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UNITED STATES NUCLEAR REGULATORY COMMISSION
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External Flood and Extreme Precipitation Hazard Analysis for Nuclear Plant Safety Session

LESSONS LEARNED FROM 1999 BLAYAIS FLOOD : OVERVIEW OF EDF FLOOD RISK MANAGEMENT PLAN

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SUMMARY

1. EDF NPP LOCATION
2. DECEMBER 1999 BLAYAIS FLOOD
3. A COMPREHENSIVE REVIEW OF THE FLOOD RISKS :
    1. OUTLINE OF THE MANAGEMENT PLAN
    2. EXAMPLES OF MODIFICATIONS IMPLEMENTED
4. OVERALL SCHEDULE OF THE REVIEW PROCESS
5. CONCLUSION : LESSONS LEARNED

1. EDF NUCLEAR POWER PLANTS LOCATION

location of NPPs

14 riverside site

4 seaside site

1 estuary site

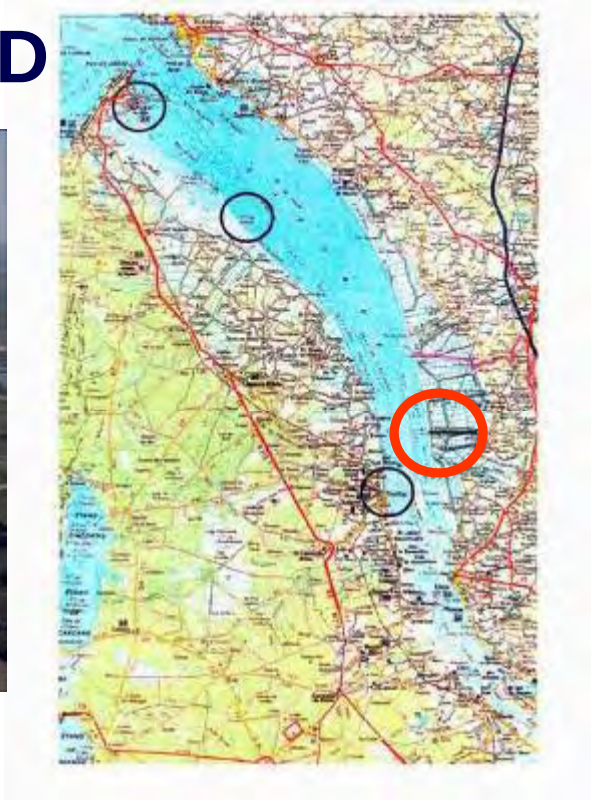
58 units in operation

1 under construction

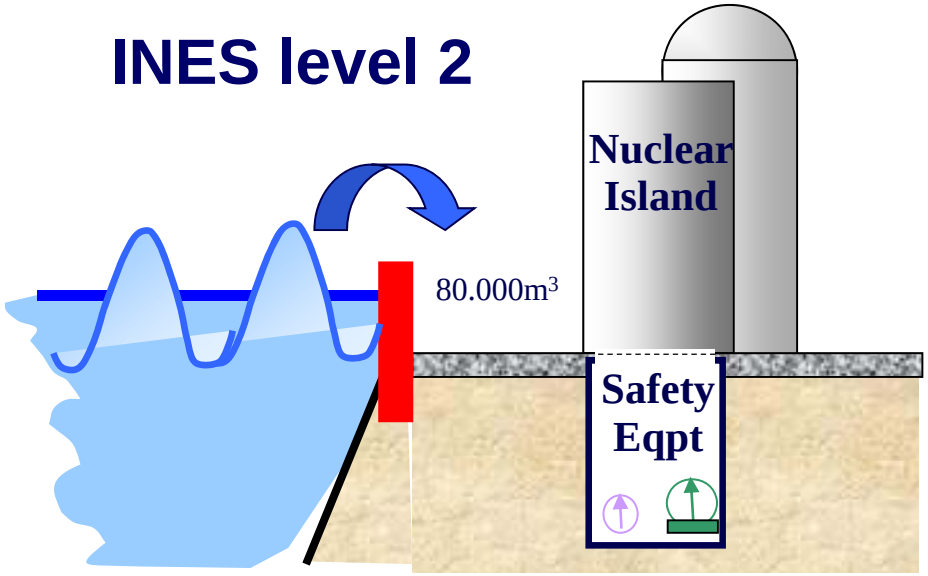
2. DECEMBER 1999 BLAYAIS FLOOD

1999 Storm

« Le Blayais » NPP partial flooding



INES level 2



High water level in the river Gironde : high tide + storm surge (+2m) and waves (2m) generated by the wind on the estuary (200 km/h)

