

## The impact of floods on SEVESO establishments

### Series of events from 1993 to 2003

## Provence-Alpes-Côte d'Azur

## Languedoc-Roussillon

## France

Warehouses  
Paper mill  
Explosives  
manufacturing plant  
Floods  
Dike failure  
Danger study  
Alert management  
Property damage  
Technical unemployment

## FOREWORD

### Flooding in the Cévennes Region in 2002



The Saint-Nicolas bridge in Uzès (Gard), submerged by flood waters - 09/09/2002



View of the bridge 5 days later

In early September 2002, intense rain beat down on the south of France for two days (Anduze: 687 mm/24h, Ners: 591 mm/24h, Alès: 514 mm/24h (\*) – (Sources: Météo France). This intense rainfall led to rising water levels from 1 to 3.5 m in an hour's time.

In the Gard, Hérault, Drôme and Vaucluse departments, the flooding resulted in 25 deaths and damage estimated at 1.2 billion euros (including 814 million euros for the Gard). 295 communities of these 4 departments were a natural disaster area.

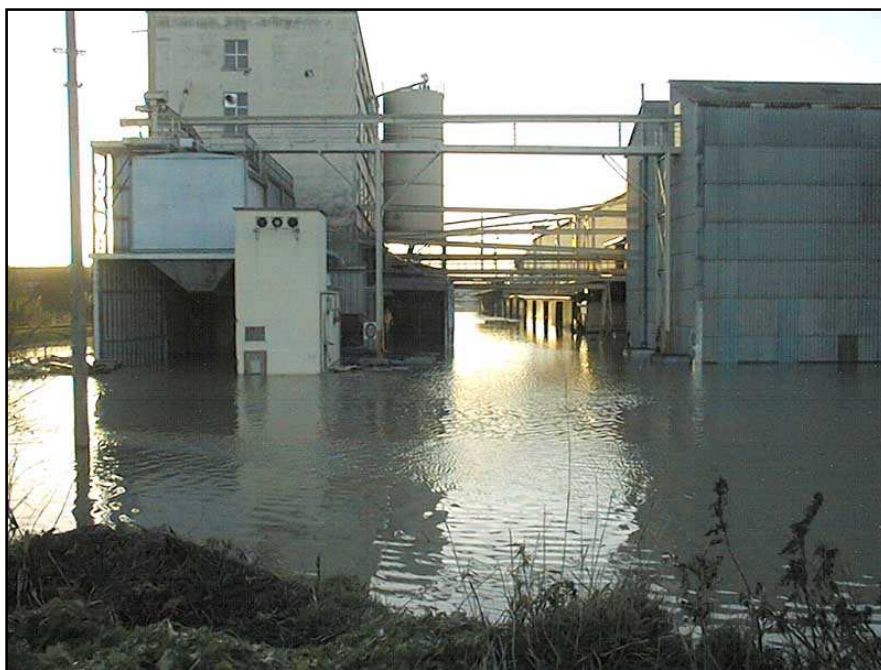
Following these dramatic events, the local communities and certain operators of industrial facilities undertook preventive operations (construction of dikes, redimensioning of rainwater networks, maintenance of rivers and streams...) and engaged in reflective thinking on:

- ✓ the reference water levels (new cartography of flood planes according to gauge heights, river flow rates...)
- ✓ the various means of communication during a crisis (the proven efficiency of the microwave network, questions regarding satellite technology...)
- ✓ alert (creation of the SCHAPI in Toulouse: Service Central d'Hydrométéorologie et d'Appui à la Prévision des Inondations)
- ✓ the maintenance of networks (electricity, water, gas, roads...)

(\*) For comparative purposes, Marseilles' average rainfall is 570 mm.

- ✓ enhanced consideration of the vulnerability of industrial sites in terms of flooding (inclusion of a "flooding" scenario in danger studies)

### The flooding of industrial facilities



**Flooding of Arles - December 2003**

As the French drainage network extends over 280,000 km of rivers, only a few geographical regions are spared the risk of flooding. Although it can prove extremely harmful in terms of human losses and property damage, the operators of installations classified for environmental protection still do not give this type of risk sufficient consideration.

In June 2003, the DRIRE of the Provence-Alpes-Côtes d'Azur Region (PACA) created a "Natural Hazards" task force with the objective to study the natural hazards likely to have an impact on industrial installations, their intensities and associated probabilities and also to define the means required to reduce their impacts. In addition, the task force reiterates the methods applicable in terms of impact analysis.

