



EUROPEAN WATER ASSOCIATION

**EWA EXPERT MEETING ON PLUVIAL FLOODING
IN EUROPE**

FINAL REPORT

28 OCTOBER 2009

BRUSSELS, BELGIUM



Published and distributed by:

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Special acknowledgements to:

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ABSTRACT

At the same time as the deadline for Member States to transpose the Floods Directive (2007/60/EC) expires, EWA has organised this Expert Meeting to gather views and experience on the significance of pluvial flood risks across Europe and to assess how these risks can be managed through the implementation of the Floods Directive. The report of this meeting can be regarded as a 'situation paper' to inform further consideration on pluvial flooding in Europe.

There are growing concerns that pluvial floods risks across Europe may not be fully recognised or addressed when Preliminary Flood Risk Assessment (under Article 4) is undertaken. The characteristics of pluvial flooding needs to be considered so that there is a common understanding, and the underlying mechanisms highlighted and examined in conjunction with other types of flooding. While there are some simple methodologies available to perform the preliminary risk assessment of pluvial flooding, it appears that accessing and understanding relevant data may be an important factor in risk assessment. In this context, local authorities have an important role to play working in conjunction with national strategic authorities. Pluvial flood risk assessment must also take into account the impact of climate change, which is likely to exacerbate the risk of pluvial flooding – resulting damage and disruption could increase considerably, particularly in urban areas, and there could be an increasing risk to life.

The meeting concluded that pluvial flooding is a topic which needs to be explored in more detail. It will be further addressed at the Workshop on Flash Floods and Pluvial Flooding being organised by Italy in Cagliari, Sardinia on 26-28 May 2010. The topic will also be considered by Working Group F. In the meantime, in order clarify the relative importance of this issue across Europe, it is proposed to circulate a questionnaire amongst Member States. Results will be reviewed at the Workshop in Sardinia in May. The aim will be to identify any needs for further guidance and research on this topic.

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1 OPENING OF THE DAY

Maria Brättemark, chair of Working Group F on Floods, opened the meeting and explained how this expert meeting relates to the activities of the working group. As presented the day before at the 6th meeting of Working Group F, this type of expert meeting aims to be complimentary to and support the workshop meetings which consider various aspects of implementation of the Floods Directive (2007/60/EC). Specifically, the meeting aims to take stock of the importance and relevance of pluvial floods across Europe and identify issues that can be further developed at the thematic workshop on Flash Floods and Pluvial Flooding that Italy is organising in Cagliari, Sardinia, on May 26-28, 2010. The report of this meeting would attempt to address the main issues and could be regarded as a 'situation paper' to inform further consideration of pluvial flooding in Europe.

Ronnie Falconer briefly introduced the European Water Association and outlined the format of the workshop. The main themes being considered were:

- Characteristics and Understanding of Relevant Processes.
- Identifying the Problem: Extent of Pluvial Flood Risk across Europe – Current and Future.
- Approaches to Mapping and Risk Assessment.
- Potential Mitigation Measures.
- Aspects Requiring Guidance and Further Research.

Conclusions from discussion of each theme are summarised at the end of each Section in this report.

The participants then introduced themselves, their background and their relevant expertise. A list of participants is included in Annex 1.



2 SESSION 1 - CHARACTERISTICS AND UNDERSTANDING OF RELEVANT PROCESSES

Introducer: Ronnie Falconer, Chairman of EWA Working Group on Sustainable Flood Risk Management.

2.1 Characteristics of pluvial floods

Under this topic, participants discussed the need for a common understanding of the characteristics of pluvial flooding to assist in the understanding of this type of flooding.

The table below compares two current descriptions presented for discussion:

	Working Group F Brno workshop, 25 May 2009	Scottish Environmental Protection Agency , June 2009
Pluvial Floods	Pluvial flooding might include ponding of rainwater in natural or artificial hollows / depressions, or overland flow of rainwater failing to infiltrate into the ground during intense or prolonged heavy rainfall	Flooding as a result of rainfall when water ponds or flows over the ground before it enters a natural or man-made drainage system or watercourse, or when it cannot enter because the system is already full to capacity.

