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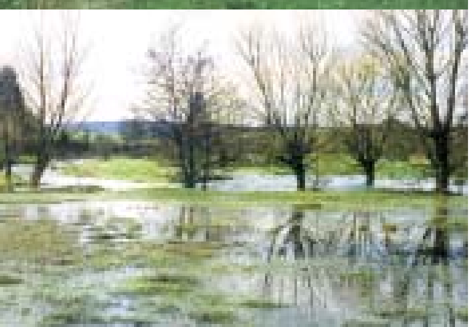

Natural Water Storage in the Low Mountain Ranges in the Catchments of the Rhine and the Meuse

Storing Water Near the Source

Less Flooding When Water is High

More Water in Dry Times

Abridged version

January 2004

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Storing Water near the Source

NATUURLIJKE WATERBERGING IN DE MIDDELGEBERGTEN IN HET STROOMGEBIED VAN MAAS EN RIJN

Minder wateroverlast bij hoog water
Meer water in droge tijden

stroming

Stroming BV
beknopte versie
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IN OPDRACHT VAN:
Stichting Ark met steun van de Nationale Postcode Loterij
Wereld Natuur Fonds

STICHTING ARK
NATIONALE POSTCODE LOTERIJ
WWF

Too much water – too little water

Many areas in Europe wrestle with high-water problems. TV programmes deluged European households with pictures of rivers in full spate: the Meuse and the Rhine in 1993 and 1995, the Elbe in 1998 and 2002, numerous rivers in Northern Italy, Switzerland and Central England in 2000, the Tisza in Hungary in 1999 and 2001. But this year almost the whole of Europe had to contend with a serious *low water* problem; water levels in rivers kept subsiding to an all-time low and made waterways barely navigable. Only few recognize that these problems are connected, and that a sustainable solution cannot be found in a new round of technical interventions. We need a new approach to ease both droughts and floods.

Traditionally, we resolved water problems where they occur: areas were drained, brooks were canalised, dikes were built, rivers were dredged, and etceteras. All these measures have one thing in common: the water is led through faster, which again has two consequences. On the one hand, the high-water problem is shunted downstream (where extra measures must be taken to avert the danger), and on the other hand, the accelerated drainage of excess water in winter causes a water shortage in summer.

After the high waters of '93 and '95, the three countries along the Meuse believed it was time to break out of the downward spiral of solving problems while creating new ones. Principles like 'room for the river' (restoring the natural water-retaining capacity of river systems) received increasing support. However, not much had come of it in actual practice, and both Belgium and the Netherlands opted again for selecting almost only technocratic solutions to mitigate the problems. Fortunately, the serious inundations also caused a turning point in thinking, and there is still the call for doing things differently. The reason this hasn't been translated into actual practice is because planning and implementing river-management measures have so far mainly been at national and regional levels. So far, a common approach on the international level, which is necessary to find an integral solution, has not been successful. The so-called 'river catchment approach', which is part of the European Framework Directive on Water, does provide new prospects in this field. Indeed, when problems are tackled at the river catchment level, it allows us to solve the problems in places where they are created, and not in places where they manifest themselves. This requires a very new approach in which we must recognise the interrelationships of events in the catchments.

A 'catchment approach' may seem complicated on first thought: many interests and various stakeholders in a vast, international area have to be reckoned with. But this broader scope also brings new opportunities and partners to the fore. The European rural areas are now going through a process of big changes, and water management can follow up on that. Some 75 million hectares of European agricultural lands will phase out production in the next few decades, and water management combined with nature development and recreation is an interesting new function for these areas. An additional attraction for water management is that the lands that are now being abandoned by agriculture are mainly located in the low mountain ranges – areas where the rains falls most and where *all* peak river flows have their origin. By linking trans-border high-water problems to prospects for local rural development, it is easier to find local support for the measures. And there is another advantage. Whereas technocratic solutions (dikes, embankments, retention basins) require space in the overcrowded river valleys, some thousands, if not millions of hectares will become vacant in the upper reaches of the catchment areas. Here vast areas can be disconnected from the fast drainage so that they are no longer productive to high-water peaks. For that matter, there are other possibilities near cities in river valleys that can contribute to a sustainable, high level of safety by the rivers. High-water channels combine well with various recreational functions which are so much needed by the modern urban dweller.

The positive contribution that a natural catchment area can make to mitigate both droughts and floods are described in WWF's vision *Bergen van Water* [Storing Water, 2000]. This vision describes a whole range of possibilities for storing and retaining excess water – from capillaries, the smallest streams in the mountains, up to the estuaries and the polders below sea level. The economic sectors that may profit from this vision are also mentioned: a number of monographs on Living Rivers (*Levende rivieren - 1995),* Growing with the Sea *(Meegroeien met de zee (1996),* Green for Gravel *(Groen voor grind (1996),* Living Water Retention *(Levende berging (1997)* and About Extraction *(Over Winnen (2003)* describe how various parties and stakeholders can make a contribution toward solving high-water problems in interesting win-win situations. And that this approach works has already been proven by the various successful projects. An example: mineral extraction downstream of the Rhine and the Meuse made it possible to substantially increase the room for the river. Nature and, in its wake, recreation are the better for it.

