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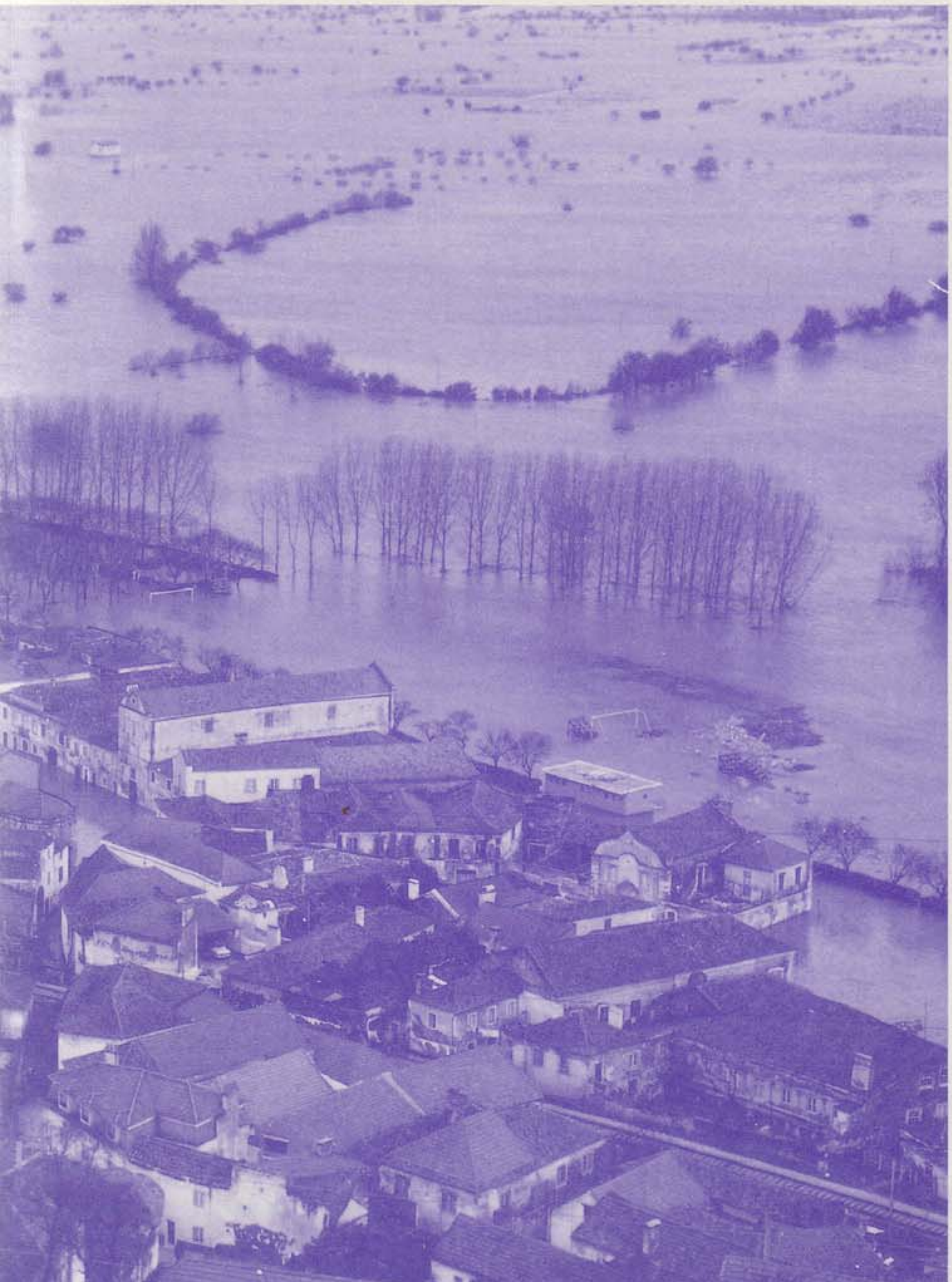

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FLOODS AND INUNDATIONS IN THE LOW VALLEY OF THE RIVER MAIOR

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Abstract

The frequent inundation of the low valley of the River Maior are caused by several aspects: the water table rise, floods in the drainage basin of Rio Maior and the invasion of the Tagus waters. Floods last long, due to the high karst spring flows, weak gradient of the valley bottom and to the fact that this one is lower than the alluvial plain of the Tagus.

