Geneva Foundation and International Committee of the Red Cross

Basra Water Supply during the War on Iraq[1]

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Basrah (Iraq) water supply

The development of the town and its water supply system.

Basrah is located on the shores of the Shatt el Arab. From the ancient location on the corniche, the town grew westward in the last century to become the second major town in Iraq.

Up to the beginning of the 2nd World War the people consumed water from the Shatt el Arab, and the area around the port was heavily inhabited due to the flourishing economic activity

In 1937, under the direction of Cpt. Morris, the British built the “old” airport, at Maqal, currently not in use, and, at the same time, the first power station at Jubaila. Electricity was thus available in Basrah before supply was available in Baghdad. The port and the living quarters of its employers, the airport and the hospital airport received electricity. A line was then extended to Basrah city, first to supply electricity to the governor’s palace and then to parts of the city centre. The city thus had electricity before having access to a reticulated water supply.

In 1946, the first water treatment station was built at al Jubaila, now known as Old al Jubaila, with water flowing from the Shatt el Arab. When the Bradiyah WTS was built, most of the eastern parts of the town, located on the corniche received water, as well as the present central areas, that is, Al Fayaliah and al Jumuriah suburbs.

In time, mud houses were built to accommodate the port workers. These were located between the urbanised area of the corniche and the central area suburbs. In 1966, in order to re-urbanise these unsafe areas, Governor el Hayani decided to allocate to 60m^2 to each family in the present huge urbanised area - named after its founder, al Hayyanniyah – located west of the al Jumhuriyah suburb. This area is easily recognisable in the present topographic maps. In the 1970s the remaining land was bought privately and developed to become what is presently called “old Basrah”. Finally, the shape of the town grew to its present layout in 1977, when the government allocated 400 m^2 of land to the employees of the university, to professionals and other governmental clerks, in an unsafe area named Al Kayabat, with peripheral areas expanding in a limited way.

To cope with the increased needs and to cover the geographical expansion linked with these developments, new supplies were needed. In 1972, the Al Muahad station, located to the north of the Al Qarmat’ali river, was put in operation, with a capacity close to 4,000m^3/h.

Industrial activity became important in connection with the economic development of the whole country with the possibility of access to the sea from the port of Um Qasr. Planners mapped out the new urban Basrah and water distribution followed. Large avenues were built allowing for identification of transmission lines to bring water from the two main stations located north of the Gurma river to the yearly growing suburbs. The population of the town is now estimated at 900,000, according to the figures from the last elections.

In fact, things changed quite dramatically with the nationalisation of the oil industry in 1972. Suddenly the country was rich and the extension of the network began, with several contracts signed with foreign companies. 54 compact units (Thyssen type CU 200 m^3/h each) were installed as a temporary measure to cope with the increased needs until a German company could complete a comprehensive study for a large water treatment station capable of treating 20,000 m^3/h, with six large underground storage reservoirs. The study was completed in 1986, however, internal disturbances and the insecurity prevailing within the city brought this project to a standstill, with foreign staff leaving the country.

In August 1988, a project to sell water from the Shatt el Arab to Kuwait was proposed to the Kuwaitis.

Fearing too high a dependence from Iraq, the government of Kuwait put forward a more acceptable project for both parties. Kuwait would receive water from the Shatt el Arab, which was suitable for some of their irrigation needs and would treat and pump channelling the amount of drinking water needed for the city of Basrah at no cost. Iraq turned down this win-win proposal and began to build the present system, using its civil engineering capacities to build an open channel, supplying softer raw water to the town. A huge reservoir was built close to the airport, where the “R zero” station was located, from which the raw water would reach the already existing stations, then treated and pumped into the network.

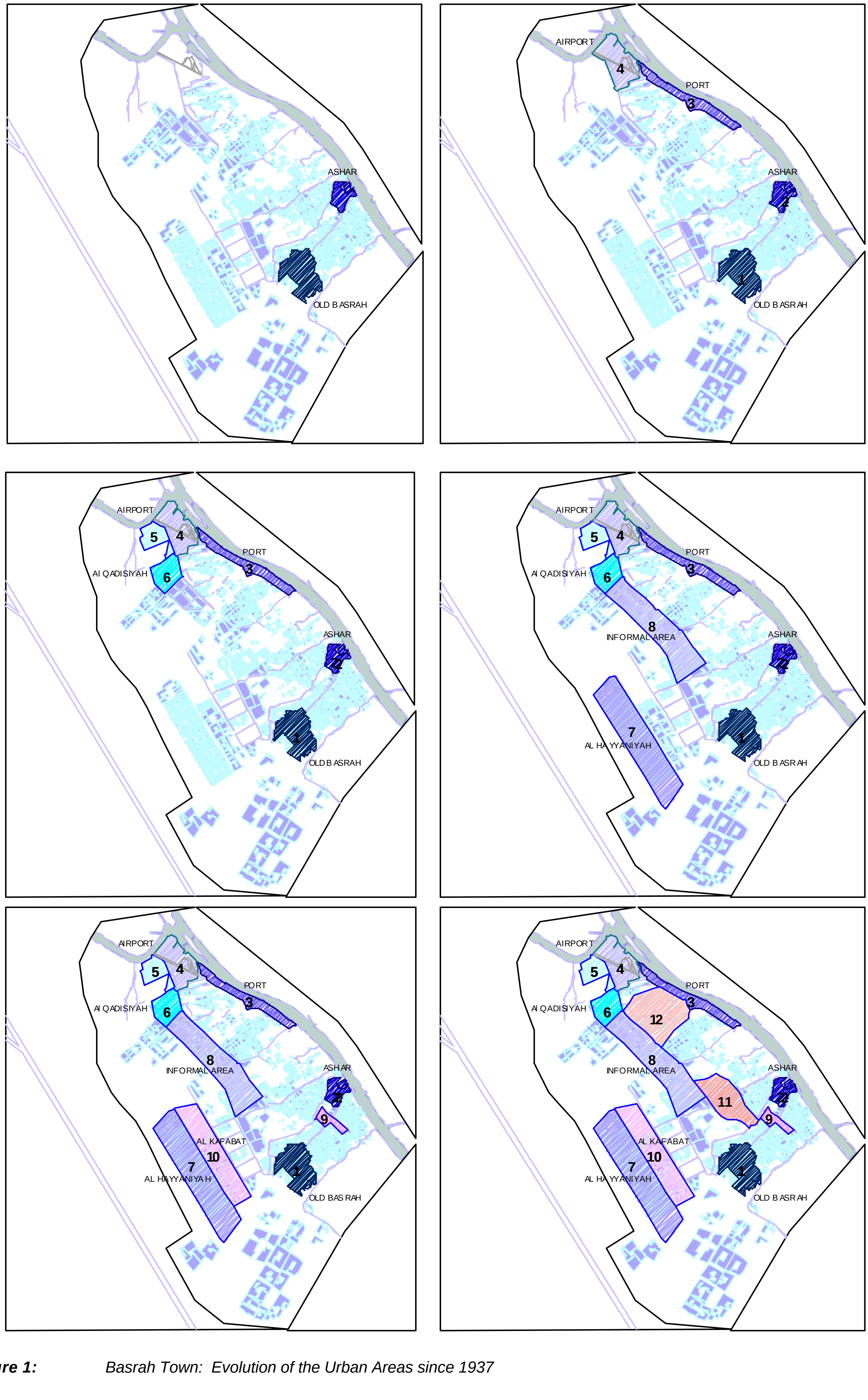


Figure 1: *Basrah Town: Evolution of the Urban Areas since 1937*

A quite important capacity to treat water was also installed within this station, with 26 CU units of 200m^3/h each, pumping water directly to the town distribution network.

The system had two main advantages: a less saline water than that of the Shatt el Arab, less corrosion problems, easier removal of the turbidity and certainly less contamination related to the navigational uses of the river. On the other hand, the channel system was quite fragile, losses from evaporation were important, up to 1m^3/s out to the 7-8m^3/s needed, requiring constant dredging to remove the silt. Damages due to unstable banks were also quite common. The problems of the stations were not solved at all, even if some improvements could be observed.

Other stations supplying the old town are still located on the Shatt el Arab, like Jubaila, al Rebat and Bradiyah. Two other stations, Al Garma 1 and 2 were built on both sides of the Kurma river. There are also a few stations belonging to private companies, which are mainly used to meet their private needs.

Production of treated water

The following table gives the years of construction of the main stations of Basrah and their nominal capacities. In principle, all together, the stations are able to treat about 22,400m^3/hour, but this is rarely the case, and it is assumed that their maximum output was close than 20,000 m^3/h, from a total of 25,000 m^3/h of raw water reaching R zero (based on a flow of 7 m^3/s).

Station	Year		Capacity m3/h
before 1946	from the Shatt el Arab		
Jubaila WTS	1946		1000
Al Bradiyah WTS	1958		2000
Al Muahad WTS	1972		4000
Shatt el Arab	1972/74		1000
Al Rebat WTS	1986		600
Al Jubaila CU	1986		1000
AQUA Thyssen 25 CU	1986		5000
Al Garma 1	1986		1400
Al Garma 2	1997		1400
R zero	1993	beginning of the construction of the channel PS1/PS2	
	1997	beginning of the construction of the Wafa al Qaeda station	
	1999	connection to the WTS and operation of the stations	
R zero treated water	1999		5000

Table 1: *Main Water Treatment Stations (WTS) of Basrah; years of construction and nominal output*

The normal output is difficult to appreciate, as failures were relatively common before the war. For instance, only 24 of the 25 CU of the Aqua Thyssen station were opera-tional and some of the other stations could not be operated on a 24-hour basis, due to power cuts and mechanical problems. Nevertheless, until precise figures are available, we will assume that a maximum of 400,000m^3 were pumped daily into the network, based on the following assumptions: 20,000m^3/h for 22 hours a day and considering a 90% pump efficiency, which is probably too high. An estimate of 350,000m^3/day is probably close to the reality.

The water supply of Basrah: a complex and vulnerable system

The raw water is diverted from the Garraf, a river located north of the town of Nassiriyah. The open channel supplies a first pumping station, PS1, close to Nassiriyah, where 17x1m^3/s electrical powered pumps and six diesel pumps of the same capacity are lifting the raw water. The set–up allows for some flexibility. In case of power problems, two generator sets of a total capacity of 2,000KVA coupled with the diesel pumps allow to pump the required volumes. From PS1 the raw water reaches PS2, a second pumping station located about 65km from Basrah, in about three days, at a speed of 0.65m^3/s. Another day is needed to reach R-zero from where the raw water is pumped to the treatment stations.

The figure on the next page gives a schematic layout of the channel, together with the location of the major towns and rivers.

