

Attachment B

Flooding and Dam Failure

The Hazard

Nature of the Hazard

Flooding occurs when normally dry land is inundated with water (or flowing mud). Flooding may result from: bodies of water overflowing their banks, including artificial ones like dams and levees; structural failure of dams and levees; rapid accumulation of runoff or surface water; hurricane-caused storm surges or earthquake-caused tsunamis; or erosion of a shoreline. (Coastal flooding and erosion are not treated in this attachment.) Typically, the two parameters of most concern for flood planning are suddenness of onset--in the case of flash floods and dam failures--and flood elevation in relation to topography and structures. Other factors contributing to damage are the velocity or "energy" of moving water, the debris carried by the water, and extended duration of flood conditions. Flooding can happen at any time of the year, but predominates in the late Winter and early Spring due to melting snow, breakaway ice jams, and rainy weather patterns.

Risk Area

All States and territories are at risk from flooding. Apart from a rainy climate, local risk factors, usually present in combination, include:

Rivers, Streams, and Drainageways

These are bodies of water often subject to overflowing. The size of the stream can be misleading; small streams that receive substantial rain or snowmelt, locally or upstream, can overflow their banks. High-velocity, low elevation flooding can be dangerous and damaging. Six inches of moving water can knock a person off his or her feet; 12 inches of water flowing at 10 miles per hour carries the force of a 100 mile-per-hour wind, although the force would be distributed differently on obstacles.

Dams and Levees

There are 74,053 dams in the United States, according to the 1993-1994 National Inventory of Dams. Approximately one third of these pose a "high" or "significant" hazard to life and property if failure occurs. Structural failure of dams or levees creates additional problems of water velocity and debris.

Steep Topography

Steep topography increases runoff water velocity and debris flow. Lack of vegetation to slow runoff is another factor. Alluvial fans, making up

twenty to thirty percent of the Southwest region, show these characteristics and face the additional complication of shifting drainage patterns and erosion.

*Cold Climatic
Conditions*

Apart from snowmelt, 35 northern States face flooding problems associated with ice jams. In the Spring, ice breaks away and then collects at constriction points in rivers and streams (i.e., bends, shallows, areas of decreasing slope, and bridges); by trapping water behind it and then later giving way, an ice jam heightens flood levels both upstream and downstream. Ice jams occur in the Fall with "frazil ice" (when a swift current permits formation of ice cover, but ice is carried downstream and attaches to the underside of ice cover there) and in Winter when channels freeze solid.

**Identifying
Hazards**

A jurisdiction's susceptibility to floods--riverine floods, ice jam floods, debris jam floods, flash floods--will in most cases be a matter of historical record, as will flood elevations. (However, planners must be alert to development upstream or extensive paving over of the ground that used to absorb runoff.) The NWS maintains a list of communities with potential flash flood problems, and stream flow data for large watersheds is kept by the USGS in cooperation with State and local agencies. Results of the Corps of Engineers' dam survey, as well as subsequent work done by many States, should be available to permit plotting of dams with an evaluation of the risk they pose. Planners have access to the National Flood Insurance Program's (NFIP) Flood Insurance Rate Maps (FIRM) and Flood Hazard Boundary Maps (FHBM), USGS topographic maps, and soil maps prepared by the Soil Conservation Service to use as base maps.

**Estimating
Vulnerable
Zones**

Using the NFIP's maps and Flood Insurance Studies (FIS) as a base, the planning team--consulting with an engineer for technical analysis--should plot dams and levees as applicable, then adjust inundation levels behind levees and progressively downstream of the dam. Where ice jams are a problem, base flood fringe boundaries should be broadened to account for higher potential flood elevations. Also, despite shallow flood elevations, it is important to map alluvial fans as high risk areas. Note, too, that areas prone to flash flooding from small streams and drainage ways may not always have been mapped as such by the NFIP. See FEMA 116, *Reducing Losses in High Risk Flood Hazard Areas: A Guidebook for Local Officials* for discussion of models and additional bibliography.

Flooding and Dam Failure Unique Planning Considerations

This section contains a listing of the functional annexes that typically would require the preparation of a hazard-specific appendices for flooding and dam failure. It also identifies the unique and/or regulatory planning considerations that should be examined by the planning team and used, as appropriate, when preparing appendices for flooding and dam failure.

