Prepared for:

Etablissement Public Loire

Flood Management for the Middle Loire; an outsiders' perspective

Report

April, 2006

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Flood Management for the Middle Loire; an outsiders' perspective

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Summary

Context and objective of this report

In June 1999, the report 'Synthesis of proposals for an overall strategy to reduce the risk of flooding by significant flood along the middle Loire' was published. In 2000, a regional plan for the Middle Loire was published within the 'Plan Loire Grandeur Nature' covering the period from 2000 to 2006. Decision makers have not yet decided which public policy should be adopted to prioritize possible measures. As a result, few technical measures to reduce flood risks along the middle Loire have been carried out since 1999.

As part of the project 'Freude am Fluss' a so called 'Intervision Team' visited the middle Loire in October 2004. This team drafted a report on flood protection along the Loire with conclusions and recommendations. With that report as a starting point, Etablissement Public Loire (EP Loire) wishes to obtain a more specific advice on how to proceed with flood management. Therefore, EP Loire asked Delft Hydraulics to study the issues and draft a concise report.

The aim of the current project and this report is to advise on flood protection strategies along the Middle Loire. The report attempts to be clear on the options and the kind of measures to be taken, and provides suggestions for the order by which measures should be taken over time to implement the strategy. The report is also intended to contribute to a new regional plan for the middle Loire for the period until 2013. For the 'Freude am Fluss' project this contributes to the deliverable of drafting regional and local plans.

This report is only a small step in a long process of re-evaluation of flood risk management in the Loire Basin. A small project like this is by no means sufficient to get a detailed picture on the diverse development issues, to resolve the divergent views around complicated issues existing in the basin, and it is certainly not sufficient to draft an integrated plan, ready for implementation. It can only contribute to the process of decision making, and that is what we hope to achieve with this "outsiders' perspective".

There are many types of measures that can be applied in the framework of flood management. Of course flood management is ultimately aimed at mitigating flood damages, so not only measures should be considered that reduce the probability of flooding, but also measures that are aimed at reducing flood damages. Therefore, a distinction is made between structural and non-structural measures. In this report non-structural measures are defined as measures to modify the susceptibility to flooding, such as watershed management, flood proofing techniques, flood warning, land-use planning and regulations, etc. Structural measures are defined as measures such as dams, reservoirs, dykes, bypasses, detention ponds, removal of hydraulic obstacles, etc.

Based on a recent detailed evaluation of many potential structural measures for the Rhine and the Meuse Rivers an overall picture emerges regarding the efficiency of various types of measures. The overall conclusion is that measures that temporarily store an amount of water, like the *vals* along the Loire, are by far the most efficient structural flood management measure.

This measure provides the largest effect per euro invested when compared to all other types of measures. Based on this, we conclude that the use of *vals* along the Loire is in essence the most efficient structural measure in flood management. Other measures, including the closing and heightening of dykes over their full length, are less efficient. This underlines the wisdom of the flood management strategy for the Loire. There is, however, an important condition for this flood management system to *remain* efficient over time. That condition is that developments in the *vals*, including the new development of housing and enterprises should be strongly limited, and damages to existing houses and enterprises should be reduced by flood proofing measures. In this way, a new type of development should be worked out, especially for the *vals*.

In the 20th century, no high river flows occurred. This led to a false sense of security, less awareness of the flooding threat and less attention for maintenance of the infrastructure. It also led to a substantial development of houses and enterprises in the *vals*. It is within this context that the 1999 plan was drafted. In essence, this plan maintains the system of *vals*. We consider this an overall wise choice. The reliance on a series of *vals* is the overall best choice that could have been made in the 19th century, and still is the best choice today. However, it could be the case that on a *local* level other types of measures deserve more attention in the plan.

Middle Loire flood management strategy

The 1999 plan does not focus only on traditional technical measures like the construction of reservoirs and dykes, but also takes into consideration options to reduce susceptibility of values (properties) to flooding, awareness raising for flooding risks, while improving the river qualities, including the natural river environment, its landscape values and cultural historic values. The overall objective of the strategy is to protect people from harm and to mitigate flood damage. In other words: the strategy is aimed to reduce flood risks, and this is done by reducing the frequency of inundation and by reducing the damage caused by an inundation.

The overall strategy is composed of four elements, each of which has one or more elements:

1. the establishment of a base for long-term actions, comprised of improvements in flood forecasting and crisis management; finding ways for a sustainable development in the flood prone areas; a programme to restore a culture in which there is an awareness for flooding risks; and regular maintenance of the river bed and the dykes of the Loire;
2. improvements in the system of dykes and intake structures (weirs), namely smoothing the slopes of dykes; reinforcing river banks; enhancing the life span of fuses at the intake structures; and improvement in the protection of values in communities that are frequently and heavily flooded;
3. the construction of three safety-weirs; and
4. development of the Veurdre dam for flood peak storage.

It is well understood that although the strategy clearly improves the present flood management situation, it can not provide *full* flood protection, in which never in the future there would be any flood damage.

Absolute protection is not possible, and some flood risk will always remain. Obviously, the question is whether or not the strategy appropriately balances the costs for investments versus the benefits of improved flood management.

As a starting point in commenting on the strategy, we strongly support the basis for the strategy, namely the realization that not all floods can be controlled. Further, it is clear that high values are at stake, and that there is substantial societal pressure to continue a further increase of developments in the *vals*, thereby increasing the potential flood damage.

The strategy builds on the fact that the resilience of the existing flood management system along the Loire is high: in case there is a flood flow on the river, the system of *vals* will work in such a way that gradually the *vals* will be inundated. The strategy is aimed at further development of this flood management system. In our view, this is a wise choice. We would like to add to this that in our view the essence of the Loire flood management system serves as a shining example for flood management along many rivers, including many (if not most) rivers in Europe.

The studies to underpin the strategy have been comprehensive in scope: hydrology and hydraulics have been studied in detail, and detailed assessments have been carried out on the flood damage potential, ecological aspects, etc. Our impression is that these studies are of high quality. Furthermore, firms of high repute have carried out the studies, and well-accepted hydrodynamic models have been applied.

The measures proposed in the strategy cover the full range from raising awareness amongst the inhabitants and maintenance measures (under the heading 'the base for long-term actions'), via local protection works to overall protection works (Veurdre dam). The range of these measures ensures balance in future flood management. If all effort were to be invested in only one or two of these three main components, imbalance in future flood management could virtually be guaranteed. Such imbalance would in particular occur in case the 'base for long-term actions' would not be implemented and other measures were to be implemented before or instead of this base.

The plan explains that implementation of the plan will result in the protection against substantial flood damage for as experienced in recent history, and a 1/200 per year protection level in the *vals* of Orléans, Cisse, Tours and Authion, in which 75% of the values along the Loire are located. For other *vals*, the safety level is lower, like for example Gien, which suffers flood damage already during a 1/50 per year flood. It remains less clear whether or not this is an optimal level of protection. One could ask the question why not realize a higher level of protection for certain *vals*, or why not aim at a lower safety level for other *vals*.

Another perspective on the issue of safety levels is to note that the topography of the Middle Loire is such that most probably substantially higher safety levels are ultimately impossible to reach, even if major investments in infrastructure were made. Increasing the overall safety level by means of heightening all dykes does not seem to be feasible. The many (to a large extent historic) bridges that cross the river would form an obstacle for such strategy because the bridges would form the bottleneck for higher river flows, contained between the dykes.

If this is indeed the case, we note that this point might serve as an important argument for the various communities along the river to be very cautious with further developments in the *vals*: such developments will increase the damage potential, while on the other hand a substantial reduction of flooding probabilities is virtually impossible to reach.

All in all, the plan identifies two safety levels for the area, with the highest level (1/200 per year) for the *vals* with the highest damage potential. From an overall point of view such distinction in safety levels seems a wise choice. It may, and probably will, however, require a considerable effort before the stakeholders in the less protected *vals* fully accept this differentiation in safety levels, although the geographic situation and the history of flood protection will help in such acceptance.

The ranking of measures with the highest priority is the following: (1) providing an impulse to sustainable development; (2) restoring a culture of risk awareness; (3) working on improvements in crisis management; (4) managing safe overtopping of dykes, in order to prevent uncontrolled breaches; (5) priority improvements for sites with high frequency flooding and serious flooding; (6) improve the stability of existing dykes; and (7) development of Veurdre reservoir. This priority setting strikes us as being a logical one. One could note that this list of priority actions is not very specific for each action. For example, it is not clarified for exactly which locations measures are proposed. This lack of specific information may hamper acceptance of plan and/or impede implementation. The plan for the period until 2013, which will be drafted in 2006, should address this. The plan for the period until 2013 should also clearly explain why the development of Veurdre dam is not listed higher up in this list. Apparently, some stakeholders believe a higher priority for this dam is warranted.

Measures possibly suitable for consideration in the flood management plan for the Middle Loire

For smooth implementation of the plan, full acceptance of the plan by all stakeholders is of crucial importance. An element in obtaining such full acceptance is that any individual stakeholder, non-governmental organization, or government agency opposed to the plan or only an element of the plan, will seek answers to his or hers ideas about alternative measures. We recommend that in the coming process of reaching a final public policy also information is provided about possible alternative measures. The idea is that any suggestion for an alternative measure is taken into consideration by the analysts, followed by an in-depth explanation what the positive and negative effects of such alternatives are. When it is clear from such explanation why a certain idea has many disadvantages, or why a certain idea can not possibly be implemented, or why a certain idea is prohibitively expensive, that idea will no longer confuse the societal discussions about the plan.

It is in this context and spirit that the report provides suggestions for alternative measures that might be addressed with the objective to address the full range of possible measures in the planning process. All in all, we do not expect miracles from alternative measures, although it is possible that new measures will be identified that will prove promising and acceptable by all stakeholders. Our reason for the suggestion to look into alternative measures is to provide the participants in the discussions about the plan with information to convince them as to why a certain measure is a good idea or not.

Towards a public policy for flood management along the Middle Loire

At this stage, there seems to be agreement between all stakeholders about the strategy on flood management for the Middle Loire, in particular for the actions planned for the period 2001 – 2006. However, for the period 2007 – 2013 an agreement about exactly which measures to carry out, and by which moment in time is not reached yet. Problems encountered are the feeling that there are too many elements in the plan, and agreement about priorities has not been reached. Further, a detailed plan how to facilitate and control the implementation of the plan is not available yet.

We offer some suggestions for the process to reach a public policy. These suggestions are related to the above described apparent lack of clear targets, the lack of a sense of urgency, how to reach agreement between stakeholders about which measures to implement, and about communication with the general public.

Targets for flood management

We consider clear and agreed targets (*objectif operationnel*) as an absolute necessity for a flood management plan to be accepted by all stakeholders. With the term 'clear' we in fact mean 'operational targets'; targets that can be used by the analysts and stakeholders to determine whether or not an individual measure or a strategy (combination of measures) will actually work in (partially) meeting the objectives of flood management.

It could be the case that the 1999 plan *implicitly* has the target to reach a certain protection level (frequency of flooding) for each of the *vals*, based on what is considered an acceptable flooding frequency for predominantly rural areas, industrial areas and urban areas. However, the 1999 plan can also be interpreted in another way: the plan explains that implementation of the plan will result in the protection against substantial flood damage for as experienced in recent history, and a 1/200 per year protection level in the *vals* of Orléans, Cisse, Tours and Authion. If the plan is read that way, than this level of protection is the *result* of the set of measures, and did not serve as a target before the measures were selected. Anybody who reads the report in such a way that these protection levels are the results of measures instead of targets could initiate a prolonged discussion on the selected set of measures. We therefore suggest that EP Loire clearly specifies the targets that were set before measures were selected, and seeks agreements with stakeholders on targets. An agreement with stakeholders on targets will – in our view –make it relatively straightforward to obtain agreement about which measures to include in the plan and about in which order.

Sense of urgency: how to communicate probabilities to the general public ?

The general public often does not fully understand discussions about probabilities of rare events like floods, and in our view this contributes to a limited sense of urgency. The prevailing perception seems to be that 'floods are a thing of the past' and 'the probability is so small that we do not have to worry'. A factor that seems to explain this perception is that the general public has difficulty dealing with small probabilities, even though the consequences can be substantial.

This in turn relates to the way authorities and experts involved discuss flooding events. Reports and leaflets on the flood management plan present flooding probabilities in terms of return periods: floods with a return period 100 years, etc. It is obvious to experts that this should not be interpreted as 'the next flood will occur 100 years from now', but many members of the general public interpret return periods that way. We suggest to shift away from the use of the term return period and instead use the probability that a certain flood may happen in a lifetime of say 80 years. A flood with a return periods of 100 years should then be formulated as 'a flood with a 55% probability of occurring at least once during your lifetime'. Formulating probabilities this way could help people understand the risk of floods compared to other risks.

Communication with the general public

Planning and decision making processes require that information is made available to all parties involved in the process. The shear number of stakeholders in flood management along the Loire requires that an explicit effort is required to inform the general public. Such communication should in our view not be limited to only the people living and/or working in the *vals*, but instead include *all* stakeholders, also those who do not live and/or work in the vals.

This information not only regards the outcome of studies, but also the basic information used in the planning process. Also, the manner in which conclusions are drawn needs to be presented to the public. We are convinced that governmental agencies are quite active in the field of public relations, but it seems not to be sufficient to 'get the ball rolling'. Experiences elsewhere show that not only could such flow of information satisfy the need to know about the background of certain (proposed) actions, but also could be of great importance in creating understanding and approval for these actions.

Making information available to the general public is one thing, but to actively involve the public in the planning process is of course another matter. To collect ideas from the general public about possible measures, the planning authority could actively stimulate the public to come up with ideas. There are two aspects to this: not only is there a possibility that quite feasible ideas are submitted, but is should also be recognized that actively collecting ideas from stakeholders will help prevent discussions later on in the process when stakeholders (individuals, non-governmental organizations, towns, etc.) feel that a proposed plan does not deserve support because their alternative idea is not considered in the planning process. To actively collect ideas from stakeholders may require a substantial effort.

It is noted, that in the near future in the context of the European Framework Directive (Article 14), public participation in establishing river basin management plans is required.

Finally, one could raise the question whether communication with decision makers is in any way different from communication with stakeholders. It is obvious that communication with decision makers is vital for progress in flood management. But just like the stakeholders, decision makers need information in order to make well-informed decisions, including information on possible alternatives.

What makes decision makers special when compared to stakeholders is that they are also concerned of political aspects of their actions, and have to make decisions over a wide range of topics. Where possible, communication with decision makers should keep these concerns in mind.

It is noted that realizing such communication will require an effort over many years. In this context, it is important to realize that given such time frame especially elected or appointed officials (Prefets, Majors, Presidents of Regions or Departments) will be replaced by people who might be completely new to the issues at hand.

1 Introduction

Context and objective of this report

In June 1999, the report 'Synthesis of proposals for an overall strategy to reduce the risk of flooding by significant flood along the middle Loire' (Ref. 5) was published. In 2000, a regional plan for the Middle Loire was published within the 'Plan Loire Grandeur Nature' covering the period from 2000 to 2006. In total a budget of € 60 million was made available for flood management. This budget includes expenditures for maintenance of dykes and other protection structures, development and operation of early warning systems and for raising public awareness. The remaining budget is available for technical measures to reduce flood risks. However, the decision makers have not yet decided which public policy should be adopted to prioritize possible measures. As a result, few technical measures to reduce flood risks along the middle Loire have been carried out since 1999.