We realise that much can be done in the lower areas of the catchment, but what prospects are there for water storage upstream, closer to the source? In a separate monograph, *Bergen bij de Bron (2003*) [Storing Water near the Source] we tried to find an answer to these questions based on our own research in various catchment areas, but especially in those of the Rhine and the Meuse carried out in 2001 and 2002. However, visits to other catchments revealed that the principles can be applied even there. Our research focussed on the following five questions:

1. what are the main principles for Storing Water near the Source,
2. what measures are involved,
3. where can these measures be taken,
4. does 'Storing Water near the Source' produce the desired results, and
5. how to finance and realise it?

Below is a brief discussion on these aspects; more details can be found in the main report.

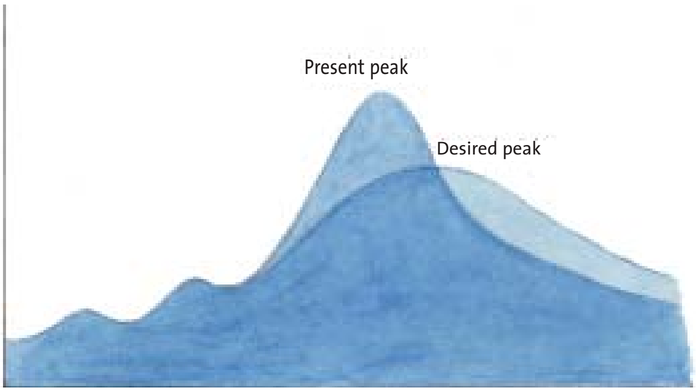

ILLUSTRATION 1 Desired change of a flood peak to mitigate the high-water problems. The shaded part is water that is kept in the catchment for a longer time.

Large areas in the low mountain ranges have gently rolling landscapes with hollows where marshes are naturally formed. Because of all kinds of operations, the water in these marshes reaches the brooks sooner than before, and increases the chance of peak flows.

1 What are the principles of Storing Water near the Source

An important starting-point of Storing Water near the Source is that measures for slowing down the discharge of water must be taken in the low mountain ranges. There are three reasons for this:

- Because of their heavy rainfall, European low mountain ranges (with a height ranging between 200 and about 1,500 metres) are important contributory factors to the discharge of the large river systems, and are also responsible for the extreme discharge peaks;
- By slowing down the water directly in the place where precipitation takes place, all inhabitants in the catchment area will benefit. This is not the case if measures are taken downstream of the main river: it doesn't help the people living nearby brooks;
- Much space is available in the low mountain ranges; population density is much lower than in the lowlands, and the most important land user – agriculture – is on the threshold of a drastic process of change whereby much land will become available for other functions.

Another principle is to make the time that water travels in the catchment as long as possible. Unfortunately, this time has been greatly reduced through the years by:

- changes in land use, by draining bogs and cutting ditches in seepage areas. This means that rainfall-runoff reaches the brooks much sooner than before, which makes that a larger part of the runoff adds to the flood peak.
- embanking and canalising natural watercourses. This makes that brook water floods its banks later than it did in natural situations, and flows much faster than before. Therefore flood peaks reach the main river sooner and are higher, and will overlap with flood peaks from other catchments more often and higher.

By lengthening the course of the water again, the discharge will be spread over a longer period and the peak discharge will decrease. (*See Illustration 1*).

By fixing their banks, the beds of the brooks have changed into deep, narrow discharge channels where flood peaks run off with ever increasing speed.

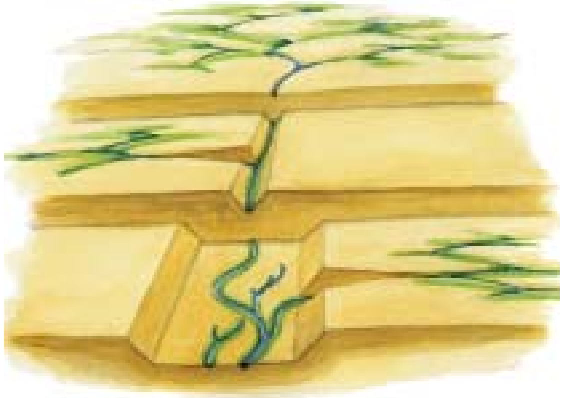

ILLUSTRATION 2 The route water follows through the low mountain range: from the plateaus with shallow, wide valleys (capillaries) via deeply cut V-shaped valleys to the gorges with broad valley plains downstream.

2 What measures can be taken

The measures that can be taken to slow down the water in the low mountain ranges can be explained best with the help of the route the water follows.

ON THE PLATEAUS

In the often hilly landscape upstream in the low mountain ranges, measures can be taken for retaining water on the land. Nearly all precipitation (90%) falls on the land and moves a rather long way through the soil before reaching the brook or river system. By increasing the sponginess of an area, the velocity of the travelling water can be slowed down. This almost always requires a change in land use. A structure-rich deciduous forest with heavy undergrowth of shrubs and herbage, and a thick layer of humus on the soil is the ideal vegetation to slow down water drainage. Unfortunately, this natural covering of the low mountain ranges has largely disappeared and changed into farmland, grasslands and into drained coniferous forests, the latter mainly in the last few centuries. These are all vegetations with little sponginess. Not only deciduous forests, but also peat moors have the ability to retain much rainwater and to discharge it slowly. This vegetation, which once covered over 10% of the low mountain ranges, has almost disappeared in the last two centuries and converted to (drained) coniferous woods.