Faced with the extensive damage caused by the Rhone and its tributaries in 2002 and 2003, the task force planned to first deal with the risk of "flooding". The DRIRE Languedoc-Roussillon ("Direction Régionale de l'Industrie, de la Recherche et de l'Environnement", Regional Industry Research and Environment Agency), DIREN PACA ("Direction Régionales de l'Environnement", Regional Environment Agency), DDE ("Direction Départementale de l'Équipement", Departmental-based Infrastructure Agencies) of the Bouches du Rhône department, the BRGM ("Bureau de Recherches Géologiques et Minières", Office for Geological and Mining Research), a departmental community, engineering firms or adjustment bureaus, manufacturers, labour unions and representatives of insurance companies all participated in this task force. The DRIRE of Upper-Normandy and Météo France also offered their support.

Several of the sites that were flooded in the Bouches du Rhône were visited within the scope of the task force's work: pesticide warehouses in Arles and Rognac, an explosives manufacturing plant in Saint Martin de Crau, and a paper mill in Tarascon... The visits in the Languedoc-Roussillon were terminated by an inquiry in an agro-pharmaceutical product warehouse in Saint Gilles (Gard). These industrial establishments were flooded by an overflowing river or canal, by the rupture of a dike or by significant volumes of run-off water.

In addition, the DRIRE agencies of the Languedoc Roussillon and PACA, in close collaboration with the CETE ("Centre d'Etudes Techniques de l'Équipement", Centre for Technical Studies on Infrastructure) of Aix and the DIREN PACA, drew up specifications for conducting "flood" hazard risk studies on the major industrial sites. This

document, available on the web site of the PACA SPPPI ("Secrétariat Permanent pour la Prévention des Pollutions Industrielles", Permanent Office for the Prevention of Industrial Pollution) (SPPPI) PACA, completes simpler guides published by various organisations (insurers...) that warn of this risk in small and medium-sized companies/industries. In the PACA Region, the Aix CETE is conducting a "vulnerability" study of SEVESO sites by taking a census of the various types of floods feared (floods, dam failures...).

## - TARASCON site (Bouches du Rhône) - (ARIA No. 26459)

### THE INSTALLATIONS IN QUESTION

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The company operates a bleached paper pump production unit that uses an ECF (Elementary Chlorine Free) process. Oxygen, hydrogen peroxide and chlorine dioxide, manufactured at the site, are the bleaching agents. Black liquor, fuel oil, methanol, chlorate and several tons of wood are also stocked at the site. The plant produces approximately 250,000 tons of paper pulp per year. Since 1953, the facility, which employs 280 people, has been located to the south of the city of Tarascon, in an industrial estate bordering the Rhone River. It is subject to authorisation with public easement (AS). A reduction in the amount of dry chlorate stored on site and, used in the process, would reduce the site's classification from "high-level SEVESO" to "low-level SEVESO".

The comprehensive development area map requires that the level of the building's ground level floors be placed above water. For the factory, rebuilt in 1981, this level is defined at dimension NGF + 10.56 m (NGF: Nivellement Général de France, French vertical datum - MSL) in reference to the maximum height of the water recorded at the site during the 100-year flood of 1856. The plant's level 0 is located at + 9.36 m NGF; the floors of the workshops and offices were raised 1.2 m. Part of the stock and utilities (lifting pumps) are located below this reference level, but the majority of the heavy equipment is above this level, owing to the presence of bases and support platforms.

Prior to the floods of December 2003 (*No. ARIA 26459*), the plant had already been flooded by 60 to 70 cm of water three times between 1992 and 1994. As a few motors had been flooded at the low points, the plant had been shut down as precautionary measure.

Measurements were taken in the establishment following the 3 other floods in 2001 and 2002, when the level of the Rhone had reached the site to a level of + 10.27 m NGF:

- the "flooding" hazard was integrated into the danger study,
- instructions on site shut-down procedures were drawn up,
- production shops, black liquor boilers and turbines were raised to + 10.56 m, 15 m and 21 m NGF respectively; electrical equipment placed above the water level,
- storage facilities were equipped with retaining basins 0.7 m high and tanks were anchored,
- piping was mounted on racks (only the water conduits were buried).

### THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

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#### Flooding of the Tarascon site

On December 1, 2003, firemen alerted the operator of the risks that the Rhone may breach its banks. The establishment began operations with a reduced workforce the following day.