As part of the project 'Freude am Fluss' a so called 'Intervision Team' visited the middle Loire in October 2004. This team drafted a report on flood protection along the Loire with conclusions and recommendations (Ref. 2, Ref. 3, Ref. 30). With that report as a starting point, Etablissement Public Loire (EP Loire) wishes to obtain a more specific advice on how to proceed with flood management. Therefore, EP Loire asked Delft Hydraulics to study the issues and draft a concise report.

The aim of the current project and this report is to advise on flood protection strategies along the Middle Loire. The report attempts to be concise and clear on the options and the kind of measures to be taken, and provides suggestions to advise on the order by which measures should be taken over time to implement the strategy.

The report is intended to contribute to a new regional plan for the middle Loire. This regional plan will be written in 2006 and will cover the period until 2013. For the 'Freude am Fluss' project this contributes to the deliverable of drafting two regional plans and three local plans.

This report is only a small step in a long process of re-evaluation of flood risk management in the Loire Basin. A small project like this is by no means sufficient to get a detailed picture on the diverse development issues, to resolve the divergent views around complicated issues existing in the basin, and it is certainly not sufficient to draft an integrated plan, ready for implementation. It can only contribute to the process of decision making, and that is what we hope to achieve.

The authors of this report have experience in flood management issues along many rivers worldwide, but not regarding the Loire. This report is of course based on documents and discussions regarding the Loire, but is essentially written from the perspective of experience with flood management issues with other rivers.

This leads to a report which is less detailed when compared to many existing reports on the Loire, but hopefully proves useful since it provides what could be called an 'outsiders' perspective' on the Loire. This explains the subtitle of this report.

Project area

The project focuses on the Middle Loire, the area between Nevers and Angers. Along this stretch of river, the cities of Orléans and Tours are two other major urban areas.

Along the Loire there exists a series of so called *vals*: areas protected by dykes from flooding by relatively small floods. With increasing river discharges more and more *vals* will be inundated successively in a controlled way (or in an uncontrolled way in case the stability of the dykes is not sufficient). The controlled inundation of *vals* may take place by one of the following three ways:

1. by means of permanent openings in the dyke (flooding generally from the downstream side of the *val*);
2. by overtopping of prepared stretches of dyke (at such location, the dyke cover is protected to prevent erosion of the dyke); or
3. by means of an initial overtopping, followed by the erosion of an easily erodable upper part of the dyke (the '*fusible'*), which creates a large diversion capacity.

Of course *vals* can also be inundated by uncontrolled dyke overtopping or dyke breaches.

The last major floods on the Loire occurred in the 19th century (1848, 1856 and 1866). During the flood of 1856, *all* the *vals* along the middle Loire were inundated, with water depth ranging between 1 and 4 m (Ref. 5).

Today, the *vals* host a wide range of land use types: agriculture, housing, industry, transport routes, nature areas, etc.

Activities

In the framework of the project, a considerable set of documents was studied (see the list of references). These documents, together with the input of various specialists on the Loire, formed the basis for this report.

During workshops in Orleans on 28 June 2005 and on 22/23 September 2005 issues and possible solutions were discussed with EP Loire and other stakeholders. During a meeting in Karlsruhe in 2006 an oral presentation will be given.

Acknowledgements

We thank Mr. R. Thepot, Mr. N.G. Camphuis and Mr. P. Philippe for their useful suggestions and help during the project. The authors of this report remain solely responsible for the way this information was condensed and presented in this report.

Overview of the contents of this report

This chapter (1) provides the background and introduction to the study conducted. Chapter 2 of this report briefly discusses the conclusions of the Intervision Team. Chapter 3 gives an overview of the societal functions of the Loire River, the complementarities and conflicts of interest. Chapter 4 discusses the types of measures available in the context of flood management. Next, chapter 5 presents the overall flood management strategy for the Loire. Chapter 6 discusses measures that are possibly suitable for flood management along the Middle Loire. Finally, chapter 7 focuses on suggestions on how to reach a public policy for flood management in the project area.

2 The conclusions of the Intervision Team

In the framework of the 'Freude am Fluss' project, an Intervision Team visited the middle Loire in October 2004. This team drafted a report on flood protection along the Loire with conclusions and recommendations (Ref. 2, Ref. 3, Ref. 30).

This brief chapter highlights the concluding remarks of the Intervision Team, and provides comments on these remarks.

The concluding remarks of the Intervision Team (Ref. 30) are the following:

1. The river Loire is a natural system and unique European heritage which will only be scarcer in the future society. The way people live with water makes the inhabitants responsible for their own risks. Participation and communication could increase the level of awareness.
2. The Middle Loire flood management strategy is generally appropriate, especially the policy of dyke reinforcement aiming at prevention of breaches – especially in the cities – in case of major floods, which is presently undertaken by the authorities. It should include negotiated priorities.
3. The safety level of the flood protection system should be defined for the main classes of occupation in the river valley.
4. The present land planning regulation is good because it stops the increase of the potential damage, but it restricts local urban development. Intense communication preparation work could allow a sustainable development in urban zones compatible with the flood risk.
5. The flood risk communication is well organized, but in this way the emphasis lays too much on dangers and risks of the river Loire. It is recommended to commit the inhabitants in a more positive way. With the Freude am Fluss project in this respect, Authorities should include more Freude aspects in its communication strategies.
6. Proper cost/benefit analysis would increase the fundaments of decision making.
7. It would be helpful if there would be a sustainable vision over a long period of time in future of development of flood free areas beside the flood prone areas, as on the river Rhine.

It will become clear from this report that we as authors of this report largely agree with above concluding remarks by the Intervision Team. More specific comments from our side are the following:

We fully agree with remark 1. It is for good reasons that the Loire valley in 2000 was inscribed on the UNESCO World Heritage List for 'its natural and cultural properties of outstanding universal value'.

We largely agree with remark 2. Throughout the world there are few if any examples that compare to the way flood management along the Loire is realized. At the same time – as outlined in section 4.5 – it is also a very efficient concept of flood management.

The reliance on a series of *vals* is in our view the overall best choice that could have been made in the 19th century, and still is the best choice today. If at all we were to comment on this remark by the Intervision Team, we would rephrase 'generally appropriate' with 'very appropriate'.

In principle we also agree with remark 3. Such definition of flooding frequencies would help clarify which measures should be implemented in the near future. However, in the case of the Loire, establishing safety levels is in our opinion not a strict requirement for successful flood management. An alternative for establishing such safety levels could be a continuation of the current policy, aimed at better protecting urbanized *vals* when compared to other *vals*.

We have some doubts regarding remark 6 on the use of cost/benefit analysis in flood management. In our view the question how to deal with intangible benefits and intangible costs of flood management improvements gives rise to long discussions about the question what to include in the cost/benefit analysis and what not. For example, one could argue that feelings of anxiety and stress, damage to cultural historic objects, etc., all should be included as benefits of flood management improvements. The same holds for environmental aspects, which – depending on whether a negative environmental effect is expected or a positive effect – could be added to the costs or to the benefits. All in all, we suggest that because there is no clear and unambiguous definition of what should be included in the analysis and what not, too much emphasis on benefit/cost analysis is not justified.

With the report by the Intervision Team as a starting point and foundation, Etablissement Public Loire (EP Loire) wishes to obtain a more specific advice on how to proceed with flood management. Therefore, EP Loire asked Delft Hydraulics to study the issues and draft a concise report, and this report is the result of that activity.

3 Brief overview of functions of the Loire

3.1 Overview of functions of the river and the river bed

General

France has a long history in water management and water resources development. Many water management projects were planned and implemented to serve flood management, navigation, hydropower generation, water supply and other purposes, in particular for regional economic development. Hydrological regimes in watersheds were changed significantly by the construction of dams, dykes and channels. Development of drainage systems and other land-use changes influenced the runoff pattern. Watershed alterations promoted human welfare, and policy makers saw opportunities to use water development as an engine for economic prosperity. The achievements were impressive: improved safety against flooding, expanded navigation on canals and rivers, availability of floodplains for agricultural and commercial uses, hydroelectric power production, etc.

There is, however, a flip-side to the coin. In many rivers that are highly controlled, including the Middle Loire, the natural floodplains were reduced in size due to the construction of dykes, reducing the flow capacity during floods. The remaining areas flooded regularly and have slowly been rising, because of silt deposition. Sand and gravel mining made the low flow channel deeper, leading to lower groundwater levels. Plants and animal species have slowly disappeared. Wetlands decreased gradually as land was converted to agricultural use. However, even to-day the Loire still contain extensive and important ecological and landscape values. This is certainly truth when compared to many other rivers in Europe.

Transport of water, ice and sediment

The most obvious, but (maybe therefore) also the most frequently overlooked function of rivers to society is the transport of water, ice and sediment. High interests are at stake to manage (control) these transport functions. The main instruments used in flood management in the Loire Basin are the construction of dykes, diversions and reservoirs. Starting downstream Nevers, dykes protect the former floodplain from inundation over a substantial stretch of the river, up to downstream of Angers. Navigation, hydroelectric power generation, water supply and recreation also benefited from reservoir construction. Sand mining in the low flow channel at best contributes to the reduction of flood stages.

Water is a source for prosperity but at the same time a source of concern. Floods in the past serve to refresh human's memory as to how dangerous and damaging a river can be. The damages caused by the floods in the 19th century were high. Flood management works (mainly reservoirs, diversions and dykes) helped in limiting damages, but the question should be raised as to how to effectively reduce the threat of future damage while supporting future (economic) development in the affected areas and areas outside the flood prone area.

An important issue for flood management is what floods can be expected, now and in the future. Of key importance is knowledge about the river system and its 'natural' development and about the effect of human interference on this system, such as construction of river works and land use changes. Insight into meteorological events leading to floods is important, as well as possible climate changes. Direct hydrologic and hydraulic consequences need to be taken into account, but also indirect effects on morphology, which may in the long run have a negative effect on the discharge capacity and the stability of the dykes. For future maintenance of the required level of flood protection, insight in the morphologic behaviour of rivers is essential.

Potentially, a number of options is available to reduce flood probabilities. These may have a major or minor effect, be expensive or relatively inexpensive, be in line or not in line with the current policy, and be more or less socially acceptable. Possible measures include raising or strengthening dykes, set-back of dykes, dredging of the main and/or side channels, the partly lowering of floodplains, and the construction of upstream reservoirs. In order to bring about sustainable protection against flooding, measures in the upstream and downstream part of the entire river need to be tuned to each other.

Housing

The Middle Loire river and the *vals* in this area cover an area of 150,000 hectares in total. In this area a total of 300,000 people live in a total of 240 communities (Ref. 5). This total includes the larger cities (like Orléans), that have the highest flooding safety level along the river. This large number of inhabitants underlines the importance of housing as one of the functions of the river bed for society. An obvious preference of the inhabitants of the various *vals* is that they would like the *val* they live in to have a relatively small, if not the smallest, probability of flooding when compared to other *vals*.

Agriculture

Agriculture is the leading commercial user of the floodplains along the Loire. Some 85,000 of the total 150,000 ha of floodplain is used for agricultural production. Some ten percent of this agricultural area is used for specialized, high value cultures. This includes horticulture, orchards, etc. Due to the fertile soils, the yield in well-drained floodplains is usually substantially higher than in the upland areas.

Industry

Mainly in the direct vicinity of towns, a small but highly valuable portion of the floodplain is occupied by industries. Traditionally, such locations offer industry the advantage of immediate access to inland water transport to bring in raw materials and transport finished products, and immediate access to cooling and process water. Nowadays, however, most of the 13.600 enterprises in the floodplain (500 of which have more than 20 employees) area are not directly linked to the river.

In the recent past, sand and gravel mining took place in the low flow channel. At various locations, especially near urban centres, this activity resulted in substantial (1 to 1.5 m, Ref. 5) lowering of the channel bed, with a noticeable effect on water levels in the river.

This does not necessarily imply only a positive effect on flood management. In cases where such flood stage reduction occurs at a diversion to a *val* that is supposed to be activated once river reaches a certain water level, this effect on flood stages implies that the diversion is activated at a later and possibly undesirable moment during the flood wave at the river. In addition, sand and gravel mining caused a strong reduction in the formation of secondary channels, with negative effects on the ecology and with no longer eroded vegetation an increase in hydraulic roughness, leading in turn to higher flood stages. Finally, deepening of the low flow channel by mining has a negative impact on the stability of adjacent dykes.

Currently such large-scale mining of sand and gravel is no longer continued.

Navigation

Today, the river is no longer used for commercial navigation. One reason for this is that the water depth in the low flow season is generally not sufficient for vessels to safely pass. This is the reason that canals like the Canal Latéral à la Loire were developed. For recreational navigation, the Loire has only recently been 'rediscovered': new initiatives were launched to attract more recreational vessels to the river.

Environment

Originally, large wetland areas were found in the Loire Basin. Wetlands are unique links between land and water. Some wetlands are almost continuously under water, whereas others may be flooded for only a short period. This means an impressive variety of wetlands and their specific habitat types and functions. Through these special conditions, wetlands are among the most biologically productive natural ecosystems in the world. For this reason, wetlands are recognized as vital to the survival of various animals and plants, including threatened and endangered species.

Furthermore, wetlands play a role in the reduction of peak water levels during smaller flood events (flood events that occur every few years), because of their capability to store floodwater and release it slowly. We expect that in the case of large events like the floods in the 19th century, the effect of wetlands on high water levels is marginal because wetlands were saturated by rainfall or already flooded in an earlier stage.

Starting centuries ago the area of wetlands decreased gradually. Wetlands were converted to agricultural land and to a smaller extent converted for residential and industrial use. Currently, wetlands account for only a relatively small percentage (estimates amount to roughly 10%) of the floodplain in the Loire Basin. Compared to Western European conditions, this is still a fairly large proportion; along the Rhine branches in the Netherlands only 2% of wetlands remain today. Since the early 1970's the value of wetlands is recognized more and more, resulting in laws and regulations for protection of the remaining wetlands. In future, the number and quality of the wetlands should even increase.

Given the frequency in which the *vals* are flooded, we suspect that the ecosystem in these refuges are more similar to 'dry-land' (upland) ecosystems, than to the ecosystems of pristine wetlands. Therefore, in this report we do not consider such dyked refuges when discussing riverine wetlands.

Of the total 150 thousand hectares of floodplains, some 36 thousand hectares are earmarked as either having a potential for ecological values or actually recognized as ecological values.

Recreation

Wetlands, storage lakes, and the river itself provide considerable opportunities for recreation. Popular activities are hunting, fishing, camping, boating, sight-seeing and bird-watching. River-related recreation is of considerable importance for the economy of local communities.

In recent years, several initiatives have been launched to stimulate recreational use of the river and the river corridor, which to date is considered only modest.

Historical and cultural resources

Floodplains along the Loire contain numerous archeological and historic sites. These sites include historic architectural treasures like the many castles, forts, quarries, and burial sites. They also include engineering features and structures like the aquaduct at Briare (1896) that leads the Canal de Briare over the Loire towards the Canal Latéral à la Loire. As a reflection of its importance, the Loire valley in 2000 was inscribed on the UNESCO World Heritage List for 'its natural and cultural properties of outstanding universal value'. Construction activities in and along the river, streambank erosion and extreme floods have the potential to affect these values.

Hydropower generation

The reservoirs in the Loire basin serve flood protection and the storage of water for use in the dry summer season. As an important side benefit, the reservoirs allow the generation of hydroelectric power. It is interesting to note that in the 60's and 70's of the previous century the focus of water management in the Loire basin was on water shortage conditions.

