The Earth in our hands

- how geoscientists serve and protect the public

2 FLOODING

Further information and useful contacts

Web sites

http://www.geolsoc.org.uk Useful links, news on flooding and summaries of conferences, meetings about flooding.

http://www.environment-agency.gov.uk Up to date information on flooding and flood warnings in the UK and government consultation papers and reports on flooding, flood defence and flood warnings. Enter "flood" in the search box.

http://detr.gov.uk/planning Planning Policy Guidance Development and Flood Risk Consultation Paper (April 2000) on the Department of the Environment, Transport and the Regions (DETR)

http://www.pbs.org/wgbh/nova/tanscripts/2307tfloo.html The transcript of a television programme made at the time of the Mississippi floods of 1993, including interviews with witnesses.

http://www.pbs.org.wgbh/nova/flood/deluge.html Very readable accounts of the flooding of major rivers including The Yellow River, Nile and Mississippi.

http://www.dundee.ac.uk/geography/cbhe The British Hydrological Society's chronology of UK events can be used to check historical detail and demonstrates that floods and extreme rainfall, though infrequent, are far from unknown.

http://www.bgs.ac.uk The British Geological Survey has geohazard databases of the UK. A major use is to help with assessment of geohazard when considering land use planning and construction. Enter "flooding" in search box. Gives details of BGS projects worldwide.

http://www.enviroinfo.org.cn/research/index_en.html Gives summaries of research papers on environmental issues as printed in the Journal of Natural Resources (China)

http://www.nssl.noaa.gov/researchitems/flooding.shtml Information from the National Severe Storms Laboratory, based in US but with useful worldwide information and scientific updates

http://www.flood plain.org/p-basics.htm The flood plain management web site, clearly explains the basics of flooding and flood protection and includes information on how homeowners can protect themselves from imminent floods and future floods.

http://www.fema.gov/library/floodf.htm US site with information on flash floods and flood plain management.

http://www.earthsat.com/ Earth Satellite Corporation site with satellite images of the world. Topics include image processing, environment (including GIS (geographic information systems) weather and geology (oil and gas industry, water and mineral exploration, and engineering support)

http://www.ncdc.noaa.gov/ol/reports/chinaflooding/chinaflooding.html Brief summaries, images and graphics of Yangtze River Basin and flooding in China in 1998 and updates

http://www.usgs.gov/wid/FS_089-96/FS_089-96.html The USGS (US Geological Society) site has information on all aspects of the geoscientists. Enter "flooding" in search box.

http://www.weather.com/learn/ The Weather Channel is a US based site which aims to educate on all things to do with weather, including severe weather such as flooding, drought, hurricanes and tornadoes.

Printed information

Barber, N. *Fire and Flood - why do they happen? Where do they happen?* (Natural Disasters, Snapping-turtle guide, Ticktock Publishing Ltd, 1999) ISBN 1 86007 108 2

Delderfield, E. *The Lynmouth Flood Disaster* (Letheren, 1953 and later editions) ISBN 0 9003 4500 4

Fagan, B. *Floods, Famines and Emperors: El Nino and the fate of civilisations* (Basic Books, 1999) ISBN 0 4650 1120 9

McGuire, W. *Apocalypse - A natural history of global disasters* (Cassel, 1999) ISBN 0 3043 5209 8

Van Rose, S. *Catastrophes - Time's trail of destruction* (Earthwise, British Geological Survey, 1999) ISBN 0 85 272354 7

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The Earth in our hands

- how geoscientists serve and protect the public

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2 FLOODING

Flooding **can be the cause of major disasters with devastating effects, taking lives and destroying homes and livelihoods. Floods can create havoc with the natural landscape and have a huge impact on business, industry and the general economy.**

There are three types of floods:

- flash floods
- river floods
- coastal floods

Flooding occurs when:

- rivers and streams burst their banks
- groundwater levels rise to the surface
- snow and ice melt rapidly
- there are exceptionally high tides and/or strong winds during coastal storms

Flooding is often triggered or made worse by:

- landslides
- dam failures
- earthquakes
- volcanic activity

Flood damage

- **Life, limb, livelihood**

Floodwaters are dangerous - 15cm of moving water is enough to knock a person down, while 60cm can move cars and buses. In the USA, 80% of deaths due to flooding occur in vehicles. Buildings may also be washed away, smashed by boulders, or buried in sediment left behind. Over 70,000 people were evacuated and more than 400,000 buildings were damaged in Holland in the 1953 floods that also devastated much of the eastern coast of England.

"Flash floods" occur suddenly when heavy rain overwhelms watercourses. They move very fast and can roll huge boulders, tear down trees, destroy buildings and wash away bridges. Walls of water can reach heights of 18m and usually contain substantial amounts of debris. In November 1997, flash floods triggered by heavy rain killed 30 people in Spain and Portugal; but they can also occur in the UK.

