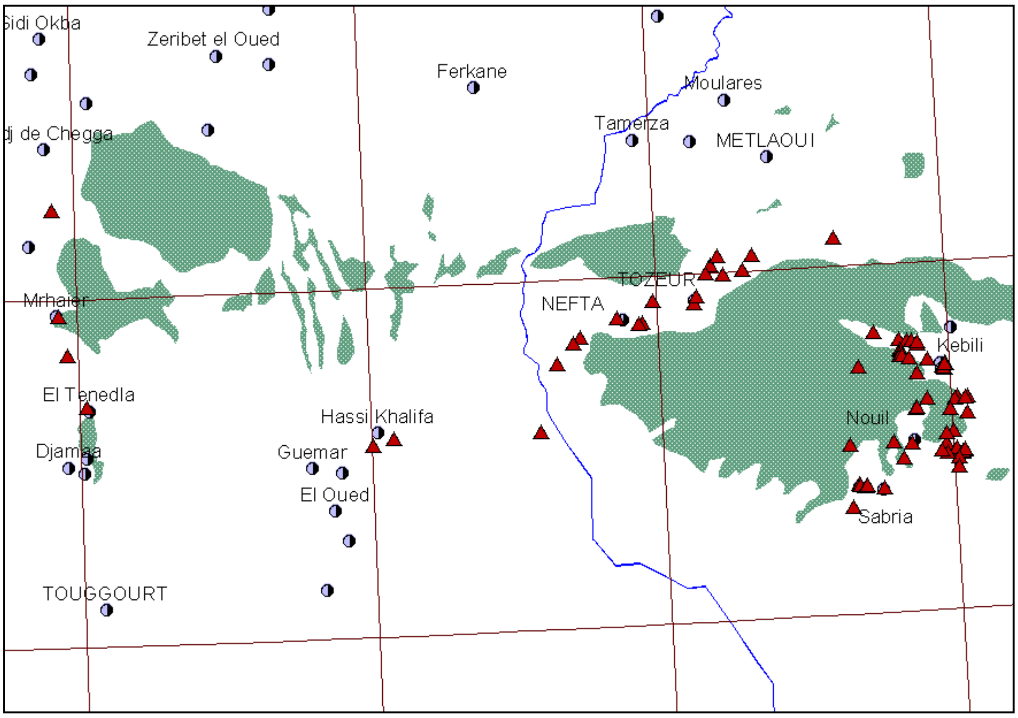


Diagram 9 : Evolution of the salinity rates at the TC in Tunisia



If we want to stick only to the study of the overall tendency over twenty years, one must dispose of a value at the beginning, for a fairly large span, in order to increase the existence probabilities (from the seventies up to the eighties) and of a value at the destination (from 1994 up to 2000). The population which meets these two criteria is too reduced : it is limited to 70 water points in Tunisia (Nefzaoua : 54, Djerid : 16) and 7 water points in Algeria. The Chart ….. takes up these information. On the cartographical level, the spatial variations of the salinity between 1980 and 2000 are drawn out in the diagram 10. They do confirm the anomalies of the curves in the Diagram 9.

Diagram 10 : Variation of the salinity rates (DR in g/L) between 1980 and 2000 In the TC around the Chotts.