Municipal and industrial water supply

The river is a source of water for municipal and industrial use: drinking water, processing and cooling water, and irrigation. The amount of water extracted for these purposes is unknown but is expected to be small when compared with the river discharge (except during prolonged dry spells). As long as the return flow from this water use (after proper treatment) is drained back to the rivers, this water use can be considered of minor importance in the overall water balance of the rivers.

Disposal of waste and cooling water

After industrial or domestic use, the water is, in most cases after treatment, discharged into the river. This can have locally a negative effect but the water quality of the rivers is generally classified as good. Four power plants use water from the Loire, but each of these plants uses cooling towers on a permanent basis.

These power plants are located at Belleville, Dampierre en Burly, St Laurent des Eaux (close to Beaugency) and at Avoine between Bourgueil and Chinon. The use of cooling towers avoids discharging water back into the river at a higher temperature.

3.2 Complementarities and Conflicts of Interest

Interactions among user groups

Some of the uses and users of the river listed above, but relatively few, have no effect at all on each other, even if they take place on the same river. Some have very large effects, ranging from total interdependence to mutual exclusion. In general, there is a range of degrees of positive and or negative interactions. The effect that one type of activity will have on another is determined by how and where those activities are designed and implemented. For example, an industrial plant discharging chemical effluent into the river can have a very negative effect on the riverine environment, but the same plant, if it treats its effluent completely or does not use the river for disposal may have no negative environmental effects. Similarly, soil conservation measures in an upper watershed may have positive effects on farmers downstream if erosion and sedimentation are reduced, whereas environmental protection activities that take the form of limiting agricultural practices (in particular related to the use of pesticides, herbicides and fertilizers) or prohibiting cultivation of certain areas may have a negative effect on the farmers involved.

In general, the argument developed briefly here is an important one in the *process* of developing a river management plan. It is that the interactions among activities in and along the river can be made more compatible and less mutually damaging when they are well planned and when the users of the river have negotiated among themselves about their activities. Where damages are unavoidable, conflicts can be minimized if compensation is agreed upon, preferably in advance.

Table 3-1 provides a rough indication of the ranges of some of the more potentially conflict-causing interactions. The table is to be read so that the columns headings give the activities that affect the activities shown in the rows. Scores of +1 and +2 indicate complementarities and positive interactions, 0 is neutral and -1 and -2 are competing or negative. The scoring is generalized, but the point is that these numbers can be pushed towards the positive side of the ranges, representing fewer conflicts and more positive interactions when planning is done.

There are other important uses of water that are not mentioned in Table 3-1, because the interactions are obvious and straightforward. Supplying municipal and domestic public water systems is one. Hydropower is another. They are left out for the clarity of the table.

Currently, the following two **main** issues are at stake: environmental protection and flood protection. Developments in flood management are of great importance for the protection of the population and economic activities. Economic development can be the result of improvements made in flood management, but can also be stimulated by increased tourism resulting from improved environmental conditions. In this line of reasoning, economic development is not an issue in itself.

It goes without saying that there are other important issues related to the various functions of the river (recreation, drinking water supply, hydropower generation, sediment mining, etc.). We feel these issues are currently not the **main** issues.

Table 3-1 Interactions among potentially conflicting river activities

	Scoring the effect of:					
	Flood management structures *)	Agriculture in the floodplain	Industry in or near the floodplain	River- based recreation	Historical & cultural preservation	Environmental protection
on flood management		+1 to -1	0	0 to -1	+1 to -1	+1 to -2
on floodplain agriculture	+2 to +1		0 to -1	0 to -1	+1 to -1	+1 to -2
on industry in or near floodplain	+2	+1 to 0		0	0 to -1	0 to -2
on river-based recreation	+1 to -1	0 to -1	0 to -2		+1 to -1	+2 to +1
on historical & cultural property	+2 to -2	0 to -1	0 to -2	+1 to 0		+2 to 0
on condition of river ecology	0 to -2	+1 to -1	0 to -2	+1 to -1	+2 to 0	

key: +2 = necessary, or highly complementary and positive effects;
+1 = generally positive;
0 = neutral: no particular advantage nor conflict (small interaction);
-1 = implementation of one means a restriction or damage to the other; and
-2 = mutually exclusive and therefore completely in competition, or highly damaging.

*) Scores in the column of effects of flood management structures relates to structures that reduce the frequency that a particular piece of land is flooded.

Table 3-1 indicates direct interactions. Indirect interactions are not listed, although they may also be very important. For instance, the effect of industrial development in or near the floodplain on river ecology is scored at 0 to -2, because industrial effects may vary between environmentally neutral, moderately polluting to so badly polluting that they destroy habitats. Industry is rarely directly complementary or positive to environmental concerns in floodplains. However, if the commitment is made to use some of the revenues, through taxes or other means, generated by industrial development to enhance environmental conditions (e.g. using some funds to establish conservation areas) then the indirect effects of the industrial development on the environment may be positive (score +1). Such indirect effects can be important in negotiations among user groups.

The conflict over flood protection and changes in preferences over time

At this stage, a clear decision on how to proceed with flood management along the Middle Loire is still awaited. There seems to be an '*impasse'* (stalemate) over the degree and extent of flood management that should be provided. There could be many reasons to explain this '*impasse'*, including potential conflicts of interests as well as political manoeuvring at different levels of government (State, Régions, Departments, etc.).

If there are more technical arguments in this stalemate, these arguments can be anywhere between two extremes: those who feel that flood protection levels should be raised significantly, including the option to increasing the heights of dykes all along the river; and those who believe improvements in flood management are not a good way to spend the taxpayers' money. In the case of the Middle Loire, arguments seem to range between strengthening the dykes and development of new reservoirs and on the other hand a more global policy of flood damage mitigation. Arguments for the first option are largely that societal and economic development in the region, particularly housing, farming and industry, will greatly be served by improved protection from floods. The arguments for the latter are primarily that floodplain protection and compensation for flood damages are expensive and that there is no compelling reason for the nation to embark on such investments. Floodplain protection measures are also frequently not environment-friendly (for example the construction of reservoirs).

Both arguments are rational, and their proponents are generally strong in their beliefs. Furthermore, preferences of interest groups change over time, and the policy climate changes and evolves. Environmental groups have far more influence at present than they did 30 years ago. In some cases, flood management measures are complementary to environmental interests, particularly when the measures involve setting back dykes, lowering floodplains or making parallel, unregulated channels or dykes that protect or encourage the re-establishment of certain kinds of habitat. In general, however, environmental interests favour less engineering and lower rather than higher dykes. River dredging and thinning of floodplain forests is highly controversial. This puts environmental groups in strong conflict with those advocating floodplain development.

Given the existing flood management infrastructure along the Middle Loire, floods that cause extensive damage are a relatively rare event. This makes communication with stakeholders about (improved) flood management difficult. To many stakeholders, floods seem a thing of the past (the last major floods occurred in the 19th century), and it proves difficult for flood managers to raise sufficient attention to this topic. Such attention drastically changes immediately after a serious flood. One could argue that – unfortunately – flood management is 'event driven'. Immediately after a (serious) flood, there is much more willingness by stakeholders and (regional and national) politics to invest in improvements. Also historic flood management along the Loire serves as prove that flood management to date is largely event driven: the flood of 1856 gave rise to important improvements in flood management.

The role of the public authorities in resolving conflicts

Clearly, there is a role for the public authorities to address the issue of flood management and to resolve conflicts between different interest groups. Given the linkages described in this chapter, flood management exceeds the level of individual citizens, communities and even regions. The minimum organizational level to address flood management is the river basin level, as reflected in the mission statement of EP Loire. One could argue that even the national level is the appropriate level, especially if funding for flood management is sought from the central government.

In practice, this flood management task will require:

- extensive data collection, much of which is or has been done along the Middle Loire;
- expert analyses of the implications of different measures to manage flooding and different mixes of land use, with different degrees of flood protection in different areas, much of which is also done at present, but which should be even broader in scope to allow for long-term basin-wide planning;
- presentation of the results of the analyses in ways that are accessible and understandable to stakeholders and decision-makers, currently a major effort of EP Loire, the Water Agency and DIREN, which should be supported and extended;
- methods to allow debate, negotiation and compromises among stakeholders;
- development plans which include decisions about what will be done where, minimizing conflicts as much as possible and possibly providing compensations for users whose interests are damaged; and
- implementation of plans that includes sensible incentives, clear roles for the public and private sectors and plans for financing the activities.

Suggestions for resolving conflicts related to flood management along the Middle Loire are presented in the following chapters.

4 Types of measures available for flood management

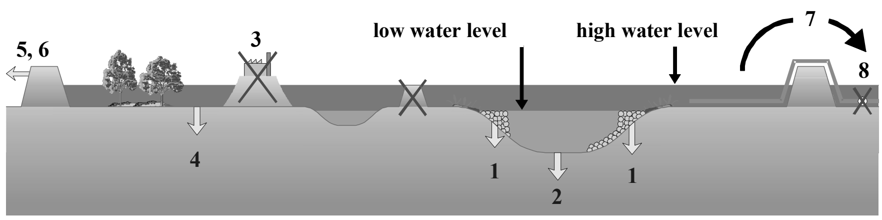
4.1 Introduction

This chapter provides an overview of many (if not most) types of practical measures that can theoretically be applied in the framework of flood management. A starting point here is that flood management is ultimately aimed at mitigating flood damages, so not only measures should be considered that reduce the probability of flooding, but also measures that are aimed at reducing flood damages.

Another starting point is that French Law (1807) states that everybody is responsible for his or her protection against floods. In line with this principle, for example, the government makes available flood risk maps in order to inform the public about the wisdom to settle at a specific location along a river.

Theoretically, an overview of types of measures should also include exotic measures like for example constructing underground tunnels to divert water from upstream areas directly to the sea, or ideas to ensure that heavy rains do not occur over the catchment area by means of cloud seeding (spraying chemicals on clouds). However, we do not consider such types of measures as *practical*. It could easily be shown that the technical or economic feasibility of such types of measures is very low. Instead, we limit ourselves here to what we consider measures that might be practical in the context of flood management along the Loire.

This overview is initially provided without comments on the feasibility for application for flood management along the Loire. Such comments follow in chapter 5 of this report.



1 - lowering of groins
2 - deepening low flow channel
3 - removing hydraulic obstacles
4 - lowering flood plains
5 - locally setting back dikes
6 - setting back dikes on a large scale
7 - detention reservoir
8 - reduction lateral inflow

Figure 4-1 Schematic representation of some types of structural measures aimed at widening and deepening a river, including detention (which is equivalent to the storage of water in *vals* along the Loire).

In flood management analysis, generally a distinction is made between structural and non-structural measures. Many definitions of these types of measures are used. In this report non-structural measures are defined as measures to modify the susceptibility to flooding, such as watershed management, flood proofing techniques, flood warning, land-use planning and regulations, etc. Structural measures are defined as measures such as dams, reservoirs, dykes, bypasses, detention ponds, removal of hydraulic obstacles, etc. Figure 4-1 illustrates a variety of (not all) structural measures.

4.2 Brief description of non-structural measures

In the category of non-structural measures, the following types of measures are available:

Measures that focus on the reduction of damage to existing values:

1. *Removing values that are susceptible to flood damage* from the *vals*. This could include houses, farms, enterprises, roads and railroads. This obviously is a drastic measure to reduce flood damage. By removing a specific value from the *val*, a future inundation of the *val* can no longer cause damage at that location. Generally, the cost of such removal is very high when compared to the Net Present Value (NPV) of the flood damage reduction. It is noted that strictly speaking the removal of buildings near inlet structures, which has the objective to guarantee the hydraulic performance of the inlet structure, is not part of this type of measure. Reason is that in this case the goal is not necessarily reduction of damage, but ensuring the hydraulic performance of the inlet instead.

2. *Flood proofing of existing buildings* in the *vals*, including houses, farm buildings and enterprises. Flood proofing of existing buildings reduces damage incurred during inundation of the *vals*. Two types of flood proofing are being distinguished: dry flood proofing and wet flood proofing. Dry proofing aims at keeping the water out of a building as good as possible, including closing ventilation openings in basements, blocking water from flowing in through doors and windows, etc. It is noted that dry proofing is only wise in case of well-built houses. Many of the about 2,000 victims during the 1953 flood disaster in the Netherlands were killed because they tried to keep the water out of their home, and the resulting pressure on the walls caused the collapse of these walls and thereby the entire house, trapping the people inside. Wet flood proofing, on the other hand, does not prevent water from flowing into a building, but instead aims at reducing damage. Examples of wet flood proofing include replacing wooden floors with stone floors, widening staircases to upstairs floors in order to easily move furniture up, replacing gypsum board walls with brick walls, replacing wooden kitchen cabinets with plastic cabinets, etc. Generally speaking, flood proofing of *existing* buildings requires an investment that by far exceeds the NPV of damage reduction. For a simple example, see Annex B of this report. All the above has to do with minimizing flood damage to properties. A completely different category is minimizing pollution after for example chemical plants are flooded. Such flood proofing needs to be considered on a case by case basis.

3. *Flood proofing distribution networks* of utilities, including distribution networks for electricity, drinking water, sewerage, telephone, cable TV, etc. Flood proofing distribution networks generally implies that distribution stations are either sealed to prevent that during an inundation water seeps in, or putting installations above the maximum inundation level. In particular for electricity and telephone networks this may be an important option to reduce flood damages. This is explained by the fact that the flooding of an individual installation may imply the outage of the system in a larger area, which may cause substantial damage (in case of a power failure) or create hazards (in case the telephone system fails). For example, if an electricity transformer station is out of operation due to flooding, a large area including buildings that are not flooded at all may loose their power supply. This in turn may cause substantial damage, which is only indirectly caused by the flood. For example, freezers may no longer work, causing its contents to melt, and the heating systems of houses may fail in winter, forcing inhabitants to stay in hotels instead of at home. Also, enterprises generally can not function without power supply. The benefit/cost-ratio of elevating such installation above the maximum flood level often is generally quite high. To a lesser extent, this may also be true for drinking water, telephone and cable TV networks. We doubt whether this also will be the case for sewerage utilities: such systems will most likely be flooded anyway, so failure of say a pumping station may not cause much additional damage.

4. *Providing flood warnings*, so that values might be best protected in case the flooding of *vals* is forecasted. A flood early warning system that informs inhabitants and other users of the *vals* of the possibility that their area will be inundated, is of great importance to minimize the loss of life due to flooding, as well as minimizing flood damage. Unlike with flooding from the sea, flooding from rivers like the Loire generally leaves sufficient time for (1) safeguarding important items (at least personal items, important papers, jewellery, etc.) and (2) actually move people out of the flood prone area. A condition for this to be successful is obviously a timely and accurate warning about upcoming events. With modern field measuring techniques (including weather radar) and means of communication (internet, mobile telephone), flood warning systems can be highly reliable.

5. *Improve crisis management plans, including evacuation plans*, so that the population, other users of the *vals* and local authorities (municipalities, fire brigade, police, ambulances, etc.) are better prepared in case *vals* need to be evacuated when an inundation is forecasted. The benefits of having such plans available (and regularly tested in practice!) is obvious: they smoothen an evacuation process, minimize damages, minimize risks of traffic accidents, and minimize stress and anxiety.

6. *Improve awareness* amongst the people that live and work in the *vals* for the possibility of floods to occur, in order to reduce potential flood damages, smoothen evacuations and reduce overall feelings of stress and anxiety in case of an actual flood. Many options exist to improve such awareness, including house-to-house distributed information bulletins, discussions in schools, TV-programs, etc.

