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ASSESSING AND REDUCING FLOOD RISKS ON MAJOR HAZARDS SITES

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During the 1980s and early 1990s, there were relatively few serious flooding events in the UK. Consequently it was widely believed that flood-defence measures have "tamed" the environment and that the risk of flooding was minimal. However, since the Easter 1998 floods in central England, there have been a number of serious flooding incidents across the UK and the public awareness of flood risks has increased significantly. Whilst media attention has focussed on the damage caused to domestic properties, flooding also occurred on a number of major hazards sites. This paper describes some of the incidents that have occurred in the process industries and the measures taken to reduce the risk and consequences of flooding.

The Environment Agency, working as part of the COMAH Competent Authority has set flood risk assessment on major hazard sites as an inspection priority. On top-tier sites, operators have been required to address flood risk as part of their COMAH Safety Report. On lower-tier sites the Agency has prioritised its inspection effort on those sites identified to be at risk of flooding. The Agency is also concerned about non-COMAH sites and will use its powers under the Pollution Prevention and Control (PPC) regulations to require operators to address flooding issues.

KEYWORDS: COMAH, Environment, Flooding, Risk assessment, Pollution Prevention and Control (PPC)

INTRODUCTION

In 1947 and 1953, there was major flooding in the east of England and the lessons learned from those events, shaped the UK flood defence strategy for the next 30–40 years.

Freshwater flooding affected the Fens of East Anglia in March 1947, following a six-week spell of severe winter weather. Heavy rain melted the accumulated snowfall producing the equivalent of 110 mm of rainfall over 24 hours and all of the major rivers leading into the Wash burst their banks. 250 square kilometres of the most productive farmland in the country was flooded, hundreds of families were made homeless, and thousands of livestock were swept away. Miraculously no-one was killed.

On 31st January 1953, a combination of spring high tides, a deep depression and northerly gales, combined to cause a tidal surge in the southern North Sea. It affected the coast from Lincolnshire to Kent and at its peak, the surge was 2½ metres above the high spring tide level. There was no flood warning system at the time and the surge struck at night, drowning many occupants of single storey beach chalets in their bedrooms. In all 307

people died, 24,500 houses were damaged and 40,000 people were evacuated. It was the worst peacetime disaster ever to strike Britain.

As a consequence of these floods, drainage work was carried out on many rivers, flood defence banks were built, a comprehensive flood-warning scheme was introduced and the Thames Barrier was completed in 1982. The effectiveness of these measures was demonstrated in 1978 when another tidal surge occurred on the north Norfolk coast. It was higher than the 1953 surge but caused significantly less damage. In Kings Lynn, for example, 15 people had drowned in 1953, whereas in 1978 there were no deaths despite extensive flooding in the town centre.

During the 1980s and early 1990s, there were relatively few serious flooding incidents in the UK due to a combination of successful flood defence measures and an absence of the relevant severe weather conditions. Unfortunately, this led to a sense of complacency in the minds of politicians and the general public, that the risk of flooding was not a serious issue in the UK. On numerous occasions, Local Authorities granted planning permission for developments in the flood plain against the advice of the Environment Agency. There was also a reduction in spending on flood defence works as Local Authorities diverted funds into other areas.

FLOODING AT BP OIL, NORTHAMPTON

The first major flooding of recent years occurred during Easter 1998. An active weather front remained stationary over central England and in many places more than 60 mm of rain fell in 48 hours. In total 5 people died, 4,500 properties were flooded and the cost of damages was estimated at £350m. The worst affected town was Northampton where two people died and 2,500 houses were flooded when the River Nene burst its banks. Most of the residents were unaware that they lived in a floodplain and were caught completely by surprise.