A change in the land use on the plateaus by switching forestry from coniferous woods to deciduous woods and where more space is set aside for developing peat moors will slow down the discharge of water in the course of time, and will have a positive effect on both the reduction of flood risks and water supplies in dry seasons.

ILLUSTRATION 3 Most precipitation falling on the land reaches the brook valleys by moving via the soil (blue arrows) over the rocky subsoil ((greyish brown). Once in the valley, it feeds a vast system of small marshes through which the water flows into the brook. In times of dryness (upstream), this sponge slowly dries up.

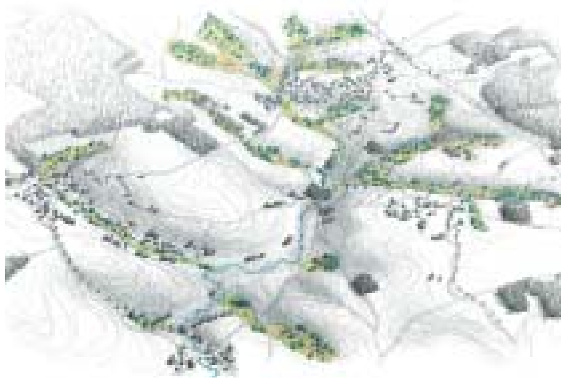

ILLUSTRATION 4 Impression of the upper part of the Ourthe catchment where all valleys that are suitable for retaining seepage water longer are re-created into transit morasses. Some 10 to 15% (about 150 hectares) of the 1,200 hectares covering area can be made into a morass, while the rest will remain suitable for agriculture or forestry. At present, even less than 1% of the surface is boggy.

IN THE CAPILLARIES

In higher upstream valleys with capillaries of the catchment, measures can be taken by filling up ditches and small brooks, which will restore the original marshes. As it is, all rainfall-runoff on the surrounding plateaus and slopes concentrate in these valleys. This water wells up from the soil and surfaces again in seepage zones from where it streams above ground downward to the brook. (*Illustration 3*)

The wide upstream valleys are in their entirety very suitable for retaining rainwater longer. Often trenches were dug and brooks were straightened when the valley was cultivated. In places where farming is no longer practised, and this process has been autonomously going on to a large degree, these trenches and brooks can be closed again. Vast marshes where water flows through can once more develop in these places. When groundwater runs off, it will flow much slower through the high vegetation, and reach the watercourse much later. It is a fortunate circumstance that every acre counts: this system does not need large connected areas. More than that, relatively small areas scattered in the catchment area are even more favourable than one big connected area.

IN THE BROOK VALLEYS

Coming from the broad boggy capillaries in the plateaus, rainfall-runoff squeezes through narrow V-shaped valleys with hardly any storage space. Here the water is led through fast, without any possibility for slowing it down. However, from the place where the brook valleys broaden downstream (*see Illustration 2*) there are possibilities for slowing down the water. When these broad valley plains are flooded during high water, they have a strong decelerating effect on the flood wave. In the course of time, the flooding frequency has dwindled by numerous interventions in the waterway. For example, counteracting the erosion of the river (banks) resulted in a further raise of the valley plains by the accumulation of loam and sand, sometimes

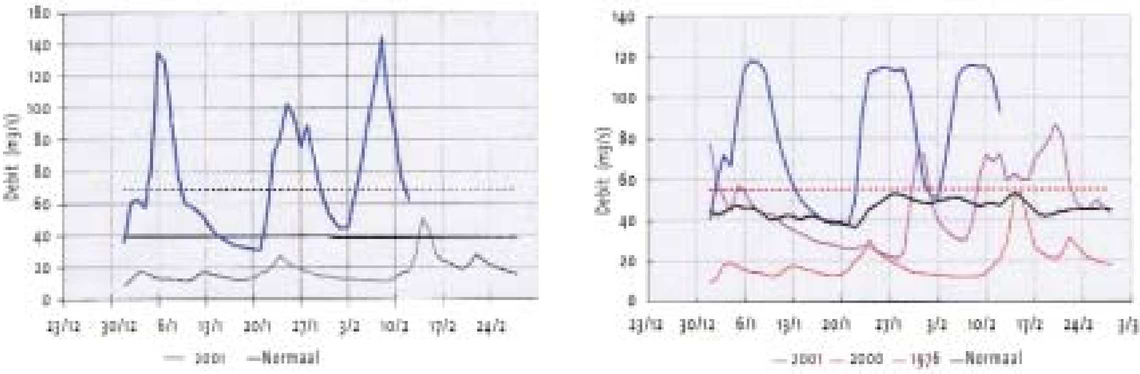

ILLUSTRATION 5a en b. The natural slow-down effect of the valley plains is still largely intact along the River Chiers in the French Meuse catchment.

Upstream (illustration on the left) of the plain in Chauvency-le-Chateau, three flood waves passed with a discharge of 157, 121 and 163 m^3/sec in 2001.