7. *Improving the management of the watersheds*, including the development of forest in the watershed area, in order to reduce flood peaks. This type of measures is one that is quite often misunderstood. The idea is that by re-introducing forest in the watershed area, in this case the area upstream of Nevers, the increased size of a healthy forest floor in the watershed will better function as a 'sponge' during rain storms, which in turn will reduce the peak river flow. Most hydrologists agree that this sponge function only has a measurable effect for events that occur more often than say once per 25 years on average. So for smaller events (the events that occur relatively often), there is a noticeable effect of upstream forests on flood peaks. For more severe events (events that occur less often) the effect of upstream forests on flood peaks is generally insignificant. Reason is that during such extreme events – during which it rains for days on end, possibly combined with a rapidly melting snow pack – the sponge either is already full. With flood protection levels along the Loire having a safety level of roughly 1/50 per year or better, it is clear that watershed management has *no* effects on the floods that are *really* important in flood management. This conclusions is not popular amongst large groups of people. The scientific facts are difficult to deny, though. Extensive research efforts in this topic of a general nature (Ref. 26 and 27) and for specific rivers like the Mississippi River (Ref. 28 and 29), and Rhine and Meuse rivers (Ref. 24 and 25) – all reach similar conclusions. This is of course not to say that re-afforestation of the catchment area can be highly desirable, but it is a widespread misunderstanding that it would make a substantial difference on peak flows for rivers like the Loire.

Measures that focus on minimizing damage related to future developments:

8. *Installing a ban on new developments* in the *vals*, including new houses, new farm buildings and new enterprises. Not adding new buildings in the *vals* would stop a gradual increase in the potential flood damage. This type of measure is often advocated in the past, and this is also the case along the Loire. Too often, though, implementation of such ban proves hard to realize when time passes. Local communities generally object to such measures because in their view it threatens social aspects (housing for young families) and economy of these communities. An alternative to this measure could be installing a ban on only large-scale developments in the *vals*, like large-scale urban expansion, large-scale development of industrial sites, large-scale development of green houses, etc. Small-scale developments (assuming that this can be defined in an effective way) could be allowed under such ruling.

9. *Flood proofing new buildings* in the *vals*, including new houses, new farm buildings and new enterprises. In above point 2) it was concluded that flood proofing of existing buildings generally requires investments that by far exceeds the NPV of damage reduction. For new buildings this may be different. The design of future buildings could relatively easily be changed to provide such flood proofing, and the additional costs for flood proofing might well outweigh the NPV of the expected annual damage due to flooding. Possible measures could include raising the floor level of the building to a higher elevation, installing meters for utilities at a higher floor level, building stone floors instead of wooden floors, etc. Such measures could be stimulated by either insurance companies (by charging a lower premiums) or by the government. There are already regulations in place regarding flood proofing of new buildings in the *vals* along Loire.

4.3 Brief description of structural (infrastructure) measures

In the category of structural measures, the following types of measures are available:

Measures aimed at reducing the flood flows:

10. *Construction of flood management reservoirs upstream of the Middle Loire*, aimed at reducing peak flows in the river. The construction of additional flood storage reservoirs located in the catchment area upstream of Nevers result in a lower probability that extreme discharges will reach the Middle Loire. Actually, there are two ways to formulate the effect of such reservoirs development: (1) a certain peak flow in the Middle Loire will have a lower probability of occurrence, or (2) an event with a certain probability of occurrence will be reduced in size.

11. *Construction of detention ponds (in fact, additional vals) upstream of the Middle Loire*, aimed at 'shaving off' the peak of the flood wave in the river. Additional *vals* upstream of the Middle Loire could – just like upstream flood management reservoirs – reduce peak flows, as schematically presented in Figure 4-2.

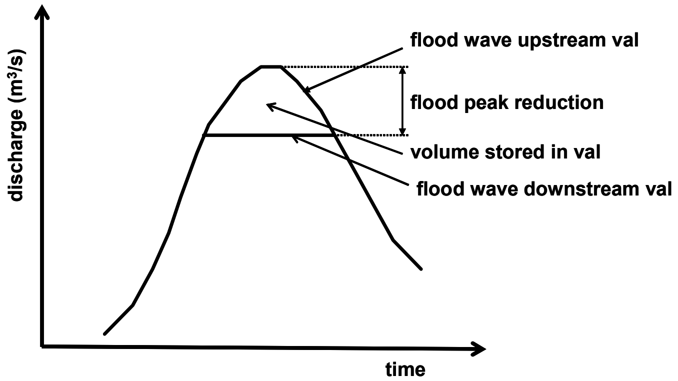


Figure 4-2 Principle of how a *val* van reduce downstream peak flows by shaving off the peak of a river flood wave.

Measures aimed at better accommodating flood flows:

12. *Heigthening and strengthening existing dykes* along the Middle Loire. Higher and stronger dykes will reduce the frequency of inundation of the *vals*, and thereby reduce the expected annual flood damage. Higher dykes will also cause higher flood stages in the river. The question is whether or not the many bridges over the Loire can safely handle higher flood stages. In particular the old, historic bridges could be a limiting factor in this, effectively making it impossible to substantially heighten dykes along large stretches of the river.

13. *Setting dykes further away from the low flow channel*. In case dykes would be moved away further away from the low flow channel, more water can be transported between the dykes. This, in turn, would reduce the frequency of inundation of the *vals*, but it would also lead to a reduction of the amount of water that can be stored in the *vals*. The net effect of this might be negative, given the fact how effective peak storage in *vals* is from a hydraulic point of view.

14. *Creation of additional detention ponds (vals) along the Middle Loire*. This measure is the same as measure 11; the only difference is that here we look at *vals* along the Middle Loire; not just upstream. Assuming there is space available, the development of additional *vals* could result in an increased capacity to reduce peak flows further downstream. Such space, however, seems to be not available, at least not at a large scale.

15. Changing the longitudinal dyke profile around *vals* or part of *vals* to *horizontal dykes*. The dykes along the Loire *vals* generally follow the slope of the river. This implies that there is a clear upper limit to the amount of water that can be stored in a particular *val*. If the water level at the downstream side of a *val* exceeds the height of the dyke, the water flows over the dyke back into the river. If, however, the height of the dykes around a *val* would be increased on the downstream side of the *val* in such a way that the entire dyke around a *val* would be horizontal instead of having a slope as the river slope, than the amount of water that can be stored in a *val* is the highest, provided of course that the inlet structure is located on the upstream side of the *val*. In line with the principle laid down in Figure 4-3, this could possibly imply an interesting flood stage reduction further downstream. However, the relatively steep slope of the river will most likely limit the large scale application of this type of measure because it would imply a substantial heightening of the dyke at the downstream side of the *val*. A negative aspect of this type of measure is, of course, that given the presence of houses in virtually each of the *vals*, the flood damage in the *val* most probably will increase when more water is stored in the *val*: inundation depths will increase, leading to more damage in the *val*.

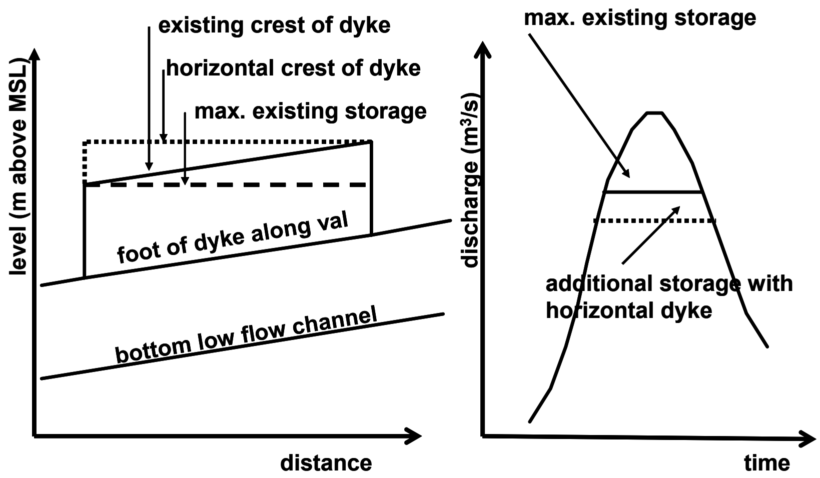


Figure 4-3 Schematic representation how horizontal dykes around *vals* could increase the storage capacity of *vals* when compared to an existing situation in which the dykes follow the slope of the river.

16. Dividing existing *vals* into smaller compartments (*compartimentalisation*) by means of additional dykes. Such compartments could better protect villages, industrial plants, etc. Compartment dykes could safeguard high value areas in the *val* from flooding during intermediate floods, but during extreme floods these compartments would also flood.

17. *Closing vals that are permanently open* to the low flow channel, to better shave the peak of the flood wave in the river. Some of the *vals* have a permanent opening to the low flow channel. Such opening is generally located at the downstream side of the *val*.

This permanent opening leads to a partial filling of the *val* already before the peak of the river flood wave is reached. If this opening was closed and replaced by an inlet structure that only diverts water during the peak of the river flow, the storage in the *val* would be used more effectively because in such situation the entire storage volume in the *val* can be used to shave off the peak of the flood wave. It is recognized that such closure would increase flood stages for smaller floods, but *potentially* this could be acceptable given the height of the existing dykes (but is already known that the closure of *vals* upstream of Gien would increase flood stages at Gien substantially, and the same is already known for the closure of *vals* upstream of the spillway in Blois).

18. *Removal of hydraulic obstacles* from the river bed between the dykes. Removal of obstacles results in a lowering of the water level, which in turn reduces the frequency of inundation of *vals*. Such obstacles might include a wide variety of objects, including bridge ramps, (old) buildings in the area between the dyke and the low flow channel, and buildings located near inlet structures that hamper the flow of water during the use of the inlet, etc. It is recognized that the relatively steep slope of the river limits the water level effect of the removal of obstacles between the dyke and the low flow channel.

19. *Development of side channels or excavation of the floodplain*. Excavation of the flood plain is over a larger area when compared to the development of a side channel. Provided there is sufficient space available between the low flow channel and the dyke, the excavation of side channels could lead to a reduction of flood stages, or, alternatively, a reduction in the frequency that *vals* will be inundated. The same can be said about the excavation of large areas in the strip of land between the dykes and the low flow channel. When developing side channels or excavating the flood plain over a larger area, care should be taken that the stability of dykes is not compromised. When compared to a general excavation of the floodplain, the excavation of side channels is generally more efficient: less material has to be excavated to reach a comparable water level reduction. Development of side channels and the excavation of floodplains could be very well combined with the developments of wetlands, which is of importance for the riverine ecosystem as well as recreation purposes. Possibly, the excavated material could be dumped in the low flow channel to compensate for the historic large scale sediment mining that took place along the Loire.

20. Development of so called '*green rivers*' along sections of the Middle Loire. This would entail de construction of two parallel dykes over a considerable length along the river. The distance between these dykes could be in the range of several hundred meters. Only during extreme events this green river carries water, thereby reducing flood stages along the river. To this end, there should be an inlet structure on the upstream side of the green river, and on the downstream side there should be a discharge sluice. Because the green river is only rarely used, land-use in the green river would certainly allow agriculture. It could be considered to actually use such green river more often than strictly necessary from a flood management point of view. Along the Rhine river in Germany this is practised for a number of detention ponds (for example polder Altenheim, where they call such flooding 'ecological flooding'). Flooding of (uninhabited) detention ponds or green rivers not only serves the ecosystem in these areas, but also serves as a reminder about the risk of flooding for the population living and working along the river.

4.4 Maintenance of existing flood management infrastructure

Above structural (infrastructure) measures assume that the existing infrastructure functions properly and is maintained well. Often, this is not the case, and this also is the situation along the Middle Loire. Therefore, the following types of measures are added to this overview:

21. Carry out *works to guarantee the stability of the existing dykes*. Erosion of the low flow channel might have undermined the outer slope of a dyke, which could lead to a collapse of the dyke during high river stages. Revetments are needed in such case to stabilize the dyke. Other examples are damage to the slopes due to grazing cattle, which requires repair works. Trees that have grown in the dyke slopes in the recent decades might call for the removal of such trees because they could be the cause of erosion of the dyke. Subsidence might call for heightening of the dyke since it no longer meets the design standards.

22. Carry out *works to guarantee that the inflow works of the vals function properly*. Several reasons might be the cause that the water levels at the inflow works of *vals* no longer meet the design criteria. Examples include that the mining of sand and gravel from the low flow channel reduces water levels. Water levels might be higher because of uncontrolled development of vegetation in the river bed. Either the cause of the change in water level can be addressed (for example: removal of forest growth from the river bed), or the inflow structure can be adapted. If, for example, sand mining has resulted in too low water levels at an inflow point, the diversion could be lowered to guarantee that the *val* is inundated when required and not too late. Another element related to the proper functioning of inlet structures is that houses have been developed in the *vals* on locations where the hydraulic functioning of inlets is compromised. For the proper functioning of the inlet structure, such buildings may need to be removed.

23. *Maintenance of the low flow channel and the area between the dyke and the low flow channel*. In case the low flow channel accumulates sediments, maintenance dredging is required to avoid effect on flood stages. Also, thinning of uncontrolled forest growth is an important – but often quite controversial – maintenance activity. If such forest is not regularly thinned or completely removed, this may have a considerable impact on flood water levels. Finally, the gradual sedimentation of the area between the dyke and low flow channel might call for maintenance work in which such deposits are removed.

4.5 Efficiency of various types of structural measures

Definition of the efficiency of structural measures

The efficiency of river engineering measures (structural measures) is defined as the water level effect of a measure, divided by the costs of the measures.

For the costs of measures the Net Present Value should be used, including not only construction costs, but also operation and maintenance costs.

The water level effect can be expressed in the vertical effect of a measure (in meters or centimetres), like for example the maximum difference in water level at a certain location between the situation before after implementation of the measure. Given differences in water level effects of various types of measures, our experience is that is better to express the water level effect in square meters, which is an integration of the vertical effect and the length over which a vertical effect occurs.

Water level effect of structural measures

To give a general description of the water level effect of structural measures, it is important to know to what level peak attenuation is important. Peak attenuation is defined as the amount of dampening of a flood wave during its way in the downstream direction of a river. Peak attenuation of a flood wave is regularly measured in comparison with water levels associated to a steady state flow which is equal to the peak flow of the flood wave.

In case peak attenuation is small or negligible, like for example on the Rhine branches in the Netherlands (only 5 to 10 cm on each on the 3 branches Waal, Nederrijn and IJssel, which are each about 100 km in length), the water level effect of measures that widen or deepen the river is highest at the location of the measure and gradually reduces to zero in an upstream direction (backwater effect).

In case peak attenuation is considerable, like for example on the Meuse river but also on the Middle Loire, river widening or deepening reduces flood stages at the location of the measure and upstream of the measure, but may also cause a *slight increase* of flood stages downstream of the measure. This hydraulic phenomenon can not be avoided, unless of course other measures further downstream are also taken. In particular the downstream increase in water levels should not be forgotten in flood management analysis because it may lead to unacceptable situations downstream of measures considered.

Efficiency of structural measures along the Rhine and Meuse, and relevance for the Loire

Below information on the efficiency of various types of structural river widening and river deepening measures is based on extensive and detailed feasibility studies for the Rhine and Meuse rivers in the Netherlands. Given the similarities with the Middle Loire, we are convinced that the overall conclusions for the Rhine and Meuse are also valid for the Middle Loire.