➡Waves came over the dyke and caused flooding on site and in units 1 and 2

➡On-site Emergency plan (36 hours)

Protection of French NPPs against external flooding before Blayais flood (Safety Rule RFS I.2.e – Issued 1984)

- **Maximum design flood level to be assessed considering :**
  - River flood
  - Dam rupture
  - Littoral flood (tide + storm surge)
  - Estuary sites
- **Protection is ensured by :**
  - Nuclear Island Platform level ≥ maximum design flood level
  - Below the platform: closure of all possible pathways to the rooms containing equipment required for safe shutdown .

BLAYAIS (1999) : Examples of damages

Door deformation

Failure of Cable opening

Feedback Analysis of Blayais flood

Flooding hazards considered in the design	Severe storm-driven waves coinciding with high estuary level exceeded the worst-case « design scenario »
Protective measures defined by design for operation	•Insufficient height and inadequate shape of the dykes •Insufficient protection of the underground rooms containing safety equipment •Difficulty to detect water in affected rooms •Inadequate warning system •All 4 units concerned, on-site organizational difficulties
Effects of the storm on the **NPP's support functions and surroundings**	•Temporary site inaccessibility (blocked roadways, phone communication,…) •Partial temporary loss of offsite power supplies •Clogging-up of filters of water intake

3. A COMPREHENSIVE REVIEW OF THE FLOOD RISKS : OUTLINE OF THE MANAGEMENT PLAN

Flooding hazards

- **Identification of <u>all</u> phenomena,** which can result in a flood at any of the 19 French NPP
- **Re-assessment** of flood hazards / impacts at each site

Protective measures

- **Identification of equipment** to be protected
- **Review of the existing protective measures** (structures, devices, procedures, organization)
- **Modifications or improvements** where required

Flooding effects on NPP's support functions and surroundings

- **Specific Flood procedures** developed as necessary
- Analysis of the risks : site inaccessibility ,loss of offsite power supplies ,heat sink behaviour, communications…
- **Means defined to avoid them or to cope with them**

Flooding hazards

IDENTIFICATION OF PHENOMENA

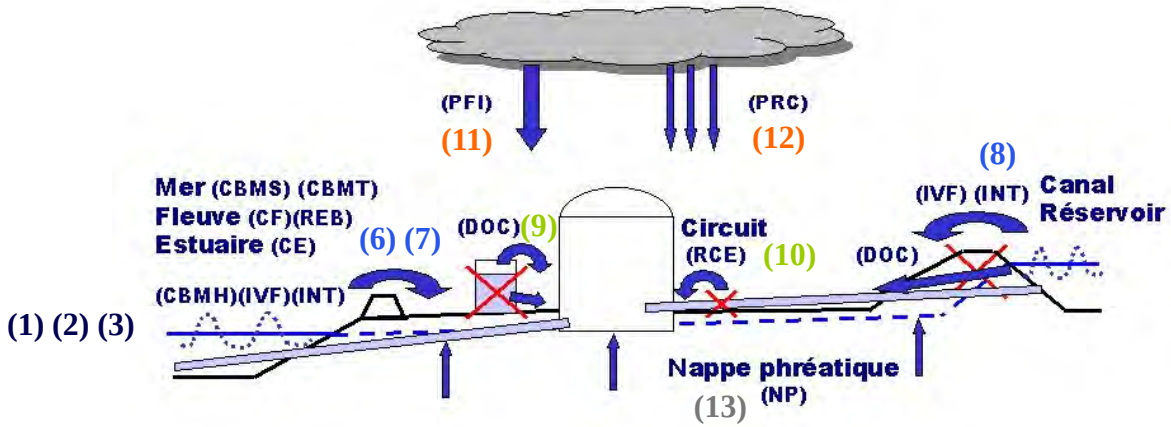
Prior to “Le Blayais” event : application of the Basic Safety Rule RFS I.2.e