Faced with the continually rising water, an alert procedure was implemented according to the water levels:

- at 6.4 m NGF, a 600 mm dia. bladder was installed on the piping to prevent the overflow of rainwater into acid effluents,
- at 9 m NGF, the personnel was evacuated and the site was secured by 25 employees (total shut-down of installations, moving of exposed equipment well above water level).

The intervention time allows sufficient reaction time to stop chips being sent and to shut down the black liquor boiler (6 hours are required for complete shut down). For flood protection, the installations are shut down and the boilers and the scrubber are secured.

A team of 25 individuals carries out these operations, while the other 255 employees are evacuated. The total security operation takes 8 hours. Shutting the machines down prior to flooding reduces the chance of equipment damage.

December 3 at 3.30 pm. The reference level of the 100-year flood of 1856 was thus exceeded by 0.74 m. As the site was completely flooded, a boat was used to check that the safety devices on the installations were operating properly. Water reached the following levels during the flood:

- 20 cm at the plant entrance,
- 40 cm in the workshops and offices,
- 1.5 to 1.6 m in certain offices located in low areas,
- 1.6 m in certain buildings.

The computer, electrical, telephone, fax and drinking water networks were lost during the flooding (required for the process). However, The level of the RHONE River at the site reached 10.50 m NGF on December 2 at 3 pm and 11.30 m NGF on the operator could be contacted by mobile telephone throughout the event.

The water receded in 24 hours, and the site became accessible by foot on December 4.

Power generators had to be rented until electrical power could be restored on December 12.

The plant was shut down for 1 month so that the site could be cleaned by employees, civil protection organisations and 300 individuals from external companies (including 60 electricians and 50 mechanics). Personnel from a departmental community, the Direction Régionale de l'Agriculture et de la Forêt and volunteers also provided assistance. Mixed teams (internal personnel, electricians, and mechanics) were formed to repair the damage as best they could.

The safety system implemented for the machines, which operated correctly, was checked after the flood.

The plant resumed normal activity on January 19.

### Consequences

The water entered via the parking lot located on the Rhone River side, to the west of the plant. From this side, the fencing protected the tanks and various equipment from debris transported by the river. However, the relatively strong current ripped away the fencing to the northwest of the site.

The current also carried off 6,000 tons of wood (which ripped away the south-side fencing) and empty or nearly empty containers (less than 3 m<sup>3</sup>). Certain pulp batches were tipped over but not carried away. Two thousand tons of pulp bales were drenched and thus lost. The storage tank, including those not anchored, did not move due to their liquid contents. However, the empty peroxide storage container moved slightly during the flooding. The environmental impact was limited as no chemical products were spilled and due to the Rhone's significant flow rate (dilution effect).

The firefighting water network was untouched owing to the fact that it was located further downstream from the stocks of wood that were carried away by the flood. The merchandise railcars remained on their rails.

Electrical substations were flooded, as well as 400 motors that had to be disassembled and cleaned. Cryptogenics was used to dry the archives. Potholes as a result of gully erosion were observed during the site visit.

The treatment plant (located 7 m below the plant) experienced numerous malfunctions; primary settling tanks were set up to evacuate the silt.

The plant's shut down resulted in production losses of 11 million euros to which can be added property damage and the site refurbishing costs. In addition, the sale of damaged pulp at prices significantly below market value also adversely affected the company.

### European scale of industrial accidents

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the 'SEVESO' directive, the floods of the Tarascon site in December 2003 can be characterised by the following 4 indices, based on the information available.

Dangerous materials released		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Human and social consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Environmental consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Economic consequences		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Production losses of 11million euros explain the **level 4** rating of the economic consequences in terms of parameter €16. The parameters that comprise these indices and the corresponding rating method are available at the following address: <http://www.aria.ecologie.gouv.fr>

## ACTION TAKEN

The plant was designed to withstand a 100-year flood (1856). The action plan was slightly modified following the floods of 2003, and preventive measures were implemented to protect the archives and the computer servers.

