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Chapter 2

ISSUES IN THE USE OF WATER IN SYRIA

Syria is considerably better endowed with water than its neighbors in the Arabian Peninsula. Although it has already experienced some local shortages, at present the country enjoys a significant surplus. Seasonal rationing notwithstanding, e.g., in Damascus, in the 1980s only Aleppo faced a present and long-term systemic shortage, a deficit which is presently being eased, but not solved, by the transfer of 80 or more million cubic meters of water per year from Lake Assad.

This surplus, however, is no cause for complacency. By our estimates and those of other authors, the amount of water available to Syria is actually diminishing. Turkey's ambitious Southeast Anatolia Project may extract over 12.3 billion cubic meters from the annual flow of the Euphrates before it reaches Syria[4637)]; this would reduce the amount of water available to Syria by some 40% by the end of the century -- or sometime thereafter, if Turkish schedules are delayed. At the same time, Syria's population is growing, its people's standard of living and water consumption expectations are rising, and the development of irrigation projects continues in various regions. Our approximation is that Syria's consumptive use of water will increase by 250% by the year 2000 and continue to grow at a reduced rate over the subsequent fifteen years. As with Turkey, these usage projections will be lower, if development requires more time than scheduled. Nevertheless, Syria's surplus, by our calculations, could be reduced to as low as one eighth of its current level by the year 2015.

To derive these approximations we first looked at demographic trends. Based on statistics from the 1981 census, we considered growth rates and momentum, age structures, and migration patterns in order to project the population of the country and the seven basins to the year 2015. These, together with projected changes in per capita usage rates, yielded estimates for domestic consumption in the seven basins and in the country as a whole.

We then looked at various predictable changes in water use. The most important of these involves the inauguration of new irrigation schemes, many of which are now planned or even under construction. We have also examined the possibility of achieving efficiencies both in municipal systems and in agricultural use and have made assumptions regarding the realization of reasonable goals. The results of these calculations are presented in a series of water balances for each basin and, finally, in a balance for Syria to the year 2015. It is this balance that supports the observation of current, but diminishing surplus with problems of absolute scarcity looming only for the more distant future. These problems are given more immediate significance in view of Syria's vulnerability to the water needs of its upstream and downstream neighbors.

In the later sections of this chapter we will examine some of the water issues which are currently claiming the attention of the Damascus government and others which we believe they will need to consider in the coming years.

2.1 Demographic Data and Trends

The most recent head count in Syria was the census of 1981, the data of which is presented by Samman[4421] in terms of total population, population by province, and population by major city. According to this source, the total population of Syria was 9.172 million, although the United Nations[4398] records the total as 9.05 million. Samman alao reports that in 1981 the Syrian population was 48% urban.

Previous analyses projecting the population of Syria to the year 2000 (al-Alawi[4412], Williams[4624]) were based on the census of 1970. We have therefore recalculated these projections based on the 1981 census, but taking into account the arguments which were elaborated in the earlier projections regarding population growth rates, the relationship of age structure to population momentum, and the rate of urbanization. The discussion of these indicators by Williams[4624] is particularly cogent; we have adapted his arguments and applied them to the 1981 data. A projection of Syria's population to the year 2015, together with the chosen parameters, appears in Table 2.1.

It is true, in these as in all projections, that the accuracy of the prediction is indirectly proportional to the length of time covered. Up to the year 2000, the predictions are probably fairly accurate; beyond that point they become increasingly speculative. We have posited that the annual growth rate will level off at 3% after 2000 for essentially political, rather than demographic, reasons. Since there is no present evidence of public concern with the high fertility rate, we expect that it will continue to be high into the foreseeable future. It is often claimed that fertility rates fall off as populations become more urban[4624]. Urban migration is expected to continue in Syria (see the percent urban column in Table 2.1). However, there is no evidence of significantly reduced fertility rates in neighboring Jordan, which is already 70% urban. In the absence of effective educational policy to the contrary, it is expected that Syria's population growth rate will remain high. Indeed, there may be an increase in the growth rate after 2010, when the bulge of children born in the 1980s comes to child-bearing age.

Table 2.1

SYRIAN POPULATION PROJECTIONS TO 2015
(starting with actual census of 1981)

Year	Population millions	Annual Growth Rate	Urban percent	Urban million	Rural million
1981 actual	9.172	3.4	47.9	4.391	4.781
1985	10.484	3.8	49.6	5.200	5.284
1990	12.633	3.7	51.4	6.493	6.140
1995	15.150	3.1	53.2	8.060	7.090
2000	17.649	3.0	55.0	9.710	7.939
2005	20.460	3.0	57.0	11.662	8.798
2010	23.716	3.0	60.0	14.230	9.486
2015	27.493	3.0	63.0	17.321	10.172

Sources:

For 1981 census see Samman(4421).

For demographic indicators, see al-Alawi(4412), Williams(4624), and Population Reference Bureau(4375). Also see US Bureau of Census, 1986 Report of the Center for International Research, and United Nations: Demographic Indicators Estimates and Assessments 1984.

Calculations by the author.

With these caveats we predict that the population of Syria will almost double by the year 2000 and will treble by 2015.

In order to translate these population figures into water consumption figures, we have estimated the 1981 population by hydrological basin and divided it into urban and rural segments (see Table 2.2). The population figures are converted to domestic water use estimates using the projections for per capita urban and rural water use posited by the World Bank in its 1980 report on Syria[3101]. The results for domestic water use by basin in 1981 are given in Table 2.3. These figures reflect estimates for actual consumption and do not account for systemic loss. (Figures which take account of systemic loss and of the savings able to be realized by reduction of systemic loss are given in Section 2.2.)

Actual Syria-wide domestic consumption up to the year 2015 is predicted in Table 2.4. By these calculations, consumption by domestic users will more than quadruple by the year 2015. It should be mentioned that we are assuming the rate of growth to be relatively constant throughout the country. On the surface, such an assumption might appear unreasonable since three cities in the Euphrates basin -- Raqqa, Hassaka, and Qamishli -- have registered growth rates of more than twice the national average. However, the growth rates of the provinces in which these cities are located were at, or even below, the national average[4421]. This appears to reflect a phenomenon of migration within the province with rural populations gravitating to their nearest market town, rather than an overall periphery to center movement[4624]. At all events, the numbers involved are small; the three towns each had populations of less than 100,000 in 1981 and should not skew the calculations too badly.

More serious is the growth rate of Damascus Province, which was more than a percentage point above the national average growth rate and which, together with Damascus City, contained almost a quarter of the population of the country. However, the government seems to be applying economic disincentives to migration toward Damascus[4362]. This question will be kept in mind when considering the overall usage predictions for the Damascus basin.

2.2 Water Balance

The above analysis gives some measure of the increasing water needs of Syria over the next thirty years. However, it is only the least of the elements to be considered, for domestic and industrial uses together account for less than 10% of Syria's water needs. By far the largest user of water is irrigated agriculture.

Table 2.2
ESTIMATED 1981 POPULATION BY BASIN ('000s)
Based on reports of 1981 census

Basin	Total pop.	Urban SW	Urban GW	Rural SW	Rural GW
Euphrates	1418	345	---	1073	---
Aleppo	1869	1177	---	692	---
Orontes	1625	177	390	234	824
Damascus	1996	---	1996	---	---
Coast	998	---	250	---	748
Yarmuk	389	---	28	---	361
Steppe	875	21	22	---	832
TOTAL	**9170**	**1720**	**2686**	**1999**	**2765**

Population serviced by: SW = surface water; GW = groundwater.

Source: Samman[4421], calculations by author.

Table 2.3
DOMESTIC WATER USE BY BASIN (Mcm/a)*
Based on population in 1981 census

Basin	Total	Urban SW	Urban GW	Rural SW	Rural GW
Euphrates	125.3	78.9	---	46.4	---
of which					
Euphrates	*[46.1]*	*[17.9]*	---	*[28.2]*	---
*Aleppo***	*[79.2]*	*[61.0]*	---	*[18.2]*	---
Aleppo	---	---	---	---	---
Orontes	57.2	9.2	20.2	6.1	21.7
Damascus	103.5	---	103.5	---	---
Coast	32.7	---	13.0	---	19.7
Yarmuk	13.2	1.1	2.6	---	9.5
of which					
Yarmuk	*[11.0]*	---	*[1.5]*	---	*[9.5]*
*Steppe***	*[2.2]*	*[1.1]*	*[1.1]*	---	---
Steppe	21.9	---	---	---	21.9
TOTAL	**353.8**	**89.2**	**139.3**	**52.5**	**72.8**

* Assumes usage of 142 lcd for urban populations, 72 lcd for rural populations, per World Bank[3101].
** Interbasin transfer

Source: AMER, calculations by author.