Based on a detailed evaluation of some 700 individual potential projects for the Rhine and some 200 for the Meuse Rivers in recent years, the following overall picture emerges regarding the efficiency of various types of measures. It is noted, however, that within a single group of measures there can be a large variation in the efficiency ranking.

1. The type of structural measure with the highest efficiency is the construction of detention basins along the river, comparable to the *vals* along the Loire. Other types of possible measures along the Rhine and Meuse have a considerably smaller efficiency rating.

Reason is that the development of detention areas is the *only* type of measure that creates a water level reduction *downstream* of the location of the measure. All other types of measures (setting back dykes, removal of obstacles, excavation of the river banks, etc.) only bring the water level down upstream of the measure, and (in case peak attenuation is important) push the water level slightly up downstream of the measure. The *vals* along the Loire that primarily store water (rather than discharge water) can be considered as detention ponds.

2. The second group in efficiency ranking is composed of the following types of measures: setting back dykes, development of green rivers, and lowering of groins. The *vals* along the Loire that not only store water but also discharge water (and deliver it back to the river further downstream) could be compared with what are called green rivers along the Rhine and Meuse.

3. The third group in efficiency ranking is composed of the removal of hydraulic obstacles (for example bridge ramps, old brick factories on flood free mounds, ferry ramps, etc.). The efficiency of this group is relatively low, often also because polluted material has to be removed, which is expensive.

4. Lowest in the ranking of efficiency is the excavation of river banks. There are two reasons to explain this: (1) the costs are high because large volumes of material need to be excavated; and (2) the water level effect of such lowering of the river bed is relatively small.

Consequences for the Middle Loire

Based on the above described experience gained for the Rhine and Meuse, it can be concluded that the use of *vals* along the Loire is in essence the most efficient structural measure in flood management. Other measures, including the closing and heightening of dykes over their full length, are less efficient: the Net Present Value of such alternatives is expected to be considerably higher. This underlines the wisdom of the flood management strategy for the Loire.

There is, however, an important condition for this flood management system to *remain* efficient over time. That condition is that developments in the *vals*, including the development of housing and enterprises, should be limited in order to minimize the damage potential.

In the 20th century, no high river flows occurred. This led to a false sense of security in the *vals*, less awareness of the flooding threat (despite the fact that flood risk maps were produced) and less attention for maintenance of the infrastructure (despite dyke strengthening programmes in the 1920's and 1970's). The absence of high river flows also led in the *vals* to a substantial development of houses and enterprises. Today, all sorts of questions are being raised about the flood management system, including the question whether or not the region should aim for a significant reduction of the probability of flooding in the *vals*.

It is within this context that in June 1999 the report 'Synthesis of proposals for an overall strategy to reduce the risk of flooding by significant flood along the middle Loire' (Ref. 5) was published, followed in 2000 by a regional plan for the Middle Loire within the 'Plan Loire Grandeur Nature' covering the period from 2000 to 2006.

In essence, the recent plan maintains the system of *vals*. Given what is presented in this chapter about the efficiency of other types of measure, this is an overall wise choice. A drastic shift towards other types of structural measures will be a costly enterprise, not in the least because – as outlined in the above – the system of *vals* is the most efficient system. The reliance on a series of *vals* is the overall best choice that could have been made in the 19th century, and still is the best choice today.

This is further illustrated by Figure 4-4. This figure shows the importance of the *vals* by presenting what large fraction of the discharge is 'shaved off' and stored in the *vals* when compared to the total discharge in the river. It is easy to imagine the enormous consequences if a drastic shift was made to other types of structural measures.

However, it could be the case that on a *local* level other types of measures deserve more attention in the plan. This will be further elaborated upon in the next chapters.

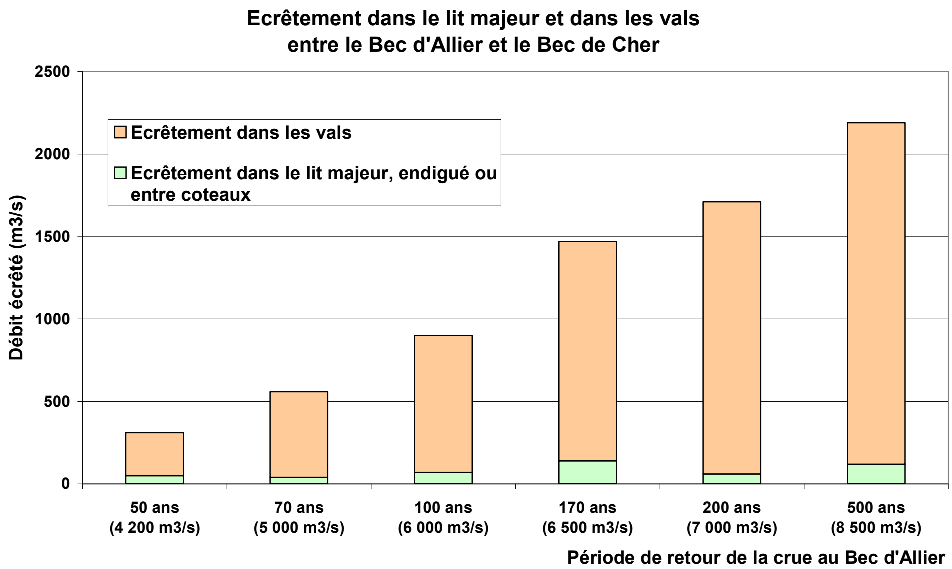


Figure 4-4 'Peak shaving' of the flood wave and storage of water in the *vals* between Bec d'Allier and Bec de Cher for various river discharges (source: EP Loire, 2004: Etude de la propagation des crues et risques d'inondation en Loire moyenne)

5 Middle Loire flood management strategy

5.1 Brief overview

This section provides a brief overview of the public policy for flood management along the Middle Loire. A detailed description is provided by (Ref. 5), as well as many publications that focus on various elements of the plan and on the various studies that form the basis for the plan (see the list of References).

The 1999 strategy for flood management for the Middle Loire reflects the public policy regarding dealing with nature-linked flood risks. The strategy does not focus only on traditional technical measures like the construction of reservoirs and dykes, but also takes into consideration options to reduce susceptibility of values (properties) to flooding, awareness raising for flooding risks, while improving the river qualities, including the natural river environment, its landscape values and cultural historic values.

Obviously, an integrated approach in flood damage mitigation calls for considering both non-structural and structural measures, and taking into account all aspects, including technical, institutional, environmental, social, etc. This clearly is the case in the strategy for flood management along the Middle Loire.

The overall objective of the strategy is flood damage mitigation. In other words: the strategy is aimed to reduce flood risks, and this is done either by reducing the frequency of inundation, or by reducing the damage caused by an inundation, or both.

The overall strategy is composed of three elements, each of which has one or more elements:

1. the establishment of a base for long-term actions, comprised of:
   a) improvements in flood forecasting and crisis management;
   b) finding ways for a sustainable development in the flood prone areas;
   c) a programme to restore a culture in which there is an awareness for flooding risks;
   d) regular maintenance of the river bed and the dykes of the Loire;
2. improvements in the system of dykes and intake structures (weirs), namely:
   a) smoothing the slopes of dykes;
   b) reinforcing river banks;
   c) enhancing the life span of fuses at the intake structures;
   d) improvement in the protection of values in communities that are frequently and heavily flooded (in particular on the *val* side of intake structures);
3. the construction of three safety-weirs; and
4. development of the Veurdre dam for flood peak storage.

Implementation of this strategy is expected to result in the protection against substantial flood damage as experienced in recent history, and a 1/200 per year protection level in the *vals* of Orléans, Cisse, Tours and Authion, in which 75% of the values along the Loire are located. Total costs amount to about € 500 million.

It is well understood that the strategy on the one hand clearly improves the present flood management situation, but on the other hand can not provide full flood protection, in which never in the future there would be any flood damage. Absolute protection is not possible, and this is well understood. There is no upper limit on the amount of flood water the river can carry, while the economic feasibility of absolute protection is by definition low. Hence, some flood risk will always remain. Obviously, the question is whether or not the strategy appropriately balances the costs for investments versus the benefits of improved flood management.

The values at risk of flooding are considerable, as illustrated by chapter 2 of this report. The potential damage of an extensive flood is estimated at € 6 billion (Ref. 5).

5.2 Comments on the overall strategy

The basis of the strategy

As a starting point in commenting on the strategy, we strongly support the basis for the strategy, namely the realization that not all floods can be controlled. Further, it is clear that high values are at stake, and that there is substantial societal pressure to continue a further increase of developments in the *vals*, thereby increasing the potential flood damage.

The strategy builds on the fact that the resilience of the existing flood management system along the Loire is high: in case there is a flood flow on the river, the system of *vals* will work in such a way that gradually the *vals* will be inundated. The strategy is aimed at further development of this flood management system. In our view, this is a wise choice. We would like to add to this that in our view the essence of the Loire flood management system serves as a shining example for flood management along many rivers, including many (if not most) rivers in Europe.

Traditionally, also along the Rhine both in Germany and in the Netherlands there were areas designated to inundate in case of high river discharges, comparable to the *vals* along the Loire. The dykes along such areas in the Netherlands were closed in the 1960's, based on the idea that dykes should be so high that the flooding probability would be very low. This has led to a 'binary' situation: either the dykes work well, or – in case of a river flow exceeding the design conditions – a large-scale disaster will take place in which there would be *uncontrolled* inundations along the river. A gradual development of a large flood in which slowly and gradually more and more *vals* would flood in a controlled way – like would happen along the Loire – is unfortunately entirely absent along the Rhine.

During the last years, the Government of the Netherlands tried to change flood management in the Netherlands in the direction of the system along the Loire. The attempt unfortunately failed, as further explained in Chapter 6 of this report.

The analysis on which the strategy is founded

The current project is too limited in scope to allow for a detailed evaluation of all the studies that have been carried out in recent years and which form the foundation of the flood management strategy.

The studies have been comprehensive in scope: hydrology and hydraulics have been studied in detail, and detailed assessments have been carried out on the flood damage potential, ecological aspects, etc. Our impression is that these studies are of high quality. Furthermore, firms of high repute have carried out the studies, and well-accepted hydrodynamic models have been applied.

Maybe one could remark that many of the studies are of a technical, civil engineering nature, while there seem to be not many studies on topics like awareness, the disbelief about flooding risks, sustainable development, etc. Even if this is the case, one could argue that this is not necessarily a problem. If there are no major elements missing from the full scope of topics that need to be addressed in integrated flood management analysis (and this in our view seems to be the case), then it is not a problem if certain topics have been studied in more detail than maybe strictly necessary. More in-depth studies can also be considered as an investment in the future.

A specific question to us was whether or not we have any comments on the split between various hydraulic units (*découpage*) that was maintained in the studies. We tend to agree with this split since they follow logical borderlines between the various *vals*.

Measures proposed and measures not proposed in the strategy

The measures proposed in the strategy cover the full range from raising awareness amongst the inhabitants and maintenance measures (under the heading 'the base for long-term actions'), via local protection works to overall protection works (Veurdre dam).

The range of these measures ensures balance in future flood management. If all effort were to be invested in only one or two of these three main components, imbalance in future flood management could virtually be guaranteed.

However, in the presentation of the strategy there seems to be little attention for possible alternative measures. This has the implication that there is little room for stakeholders who disagree about plan elements to learn about alternatives, and to learn that alternatives are less desirable than the proposed plan. This would help to better understand and ultimately accept the plan. This is further elaborated in chapter 5 of this report.

Safety levels

The plan explains that implementation of the plan will result in the protection against substantial flood damage for as experienced in recent history, and a 1/200 per year protection level in the *vals* of Orléans, Cisse, Tours and Authion, in which 75% of the values along the Loire are located. For other *vals*, the safety level is lower, like for example Gien, which suffers flood damage already during a 1/50 per year flood.

It remains unclear as to whether or not this is an optimal level of protection. One could ask the question why not realize a higher level of protection for certain *vals*, or why not aim at a lower safety level for other *vals*.

The Intervision Team (Ref. 2) noted that France lacks a system in which safety standards against floods are set for various types of land use (densely populated areas, industrial areas, villages, agricultural land). We agree that having such system would be desirable, but at the same time we acknowledge that setting up such system only for the Loire basin would not be extremely productive. Even if the economics of such an analysis would result in considerably higher safety levels for the Loire, it remains to be seen whether or not the general taxpayer in France would be willing to significantly contribute to the considerable investments that most likely would be required, if not similar assessments have been made for other river basins in France.

Another perspective on the issue of safety levels is to note that the topography of the Middle Loire is such that most probably substantially higher safety levels are ultimately impossible to reach, even if major investments in infrastructure were made. Increasing the overall safety level by means of heightening all dykes does not seem to be feasible. The many (to a large extent historic) bridges that cross the river would form an obstacle for such strategy because the bridges would form the bottleneck for higher river flows, contained between the dykes. If this is indeed the case, we note that this point might serve as an important argument for the various communities along the river to be very cautious with further developments in the *vals*: such developments will increase the damage potential, while on the other hand a substantial reduction of flooding probabilities is virtually impossible to reach.

As mentioned earlier in this report, there is only one practical way to ensure the peak discharges at Nevers – the upstream starting point for the Middle Loire – are reduced. That option is providing more peak flow storage upstream of Nevers. This can be realized either by the development of additional dams or *vals*, but both options will be hard to realize in today's day and age.

All in all, the plan identifies two safety levels for the area, with the highest level (1/200 per year) for the *vals* with the highest damage potential. From an overall point of view such distinction in safety levels seems a wise choice. It may, and probably will, however, require a considerable effort before the stakeholders in the less protected *vals* fully accept this differentiation in safety levels.

Priority setting between the various elements of the Middle Loire flood management plan

Section 3.5.1 of the plan (Ref. 5) provides a priority setting between the various elements of the plan. The ranking of measures with the highest priority is the following:

1. providing an impulse to sustainable development;
2. restoring a culture of risk awareness;
3. working on improvements in crisis management;
4. improve the stability of existing dykes, in order to prevent uncontrolled breaches;

5. priority improvements for sites with high frequency flooding and serious flooding; and
6. development of Veurdre reservoir.

This priority setting strikes us as being a logical one. Restoring a risk culture is of high priority: it will ensure that a further increase of values at risk is minimized. Crisis management deserves top priority because there always is a probability of flooding and damage, stress, anxiety and damage can be minimized provided such crisis is managed properly. Fixing weak spots in the existing dykes is also top priority: uncontrolled breaches should be avoided as much as possible since they would create substantially more damage than a controlled inundation. This is because the erosion of an uncontrolled breach will result in an inflow of water which is much larger than a controlled inflow, resulting in unnecessary large amounts of damage (and possibly loss of life since warning times will be relatively small in case of an uncontrolled breach). The same holds for improvements at sites which frequently inundate or flood deeply.

Veurdre reservoir is an important technical measure because it has a positive effect on downstream peak flows: the entire Middle Loire will benefit from this reservoir. It should be well understood, though, that also after completion of Veurdre reservoir there still is a significant probability of flooding. It is because of this that the plan puts priority on actions related to what is called 'the basis for long-term development', namely the improvement of risk awareness, crisis management plans, dyke stabilization, etc., and we fully agree with that choice.

One could note that this list of priority actions is not very specific for each action. For example, it is not clarified for exactly which locations measures are proposed. This lack of specific information may hamper acceptance of plan and/or impede implementation. This is further elaborated upon in chapter 6 of this report.