Key words: floods, water table, karst springs

1. GEOGRAPHICAL FRAMEWORK

The river Maior is one of the main tributaries of the right bank of the low Tagus (Fig.1). Its drainage basin is in a rural region with intense animal and plant-farming.

The drainage basin of the river Maior, with 656 km^2, is situated in the contact between two morphostructural units (Fig.1): the Mesozoic sedimentary basin in the upper section and the Cenozoic sedimentary basin of the Tagus in the middle and lower section (71% of the total area of the basin).

The upper section of the basin is made up, mainly, of sedimentary formations from the lower Jurassic to the Cretaceous: marls and evaporitic rocks upon which there are, more or less karstified, thick limestone layers, interlayed by detritical formations. This sector is dominated by a discontinuous alignment of limestone little mountains (Espigão-Candeeiros, of NNE-SSW orientation), made up of anticline folds (or half-folds) with faults on the eastern side.

The middle and lower sector is made up of materials from the Paleogene to Holocene, mostly of the detritical nature. We highlight, because of their length, the sandstone clay Miocene complex with discontinuous and thin limestone layers. The structure is monoclinal, evolving, progressively, into a horizontal one towards SE. This section is dominated by plateaux and cuestas.

2. THE LONGITUDINAL PROFILE OF THE RIVER MAIOR

The river Maior flows for 43.25 km as far as the alluvial plain of the Tagus. Its fluvial regime and its longitudinal profile are clearly influenced by the geomorphological features of the two morphostructural units which it crosses (the same happens with its main tributaries).

Thus, when crossing the limestones of the Mesozoic sedimentary basin, the river has a temporary regime due to the high permeability of the karstified limestones. In this first section the river has two sub-sections: the former between 200 and 150m high with a small channel slope (9.3m/km, Fig. 2A), and the latter between 150 and 80m high, with a deep incision (about 70m), when crossing the extreme southern tip of Serra dos Candeeiros, reason why it has a higher channel slope (15.8m/km, Fig.2B).

At the end of this section are the karst springs of the river Maior, at a height of 90 and 80m (Fig.2). They are fed by the karstified Dogger limestones whose thickness above the springs is about 350m. The springs are divided into two sets: the former usually named "Bocas do Rio Maior" (Mouths of the river Maior), at 90m high, are temporary; the latter at 80m high, is called "Fontes" (Fountains) and is made up of exsurgences, almost all of them being permanent.

Upstream of the karst springs, the river Maior

Ramos C. (1996) - Floods and inundations in the low valley of the river Maior. *In: A. B. Ferreira & G. T. Vieira (eds.), Fifth European Intensive Course on Applied Geomorphology - Mediterranean and Urban Areas, Departamento de Geografia, Universidade de Lisboa, 177-183.*