*As raising the height of the installations was cost prohibitive, a dike project, required by the insurance companies and the site's shareholders, was subject to a public inquiry by way of the "water police". The height of the dike will be based on the flood of 2003, which will represent the reference in terms of PHEC ("Plus Hautes Eaux Connues", highest known flood waters), with an occurrence estimated at 300 / 500 years.*

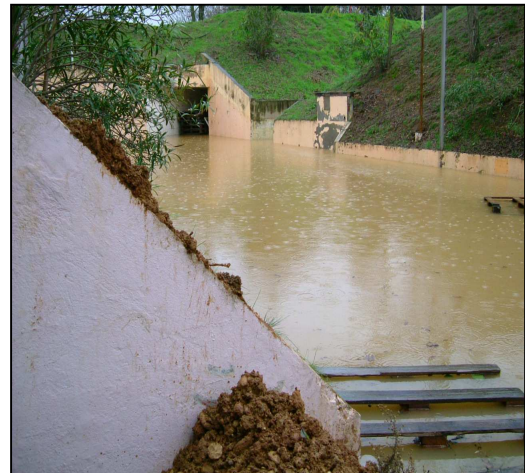
## ST MARTIN DE CRAU site (Bouches du Rhône) - (ARIA No. 26460)

### THE INSTALLATIONS IN QUESTION

The company operates an explosives manufacturing plant located within the *commune* of St Martin de Crau in the township of Arles in the northwest of the Bouches du Rhône *département*. The plant is located in the heart of the Crau plane, which is a sparsely populated urban area.

The facility, which employs 63 people, is classified as high-level SEVESO under the terms of European regulations and subject to authorisation with public easement (AS) as per French regulations. The plant is not located in a flood-risk area and had never been flooded prior to December 2003.

Fifteen hectares of marshland are located near the administrative buildings to the northeast of the site. Numerous canals empty into this marshland and is subsequently used as an outlet for the overflow of water from heaths in the surrounding area. A 150 m³/h lifting pump discharges the marsh water via canal to the Chapelette marshes to the northwest.



### THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

#### The flooding of December 4, 2003 at the St Martin de Crau site

The strong rains that had continued for one week flooded the land next to the site and raised the water level in the Langlade canal on the plant's southern border by 2 m. The gates, closed for an unknown reason, were unable to drain off the canal's overflow.

A wave of water entered the site from the southwest and flowed into the 15 ha of marshland. The 150 m³/h pump, flooded by the rapidly rising waters, was unable to prevent the site from being flooded where the



Workshops

water level had already reached 1.2 m. The operator had set up the 4 pumps available on the site in strategic locations.

As the water pumped from the site was discharged into a second small marshy area, it eventually flooded the northern zone of the site where a transformer was located. This transformer was not damaged. The back-up pumps, requisitioned from other industrial sites and providing a total flow rate of 2,000 m³/h, were able to control the rising waters in the marshland.

After a week of pumping, the CHAPELETTE canal returned to its normal level.

**Consequences**

Although the production buildings, sensitive equipment and stocked products were not damaged, a 2-week shut-down resulted in operating losses estimated at more than 100K euros.

**European scale of industrial accidents**

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the 'SEVESO' directive, the floods of the St Martin de Crau site in December 2003 can be characterised by the following 4 indices, based on the information available.

Dangerous materials released		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Human and social consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Environmental consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Economic consequences		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Production losses, estimated at more than 100K euros, explain the level 1 rating of the economic consequences in terms of parameter 16. The parameters that comprise these indices and the corresponding rating method are available at the following address: <http://www.aria.ecologie.gouv.fr>

**ACTION TAKEN**

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The operator added the addresses and phone numbers of companies that could provide back-up pumps in the case of an emergency to the Internal Contingency Plan. No other measure concerning the floods was taken in terms of the Internal Contingency Plan or the Danger Study.

**- ROGNAC site (Bouches du Rhône) - (ARIA No. 29646)**

**THE INSTALLATIONS IN QUESTION**

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The facility stocks, re-labels, prepares, repackages and palletises merchandise. In 2 hangars with a total surface area of 11,000 m², it stocks pesticides, bulk products in silos, plastic materials and power generators. 37 employees are at the site during the day.

This company is no longer classified as 'low-level SEVESO' due to the limitation of its pesticide storage which had been partly transferred to another site.

Located at the base of a hill, the site is surrounded by a rail line. The elevated upstream part of this rail line forms a dike.

## THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

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The site was subjected to 2 floods in 1993 and in 1994.

✓ The floods of September 1993 followed an intense period of rain lasting 2-3 days. The rail spur channelled the rainwater running along the hill behind the site via underground passageways, which lead to the very rapid rise in the water level.