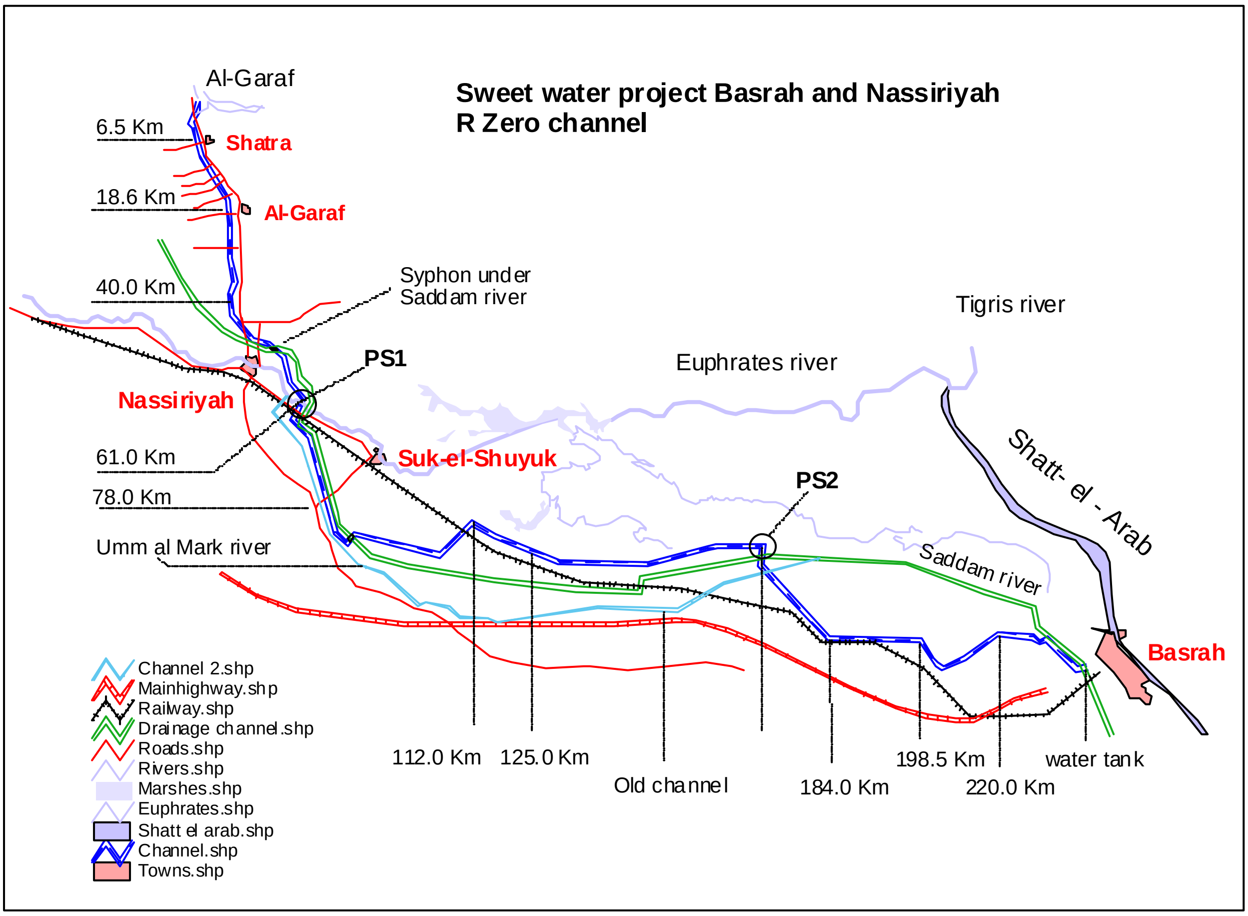


Figure 2: *Layout of the raw water open channel*

At PS2, a similar set-up is installed. 14 electrical powered pumps and five diesel pumps, each with a flow rate of 1m^3/s, pump the water to cross the Saddam river and to reach its final destination at R-zero, where a complex system of "chicanes" enhances the sedimentation of the suspended solids.

Figure 3 a,b,c,d:
Intake at PS2, diesel and electrical pumps, pipeline over the Saddam river and open channel to R-zero. The low output is easy to observe (20-04) close to 1.5m^3/s and the consequent low level of the water in the channel is also visible

The raw water is then pumped to the different stations with an impressive series of electrical pumps. The following figure shows the main pumping assembly.

Figure 4: *High lift pumps room at Wafa el Qaeda (R-zero)*

The operation of this pumping station is essential to supply the treatment stations with raw water. Nevertheless, in case of problems, as these stations were previously pumping raw water from the Shatt el Arab, their reconnection to their source of raw water would have allowed them to operate almost at their nominal capacity. In fact, poor maintenance and repairs, not really considered essential in normal times, led to a significant decrease of the possibility to pump from the Shatt el Arab. Raw water is also supplied from Wafa al Qaeda via three other transmission lines to Khor el Zubair and Abu Kasib and to Shuaiba with treated water, through the 26 CU. From these units treated water is also pumped to the city.

WTS supplied	Line diameter	No. of pumps	Capacity/pump m3/h
Al Hartha 25	1200	6	1500
Basra Unified	1200	6	1500
Jubaila/Rebat	1000	4	1500
Bradiyah	800	3	1500
Khor al Zubair	800		
Abu al Kasib	1000	6	550
Shuaiba	**500**	**4**	**800**
25 CU treated water	**1200**	**6**	**1000**

Table 2: *Stations supplied from Wafa el Qaeda, transmission lines diametres, umbers of pumps per line and capacity in m^3/h*

Located close to the Basrah international airport, Wafa al Qaeda was prone to be damaged in case of intense military operations. The control of the airport by the coalition forces would inevitably isolate the location from the city centre, leading to a problematic operation, requiring a number of skilled personnel, not really keen to report to work in such situations. Its electrical dependence from the network was evident, even if powerful generators were located to maintain at least 40% of its normal capacity. But the operation of the gensets can only be maintained with the presence of dedicated operators.

Operators are also required at PS2 and at PS1, and the system would become quite un-operational in case of stable frontlines located between all these premises. The whole system was prone to collapse because of its complexity and vulnerability and the only hope to maintain a minimum supply to the town lay in the possibility to reconnect all the treatment stations to the Shatt el Arab, even if its water would have been more saline than the normal one.

In case of any damage to the network, most likely to occur in such situations, diesel generators capable to operate the stations at 40% of their normal capacity, until a viable solution could be found would provide power. The problem of the presence of the operators would have had to be solved in any circumstances.

Transmission lines

The raw water transmission lines (yellow line) and those of the treated water (> 900mm diameter) of the Basrah network are shown in the following figure, together with the primary network lines (blue lines from 300mm to 800mm diameter). These lines have been located with a high precision on the satellite image, with a resolution of 0.65m/pixel (Early bird image), allowing to locate quite precisely any leak or problem using GPS devices (precision 20fts).

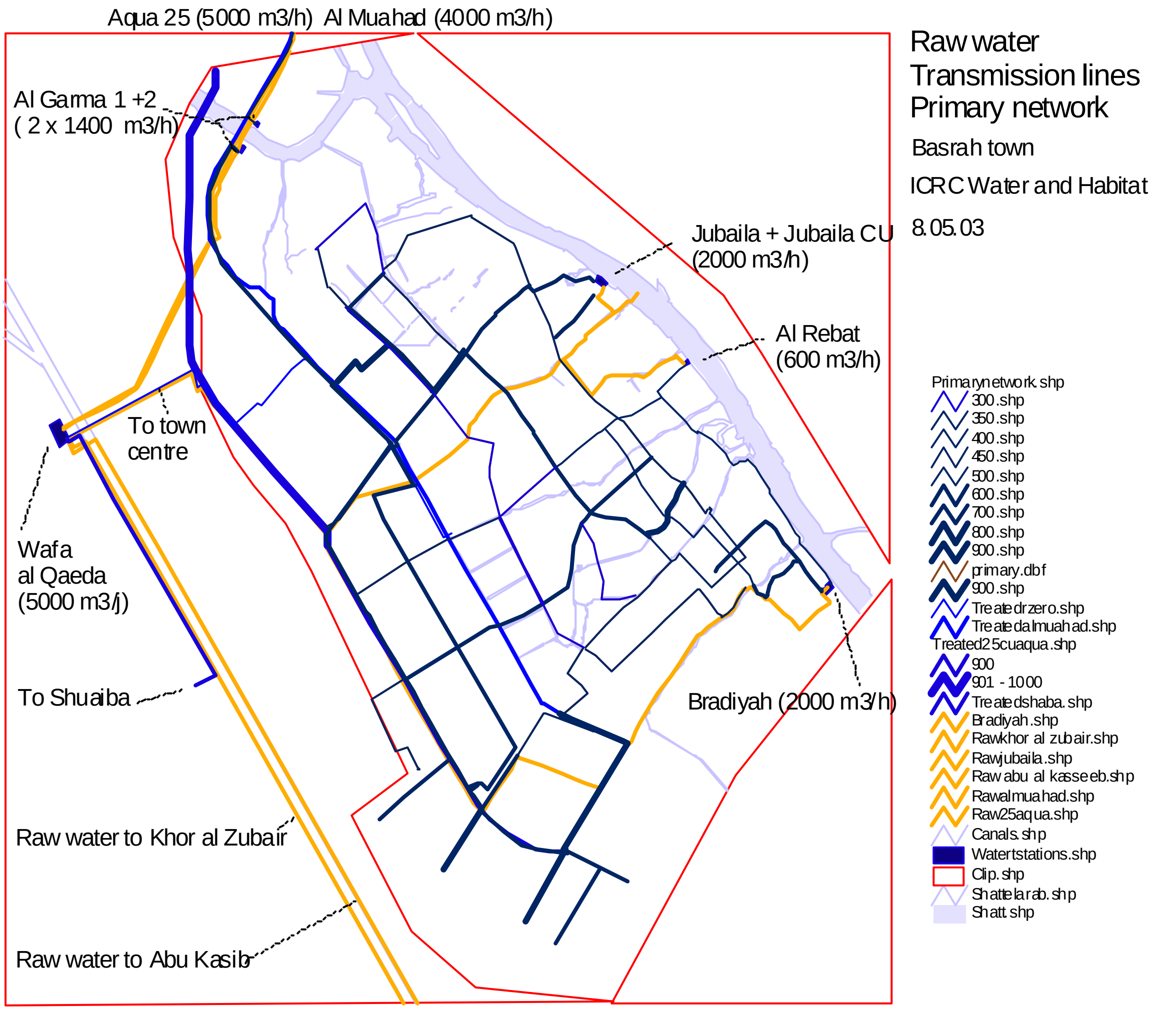


Figure 5: *Transmission lies (raw water and treated water), primary network, location of the water treatment stations (WTS)*

We have already outlined the potential problems identified with the supply of raw water through the Garraf/ Nassiriyah/Basrah channel and those related to the power supply of the R zero station (Wafa al Qaeda). Water is then pumped from Wafa al Qaeda to the different transmission lines. In principle, transmission lines should not be affected by the conduct of the hostilities, unless they are located in strategic locations, prone to be heavily shelled. Also damage is observed when they are located on the frontlines. Unfortunately, it is almost impossible to anticipate where such damage may occur. Some strategic locations may be more affected, like bridges, airports or transmission lines close to defence positions. In the particular case of Basrah, direct damage due to the hostilities was observed close to the airport highway bridge, on both sides of the Saddam river.

Figure 6 a, b: *Damage and repairs on the transmission lines and problems due to UXOs*

Despite the intense fighting, leaks were limited, only visible when the water was pumped into the lines and when surveys could be carried out. For instance, a major leak was observed on the raw water transmission line to Abu Kasib (1000mm diameter). Repairs carried out in such locations must be done with the necessary precautions, as UXOs[1] may be present. Repairs at one of these locations had to be interrupted due to the discovery of a 150mm shell, probably unexploded. Clearing was done manually in one day by “skilled civilians” who were attracted by the relatively high value of the metal, close to 6,000 I.D. per shell (2.5 USD at the exchange rate of 1 USD = 2000 I.D. prevailing end of April). The repair was completed successfully the next day by an ICRC contractor, allowing the resumption of the pumping to most of the Abu Kasib stations, temporarily supplied from the Shatt el Arab. Leaks in the raw water transmission lines may be problematic for several reasons. Less water will reach the WTSs and people may use water unfit for consumption, as its taste is better than the treated one, particularly if the WTSs will have to revert to the Shatt el Arab and blend the raw water to maintain its output.

An example of such damage is shown in the next figure where the observable leaks on the raw water pipeline supplying the Bradiyah WTS have been collected using a GPS and mapped. In this particular case repairs would have been easy if an alternative source would be available to cope with the needs of the people living in this area, probably poorly supplied with treated water. Decreasing the quantities of water reaching the Bradiyah station is, however, decreasing the amounts which would be pumped into the network.

Figure 7: *Leaks observed on the raw water pipeline supplying Bradiyah WTS from Wafa al Qaeda. Not yet repaired on 10.05.03.*

The losses and the consequent damage are most likely to continue until normal functioning of the network will guarantee the supply to the temporarily deprived areas. It is therefore essential to improve the supply of raw water to normal values and to avoid any drastic decrease of the amounts delivered from R zero to all the stations.

Other locations are prone to be damaged. In Basrah, the pipelines are quite visible where they are crossing the relatively complex network of canals or where they cross under the bridges. These locations would have been particularly at risk and one would have expected many makeshift connections or direct punching.