5.3 Comments on small elements of the plan

Compartmentalization of the *fusible*?

A minor comment on the plan refers to the diversion works at the Val d'Orléans. This concerns a 500 m long erodable part (*fusible*) with a height of roughly 1.6 m. In case this diversion would be activated, we expect that erosion of the top part would widen the inflow rapidly. It might be that this way more water is diverted than strictly necessary for optimal flood management. If that is the case, it could be worthwhile to slightly adapt this structure in such a way that a number (say 5) compartments in the erodable part of the diversion were made, separated with a simple fixed (steel or concrete) wall. The various compartments would each have a different crest level, with differences of roughly 5 to 10 cm. If the lowest compartment erodes first, the consecutive compartments would be activated only if the flood stage in the river would be sufficiently high. In that way, the diverted flow could be slightly better managed than with the current design. The small difference between the crest levels of the various compartments calls for accurate maintenance to compensate for damage to the crest, subsidence, etc.

Options to replace the *fusibles*?

EP Loire specifically requested us to comment on ideas to replace the erodable part (*fusible*) at inlet structures with movable devices. In the following, we will refer to such mobile devices as *small* gates. We use the term small gates, because we also note the option to replace the *fusible* with a gate over the full height of the existing dyke. To finalize the options for inlet structures, we should also mention the option to replace the *fusible* with a fixed non-erodable stretch of dyke. All in all, we see the following options for inlet structures, more or less arranged in the order in which increased technology is applied:

1. A fixed, non-erodable stretch of dyke, built precisely at such level that water starts flowing over this stretch of dyke when an inflow in the *val* is intended. In order to avoid backwater effects, this stretch of dyke may will have to be considerably longer than a *fusible*, possibly in the order of kilometres in length.
2. A dyke with a *fusible* on top, like in the existing situation.
3. A small gate located in the top part of a dyke, to replace the *fusible*.
4. A gate over the full height of the dyke. Since such gate offers a large diversion capacity, the length of this structure can be considerably shorter than a *fusible*. In other words: this can be a more compact structure than options 2 or 3.

In many places examples can be found of many of the above types of inlet structures, be it that in some examples the direction of the flow is opposite from the direction of a river diversion. For example, in the Netherlands *fusibles* have been built to drain (not inundate) polders in case the polder is accidentally flooded. Fixed, non-erodable stretches of dykes are also found in the Netherlands, but these are built to guide the flow in the river itself to serve commercial navigation.

We are not aware of examples where small gates on top of dykes serve as inlet structures. The technology for such structure, however, seems readily available. Such gate could move vertically, or could swing with a hinge either on the top side or on the bottom side. Operation could be realized manually, or be fully automatic.

Studies on possible detention ponds along the Rhine Branches in the Netherlands (Ref. 31) analysed in detail the question which of the above types of inlet structures should be preferred. Many aspects were studied, including hydraulic, morphological, operational and maintenance aspects, sensitivity of the structure for failure, flexibility of the structure under changing hydraulic circumstances, and the cost aspects.

For the Rhine it was concluded that a fixed inlet in fact is not a feasible alternative: the length of the structure would have to be 7 km in order to divert 1.000 m^3/s without too much backwater effect. Given the larger slope of the Loire a smaller length might be sufficient, but nevertheless several kilometres might be needed. This does not seem to be practical.

A gated structure over the full height of the dyke has the advantage of a compact structure when compared to a series small gates on top of the dyke. When compared to a *fusible*, gated structures have the important advantage of providing more control over the exact timing of the inflow as well as the amount of inflow in the *val*. This helps to minimize flood damage in the *val*.

An important disadvantage of gated structures when compared to *fusibles* has to do with the required maintenance of a gated structure. The structure has to be kept clean, painted and greased during many, many years without actual use of the structure. With the low frequency of use of the inlets, it is easy to imagine that authorities may lose attention for carrying out such maintenance. Without such maintenance, though, the proper opening of the gate will not be guaranteed, and this can possibly lead to disasters on other locations.

Finally, there is the important disadvantage of gated structures when compared to *fusibles* which has to do with possible vandalism or even sabotage. During a flood event, emotions may run high. It will take a quite courageous operator to withstand the pressure from local stakeholders and open the gate when required. At the same time, it is not unthinkable that forces opposed to opening the gate may turn to violence or sabotage to prevent opening gates. After all, it will always be relatively easy to prevent opening gates by blocking the mechanism in one way or another, even if the opening mechanism is fully automatic. This supports the choice for an inlet structure that can be activated without operators and that also can not be vandalized.

In this context, it is useful to mention events that took place during the 1937 flood along the Mississippi River, between the city of Cairo and the confluence with the Red River. At that location there are several dyke sections that can be dynamited to divert water from the river during extreme discharge situations. On 25 January 1937, authorities ordered the inhabitants to evacuate because they intended to dynamite one of these plugs. Men armed with shotguns gathered at the fuse plug to prevent the engineers from opening the fuse plug. Missouri State Police and National Guard units had to clear the levee, and on 25 January 1947 the fuse plug was dynamited.

All in all, it is difficult for us to give an overall advise in favor or against a specific type of inlet structure. Replacing the existing *fusibles* with gated inlet structures needs in our mind more detailed analysis of in particular the question whether the advantage of gated structures (better control of the flow of water and the timing of that inflow) outweighs important disadvantages, in particular the question whether or not maintenance over prolonged periods can be guaranteed, and whether the operators during the emotional period of high river flows can withstand local opposition against opening gates.

6 Measures possibly suitable for consideration in the flood management plan for the Middle Loire

In the previous chapter it was concluded that the flood management plan for the Loire does not offer much information about possible alternatives to the measures proposed in the plan. Ref. 5 does provide information about possible alternatives, but Ref. 8 does not.

For smooth implementation of the plan, full acceptance of the plan by all stakeholders is of crucial importance. An element in obtaining such full acceptance is that any individual stakeholder, non-governmental organization, or government agency opposed to the plan or only an element of the plan, will seek answers to his or hers ideas about alternative measures.

Examples of this interaction with stakeholders in flood management along other rivers are:

1. The dyke reinforcement along the Rhine Branches in the Netherlands that was started in the 1960's. It took a near flood in 1995 and the evacuation of more than 200,000 people to finally get full agreement about the implementation of the measures involved. The discussion about this dyke strengthening continued for 30 year. To a large extent the cause of the disagreement between government agencies and the population had to do with the proposed way of dyke strengthening, which proved impossible to accept by the (local) population. In hindsight it can be stated that if more attention had been given early on in the planning process to the alternatives brought forward by stakeholders, less obstacles would have been encountered in the decision making process.
2. The so called Room for the River project along the Rhine Branches in the Netherlands has the objective to safely deal with a discharge of 16.000 instead of 15.000 m^3/s. The strategy to realise that is to rely on widening and deepening the river, with dike heightening only as a last resort. In the planning process, in total some 700 individual measures were identified and studied, including many options not brought forward by the government, but instead by local water boards, provinces, towns and private citizens. Each of these ideas was studied at the same level of detail, and each idea was fully included in the process to obtain an agreement between the government and local authorities about which measures to propose in an Environmental Impact Assessment. This process of reaching an agreement about which projects to implement went smoothly, and it is widely acknowledged that an important element in reaching this agreement had to do with the fact that each and every alternative measure was seriously considered in the studies and discussions.

It is based on the above that we recommend that in the coming process of reaching a final public policy also information is provided about possible alternative measures. This is not to say that alternative measures are better than the measures that are proposed in the plan. On the contrary: we hope that there will be no better alternatives available, because if that were the case it would imply that actually the plan is not optimal.

Instead, the idea is that any suggestion for an alternative measure is taken into consideration by the analysts, followed by an in-depth explanation what the positive and negative effects of such alternatives are. When it is clear from such explanation why a certain idea has many disadvantages, or why a certain idea can not possibly be implemented, or why a certain idea is prohibitively expensive, that idea will no longer confuse the societal discussions about the plan.

It is in this context and spirit that this chapter comes back to the long list of types of measures presented in chapter 3 of this report and explores what alternatives to the plan could be identified. Below numbering of types of measures is the same as the numbering in chapter 3.

Non-structural measures that focus on the reduction of damage to existing values:

1. *Removing values that are susceptible to flood damage* from the *vals*, i.e. housing, farms, and enterprises, roads and railroads. We expect that it is easy to prove that the cost of such removal is very high when compared to the Net Present Value (NPV) of the flood damage reduction that can be obtained with such removal.

2. *Flood proofing of existing buildings* in the *vals*, including houses, farm buildings and enterprises. The flood management plan for the Middle Loire addresses this option, but to us it is not fully clear what concrete measures are included in the plan.

3. *Flood proofing distribution networks* of utilities, including distribution networks for electricity, drinking water, sewerage, telephone, cable TV, etc. The flood management plan addresses this option, but to us it is not fully clear what concrete measures are included in the plan.

4. *Providing flood warnings*, so that values might be best protected in case the flooding of *vals* is forecasted. The flood management plan proposes a warning system as an element of the plan.

5. *Improve crisis management plans, including evacuation plans*. Under the heading 'improve crisis management' this topic is included in the plan as one of the top-priority elements.

6. *Improve awareness*. Under the heading 'restoring a culture of risk' this option is included as one of the top-priority elements in the plan.

7. *Improving the management of the watersheds*, including the development of forest in the watershed area, in order to reduce flood peaks. With reference to many studies carried out world-wide on this topic, it can be explained to stakeholders that re-afforestation of the watershed has very limited if not zero effect on peak flows during extreme events.

Measures that focus on minimizing damage related to future developments:

8. *Installing a ban on new developments* in the *vals*, including new houses, new farm buildings and new enterprises. Along many rivers, this measure has been tried in the past and it proved difficult to maintain after many years without flooding events. Along the Middle Loire, a ban is in place on large-scale developments in the *vals*.

9. *Flood proofing new buildings* in the *vals*. The flood management plan for the Middle Loire addresses this option, with reference to the Law on the Prevention of Risks. There is a legal obligation in place for new buildings in urban areas to have the first floor level 0,5 m above the land level, to build (at least) one floor level above the flood stage, and to have an escape window in that upper floor. The replacement of buildings in rural areas also have to follow these rules. These rules clearly help to mitigate flood damages.

Structural measures aimed at reducing the flood flows:

10. *Construction of flood management reservoirs upstream of the Middle Loire*, aimed at reducing peak flows in the river. Construction of the Veurdre dam is an important element of the plan. It might be worth to make it very clear to stakeholders that there are no practical options for additional reservoir development.

11. *Construction of detention ponds (in fact, additional vals) upstream of the Middle Loire*, aimed at 'shaving off' the peak of the flood wave in the river. A study in 1996 on options for additional *vals* between Villerest and Nevers concluded that given the slope of the river there are no practical options for additional *vals* upstream of Nevers in which the benefits (flood stage reduction) outweigh the costs involved. It might be worth to make the results of that study very clear to stakeholders.

Structural measures aimed at better accommodating flood flows:

12. *Heigthening and strengthening existing dykes* along the Middle Loire. In our view, the plan should outline the consequences of substantially increasing the height and strength of the dykes in order to replace the use of the *vals* for flood storage. We suspect that the idea that the *vals* no longer will be flooded deliberately will be appealing to many inhabitants, and in our view the plan should clearly demonstrate why such development is not a good alternative, either because it is not economically feasible, or because it is not technically feasible (for example because the bridges over the river would form an obstacle for such development).

13. *Setting dykes further away from the low flow channel*. The plan does not seem to address this option. We suggest to investigate options to locally set dykes further away from the low flow channel. This would result in a higher flow capacity between the dykes, and consequently less often use of the *vals* for flood storage. We can not exclude, however, that the net effect of setting back the dykes might be negative, given the fact how effective peak storage in *vals* is from a hydraulic point of view.

14. *Creation of additional detention ponds (vals) along the Middle Loire*. Over virtually the entire length of the Middle Loire dykes exist, so it can be easily explained that there are not many options for this type of measure. Two examples could be mentioned where it could be promising to create an additional *val*: near Bec d'Allier and St. Brisson (Briare Gien).

15. Changing the dyke profile around *vals* or part of *vals* to *horizontal dykes*. We suggest to investigate the effects and consequences of this option, including of course a potential increase in flood damage in the *val* because of an increased flooding depth in the *val*. The Val d'Ouzouer is mentioned as an example where this measure might be feasible: either by changing the profile of the dykes around the *val*, or by building new dykes inside the *val* (a *val* within a *val*, so to speak). Also Cours les Barres (left bank) and La Charite (left bank) could be *vals* where this type of measure could be feasible. For other locations, additional study could show whether or not this is a promising option.

16. Dividing existing *vals* into smaller compartments (*compartimentalisation*) by means of additional dykes. We suspect that many stakeholders might suggest this option. The plan does not seem to address this possibility, so it remains unclear whether this is a promising option or not. We suggest to investigate this, including of course negative aspects like increased damage due to increased flooding depths.

17. *Closing vals that are permanently open* to the low flow channel, to better shave the peak of the flood wave in the river. Two locations were suggested to us where this might be an option: (1) at La Charité, just north of RN151 on the left bank of the river there is an opening of several kilometres in length, and (2) at Gien, immediately downstream the bridge on the left bank, also an opening of several kilometres in length. We suggest to investigate the effects of closing these and possibly other permanent openings and installing an inflow structure. Such development might lead to higher flood stages during relatively small flood events, but this could be avoided if a movable gate were to be installed. If the permanent opening is explained because a tributary discharges to the Loire, then a discharge sluice that closes during high river stages could be installed.

18. *Removal of hydraulic obstacles* from the river bed between the dykes. Detailed inspection of the river profile might show locations where it is worthwhile to remove an obstacle that impedes the flow. We suggest to look into this option. If it proves to be a good option, it most probably is an option that will hardly be controversial.

19. *Development of side channels and the excavation of floodplains*. It seems to us that the plan does not address this option, although (Ref. 13) reflects that many possible locations for this measure were studied. From experience elsewhere it is known that this is a relatively expensive option (Rhine), unless valuable sand and gravel can be mined from the river banks (Meuse). In any case, we suggest to explain to stakeholders whether or not this is a good option.

20. Development of so called '*green rivers*' along sections of the Middle Loire. Several options seem available along the Loire, including the existing Blois green river near Gien (where properties are being purchased behind the inlet structure / La Boire de la Bouillie), and downstream Tours on the Vieux Cher. Until the plan addresses such options it may be brought up in discussions. We therefore suggest that the plan addresses this idea.

Measures aimed at maintenance of existing flood management infrastructure:

21. Carry out *works to guarantee the stability of the existing dykes*. This type of measure is – for good reasons – a top-priority element of the plan.

22. Carry out *works to guarantee that the inflow works of the vals function properly*. This measure is included in the plan. An example is how sand mining in the Loire in the vicinity of the Jargeau weir in the Val d'Orléans has reduced flood stages in such a way that instead of inundation of the *val* during a 1/150 flood, it now will work only for a flood of 1/500 years probability (Ref. 5). An important negative aspects of this is that the city of Orléans, for which the Val d'Orléans provides protection, is less well protected against river floods. The plan intends to correct this, with the objective to realize a better balance in flooding frequencies of the various *vals*.

23. *Maintenance of the low flow channel and the area between the dyke and the low flow channel*. This measure will most likely be addressed in the second stage of the Middle Loire Study. The measure would limit accumulation of sediments, which could lead to unnecessary high flood stages. Also, uncontrolled growth of forest is an important – but often quite controversial – maintenance activity. We also suggest to study options for a regular thinning of flood plain forest, in order to reduce hydraulic roughness. Such thinning could be in line with ideas about cyclic rejuvenation, as proposed by the Radbout University, Nijmegen.