These descriptions have to be considered with the general framework of surface water floods which describes flooding from sewers, drains, small watercourses and ditches that occurs during heavy rainfall in urban areas. It includes pluvial floods, sewer floods, floods from small open-channel and curved urban water courses and overland flows (DEFRA, UK, Guidance on Surface Water Management Plans (First Edition) February 2009).

The following points came out from the discussion:

- Heavy rainfall is only one part of the equation and must be balanced against the drainage and infiltration capacity.
- In urban areas, land use change can significantly alter infiltration capacity and most of the drainage capacity lies with the sewerage system. In those cases, it is often a matter of infrastructure planning and design. For these reasons, it is generally an acute problem in urban areas but it can also happen in rural areas.
- It is important to get right a common understanding of flash and pluvial floods first. Then the characteristics of other types of flooding (surface water flooding, excess water flow, urban floods, etc.) can be related to these.
- Pluvial flooding clearly falls under the scope of the Floods Directive. Only flooding related to sewer infrastructure blockage or failure can be excluded. Rainfall derived sewer flooding is generally accepted as being included.

The following description of Pluvial Flooding is proposed:

Pluvial Flooding is flooding as a result of heavy rainfall when water, which does not infiltrate into the ground, ponds in natural or artificial hollows or flows over the ground as overland flow, **before** it enters a natural or man-made drainage system or watercourse or when it cannot enter because the system is already full to capacity. Usually associated with short duration high intensity rainfall but can also

occur with lower intensity rainfall over longer periods, or melting snow, and can be worse when the ground is saturated, frozen, compacted, developed or otherwise has low permeability. High velocity overland flow and deep ponding pose a particular hazard.

[Pluvial Flooding is in some countries referred to as Excess Water Flooding and in this case includes Groundwater Flooding.]

In relation to pluvial flooding the following description of Surface Water Flooding is proposed:

Surface Water Flooding arises from a combination of flooding from surface runoff, sewers, drains, small watercourses and ditches that occurs during heavy rainfall. The impact is often greatest in urban areas. It includes:

- Pluvial flooding (as defined above)
- Sewer or drainage system flooding (when the capacity of underground systems is exceeded due to heavy rainfall – not due to blockage or structural failure of the system)
- Flooding from small open-channel or culverted watercourses (usually in urban areas)
- Flooding from groundwater.

2.2 Characteristics of flash and pluvial floods

The table below summarises the comments made during the meeting:

Flash Floods ¹	Pluvial floods
Caused by the same extreme rainfall.	
Predictable but difficult to forecast.	
Flash flooding usually arises from a watercourse.	Pluvial flooding arises from rainfall runoff before it reaches a watercourse or drainage system or when it cannot enter.
Small basin events. Importance of thunderstorm speed and direction.	Local events but can be widespread with locally intense cells.
High velocity + debris. Can be a significant risk to life.	Usually no transport of debris. Can be a risk to life where high velocity or deep ponding.

Participants agreed that the two types of floods can be hard to distinguish and they can occur at the same time. Better understanding of these interactions is important to disentangle the different types of flooding and this can be important in developing appropriate solutions.

¹ During those discussions, participants used the description of flash floods agreed at CIS thematic Workshop on Preliminary Flood Risk Assessment, Brno, May 2009. A flash flood is rapid flooding occurring on smaller rivers and streams. It is caused by heavy (excess) rainfall associated with thunderstorms. Its time to peak generally ranges from few minutes up to few hours

2.3 **Factors that influence the severity of pluvial flooding and impact**

The table below summarises the factors and processes that characterise pluvial flooding or can influence the severity of pluvial flooding.