Downstream in Carignan (illustration on the right), the peak arrived clearly levelled down and about 25% less high (118 m^3/sec at most). The water that was retained on the plains followed after the peak, which made that the peak was maintained for a longer time (compare Illustration 1).

even to 3 metres. As the brook bed did not rise, the frequency of flooding decreased more and more, and an ever-increasing quantity of water was discharged through the bed with ever-increasing flow rate. The slow-down effect of the valley plains – the 'safety brake of a flood wave' – is activated later and later, with disastrous consequences for the situation in the main stream. The faster the floods travels through the brooks, the more the chance that the waves from different brooks arrive simultaneously at the main stream to cause an extreme water level.

The slow-down effect of valley plains can be restored:

- by taking measures that encourage flooding. By allowing erosion again, the natural brook bed will be restored (wider and less deep).
- by leaving dead trees in the brook. Obstacles force the water flow into a new direction and encourage the process of erosion, causing the valley plain to be flooded as obstacles dam up the brook.
- By reserving parts of the valley plains that for their location, land use and surface area are most suitable for flooding the area.

These measures must be carried out on a large scale to create brooks that overflow their banks earlier with every high-water event. The total surface need not be vast as long as these measures are taken scattered over the whole catchment.

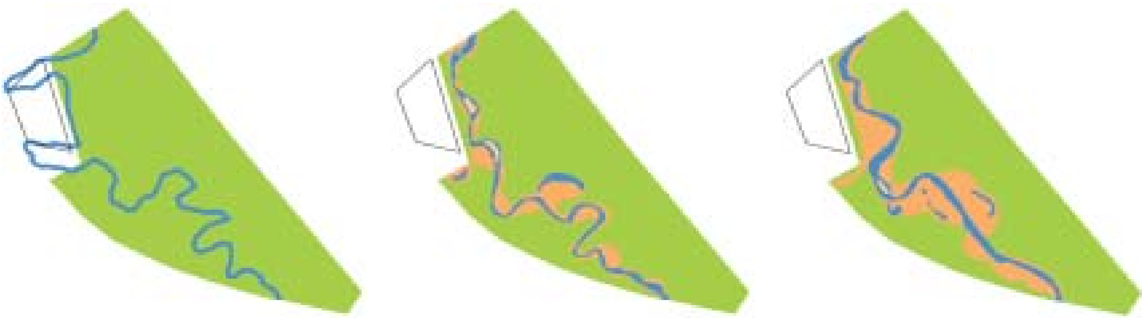

ILLUSTRATION 6 a t/m c. The River Worm near Haanrade in 1924, 1975 and 1989. After the brook bed had been given 'free rein', the valley plains could enlarge; floods occurred more frequently and flood waves were delayed.

3 Where to find suitable locations for Storing Water near the Source

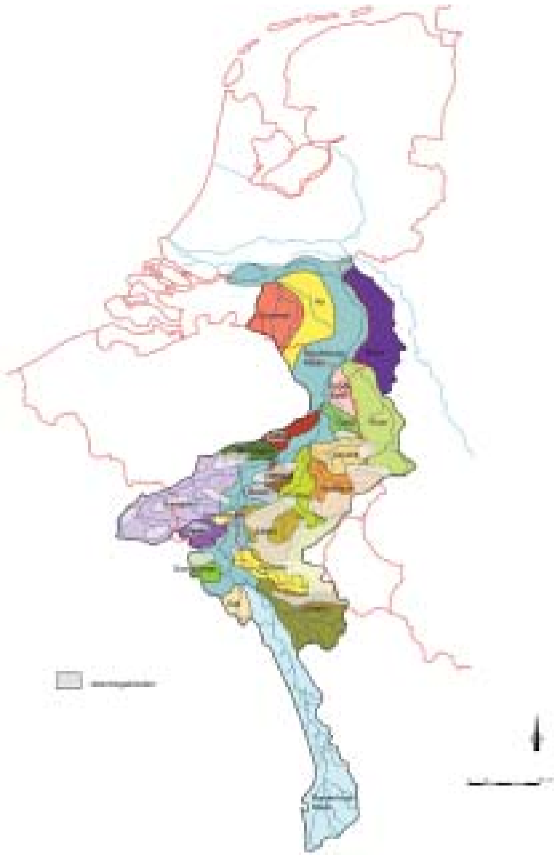

ILLUSTRATION 7 There are regions with capillaries with sufficient room to retain water for a longer time in all catchment areas of the Meuse. Similar maps can be made of the Rhine catchment.

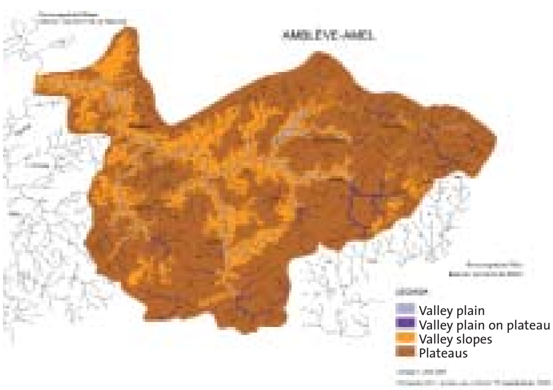

ILLUSTRATION 8 In the Amblève catchments it is easy to make out the capillaries as a intricate network on the plateaus. By undoing drainage and trenching, the duration of water retention in the area can be prolonged substantially.