Table 2.4

DOMESTIC WATER CONSUMPTION 1981 TO 2015

	1981	1985	1990	1995	2000	2005	2010	2015
Total pop. (mn.)	9.17	10.5	12.6	15.0	17.7	20.5	23.7	27.5
Urban population	4.39	5.20	6.49	8.06	9.71	11.6	14.2	17.3
Per Capita (lcd)	142	155	170	183	200	200	200	200
Consump. (Mcm/a)	228	294	403	538	709	851	1039	1264
Rural Population	4.78	5.28	6.14	7.09	7.94	8.80	9.49	10.2
Per Capita (lcd)	72	80	90	95	100	100	100	100
Consump. (Mcm/a)	126	154	202	246	290	321	346	371
TOTAL CONSUMPTION (Mcm/a)	354	448	605	784	999	1172	1385	1635

Sources:

AMER population projections by author, see Table ~~X.X~~ 2.1.
Per Capita use assumptions from World Bank[3101], p. 284.
Calculations by the author.

To provide the basis for an analysis of the agricultural uses of water, we have calculated water use by province based on the statistics reported for land use in the 1981-82 agricultural year[3220]. Water usage is calculated using crop irrigation requirements that vary with season, climate, and categories of crops. The CIR figures include consideration of plant evapotranspiration, but do not include losses in the system itself. Systemic losses are calculated in the column headed Estimated Water Loss. The results are shown in Table 2.5, with a total water use for irrigation of 6,158 Mcm per year countrywide.

In Table 2.6 we collate by basin the results of Tables 2.3 and 2.5 and add estimates of the water use for industry. Industrial water use is not recorded in statistical reports on Syria. A total figure nationwide of 288 Mcm/year was cited by the World Bank report of 1980[3101], but was not designated to particular areas. The allocation of this usage figure to basins was done in proportion to the number of industrial workers in each locale. This is a dubious procedure, since not all industries consume water at the same rate. Impressionistically one can say that the petroleum extraction industries of the Euphrates basin are not highly water consumptive, while the textile and food processing industries of Damascus, Aleppo, and the Orontes basin are heavy consumers. Thus a result that allocates the major portion of industrial water use to these three areas is qualitatively correct. The numbers are small in any event.

The use, loss, and withdrawal figures of Table 2.6 form the basis for the projection of water use in Syria by basin over the next 30 years. Since the assumptions about economic development and attendant water usage vary from region to region, each basin will be discussed separately. The discussion amplifies only certain parts of each table, which should be examined concurrently.

2.2.1 The Euphrates

The water balance on the Syrian stretch of the Euphrates is expected to change dramatically by the end of the century (see Table 2.7). Both Turkey and Syria are engaged in major development projects that will significantly change the quantity and quality of Euphrates water. A 1987 study by John Kolars[4637] estimated that Turkey's drawdown could increase by more than 12 billion cubic meters by the year 2000. Up to 1,600 Mcm are lost each year through evaporation from Lake Assad.

The amount of water entering Syria on the main stem of the Euphrates varies considerably from year to year. For purposes of the present analysis, we have adopted the Syrian estimate of an average flow of 830 cubic meters per second[4383], which yields an annual figure of slightly more than 26 billion cubic meters.

Table 2.5

SYRIAN AGRICULTURAL WATER REQUIREMENTS - 1982

MOHAFAZAT	Irrigated Area(1) (ha)	Water Required(2) (cu m/ha)	Water Required (Mcm)	Source of Water	Source by Area(3) (% of ha)	Water Required (Mcm)	Estimated Water Loss(4) (Mcm)	Total Water Needed (Mcm)
Damascus								
Fruit Trees	31,575	15,161	478.7	Pumped (GW)	66.1%	490.8	86.6	577.4
Summer Crops & Vegs	26,002	7,480	194.5	Pumped (SW)	0.8%	5.9	1.0	6.9
Winter Crops & Vegs	33,820	2,048	69.3	Gravity (SW)	33.1%	245.8	105.3	351.1
TOTAL	91,397	8,124	742.5	TOTAL	100.0%	742.5	192.9	935.4
Dar'a								
Fruit Trees	1,959	13,489	26.4	Pumped (GW)	17.2%	16.3	2.9	19.2
Summer Crops & Vegs	5,336	9,560	51.0	Pumped (SW)	31.7%	30.1	5.3	35.4
Winter Crops & Vegs	5,296	3,317	17.6	Gravity (SW)	51.1%	48.5	20.8	69.3
TOTAL	12,591	7,545	95.0	TOTAL	100.0%	94.9	29.0	123.9
Sweida								
NO IRRIGATED AGRICULTURE								
Quneitra								
Fruit Trees	180	13,228	2.4	Pumped (GW)	0.0%	0.0	0.0	0.0
Summer Crops & Vegs	898	9,123	8.2	Pumped (SW)	0.0%	0.0	0.0	0.0
Winter Crops & Vegs	673	1,802	1.2	Gravity (SW)	100.0%	11.8	5.1	16.9
TOTAL	1,751	6,739	11.8	TOTAL	100.0%	11.8	5.1	16.9
Homs								
Fruit Trees	5,019	14,506	72.8	Pumped (GW)	41.7%	153.4	27.1	180.5
Summer Crops & Vegs	29,148	8,748	255.0	Pumped (SW)	1.9%	7.0	1.2	8.2
Winter Crops & Vegs	14,596	2,748	40.1	Gravity (SW)	56.4%	207.5	88.9	296.4
TOTAL	48,763	7,545	367.9	TOTAL	100.0%	367.9	117.2	485.1

[1] Area double-cropped = 2 ha. [2] Based on calculations of similar climate regions in Jordan[2820].
[3] Area double-cropped = 1 ha. [4] Estimated losses: pumped GW = 15%; pumped SW = 15%; gravity SW = 30%.

MOHAFAZAT	Irrigated Area(1) (ha)	Water Required(2) (cu m/ha)	Water Required (Mcm)	Source of Water	Source by Area(3) (% of ha)	Water Required (Mcm)	Estimated Water Loss(4) (Mcm)	Total Water Needed (Mcm)
Hama								
Fruit Trees	2,384	14,506	34.6	Pumped (GW)	67.2%	167.7	29.6	197.3
Summer Crops & Vegs	20,711	8,487	175.8	Pumped (SW)	6.4%	16.0	2.8	18.8
Winter Crops & Vegs	16,442	2,387	39.2	Gravity (SW)	26.4%	65.9	28.2	94.1
TOTAL	39,537	6,313	249.6	TOTAL	100.0%	249.6	60.6	310.2
Ghab								
Fruit Trees	240	8,504	1.7	Pumped (GW)	32.3%	66.3	11.7	78.0
Summer Crops & Vegs	42,970	4,618	198.4	Pumped (SW)	0.0%	0.0	0.0	0.0
Winter Crops & Vegs	5,439	957	5.2	Gravity (SW)	67.7%	139.0	59.6	198.6
TOTAL	48,649	4,220	205.3	TOTAL	100.0%	205.3	71.3	276.6
Lattakia								
Fruit Trees	7,123	8,504	60.6	Pumped (GW)	28.4%	46.5	8.2	54.7
Summer Crops & Vegs	20,029	5,102	102.2	Pumped (SW)	50.8%	83.3	14.7	98.0
Winter Crops & Vegs	649	1,673	1.1	Gravity (SW)	20.7%	33.9	14.5	48.4
TOTAL	27,801	5,895	163.9	TOTAL	99.9%	163.7	37.4	201.1
Tartous								
Fruit Trees	4,494	8,504	38.2	Pumped (GW)	68.9%	91.1	16.1	107.2
Summer Crops & Vegs	18,928	4,843	91.7	Pumped (SW)	10.7%	14.1	2.5	16.6
Winter Crops & Vegs	1,368	1,673	2.3	Gravity (SW)	20.4%	27.0	11.6	38.6
TOTAL	24,790	5,333	132.2	TOTAL	100.0%	132.2	30.2	162.4
Idleb								
Fruit Trees	1,353	13,228	17.9	Pumped (GW)	55.6%	53.5	9.4	62.9
Summer Crops & Vegs	9,102	7,859	71.5	Pumped (SW)	20.8%	20.0	3.5	23.5
Winter Crops & Vegs	3,423	1,972	6.8	Gravity (SW)	23.6%	22.7	9.7	32.4
TOTAL	13,878	6,928	96.2	TOTAL	100.0%	96.2	22.6	118.8

[1] Area double-cropped = 2 ha. [2] Based on calculations of similar climate regions in Jordan (2820).
[3] Area double-cropped = 1 ha. [4] Estimated losses: pumped GW = 15%; pumped SW = 15%; gravity SW = 30%.