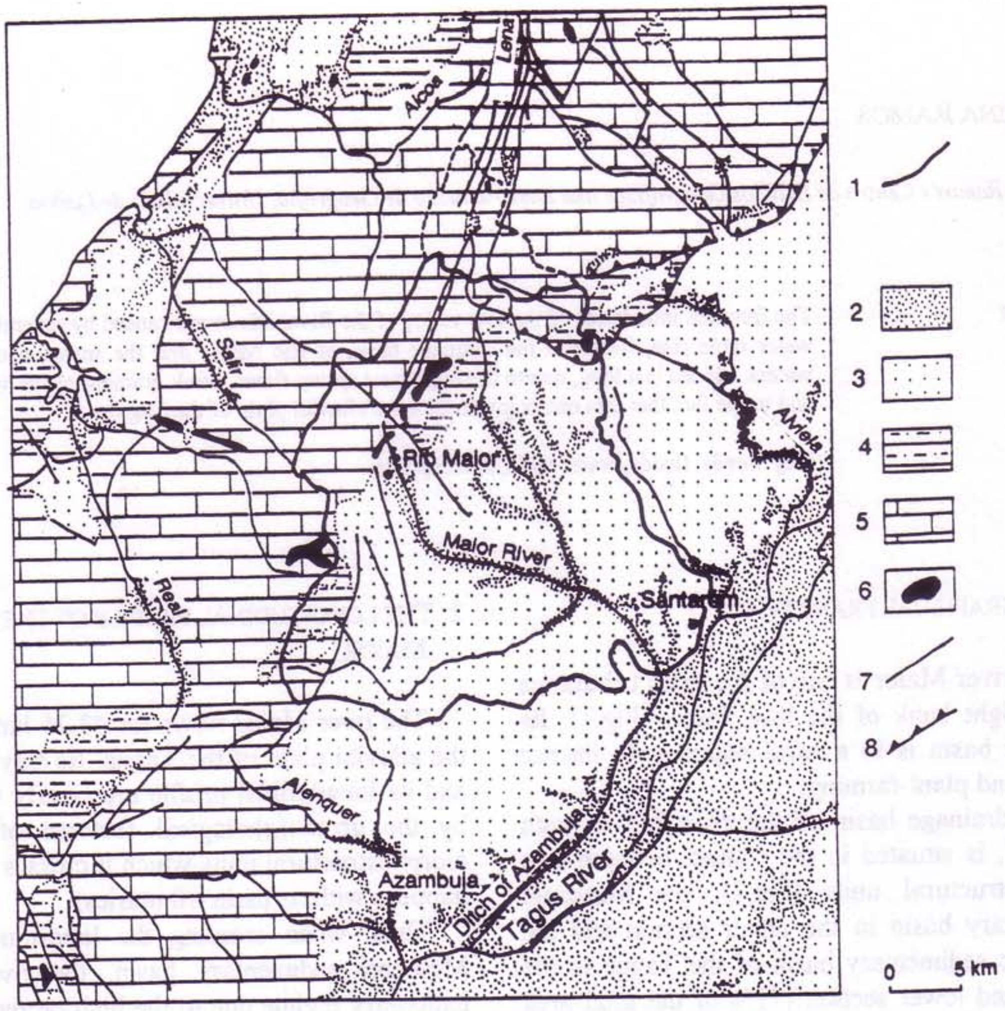

Fig.1 - The river Maior basin. Legend: 1) limit of the drainage basin; 2) Quaternary (alluvial deposits and sand dunes); 3) Pliocene, Miocene and Paleogene (sandstone-clay complexes); 4) Cretaceous (sandstone-clay complex); 5) Jurassic (limestones); 6) Alpine volcanic rocks; 7) fault; 8) overthrust.

remains dry almost all year long, presenting a weak streamflow when heavy rainfall occurs. This seems to point out that the upper valley may have formed in a Quaternary environment with more abundant rainfall than today.

Downstream of the karst springs ("Fontes") lies the second section of the river with a permanent regime and a drastic decrease in the channel slope when entering the Tertiary basin of the River Tagus (Fig.2). Its weak channel slope (4.5m/km, between 80 and 30m high and 1.3m/km, between 30 and 2m high) can be an answer to the continuous silting up of its valley bottom.

3. FLUVIAL REGIME

3.1 The influence of the karst springs

The river Maior has a gauging station working since 1976 (Ponte de Freiria) at a height of 10m. Besides this there was another one upstream (Rio Maior) with data from 1978 to 1989. It was located at a height of 72m downslope of the karst springs.

Comparing the data from the gauging stations of Rio Maior (drainage area 28 km^2) and Ponte de Freiria (drainage area 184 km^2) in the period commun to both stations, half of the streamflow (49%) has its origin in the area located