The areas in the low mountain ranges that are suitable for retaining and delaying water can be found in two places: the capillaries of the highest parts of the catchment, and further downstream where the brooks flow through wide valley plains.

IN THE CAPILLARIES

We can find the broad valleys where the capillaries are located everywhere in the upper catchment of the lower mountain ranges from where the Rhine and the Meuse get their water. Here rainwater-runoff can be retained by increasing the sponginess of the soil and by restoring the marshes. With the help of topographic maps we examined all capillaries in the Ardennes (there are thousands and thousands of them) for their water-retaining capacity. It proved that capillaries in valleys that are wide enough to hold (much) water were found in all catchments of the Meuse. (*See Illustration 7*).

As much as 55% (650 km of the total 1,180 km) of all upstream brooks in the Amblève catchments is more or less suitable. For an estimated average width of 150 metres, some 10,000 ha will be available for retaining water longer. This is a mere 10% of the Amblève catchments, but here the water seeps from an area that covers about 60% of the catchment.

ALONG THE BROOKS IN THE BROAD VALLEY PLAINS

Downstream in the low mountain ranges, the valleys broaden to wide valleys that play an important part in delaying flood peaks. There are wide valley plains in all catchments of the big rivers. The Amblève catchment (*Illustration 8*) has a total length of brooks with valley plains of 217 km; this is 18% of the total length of the valley. After deducting the areas that are not suitable for water retention because of existing buildings,




Photographs of the reference areas along the Amel, the Warche and the Holzwarche.

The wide valley plain of the Ourthe between Hotton and Durbuy.

some 125 km to 150 km with a total surface of over 3000 ha (3% of the catchment area) remains. When half of it is made suitable for the retention of water, about 30 m^3/sec can be retained in the valley plain during a period of 36 hours when the floodwater is 25 cm deep. This is 10% of the peak discharge during high water. Numerous brooks have such wide valley plains in other catchments of the Meuse and in the Rhine catchment area. Where the brooks run through limestone hills, valley plains can be several hundred metres wide.

4 Does Storing Water near the Source give enough results?

The study 'Storing Water near the Source' aims at delaying part of the precipitation that falls in the catchment area to such a degree that the high-water peaks downstream become smaller (see Illustration 1). To answer the question whether the proposed measures would lead to a substantial drop in the water levels downstream, extensive research is done into the origin and composition of peak river flows, some findings of which are explained below.

ORIGIN AND COMPOSITION OF PEAK RIVER FLOWS

Analysis of the extreme high-water peaks of the Rhine and the Meuse proves that they develop during a short period of heavy downpour within a much longer wet period. For example, wet periods often cause water levels in the Meuse varying between 1,000 and 1,500 m^3/sec. When this is followed by one or two days with 5 to 7 cm rain, the river water discharge rises quickly to extreme water levels above 2,500 m^3/sec. This peak level arrives at Maastricht in about 40 hours (35 - 45) after the period with