<ul style="list-style-type: none"> ➤ <u>Rainfall</u> <ul style="list-style-type: none"> - intensity thresholds important for forecasting - spatial extent (can be very localised or high intensity rainfall cell within much wider event) - storm movement (direction and speed) - climate change (potentially 30% increase or more in peak rainfall intensity by 2100) ➤ <u>Topography and infrastructure</u> <ul style="list-style-type: none"> - important to identify surface water flowpaths and areas of ponding - steepness (high velocity surface flows could be a risk to life) - road or rail embankments can be barriers to surface flow and cause deep ponding - road or rail underpasses may be vulnerable ➤ <u>Permeability of underlying ground and antecedent soil conditions</u> <ul style="list-style-type: none"> - relevant to runoff threshold - can affect rate of dissipation. - wetness of the ground a factor - frozen ground can lead to rapid runoff ➤ <u>Surface and underground drainage capacity</u> <ul style="list-style-type: none"> - often totally overwhelmed - can influence drawdown - can also contribute to surface water flooding - dynamic exchange can occur between above and below ground systems - tide-locking can exacerbate ➤ <u>Doorway threshold levels</u> <ul style="list-style-type: none"> - can be a critical factor especially if at or below ground level - access ramps to below ground areas may be particularly vulnerable - basement flats vulnerable and could be a risk to life if adjacent to a flowpath or within a ponding area ➤ <u>Sensitivity of Land Use</u> <ul style="list-style-type: none"> - can influence permeability - can significantly influence damage consequences ➤ <u>Interaction with other types of flooding</u> <ul style="list-style-type: none"> - fluvial flooding - flash flooding from watercourses - tidal flooding - sewer flooding - groundwater flooding

The importance of all these elements was recognised by the participants.

2.4 **Conclusions**

- There was acceptance to continue with the terms “pluvial” and “flash” flooding in order to reflect the differences in the way in which these types of floods are generated. They can both be due to the same type of intense rainfall but are different in terms of their characteristics and potential consequences.
- It was considered that both the Brno and SEPA descriptions were good starting points which broadly capture the main elements of pluvial flooding. Further refinement was proposed which would help to avoid confusion with terminology. Proposed descriptions for Pluvial Flooding and Surface Water Flooding are presented at the end of Section 2.1.
- In terms of looking at the processes, it would be worthwhile undertaking research to study the characteristics of past pluvial events in order to understand the nature of these events better.

3 **SESSION 2 - IDENTIFYING THE PROBLEM: EXTENT OF PLUVIAL FLOOD RISKS ACROSS EUROPE**

Introducer: Ad De Roo, Action Leader Floods, EC Commission, JRC

3.1 ***Underlying causes of pluvial flooding phenomenon***

Pluvial flooding is usually associated with high intensity rainfall events (typically >30mm/h) but can also occur with lower intensity rainfall or melting snow where the ground is saturated, frozen, developed or otherwise has low permeability. Two types of overland flow can be identified:

- Infiltration excess overland flow (Horton type). In this case, rainfall intensity exceeds the infiltration capacity.
- Saturation excess overland flow (Dunne type). In this case infiltration capacity is very limited, so that any precipitation or snowmelt is excess water.

3.2 ***Degree of general concern across Europe***

To date Western Europe appears to have been more affected by major pluvial flooding with recent floods in Ireland and England being notable examples. However, participants were of opinion that conditions for pluvial flooding can happen anywhere across Europe at any time. All European countries are likely to have a pluvial flood risk to a greater or lesser degree.

In some Member States, however, pluvial flooding falls entirely within the remit of local authorities (especially as they usually deal with the capacity of drainage infrastructures in urban areas). This may make it difficult to assess the significance of the phenomenon at national level.

It emerged from the discussion that some Member States are likely to give a low priority to pluvial flood risk compared to other floods risks. It would be important to understand the basis on which such an assessment may be made – any determination of the significance of this type of flooding must be based on sound evidence.

3.3 *Climate change impact*

Climate change is very likely to exacerbate the risk of pluvial flooding. In this context, assessing the likely variations in projected rainfall intensity across Europe due to climate change would be very useful. Models tend to indicate that the average runoff will increase in Northern Europe and will decrease in Southern Europe. For the latter however, this does not mean that the frequency of extreme rainfall events will decrease.