Table 2.5 continued

MOHAFAZAT	Irrigated Area(1) (ha)	Water Required(2) (cu m/ha)	Water Required (Mcm)	Source of Water	Source by Area(3) (% of ha)	Water Required (Mcm)	Estimated Water Loss(4) (Mcm)	Total Water Needed (Mcm)
Aleppo								
Fruit Trees	5,665	13,489	76.4	Pumped (GW)	84.4%	521.8	92.1	613.9
Summer Crops & Vegs	42,765	9,890	422.9	Pumped (SW)	15.6%	96.5	17.0	113.5
Winter Crops & Vegs	34,007	3,499	119.0	Gravity (SW)	0.0%	0.0	0.0	0.0
TOTAL	82,437	7,500	618.3	TOTAL	100.0%	618.3	109.1	727.4
Hassakah								
Fruit Trees	2,556	19,098	48.8	Pumped (GW)	43.4%	318.5	56.2	374.7
Summer Crops & Vegs	44,952	9,923	446.1	Pumped (SW)	53.1%	389.7	68.8	458.5
Winter Crops & Vegs	43,247	5,529	239.1	Gravity (SW)	3.5%	25.7	11.0	36.7
TOTAL	90,755	8,087	734.0	TOTAL	100.0%	733.9	136.0	869.9
Raqqa								
Fruit Trees	179	19,098	3.4	Pumped (GW)	48.7%	176.7	31.2	207.9
Summer Crops & Vegs	25,411	9,843	250.1	Pumped (SW)	43.6%	158.2	27.9	186.1
Winter Crops & Vegs	19,875	5,501	109.3	Gravity (SW)	7.7%	27.9	12.0	39.9
TOTAL	45,465	7,978	362.8	TOTAL	100.0%	362.8	71.1	433.9
Deir ez-Zor								
Fruit Trees	4,177	19,098	79.8	Pumped (GW)	1.8%	17.4	3.1	20.5
Summer Crops & Vegs	65,620	10,191	668.7	Pumped (SW)	98.2%	951.2	167.9	1119.1
Winter Crops & Vegs	38,374	5,736	220.1	Gravity (SW)	0.0%	0.0	0.0	0.0
TOTAL	108,171	8,954	968.6	TOTAL	100.0%	968.6	171.0	1139.6
C.A.D.E.B.								
Fruit Trees	467	19,098	8.9	Pumped (GW)	0.0%	0.0	0.0	0.0
Summer Crops & Vegs	19,159	9,777	187.3	Pumped (SW)	0.0%	0.0	0.0	0.0
Winter Crops & Vegs	9,581	5,499	52.7	Gravity (SW)	100.0%	248.9	106.7	355.6
TOTAL	29,207	8,522	248.9	TOTAL	100.0%	248.9	106.7	355.6

1 Area double-cropped = 2 ha.
2 Based on calculations of similar climate regions in Jordan[2820].
3 Area double-cropped = 1 ha.
4 Estimated losses: pumped GW = 15%; pumped SW = 15%; gravity SW = 30%.

Table 2.5

MOHAFAZAT	Irrigated Area(1) (ha)	Water Required(2) (cu m/ha)	Water Required (Mcm)	Source of Water	Source by Area(3) (% of ha)	Water Required (Mcm)	Estimated Water Loss(4) (Mcm)	Total Water Needed (Mcm)
TOTALS								
Fruit Trees	67,371	14,110	950.6	Pumped (GW)	---*	2,120	374	2,494
Summer Crops & Vegs	371,031	8,418	3,123.4	Pumped (SW)	---*	1,772	313	2,085
Winter Crops & Vegs	226,790	4,070	923.0	Gravity (SW)	---*	1,105	474	1,579
TOTAL	665,192	7,512	4,997.0	TOTAL		4,997	1,161	6,158

* Percent of ha irrigated countrywide by each water source is not the same as percent of water used or required countrywide from each water source. The precent of ha figures were used only to approximate the percentage of water sources in each Mohafazat. The countrywide totals for water required were calculated by adding the totals of each Mohafazat. Total percentages for each source per ha are as follows: 46.7% from pumped groundwater; 34.1% from pumped surface water; and 19.1% from gravity surface water. The precentage of water required (before losses) from each source are as follows: 42.4% from pumped groundwater; 35.5% from pumped surface water; and 22.1% from gravity surface water. The discrepancy occurs because groundwater use is more prevalent in Mohafazats with lower crop water requirements.

Source: Syria - Ministry of Agriculture and Agrarian Reform, *The Annual Agricultural Statistical Abstract*, 1982[3220].

1 Area double-cropped = 2 ha.
2 Based on calculations of similar climate regions in Jordan[2820].
3 Area double-cropped = 1 ha.
4 Estimated losses: pumped GW = 15%; pumped SW = 15%; gravity SW = 30%.

Table 2.6

TOTAL WATER PRODUCTION BY BASIN - 1981 (In Mcm/yr)

	Domestic			Agriculture			Industry*		A + D + I		
	Use	Loss	Withdrawal	Use	Loss	Withdrawal	% of employ.	Mcm	SW	GW	TOTAL
Euphrates	125.3	50.2	175.5	2314.2	484.8	2799.0	2%	6	2371.3	609.1	2980.4
Aleppo	--	--	--	618.3	109.1	727.4	28%	80	113.5	693.9	807.4
Orontes	57.2	22.9	80.1	919.0	271.7	1190.7	20%	58	693.4	635.4	1328.8
Damascus	103.5	41.5	145.0	742.5	192.9	935.4	26%	75	358.0	797.4	1155.4
Coast	32.7	13.1	45.8	295.9	67.6	363.5	18%	52	201.6	259.7	461.3
Yarmuk	13.2	5.3	18.5	106.7	34.1	140.8	--	--	123.1	36.2	159.3
Steppe	21.9	8.8	30.7	--	--	--	6%	17	--	47.7	47.7
TOTAL	353.8	141.8	495.6	4996.6	1160.2	6156.8	100%	288	3860.9	3079.4	6940.3

Loss @ 28.6% = 141.7
Total Produced = 495.5

Loss calculated by
AMER - Table 00

* Based on total use of 288 Mcm, allocated in proportion to number of industrial workers in basin. All industries have private wells. World Bank[3101].

Kolars's data from Turkish measurements yields an additional billion cubic meters available for Syria. Nearly half of this flow could disappear within the next two decades. By the turn of the century, the amount of water available for Syrian use from the Euphrates and its tributaries could be as little as 14.2 bcm.

Interestingly, this figure is almost identical to the amount of water allegedly guaranteed Syria by Turkey in a pair of protocols signed in Damascus in July, 1987, valid for two years with annual renewal thereafter. The Turkish newspaper *Cumhuriyet* (July 18, 1987) reported that Turkish Prime Minister Ozal had promised Syrian Prime Minister Kassem to provide Syria with 500 cu m/s from Ataturk Dam (15,768 Mcm/yr). This compares to our estimate of 15,800 Mcm/yr to be available for Syria in the year 2000 before evaporation from Lake Assad, including the flows of the Balikh and Khabur tributaries. The companion protocol was a security agreement whereby the two prime ministers pledged to prevent cross-border strikes and to cooperate through Interpol on counterinsurgency intelligence. Syrian President Assad is reported to have intervened personally to expedite negotiation of these agreements. The protocols apparently took no cognizance of a previous Turkish agreement with Iraq to supply that country with the same amount of water, presumably the same water since there would not be enough water in the system for Turkey to release 500 cu m/s to each downstream riparian and yet divert water to Southeastern Anatolia.

The increase in Syrian usage is detailed in Table 2.7. The calculations on agricultural usage were expounded in detail in Kolars's 1987 report[4637], along with the revision of Syrian expectations from its irrigation projects from a maximum of a million hectares of land down to less than half a million. The figures given in Table 2.7 differ from those of Kolars in that they reflect a later year with a higher reported irrigated hectarage. The water use base is lower, however, since it does not allow for the withdrawal of waters which will ultimately return to the system as return flows. The amounts of these return flows are not insignificant for the Euphrates (compare the predicted residues of Table 2.7 with Kolars's results in Fig. 1.2), but the returned waters will be of dubious quality and problemmatic utility.