The flooding in Northampton also affected a number of commercial and industrial premises including a fuel distribution and storage terminal operated by BP Oil, which is a lower-tier establishment under the Control of Major Accident Hazards (COMAH) Regulations 1999. Most of the site was flooded to a depth of approximately 0.5 metres, though there was no loss of containment that might have caused pollution of the River Nene. Damage was restricted to the offices, some pumps and underground power cables. An HSE specialist inspector conducted a thorough inspection of the tanks to ensure that there had been no flotation or other damage and the site returned to full operation within 6 weeks. There are a number of reasons why the flooding caused so little damage, including:

- Northampton is a simple fuel storage and distribution terminal (no chemical processing).
- The entire inventory was contained in large storage tanks built on plinths that remained above the level of the floodwater.
- Prompt action by the staff prevented rainwater accumulating on the floating roof tanks which could have led to the collapse of the roofs.
- There were no materials stored in drums or bags which could have been washed away or affected by the floodwater.

- BP Oil was able to maintain the supply of fuel to customers by utilising its other storage and distribution terminals at Hemel Hempstead and Birmingham.
- BP Oil, being a major company, was able to pay for the cost of cleaning up the site and returning it to normal operation.

The flooding of the BP Oil terminal did not cause significant harm to human health or the environment and consequently it did not act as a "wake up call" to the COMAH Competent Authority regarding the risks of flooding on COMAH establishments. (The Competent Authority (CA) for the COMAH regulations in England and Wales comprises the Health and Safety Executive (HSE) working jointly with the Environment Agency (EA) (and in Scotland the HSE working jointly with the Scottish Environment Protection Agency (SEPA)).

LESSONS LEARNT FROM THE EASTER 1998 FLOODS

Following the Easter 1998 floods, the Environment Agency board commissioned an independent report, which concluded that whilst the flood warning system had worked properly, significant improvements could be made. The Agency carried out a wide-ranging review of its flood defence activities and identified the following improvements:

1. Publicity campaigns to increase public awareness of flooding and to encourage at-risk homeowners to develop a flood plan.
2. Publication of indicative flood plain maps on the internet.
3. Upgrading of river flow telemetry systems.
4. New computer models to be used for flood forecasting.
5. Better communications with the Met Office and the emergency services.
6. More understandable flood warnings codes.
7. The use of automated telephone phone messaging to disseminate flood warnings.

The Agency launched all these improvements during "Flood Awareness Week" in September 2000. This publicity campaign used television, posters and newspapers and was timed to coincide with the start of the winter flooding season.

FLOODING AT CSG, SANDHURST, GLOUCESTER

The autumn of 2000 was the wettest for 270 years and the prolonged heavy rainfall caused significant river flooding in many places, with North Yorkshire, the Severn Valley, and parts of Kent and Sussex particularly badly affected. In total 2 people died and 10,000 properties were flooded (though flood defences protected 280,000 properties). The total bill for damages was estimated at £1.0bn. The improved flood warning arrangements introduced by the Environment Agency following the Easter 1998 floods undoubtedly reduced the loss of life and assisted the work of the emergency services. The flooding also contributed to a major accident that occurred at a waste treatment and storage site operated by Cleansing Services Group (CSG) Ltd in Sandhurst near Gloucester. The incident started in the early hours of 30th October 2000 during a severe storm, when there was a major fire in a waste storage area. Approximately 180 tonnes of mixed chemical waste including flammables, toxics and chlorinated hydrocarbon solvents were consumed in the fire. Gloucester police

set up Gold Control to manage the fire as a major incident. 60 people were evacuated from their homes by the emergency services and 13 people, mainly emergency service personnel, were taken to hospital as a precautionary measure, though none were admitted. The site had notified the CA that it was a COMAH lower tier establishment and the fire was reported to the European Commission as a COMAH major accident because of the quantities of dangerous substances involved and the evacuation of local residents. Agency flood warnings indicated that the site, which is alongside the River Severn, would flood within days and actions had to be taken to make the site safe by moving fire-damaged and other material beyond the reach of flood waters. The flooding occurred on 3rd November, and local residents had to be evacuated for a second time. The CA issued a COMAH prohibition notice though this was withdrawn when the company notified the CA that the inventory had been reduced such that COMAH no longer applied. It was replaced by an improvement notice served under the Health & Safety at Work Act 1974. The Agency issued a notice of suspension for the Waste Management Licence and two years later, most waste management activities remain suspended, though CSG have been permitted to store empty vehicles and empty containers on site. The incident at CSG raised two particular areas of concern for the Competent Authority; the fire risks of storing mixed waste materials at waste transfer stations and the risk of flooding on major hazard establishments.