Figure 8 a, b: *Canal crossing where damage may be easy, but also easy to spot*

1 UXO (unexploded ordnance) or also ERW (Explosive remnants of war)

The situation of Basrah during the war and in the immediate aftermath of it.

Contingency measures

A contingency plan for Basrah has been prepared following the approach outlined and finalized for Baghdad and other towns during the months before the onset of the conflict. 14 WTSs were surveyed in Baghdad and in other 27 major towns of the country, including Basrah. All these assessments facilitated emergency intervention during the hostilities, as ICRC

- had a sound knowledge and understanding of the systems and locations of all plants and hospitals, with databases and maps;
- had a relevant human resource capacity, both expatriates and local, as well as a strong network of contractors and mobile workshops to carry out rapid survey and repairs;
- had maintained and developed excellent contacts with the concerned authorities and water treatment station's engineers and operators, in order to obtain easy access to the plant and for the operators.

In the framework of the a/m contingency plan, a number of assessments were carried out to:

- provide technical assistance to the water authorities to overhaul and maintain back-up generators at key water treatment stations;
- assess the availability of treatment chemicals and diesel;
- train operators and diesel mechanics at each WTS and CU sites;
- sign maintenance contracts to overhaul and maintain the gensets at the three major treatment stations of Basrah town (al Muahad, Bradiyah, Wafa al Qaeda);
- pre-establish maintenance contracts to address emergency needs;
- pre-position hygiene kits in the major hospitals of the town and of the governorate, as well as collapsible tanks and water bags to cover immediate drinking needs and to prepare ORS[2];
- Contract water tankers to deliver water to the installed reservoir at the selected hospitals.

Emergency intervention strategy

The aim of all interventions was to maintain the objectives defined during the contingency plan, that means a minimum of about 30-40% of the normal distribution, if not more, until a clearer image of the situation would be available. Eventual damage would have to be assessed rapidly and repairs, if possible, undertaken immediately.

The essential steps of the whole system had to be analysed. That meant:

- access to the main stations to assess the situation;
- access to the main stations for the operators in case of any possible presence of a front line;
- availability of the power supply;
- availability of raw water;
- technical damage or technical failures;
- operation of the generators at the contingency plan level and availability of diesel;
- use of Shatt el Arab water in case of absence of raw water.

In fact, all these parameters have a different weight from one station to the other. Some of the stations can be operated relatively well with raw water from the Shatt el Arab, others cannot. As an example, the 26 CU at the Wafa al Qaeda station, requires raw water from the channel, otherwise they stop working. Those located on the shores of the Shatt el Arab are less dependent on this raw water, but the low lift pumps cannot supply the same amounts, as their use has been become progressively obsolete.

Availability of the raw water

This was one of the main problems. Without raw water there was no hope to boost up the production and the distribution to the network to their normal levels. As the water was coming from quite far away, more than 220 km for PS1 and about 65 km for PS2, the lack of communication between the R zero manager and the two stations and the general security within the area, hindered understanding what was happening along the channel and why the raw water delivery was changing from one day to another. Only when ICRC engineers and one of the irrigation managers reached both the locations, did the problems became evident.

Electricity was cut in both stations but the necessary number of pumps could be maintained in operation with the use of gensets and by operating some of the diesel ones, up to a flow of 7-8m^3/s. A contractor was immediately dispatched to Nassiriyah. Diesel stocks were sufficient at both stations, but security became quite fragile when armed looters began to show interest in any marketable items such as batteries, copper wires, etc. After endless voicing and almost daily surveys of PS2 and along the channel to assess eventual damage, the situation finally improved, with the establishment of mobile patrols at PS2. Simple problems, like the transfer of fuel from the protected reservoir to the pumps had to be solved, with the rental of a tanker truck, positioned at PS2 until a more permanent solution could be found, with a tanker from the Ministry of Irrigation.

2 ORS Oral rehydration solution

A further problem, to be addressed later, was not taken into consideration immediately. The channel needed to be dredged regularly as silt deposits collected at the bottom. Special dredging equipment was used for this purpose. Unfortunately, it was impossible to protect the equipment from looters, as it was stationed on the right bank of the Saddam river, even though not far from the station's premises. Essential parts were removed, with the consequent long-term immobilization of these machines, which were difficult to replace.

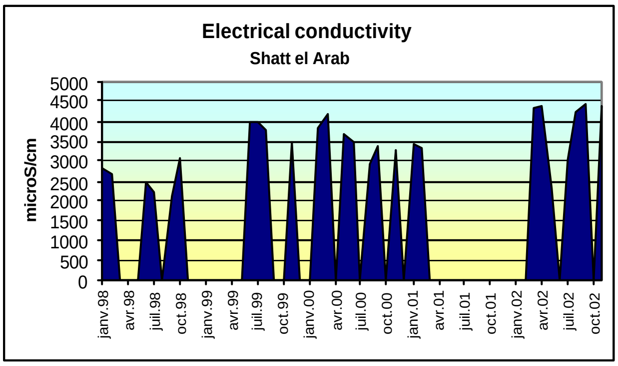
***Figure 9:** Damage by looters at the circuit breakers transformers control boards at PS2*

But the main damage has been done on the circuit breakers and control boards of the transforming units. Isolation oil was also drained from the transformer, which was relatively a minor problem. More difficult to assess was the damage done to the SP3 sub-station, essential to supply electricity to PS2, in order to restore its normal functioning. Looters were active for a while as no protection was granted to these premises, until very late, when a special police force was finally created, at the beginning of May 2003. When some units were eventually dispatched to these locations, the damage was too important for a quick repair.

Quality of the raw water and use of the Shatt el Arab.

Data for the Shatt el Arab and for the raw water collected since 1998 by the Department of Irrigation as illustrated in the next figure highlights the exact problem related to the salinity. For the Shatt el Arab, salinity expressed as the electrical conductivity (E.C. in microSiemens/cm at 25 oC) is increased from about 2,500 uS/cm in 1998 to 4,500 uS/cm in October 2002. A more careful analysis would probably show some patterns related to specific rainfall episodes or management of river dams. For the Al Garraf raw water the fluctuations are less important and a mean conductivity of 1,500 uS/cm can be considered, close to the WHO guidelines for drinking water. Data also shows how important it was to build the channel, owing to the significant increase of the salinity of the previous source of raw water.

Turbidity of the raw water from the Al Garraf is higher than that of the Shatt el Arab, laying close to 50 NTU. But the difference is not really too significant if compared to the mean values of 30-40 NTU of the Shatt el Arab. Use of Aluminium sulphate should not be too important, with a dosage close to 20 mg/l, even if the nature of the colloids differ.



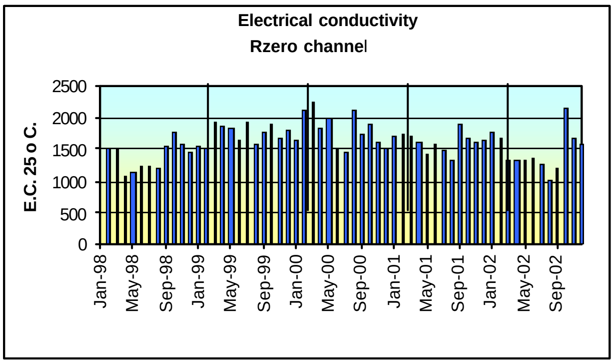


***Figure 10:** Evolution of the salinity (as E.C. during the last 3 years for raw water (Al Garraf) and the Euphrates*

These values are quite important: first they show the trend in the increase of the salinity, as outlined above, but also they show that the emergency connections to the Shatt el Arab, decided when raw water from the channel was lacking, was temporarily justified, as the salinity is higher but not dramatically higher. Compared to the problems the inhabitants would face, access to water, even if slightly more saline, would allow people to use it for domestic purposes, as well as for cooking and drinking. However the danger lies in the rejection of it, due to its highly saline taste. Information to people was not easy as the usual communication systems were not operational. Unfortunately, people started to puncture the raw water pipeline, looking for softer untreated water, as shown above.

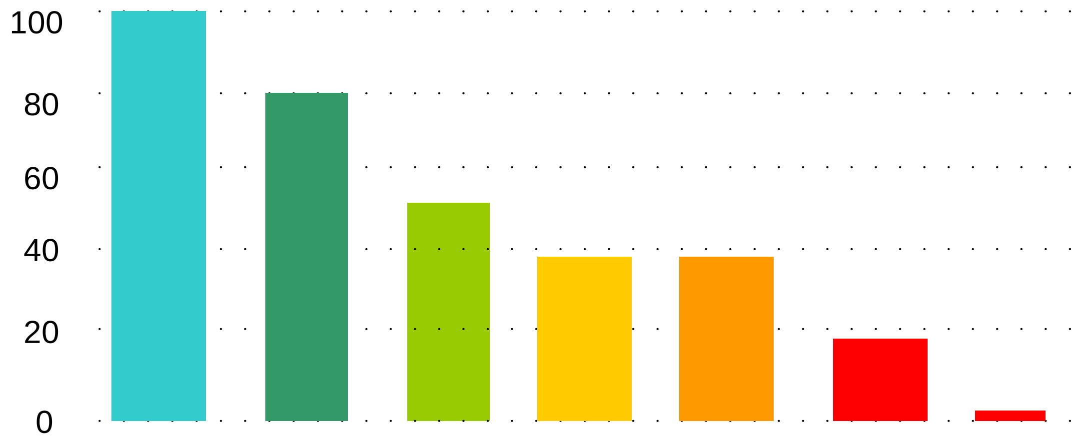
Water production and distribution system	
23.03. 03	connected Bradiyah WTS to Shatt el Arab connected Al-Muahad WTS to Shatt el Arab, re-operated WTS and CU at 60 % of capacity with generators
25.03.03	re-supplied Al-Hussain booster station at 40 %
26.03.03	restored operation of 9 raw water pumps in Wafa al Qaed (4500 m3/h) to supply Al Rebat and Al Jubaila WTS's by operating 3 x 1250 KVA generators restored operation of 15 CU 1000 m3/h to supply treated water to north Basrah by operating 3 x 900 KVA generators
27.03.03	connected al-Jubaila to Shatt el Arab connected al Rebat WTP and CU to Shatt el Arab
29.03.03	increased the production at 26 CU of Wafa al Qaed to 20 units (4000 m3/h)
Electrical power stations and generators	
23.03.03	1000 KVA Generator transferred from al-Iskan company to al Muahad WTS.
6.04.03	Work on electrical line supplying Wafa el Qaeda in coordination with Royal engineers.
9.04.03	Work on the high tension line supplying Wafa al Qaeda completed, fed using airport line feeder.Repairs of the high tension line supplying Najibiyah power station, supplied batteries and fuel to grain silos; generators to be used to energize/restart the power station.
12.04.03	First assessment to Nassiriyah and PS1. Sent a contractor to repair the generators.
Surveys to assess emergency needs in the southern governorates	
On a daily basis the water treatment stations and transmission lines	
12.04.03	first assessement in Nassiriyah, PS1, PS2, power. Almost daily assessments in PS2
21.04.03	Assessment of the situation of the WTS in al Madina, Qurna, 9 stations .
24.04.03	Assessment Abu Kasib WTS and Basrah
27.04.03	Assessment in Ti-Qar governorate, 43 stations surveyed
27.04.03	Assessment in Amhara town, 3 main stations surveyed
5.05.03	Completed assessment in Ti-Qar, 59 stations surveyed.
8.05.03	Assessment in Missan governorate, 9 stations surveyed

Table 3: *Specific emergency interventions (partial) to restore the water supply of the town*

The water treatment stations

Three stations are of particular importance: 26 CU at Wafa al Qaeda (5 000 m^3/h), Al Muahad (4,000 m^3/h) and 25 CU (5,000 m^3/h). These three stations supply more than 60% of the drinking water for Basrah. Clearly, when one of these stations is not working entire areas of the town are not supplied. When the power is off, only part of the normal capacity can be restored and again, even if to a lesser extent, some of the suburbs lack water. Different degrees of emergency may be reached, dictated by the interactions between different parameters, outlined above, down to a minimum level of operation, defined according to the contingency plan, when the gensets will have to be used and when the raw water will have to come from the Shatt el Arab. The total production available and therefore the access to water of the inhabitants will depend on the degree of the operation of each station, bearing in mind that three of them are of paramount importance. The effects of these interactions on the production are represented schematically in the next figure. Access to the stations has not been considered here as nothing can work, as in almost all the stations, without the presence of a minimum of personnel.