The schedule for completion of agricultural projects is that projected by Kolars, although we doubt whether even these diminished expectations will be realized -- in area or time. The Euphrates projects have throughout been plagued by technical problems and inadequate planning. The redesign and reconstruction of canals which collapsed because of dissolving subsurface gypsiferous deposits cost Syria many years of delay, but it has been done. More serious is the need for agricultural planning and training to compensate for the impact of gypsum on plant growth. The choice of crops and the methods to be used in plowing, sowing, and irrigating these crops must all be revised in the light of what is now known about the soils[4328]. These problems have delayed the

Table 2.7

WATER BALANCE IN THE EUPHRATES BASIN: PROJECTIONS TO 2015 (In Mcms)

	1981/82	1990	1995	2000	2005	2010	2015
Water at Border*	26,200	26,200	26,200	26,200	26,200	26,200	26,200
New Turkish depletions	--	2,000	9,800	12,300	12,300	12,300	12,300
Added in Syria	1,900	1,900	1,900	1,900	1,900	1,900	1,900
Available in Syria	**28,100**	**26,100**	**18,300**	**15,800**	**15,800**	**15,800**	**15,800**
Evaporation from Lake Assad	1,600	1,600	1,600	1,600	1,600	1,600	1,600
Available for use	**26,500**	**24,500**	**16,700**	**14,200**	**14,200**	**14,200**	**14,200**
Domestic use	*125*	*214*	*277*	*353*	*414*	*489*	*577*
Rate of loss %	*(28.6)*	*(28.6)*	*(28.6)*	*(21)*	*(16)*	*(12)*	*(12)*
Domestic loss	*50*	*86*	*111*	*93*	*78*	*67*	*78*
Domestic w/d	175	300	388	446	492	556	655
Agriculture w/d	2,800	4,900	8,387	10,476	10,465	10,455	10,445
Industrial w/d	6	6	6	6	6	6	6
TOTAL WITHDRAWAL	**2,981**	**5,206**	**8,781**	**10,928**	**10,963**	**11,017**	**11,106**
Residue	**23,519**	**19,294**	**7,919**	**3,272**	**3,237**	**3,183**	**3,094**

* Water at border reflects the long-term flow measurements at Birecik across the border in Turkey. Note that new Turkish depletions could range as high as 16,000 Mcm in the next century if all Turkey's development schemes are realized[4637].

1. Agricultural figures assume that Turkish and Syrian agricultural development will be complete by the year 2000. This is a very optimistic assumption; developmental delay will delay the depletion rate. See Kolars[4637] for detailed arguments.

2. Domestic loss assumes that repairs in the Euphrates Basin will lag behind the rest of Syria but be complete by the year 2010. Note that the cities in the Euphrates Basin have current loss rates of up to 50% (Tishrin[4410]). Domestic withdrawal includes the transfer of water to the city of Aleppo.

3. Industrial figures assume that water use is held constant. Industrial development has stagnated in the 1980s and is not a high priority in the present Five Year Plan.

Sources: Tables 2.4-2.6, calculations by author, and Kolars[4637].

relocation of peasants displaced by Lake Assad far beyond the term originally forecast. Only in 1986, a dozen years after the flooding of the lake, did the amount of irrigated land reclaimed exceed that which was taken out of use to make room for the dam and lake[45 69].

While accepting, with the above reservations, Kolars's projections on the development of irrigated agriculture in the Euphrates basin, we have for the period after 1995 included a small projection for improved efficiency in distribution systems and on-farm use. This would come mainly in the gravity-flow systems of the GADEB (General Administration for the Development of the Euphrates Basin) projects. A loss ratio of 30% is cited for gravity-flow surface irrigation, while pumped irrigation gets by with a 15% loss. Upgrading the surface systems should save at least a major part of that loss. It is unlikely that such efficiencies will be sought while the main emphasis is on land reclamation projects and water is sufficiently plentiful to be delivered free. There is room for improvement, however, and we assume that such improvement will be undertaken when basic infrastructure is in place. Between 1990 and 2015, we calculate a reduction in distributional losses in gravity flow systems from the current 30% to about 20%.

Beyond these efficiencies, of course, would be the widespread conversion to drip irrigation, greenhouses, and plasticulture for appropriate crops -- expensive, but yielding spectacular water savings and impressive increments in productivity. These will no doubt be viewed with favor by Syrian planners and peasants when the diminishing water supply becomes apparent. This perception should come by the turn of the century in the Euphrates basin, but lag time for planning and implementation will probably put the large-scale realization of such schemes beyond the term of our projections.

Domestic use will grow with increased population and improved services. This is projected on the line labeled *Domestic use*. Loss in domestic systems is estimated in accordance with the assumption that improvements in distribution systems will begin by 2000 and be complete by 2010. The use of the nationwide loss rate of 28.6% for the period before 2000 is probably an underestimate. The loss rate for Hassaka City in 1986 was reported to be 50%[44 10], and Raqqa and Deir ez-Zor are unlikely to be much better. Total withdrawals for domestic use are projected on the line labeled *Domestic w/d*. This figure includes projections for increased interbasin transfers for domestic use to Aleppo in proportion to its population increment.

Industrial use is not yet significant in the Euphrates basin. There is some food-processing and a still non-functional paper mill to utilize the region's straw. Both of these could, in theory, become major water consumers. However, in view of the region's unfinished business in land reclamation and the exciting new low-sulphur oil fields that have been discovered, it is assumed that industrial development and industrial water use will remain near their present level.

Between Turkish and Syrian developments, the bottom line for the Euphrates basin in Syria is a projected decrease from a residue of 23.5 billion cubic meters of water in the early 80s to a residue of 3 billion cubic meters in 2015. The augmentation of these flows of fresh water with significant amounts of return flow offers little joy, since the re-used waters will be degraded by pollution, salination, and sedimentation[4637]. These matters should be of concern to Syria and deserve the most urgent consideration in Iraq.

2.2.2 The Orontes

The Orontes River valley was the site of the Ghab Project, the first of Syria's great development schemes and the most advanced in terms of socio-economic benefits and negative ecologic impacts. The flowering of the rift valley after the draining of the malarial swamps in 1969 has been remarkable, and the original agricultural projects have more recently been supplemented by a diversifying economy whereby the profits of agricultural effort have been ploughed back into a burgeoning service sector -- mechanics, machine rental, marketing, inputs for extra between-season crops, and other enterprises[4255]. But, already in the 1970s, the Orontes was in some sectors too polluted for human consumption.

In the upper reaches of the river, the main source of the river's pollution is industrial and domestic. The metropolitan centers of Homs and Hama are badly in need of wastewater treatment. The World Bank[3100] cited this problem and the incidence of related water-borne disease in 1980. By 1988, numerous projects were contracted to provide sewage treatment facilities for these cities (MEED, 1/10/87, 8/8/87, 8/15/87, 10/10/87, 1/23/88). Because of the number of projects underway, we forecast that sewage treatment and ultimately water reclamation will be more rapidly achieved in the cities of the Orontes basin than in many other parts of Syria.

An accelerated schedule for water treatment in the Orontes basin is an urgent necessity. By our calculations (see Table 2.8), the basin will face an absolute deficit by the year 2000, and the situation will worsen steadily thereafter. Syria already uses more than 90% of the water available to it in the Orontes. It already has to pipe in drinking water for Homs from nearby springs, because the surface water is not potable. In view of the basin's impending scarcity, the quality of the water supply in the Orontes must be restored as soon as possible. The region cannot afford the luxury of wasting its water resources through avoidable pollution.

Table 2.8

WATER BALANCE IN THE ORONTES BASIN: PROJECTIONS TO 2015 (In Mcms)

	1981/82	1990	1995	2000	2005	2010	2015
Water in system	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Used in Lebanon*	80	80	80	80	80	80	80
Available in Syria	**1,420**	**1,420**	**1,420**	**1,420**	**1,420**	**1,420**	**1,420**
Domestic use	*57*	*97*	*126*	*161*	*189*	*223*	*263*
Rate of loss %	*(28.6)*	*(24)*	*(20)*	*(16)*	*(12)*	*(12)*	*(12)*
Domestic loss	*23*	*31*	*32*	*30*	*26*	*30*	*36*
Domestic w/d	80	128	158	191	215	253	299
Agriculture w/d	1,191	1,196	1,185	1,175	1,165	1,157	1,143
Industrial w/d	58	58	58	58	58	58	58
TOTAL WITHDRAWAL	**1,329**	**1,382**	**1,401**	**1,424**	**1,438**	**1,468**	**1,500**
Residue	**91**	**38**	**19**	**-4**	**-18**	**-48**	**-80**

* Per agreement between Syria and Lebanon in 1972.

1. Agricultural figures assume that between 1990 and 2010 there will be a gradual increment of up to 26 Mcms for new projects planned in the neighbourhood of Ain Zerqa. Figures also assume that starting in 1995 the loss from gravity surface water will be reduced over a twenty year period from the present 30% to 20% in 2015.

2. Domestic loss assumes that repairs in the Orontes Basin will reduce the domestic loss ratio to 12% by 2005. Contracts are out for repair and sewage for Hama and Homs, so loss reduction should be well ahead of some other regions.

3. Industrial figures assume that water use is held constant. Industrial development has stagnated in the 1980s and is not a high priority in the present Five Year Plan.

Sources: Tables 2.4-2.6, calculations by author.

The flow of the Orontes in Syria derives in almost equal portions from surface water crossing the border from the Lebanese Bekaa Valley and groundwater from springs within Syria. Although the flow is highly variable depending on each year's rainfall, the average is 1,500 Mcm/year. Of this, 80 Mcm was guaranteed to upstream Lebanon by a 1972 agreement, which leaves 1,420 Mcm/year for Syria. (Note that the Afrine River, which is topographically part of the Orontes basin, will be considered in conjunction with the Aleppo region to which it belongs administratively.) Since the Afrine joins with the Orontes downstream from Syrian-controlled territory, it is, for all Syrian purposes, a self-contained unit.