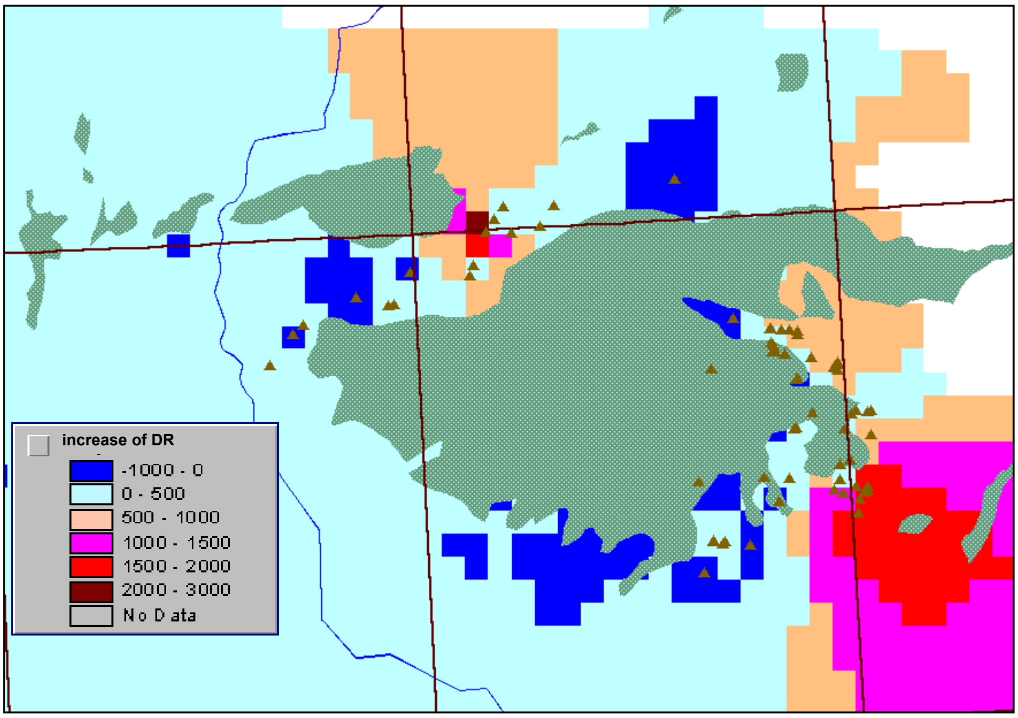


Chart 7 : Evolution of the salinity rates at the Terminal Complex between 1980 et 2000

Région	NOM	NOCLAS	RS 80	RS 99	DRS	Région	NOM	NOCLAS	RS 80	RS 99	DRS
Nefzaoua	Fatnassa 2	14378	3640	2580	-1060	Nefzaoua	Tarfaîet El Kroub Stil	13551	1140	1920	780
Nefzaoua	Bou Abdallah 1	9632	3260	3620	360	Nefzaoua	Tarfaîet El Kroub	6522	1580	2840	1260
Nefzaoua	Bou Abdallah 2	9653	2920	4200	1280	Nefzaoua	Sabria 2	17609	1720	1460	-260
Nefzaoua	El Gléa 1	13529	2840	3940	1100	Nefzaoua	El Faouar west	17675	1760	1640	-120
Nefzaoua	Oued Zira 2	16731	2460	3560	1100	Nefzaoua	El Faouar 3	11334	1360	1320	-40
Nefzaoua	Ziret Louhichi	13528	2640	3600	960	Nefzaoua	El Faouar 4	19343	1500	1600	100
Nefzaoua	Zt.Oul.Touati	14658	2620	3540	920	Nefzaoua	El Faouar 1	5571	1560	1800	240
Nefzaoua	Negga 4	9617	2040	1920	-120	Nefzaoua	El Faouar 2	5484	1580	1670	90
Nefzaoua	Negga 5	16703	2100	2004	-96	Nefzaoua	Guidma 1	6689	1660	1620	-40
Nefzaoua	Negga 6	18774	1980	2140	160	Nefzaoua	Bechni	18681	1820	1900	80
Nefzaoua	Negga 2	72	2040	1820	-220	Nefzaoua	Blidette 3	18746	1880	1859	-21
Nefzaoua	Negga 1	47	2040	2049	9	Nefzaoua	Ben Zitoun 2	18641	1760	1730	-30
Nefzaoua	PIEZ.Negga	18780	2060	2000	-60	Nefzaoua	Ben Zitoun 1 bis	19053	1820	1900	80
Nefzaoua	telmine 2	5585	1860	2600	740	Nefzaoua	Dergine El Ameur	18755	1700	1520	-180
Nefzaoua	Guettaya 7 bis	18851	1760	1889	129	Nefzaoua	El Hsay 4	6815	2880	5222	2342
Nefzaoua	Guettaya 3	14017	1900	1880	-20	Djerid	El Hamma 4	06922005	4665	4520	-145
Nefzaoua	Guettaya 1	73	1980	1860	-120	Djerid	El Hamma 7	08837005	6230	6220	-10
Nefzaoua	Kébili Ouest	18475	1780	1760	-20	Djerid	Zaouiet El Arab	09495035	1720	1900	180
Nefzaoua	Dar El Gaied	13993	2420	2760	340	Djerid	Oued Dghouumes 2	13991005	4530	4960	430
Nefzaoua	Dar Kouskoussi	5193	3280	4660	1380	Djerid	El Moncef 3	14137005	2260	2380	120
Nefzaoua	Ras El Aïn 1	6756	2360	3039	679	Djerid	Sedada 6	14626005	1845	1900	55
Nefzaoua	Ras EL Aïn 2	18993	1640	3360	1720	Djerid	Sif El Akhdar	14628005	2255	2320	65
Nefzaoua	Ras El Aïn 4	19003	2260	1940	-320	Djerid	Chouchet Zerga	16695005	2940	3040	100
Nefzaoua	Scast 4	5713	1660	2140	480	Djerid	Nefta Sonede	17622005	3540	2620	-920
Nefzaoua	Scast 3	387	1560	2260	700	Djerid	Oued Tozeur 5	18650005	2173	2600	427
Nefzaoua	Chott salhia 1	12320	1560	1439	-121	Djerid	Hamma 15	18786005	2140	7400	5260
Nefzaoua	Chott salhia 2	13997	1540	1380	-160	Djerid	Tozeur Gare 2 bis	18999005	1900	2120	220
Nefzaoua	Bechelli 3	13994	1600	1460	-140	Djerid	IBN Chabbat 8	19019005	3100	3060	-40
Nefzaoua	Chott yane	19102	1120	1800	680	Djerid	Garaet Jaballah	19091005	2800	2780	-20
Nefzaoua	Bourzine 1	14623	1380	1420	40	Djerid	ERRACHED 1bis	20288005	2790	2840	50
Nefzaoua	Smida	19092	1100	1180	80	Djerid	Seddada 4	X0600010	3450	2940	-510
Nefzaoua	Grad 1	5754	1120	1700	580	Algérie	F SOVIETIQUE N 34	G01000345	3468	4204	736
Nefzaoua	El Ghoula	18735	1160	1560	400	Algérie	DUQUENOY Nø5 … M'R	H01000043	3374	3474	100
Nefzaoua	Douz Sud	14023	2540	4050	1510	Algérie	AIN CHERGUIA EL HOZ	H01100463	7242	7689	447
Nefzaoua	DOUZ 6	17790	1720	4620	2900	Algérie	SOVIETIQUE Nø53	H01100511	3800	4645	845
Nefzaoua	Douz ouest	17615	1720	3600	1880	Algérie	SAHANE BERRY 3	H01200040	2292	2500	208
Nefzaoua	Douz 2 bis	30	2480	3720	1240	Algérie	HASSI KHALIFA AEP	H01200044	3080	3055	-25
Nefzaoua	DOUZ SONEDE	6999	1900	3340	1440	Algérie	RAS EL KELB	H01200055	2684	3138	454
Nefzaoua	Bou Hamza 1	14622	1720	3980	2260						