AGENCY ASSESSMENT OF FLOOD RISK

After the Autumn 2000 floods, the Agency again reviewed its flood defence procedures and published a report on the lessons learned. The CSG incident and a number of other flooding issues on major hazard sites (see Table 1) were reviewed by Agency staff from Process Industry Regulation (PIR), Waste Regulation and Flood Defence. Their conclusions were:

- Many major hazards sites are located on an indicative flood plain and are therefore susceptible to either fluvial or tidal flooding. (These locations were chosen because they provide level building land, access to good transport links, a supply of cooling water and a discharge route for liquid effluents).
- Many sites were built during the 1950s and 60s and the flood defences provided at the time might not be adequate to protect against the anticipated effects of sea-level rise and climate change.
- Many sites have never experienced flooding hence flood risk might not have been properly addressed as part of the on-site and off-site emergency plans.
- Flooding of major hazards sites could lead to the loss of containment of dangerous substances and have a significant effect upon the environment. Pollution could affect the water courses themselves, adjacent sensitive habitats and necessitate closing drinking water intakes with consequent disruption to public water supplies.
- Flooding could also have significant financial and operational implications for the site concerned. It could lead to some operators going into receivership, leaving the Agency and Local Authorities to deal with land contamination and clean-up issues. (Some 10% of domestic properties flooded in autumn 2000 were still uninhabitable a year later and the restoration costs averaged £40,000 per property).

Table 1. Flooding incidents and issues at other major hazard sites in the UK 1999–2002

Operator details	Flooding incidents and risk assessments	Flood defence improvements
Hickson & Welch Castleford, Yorks Organic chemicals manufacture COMAH top tier (TT)	This has been a chemicals manufacturing site since the early 1900s, built on both banks of the River Aire. In 1979 part of the site was flooded when river levels were high and water backed up through the surface water drains.	In 2000, work was completed on a "site kerb" and drainage improvements to protect the river from spillages and/or fire water run-off. In October 2000, when the River Aire reached its highest level for 200 years, this system protected the site from flooding.
Syngenta Ltd., Yalding, Kent. Pesticides and herbicides formulation, filling & packing. COMAH top tier (TT)	This has been an industrial site since the early 1900s, located alongside the River Medway. The lower part of the site, including some manufacturing buildings, was flooded in 1968, with further minor flooding of roadways occurring every few years. In October 2000 the lower parts of the site were flooded to a depth of 1 metre. Materials were removed from production areas and there was no loss of containment. Production was disrupted for two days whilst waiting for water levels to fall.	Following the 1968 flood, warehousing was relocated to higher ground and a site storm and fire water storage system was built to protect the river. The system also acts as a flood defence structure to prevent minor flooding. There is a flood emergency plan in place, which worked effectively in 2000.
Tessenderlo Fine Chemicals, Leek, Staffordshire. Organic chemicals manufacture. COMAH lower tier (LT)	This site is located on the banks of the River Churnet and was originally a 19th Century dye works. The lower part of the site flooded in October 1998 and November 2000. Flood	A new warehouse has been built on high ground above flood level and the design for a new water abstraction point has incorporated features to prevent flood damage. A new ETP has been designed and