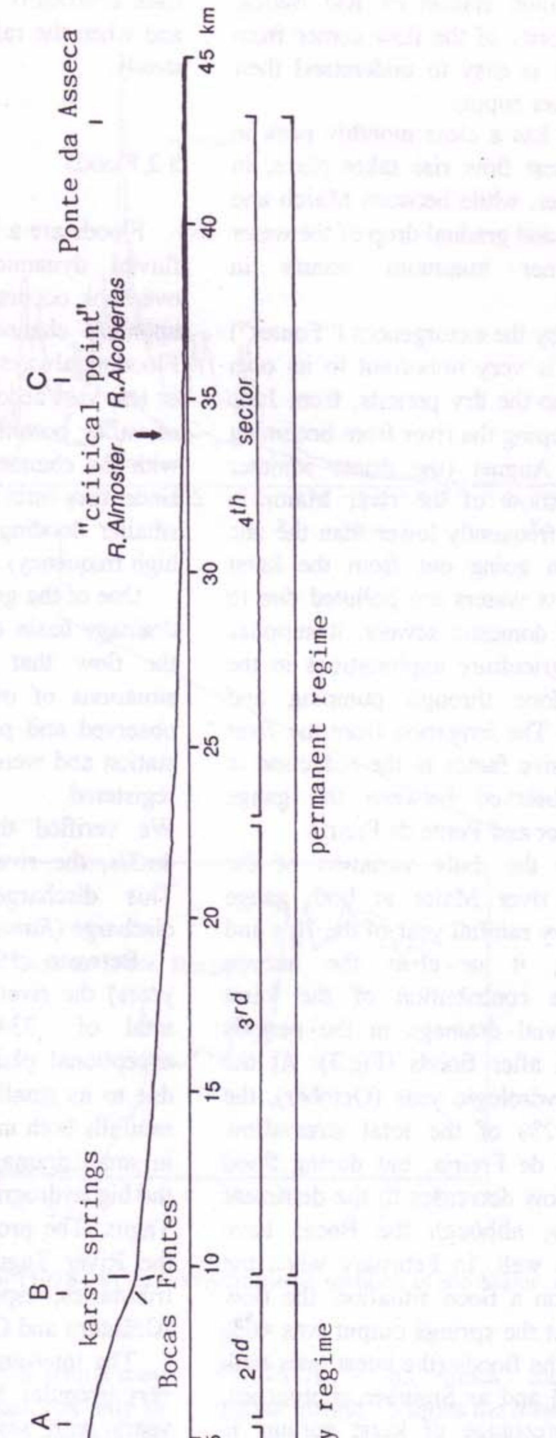

Fig.2 - Longitudinal profile of the Maior river.

upstream of the gauge station of Rio Maior. Since the great majority of the flow comes from the karst springs, it is easy to understand their importance in the river supply.

The river Maior has a clear monthly peak in February. The highest flow rise takes place, in average, in December, while between March and June there is a slow and gradual drop of the water level. The Summer minimum occurs in August/September.

The role played by the exsurgences ("Fontes") of the river Maior is very important to its own feeding, especially in the dry periods, from June until September, keeping the river from becoming dry. In July and August (the driest summer months) the streamflow of the river Maior in Ponte de Freiria is frequently lower than the one the river has when going out from the karst springs. Although its waters are polluted due to swine farming and domestic sewers, it supplies water to several agriculture exploitations in the valley. This is done through pumping and irrigation channels. The irrigation from the river seems to be a decisive factor in the reduction in the streamflow observed between the gauge stations of Rio Maior and Ponte de Freiria.

If we compare the daily variation of the discharges of the river Maior at both gauge stations, in the heavy rainfall year of the 70's and 80's (1978-1979), it is clear the uneven importance of the contribution of the karst springs to the fluvial drainage in the periods before, during and after floods (Fig.3). At the beginning of the hydrologic year (October), the Fontes supplied 52% of the total streamflow measured in Ponte de Freiria, but during flood periods the karst flow decreases to the detriment of the quick flow, although the Bocas have started working as well. In February when the river was always on a flood situation, the flow volume measured at the springs output was 40% of the total. After the floods (the latest ones took place in mid-April) and as Summer approaches, the streamflow percentage of karst springs is increasing comparing to the total amount of water carried by the river, due to the higher decrease in the quick flow.

On Fig.3 we can see the time when the Bocas (mouths) "blow up" (as the local population calls it), because from that moment on, the river flow rises drastically in the Rio Maior gauge station and when the rainfall decreases or ends, it keeps steady.

3.2 Floods

Floods are a hydrologic phenomenon linked to fluvial dynamics and take place when the overbank occurs, that is, when a river leaves its apparent channel and occupies the floodplain. Flooding always implies inundation, wich is more or less vast according to its magnitude and width of valley bottom. The riverside lands in contact with the channel are most vulnerable to floods, since they are submerged even in the case of smaller flooding events (low magnitude but with high frequency).