The following points came out from the discussion:

- In the current context of uncertainty, long-term changes in weather patterns are difficult to predict. One of the key challenges is the down-scaling of predictions.
- Increasing pluvial flood risks are not driven only by climate change but also by enhanced vulnerability, especially in urban areas.
- Some evidence suggests that increase in rainfall is not necessarily directly proportional to increased risk of pluvial flooding. Even a moderate increase in rainfall could result in a very significant increase in pluvial floods events and risk.

3.4 *Conclusions*

It came out firmly that pluvial flooding is an issue that should be of concern right across Europe and that if a Member State should decide that pluvial flood risk is not significant, and not proceed with mapping of pluvial flood risk, they would need to produce clear evidence on which this decision is based.

In order to clarify whether pluvial flooding is uniformly a problem across Member States, it was proposed to draft a questionnaire to circulate to Member States prior to the workshop in Sardinia. The main elements of this questionnaire were discussed:

- Descriptions of pluvial flooding and flash floods that are used by Member States
- Identifying the extent to which pluvial and flash flooding are seen as a significant problem to be assessed through the preliminary risk assessment exercise.
- Review of the institutional arrangements to check whether or not they are masking the recognition of pluvial flooding as a problem.
- The general level of vulnerability as perceived by Member States.

4 **SESSION 3 - APPROACHES TO MAPPING AND RISK ASSESSMENT**

Introducer: John Martin, Office of Public Works, Ireland Representative

4.1 *Pluvial flood mapping for the Preliminary Flood Risk Assessment*

Participants discussed whether an effective template methodology is available for Member States to carry out the Preliminary Flood Risk Assessment, considering:

- “Available or readily derivable” data
- “Past Floods” (historical)
- “Future Floods” (predictive)

Participants were of the view that even mapping based on preliminary broad scale screening using simple methods could, when considered with any available records and observations of pluvial flooding, provide evidence on which to base an assessment of the likely significance of pluvial flooding in comparison with other types of flooding.

Such techniques are currently available and can be applied on a national basis. At the Preliminary Flood Risk Assessment stage some form of evidence base will be necessary in order to justify the level of significance assessed for pluvial flooding.

It was recognised that pluvial floods may often go unnoticed in comparison with river floods as they can often be very localised and they can be masked by river (or tidal) flooding or sewer flooding if this occurs at the same time. However, some recent studies suggest that potential damages associated with pluvial flooding can in some areas be of a similar order to those associated with river flooding.

It was considered that good practice examples on preliminary screening and mapping of susceptibility to pluvial flooding could be of assistance to Member States.

4.2 *Rainfall and hydrological considerations for pluvial flood mapping*

Participants discussed the hydrological data appropriate to use with mapping models to generate representative mapping according to Article 6 of the Floods Directive. Key points for discussion were:

- Input data
- Design rainfall/storm events
- Storm duration
- Spatial distribution, areal reduction factor and blanket rainfall assumptions
- Assessment of infiltration (it can only be estimated by indirect methods)
- Processes for generating flow (% runoff)
- Climate change

4.3 *Assumptions and considerations in detailed pluvial mapping (article 6)*

Participants discussed the most appropriate methods for developing pluvial flood maps in the areas of potentially significant flood risk. Key points for discussion were:

- Hydrodynamic versus static GIS based methods (wet/dry)
- Model resolution (detailed LiDAR versus less accurate regional digital terrain models)
- Consideration of drainage systems
- Consideration of built infrastructure
- Flow/velocity mapping for critical flow routes
- Calibration/validation of methods
- Site inspections for verification, preliminary risk assessment and identification of mitigation measures

4.4 *Conclusions*

Participants agreed that a top-down risk based approach is a principle that should generally be applied. It means undertaking first high level analysis with simple methods and historic data to screen areas which may be at greater risk and, afterwards, undertaking more detailed analysis for areas identified as likely to have a significant risk. At all stages, site inspections can prove to be valuable for verification, risk assessment and to understand flood mechanisms which will assist in identifying appropriate mitigation measures.