(1)River flood, (2) Dam failure, (3) Tide, (4) Storm surge, (5) Tsunami

New methodology : 8 “additional” phenomena taken into account

(6) Wind-waves on sea
(7) Wind-waves on river or channel
(8) Swelling due to operation of valves or pumps
(9) Water retaining structures (other than dams) deterioration
(10) Circuits or equipment failure
(11) Rainfall on site, brief and intense
(12) Rainfall on site, regular and continuous
(13) Groundwater rise

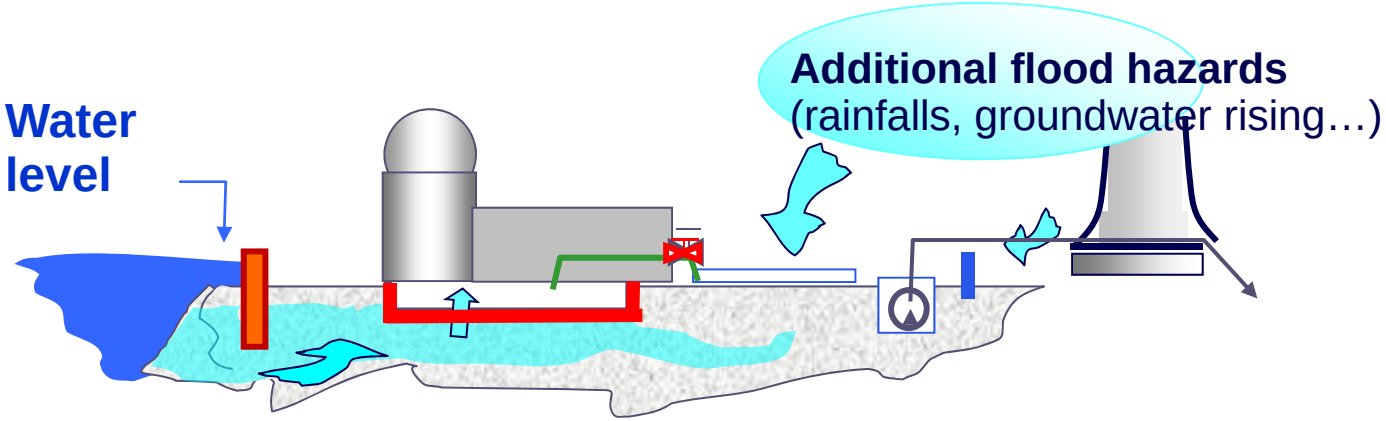
+ Realistic combinations of phenomena



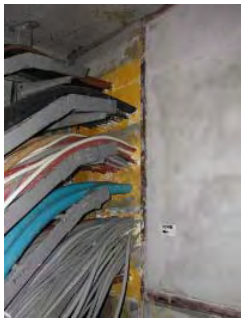
Protective measures

PROTECTION OF EQUIPMENT (1/2)

➔ Set up of a compact “watertight area”



- At all NPPs, protection against water ingress of the substructures of the buildings containing equipment to be protected (plugging of openings, reinforced doors,…)



Qualified material to plug the waterpaths and openings

Protective measures

PROTECTION OF NI AND PUMPING STATION PLATFORMS (2/2)

Protection of structures/devices reviewed :type, height, margins, settling, stability, safety classification, seismic resistance, power-supply, maintenance… ➔ Improvements where required