One of the goals of the field work made in the drainage basin of the river Maior was to define the flow that causes the overbank. Several situations of overbank and pre-overbank were observed and pictures were taken at the gauge station and were compared with the data already registered.

We verified that when the discharge reachs 8m3/s, the river Maior initiates the overbank. This discharge is named minimum flood discharge (*Ramos*, 1994).

Between 1976-1977 and 1979-1980 (14 years) the river Maior registered 41 floods (a total of 334 days). Floods are not an exceptional phenomenon in this drainage basin due to its small size. As a matter of fact, heavy rainfalls both in time and space can cause floods in small drainage basins, but they hardly affect the big hydrographic basins like the one of River Tagus. The probability of a flood occurrence in the River Tagus is smaller than in one of its tributaries, especially after the construction of Alcântara and Cedillo dams.

The inter-annual distribution is, as expected, very irregular: there are years without floods and years with several flood events. Floods have taken place between the second week of November and the first week of May. December, January and February were the most affected months. These three months have registered, on the whole, 80% of the flood days.

Rainfall is the only cause of floods in the river

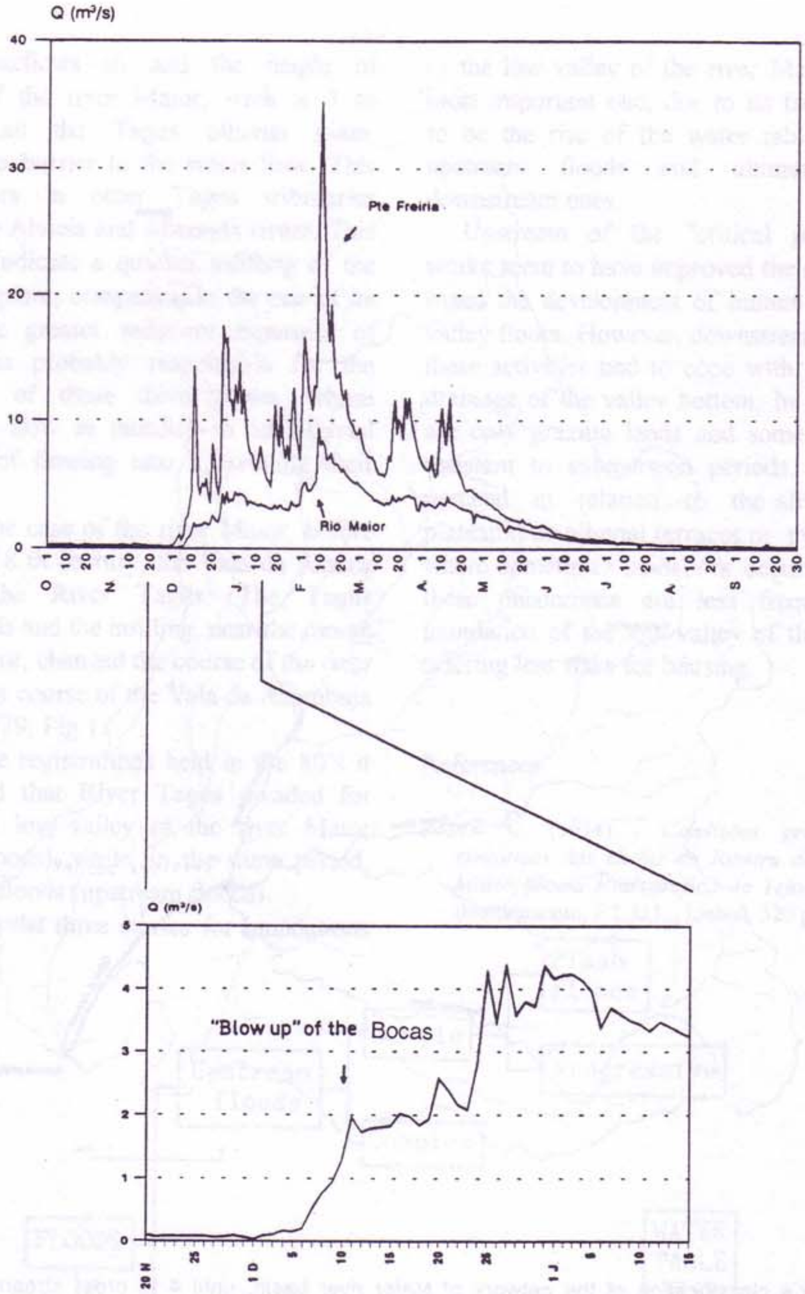

Fig.3 - Daily discharges of Maior river (1978-79), in the hydrometric stations of Rio Maior and Ponte de Freiria (*Ramos*, 1994, p.388).