Usage within the Orontes basin will be a complex of rising and falling variables. Domestic usage will rise steadily, more than doubling by the year 2000 and trebling by 2015. This projection assumes, in the light of perceived urgent need and contracts outstanding, that Homs and Hama will be well ahead of the rest of Syria in upgrading water distribution and treatment systems[4674)]. A reduction of the domestic system loss ratio to 12% is posited by the year 2005. We calculate that agricultural water usage will actually diminish slightly through the upgrading of systems, even though some small new irrigation projects are envisioned in the vicinity of the prolific Ain Zerqa. Additional expansion of irrigation will surely be constrained by the declining discharge of springs and artesian wells. This situation is already being reported[4675)]. It is assumed that industrial water use remains constant. Industrial development does not have a high priority in the current Syrian Five Year Plan and investment budget[eeee)].

The sum of our calculations is shown in Table 2.8. Overall water needs in the Orontes basin will increase by 7% by the year 2000 and by 14% by 2015. Demand will exceed supply by 2000. By 2015, the excess of demand over supply will equal the 80 Mcm/year upstream drawdown allocated to Lebanon.

2.2.3 Damascus Basin

The sources of water for the Damascus basin (see Table 2.9) consist of approximately 300 Mcm/year of surface water -- much of which is used or dissipated before it reaches the plain -- and an estimated safe yield of 1,200 Mcm/year from groundwater[4383)(4274)]. Recent reports of domestic rationing in Damascus City and its environs[4269)] do not clarify whether this shortage is because of overdraft on the available supply, temporary drought, or inadequate pumping and distribution systems; it could be all three.

Table 2.9

WATER BALANCE IN THE DAMASCUS BASIN: PROJECTIONS TO 2015 (In Mcms)

	1981/82	1990	1995	2000	2005	2010	2015
Water Available	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Domestic Use	*104*	*177*	*230*	*293*	*344*	*407*	*480*
Rate of loss %	*(28.6)*	*(24)*	*(21)*	*(18)*	*(15)*	*(12)*	*(12)*
Domestic loss	*41*	*59*	*61*	*64*	*61*	*55*	*65*
Domestic w/d	145	236	291	357	405	462	545
Agricultural w/d	935	935	925	916	907	899	891
Industrial w/d	75	75	75	75	75	75	75
TOTAL WITHDRAWAL	**1,155**	**1,246**	**1,291**	**1,348**	**1,387**	**1,436**	**1,511**
Residue	**345**	**254**	**209**	**152**	**113**	**64**	**-11**

1. Domestic figures assume that repairs in Damascus will reduce loss to 12% by 2010.

2. Agricultural figures assume that starting in 1995 the loss from gravity surface water irrigation will be reduced over a twenty year period from the present 30% to 20% in 2015.

3. Industrial figures assume that water use is held constant. Industrial development has stagnated in the 1980s and is not a high priority in the present Five Year Plan.

Sources: Tables 2.4-2.6, calculations by author.

Projects planned or underway for Damascus include pumps to enhance the flow of Ain Fijeh[4674], a computerized control system to improve management (MEED, 2/20/88), and wastewater treatment (MEED, 11/15/86). Some of these projects have been tendered more than once, presumably because of difficulties in arranging financing.

In computing the water balance for the Damascus basin, the most significant variable is domestic use: the increase in population and in per capita consumption. The population growth rate for Damascus City and Province has been approximated by the countrywide growth rate of 3.46%. In fact, the growth of Damascus City in the 1981 census was only 3.02%, while Damascus Province was significantly higher at 4.65%. Calculating the two segments at their individual growth rates yields an additional 2-3% in population at the end of a decade as compared to the figures derived by applying the countrywide average or an additional 5-6 Mcm/year in domestic usage. This seems relatively insignificant, so the simpler derivation has been used for the sake of countrywide consistency.

Moreover, the differential in growth rates may well be reduced. In the late 1970s and early 1980s, it was reported that the Syrian government was seeking to discourage migration to Damascus. Housing costs in the capital were several times higher than those in provincial centers, while salaries were standard throughout the country for similar jobs and seniority. Thus, a teacher in Raqqa could maintain a higher standard of living for his family than one in Damascus for the same amount and level of work. This imposed a strong disincentive for moving to Damascus in cases where it was not professionally necessary[4362]. It does not, of course, impede migration for individuals who can find higher level and higher paid jobs in the city than in the provinces, but many seem to be able to accomplish their goals by moving from a village to a provincial center rather than to the capital.

Because problems are already apparent and work is underway in Damascus, we assume that the upgrading of networks will proceed on a reasonable schedule. Some reduction in the domestic loss ratio is projected as early as 1990 with upgrading to be complete by 2010. This means by that year an annual saving of some 100 Mcm over what the loss would have been without the upgrading of the systems. Nonetheless, domestic water needs will more than treble by 2015 and will rise thereafter in direct proportion to population growth.

For agriculture, we project a small decline in water use because of the repair and upgrading of surface irrigation systems. It seems unlikely that agriculture, which in this region functions in competition with the spreading urban sprawl, will experience any significant expansion -- and, indeed, no such plans are reported. Thus, the upgrading of existing surface irrigation systems will represent a real saving in water used for agriculture of about 5%.

As in other regions of Syria, we do not assume any significant growth in water use for industry. Industrial growth is not a high priority in present Syrian planning and has been virtually stagnant during the 1980s. While some growth must surely take place over the next thirty years in this major metropolitan area to provide employment for additional population, it will be imperative that new enterprises should not be heavy water consumers and should be equipped with the most water efficient technologies.

The realities of the situation will impose this necessity. For by 2015, we foresee that the Damascus basin -- even with the conservation measures we assume -- will be in a state of absolute annual deficit. If systems are not upgraded or if population grows at an accelerated rate, the basin will pass into deficit several years earlier. The recurrent seasonal shortages should help to focus attention on these needs.

2.2.4 The Coastal Plain

The Coastal Plain in Syria is a semi-humid zone with copious rainfall. The Ansariya mountains, which bound the plain, snare the Mediterranean clouds to drop the major burden of their precipitation on the westward side of the range. This water returns to the sea by way of several major rivers, many small rivulets, and innumerable springs, some of major dimension. Perhaps because of the comparative richness of the resource, the gauging of water flows in the Coastal Plain is very incompletely reported. We have estimated the total water available -- surface water and groundwater -- to be on the order of 1,110 Mcm/year, but this may overlook the product of some of the smaller wadis and wells.

By our calculations (see Table 2.10), about 40% of this water was utilized for domestic, agricultural, and industrial uses in the early 1980s. By 2015, this use ratio will rise to 80%, still leaving a residue of some 200 Mcm/year.

The extension of domestic water services into smaller communities has been a constant theme with Syrian planners and is the target of numerous projects in the coastal region[cccc)]. Some observers have charged that Syria's governing elite, most of whose top leaders are Alawites from Latakia Province, are taking care of that region first[xxxx)]. But it could as well be said that the relative abundance of water resources in the region makes the provision of such services easier in the Coastal Plain than in other areas. By the same token, we anticipate that the upgrading of existing distribution networks will lag behind that of cities facing immediate scarcities, although some such repairs will have to be undertaken within the next two decades. Combining these considerations along with population growth, we predict that

Table 2.10

WATER BALANCE ON THE COASTAL PLAIN: PROJECTIONS TO 2015 (In Mcms)

	1981/82	1990	1995	2000	2005	2010	2015
Water Available	1,110	1,110	1,110	1,110	1,110	1,110	1,110
Domestic Use	*33*	*56*	*73*	*93*	*109*	*129*	*152*
Rate of Loss %	*(28.6)*	*(28.6)*	*(24)*	*(20)*	*(16)*	*(12)*	*(12)*
Domestic loss	*13*	*23*	*23*	*23*	*21*	*18*	*21*
Total domestic w/d	46	79	96	116	130	147	173
Agriculture w/d	364	540	538	661	659	657	655
Industrial w/d	52	52	52	52	52	52	52
TOTAL WITHDRAWAL	**462**	**671**	**686**	**829**	**841**	**856**	**880**
Residue	**648**	**439**	**424**	**281**	**269**	**254**	**230**

1. Domestic figures assume that repairs to urban systems will reduce loss from 28.6% to 12% by 2010.

2. Agricultural figures include an additional 30,000 ha to be irrigated by 1990, and 21,000 ha to be irrigated on Akkar Plain therafter (by 2000?). Figures assume that new irrigation will be designed for maximum efficiency with loss of 15%, and that loss will be reduced on existing gravity flow irrigation from 30% to 20% over the period 1995-2015.

3. Industrial figures assume that water use is held constant. Industrial development has stagnated in the 1980s and is not a high priority in the present Five Year Plan.