The wave of water passed through the site and emptied through the entry gate into the avenue. The wave lasted 3 to 4 hours and flooded the offices, storage units and warehouse packaging areas under 50 cm of water.

The very sudden wave occurred around 6-7 am. As no one was at the site at the time, the flooding was reported only later in the morning. No preventive measures had been foreseen.

The damage primarily concerned the machines and the offices, as the computer network had been disconnected. Flammable pesticides, stuffed animals and life preservers were being stored when the flooding took place. Financial losses were estimated at 7 MF, in addition to a significant loss of clientele.

✓ The second floods in Oct.-Nov. 1994 were more extensive. The torrential and intense rains (lasting between 24 and 48 hours) caused an 80 cm-high wave that remained at the site for more than 10 hours. The water followed the same path as the first floods.

The flooding slightly damaged the machines, although the damage was concentrated in the offices and the merchandise stored in the cells. A second warehouse, located on higher ground, had less damage. The computer network was also disconnected during these floods.

Financial losses were evaluated at 6MF despite the measures taken following the floods of 1993.

### European scale of industrial accidents

The indices are as follows for each of the establishment's floods:

Dangerous materials released		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Human and social consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Environmental consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Economic consequences		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Property damages of 7 and 6 MF (1.1 and 0.9M €) explain the level 2 rating relative to the economic consequences in terms of parameter 15.

## ACTION TAKEN

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Following the 2<sup>nd</sup> flood, the operator introduced a permanent monitoring program through a 24/7 duty cycle on the site. In case of new floods, a team of 3 or 4 people would be made up to rapidly secure the equipment and sensitive merchandise.

The *commune* built an underground canal connected to the Etang de Berre which collects water from the entire industrial area. It also created a retaining basin upstream from the industrial site designed to handle 100-year floods.

In the event of a 100-year flood, most of the surplus water would be released back into the canal. The *commune*, thus informed the operator that the site may nevertheless be flooded by 10 cm of water. The latter had 20 cm walls built in front of the emergency exits of the storage units and called for a dam arrangement with transport containers to channel the flow of water.

In most cases, industrial zones are protected only against 100-year floods. Public infrastructures generally do not protect against major floods and the operators of classified installation must undertake additional actions.



## - ARLES site (Bouches du Rhône) - (ARIA No. 26457)

### THE INSTALLATIONS IN QUESTION

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The company stocks and distributes finished pesticide products, without transfer operations and does not sell to the public directly. The storage activity involves 3,600 m<sup>2</sup> and an average height of 7 m (4 levels). The facility has a maximum storage capacity of 3,000 tons, and 48% of the merchandise is governed by legislation relative to dangerous materials.

Located in the Arles industrial zone, the establishment is classified as 'high-level SEVESO' and employs 6 to 8 people. The Grand Rhone is located 750 m to the west and the Vigueirat canal is 1,100 m to the east.

Prior to the floods, the site was not registered as being in a flood-risk area as it was protected by a reliable dike. Since that time, the DDE has downgraded the zones from "protected by reliable dike" to "submersible protected by a dike".

### THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

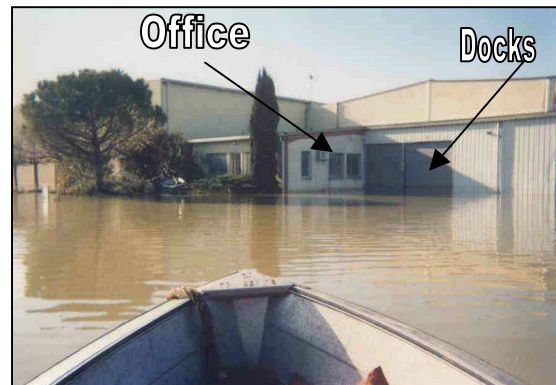
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#### Flooding of the Arles site

The flooding of the site in December 2003 resulted from a dike on the Rhone failing at Avignon.

On December 3, the flow rate of the Rhone River had increased significantly. On December 4 at 4 am, the Town Hall sent a fax to announce that the industrial zone would receive 20 cm of water. As the building's docks are 1.2 m above ground level, the facilities were considered to be above the rising water level.

Precautionary measures were nevertheless taken in the morning. From 9 am to 12 pm, while the rest of the personnel had evacuated, 2 employees used the detailed list of stored products to move sensitive merchandise onto the docks, closed the valves to prevent water from entering through the rainwater drainage network and disconnected the electricity and the foam generator.