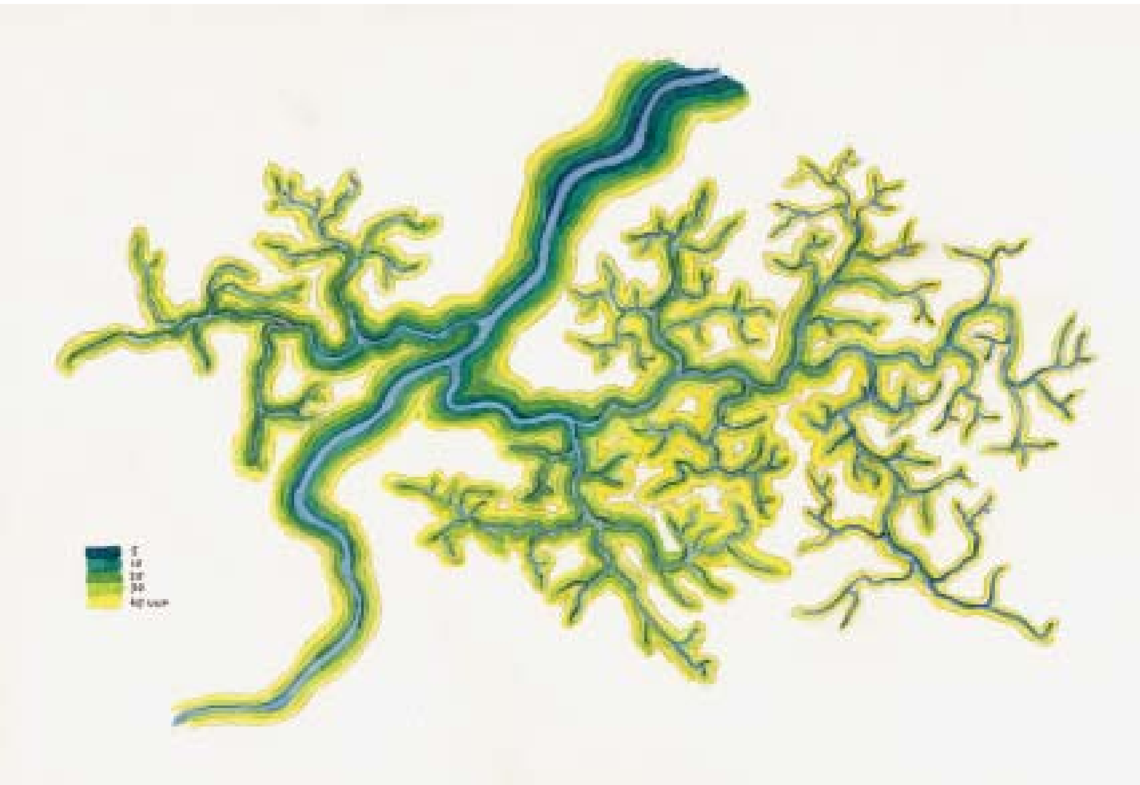

ILLUSTRATION 9 Downstream, from the furthest catchment regions that contribute to the composition of a flood wave, the surface area of lands that contribute increases on both sides of the brooks.

extreme rainwater-runoff. The question is now whether Storing Water near the Source will delay sufficient water volume to lower these peaks and even higher ones.

By the velocity of water through the various brooks (*Table 1*) we can confirm that the water of the flood peak near Maastricht originates from the whole catchment, though further upstream there is less land that contributes to the peak (*See Illustration 9*). By linking the type of landscape with land use in the catchments of these brooks we can calculate in percentage terms how much runoff in the various regions in the catchment contributes to a flood wave (*Table 2*).

Based on the origin of the flood, it was calculated to what extent the proposed measures for abating flood waves contributed (*See Table 3*).

TABLE 1 The time needed by flood waves from the side brooks of the Meuse till Maastricht.

SIDE BROOK	From its mouth	From its capillary
Vesdre	5 hours	9 - 12 hours
Ambleve	5	11 - 15
Ourthe	5	11 - 18
Sambre	9	15 - 40
Lesse	11	14 - 21
Viroin	15	17 - 23
Semois	20	25 - 40
Chiers	37	40 - 72
French Meuse	37	50 - 170

Except from the Chiers and the French Meuse, all the water from a watercourse in the Ardennes part of the catchment arrives within 40 hours, and contributes to the creation of a flood wave. The side brooks near Maastricht contribute relatively the most, because all the water from the capillaries and the surrounding lands arrive within 40 hours (See also Illustration 11). Remote areas in the catchment (upper reaches of the Sambre and the Semois) contribute much less to the composition of the flood wave).

TABEL 2 Contribution of various catchment regions to the composition of a flood wave.

TYPE OF LANDSCAPE	surface area (in % van the catchment)	% runoff from landscape that contributes to peak	rel. contribution of landscape to flood wave	contibution to peak discharge (e.g. 2000 m^3/sec)
Catchment	100%	20%	100%	2000 m^3/s
Watercourses & lakes	1%	100%	5%	100 m^3/s
Paved	4%	50%	10%	200 m^3/s
Valley plain downstream	2%	75%	7,5%	150 m^3/s
Valley plain upstream	1%	50%	2,5%	50 m^3/s
Areas with steep slopes	30%	25%	37,5%	750 m^3/s
Regions with capillairies	40%	15%	30%	600 m3/s
Drained plateaus	5%	30%	7,5%	150 m^3/s
Other plateaus	17%	0%	0%	0 m^3/s

To calculate the contributions, the following steps were taken.

1 For every landscape, it was estimated how much % of the catchment is covered.
2 Based on the distance from Maastricht (far away, close by), soil conditions (porous, rocky), relief (flat, steep) and land use (natural, boggy/drained farmland) it was estimated which part of water-runoff from a type of landscape contributes to a flood wave. Example: 15% of the precipitation volume falling in the capillaries region reaches Maastricht within 40 hours.
3 By multiplying the relative surface area with the contribution, we can find the ratio to which the landscape types contribute to the composition of a flood peak. Example: 30% of the water in the flood peak originates in the capillary regions.
4 The last column indicates how much these landscapes contribute to a flood peak that results in an extra supply of 2000 m^3/sec coming on top of the already existing discharge. Example: If there is an extra discharge of 2000 m3/s, some 600 m^3/s originates in the capillary regions.

TABLE 3 Reducing the contribution to an extreme flood wave after realising retardation measures.

TYPE OF LANDSCAPE	contribution to at present	composition of the high water peak after retardation measures	reduction
Watercourses	50 m^3/s	50 m^3/s	0 m^3/s
lakes	50 m^3/s	50 m^3/s	0 m^3/s
Paved	200 m^3/s	190 m^3/s	10 m^3/s
Lower valley plains	150 m^3/s	150 m^3/s	0 m^3/s
Upper valley plains	50 m^3/s	20 m^3/s	30 m^3/s
Sleep slopes	750 m^3/s	700 m^3/s	50 m^3/s
Capillairies	600 m^3/s	400 m^3/s	200 m^3/s
Drained plateaus	150 m^3/s	75 m^3/s	75 m^3/s
Other	0 m^3/s	0 m^3/s	0 m^3/s
Discharges already present	1000 m^3/s	1000 m^3/s	geen
Sub total	3000 m^3/s	2635 m^3/s	365 m^3/s
Reduction as a result of storing near the source(10%)	not applicable	165 m^3/s	165 m^3/s
Total	3000 m^3/s	2470 m^3/s	530 m^3/s

This is calculated with a contribution of 2,000 m^3/sec caused by 1 or 2 days of extreme rainfall within a wetter period that had already caused an increase water level of 1,000 m^3/s (‘discharge already present in the Meuse’).