Table 1. Continued

Operator details	Flooding incidents and risk assessments	Flood defence improvements
	warnings enabled the toxic material to be moved from the warehouse on to higher ground. The drum storage area was flooded but no material was lost. The effluent treatment plant (ETP) was inundated with flood water, halting production for 1 day. This site is near the top of the river catchment hence flooding occurs rapidly following heavy rainfall, then recedes within hours.	will incorporate above ground tanks and a 1.2m high bund wall to keep out floodwater, adding approximately 2% to the total project cost. A staged emergency flood plan is in place.
Avonmouth Industrial Complex including; Astra Zeneca (organic chemicals manufacture, TT), BG Transco (gas storage, TT), BP Oil UK (fuel storage, LT), Britannia Zinc (metal production), Tera Nitrogen (Fertiliser manufacture, TT), Rhodia (Inorganic chemicals manufacture, TT)	These sites are built on flat ground alongside to the Severn estuary. There was no flooding in 1998–2000. COMAH safety reports have assessed that there is a risk of flooding up to 0.5 m deep occurring at a frequency of 1 in 100 years. This frequency may increase to 1 in 50 years due to sea level rise associated with climate change. There have been significant developments in the area since the last full topographical survey in 1976, particularly the M49 motorway, built across the area on embankments in 1996–98.	The Environment Agency is carrying out detailed modelling of the flood risks, including the use of aerial LIDAR (Light Detection And Ranging) surveys flown in January 2002. The work is due to be completed by the end of 2002 and it is anticipated that there will be a programme of works to improve the flood defences. Emergency planning arrangements will be reviewed to ensure there are designated site access routes above the level of any floodwater.

AGENCY POLICY ON MANAGEMENT OF FLOOD RISK

In May 2002, the Environment Agency introduced a new policy on the "Management of Flood Risks at Major Installations". The policy provides a structure for assessing flood risks

on COMAH sites and those regulated under the Pollution Prevention and Control (PPC) Regulations 2000. In applying the policy, the Agency will distinguish between:

a) Planning application proposals for the developments of the new installations. These will be addressed by using Planning Policy Guidance Note PPG25 on Development and Flood Risk and by pre-application discussions on permitting.
b) Existing operating installations that are already permitted. These will be targeted on a risk and priority basis as part of a rolling programme:

- The Agency has conducted a top-level indicative screening of installation, using Geographical Information Systems (GIS) overlays of site-types located in the indicative flood plain (roughly equating to a 1 in 100 year return period for flooding without defences).
- The second screening will be carried by staff in Area offices, based on local knowledge of the sites. It will consider the extent of the potential hazard or consequences if flooding of the installation occurs. This may remove some sites from consideration.
- Prioritisation of the potential hazards will be in the following order:
  i. COMAH top-tier establishments. The Agency will ensure that flood risk is addressed in safety reports submitted to the CA and this should be completed by mid-2003.
  ii. COMAH lower-tier sites. The Agency has listed those at risk of flooding and will inspect them on a rolling prioritised basis.
  iii. Other industrial sites subject to PPC, flood risk be addressed through the PPC application and permitting programme which is phased to last until 2007. (The PPC regulations require operators to ensure that the consequences of accidents are minimised. This is a new duty compared to the previous IPC regulations and the Agency is interpreting this as a requirement for the operators to address the issue of flood risk).

SITE SPECIFIC FLOOD RISK ASSESSMENT

Some of the issues that will need to be considered by site operators carrying out flood risk assessments include:

1 Before flooding occurs:
  a How long in advance will flood warnings be issued (this may be only a few hours for sites at the top of river catchments or those subject to tidal flooding).
  b How will flood warnings be received and who will act on them?
  c Can critical parts of the site infrastructure be protected by raising them on plinths above flood level or surrounding them with flood walls?
  d Can the process be shut down and dangerous substances secured in the time available before flooding occurs?
  e Can staff be evacuated safely?
2 During a flooding incident:
  a How deep will the site flood and for how long?

b How will staff gain access to the site during the flooding incident? (All the available boats may be needed to evacuate local residents.)
c Can containment of dangerous substances be maintained ? (Consider flotation of storage tanks and drums being swept off-site).
d Can site services be maintained during the flooding event? eg electricity, compressed air, nitrogen, etc.
e How will the concerns raised by press and media and local population regarding pollution risk be addressed?