Percentage of production



Power	**100%**	**50%**	**100%**	**0%**	**50%**	**0%**	**0%**
Gensets	**0%**	**50%**	**0%**	**100%**	**50%**	**100%**	**0%**
Raw water	**100%**	**100%**	**0%**	**100%**	**0%**	**0%**	**N.R.**
Shatt el Arab	**0%**	**0%**	**100%**	**0%**	**100%**	**100%**	**N.R.**

Figure 11: *Matrix of problems and effect on the production for a station*

Hours of production were recorded every day from the beginning of the crisis, 20 March 2003. Hours of power availability from the network, hours of operation of gensets and number of pumps operated for each station were collected regularly as from the 20 of April. Data from the previous days have been obtained from the station's log-books and from direct interviews of the operators, when data were poorly consigned. Data were transcripted in an Excel worksheet [R(3)] form and the daily production computed. The results are shown in the next figure, where the total amounts of water pumped into the network is shown, summing up that of all the stations.

We can immediately observe that the daily quantities of water pumped into the network were almost over 100,000m^3, decreasing quite steadily immediately after the onset of the hostilities, 20 March.

From 23 March on, the amounts could be maintained slightly over the 100,000m^3/day, set as an objective in ICRC's contingency plan, which is close to about 1/3 of the normal production. If almost all the stations could work at the defined objectives, some problems were experienced with Aqua 25, where one of the generators has technical problems, not possible to repair in a short time. It is clear that with Aqua 25 down, with R zero treated water down to much less than the set objectives some areas, specifically supplied by these two plants were in a difficult situation. Power was the problem in Aqua 25, but at R zero (Aqua 26) the poor performance was due to poor supply of raw water. Knowing that most of the other stations were in the meantime connected to the Shatt el Arab, the 26 CU units received proportionally more raw water than in normal cases.

3 R Microsoft

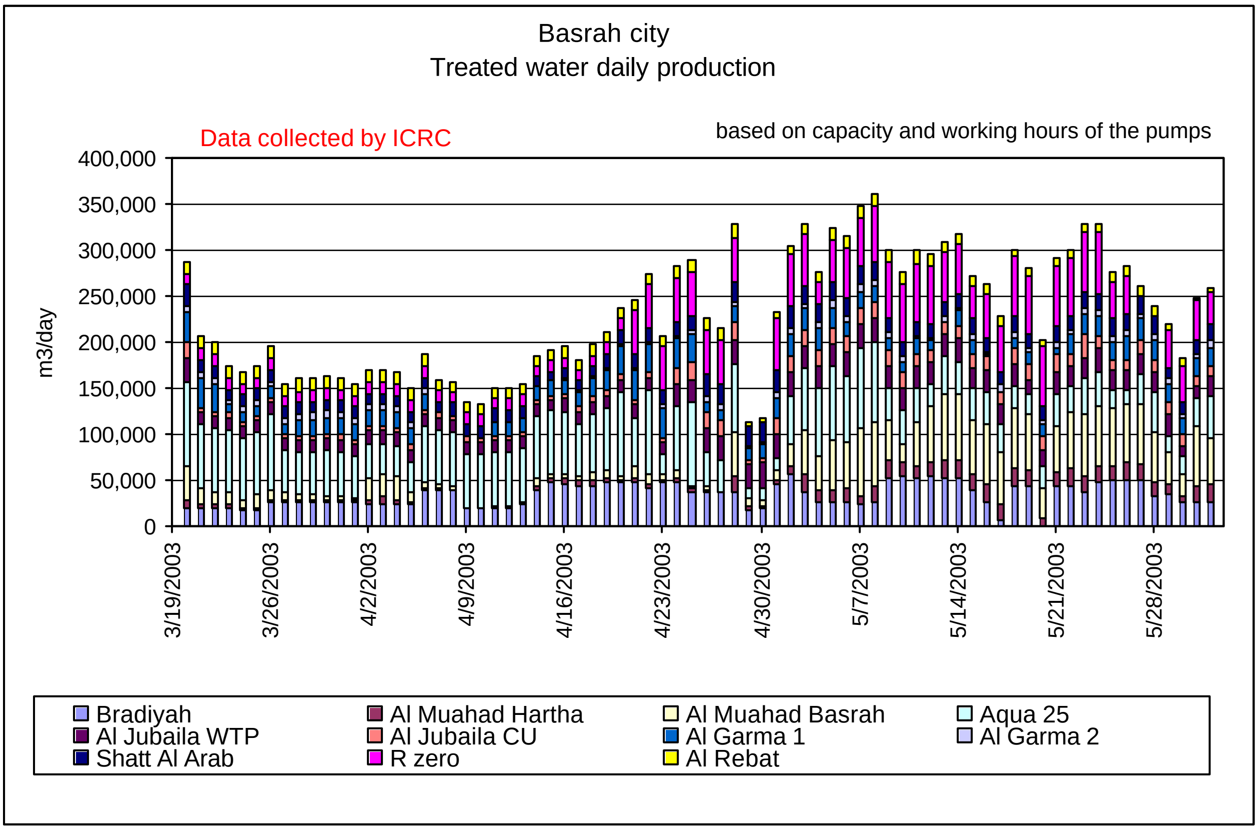


Figure 12: *Water pumped into the network from the different WTS*

On 9 and 10 April the figures are lower than 100,000m^3/d. It must be pointed out that the data have been computed from the daily hours of operation of the pumps. It is very possible that the total amounts may be lower, as outlined before; the pump's efficiencies are not taken into account. Also, one has to bear in mind how difficult the work was for the operators. A power cut means in general at least half an hour without water, as the operators have to wait for at least 5-10 minutes before switching to the gensets. Then they have to wait for at least 5 minutes before they are able to put the load on it. In the meantime, they have to close the main gate valves in order to restart the pumps, even if the procedure has not always been followed. Half an hour means 2,500m^3 for a station like Aqua 25, but of course less if not all the pumps are operated. That means that a power failure does not really change a lot of the outputs, but several ones may be significant. In the absence of any communication there are no alternative ways to anticipate any switch and loss of production or distribution as inevitable.

Anyway, no flow meters were operational and this was the only method we found to monitor the evolution of the situation. Some data are also lacking for several stations. But the observed trends were always related to a specific problem. An in-depth analysis would certainly show that any particular decrease of the production of a station would be associated with a technical failure, a problem with the gensets and clearly to the lack of raw water.

Power and water

The situation was quite bleak from the 9 to 15 April, when the many factors described above were interacting. Power had been restored at Najibiyah power station (2 x 100 MW/h but working at 100 MW/h with only 2 boilers over 4) but it was quite difficult to stabilise. Restarting the power station was already a complex operation, since about 10 MW are needed to energize it. This was done using the grain mills generators, brought in operation with minor interventions, like the supply of batteries and replacement of minor items in only a few of the eight gensets. On 19 April, the normal pipeline supplying crude oil to Najibiyah was sabotaged beyond repair by unknown fellows. Only a day's supply was left, and the director of the production had to stop one of the boilers early in the morning, to save fuel. The station came close to shutting down, working on only one boiler with an output of 50 MW/h. Fortunately an alternative solution was found to re-divert the crude oil to another pipeline, avoiding the rental of about

20 tankers (each of 36,000 litres) to transport an estimated daily use of 650-700 MT of crude oil.

The effect of a power cut on the water supply were evident at the end of April, when the situation of power supply of the water treatment stations was becoming quite stable. Two towers of the 132 KV line supplying Al Muahad and Aqua 25 were damaged by looters. Another was in fragile situation. Cables were removed (section: $152mm^2$) and sold for their copper value, close to 2 USD/kg. The length of the cable between two towers is about 330m and every meter represents about 1.3Kg of copper. It is easy to compute how much one would make with the 3x330 lengths. The quantities of water pumped into the network fell again, close to $100,000m^3$/day, and fears for the whole town supply raised again enhanced by the re-deployment of the British forces, leaving Al Muahad without protection. Fortunately, the distribution teams of the Electrical Department for Southern Iraq were able to install three towers in a few days, and power to the stations resumed on 2 May. A few problems with the transformers delayed the connection to the station but on 5 May production resumed to reach $300,000m^3$/day.

With the exceptions of the problems outlined above the 132KV grid was considered as being quite stable at the beginning of May. Several stations could be restarted: Khor al Zubair (2x 63MW/h) supplied regularly by diesel for about one week, Al Hartha (4x100MW/h). Almost all the substations could be supplied, with the exception of SP3. Nassiriyah power station was put into operation on 23 April and from there power was transmitted to Amhara and to Qadisiyah. All the southern governorates more or less had electricity. Power cuts were still experienced in remote areas, like in Qurna or in Madina districts where power was down sometimes for more than 12 hours a day, with a consequent effect on those stations not equipped with gensets. To maintain a more regular water distribution, ICRC supplied 36,000 litres to Qurna Unified WTS, equipped with gensets.

On 3 May the electrical department began to tackle the damage to 400KV grid, in order to connect the Southern areas to the north. Four towers of the Ultra high-tension line were still down close to the Al Zubair bridge and had to be lifted up and fixed. The work due to be completed in about one month. Then electricity would be dispatched to Baghdad, as it was done before the war, when 46% of the power produced in the south was used in the capital. How this would affect Basrah was not known, but fears were evident among the concerned stakeholders.

Damage to the network

The problems of the transmission lines have been outlined before and any leak in these high sections pipelines must be repaired immediately. Important leaks like the one shown in the next figure, on the treated water pipeline to Shuaiba were observed and repaired only when the pressure in the pipeline was important. These leaks too can be easily repaired by a team specifically in charge of the large pipelines and equipped with the necessary tools to carry out the job. Other “minor leaks “ are more difficult to spot.

Figure 13: *Leaks at the treated water pipeline to Al Shuaiba*

As a rule of thumb, experience from other war situations [4] show that after the active hostilities, for about one leak in the main transmission lines, or primary network, at least 10 can be observed in the secondary network, with many more, up to hundreds, in the tertiary one. The number of the last ones is dependent on the type of conflict and on the movement patterns of the population of the affected suburbs. If the people do flee a particular area the great majority of the leaks are due to outages from the taps left open in the houses. These leaks are again quite easy to control by any organized leak control team.

In Basrah, like in most of the towns of the country, the inhabitants did not move from the town. Those who could afford to left before the onset of the hostilities, for the countryside, considered less prone to intense battles. Fears of looting retained many inhabitants in their houses, but also may be, because they were probably thinking that the war would be quite clean, with precise surgical strikes and localised battles. Whatever the reason, people remained “trapped in the city”.

4 P.G. Nembrini and al. , Water supply of Kisangani (RDC), data to be published

Leaks or illegal tapping

Other patterns of leaks appeared in this context. Illegal connections did increase, even if precise baseline data are lacking. More visible were the man made leaks to tap water from the pipes, particularly where water was lacking, like in the suburbs supplied by al Muahad and Aqua 25, when their production was down.

Leaks are considered as "opportunistic ones ", due to poor behaviour of citizens, who were not hesitating to break any visible pipeline to get water out of it, whatever it was raw water or treated water. A large variety of leaks could be observed:

- major pipe breaks;
- minor leaks with the pipe punched and water collected from the flow;
- quite well done makeshift tapping, similar to collar connections, to primary or secondary networks pipes, where the pressure is higher and there is some chance to get water;
- tapping into the mains using a centrifugal pump to "suck" out water;
- "organized" large illegal connections.