Maior. The amounts of daily rainfall which may cause floods, can change a good deal, not only in terms of accumulated rainfall, but especially in terms of initial flow, that is the flow that streams have the day before overbank.

The maximum instantaneous discharge registered at Ponte de Freiria, took place on the 10th February 1979, corresponding to the greatest floods of the century in the River Tagus: $47.02m^3/s$ - 63 times the semi-permanent discharge and 28 times the mean discharge.

4. THE INUNDATION AREA

The observation of the hydrographic network of the drainage basin allows to detect the "critical point" of the basin, that is, the confluence

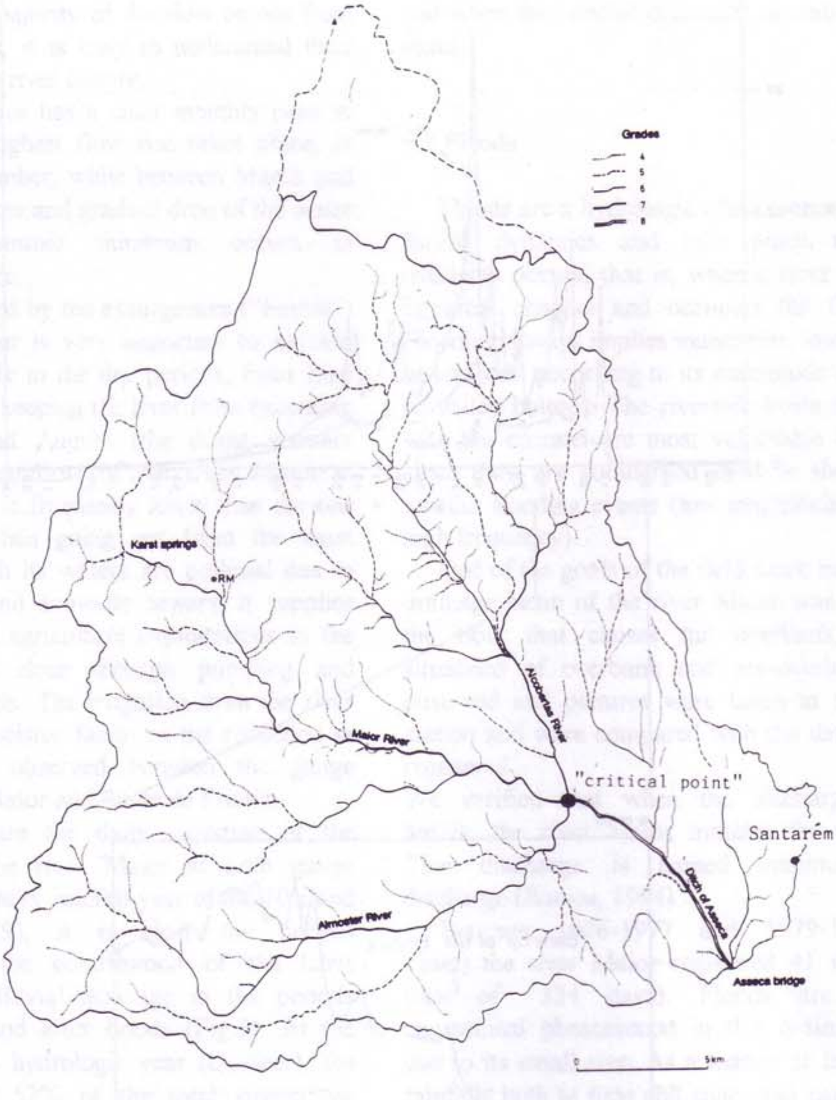

Fig.4 - Strahler´s classification of the network of Maior river basin, until 4 th order streams (*Ramos*, 1994, p.337).

between the river Maior and its two main tributaries: Alcobertas river and Almoster river (Fig.4). The waters from 88% of the drainage area flow into this point making it very vulnerable to floods. At the end of their course, Alcobertas and Almoster rivers are artificially channelled to ease the drainage into that confluence. From the "critical point" up to the Tagus alluvial plain (Ponte da Asseca, "Asseca Bridge") - the low valley of River Maior - waters are channelled through the Vala da Asseca (ditch) with 9.3km long (Fig.4). Downstream of the "critical point" the valley widens and the floodplain ranges from 400m to 1500 wide (Fig.2C).