All in all, we do not expect miracles from above list of alternative measures, although it is possible that new measures will be identified that will prove promising and acceptable by all stakeholders.

Our reason for the suggestion to look into alternative measures is to provide the participants in the discussions about the plan with information to convince them as to why a certain measure is a good idea or not. Maybe such approach could be of interest for the upcoming study on the Val d'Orléans that the DIREN envisages to carry out.

Our experience with similar studies for the Rhine, Meuse and Mississippi is that the process to reach agreement about flood management plans meets considerably less obstacles if the studies provide answers to *any* idea that is generated by the stakeholders. This is further elaborated upon in the next chapter of this report, that focuses on the process to reach a public policy.

7 Towards a public policy for flood management along the Middle Loire

7.1 General

At this stage, there seems to be agreement between all stakeholders about the strategy on flood management for the Middle Loire, in particular for the actions planned for the period 2001 – 2006. However, for the period 2007 – 2013 an agreement about exactly which measures to carry out, and by which moment in time is not reached yet. Problems encountered are the feeling that there are too many elements in the plan, and agreement about priorities has not been reached. Further, a detailed plan how to facilitate and control the implementation of the plan is not available yet.

This chapter provides some suggestions to help reach such agreement, which should have the form of a so called public policy, a plan of action formally agreed to by all parties involved.

We see four important ingredients for a plan to be agreed upon and implemented successfully:

1. The initiator of the plan must have a *mission*, and ideally there is also a sense of urgency about the problem at hand.
2. There must be an agreed *vision* on how to realize this mission, and there should be little or no disagreement between stakeholders about this vision.
3. There must be clear *targets* to be reached by the plan. These targets should be so clear that they can be applied in the analysis to support the plan.
4. There must be concrete *measures* available to realize the plan, and there must be agreement between stakeholders about the implementation of these plans.

In the case of flood management along the Middle Loire, the initiators clearly should be the government and EP Loire. There seems to be no disagreement in the region that flood management along the Middle Loire should be initiated at the river basin level, and that is what EP Loire stands for. There is no doubt that this organization is well aware of its mission in the field of flood management.

The Government and EP Loire seem to be fully aware about the urgency to improve the flood management situation. Many other stakeholders, though, seem to lack this sense of urgency. This can also be concluded from the considerable number of new houses and enterprises that the communities allowed to be developed in the floodplain in recent decades: an impending crisis.

A clear vision on flood management does exist and is formulated in the flood management plan, namely a vision on sustainable development of the project area, and to support such development the vision focuses on improvements in flood management along the Middle Loire. Stakeholders by and large seem to agree on this overall vision.

We are not sure that there are sufficiently clear targets (*objectif operationelle*) for the flood management plan. The plan is composed of a set of individual measures, but exactly what *targets* these measures should reach remains less clear. We suggest that this point is clarified in the near future, not in the least because disagreement about targets could lead to disagreement about measures. Section 7.2 below further elaborates on targets.

Next, there seems to be no lack of possible measures. What is lacking at this stage is agreement about exactly which measures to select and implement.

The question is how to reach a public policy, accepted by all stakeholders and fixed in formal agreements, including a timeline for implementation, a clarification of the responsibility of all parties involved, and – of course – clarity on the funding of individual measures.

7.2 Suggestions for the process towards a public policy

This section contains a number of suggestions for the process to reach a public policy. These suggestions are related to the above described apparent lack of clear targets, the lack of a sense of urgency, how to reach agreement between stakeholders about which measures to implement, and about communication with the general public.

Targets

We consider clear and agreed targets as an absolute necessity for a flood management plan to be accepted by all stakeholders. With the term 'clear' we in fact mean 'operational targets'; targets that can be used by the analysts and stakeholders to determine whether or not an individual measure or a strategy (combination of measures) will actually work in (partially) meeting the objectives of flood management.

There are several examples from other rivers that can be introduced here as an example:

- In the Netherlands, the targets for flood management are laid down in the law in terms of the probability that certain river flows and associated water levels are exceeded (ranging from 1/1,250 per year for the rivers to 1/10,000 per year for the coastal region). Note that the target is specified in terms of river flow probabilities, which is not the same as inundation frequencies (see also Annex C of this report). For analysts and stakeholders it is relatively easy to determine which measures are needed to meet this target.
- The International Rhine Committee (IRC) has laid down an Action Plan for flood management along the Rhine. Targets of this plan are a certain flood stage reduction at various points along the Rhine. These targets are not fully 'operational'. For example: one of the targets of this Action Plan is a flood stage reduction of 40 cm at the border between the Netherlands and Germany.

> Unfortunately, it remains unclear whether it is a task for the Netherlands to widen and/or deepen the river in such a way that at the border this flood stage reduction results, or whether it is a task for Germany to develop reservoir or detention areas (*vals*) to achieve a reduction in discharge so that the flood stage will drop.

For flood management along the Loire, there would be several alternative ways to formulate such targets. One could think of the following *examples* (and more alternatives could be mentioned):

1. A target that specifies a certain protection level (frequency of flooding) for each of the *vals*. Such frequency could be based on what is considered an acceptable flooding frequency for predominantly rural areas, industrial areas and urban areas. If targets are specified in this way, measures could be selected according to for example minimum costs.
2. A target that specifies that the benefits of flood stage reduction exceed the costs of measures. The benefits are obviously in terms of a reduction of the expected annual flood damage. These benefits could include direct material damage, but could also include indirect damages, and benefits in terms of a financial equivalent for feelings of stress and anxiety.
3. A target to maximize benefits (flood damage reduction) for a certain total project budget.
4. A target that the biggest river flow known from the recent history will not cause damage after implementation of measures. Until about 1950 in the Netherlands this was the target for flood operational flood management.

It could be the case that the 1999 flood management plan *implicitly* followed the set of targets as specified under above point 1. However, the 1999 plan can also be interpreted in another way. Ref. 5 explains that implementation of the plan will result in the protection against substantial flood damage for as experienced in recent history, and a 1/200 per year protection level in the *vals* of Orléans, Cisse, Tours and Authion. If the plan is read that way, than this level of protection is the *result* of the set of measures, and did not serve as a target before the measures were selected. Anybody who reads the report in such a way that these protection levels are the results of measures instead of targets could initiate a prolonged discussion on the selected set of measures. We therefore suggest that EP Loire clearly specifies the targets that were set before measures were selected, and seeks agreements with stakeholders on targets. An agreement with stakeholders on targets will – in our view – not only make it relatively straightforward to obtain agreement about which measures should be included in the plan and which measures should not, but such agreement will also contribute to reaching an agreement on the priority setting between measures.

Sense of urgency: how to communicate probabilities to the general public ?

The general public often does not fully understand discussions about probabilities of rare events like floods, and this – in our view – contributes to a limited sense of urgency. In case the previous flood took place a long time ago, like in the case of the Loire where is was back in the 19th century that large floods occurred, a prevailing perception seems to be that 'floods are a thing of the past' and 'the probability is so small that we do not have to worry'.

A factor that seems to explain this perception is that the general public has difficulty dealing with small probabilities, even though the consequences can be substantial.

This in turn relates to the way authorities and experts involved discuss flooding events. Reports and leaflets on the flood management plan present flooding probabilities in terms of return periods: floods with a return period 100 years, 500 years, etc. It is obvious to experts that this should not be interpreted as 'the next flood will occur 100 or 500 years from now', but many members of the general public interpret return periods that way.

We suggest to shift away from the use of the term return period and instead use the probability that a certain flood may happen in a lifetime of say 80 years. A flood with a return periods of 100 years should then be formulated as 'a flood with a 55% probability of occurring at least once during your lifetime' [1)]. A return period of 500 years would translate to a probability of 15% of occurring at least once during a lifetime. One could add that there is a probability of 19% that a 1/100 year flood occurs two times during a life time, and a 1% probability that a 1/500 year flood occurs at least two times during a lifetime, etcetera. Formulating probabilities this way could help people understand the risk of floods compared to other risks.

In this context it may be worth to bring forward a recent example from a study in the Netherlands in which flooding risks were compared with other man-made group risks like accidents at nuclear power stations, airplane crashes on cities, accidents at petro-chemical facilities, accidents with the rail transport of chemicals, etc. It turned out that the risk of casualties from flooding in the Netherlands is *substantially higher* than the risk of casualties caused by all other types of events together. This simple message served well in translating the message that flood management in the Netherlands deserves more attention.

An example on how agreement between stakeholders can be reached: the Planning Kit

In recent flood management planning projects for the Rhine and Meuse rivers in the Netherlands, the initiator of the project (the central government) included each and every idea that was brought forward for individual measures. These ideas came from the general public, towns, water boards, and provinces. Of course the government also generated ideas for measures.

Each idea was analysed thoroughly. All in all, for the Rhine some 700 project ideas were considered. All these measures and their effects on water levels, costs, nature, agriculture, employment, etc. etc. were collected in what is called the Planning Kit. This Planning Kit in turn proved instrumental in reaching agreement between stakeholders (politicians, government agencies, provinces, municipalities and citizens) about what to do.

[1] *The probability that a flood with return period T years occurs during a lifetime of L years at least once equals 1-(1-1/T)^L; the probability that the T years flood occurs exactly once during a lifetime equals ((1-1/T)^(L-1))*(1/T)*L; etc.*

The amount of information made available by the Planning Kit is equivalent to a large set of reports and documents. The big difference is the way in which the information is presented: the Planning Kit allows the user to select measures on a map (or from a spreadsheet), and the user immediately sees to what extent the measure contributes to reach the target of the project. Also combinations of individual measures can be analysed within seconds.

The Planning Kit is nothing more than an (impressive) envelope around information that has been collected in other studies. It combines all that information in a decision support tool that allows the user (politicians, specialists as well as the general public) to discuss flood management options. The Planning Kit fits on a CD, and thousands of copies have been distributed to interested parties. A simplified version of the Planning Kit for the Rhine can be seen at www.ruimtevoorderivier.nl/watermanager/ This Internet version, which unfortunately is available only in the Dutch language, allows the user to study the effects of (combinations) of measures, and proves quite a success.

Three consequences of the Planning Kit deserve to be mentioned in this context:

1. The stakeholder that presented his or her idea for flood management, receives information about how well (or how badly) that measure will perform. This implies that bad ideas are quickly excluded from further discussions.
2. Since all potential measures are included in the Planning Kit and since all measure were analysed with the same level of detail, it proved relatively easy to reach agreement with stakeholders about which measures to include in the plan. In sessions with regional representatives of stakeholders, the information provided by the Planning Kit was the centre of the discussions.
3. In case a stakeholder is opposed to a certain measure, he or she can use the Planning Kit to propose an alternative measure that would have comparable effects, be not much more expensive, etc. If that stakeholder can not find such alternative, this helps in accepting why the measure he or she does not favour deserves support anyway.

We suggest EP Loire to consider developing a presentation tool for the Loire with the Planning Kit for the Rhine or Meuse as an example. We expect such tool can play an important role in obtaining agreement and priority setting with the stakeholders.

The targets for flood management in the Netherlands are clear and in comparison to the Loire river relatively straightforward. The Netherlands Flood Management Law details the frequency of the river discharge that the flood management system should safely deal with. Also, the law specifies that every five years the design discharge associated to this frequency is calculated again. In 1998, the national parliament approved a shift in flood management policy, namely to focus on widening and deepening the river, with dike heightening as a last resort. When in 1996 the design discharge was increased from 15.000 to 16.000 m^3/s for the Rhine (with a similar shift for the Meuse), the target for the project was clear: safely deal with the increase in design discharge, rely on measures that widen and deepen the river with dike heightening as a last resort, and possibly improve the state of the environment.

In the case of the Loire, the flood management problem is more complex since there is no situation like in the Netherlands where the law specifies safety levels and all flood managers have to is ensure that these safety levels are realized in the field.

Additional factors, like crisis management, vulnerability, awareness, etc. are also important along the Loire. Given this complexity, it might be inspirational for the Loire flood managers to also consider developments in the Netherlands that followed the above described Planning Kit.

In late 2005, the development was started of a new tool that is intended to facilitate a societal discussion about safety levels in the Netherlands. These safety levels were established in 1960 and need updating given population growth and the increase in values at risk. This tool will not only focus on the costs and benefits (less casualties, less damage) of providing measures aimed at higher safety levels, but also focus on non-structural measures like flood proofing, crisis management plans, the development of compartments in floodprone areas, etc.

Communication with the general public

Planning and decision making processes require that information is made available to all parties involved in the process. The shear number of stakeholders in flood management along the Loire requires that an explicit effort is required to inform the general public. This information not only regards the outcome of studies, but also the basic information used in the planning process. Also, the manner in which conclusions are drawn needs to be presented to the public.

We are convinced that governmental agencies are quite active in the field of public relations, but it seems not sufficient to 'get the ball rolling'. Experiences elsewhere show that not only could such flow of information satisfy the need to know about the background of certain (proposed) actions, but also could be of great importance in creating understanding and approval for these actions.

It is clear that only preparing thick reports is not automatically the answer. Clear and concise brochures, video tapes, TV presentations, personal appearances at meetings, internet applications, CD-roms with a Decision Support System 'for home use' are but few of the many options to improve the communication with the many stakeholders and the public in general.

Considering the literature available for the Loire, we noticed a wide appreciation for the importance of 'public relations', but we are surprised to note that communication with the general public seems to have come to a virtual halt since the year 2000.

Making information available to the general public is one thing, but to actively involve the public in the planning process is of course another matter. To collect ideas from the general public about possible measures, the planning authority could actively stimulate the public to come up with ideas. There are two aspects to this: not only is there a possibility that quite feasible ideas are submitted, but is should also be recognized that actively collecting ideas from stakeholders will help prevent discussions later on in the process when stakeholders (individuals, non-governmental organizations, towns, etc.) feel that a proposed plan does not deserve support because their alternative idea is not considered in the planning process.

To actively collect ideas from stakeholders may require a substantial effort. Not only is an effort required on the actual collection of ideas (using the media, using the internet, organizing town meetings, organizing meetings with interest groups, etc.), but also an effort is required to analyze each idea, report on the findings of that analysis, and communicate the findings back to the stakeholder that launched a particular idea.

The experience with the involvement of stakeholders in recent flood management planning projects in the Netherlands for both the Meuse and Rhine river is clearly positive, and both the stakeholders and the planners share this opinion. The way that process was conducted clearly initiated commitment by stakeholders and their representatives. This, of course, does not imply that the actual implementation of measures will not meet problems with individual property owners or interest groups, but the feeling is that at least the planning process went substantially smoother with the involvement of stakeholders than would have been the case without such involvement.

It is noted, that in the near future in the context of the European Framework Directive (Article 14), public participation in establishing river basin management plans is required.

Finally, one could raise the question whether communication with decision makers is in any way different from communication with stakeholders. It is obvious that communication with decision makers is vital for progress in flood management. But just like the stakeholders, decision makers need information in order to make well-informed decisions, including information on possible alternatives. What makes decision makers special when compared to stakeholders is that they are also concerned of political aspects of their actions, and have to make decisions over a wide range of topics. Where possible, communication with decision makers should keep these concerns in mind.

An example of how a public policy should *not* be developed ?

The following could maybe be seen as an example on how a public policy should *not* be developed. This example has to do with the management of extreme river discharges in the Netherlands.