Sources: Tables 2.4-2.6, calculations by author.

domestic water use will nearly quadruple by 2015. After the Euphrates, the Coastal Plain has the most potential for agricultural development. There are at least sixteen dams completed, under construction, or planned for the near future in the region, of which ten are intended at least in part to provide water for irrigation[4674)(4677)]. If fully implemented, these projects could bring more than 50,000 new hectares of land under irrigation, almost doubling the use of water for agriculture by 2015.

The expansion of port facilities in the coastal cities is one of the exceptions to the observation of stagnation in industrial development. This activity should not, however, represent a major increase in industrial water use, which is posited as remaining constant throughout the period.

Although water quantity in the Coastal Plain seems moderately adequate for the foreseeable future, there is another problem that requires close scrutiny. There have been some scattered reports of wells in the area becoming salty[ssss)]. It is possible, of course, that an individual well or spring may be contaminated through a purely local phenomenon such as infiltration from nearby agricultural return flows or other pollutants. It is also possible, however, that the Syrian coastal aquifer is subject to the same sort of sea-water seepage as the coastal aquifers farther south along the Mediterranean littoral. Syria needs to watch this situation carefully to prevent permanent degradation.

2.2.5 The Yarmuk

The Yarmuk basin has the least water and the hottest politics of all the Syrian hydrologic regions. Unlike the other basins, which provide thousands of million cubic meters of water per year, the Yarmuk in Syria yields an average of just over 300. Yet that 300 Mcms is desperately needed by Jordan, whose total water budget is a small fraction of Syria's residue. Israel, whose big guns overlook Syrian villages from the occupied Golan Heights, has also staked a claim to Yarmuk water because of the serious water scarcities which it faces.

The present and predicted balance on the Yarmuk basin in Syria is shown in Table 2.11. The sources of water in the basin derive from surface flows and from the springs fed by the limestone water-bearing strata of the Anti-Lebanon and Lebanon ranges. The total spring flow of the region is estimated at 145 Mcm/year, but some 120 Mcm of this is contributed to the surface flow of the river. In all, the total flow of the Yarmuk basin can be estimated at an average 433 Mcm/year (down from estimates earlier in the twentieth century of nearly 500 Mcm), of which a quarter of the

Table 2.11

WATER BALANCE IN THE YARMUK BASIN: PROJECTIONS TO 2015 (in Mcm)

	1981/82	1990	1995	2000	2005	2010	2015
Water in system*	433	433	433	433	433	433	433
Enters downstream from Syria	116	116	116	116	116	116	116
Available in Syria	**317**	**317**	**317**	**317**	**317**	**317**	**317**
Domestic use	*13*	*23*	*29*	*37*	*44*	*52*	*61*
Rate of loss %	*(28.6)*	*(28.6)*	*(28.6)*	*(24)*	*(20)*	*(16)*	*(12)*
Domestic loss	*5*	*9*	*12*	*12*	*11*	*10*	*8*
Domestic w/d	18	32	41	49	55	62	69
Agricultural w/d	141	153	153	149	145	144	144
Industrial w/d	--	--	--	--	--	--	--
TOTAL WITHDRAWAL	**159**	**185**	**194**	**198**	**200**	**206**	**213**
Residue	**158**	**132**	**123**	**119**	**117**	**111**	**104**

* Water available in system determined by extrapolation from long-term flow data at Maqarin, Mukheiba, and Adasiya(4220), including water that originates in both Syria and Jordan (no significant Yarmuk flow originates in Israel). Water available to Syria includes associated groundwater but excludes water originating in Jordan.

1. Domestic water includes a very small inter-basin transfer to the city of Suweida. It assumes that upgrading of distribution systems will lag behind the rest of Syria, but that from the year 2000 to 2015 such repairs will be made and the rate of loss will be lowered from 28.6% to 12%.

2. Agricultural water assumes an increase of 3,000 ha of irrigation by 1990. Also assumes that the rate of loss in existing irrigation systems using gravity flow surface water will be reduced from 30% to 20% during the period 1995-2010.

3. Due to scarcity, it is assumed that no heavily water consuming industries will be inaugurated in this region.

Source: Tables 2.4-2.6, calculations by author.

flow (116 Mcm) originates outside Syrian territory in left-bank tributaries from Jordan. The water available in Syria is thus 317 Mcm/year.

In 1981-82, we estimate that Syria utilized 159 Mcm of ground and surface water in the Yarmuk basin. This included a very small (approximately 2 Mcm) transfer of drinking water to Suweida city, but the major consumer was agriculture. We predict a four-fold increase in domestic consumption within the basin by the year 2015, as population grows and domestic systems are extended, with some savings in the latter part of the period from repair of leaky municipal networks. At the same time, we anticipate a small increase in agriculture usage as some 3,000 additional hectares are opened for irrigation, but suggest ample room for improvement in the existing gravity-flow surface irrigation systems, which constitute more than half of the irrigated area in Deraa province. The net result will be a 9% increase in agricultural water use over the next decade, an increase which will shrink almost to 1981 levels in the subsequent fifteen years through conservation. Industrial water use in the area is now essentially nil and will probably remain so.

The population density of southwestern Syria is low. All of Deraa province has a population only slightly greater than the city of Homs, and the potential for agricultural development beyond what is already planned is not great. A major factor for Syria in relation to this area, however, is the supply of power for its overburdened electrical grid. These realities are reflected in the 1987 agreement with Jordan to build (after thirty-five years of talking and planning) the Unity Dam on the Yarmuk. Syria will get 75% of the hydroelectric output, but little additional water; Jordan will get the water it desperately needs[eiux)]. The unknown factor in the plan is Israel, whose few miles foothold on one bank above the mouth of the Yarmuk gives it riparian status, although its territory contributes no water to the river's flow. By all indications, discussions are underway[(C.I.)] to obtain Israeli acquiescence to this project, but the price to be paid is still subject for speculation.

2.2.6 Aleppo and Its Environs

Aleppo is already in trouble. Its surface water -- principally the Qweik -- is either drawn off for use in Syria or neighboring Turkey, north of the city, or polluted beyond hope or prayer. Its groundwater is estimated at 334 Mcm/year safe yield[4383)], but is probably being drained for irrigation through unlicensed wells at a much heavier rate and with unforeseeable consequences.

The aggregated statistics for Aleppo province include the verdant Afrine valley, so we have combined the Afrine with Aleppo proper, both for usage and for available supply. The putative flow of the Qweik and groundwater in the Aleppo basin total an average annual supply of 413 Mcm/year[4383]. The Afrine river averages 252 Mcm/year[4106], and some eighteen springs nearby yield an average of 86 Mcm/year[3046], totaling 338 Mcm/year for the Afrine valley. The total supply for Aleppo province is thus on the order of 750 Mcm/year.

In Table 2.12, there is no withdrawal indicated for domestic use. Major municipal needs have for the past decade been supplied by pumping from Lake Assad. Projections on the growth of domestic use in Aleppo province have thus been included in the computations of the water balance for the Euphrates basin (see Tables 2.3 and 2.7) and are not registered on Table 2.12. It is likely that some water, especially for rural domestic use, is still drawn from the waters of the local basin. The assumption that all domestic water is supplied from the interbasin transfer will then represent an underestimate on the amount of water drawn from Aleppo's water budget. In other words, the local situation might be even worse than it looks in Table 2.12.

Agricultural use predicts no expansion of irrigated agriculture for Aleppo itself, but does include the 20-30,000 hectares scheduled for irrigation after the completion of the April-17 Dam on the Afrine[3046][4674]. Since this project will involve pressure-pipe irrigation, the water use has been computed at the more efficient 15% distribution and on-farm loss ratio. Moreover, there is no estimate for savings by routine upgrading of agricultural systems, as all agriculture in Aleppo province is serviced by pumped water. The 1981-82 agricultural water usage for Aleppo, including the Afrine, was calculated at 727 Mcm/year. Over the subsequent thirty years, this withdrawal will grow to 960 Mcm/year according to projections.

Industrial water use is estimated at a constant 80 Mcm/year throughout the period of our projections.

The above assessment shows a system already being rescued by interbasin transfers in 1980 and already significantly overdrawn on its identified supply and with no prospect but to get worse. According to these calculations, by 2015 the province will be consuming almost 40% more water each year than it actually has. This is, of course, a contradiction, since water is not created by a genii with a lamp. People can*not* use something which does not exist. There are several possibilities to account for the current calculation of deficit.

First, the province -- and especially those parts of it that are closest to Lake Assad -- may be getting more water from the lake than is reported in the officially piped interbasin transfer.

Table 2.12

WATER BALANCE IN ALEPPO BASIN(S): PROJECTIONS TO 2015 (in Mcm)

	1981/82	1990	1995	2000	2005	2010	2015
Water available*	750	750	750	750	750	750	750
Domestic w/d	--	--	--	--	--	--	--
Agricultural w/d	727	777	827	877	925	960	960
Industrial w/d	80	80	80	80	80	80	80
TOTAL WITHDRAWAL	807	857	907	957	1,005	1,040	1,040
Residue	-57	-107	-157	-207	-255	-290	-290

* Water available reflects both the waters of the Qweik basin and the Afrine River basin. Hydrologically, the Afrine is a tributary of the Orontes, but present political geography makes it an adjunct of its neighbor Aleppo insofar as Syria is concerned. The aggregation of Syrian statistics includes the Afrine basin with data on the Aleppo Muhafaza of which it is a part.