The riskier inundation area of all the drainage basin is the section between the "critical point" and Ponte da Asseca due to four main reasons: all the flow of the drainage basin flows into it and the ditch cannot discharge the surplus; the weak slope angle of the valley bottom (0.43m/km); the River Tagus proximity, which sometimes, overflows it; and the height of valley floor of the river Maior, wich is 3 to 5m lower than the Tagus alluvial plain, which acts as a barrier to the water flow. This situation occurs in other Tagus tributaries valleys, like the Alviela and Almonda rivers. This fact seems to indicate a quicker infilling of the Tagus alluvial plain, comparing to the one of its tributaries. The greater sediment dynamics of River Tagus is probably responsible for the course detour of these three rivers, whose tendency is to flow in parallel on its alluvial plain, instead of flowing into it, keeping their course.

In fact, in the case of the river Maior, before the end of the 18 th century, the Vala da Asseca flowed into the River Tagus. The Tagus successive floods and the infilling, near the mouth of the river Maior, changed the course of the river up to the current course of the Vala da Azambuja (*D.G.R.A.H.* 1979, Fig.1).

Based on the registrations held in the 80's it has been found that River Tagus invaded for three times the low valley of the river Maior (downstream floods), while, in the same period, this one had 25 floods (upstream floods).

From among the three causes for inundations of the low valley of the river Maior (Fig.5), the most important one, due to its frequency, seems to be the rise of the water table, followed by upstream floods and ultimately, by the downstream ones.

Upstream of the "critical point" drainage works seem to have improved the streamflow and eased the development of human actions in the valley floors. However, downstream of this point, these activities had to cope with the insufficient drainage of the valley bottom. In this way, there are only grazing lands and some cultures more resistant to submersion periods. Settlementsare perched in relation to the alluvial plain: on plateaux, on alluvial terraces or even on slopes, where sometimes landslides occur. Nevertheless, these phenomena are less frequent than the inundation of the low valley of the river Maior, offering less risks for housing.

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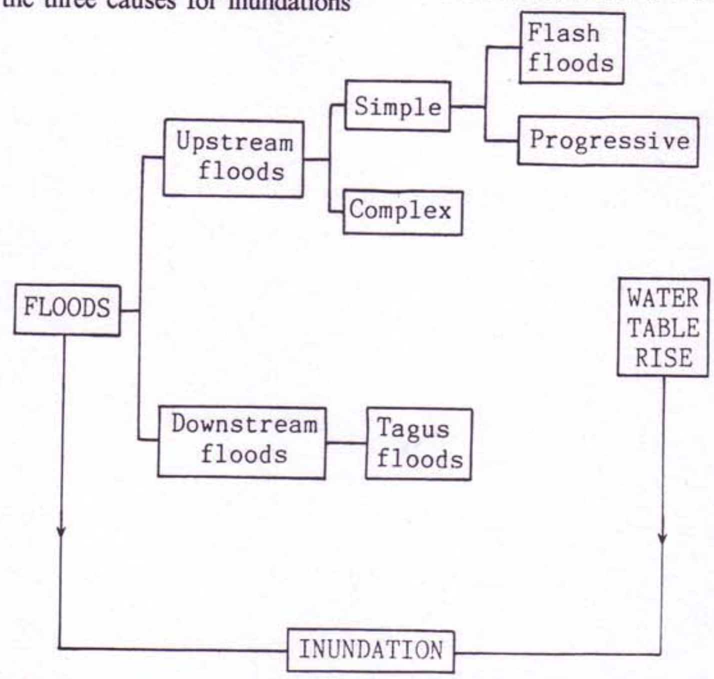

Fig.5 - Main causes of the inundation of Maior river low valley (*Ramos*, 1994, p.449).