The last three categories exist in almost any network. They are considered as "illegal connections". In some situations [5], they are responsible for a large part of the UFW (unaccounted for water), particularly if they are quite important, like the organized large connections. They are generally installed with some sort of agreement from the utility surveyors and may not be easy to control. They are likely to increase during water shortages and are common in areas poorly supplied. They do not dramatically affect the access to water and the quantities of water available for the people as long as the diameter of the connections remains small. Several examples of these leaks and illegal connections are shown in the figures of the next page.

To get some control of these leaks is not easy. Normally repair teams are operational to mend and to get rid of the most problematic connections. But repairs are not the first priority. Water must flow first, regularly, and it would be a mistake to try to tackle this problem too early. As outlined before, major repairs have been undertaken on the high section pipelines, as these are important not only for the area poorly supplied but also for larger area of the town, where such problems may not occur.

Five teams were operational in this field before the war. One was exclusively devoted to the transmission lines and to the primary network, and the others were dealing with the minor losses. As most of the cars of the utility were stolen or damaged, their efficiency was quite poor. Transportation and tools were lacking and what was available had to be used for the prioritised interventions.

"Minor leaks can wait" was the strategy, even if one would try to avoid a consequent damage of the network, due to an epidemic" increase of such leaks.
While other activities were under way, their locations were mapped, using GPS coordinates collected by our teams or map grids coordinates (MGRS) collected by army patrols of the British forces. Daily exchange of information allowed us to map areas particularly affected and match them with specific reasons due to any distribution failures. Major leaks like those shown in the above figures are visible ones and can be repaired quite easily.

Problems do occur when people are in real need of water and are ready to break the pipes again and again, particularly when these pipes are easy to damage, like the asbestos-cement ones.
This pipe (asbestos cement 300mm diameter) is located behind the general hospital. It has been repaired on several occasions, (7 times on 10 May) but was broken almost immediately. As it can be seen, pressure is high but

Figure 14 a: *Air valve leak on a primary network pipe*

Figure 14 b: *Water from leaks on a transmission line*

5 Gaza strip water supply. 2000. More than 11'000 illegal connections reported. Personal communication, LEKA.

Figure 14 c: *Broken AC pipe (General Hospital)*

Figure 14 d: *Illegal tapping on a secondary line*

Figure 14 e: *Poor collar connection*

Figure 14 f: *Tapping on a transmission line*

Figure 14 g: *House connection*

Figure 14 h: *Poor tapping in mains*

Figure 15: *Leaks in the asbestos-cement pipe behind the General Hospital*

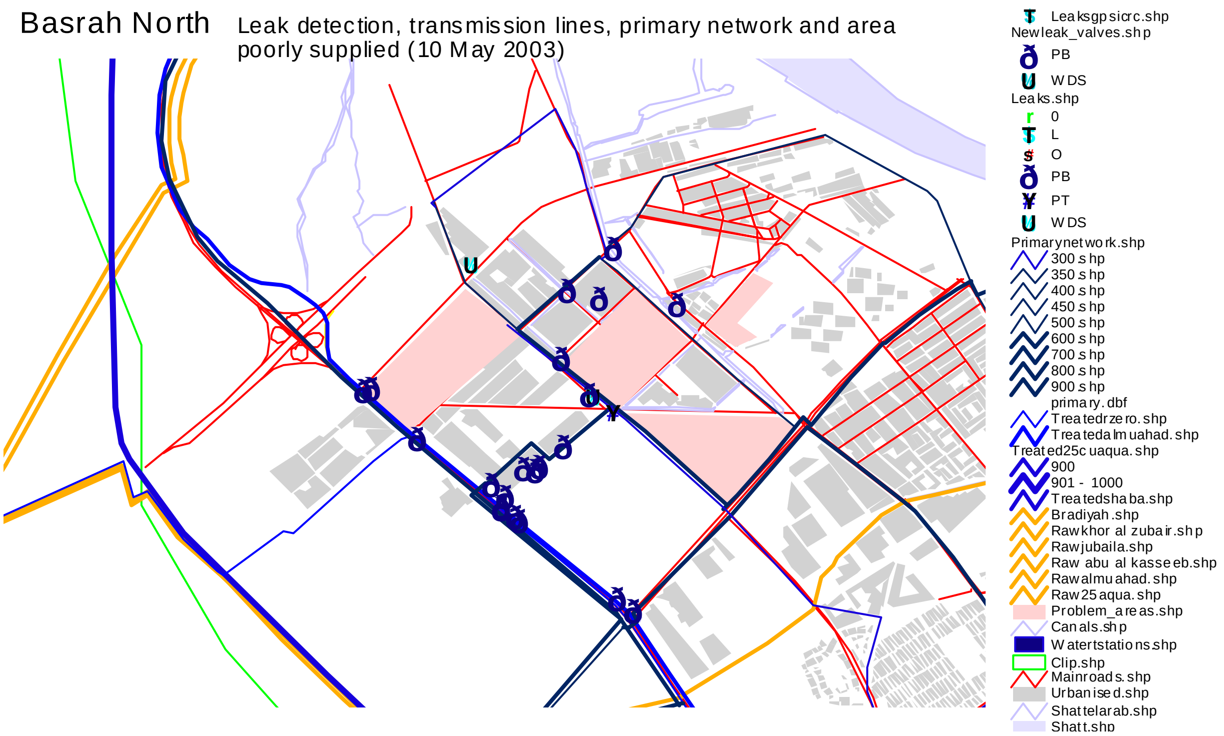
it will certainly result in poor pressure at other locations of the network, due to these important losses. A safer solution will have to be found, and eventually a device to allow people to fetch water, without creating further damage. The problem here is not only due to effect on pressure but also to the possible cross–contamination in case of pressure decrease, as the pipe is in close contact with sewage water. Sooner or later the contamination will most likely occur and the network will have to be flushed and then disinfected with important levels of residual chlorine for several days, until one is sure that any possible health related illness is combated.

The figures on the next page show, for Basrah North and Basrah South, the location of some leaks or illegal tapping or connections. During the first assessment a clear distinction between the different categories was not made. Symbols located close to a main transmission line or a primary network pipe are clearly due to pipe bursting or to poorly done pipe tapping. Those located away from the pipes are probably illegal connections or leaks observed in the secondary network. Many of these leaks have been recorded by the patrols of the British forces and only later can a better distinction and codification be made.

These problems will have to be tackled anyway, together with the management of the network and the organisation of the repair teams. UNICEF was ready to take over this programme and to bring in a specialist in network management, in order to assist the utility in this essential task. Transport for the teams, repair clamps (quite difficult to order due to pipes brought in from different origins and irregular diameters) mobile welding machines, tools would have to be provided but also, an effort would have to be made to define the assessment strategies, the intervention of the teams and their reporting, presently left to the memory of the living technicians or engineers, as many papers have been looted.

As outlined above, leaks on the tertiary network were not important, even if this still remains to be confirmed by a more in-depth analysis. As it can be seen from the previous figures, a large number of leaks were made on pipes of relatively large diameters and a lot in the transmission lines, particularly on the visible line delivering raw water to the Bradiyah WTS, where the pipe has been punctured in at least 20 locations. Air valves were opened to release water, with geysers pouring out in the sky. Water dig sites were the density of water dig sites was obviously high were the pressure was poor. In the suburbs that needed water (see map) digging became a normal activity, with people trying to tap water with collars, very often linked to a pump, to overcome the poor pressure. Only a few locations have been mapped, as this problem was not considered too damaging for the network, and therefore left for further attention.

Clearly, the number of illegal connection was on increase. Small diameter GI (galvanized iron) pipes were easily available in the “looters marked” or even looted by the people in need for a water connection. Pipes were laid in a temporary way on the sides of the roads or wherever they were needed, and connected to a main, sometimes in a professional manner.
Of increased concern, were other professional connections like the one shown in the next figure, where the raw water pipeline supplying Bradiyah, was connected using a 100mm pipe (4 inches) to the treated water



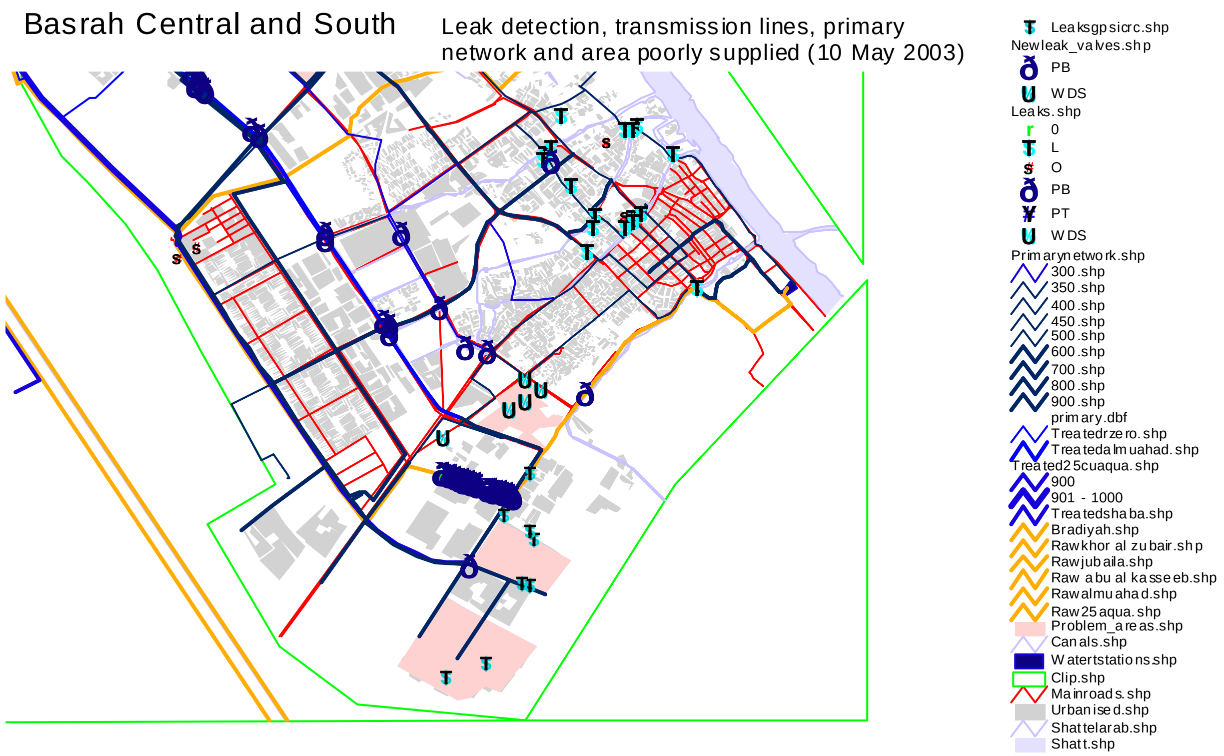


Figure 16: *Leak detection, raw water transmission lines, treated water transmission lines, and primary network layout and poorly supplied areas*

__Figure 17 a, b:__ Makeshift "professional" illegal connection or pump tapping

distributed from the station and then tapped at several locations. It appears that the collars were located after the branch to take advantage from the better pressure due to the transmission line, disregarding the contamination problem. Unfortunately, customers located down flow may not be aware of the problem and would certainly be affected by any water borne disease carried in the raw water. It is not clear when such a system was installed, but what is clear is that it will have to be removed.

__Figure 18 a, b:__ Illegal branching and connection, to be removed

Access to water and specifically to drinking water and distribution by tankers

Several suburbs of the town were poorly supplied. At the end of April and until the beginning of May, the most affected ones were those supplied by the main lines from Muahad and from Aqua 25 WTS and some areas also supplied from Bradiyah. Particularly affected were the suburbs of Al Mankubin, Al Hayy Al Markazi and al Hadi, north of Basrah. Normally these suburbs should have received supply from al Muahad WTS main transmission line and also from Al Jubaila WTP. With both stations producing only 30-40% of their normal production for several days the inhabitants of these areas were in a precarious situation. In the southern areas, the suburbs of al Keblah and the areas located south of the General Hospital were also poorly supplied, either because they were at the very end of the Al Muahad line or at the end of the line supplied by Aqua 25 WTS. A significant number of water digging sites, illegal connections and pipe tapping were observed in these suburbs.