In Table 3 it was assumed that the capillaries have enough space to retain the groundwater that surfaces from the slopes for such a long time that the runoff does not even enter the flood wave. This means that a larger volume of water is discharged after the peak, which increases the risk that this volume will coincide with a second peak after another extreme rainfall. It is therefore also very important to delay the water from the capillaries where it takes a longer time to travel, such as those in the French Meuse and the Sambre. If retardation measures are taken in the capillary regions scattered throughout the Meuse catchment, the largest decrease of peak of the flood wave will be achieved. (As it will not be possible to disconnect all capillaries, we made calculations for half the volume of capillaries.) Decreasing the surface of drained and trenched lands on the plateaus also gives relatively good results. Possibilities to delay the water in urban areas are limited because this needs very substantial investments to retain even a small part of the water. The contribution can be decreased by other land uses on the steep slopes, and this gives good results, as the surface is sizeable. The wide downstream valley plains offer good prospects to top off the flood wave by ‘storing water flowingly’. In that case, the contribution is estimated to be 10%.

After adding up all contributions to water decrease, including the retarding effects of the valley plains, it will give near Maastricht a flood peak decrease of over 500 m^3/sec. This is a substantial reduction. By way of comparison: all measures intended in the last few years for flood abatement in the Meuse were aimed at a total decrease of 300 m^3/sec. However, when aimed at 500 m^3/sec, we must allow for two modifications: these are *rough* estimates started from premises, and these are *maximum* estimates whereby the water is delayed from a large part in the catchment that offers the possibility.

Not only along the main river, but also along its branches do the interventions have a positive effect. The relative share of the capillary regions in the land use is larger, which makes the decrease larger as well. As the flood waves in the tributaries are also built up by waves from the many side brooks, it is worthwhile to delay the velocity of these flood waves to make them join the tributary one at a time. Especially the water retained on the plateaus and in the capillaries will generally need so much travelling time that it will raise low water levels in dry seasons.

5 How to finance and realise Storing Water near the Source?

To delay the composition of flood peaks, we need areas all over the catchment where water can temporarily be retained. It is fortunate that the function of water buffer can be combined well with other uses in the rural area. This means that the necessary area need not be 'reclaimed' through space claims, but can be found in partnerships. Indeed, retaining water is not only attractive for the agricultural sector, but also for drinking-water collection, navigation, industry, nature conservancy and recreation and tourism. Partnerships with these functions are possible from source to mouth, which is why it is in line with the European Water Framework Directive, whose main issue is planning and action on catchment level. The catchment plans for retaining water therefore form the international political framework, whereby enlightened self-interest is the realistic driving force. Below we make a round along the potential partners.

THE AGRICULTURAL SECTOR AS A PARTNER

Areas where measures for abating high water problems can be taken now often have an agricultural purpose. It is therefore important that the retention of water also offers attractive prospects for farmers. The importance of agriculture takes place on two levels. On the one hand, the developments on the European level call for finding new forms of land use. On the other hand, local circumstances often give cause for creating new developments in a region. The possibilities may vary from place to place.

European agriculture is changing drastically. In the last decade, some 200,000 European farmers saw no other possibility than to stop their enterprise. Part of these enterprises were taken over by colleagues with more capital, but for all this, an estimated 60 - 90 million acres of farmland will still be left fallow in the years to come. As less and less people in Europe can have an adequate income from agriculture and as mainly barren regions will be abandoned, it is important to find alternative functions. This is not only paramount to the individual farmer but also for the region in question: without new economic driving forces general deterioration lurks. Storing or retaining water combined with other functions may become such an economic driving force in agricultural areas where almost everybody has left. Especially because it often involves the marginal parts of a farm, there is every chance that the farmer, on a voluntary basis, is willing to opt for allowing his lands to become wetter if he receives financial compensation. The compensation should be based on the effect the measure has on the retention of water, and should be properly related to the loss of production and the value of the land. With the money received from water retention, the farmer can again invest in improving his farm on other (drier) lands. This will give a new 'mixed' farm with profits from agricultural production and from water retention. A third pillar of such a farm could be extensive meat production linked with the grazing management of the new nature areas.

Storing Water near the Source can also offer prospects to agriculture in the downstream valley plains. Here the prospects for agriculture are still good, and as the interest of the individual farmer may vary they can opt for co-operation on a voluntary basis. Especially farmers that own valley plains located at great distances from their enterprise would more easily opt for selling if given the choice between 'money or land'. As there is a substantial drop in the valley (5 - 7 metres per km), it is worthwhile to take measures for water retention in small areas without troubling the people upstream. Most effective are the valley plains where brooks are given free rein and where vegetation offers much resistance, but also valley plains that are still used as pastures are effective in floods. Management contracts may be concluded for these lands, which are related to the effect of the water storage as well as to the loss of income. This approach has already been tried and tested in purchase arrangements of nature areas and in management contracts with farmers in various member states of the European Union. Should the farmer have no one to succeed him, the land can be purchased after expiration of the contract. This can be a socially attractive option for farmers.