3 After a flooding event:
a Can sites services be restored rapidly?
b How will the site clean-up be carried out? (this may involve the disposal of sludges contaminated with dangerous substances).
d Will the stocks of spare parts be adequate?
e How long are the lead times for replacement of critical items?
f Is there a contingency plan to ensure continuity of supply to customers during interruption to business.

EUROPEAN FLOODING INCIDENTS

In August 2002, severe flooding in central Europe, affected several major hazard sites including:

1. The Fluorochemie factory in Dohna, Saxony that was successfully shut down before being completely inundated by the floodwaters of the river Elbe. Two railway tank wagons containing liquid hydrogen fluoride were abandoned in Schlottwitz station when the track was flooded and they had to be monitored by helicopter.
2. The Spolana chemical factory outside Prague had a chlorine leak when pipework around a storage tank was damaged by debris washed down by the floodwaters of the river Danube. The fire service plugged the leak but had to abandon the site when the flood water rose above the tank. Several days later when the floodwater had receded it was discovered that the entire tank inventory of 80 tonnes of liquid chlorine had been lost. Residents were required to shelter indoors, but there was no harm to people or the environment. There were also concerns that contaminated soil containing mercury and dioxins may have been washed away into the river during the flooding event.

CONCLUSIONS

During the last five years, there have been several serious flooding incidents across the United Kingdom. The focus of attention has been on the damage caused to residential property and only one major hazard site, a waste treatment and storage site operated by CSG Ltd in Gloucester, has been severely affected. It has been suggested that these flooding events are due to changes in the climate associated with global warming, and that further flooding is likely to occur in the future. A large number of process industry facilities are at risk because they are located in the indicative flood plain. That risk is being evaluated by the Environment Agency in order to ensure the highest standards of environmental protection.

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Figure 1. BP Oil (UK) Ltd., Northampton terminal. Easter 1998.

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Figure 2. CSG, Ltd., waste storage & treatment facility, Gloucester. November 2000.

Figure 3. Tessenderlo Fine Chemicals, Leek, Staffordshire. November 2000.

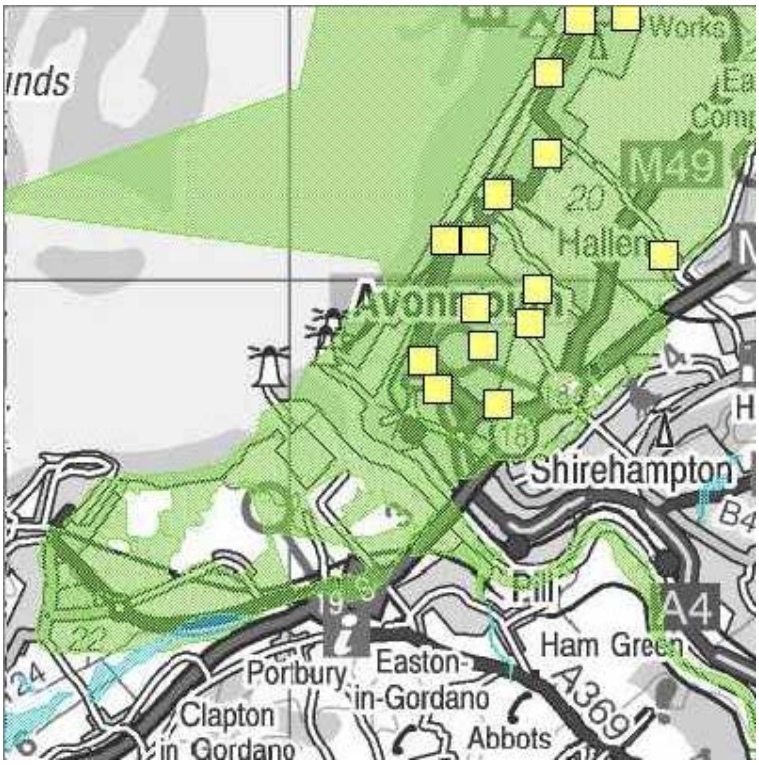

Figure 4. Avonmouth, agency website map – flood plain and process industry site