Water distribution by tankers

When access to drinking water is problematic distribution by tankers may alleviate the burden of the inhabitants of the affected suburbs. Right from the beginning of the hostilities it was clear that some suburbs would be more affected than others. Contingency plans were drafted and preparation was quite high. ICRC pre-contracted several tankers to cope with the needs of the hospitals. Coordination meetings held in Kuwait city with UNICEF representatives allowed the ICRC to install several collapsible reservoirs at selected locations, mainly hospitals, in order to improve their storage capacity.
ICRC tankers would then refill them regularly, according to the daily consumption and according to the evolution of the town water supply. UNICEF was contracting 11 water tankers (or more) to distribute daily between 160,000 to 200,000 litres for Basrah town and was ready to boost up the operation in case of specific needs. An important operation was set up to cover the needs of Safwan, which was without water since the beginning of the war. Collapsible reservoirs were installed and supplied every day. Data on this operation were scanty but may be made available soon. The security of the water distribution points was granted by the community.

ICRC tankers were refilled at Um Qasr, where water was available from a pipeline, laid by British forces. UNICEF tankers, in need of relatively large amounts, were also refilling at the same pipeline, but had to come from the Kuwaiti side and cross the border daily, loosing between 1 to 2 hours, allowing them to complete only one rotation. The tankers were then escorted by British forces to their distribution points, located where needs were identified. Street distributions were quite popular and relatively organized, with several armoured vehicles covering the operation.

ICRC began to supply the hospitals from 6 April using five water tankers. A mean amount of 30,000 litres were supplied for the five hospitals where reservoirs were installed. Beginning in May, the al Zubair Health Centre was added to the list, due to the problems faced by the Al Hussain booster station, which was completely looted thus leaving about 5,000 families of the locality without water. On 16 May, three ICRC water tankers begun to distribute water at a mean 50m³/day to the deprived families in Al Zubair, operation which would be continued until the re-commissioning of the Al Hussein booster station.

The breakdown of this distribution is shown in the next figure. Initial data is lacking, but quantities were close to 30m³/day for all the five hospitals.

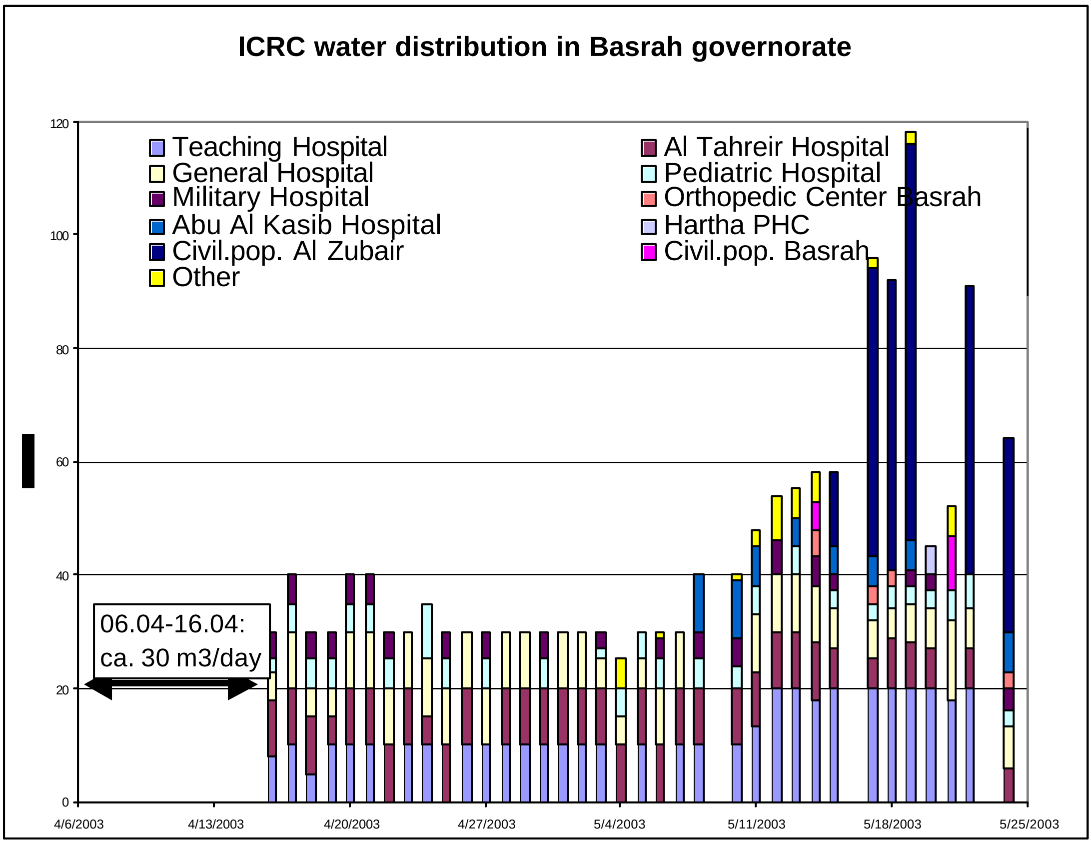


Figure 19: *Quantities distributed to the hospitals and to civilians (al Zubair)*

Figure 20: *Reverse Osmosis (RO) wwater selling point*

At the beginning of May, the tankers were allowed to refill at the Petrochemical Factory (south of Al Zubair) where RO water was available in large quantities, up to 450m^3/h. Agreements were also signed with the RO units installed by the UERCS (United Emirates Red Crescent Society) within the Al Rebat station. Their production was fairly limited, up to 45m^3/d but was very useful in case of emergency.

In May other units resumed their operation within the town. Their location and capacity are shown in the following figure, where a significant part of the RO distribution points are also mapped. RO units are producing very soft water, which was used by many inhabitants of Basrah, before the war. The water is chlorinated up to 3m^3/l at the refilling point, at least as far as the Petrochemical Factory is concerned, and distributed by private water tankers to the RO reservoirs, from where it is sold to the customers. Water tanker operators pay about 2,000 I.D./m^3. Water is purchased by the retailers at 4,000 I.Dinars/m^3 and sold at 200 sometimes 300 or more I.D. for a 20-litre jerry can. The water was not blended as it should be done to improve its mineral content, but precise data could not be obtained.

What was known was that the business was due to resume soon and reach its normal pace. Water tanker owners began to report to the RO stations already selling water, mainly to the Petrochemical station. It was therefore of paramount importance to avoid any interference with these activities, avoiding any competition between distributors of free water and RO retailers.

The locations of the RO water selling points were tentatively mapped to identify areas quite well covered, where water distribution would be damaging to the business. Not surprisingly, RO distribution points are located in areas where people may afford to pay for water, in the Old town, in Ashar, in the former British suburbs and along the main axis. A total of 145 RO distribution points were located. Areas covered by UNICEF distribution points are more or less distant from these RO water selling points, more likely to supply less well off people. RO seems to be cheap, between 200 and 400 I.D per jerry can, for a total of about 6-8,000 I.D/month for a family using 20 litres/day. At the prevailing exchange rate, close to 1 USD/2000 I.D. (end of April) the mean cost of purchasing RO water would be close to 6-8 USD, which is sometimes the monthly income of a family. Only wealthy families can afford to pay such amounts and no doubt, the water distributed through the network was essential for the economic survival of the majority of the population. A flat monthly rate is paid, when it is paid, and averages 4,000 I.D. for 1m^3 and not for 20 litres.

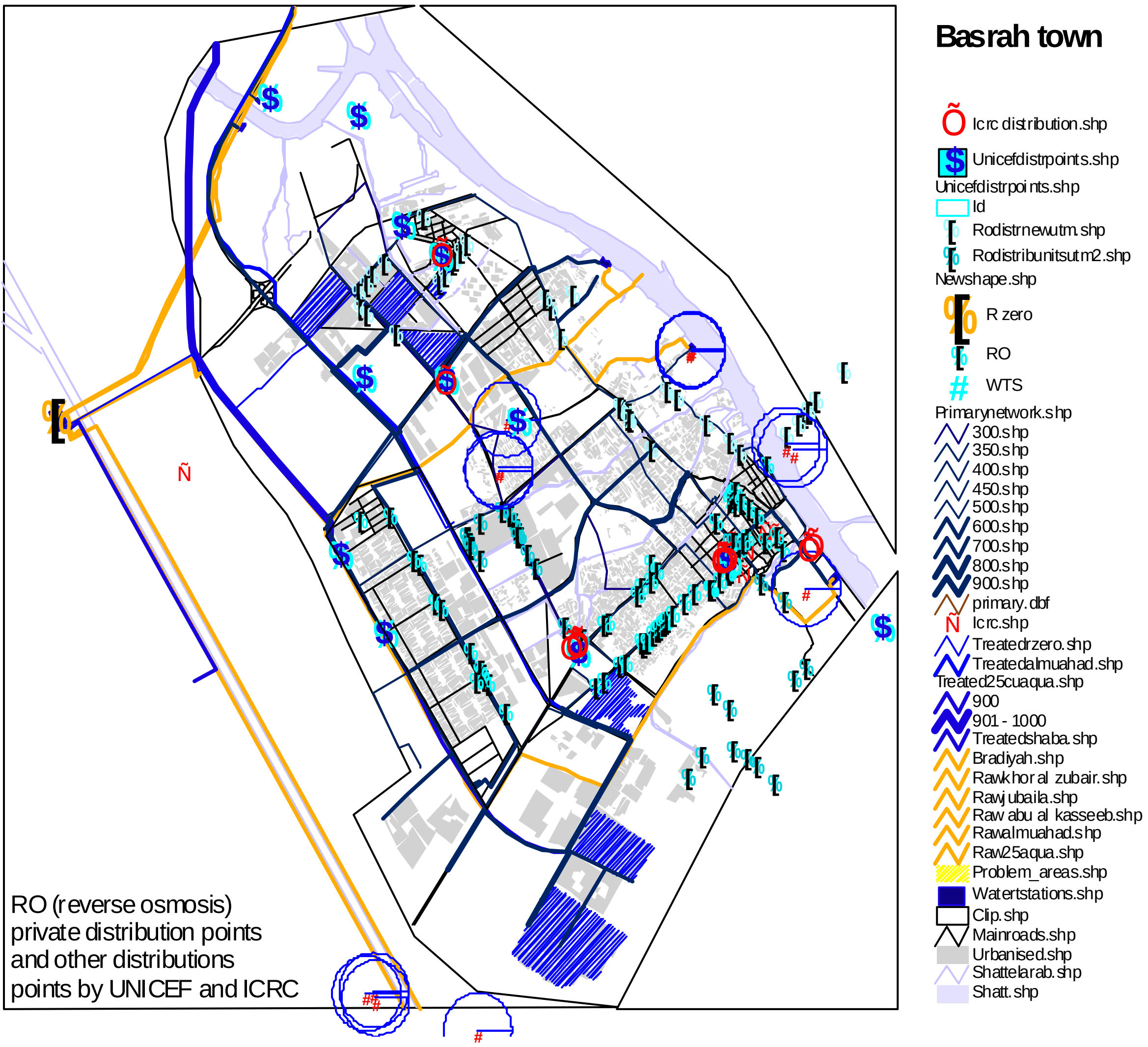


Figure 21: *Area poorly supplied, location of the RO production stations, of the RO distribution points (partial) of the UNICEF (street) and ICRC distribution points (H = Hospitals)*

A good sign of the recovery of this business were the amounts distributed to private tankers at the RO station of the Petrochemical Factory, quickly reaching 700m³ daily and about 1,000m³/day at mid-May, when UNICEF and ICRC boosted up their distribution, as it can be seen from the next figure. This means that about 500,000 litres are distributed daily to the RO and to private people who are able to pay for the water.