- **Subsidence**

Flooding may cause subsidence, particularly in areas underlain by limestone or soluble minerals such as gypsum. Cracks and fissures in rock can be enlarged and some clays swell when wet, causing ground heave that can damage buildings.

- **Pollution**

Flood waters may be polluted by sewage or rotting bodies. If pollutants enter water supplies the risk of diseases such as cholera, malaria (more standing water for mosquito reproduction) and dysentery are increased. Sometimes, aftermath *epidemics* cause more deaths than the floods themselves. In urban or industrialised areas, sewage, chemical waste, landfill leachates, mine discharges and spoil can be liberated by overflowing rivers, burst pipes and rising groundwater. Flooding of solvent and fuel storage facilities may lead to contamination.

In 1999 floods accounted for 37% of natural disasters (wind storms 34%; earthquakes 14%; others 15%).

About these briefings

The Earth is a dynamic planet. It is active and productive, offering humanity enormous opportunities. However, living on it also presents us with many dangers; some of our own making.

In our interaction with the Earth, geoscientists are in the front line. They seek and find the raw materials we use for agriculture, roads, buildings, energy, water supply and all the industries that provide wealth and health.

Geoscientists help society understand natural hazards and mitigate their effects. Such dangers include floods, landslips, volcanic eruptions and earthquakes.

Geoscientists also help to minimise hazards we have created (or made worse) by our activities. These include subsidence, and the disposal of waste.

With their unique understanding of the immensely long time spans over which Earth processes operate, geoscientists help communities world-wide to learn how to use the planet's resources safely, wisely, and sustainably.

This series of information sheets is dedicated to bringing this role to public attention.

The Geological Society

Flooding worldwide

In 1999 floods accounted for 37% of natural disasters (wind storms 34%; earthquakes 14%; others 15%). Floods in India and Bangladesh resulted in economic losses of US$5 billion and insured losses of US$ 3.3 billion.

In south central China (1998)the Yangtze River and its tributaries broke their banks, killing 3565 and making 14 million homeless. In all, 240 million people were affected. The floods destroyed five million houses, damaged a further 12 million, inundated 25 million hectares of farmland, and caused over US$20bn in estimated damages.

Flooding in the UK

There have been many examples of disastrous flooding in the UK over the past 50 years. Flood plains*, narrow valleys and coastal areas are most commonly affected. Low-lying coastal areas are more likely to be flooded than inland areas where water has a chance to soak into the ground, and river channels can carry away the excess.

During the night of 15 August 1952, a flash flood killed 34 people in the town of Lynmouth, Devon. Ninety-three houses were washed away or damaged beyond repair, and cars were swept out to sea as a wall of water over 9m high swept down narrow valleys and through the town.

The floods of Easter 1998 caused £400m damage, caused five deaths and resulted in the evacuation of 1500 people.

Autumn 2000 was the wettest since records began in 1766, with an average 460mm of rain falling in the period September to November. Some areas in the UK saw the worst floods for 300 years. Two people died and 7406 properties were flooded. However, flood defences protected more than 400,000 homes - the Environment Agency spends more than £25m a year on flood defence schemes for Britain.

In Ryedale (North Yorkshire), residents who had been flooded out three times in less than two years set up a campaign with signatures from more than 1200 residents, asking the Environment Agency to save the village from future flooding. When River Derwent and Pickering Beck both burst their banks, flooding had an impact on the whole of the community including the railway. The main line from York to Scarborough was closed for eight days, rail companies and passengers were affected for months and Railtrack spent about £1.2m repairing damaged equipment.

In Norfolk, newspaper headlines (December 2000) warned that thousands of East Anglians were unaware that their homes were at risk from flooding. By March 2001, torrential rain and flash floods brought roads and town centres to a standstill. The Broadland flood defence scheme (20-year civil engineering project costing £132m) aims to protect 240km of flood banks, 1700 homes and land in the Broadland area from flooding.

** flat alluvial tracts bordering rivers that accommodate water that can no longer be carried in the river channel.*

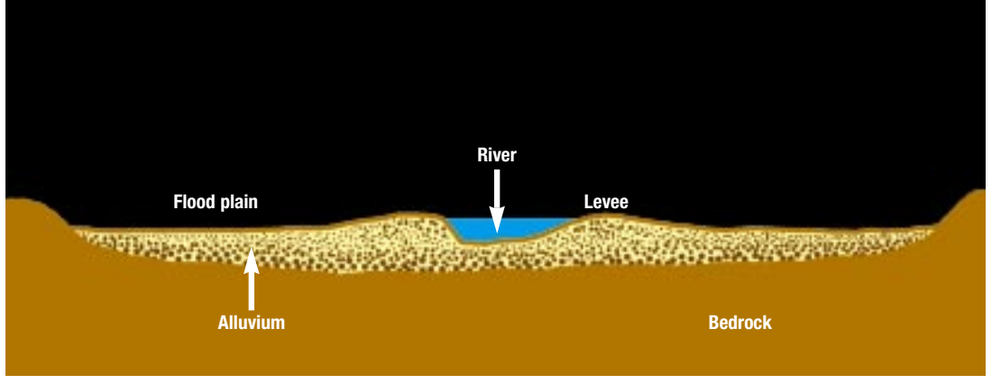

Fig. 1: A river bordered by natural levees. These may be raised to increase flood protection to the outlying flood plain, but in the long term such measures can prove unsustainable.