1. Domestic withdrawals are nil because Aleppo is supplied by interbasin transfer from the Euphrates at Lake Assad.

2. Agricultural withdrawals include, in 1990 and after, a phasing in of the planned new 20,000 ha of sprinkler irrigation in the Afrine[3046].

3. It is assumed that industrial withdrawals will remain constant. Industrial growth is not the highest priority for the current Five Year Plan. Further, in view of the scarcity of water in Aleppo, it is assumed that any industrial expansion will be chosen with a view to water efficiency.

Source: Tables 2.4-2.6, calculations by author.

Second, more water may be pumped from underground aquifers than the safe yield. There are reports of myriad unlicensed wells and of a bureaucracy unable to keep pace with needs, but generating red-tape so daunting as to discourage compliance with reporting requirements and regulations. There are also reports of groundwater degradation [jprs). [4207?]

Third, the other half of the second conjecture, is that the assessment of Syrian groundwater is incomplete. There may be more water available for use in the basin than the estimated safe annual yield. The danger of acting on this assumption is that overdrafts may degrade the remaining resource.

What is certain is that Aleppo does have a serious problem. Whatever expedients may be employed to meet minimum needs at present, the prospect for the future requires serious consideration and major effort. The impact of water scarcity has surely already been felt. Already in the mid-70s, Aleppo's per capita consumption was less than that of several smaller Syrian cities. The World Bank estimated that in 1974, the last date for which full statistics were available to it in 1980, the domestic consumption for Aleppo was 71 cu m/yr (196 lcd). It was exceeded by Damascus, the capital and largest city, with 309 lcd; Raqqa with 407 lcd; Latakia with 335 lcd; and Homs with 233 lcd[3101). This already represented a constraint on the standard of living for Syria's second city.

2.2.7 The Steppe Region

The Steppe region in Syria is a vast, sparsely populated area encompassing several drainage basins. There is virtually no surface water. The unpredictably occasional flash flood evaporates or percolates into groundwater or may remain ponded for part of a season to serve ephemeral local uses. All reliable water for the region comes from underground aquifers and finds its way to the surface through natural springs or is pumped up in wells and boreholes.

The proven annual discharge of the Steppe region is 330 Mcm. Of this, 16 Mcm wells up in springs in the Tadmar-Palmyra oasis; most of the remainder is in the Hauran (Jebel el-Arab/Jebel Druze) section of southern Syria. Both of these areas have been inhabited since ancient times and bear evidence of the hydrologic efforts of Greco-Roman and Arab engineers. Straight lines of boreholes stretch east across the desert, testifying to the *qanat* structures burrowed beneath the surface.

It is not known just how much water lies beneath the surface of the Syrian Steppe and how much *could* be extracted safely for human use. The safe yield of the regional basalt and carbonate aquifers is unknown, for Syria as well as for Jordan, Iraq, and

Saudi Arabia, with whom it shares those aquifers. Jordan, down gradient from Syria, uses some 30 Mcm/year from the basaltic Rijam formation[4072]. This is already too much usage for that sector; the Azraq oasis is drying up, and increased Syrian use would no doubt hasten the depletion. On the other hand, scattered soundings have found major water-bearing fossil formations at depths of 1500 meters or more. In short, the present constraint in the area is one of lack of knowledge, rather than proven lack of water.

Actual water use in the Syrian Steppe is still limited (see Table 2.13). There is little or no recorded irrigation. The major water use for the region is human consumption with some industrial use also reported. It is estimated that water use for the Steppe (Palmyra, Suweida, and other scattered settlements) will treble by 2015.

The interbasin transfer of water from Ain Muzeirib to Suweida is assumed to be continuing and has been counted with the Yarmuk basin. This 2 Mcm transfer, though small, was significant for hygiene in the region. In 1974, domestic consumption in Suweida was 39 lcd, based on production totals with only 23 lcd actually reaching the consumer[3101]. This compared unfavorably to the international minimum standard of 40 liters per capita per day to maintain health[4673]. By the end of the decade, as a result of the interbasin transfer, Suweida was producing 139 lcd for its residents or, allowing for systemic losses, an actual consumption of 80-100 lcd. This represents a dramatic improvement.

In 1981-82, the use of water in the Syrian Steppe was 15% of the estimated safe yield of its groundwater. By 2015, if no new resources are developed, use will be approaching 50% of the safe yield.

2.2.8 Countrywide Water Balance

Syria over the next thirty years will present a picture of countrywide water surplus, but regional water scarcity. The total balance will dwindle from the massive surplus of 25,000 Mcm in the early 1980s to a much more moderate surplus of 3,000 Mcm by 2015. Yet Aleppo basin is already experiencing a deficit and would, projecting the trends, be using more than half again as much water as it possesses -- if that were possible. The trends for the Orontes basin show a deficit by the year 2000. Damascus will pass into deficit sometime after 2010.

The major change over the period will be the marked decrease in the water available in the Euphrates. The residue in the river will be one eighth what it was in the 1970s. The flow will be far more regular than in the natural regime, but the average monthly

Table 2.13

WATER BALANCE OF STEPPE REGIONS: PROJECTED TO 2015 (in Mcm)

	1981/82	1990	1995	2000	2005	2010	2015
Water available*	330	330	330	330	330	330	330
Domestic use	*22*	*38*	*49*	*62*	*73*	*86*	*102*
Rate of loss %	*(28.6)*	*(28.6)*	*(28.6)*	*(26)*	*(24)*	*(22)*	*(20)*
Domestic loss	*9*	*15*	*20*	*22*	*23*	*24*	*25*
Domestic w/d	31	53	69	84	96	110	127
Agricultural w/d	--	--	--	--	--	--	--
Industrial w/d	17	17	17	17	17	17	17
TOTAL WITHDRAWAL	**48**	**70**	**86**	**101**	**113**	**127**	**144**
Residue	**282**	**260**	**244**	**229**	**217**	**203**	**186**

* Water available includes 16 Mcm/a[4274] in groundwater identified in the Palmyra region and 314 Mcm in the Hauran[4383]. All authors warn of the extremely sketchy nature of these assessments.

1. Domestic use projections assume that these remote small towns and settlements will lag far behind the rest of Syria in repairing their systems and providing better sewerage, but that some progress will be made.

2. There is no irrigated agriculture indicated for these areas. Nearly all the irrigated agriculture in the Douma district of the Damascus Muhafaza lies within the Damascus hydrological basin.

3. Industrial withdrawals project no increment. Industrial growth has been stagnant in the 1980s and is not given high priority in the current Five Year Plan.

Source: Tables 2.4-2.6, calculations by author.

flow will be but a fraction of the river's normal flow for August, its driest month. One wonders if the ecological impact of such a major reduction in a historic river has been assessed. Turkish and Syrian uses will leave little to maintain the ecosystem of the lower river valley, let alone for historic or planned uses by the lowest riparian, Iraq. Syrian concern over Turkey's plans -- and Iraqi concern for Syria's plans -- are both well founded.

These trends point to issues that must be addressed in the near term. Plans must be made now to meet the regional scarcities that will be forthcoming, and the complacency natural to a country that has enjoyed an abundance of water must be overcome. Where possible, water supplies must be augmented by identifying new resources or capturing and upgrading wasted resources. Care must be taken to avoid the degradation of existing supplies.

Fortunately, there are signs that the Syrians are aware of these problems. The final sections of this chapter review some of the issues that are now receiving attention or that, we believe, will require attention by early in the twenty-first century.

2.3 Current Issues

To judge by development plans and projects under construction, Syria is well aware that it faces water problems. Even though its projected annual surplus in the year 2015 is greater than the total water budget of either Jordan or Israel, Syria is giving top priority to water projects in its development (investment) budgets. Concern is evidenced both for water in itself and for water as a source of hydroelectric power, another major priority.

The Euphrates region remains a concentration. Two new dams are under development. The Baath Dam[4677)], 26 kilometers downstream from the great Euphrates Dam, will control the outflows from the Euphrates Dam and will work in tandem with it to generate electricity on a rotating schedule: one dam generates, while the other refills its reservoir, using each drop of water twice. The Baath Dam is just about complete. A third dam, Tishreen, has been planned upstream at Yusuf Pasha, at the tip of Lake Assad, also for power production[4674)]. These three dams will completely regulate the flow of the river in Syria and considerably augment the supply of electricity -- provided there is enough water in the river to turn the turbines. Careful coordination with Turkey is obviously needed to make sure that the design of these facilities is consonant with the status of the river in coming decades.