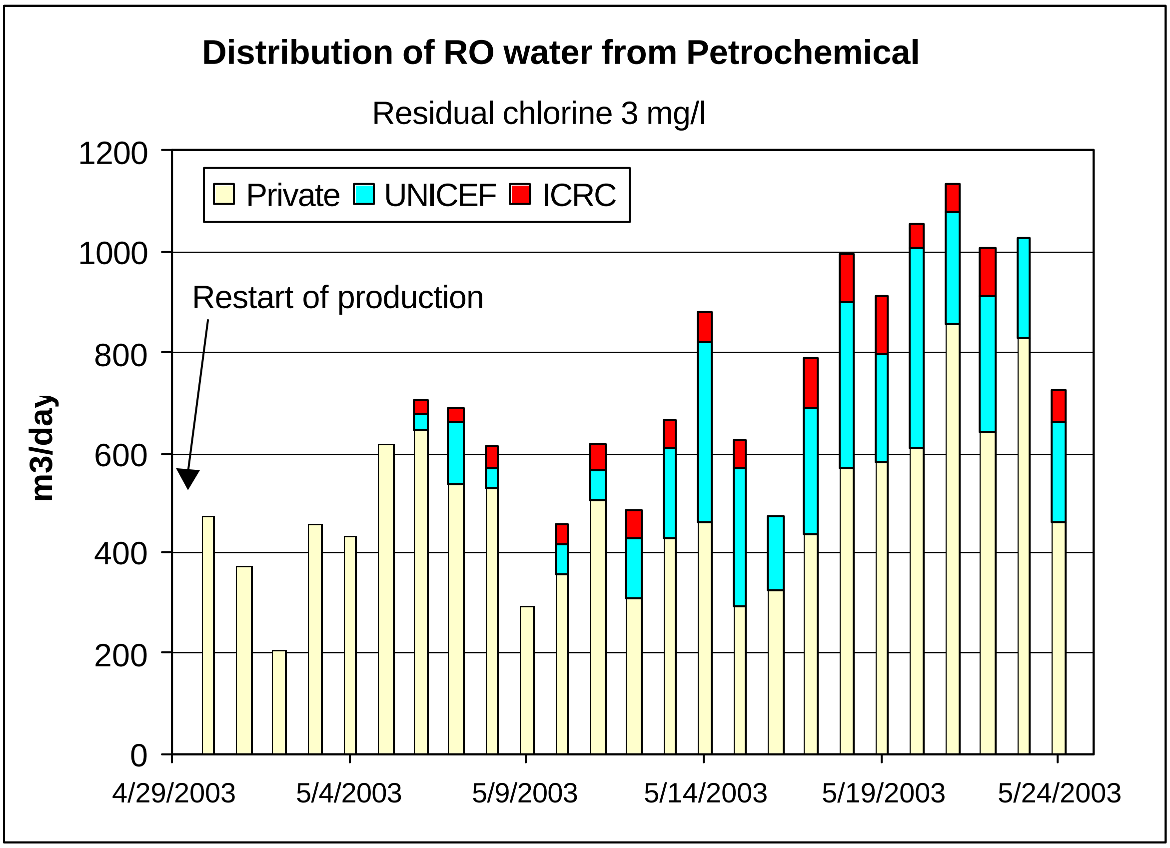


Figure 22: *Quantities distributed to tankers by categories at the Petrochemical RO*

The quantities are important but a more in-depth analysis would have to be carried out to find out the destination of all these tankers.

As water was for free, water distributions were extremely popular. Very visible large crowds attended street distributions, even if the total amounts were extremely small compared to what was pushed every day through the network, even during the bad ones, close to 300,000,000 millions of litres, compared to the 160-200,000 distributed by tankers. If one wants to be visible, that is the way. No doubt, visibility needs certainly dictated such approaches, even if needs were there. However, the distribution points set up at the edge of the Al Hayanniyah suburb, poorly covered during the bad days, should have been removed quickly, once water distribution resumed to normal.

Quickly set up, water distribution by tankers should also be stopped quickly, to avoid the establishment of unnecessary habits, difficult to eradicate. It was also wise to avoid the installation of fixed reservoirs, again difficult to remove, and leave their use to areas where water would be lacking for longer periods, due to more serious damage and impossible to repair in a few days.

Leaks, disinfection and public health

As the water distribution was beginning to reach its normal level, concerns grew among all the humanitarian actors about the quality of the water distributed through the network. Outbreaks of water related diseases have been common during the last years. Diarrhoeal diseases were considered one of the main mortality cause for the under five during all the sanctions years. Figures were somehow extrapolated but the problem was important. Cholera outbreaks were part of the endemic diseases in the southern towns of the country and outbreaks were recurrent. In 2002, 200 cases of cholera were reported and in 1989 the number of cases was more important, up to 1,200. Food, ice, sold by street vendors, and poor hygiene has been the cause of these previous outbreaks.

Water distributed through the network is in principle chlorinated and if levels of residual chlorine are maintained over 0.1 to 0.3mg/l at the end of the network one can reasonably admit that the water is safe. The interruptions of the distribution during several weeks, the leaks made and the problems of access to water described above prompted the need of an initial study to gain precise information on the situation of the disinfection.

A rapid survey of the levels of residual chlorine in different area of the town was launched on 3 May and repeated on 6 and 8 May and in the following days. Four teams of surveyors from the Directorate of water, in charge of the analysis before the war, were hired and later a surveyor of the Department of the Environment joined the teams, as this was apparently the way that such monitoring was carried out. From a total of 81 sampling locations the number has been increased to 192 to cover all the areas of the town. The sampling locations were mapped precisely on the NIMA 1:15,000 map[6] in order to facilitate any future interpretation as it was foreseen, when it would be possible, to hand over this activity to UNICEF, the agency having expressed its intention to be involved in the management of the network and in a leak control programme. The results in table III must be considered as exploratory.

Date	No. of sampling Locations	No.>0.1 mg/l of res. Chl.
3.05	81	5
6.05	77	8
8.05	116	16

Table 4: *Preliminary results of the residual chlorine sampling campaign*

One of the initial objectives of this survey was to allow for normal services to resume this essential activity. The other was to appreciate the extent of the disinfection in a situation where cross-contamination was considered high. Sampling areas were chosen according to network coverage.

In these initial tests residual chlorine levels were found only in a few areas supplied from the al Rebat station, namely in the Old Basrah town and at Timmamiyah, in Al Makil, supplied from al Muahad and from al Jubaila and in a few locations north of the Gurma river. The following figure shows the sampling points and the locations where residual chlorine was found. Levels at the stations were also checked and were in general over 2.5 mg/l, probably not sufficient to cope with the chlorine consumption substances likely to have entered the pipes. The results were due to be used to adjust the chlorination levels at the stations. It was foreseen that after a regular pumping, most of the pipes would have been flushed, with levels of chlorine increasing in all the suburbs.

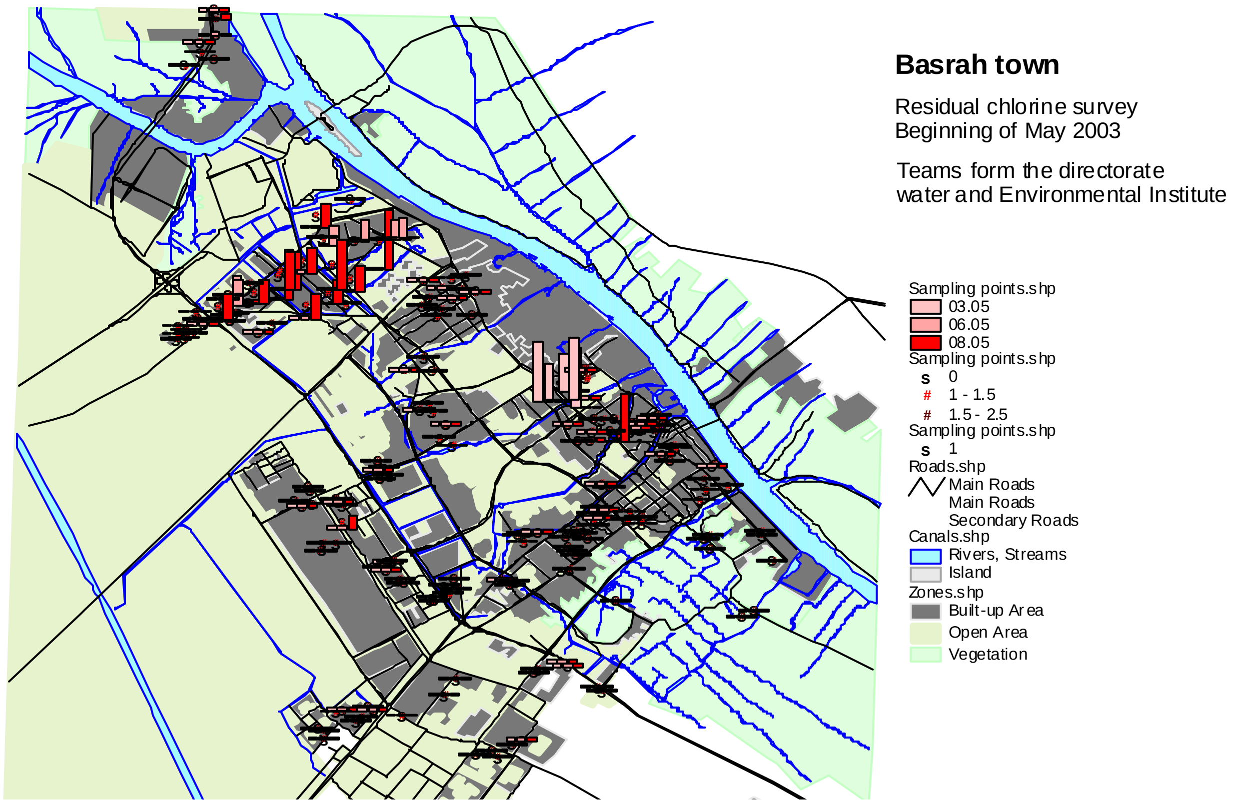


Figure 23: *Location of the sampling points (192) and levels of residual chlorine from three preliminary surveys (May 2003)*

6 NIMA (National Imagery and Mapping Agency, US Government)

A further survey carried out jointly by the ICRC and UNICEF, during the a/m hand-over, showed that the levels of residual chlorine were declining quite fast in function of the distance of the sampling point from where the water was pumped into the network, at the different stations. It is very possible that during the crisis the treatment has been somehow difficult to calibrate, the operators having to switch from the raw water to the Shatt-el-Arab from time to time, with little time to properly adjust the dosage of the treatment chemicals. This operation has always been the weak point of the treatment, with current analytical tests barely performed and operators not really perfectly trained, capable to set the calibrations of the dosing pumps and of the chlorinators but not really conscious of the behaviour of the different raw waters. As a consequence the amounts of chlorine consuming substances, which have entered the network may have been important and until they will be oxidized, it will take some time. Acceptable chlorine residual levels at the end of the lines may be measured only in several weeks, particularly in some lines, particularly affected by these problems. The next figure shows the results obtained for most of the distribution lines receiving water from a particular station.