Little by little the water rose above the loading docks and reached the storage units; 0.9 m at mid-day and 1.43 m the next day. Surveillance rounds of the facilities were conducted and the water level monitored for 14 days following the flood.

On December 17, the DRIRE proposed the Prefect to authorise the operator to pump the water contained in the cells following analysis by an external company. The establishment resumed its activities on January 5 after the facilities had been cleaned.

Level achieved by water

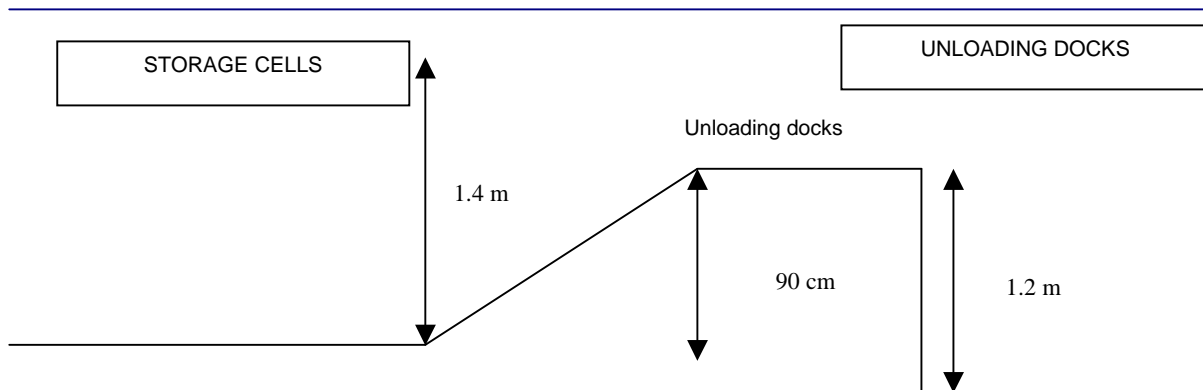


Diagram of water heights on the docks and storage cells

**Consequences**

Property damage was estimated at 4M euros. At the time of the flooding, 1,300 tons of merchandise were stored in the halls, including 400 t on the ground. Approximately 1/4 of the stock was saved, while the remainder was either destroyed or downgraded.

Many of the chemical products were liquid and packaged in plastic jugs, metal, aluminium or cardboard drums. The heavy-duty packaging for the dangerous materials did not suffer extensive damage. However, the Kraft drums in which the 'chlorine' tablets (DCCNa) were packed sagged, generating odours which alerted the firemen patrolling on site.

The pallets were not moved; only a few boxes were swept away by the current.

All the motors of the forklifts, parked on the dock, were flooded. Part of the archives stored in the administrative buildings was damaged.



Cracks were observed in the storage unit floor slabs. There where, however, no visible traces of impacts or deformations on the racks.

**European scale of industrial accidents**

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the 'SEVESO' directive, the flooding of the pesticide product storage and distribution site in December 2003 can be characterised by the following 4 indices, based on the information available.

Dangerous materials released		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Human and social consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Environmental consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Economic consequences		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

The four million euros in property damage explains the level 3 rating of the economic consequences in terms of parameter 15. The parameters that comprise these indices and the corresponding rating method are available at the following address: <http://www.aria.ecologie.gouv.fr>

## **ACTION TAKEN**

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Following this episode, the operator included the 'flood' risk in the danger study and reviewed the site's Internal Contingency Plan.

A direct telephone line to the municipal flood-warning department was installed and a permanent monitoring program was set up for the site (in terms of an on-call system). Even in the event of a minor alert, all merchandise must be secured.

In terms of stock management, sensitive merchandise are automatically placed on level 1, only drums (metal, or jugs) can be stored at floor level.

Barriers measuring 90 cm high and guided by rails are placed on the doors of storage units and emergency exits.

## **- SAINT GILLES site (Gard) - (ARIA No. 29661)**

In early December, the Rhône also flooded a pesticide products warehouse in the Gard after a dike broke. The operator implemented emergency measures similar to those taken for the Arles warehouse. Even while limited, there was significant damage owing to the lack of a 'flood risk' prevention plan.

## **THE INSTALLATIONS IN QUESTION**

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The company in question stored agro-pharmaceutical products.

One thousand tons of chemical substances can be stored in three 480-m<sup>2</sup> storage bins, each capable of holding 330 t of merchandise over an average height of 7 m (4 or 5 levels). The facility is classified as high-level SEVESO under the terms of European regulations and subject to authorisation with public easement (AS) as per French regulations.