➔ **Dykes/walls raised or extended or reinforced at some sites**

Protective measures

FLOODING PROCEDURES

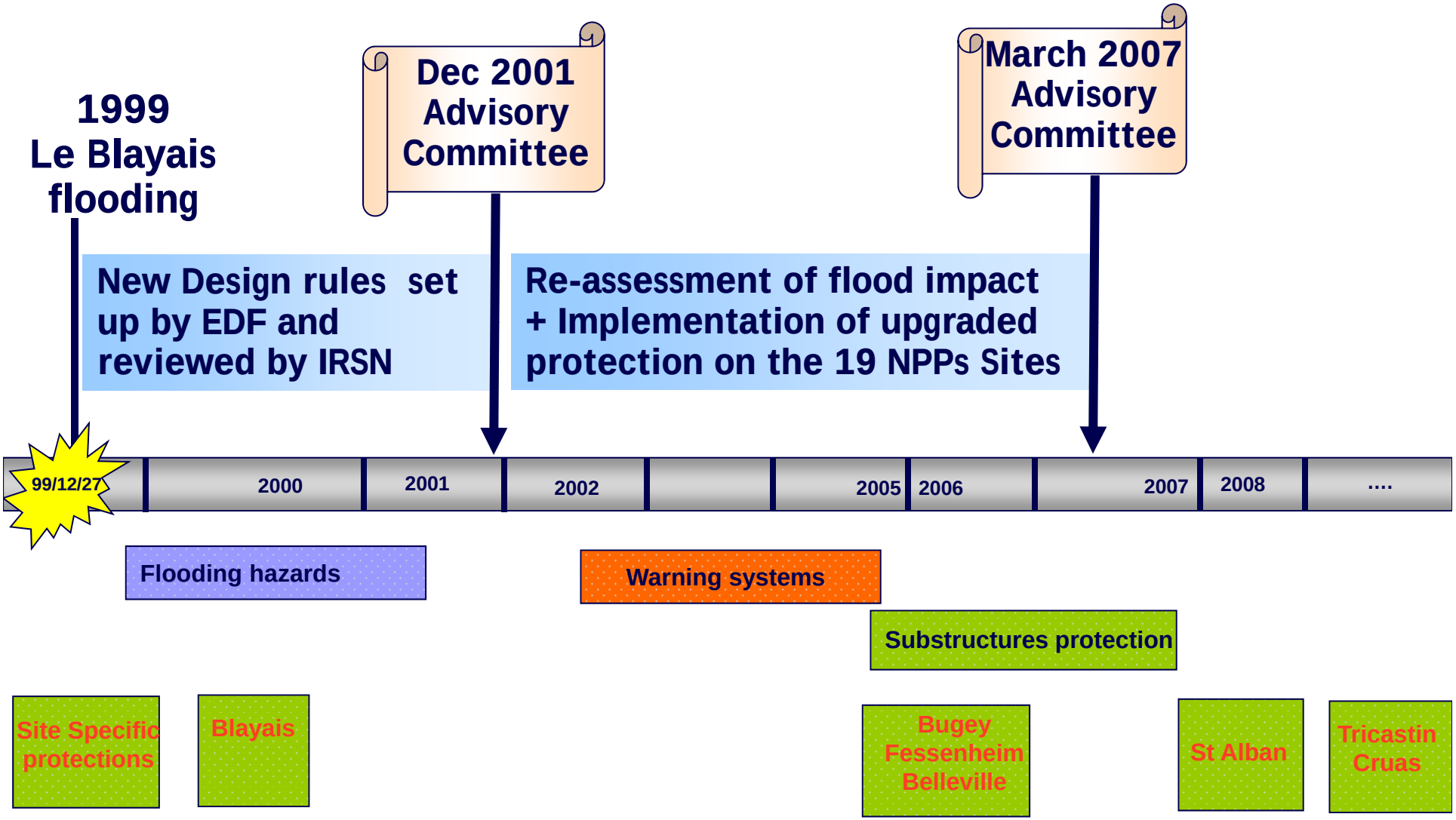
Flooding effects on NPP's support functions and surroundings

Warning based for predictable hazards, **Procedures** adapted to site vulnerability *(platform submersion, site isolation, loss of the external power supplies, heat sink filtration affected by flooding)*

At most sites, implementation of "flooding" procedures :

- Prepare site protection during the warning phases (closure of paths/openings through dykes and "watertight area", tanks filling-up,…)
- Bring the plants to safe shutdown state if required

4. OVERALL SCHEDULE OF THE REVIEW PROCESS



5. CONCLUSION : LESSONS LEARNED

1. **LE BLAYAIS EVENT USED AS AN OPPORTUNITY TO REASSESS DESIGN RULES AND IMPROVE NPP PROTECTION AGAINST EXTERNAL FLOODING**

   Updated design rules approved by French Safety Authority,

2. **A COMPREHENSIVE REVIEW, CARRIED OUT OVER 7 YEARS INVOLVING VARIOUS SKILLS :R&D, ENGINEERING, OPERATION**

3. **UPGRADED PROTECTION OF MOST NPP AGAINST FLOOD (about 110 M€ expenses) AND SET UP OF SITE SPECIFIC FLOODING PROCEDURES**

4. **A CLIMATE SURVEY PUT IN PLACE IN ORDER TO PERIODICALLY REASSESS THE NEED FOR ANY ADDITIONAL MEASURES (basically on a 10 year time frame)**

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Thank you !

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