The farmer as a partner

On the plateaus, measures can be taken regionally to decrease water runoff and to delay emission into the soil.

- Farmers will be compensated for letting the land in the capillaries become wetter. They will remain the owners, and must take water-retaining measures, or sell the land to a water or nature management organisation.
- Farmers can make parts of the valley plains suitable for water retention while retaining an agricultural function. These plots may also be sold.
- All local measures are on a voluntary basis: the choice of participating or not lies with the farmer.
- The measures would mean a financial boost in the farming community.
- The necessary funds are produced by the stakeholders downstream.

Drinking-water management as a partner

Measures that are taken within the framework of Storing Water near the Source delay water discharge from an area. The discharge will be less in wet seasons and more in dry seasons. This is favourable for drinking-water collection, as this would prove very useful when supply is increased during dry seasons. In addition, the longer the water stays in the soil and in boggy areas, the longer the biological purification process takes.

Navigation as a partner

In dry seasons, the discharge into rivers, especially rain-fed rivers, can be reduced to almost zero. In order to keep these rivers and the canals that are fed by them suitable for navigation, extra water is very important in dry periods. As relatively small volumes suffice (only a few dozen of m^3/sec), the retention of water has a substantial positive effect soon.

Industry as a partner

Water is used as cooling-water in all sorts of industrial installations. In principle, the water can remain chemically clean, though it is burdened thermally. To avoid a too severe warming, increasing the water supply is here very important too, especially in dry seasons.

Nature management as a partner

The measures taken within the frame of Storing Water near the Source will substantially increase the surface of nature areas, and the ecological value and quality of the landscape will improve greatly by these measures. Natural processes are enhanced, and many organisms will benefit from them. The landscape will become more varied and interesting, and the visitor will get more enjoyment out of it. Moreover, nature areas along the river are very scarce, not only in Europe but all over the world. If there is a place somewhere where results are achieved promptly, both in quality and in quantity, it is along the brooks and the rivers. Storing water is even more interesting for international nature conservation because it may become the driving force behind the realisation of the European Ecological Network. River systems offer an exquisite basis for developing such green and blue ecological network.

Recreation and tourism as partners

More natural brooks, flowery marshlands, vast bogs and varied deciduous forests will make it more attractive for residents of a region to spend their free time in the landscape. Urban dwellers will also like holidaying in these regions. As tourism is the fastest growing sector in the European economy, the improved quality of nature and the attractiveness of a region will bring a strong economic partner within reach.

Via international co-operation to national implementation

Because of the very nature of the proposed measures, it is impossible if not undesirable to draw up a spatial plan. The measures can be carried out in a large number of small locations, and it is all the same where these plots are located as long as they belong to the described categories. That is why a process must be started along gradual lines, whereby the different partners from international, national and regional levels are encouraged to co-operate in natural water retention. On the international level co-ordinated by the EU or by international river committees, downstream partners must show willingness to pay for retaining water higher up in the catchment (compare the investments made in the past by Rotterdam to decrease pollution from upstream.) Following on this, national or regional authorities must channel international willingness to the most suitable partners and regions. A consultative body on which stakeholders have seats can advise the government on the most suitable regions for taking measures. At the national level, a system can be set up for management compensations and for land acquisition, and can lay down the management in local water management plans.

ENCOURAGEMENT ON THE INTERNATIONAL LEVEL, REALISATION ON THE NATIONAL LEVEL

ON THE INTERNATIONAL LEVEL, co-ordinated by the European Union, the following incentives should be provided:

- encourage partners to pay for retaining and delaying the water
- develop the principles of the various ways of retaining water
- describe the applicable measures
- roughly fix the areas per zone that would serve as guidelines for the effects to be achieved
- lay down the measures in catchment plans (has been made mandatory by the EU) to be approved by the national authorities
- apply own EU tools (such as agricultural aid) to implement these measures

NATIONAL OR REGIONAL AUTHORITIES contribute to the realisation of natural water retention in the following ways:

- a consultative body (of all groups of stakeholders (partners): farmers, landowners, cities, provinces, water management authorities, conservationists, recreational amenities boards, users of water) advise the central authority on the measures to be taken.
- zones are designated where the various measures are to be applied, with priorities
- compensation for management contracts are confirmed, based on the water-storing effect and the loss of production and capital.
- a system for acquiring regions is developed
- farmers and landowners are invited to make use of the arrangement
- the management is conformed in local water management plans

Pilot areas

To make clear to everyone what is important in natural water retention and to lead the discussion about the effects properly, it is of overriding importance to set up clear and convincing pilot areas. Both existing remnants of nature areas, which play a role as references, and new regions where this management is carried out are important in this field. Via the management and opening to the public, nature and water management authorities can play a key role in the discussions about this subject. The various partners that have an interest in the above measures can be the sponsors.

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