The future - and the role of geoscientists

Globally, more than 100 million people are at risk from floods already. Almost the entire population of Bangladesh lives in a flood-prone area and most of Holland is also at high risk.

Average global temperatures are expected to rise, and as a result average sea levels could be as much as 40cm higher by 2080. In England, annual rainfall is expected to increase by up to 10% by the 2050s, with the largest increases in the north west.

Table: How predicted rates of sea-level rise could affect the UK (2000-2050). Source: Environment Agency

Environment Agency Region	Predicted rise
NW and NE (N of Flamborough Head)	4mm/yr
SW	5mm/yr
Anglian, Thames, S & NE (S of Flamborough Head)	6mm/yr

[The above figures were adopted by the UK Ministry for Agriculture, Fisheries and Food (MAFF) following the 1990 reports of the Intergovernmental Panel on Climate Change]

Geoscientists are well placed to identify areas that are likely to suffer from flooding, from their understanding of landscape, hydrology, geology and an understanding of the way rocks and soils store and transmit water. They can recommend flood management and defence schemes, which may include levees, barriers and dams, and will be on hand to give advice in their siting, engineering design and construction.

Levees, barriers and dams

Huge earth banks (levees) designed to contain the river during a flood, have been constructed to protect towns and farmland along the Mississippi. The Mississippi floods of 1993 followed the wettest summer on record, however, and the floodwater overtopped levees more than 6m high. An area 800km long by 320km wide was inundated and more than 50,000 homes were damaged.

In some instances it may be better to allow nature to proceed without intervention. Levees may cause as many problems as they solve.

Where properly constructed, dams on rivers prone to flooding can be used to regulate river flow and reduce downstream risk. The Romans built coastal floodwalls, and today flood barriers can protect river mouths from freak tides and storm surges. Since the construction of the Thames Barrier in 1983, London has been protected from storm surges occurring at times of high tides.

There are several examples of successful construction and siting of dams in the UK and no major dam failures. Geoscience has been of benefit in siting dams at:

- Caban-Goch Dam in the Elan Valley, Mid-Wales (Birmingham waterworks) sited on the solid buttress of a rocky ridge along the valley
- Clywedog Dam at Llanidloes, a flood control dam on the River Severn, sited on a strong geological outcrop

Warning systems

Those living under flood threat need effective early warning systems. Accurate weather forecasting is the first priority, but a detailed understanding of the factors affecting hydraulic flow in valleys, flood plains and coastal or estuarine environments is vital.

Saturation levels depend on, and can be assessed by considering, local geology, which influences the permeability of the substrate. Water table levels (the upper surface of the groundwater) require constant monitoring.

Flood warning is the precursor to evacuation, the aim of which is to save lives and protect property. Flood management schemes and disaster contingency plans reduce the number of lives at risk. The British Geological Survey (BGS), Centre for Ecology and Hydrology (CEH) and other institutions use remote sensing information to analyse landforms and produce digital terrain models vital to assessing associated risks.

Managing risk on flood plains

Floods are the most frequent natural disaster to affect developing countries, which commonly cannot afford flood protection and management schemes. Such flood plains and coastal areas are typically densely populated. Although this is partly due to poor (or non-existent) urban and social planning, seasonally flooded areas attract populations because they are easy to farm and irrigate.

In developed countries such as the UK, geological maps showing alluvial deposits are an important basis for identifying flood plains. In conjunction with topographical maps and land-use information they show where infrastructure development has taken place on flood plains, and can be used to predict foundation conditions in areas of potential flooding and so produce risk maps.

In Britain the policy for flood and coastal defence is determined by MAFF, including setting policy aims, objectives and targets for the operating authorities which include the Environment Agency (EA), Internal Drainage Boards (IDBs), Local Authorities and Maritime Local Authorities. The Environment Agency is primarily responsible for sea defences and works on main rivers.

Approximately 8% of total area of land in England is at risk from river flooding, including tidal rivers and estuaries, and 1.5% of the total land area is at risk of direct flooding by the sea. About 5m people in the UK live on flood plains; major infrastructure (railways, roads) follow them, and they are often considered to be prime development sites. To protect them, geoscientists increasingly make use of advanced technology. Flood plain management tools include: automated hydraulic monitoring, a full complement of satellite imaging, remote sensing, and GIS (geographic information systems) for flood impact assessment and mitigation.