Major rivers in the Netherlands are the Rhine and Meuse. Flood management along the Rhine Branches in the Netherlands solely relies on a system of about 600 km of dykes, and the same is true for the lower stretch of the Meuse River, where about 300 km of dykes protect the floodplains. The height of the dykes is determined by the so called design discharge, which is updated every five years. This design discharge, in turn, is determined by a frequency that water levels in the rivers can be exceeded. For most of the length of the rivers, the Flood Defence Law specifies this frequency at 1/1,250 per year. With increasing design discharges, the policy nowadays is to make more room for the river, with dyke heightening as a last resort.

In 2000, the government realized that even though the safety level is high, there still is the possibility that the river flow may exceed the design discharge. An independent committee was charged to advise on what strategy the country should adopt to deal with such situation. This committee advised to develop so called emergency spill areas.

During an extreme event, deliberate flooding of these areas would be initiated by means of a controlled inflow in order to protect more downstream areas with higher values. The government accepted this advice, and set out a policy to (1) make reservations in the spatial planning legislation to prevent large scale developments in these areas, (2) to reserve the required budget for additional protection works, an inlet structure, etc., and (3) to carry out feasibility studies into technical aspects and the regulations to be developed for paying the damages incurred by the inhabitants of these areas.

Supporters of emergency spill areas along the Rhine pointed at the following arguments:

(1) The probability of an actual flood in the emergency spill area will not increase when compared to the safety level laid down in the law: the spill area will only be flooded if the river discharge exceeds the 1/1,250 discharge.
(2) In case of an actual inundation of the emergency spill area, damages would be fully compensated by the government. This, while the Netherlands government has no legal obligation to pay for damages in case of a flood, and while flood damage insurance is not available (the insurance sector can not afford paying the gigantic damages that occur in the Netherlands in case of a flood).
(3) Areas designated as emergency spill areas would remain open in the future: large scale urban expansion in such areas would be blocked, while the normal growth of villages and farms would be permitted. The fact that such areas would remain rural could be considered as an advantage in a densely populated country like the Netherlands.

A local action group in the most populated emergency spill area (i.e. Ooijpolder, with a population of about five thousand people) strongly opposed the idea that their area would be among the first to be flooded during an extreme event. Intensive lobbying by this group and wide coverage of their cause in the media finally led to a success for this action group: early in 2005 the government fully abandoned the idea of developing emergency spill areas along the Rhine. An emergency spill area along the Meuse met with a lot less opposition, and will be implemented in the coming years.

In the societal discussion about emergency spill areas, the example of the Loire was brought forward as an example where emergency spills are fully incorporated in the flood management strategy. The *vals* indeed serve as spill areas. Pressure from the local population of the areas adjacent to the Rhine, however, lead to a total rejection in the National Parliament of such emergency spill areas along the Rhine. So for the near future in the Netherlands, it will be like Russian roulette where a dyke will overtop or fail in case of river flows higher than the design discharge for which the dykes are built, and which polder along the river will be flooded. In our view this is a sad example on how a public policy should *not* be developed.

8 References

Ref. 1. DIREN (Jean Maurin, Fabien Pasquet). Les digues de Loire : utilisation du modèle hydraulique Loire moyenne pour le dimensionnement fonctionnel des levées et des ouvrages annexes. Exemple de la protection du val d'Orléans

Ref. 2. Radboud University (Freude am Fluss). Intervision meeting Middle Loire, October 18-22, 2004

Ref. 3. Radboud University (Freude am Fluss). Réduction du risque d'inondation en Loire moyenne. Rapport de la semaine d'expertise européenne effectuée du 18 au 22 octobre 2004. (French version of main sections of the English report, Ref. 2).

Ref. 4. Freude am Fluss. Mieux vivre au bord du fleuve (Leaflet).

Ref. 5. Equipe Pluridisciplinaire. Plan Loire Grandeur Nature. Synthèse des propositions pour une stratégie globale de réduction des risques d'inondation par les crues fortes en Loire moyenne. 30 juni 1999, version finale validée. (also in digital format)

Ref. 6. DIREN. Atlas des zones inondables de la vallée de la Loire: Val d'Orléans et Val de Bou. (on loan !)

Ref. 7. Plan Loire Grandeur Nature. Stratégie de l'Etat pour les travaux du lit et des levées domaniales du bassin de la Loire. MOG05-071 June 2005 for a seminar on 28/6/05. (also in digital format)

Ref. 8. Plan Loire Grandeur Nature. Réduire les risques d'inondation en Loire Moyenne. May 2003. (also in digital format)

Ref. 9. Préfecture de la Région centre et du Loiret. Contrat de plan Etat - Région (2000 - 2006). Intégrant la révision à mi-parcours (avenant no 4 du 13 janvier 2004). (only first 5 chapters available) (also in digital format)

Ref. 10. EP Loire / Hydratec. Reconstitution et simulation de la crue de décembre 2003 entre Nevers et Tours, avec et sans l'action du barrage de Villerest. June 2004. (also in digital format)

Ref. 11. Equipe Pluridisciplinaire. Plan Loire Grandeur Nature. Extension prévisible des inondations pour les crues fortes en Loire moyenne: Val d'Orleáns - Val de Bou. Sogréah, January 2003. (Inundation maps based on the Hydra model with 6 return periods (from 50 – 500 yrs) (only in digital format)

Ref. 12. Equipe Pluridisciplinaire. Plan Loire Grandeur Nature. Les enseignements du modèle Loire. Leaflet. February 1998.

Ref. 13. Equipe Pluridisciplinaire. Plan Loire Grandeur Nature. Restaurer et entretenir le lit de la Loire. Leaflet. February 1999.

Ref. 14. Equipe Pluridisciplinaire. Plan Loire Grandeur Nature. Enjeux et dommages dans le lit de la Loire. Leaflet. June 1999.

Ref. 15. La Loire et ses terroirs - le magazine du fleuve et des homes. Lutte contre les crues et les inondations en Loire moyenne. A l'heure du bilan. Philippe Auclerc Dossier No 30 Hiver 1998-99.

Ref. 16. Equipe Pluridisciplinaire. Plan Loire Grandeur Nature. Les déversoirs présents sur les levées de la Loire : comment fonctionnent-ils et en quoi sont-ils des ouvrages de sécurité pour la population? N-G Camp'huis 18-08-2003. (also in digital format).

Ref. 17. DIREN Centre. Etude globale de réduction du risque inondation sur les vals de l'Orléans. Séminaire technique mardi 28 juin 2005.(also in digital format).

Ref. 18. DIREN Centre. Activités de l'Arrondissement Interdépartemental des Travaux Loire, créé au sein de la DDE du Loiret. Bilan 31.12.2004. pages 337 -346.

Ref. 19. Terre Sauvage. Terre Sauvage, Numéro spécial Loire avec le WWF. Loire, fleuve libre !

Ref. 20. IFEN, Institut Français de l'Environnement. Les risques naturelles. Part of the publication 'l'Environnement de la Région Centre', 2004 (also in digital format).

Ref. 21. Préfecture de la Région Centre. Schéma Directeur de Prévision des Crues du bassin Loire- Bretagne, mai 2005 + note de présentation. (also in digital format).

Ref. 22. Hydratec / Equipe Pluridisciplinaire. Plan Loire Grandeur Nature. Etude d'homogénéisation des simulations d'amélioration de la situation actuelle en Loire Moyenne produites avec le modèle Hydra. May 2005 (also in digital format).

Ref. 23. Secrétariat du Plan Loire. Plan Loire Grandeur Nature. Tableau de bord du plan Loire. Etat au 31 déc 2004 (436 pages) (also in digital format).

Ref. 24. Hooijer A, Klijn F, Kwadijk J, Pedroli B (eds). 2002. Towards Sustainable Flood Risk Management in the Rhine and Meuse River Basins: MainResults of of the IRMA-SPONGE Research Program. NCR-publication 18-2002. NCR: Delft.

Ref. 25. Bronstert, A.; Niehoff, D.; Bürger, G. (2002): Effects of climate and land-use change on storm runoff generation: Present knowledge and modelling capabilities. Hydrological Processes, 16, 2, 509-529.

Ref. 26. Bruynzeel, L.A. (1990). Hydrology of moist tropical forests and effects of conversion: a state of knowledge review. UNESCO, 224.

Ref. 27. B. Ott and S. Uhlenbrook (2004) Quantifying the impact of land-use changes at the event and seasonal time scale using a process-oriented catchment model. Hydrology and Earth System Sciences) 8: 62–78

Ref. 28. Interagency Floodplain Management Review Committee (Galloway Committee), 1994: *Sharing the Challenge: Floodplain Management into the 21st Century.*

Ref. 29. Scientific Assessment and Strategy Team (SAST), 1994: *A Blueprint for Change, part V, Science for Floodplain Management into the 21st Century*, Washington, DC, June 1994.

Ref. 30. Sogreah Consultants (2004). Project Europeen Interreg 3B Freude am Fluss. Intervision Loire 2004. Expertise Europeenne de la strategie globale de reduction du risqué d'inondation en Loire Moyenne. Compte rendu de la semaine de visite de la Loire Moyenne effectuee du 18 au 22 Octobre 2004. Sogreah / MML-PST / No. 1740280 Novembre 2004.

Ref. 31. Delft Hydraulics (2001). Effectiviteit van retentie langs de Rijntakken / Effectiveness of detention ponds along the Rhine Branches. Project R3294.66 Delft, May 2001 (in Dutch only).

A Glossary of terms

Abiotic: not pertaining to life (abiotic elements of a river system include flow velocity, water depth, size of bottom sediment, etc.).
Biotic: pertaining to life (biotic elements of a river system include fish, water-fowl, plants, micro-organisms, etc.).
Environmental restoration: improving the ecosystem from the existing situation to some agreed state, not necessarily the original, pristine state.
Institutional measures: policies or regulations controlling or specifying activities (examples: a regulation prohibiting housing development in the floodplain; a policy requiring all communities to have a flood evacuation plan; etc.).
Morphology: study of sediment movement, deposition and erosion in rivers.
Net Present Value (NPV): is a form of calculating discounted cash flow. It encompasses the process of calculating the discount of a series of amounts of cash at future dates (for example annual expected flood damages, or annual maintenance costs), and summing them. See for an example also Annex B of this report.
Non-structural measures: measures to modify susceptibility to flooding (such as watershed management, flood proofing techniques, flood warning, etc.).
Peak attenuation: the amount of dempening of a flood wave during its way in the downstream direction of a river. Peak attenuation of a flood wave is regularly measured in comparison with water levels associated to a steady state flow which is equal to the peak flow of the flood wave.
Stakeholder: a person who has an interest in river (basin) management.
Strategy: a plan to reach a specific goal, composed of a set of individual measures (for example: flood warning measures, development of diversions or reservoirs, etc.).
Structural measures: measures such as dams, reservoirs, dykes, side channels, locks, etc.

B Sample cost benefit analysis for flood proofing of existing houses

This annex provides a simplified cost benefit analysis to show that flood proofing of existing houses in the *vals* along the Loire most probably is not economically feasible.

The following assumptions, also presented in Figure B-1, are made in this simple example:

1. The existing flooding probability of a particular *val* is a 1/100 per year.
2. If the *val* floods (1/100 per year probability) the order of magnitude of the material damage (direct damage) to an individual house amounts to € 25,000.
3. If the *val* floods during an extreme event of 1/500 per year probability the order of magnitude of the material damage in that house amounts to € 50,000.
4. For all floods with a probability smaller than 1/500 per year (1/1,000; 1/5,000; etc) the damage remains € 50,000.

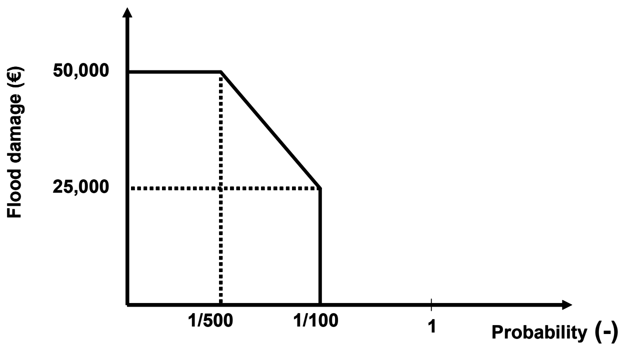


Figure B-1: Relation between flood damage (€) and flood probability for a sample house in a *val* along the Loire.

With these assumptions, the annual expected damage related to that house in the existing situation amounts to € 400 per year. This amount is calculated as the surface area under the line in Figure B-1.

Next, let us assume that we want to flood proof that house to safely deal with a 1/500 per year situation. If such flood proofing would be done, the house would still flood with a probability of 1/100 per year, but damage would only occur during floods with a probability of 1/500 or smaller. In that case, the expected annual damage would amount to € 50,000 multiplied by 1/500 is € 100 per year.

The benefit of that improvement in protection amounts to € 400 – € 100 = € 300 per year. The Net Present Value (NPV) of that benefit amounts to 300 * 25 = € 7,500, according to:

$$NPV = B_0 \sum_{t=0}^{t=T} \left(\frac{1+W}{1+R} \right)^t$$

In which:

NPV	= Net Present Value ($)
B_0	= annual benefits in the present situation (€ 300)
T	= time horizon (assumed infinite)
R	= interest rate (without inflation), say 5% per year, so 0.05
W	= increase in wealth, say 1% per year, so 0.01

If the benefits of improved flood protection are allowed to be equal to the investment costs, hence the benefit cost ration equals 1, then we have a budget for investments available of € 7,500. This investment should bring the protection level of that house up from 1/100 to 1/500 per year.

We consider it highly unlikely that for a budget of € 7,500 a house can be flood proofed in such way that no damage to the house is incurred in events with a probability of occurrence larger than 1/500 per year. The use of other assumptions about damages or probabilities, of course within reasonable ranges, will most likely lead to the same conclusion. Therefore, this example illustrates that the flood proofing of existing individual houses is generally not economically justified.

C River flow frequency and inundation frequency

In case flood protection is provided by dykes, there is a distinct difference between the frequency that dyke-protected land is flooded, and the frequency that a certain river flood occurs.

The definition of the frequency that a certain river flood occurs is obvious. Averaged over a number (large) number of years, it is the number of times per year that a certain river flow occurs. The inverse of this value is often, and also in the literature related to the Middle Loire, referred to as the return period of a river flood. Dykes are generally built in accordance with the water level that associated to a certain river flow, and this river flow has a certain frequency. The flow for which the dykes are built is generally called the design flow, and to this flow the so called design water levels are linked.

This design flow frequency is not necessarily equal to the frequency that dyke-protected land is flooded. Dykes can also fail at flows lower than the design flow, and dykes may also withstand a flow that is higher than the design flow, for example because a dyke generally has a certain freeboard, or because a well-built dyke may be overtopped with water – leading to a relatively small inundation – without the creation of a breach in the dyke, which would lead to a real inundation.

In practice, often the terms flow frequency and flooding frequency are used without realizing this difference. Often it is assumed that once the river flow equals (or exceeds) the design flow, flooding of dyke-protected land occurs.

In itself, neglecting this difference is no major issues, provided that one condition is met. This condition is that the dykes should not fail in case the water level is below or at the design water level (like seem to have happened at some locations during hurricane Katrina in the New Orleans area, USA). This, in turn, has implications for maintenance of the dyke system. For example, if – like in the case of the Middle Loire – erosion of the river bed reduces the stability of the dykes, measures are imperative to guarantee the structural integrity of the dyke system.