Syria has been building and planning dams all over the country[4677)]. Some are large, e.g., the dams on the Afrine and the Kebir Shemali, and many are small. Some will produce electric

Table 2.14

WATER BALANCE FOR SYRIA PROJECTED TO THE YEAR 2015 BY BASIN
(in Mcm)

	1981/82	1990	1995	2000	2005	2010	2015
Water Available							
Euphrates	26,500	24,500	16,700	14,200	14,200	14,200	14,200
Orontes	1,420	1,420	1,420	1,420	1,420	1,420	1,420
Damascus	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Coastal Plain	1,110	1,110	1,110	1,110	1,110	1,110	1,110
Yarmuk	317	317	317	317	317	317	317
Aleppo	750	750	750	750	750	750	750
Steppe	330	330	330	330	330	330	330
TOTAL Available	**31,927**	**29,927**	**22,127**	**19,627**	**19,627**	**19,627**	**19,627**
Water Withdrawn							
Euphrates	2,981	5,206	8,871	10,928	10,963	11,017	11,106
Orontes	1,329	1,382	1,401	1,424	1,438	1,468	1,500
Damascus	1,155	1,246	1,291	1,348	1,387	1,436	1,511
Coastal Plain	462	671	686	829	841	856	880
Yarmuk	159	185	194	198	200	206	213
Aleppo	807	857	907	957	1,005	1,040	1,040
Steppe	48	70	86	101	113	127	144
TOTAL Withdrawn	**6,941**	**9,617**	**13,346**	**15,785**	**15,947**	**16,150**	**16,394**
Residue							
Euphrates	23,519	19,294	7,919	3,272	3,237	3,183	3,094
Orontes	91	38	19	-4	-18	-48	-80
Damascus	345	254	209	152	113	64	-11
Coastal Plain	648	439	424	281	269	254	230
Yarmuk	158	132	123	119	117	111	104
Aleppo	-57	-107	-157	-207	-255	-290	-290
Steppe	282	260	244	229	217	203	186
TOTAL Residue	**24,986**	**20,310**	**8,781**	**3,842**	**3,680**	**3,477**	**3,233**

Source: Tables 2.7-2.13, calculations by author.

power, others merely create a small impoundment from which local residents can draw for seasonal crop or animal needs. The functions of these dams reflect the priorities that Syria has set for its development: rural electrification and improved agriculture. Indeed, thermal power plants run a close second to water development in terms of infrastructure work underway in Syria[eiux)].

One major area of effort, with several projects contracted, is the development of wastewater treatment for Syria's major cities. Into the 1970s, Syria had virtually no treatment facilities; chemical and biological pollution, with their attendant burden of water-borne disease, were seen as major problems[3094)]. Work for sewerage and treatment installations is now under contract for Damascus, Homs, Hama, and Aleppo (MEED, 1986-88 *passim*). A treatment unit for the Orontes at Mehardeh has also been tendered. Water quality treatment is obviously a needed development, not only because it is related to human disease, but also because it is a conservation measure and one directed at precisely those regions -- the Aleppo, Orontes, and Damascus basins -- that face problems of impending scarcity. The computerized water management system, which was tendered in April, 1988, will conserve additional water for Damascus (MEED, 4/2/88).

Finally, in accordance with the agreement of September, 1987, Syria is participating with Jordan in the joint project to build the Wahdeh (Unity) Dam on the Yarmuk. The Mount Kassioun Company of Syria is one of a consortium of three firms (the others are from Jordan and Italy) which have contracted for the first phase of construction, the tunnel to divert the river's water around the dam site while work is going on.

2.4 Emergent Issues

The change in the regime of the Euphrates River is a matter of legitimate concern to Syria. Turkey's massive Southeast Anatolia Project (GAP) will have several sure outcomes vis-a-vis Syria:

(1) There will be much less water in the main stream of the river (down by a factor of eight). This, together with recent droughts, has already affected the functioning of the turbines at Syria's Euphrates Dam, and the impact will worsen as the GAP progresses. Syria must keep this in mind in positioning the facilities at its new dams and in installing pumps for irrigation in the Euphrates Valley, as well as in its forecasts for total water available for use.

(2) There will be at least some increment in the flows of the Euphrates tributaries, the Balikh and Khabur. The amounts of these increments are difficult to predict, but Syria's resettlement of dislocated peasants into the far northeast of the country puts them in position to take advantage of such increments when they occur.

(3) The return flows from Turkish irrigation, when it is developed, will cause water quality problems downstream. This will involve chemical pollution from fertilizers and pesticides, increased mineralization leached from salts in the soil, and increased sedimentation. Which of these will be most serious depends on the as yet undetermined path followed by the return flows, but geography dictates that the Balikh and Khabur tributaries will be the most vulnerable.

Syria has had to rethink its plans for irrigation in the Euphrates region. In part, this is because some of the soils have proven to be inappropriate for irrigated agriculture. As a result some of the areas originally slated for irrigation are being returned to rangeland to prevent a "dust bowl" phenomenon. Current Syrian plans call for development of less than half the hectarage originally intended and are placing more emphasis on rainfed crops. In view of Turkey's schemes, the lowered Syrian expectations may serve to make Syria less vulnerable to upstream changes which alter the regime of the river. However, these more realistic goals make it more difficult for Syria to meet the needs of the people of the region, especially those who were displaced more than a decade ago for dam construction.

Obviously, cooperative planning among the riparians of the Euphrates basin is an urgent priority. Only by working together can the parties have a full base of information to use the resources of the river to best advantage.

Groundwater is Syria's last undeveloped source of water. Some work has been done on assessing groundwater resources, but much more is needed. The Syrian government has undertaken studies, especially in regions where the water table is dropping and springs are drying up. Basic geological studies have been done by scholars at ACSAD (the Arab Center for the Study of Arid Zones and Dry Lands), an Arab League agency headquartered in Damascus. In addition, a number of discoveries, especially of very deep fossil water deposits, have been made incidental to oil drilling.

Syria has two needs with respect to groundwater. *First*, it needs a comprehensive assessment of all the country's aquifers, with conservative estimates of the safe yields of those aquifers and of the steps necessary to prevent contamination from neighboring salt water deposits. *Second*, it needs a better system of monitoring and enforcement on private wells so as to prevent unregulated overdrafts on local or regional aquifers. This need is not only apparent in the oasis cities, but also in the Orontes Valley and the Coastal Plain.

Looking toward the more distant future, when Syria may join its neighbors in a state of water scarcity, there is a third need. There needs to be a region-wide study of the deep groundwater resources that underlie the Arabian Peninsula and, along with this, multi-lateral agreements allocating usage within the safe yield limits of those resources.

Water quality control is both a health need and a conservation opportunity. Syria is working to install the treatment facilities that are essential to the health of its people and to prevent the degradation of existing water supplies. The health need has been recognized for a decade or more and is one of the stated priorities of Syrian development planners. Despite some regrettable delays (presumably for financial reasons), work is proceeding in this area.

What does not yet seem to be on the Syrian agenda is the large-scale reclamation of sewerage waters for re-use. This is a topic that deserves attention from Syrian planners. Five of Syria's metropolitan areas have a critical mass of population and generate enough wastewater to make water reclamation a viable option. Four of these five cities are in areas that face local shortages within the period of our projections. Two of those four sit astride major groundwater basins that would be prime candidates for artificial recharge; the other two might also offer opportunities for recharge, as well as (and this last has been suggested) opportunity for direct re-use of reclaimed water in industry or agriculture.

Conservation in the more general sense is an urgent need. Syria's urban water distribution systems lose far more through leaking joints and other disrepair than is acceptable even in lands far richer in water resources. In an arid land like Syria, a 30-50% loss ratio is simply not admissable. Irrigation systems also incur higher than acceptable rates of systemic loss. (Let us state for the record, however, that Syria shares these unacceptable loss rates with its neighbors.)

The projections in this study assume a slow, but steady effort on the part of Syria to improve these systems and reduce loss ratios. Consideration was given in casting these projections to the urgency of the need in a particular area, as well as to the magnitude of the task -- which obviously cannot be accomplished overnight. But if these efforts are not undertaken expeditiously, the shortages we foresee will be manifested much sooner than we have predicted.

The corollary of repair, of course, is better monitoring and regulation. The computerized water management network for Damascus is but one of several such upgraded systems that Syria will need to install in the coming decades, if it is to keep proper track of its water and collect the fees needed to keep the systems functioning.

Ultimately, Syria may need to investigate <u>alternative technologies</u> to supplement its water supply. Some experimentation has already been done with mesh walls in wadis to trap flashflood waters for recharge to groundwater[4327)]. Small-scale desalination projects might be locally useful in dealing with brackish groundwater. Re new agricultural technologies, better plant strains are being developed by the Syrian Department of Agriculture in cooperation with ICARDA, an international agricultural research agency in Aleppo.

Such creative thinking, as well as careful planning with an eye to water efficiency, will be needed if Syria is to avoid long-term water problems.