The floor of each unit is designed to be hermetic to firefighting waters, among other things.

## **THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES**

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### **Flooding of the Saint Gilles site**

In the morning of December 3, 2003, the Prefecture of the Gard department contacted the industrial sites to inform them of water rising in Saint-Gilles as a result of the heavy rain that had fallen in the region the previous days and that several dikes along the Rhone had failed. The Classified Installations Inspectorate was informed in the same manner.

As a precautionary measure, the operator of the agro-pharmaceutical products warehouse placed the most sensitive products and those with cardboard packaging at a height of 1.8 m. The products were then raised to a height of 3 m as a precaution.

The 3 employees present were working up to the time when



water began to enter the storage units.

The means of communication (conventional telephone line) and the electrical installations were inoperative. In contact by mobile telephone with the operator, the rescue services were able to evacuate the employees by raft.

The operator then pumped the water retained in the storage units outside the buildings.

**Consequences**

Several days later, the Classified Installations Inspectorate noted that the water had risen 90 cm in the storage units and 57 cm to the level of the loading dock and offices.

Considering the relatively slow kinetics of the flood and the measures taken, no accidental pollution was noted after the water had risen in the 3 storage units.

The company was able satisfy its customers' needs from its head office, thus avoiding operating losses.

However, the cost of the damage caused to the offices (furniture, floors, walls...) and equipment (UPS, vacuum, fire detection battery...) was nearly 80,000 euros.

The damaged pesticide products (packages or labels damaged...) represented losses estimated at more than 40,000 euros.



**European scale of industrial accidents**

The following indices were determined for the flooding of the Saint Gilles site:

Dangerous materials released		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Human and social consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Environmental consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Economic consequences		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

The 120,000 € in property damage explains the level 1 rating of the economic consequences in terms of parameter 15.

**ACTION TAKEN**

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As the agro-pharmaceutical product storage site at St. Gilles had never been flooded prior to December 2003, it did not have a "flood" prevention plan. Nevertheless, the measures undertaken immediately proved efficient, even without benefiting from the public rescue services that were extremely busy providing assistance to the populations in need.

The Classified Installations Inspectorate requested that the operator:

- check the electrical installations and major safety-related equipment prior to resuming any activity,
- in terms of the safety management system, implement site securing procedures for the "flooding" hazard,
- integrate the "flooding" scenario into the Internal Contingency Plan.

Furthermore, the operator:

- raised the electrical installations above the flood water level,
- modified the management of stocks in order to raise humidity-sensitive products,
- rework the sealing of the 3 storage units (with the application of resins), even though the floor was not damaged.

## - Lessons learned -

### National level concerns

This summary of the Provence-Alpes-Côte d'Azur and Languedoc-Roussillon regions shows that the risk of flooding can take several forms (direct overflowing of rivers or canals, trickling, dike failures...) and can take place more or less suddenly in numerous locations. This situation, however, is not specific to these regions, the flooding of the Tarn in 1999, Brittany and Somme departments in 2001... are a firm reminder. In addition, the climatic changes warn of a general increase in this type of phenomena.

At present, the PPRI ("Plans de Prévention des Risques d'Inondations", Flood Prevention Plans) define the construction standards required for local urban planning documents in terms of public easement. They generally take the level of the PHEC ("Plus Hautes Eaux Connues", highest water levels) into consideration or those of the 100-year floods by default, but the strictest criteria may be retained. The PPRI of the Yvelines region also indicates raising installations 20 cm in relation to the PHEC.

The public or private infrastructure (collective or otherwise) can have a strong influence on the risk of flooding (backfill, roadways, wastewater systems, location of industrial zones... and more generally, all structure likely to modify the flow of water). It is thus of utmost importance that those involved in regional planning address these questions.

### Consideration of the "flooding" hazard in classified installations

Detailed studies addressing the types of possible flooding, their intensity and probability of occurrence and preventively defining the means to implement in classified installations in order to limit the human, property and environmental consequences are required. In these circumstances, the use of dangerous materials or processes could have ecological and public health repercussions depending on the characteristics and quantities of products involved. These studies concern both new installations and existing sites where the prevention or protection measures can often be improved.