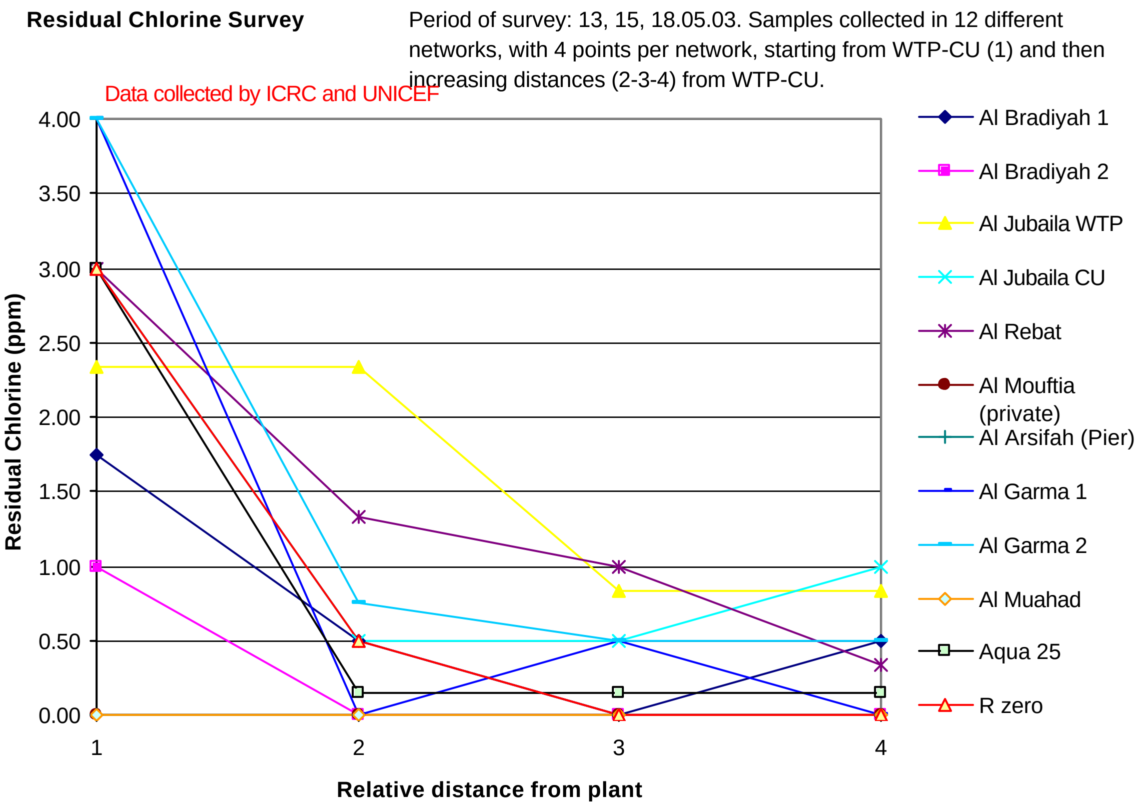


Figure 24: *Residual chlorine measured at the stations and at several kilometres from the injection point*

“Cholera” outbreak

It was easy to link the “cholera” outbreak to the poor distribution of potable water from the network. According to WHO representatives and the special envoy, “an outbreak of cholera, probably affecting several hundred of people”, was occurring[7]. In fact, of the 18 cases reported, 16 were affecting children under five years of age, and only four of the 38 samples processed in the Kuwaiti’s Public Health Laboratory were consistent with “Vibrio” cholera (serotype Inaba), common to all al Basrah and known to be a benign variety. Of the 18 suspicious cases, all were considered mild in nature and no major complications were observed after treatment, partially with ORS and partially with intravenous fluids. It was clear that it was not possible to be specific about the exact situation of any epidemic until a clear epidemiological surveillance would be put in place with a clear case definition and reliable laboratory surveillance. Bearing in mind how people collected water the monitoring steps will have to be maintained and improved.

7 Iraq hospital report 17 cholera cases, Associated Press, Basrah, Iraq May 7.

Consequences of the lack of enforcement of law and order.

If the control of Basrah has been achieved with little or acceptable damage, the period following the full control of the town by British Forces saw the onset of general and widespread looting of any governmental buildings or premises. Even if signs of return to normality were visible, like the reopening of most of the shops and of the schools, most parents were reluctant to send their children to schools, concerned about the safety of their children, following rumours of abductions and threats. Security became the major issue, as operators or official car drivers were intimidated or threatened on their way to work or on duty. Vehicles, trucks, computers, furniture, etc. were first targeted. Looters then began to be interested in any public or private property left unguarded and without protection.

As far as water and electricity is concerned, pipes, batteries, cables, electrical motors, tools, and other materials were targeted. Looters did not hesitate to use cranes and trucks to remove valuable equipment and sell it for its raw material value. At the end of April it was foreseen that if damage done to the infrastructure would go on as it was, we would come to a point whereby little would function any longer.

It is not the first time that the town is experiencing similar situations. Already in 1914, when the town was taken by the British Forces, looting went on for about a week, targeting rich Jewish properties and properties of Ottoman empire's civil and military servants. In 1991 war, following the Shiite's up-rise, most of the governmental buildings were looted and damaged too, during the brief period of state vacancy.

If most of the water treatment stations were finally protected by armed troops after weeks of repeated voicing, several others remained unprotected and vulnerable to looters. British forces finally managed to organise mobile patrols at PS1, improving significantly the protection and the operation of this essential pumping station. Despite that, some problems still occurred in between the rotations of the patrols.

Other premises, like the Al Hay Hussein booster station, located within the Al Hayyanniyah suburb, were damaged to a point that they would have to be re-equipped completely, with all the electrical boards looted, and with some pumps and all the window frames removed.

Figures 25 a,b: *Al Hussain booster station and cables prepared to be sold*

This station was pumping treated water (ex Al Bradiyah or Aqua 25) to the small town of Al Zubair, located South-West of Basrah. As a consequence, 5,000 families will have to be supplied by tankers until it is possible to repair it, which will certainly take months, owing to the damage made.

These are only a few examples of the damage due to widespread looting. It could have been avoided if a clear mandate would have been given to the Occupying Forces. It appears that this aspect of the war has been "forgotten" or "neglected", despite the specific provisions drafted in the Hague Conventions[11] , stating clearly the responsibility of the Occupying Powers in the maintenance of law and order.

The intervention of the Occupying Forces has been quite loose and seemed "to be left to their own preferred reading of customary law, their national military cultures, and their ideological persuasion"[12].

[11] Regulations respecting the laws and customs of war on land, The Hague, 18 October 1907, Section III, Art. 43. "The authority of the legitimate power having in fact passed into the hands of the occupant, the latter shall take all the measures in his power to restore, and ensure, as far as possible, public order and safety, while respecting, unless absolutely prevented, the laws in force in the country".

[12] It is the duty of the inhabitants to behave in peaceful manner, to carry on their ordinary pursuits as far as possible, to take no part in the hostilities, to refrain from any act injurious to the troops of the Occupant or prejudicial to the troop of the Occupant or prejudicial to their operations, and to render Obedience to the officials of the Occupant. Any violation of this duty is punishable by the Occupant. In "The Law of War and Land, being part 3 of the Manual of Military Law (London, HMSO, 1958), sec. 552 quoted in Geoffrey Best war and law since 1945,Clarendon Press Oxford, 1994.

The Geneva Conventions are less specific in this aspect. Article 56 considers the duties of the Occupying Power in ensuring and "maintaining, with the cooperation of national and local authorities, the medical and hospital establishments and services, public health and hygiene in the occupied territories, with particular reference to the adoption and application of the prophylactic and preventive measures necessary to combat the spread of contagious diseases and epidemics"[14]. Article 54 of Protocol I of 1977 additional to the 1949 Geneva Convention, and related articles, protects objects indispensable to the survival of the civilian population, including drinking and irrigation water, from being attacked during the hostilities, but does not contemplate their destruction due to looting and thefts. The situation was due to improve by mid-May when armed police units were finally set-up by the Occupying forces.

The ICRC and its Iraqi counterparts were able to liase with the British Forces in order to ensure that any damage resulting from conducting military operations did not result in any dramatic consequences for the civilian population. Information was exchanged daily and cooperation was quite remarkable, with meetings taking place at the ICRC's sub-delegation offices, until a more suitable location was found to host these technical meetings.

If the military operations were conducted in order to avoid any unnecessary damage to the installations indispensable for the survival of the civilian population and in compliance with all the provisions of Geneva Conventions and International Law concerning the conduct of the hostilities, the lack of a proper enforcement of law and public order have created significant damage which could have been easily avoided. By mid May it was too early to appreciate the extent of the damage due to this "neglect" but it can be easily assumed that its importance is relevant.

Figures 26: *Al Husai booster station after looting*

[13] Article 56, 1949 Fourth Geneva Convention.

Conclusions

The battle for the control of the town of Basrah could have resulted in severe damage to the infrastructure for the distribution of water and electricity, depriving an estimated 900,000 people with their normal access to water, with possible dramatic consequences due to outbreaks of epidemics linked with the poor access to water, obliging many people to revert to polluted sources.

Fortunately, military operations were conducted in such a way that damage has been limited. Despite this, owing to the complexity and to the vulnerability of the water supply system of the town, supplied with raw water from very far away, many problems had to be faced. Thanks to the preparedness of the ICRC, its contractors and its Iraqi counterparts of the Water Board and of those of the Electricity production and distribution, damage could be repaired relatively quickly.

The quantities of water distributed during the most critical period, from the end of March until mid-end April, were always close to 100,000m^3/day, about 1/3 of the "normal" production. By beginning of May, despite daily fluctuations due to several problems linked with the fragility of the system, the quantities of water distributed into the network were close to those of the pre-war time, up to about 300,000m^3/day and even more.

Due to the fact that for many days the raw water conveyed from North of Nassiriyah through a 225km open channel did not reach the main distribution station R zero, the engineers took decided to reconnect all the stations to the Shatt-el Arab, to maintain a minimum of water flowing into the network, until the problems could be tackled. Several suburbs, depending almost exclusively from one of the nine stations of Basrah, despite the interconnected network, were in dire need of water, with low pressure in their pipes, triggering an important but limited number of damage, due to pipe breaking, tapping or from the installation of illegal connections, often poorly done.

Disinfection of water, carried out by all the stations in their usual way, with the use of liquid chlorine, available in sufficient quantities and due to be re-supplied with 50MT by British forces from Kuwait, was not sufficient, at least according to the first surveys carried out by the ICRC between 3 and 8 May. These surveys, initiated before the onset of the "cholera epidemics" showed low or insignificant levels of residual chlorine, with only a few suburbs correctly covered. The situation would improve and would certainly become normal when all the main leaks and damage would have bee repaired.

Fears for an "announced" outbreak of "cholera", rose when 18 cases of "diarrhoea" were admitted to the hospitals. The network water was almost immediately considered as the vehicle of the disease, which turned out to be quite mild, and relatively limited, despite the attention it attracted from the media covering the post-war phase. No doubt, several suburbs remained poorly supplied, even if a better management of the network would have allowed to reduce the inequalities of the pressure.

The huge task of the organization of the repairs, the management of the network and the control of the disinfection was finally taken over by UNICEF, with distribution of water by tankers being limited to suburbs in real need. The exercise was carried out in coordination with the ICRC and other actors, avoiding areas where private tankers were supplying distribution points with reverse osmosis water, a normal business before the war.

With the resumed power production and the stabilization of the 132KV electrical network, the distribution became more and more regular despite daily breakdowns due to makeshift repairs and sabotage, or organized looting.

Looting became one of the main "collateral damages" of the whole military operations. Public and private property was targeted, as the enforcement of the law and order remained neglected by the occupying forces, in this case the British Army. A window of opportunity for looters and thieves existed between the "end" of the active military operations and the beginning of April. A police force was set up in mid May. Damage to the infrastructure was important, with cables, pumps, electric boards, etc. being put out of order to an extent that any repairs would take months, not to mention that expensive equipment would need to be replaced completely.

The role of the ICRC was of paramount importance as their engineers acted as a focal point for all the acting local counterparts, without whom nothing would have been possible. Whenever it was needed, essential support was made available, like cranes, tools, transport, etc. and protection granted. In the early phase of the military operations, when the coalition forces occupied the airport and the town remained under Iraqi control, ICRC engineers managed to negotiate for access to R zero, located close to the airport, allowing their Iraqi counterparts to carry out the necessary repairs. Their commitment and competence was invaluable.

The cooperation with the British forces has been exemplary in that context and all along the delicate phase of the post-conflict. However enforcement of law and order has been too slow, despite repeated voicing from ICRC and from all other humanitarian actors. When action was finally taken, damage from looters was sometimes irreparable. Data collected from the onset of the crisis proved to be essential to understand the global evolution of the resumption of the water distribution and to silence rumours, triggered by the understandable fear of epidemics, as unfortunately, is the case in such situations.

Essential information, for instance locations where significant quantities of RO (reverse osmosis) water were produced was shared with other actors, saving unnecessary travelling time and therefore streamlining their interventions. Thanks to the knowledge gained during many years of presence and to the relationships built between the ICRC and the technical counterparts and authorities before the onset of the conflict, the response has been efficient and as per the textbooks. A major crisis and huge loss of lives have certainly been averted.

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