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FUTURE DROUGHTS, WATER SHORTAGES IN PARTS OF WESTERN EUROPE

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Public water supply in Europe relies very heavily on ground water. Recharge of ground water takes place mainly in the winter months. An analysis of winter rainfall data shows that current recharge rates are abnormally high, and that during several periods in the past the rate has been less than half the current value. A return to such low values could have catastrophic consequences, but even more modest drops would be serious. Useful predictions must be based on climatic models and the full use af climatic, paleohydrological and historical data.

GROUND WATER RECHARGE

To demonstrate the varation in ground water recharge, the recharge in Denmark will be discussed.

Figure 1 shows the rainfall during the five winter months November, December, January, February, and March, both in the Århus-region in Denmark, and in England/Wales. The Århus graph contains long and short waves. After 1900 the waves are relatively regular, but before 1900 there is a long period with very low winter rainfall. This period is very critical for the ground water recharge.

Two similar critical periods can be recognized on the England/Wales-curve.

The Århus-region has an average annual rainfall of 683 mm. On the winter curve, Fig. 1, the following periods can be seen:

1862 - 1985 overall average	254 mm
1864 - 1894 average of 30 years	214 mm
1950 - 1985 average of 35 years	272 mm
Maximum difference between periods	58 mm

The England/Wales has an average annual rainfall of 912 mm. On the winter curve the following periods can be seen:

1766 - 1985 overall average	383 mm
1775 - 1800 average of 25 years	330 mm
1950 - 1985 average of 35 years	417 mm
1900 - 1985 average of 85 years	418 mm
Maximum difference between periods	88 mm

The importance of this differences become obvious when it is compared with the average base flow in streams. In the Århus-region baseflow is 91 mm.

In great parts of Europe the surplus river water resources is 100-200 mm per year (USSR COMMITTEE of IHD, 1976). Compared with this 60-90 mm is a large amount of water.

Figure 1 shows that the winter rainfall in the Århus-region has been increasing through the last 30-40 years.

The increased winter rainfall and ground water recharge in the Århus region can be demonstrated by an example.

In 1971 new water works were built in an area close to the town of Silkeborg in Jutland. There is no other major ground water abstraction in the area.

The water works abstract 2.4 mio m^3/year *i.e.* 7,000 m^3/day. The drawdown in the monitoring wells was predicted to be 2 metres. Because of the increased ground water recharge the ground water table has in fact risen one metre. Not surprisingly, the local Council thinks that this is really the best water works they ever built.

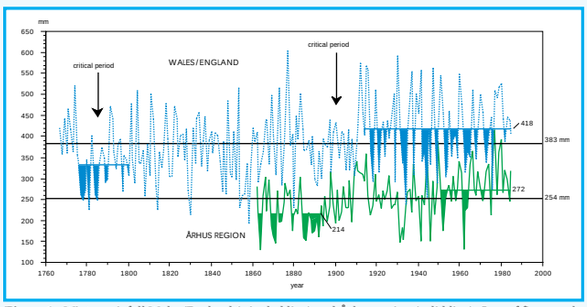

Figure 1. *Winter rainfall Wales/England (stippled line) and Århus region (solid line). Sum of five months, November to March, in millimetres.*

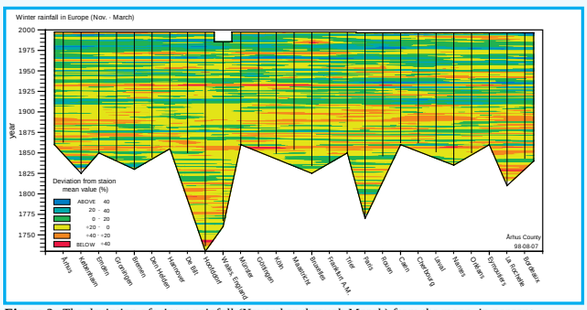

Figure 2. *The deviation of winter rainfall (November through March) from the mean, in percent.*

IMPLICATIONS FOR WATER SUPPLY

The water industry in Denmark bases its development plans on the increase in ground water recharge through the last 30-40 years, which is the highest ground water recharge recorded though the last 125 years.

In many regions in Denmark present ground water abstraction is already very close to the limit of the resources. In some areas the abstraction rate is now already greater than the recharge.

For example the water demand in the Århus-region has lowered the ground water table by more than 10-30 metres through the last 40 years.

If the ground water recharge should ever be reduced to half of the present rate (such as occurred in 1880-1910) the water industry in many regions of Denmark would be faced with catastrophy: water shortage, salt water intrusions. Some streams and wetlands might dry up completely.

The same problems are likely to occur in the belt of cities shown in figure 3. Figure 2 illustrate the diviation of winter rainfall from the mean, in percent.

Through the last 25 years the winter rainfall has been increasing in the belt stretching from southwest France through northwest Germany to southwest Scandinavia. In the same belt winter droughts can be seen in 1930 and 1974. In the period from 1880 to 1910 there has been a long period with low winter precipitation.

France experienced a period of low rainfall from 1989 to 1992 with ground water levels very low through out the country and of record lows in some areas. This drought experience led to adoption of a new national water control legislation in 1992.

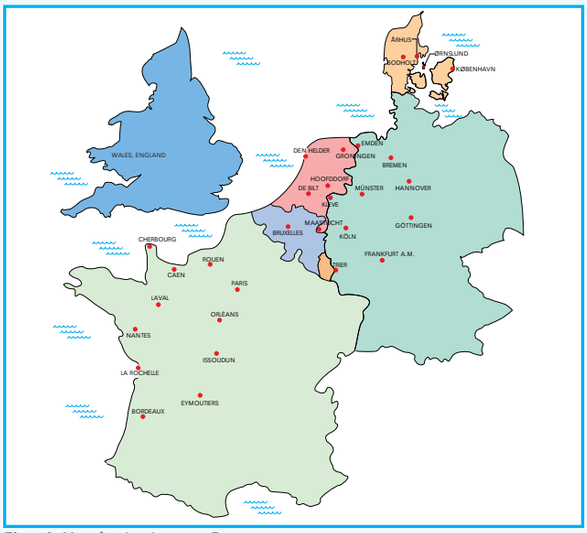

Figure 3. *Map of stations in western Europe.*

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