It was acknowledged that data on observed incidents of pluvial flooding is very valuable and should be used as much as possible together with mapping methods.

It was considered inappropriate to impose any fixed methodology on Member States. Instead good practices examples showing how to collect data and to apply various assessment methodologies could be beneficial. The active participation of local authorities is considered important in assessing the level of risk.

5 SESSION 4 - POTENTIAL MITIGATION MEASURES

Introducer: Eliot Gill, UK Representative

This session was based on the lessons learned during the floods that occurred in Summer 2007 in England which caused over 3 billion € damages, over 60% of which was due to pluvial flooding and occurred in areas away from rivers where no flood risk had been previously identified or mapped.

The types of mitigation measure were broadly classified under three categories. Solutions are likely to comprise of a mix of measures.

5.1 Improved conveyance

This option is mainly applicable to larger sewers and urban watercourses. Key points for discussion were:

- Effective option so long as runoff can enter sewers/channels
- Potential pollution control benefits (CSOs) as well
- Standard of protection? – sewers often designed to 1:30 annual probability of surcharging and flooding.
- Not adaptable to climate change (especially the underground infrastructure)

5.2 Source control and overland flow routing/storage

Key points for discussion were:

- These measures slow water down
- SUDS (Sustainable Urban Drainage Systems) are relevant
- Can store and delay locally (at property scale)
- Use roads and streets to route water to storage areas
- Use temporary dual purpose flood storage areas
- Link with urban green space

5.3 Resistance, resilience and non-structural measures

Key points for discussion were:

- Defend vulnerable property (permanent or temporary resistance and resilience measures)
- Spatial planning - avoid building in areas prone to pluvial flooding
- If unavoidable, build with pluvial flooding in mind – resistance and resilience measures
- Public awareness / flood warning can be effective

5.4 **Conclusions**

It emerged from the discussion that the solution often rests in identifying a mix of several mitigation measures. This can be far easier for new development than for retrofitting existing infrastructure. Because of climate change uncertainty there is an obvious need to favour adaptable measures and to also rethink approaches to urban design. This requires effective collaboration between engineers, architects and urban planners. It was considered that approaches to assessing the relative costs and benefit of mitigation measures would be worth further investigation.

Much guidance is being developed across Europe particularly in relation to SUDS. It would be very helpful to gather good practices and examples which could be referred to. These should also cover land planning control measures. Working Group F on Floods should consider ways to facilitate preparation of a catalogue of good practice, win-win measures and relevant examples. Existing guidance documentation should be catalogued.

The importance of public consultation at local level was emphasised in this context. National legislation may also help to resolve planning issues and provide the tools to incentivise people's behavior to contribute to sustainable but safe measures. In addition, education is also necessary to raise public awareness and should be supported by appropriate material. At the same time, it has to be made clear that it is not possible to defend against every risk – the issue is one of risk management.

6 **SESSION 5 - ASPECTS REQUIRING GUIDANCE AND FURTHER RESEARCH**

A number of current research initiatives relevant to pluvial flooding were reviewed as background to consideration of needs for further research and guidance.

6.1 **Presentation of FP7 research project IMPRINTS²**

Introducer: David Velasco (CRAHI, Spain)

The objective is to improve the preparedness and the operational management of flood risks by developing an integrated and interactive platform that will serve better the decision-makers (basin practitioners, emergency agencies, meteorological companies). It is aimed at filling the gap between what we know and can be done and what is available in operational centres.

The main steps in the project are:

- Advanced Rainfall Forecasting
- Flood/Damage Forecasting guidance for risk management (based on advanced rainfall forecasts and radar)
- Probabilistic Hydrologic Forecasting (based on advanced hydrological models)
- Flood/Damage Forecasting Early Warning using a rule-based system for complex processes
- Assessment of Impacts induced by future changes (climate, land use, forest fires, etc.)