In this respect, the memorandum of the French Minister of Ecology and Sustainable Development of January 15, 2004 entitled 'National actions 2004' emphasized that the prevention of "flood" risks must take increased precedence in the danger studies of SEVESO sites. There are no national technical regulations that specifically address the flooding of classified installations, comparable to that of lightning or earthquake activity. Also, the analysis of this risk and developing the means of appropriate prevention and protection for each installation concerned is even more important.

The measures imposed on classified installations subject to authorisation must take the extent of the possible consequences into account on a case-by-case basis, as well as the technical and organisational measures available. It should be observed that the reference floods retained for the definition of these means are strongly influenced by the extent of the last catastrophe that occurred. As in the case of the Tarascon site, the 2003 flood corresponding to the highest flood waters known (PHEC) estimated to occur every 300 to 500 years, was taken into consideration.

The frequency and the extent of the floods in the recent past confirm the need to better analyse this type of risk and the internal measures to be adopted, at least for the danger studies of classified installations. Several general recommendations were formulated in this respect.

Firstly, the kinetics of the natural phenomenon must be considered. It particularly concerns taking into consideration the time available between this alert and the flooding in order to classify the various measures to be implemented:

- those dealing with prevention and protection that require an excessive period of time. They must be set up independently of the alert and are to be regarded as "permanent",
- intervention actions that can be reasonably implemented after the alert with a sufficient safety margin.

The measures to be implemented must also be proportioned to the extent of the stakes and interests to be protected. Analysis could take place according to the following scenario:

- ✓ identification of the type(s) of possible floods to which the industrial site is subjected without limitation in terms of frequency,

- ✓ data collection: topography of the site, hydrogeological and hydrological data, information on floods (PHEC, flood flow rate, rate of water increase, submersion duration, warning lead times...), feedback on floods at the site or similar sites,
- ✓ characterisation of the reference flood scenario(s),
- ✓ determination of the site's zone that would be effected by floods,
- ✓ for these zones: risks for processes and products,
- ✓ detailed risk analysis, identification of major accident scenarios, safety-related elements, evaluation of the consequences by considering the "flood" risk (loss of utilities, equipment floatation and/or overturn study...),
- ✓ definition of appropriate protection, intervention and prevention measures.

Experience has shed light on permanent measures to prevent a site from being flooded or to reduce the risks and damages that it may encounter; the following examples may be cited:

- dikes around the site to be protected,
- sufficiently dimensioned rainwater storage basins,
- constructions on a crawl space, enabling the floor to be built above the reference flood level,
- implantation of a building in the direction of the current, in order to limit the obstacle effect against the flowing water,
- reinforcement of the building structure so that it can resist the forces exerted by flowing flood water and the differential settling after the water has receded,
- raising / protection of the most important or water-sensitive storage areas and equipment (at risk or with windows, for establishment operation) by low walls,
- ballasting, anchoring, sealing of tanks that could be dangerous or polluting,
- placement of electrical, telephone, computer, gas, and drinking water networks above the water level,
- creation of a refuge area for the employees above the water level
- construction of non-floodable access roads to facilitate intervention in the buildings,
- a visual identification system of electrical power supply disconnection devices or wastewater network valves,
- installation of drainage systems for flooded areas in order to reduce submersion time...

Despite all the measures that could be implemented at a site, the flood alert procedures must not be neglected. Radios, which cover the entire territory, and telephone, via simultaneous calls, are two particularly efficient means. In this respect, the actual operability of the means of communication between the operators and the organisations in charge of the alert must be frequently checked.

Furthermore, the establishment's internal contingency plan must reiterate the actions to be taken in case of a weather early-warning and flood warning, the personnel evacuation procedure and specialised rendezvous and refuge locations, the precautions to be taken depending on the nature of the products and the equipment concerned, the designation of the intervention team and the temporary measures to be taken, such as:

- shutdown of activities, securing of installations, interruption of product transfer operations,
- disconnection of power supplies (electricity, gas...),
- locking and sealing of certain openings,
- placement of sensitive or "at risk" elements above the maximum probable water level,
- moving of critical stock and equipment away from the flood zone,
- plugging of wastewater and rainwater networks,
- pumping of water to control the rising water in units running the greatest risk...

Regular monitoring of the weather forecast allows one to be regularly informed of alert messages in order to allow sufficient reaction time to implement these measures.

Finally, it is useful to point out the interest that operators have in having their own flood control equipment (pumps, power generators, life rafts...) as the rescue services are often very busy during floods providing assistance to the population.