CONCLUSION

As a conclusion, if we consider that for the Terminal Complex in Tunisia, there exists a quality monitoring network, which is fairly steady, and this network allows already to lay down the basis of a deep investigation relating to the evolution of the salinity rates around the chotts, it is not the same case at all for Algeria and Libya ; the same is valid for the whole of the Intercalary Continental, there does not exist installed and steady facilities for the follow up of the quality, except for the small core which surrounds Chott Djerid; a lot remains therefore to be done in order to design, install and implement the SASS Quality Network.

NORTH WESTERN SAHARA AQUIFER SYSTEM

JOINT MANAGEMENT OF A TRANSBORDER BASIN

A STUDY ON SASS OBSERVATION NETWORKS

Serving as a driving and facilitating force, OSS, in carrying out the SASS Programme, relies first and foremost on the expertise available in specialised, well experienced institutions of the three countries as well as on broad international partnership.

The North-Western Sahara Aquifer System, (NWSAS), shared by Algeria, Tunisia and Libya, has considerable water reserves that cannot be totally exploited and are only very partially renewed. The NWSAS stretches over a million km2 and is composed of two major water-bearing layers, the Continental Intercalary and the Terminal Complex. Over the last thirty years, abstraction by drilling has risen from 0.6 to 2.5 billion m3/yr. This rate of abstraction involves many risks: strong impact on neighbouring countries, salinisation, elimination of artesianism, drying up of outlets, etc. Simulations on the NWSAS Model have enabled OSS to pinpoint the location of the most vulnerable areas and map the risks facing the aquifer system. The three countries concerned by the future of the NWSAS will need to work together to develop a joint management system for the basin. A consultation mechanism needs to be instituted and gradually put into operation.

The present note conducted by Professor Mustapha BESBES, within the framework of the project TCP/RAB/0065, upon the joint request of the World Organisation for Agriculture and Food (FAO) and the Sahara and Sahel Observatory (OSS), makes up the first tentative to work out the implementation of the SASS observation networks (Piezometry and quality).

PARTNERES

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- Direction Générale des Ressources en Eau (DGRE, Tunisie)
- General Water Authority (GWA, Libye)
- Fonds Internationanal de Développement Agricole
- Département du Développement et de la Coopération Suisse
- UNESCO
- Organisation des Nations-unies pour l'Alimentation et l'Agriculture
- Allemagne (GTZ)
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