² See also the project's website <http://www.imprintsfp7.eu>

6.2 **Presentation of INTERREG IVB project FLOODRESILIENCY³**

Introducer: Tony Maguire (Dublin City Council, Ireland)

This project is aimed at developing a multi-hazard flood risk management framework and will address the following themes:

- Urban flood resilience.
- Room for the river.
- Pluvial flood resilience.
- Climate change.
- Innovation

The project involves 11 partners and covers 8 cities in Ireland, Belgium, the Netherlands, Germany, France and the UK. Strategy and capacity building is based on the 4A's model:

- Awareness (Policy Makers and Politicians / Professionals / Public)
- Alleviation
- Avoidance
- Assistance

The presentation detailed the case of Dublin city in relation to pluvial flood occurrence, impact and public involvement. In this context, it was felt that, when communicating with the public, it would be more appropriate to categorise flood events (perhaps in a similar way to the categorisation of hurricanes) rather than to refer to the return period or annual probability, although probabilities will remain the basis for engineering appraisal.

6.3 **The state of play in the Tisza Basin (Danube)**

Introducer: Zsuzsanna Priváczkiné Hajdú (Tisza River, Hungary)

Surface water inundation from direct rainfall, which is generally termed “excess water flooding” is a real issue of concern in Hungary. About 50% of the territory is lowland. For this reason, the phenomenon has been reviewed in detail and an extensive set of data covering the period 1940-2002 is available. It was considered that ‘excess water flooding’ could be regarded as pluvial flooding on the basis of the descriptions discussed earlier (see Section 2.1) but that it also includes groundwater flooding.

On this basis, the presentation pointed out some needs for action:

- to clarify and harmonize descriptions of types of flood events as a prerequisite to develop better understanding of the flood mechanisms and to identify natural versus anthropogenic drivers. In the Hungarian legislation, 50 different descriptions are currently used.
- to harmonize land use and rural development plans with the way that drainage systems work.
- to develop a management framework (data acquisition, national versus local, synergies with the WFD, etc.)

³ See also the project's website <http://www.floodresiliency.eu>

6.4 Conclusions

Participants emphasised the importance of data collection. This was linked to the proposal to set up a “clearing house” mechanism as described in the EC White Paper on Climate Change Adaptation. It would provide an access portal that would not necessarily be a central repository for data but rather a route to retrieve the data.

It was also felt that there is a need for awareness raising about pluvial flood problems, which is generally not perceived as an issue of high importance in many Member States. In the future, it is very likely that climate change will exacerbate this type of flooding.

It was considered that issues for further research and guidance should be given further consideration at the Workshop on Flash Floods and Pluvial Flooding in Sardinia and specifically identified as a planned outcome from the workshop.

7 SESSION 6 – THE WAY FORWARD TO THE SARDINIA WORKSHOP IN 2010

It was agreed that EWA will prepare a draft Report on the expert meeting which will be circulated for comment to members of Working Group F who were not able to attend the meeting but would like to contribute. Those attending the meeting will also be given the opportunity to review the draft Report. Comments will also be sought from the EWA Sustainable Flood Management Working Group. Thereafter a Final Report of the meeting will be prepared as input to the Workshop on Pluvial and Flash Flooding in 2010. The Final Report will also be presented to Working Group F for consideration.

Concerning the thematic workshop to be organised by Italy in Cagliari, Sardinia on 26-28 May 2010, it was concluded that pluvial flooding should be incorporated and addressed in conjunction with flash floods. Issues identified at the expert meeting can be developed further at the workshop along with those for flash floods. EWA would be invited to join the organising committee for the workshop and to contribute to drafting of the programme. It is anticipated that an important outcome from the workshop will be the identification of specific needs for further guidance and research.

As a first step in this direction, in line with the outcomes of the meeting, a questionnaire will be elaborated and circulated to the full membership of Working Group F in order to review how the pluvial flood issue is dealt with by Member States and how the issue is addressed within the framework of Floods Directive implementation. The results of this questionnaire will be collated for the workshop in Sardinia and also circulated to Working Group F.

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