Direction and Control

The extent of the initial response will depend on warning time, which varies with the cause of the flooding and the distance a jurisdiction is from the origin of the flooding. Intense storms may produce a flood in a few hours or even minutes for upstream locations, while areas downstream from heavy rains may have from 12 hours to several weeks to prepare. Flash floods occur within six hours of the beginning of heavy rainfall, and dam failure may occur within hours of the first signs of breaching, but floods from snowmelt can take months to develop.

The EOPs of jurisdictions located downstream of a heavy flood source should address the following planning considerations in one or more appendices to a direction and control annex:

Floodfighting

Relevant floodfighting considerations include:

- Obtaining and keeping current a list of all dams in or near the jurisdiction, by location and name.
- Coordination with a dam's staff during disaster or disaster threat situations to facilitate expeditious notification and the exchange of information.
- Maps that identify the likely areas to be inundated by flood waters.
- Identification of potential locations for the placement of temporary levees and inclusion of this information on the appropriate maps.
- Obtaining a labor force to perform flood fighting tasks associated with building a levee (e.g. fill and place sand sandbags to prevent flooding).

- Obtaining assistance from the U.S. Army Corps of Engineers to build temporary emergency levees.

Search and Rescue

Conduct aerial and waterborne search and rescue once flooding occurs. Include provisions for the rescue of stranded animals and the disposal of dead ones.

Continuity of Operations

Address the relocation of government resources, vital records, and equipment to assure continuation of services and to prevent damage or loss.

Inspection and Condemnation

Structures left standing may still have been weakened by water pressure and debris flows. Building interiors will be filled with mud and filth, and some building materials will be waterlogged.

Therefore, it will be necessary to inspect buildings and other structures to determine whether they are safe to inhabit after a flood has occurred. Activities may include:

- Identifying buildings and structures that may threaten public safety.
- Designating those buildings and structures that may be occupied.
- Identifying/marketing those buildings and structures that are to be condemned.

Warning

The NWS is responsible for most flood warning efforts in the United States. For large river systems, hydrological models are used by River Forecast Centers. For many--not all--smaller streams, the NWS has developed a system called ALERT (Automated Local Evaluation in Real Time) that does not rely on volunteer observers. However, some communities may still need to use volunteer observers to monitor water levels, the effectiveness of the levee system, or even to back up automated systems. The following planning considerations should be addressed, if appropriate, in one or more appendices to a warning annex:

Automated Warning

Include a listing that identifies location and telephone numbers for all automated dam and river warning devices within or upstream of the jurisdiction, if available.

*Use of
Volunteers*

If the jurisdiction relies on a volunteer warning network an appendix should describe:

- Composition and locations of each team in the network.
- How and when the network teams are activated (e.g., automatically with an NWS flood watch or as directed by the Emergency Manager).
- The type of information to be reported and the frequency of reporting.
- The means established to facilitate reporting.
- How warning information is passed on to response organization members.
- How the warning data received will be disseminated as emergency public information.

Dam Failure

In jurisdictions that are vulnerable to flooding from dam failure, an appendix should include provision for:

- Alerting the Warning Coordinator and other key members of the emergency management staff when the local authorities receive notification that a problem exists or may occur at the dam.
- Disseminating emergency warning information (to the public and other key response personnel) received from the dam's emergency management staff. Typically, a warning message should address a serious situation that could develop (alert) or inform the audience when an excessively high runoff occurs or a dam failure threatens (warning).
- Coordinating with the PIO to facilitate the timely warning of the population at risk from dam failure.

**Emergency
Public
Information**

Public information begins with communication of risks to the community, to potential home buyers, and to applicants for construction permits. Knowledge of being in a flood zone, of being downstream of a dam, of being protected by an inadequate levee, and the like, may rivet attention on

the rest of the public information strategy. The population should be educated about what the levels of warning imply, should know how to interpret a predicted flood level as it relates to their property, and should be informed about expedient loss-reduction measures they can apply to their property.

Provisions must be made to prepare and disseminate notifications, updates, and instructional messages as a follow-up to the original warning. The following planning considerations should be addressed, if appropriate, in one or more appendices to an EPI annex:

*When Floods
Develop
Slowly*

For flood emergencies that develop slowly enough to permit evacuation, provide the public information and instruction on:

- Expected elevation of the flood waters, and instructions on when to evacuate.
- Where to obtain transportation assistance to evacuate.
- Designated travel routes and departure times.
- Status of road closures (what routes must be avoided due to probable inundation).
- What to take or not to take to shelters (including options available for companion animals).
- Location of mass care shelters and other assistance centers.

*Transition to
Recovery*

As the initial response shifts to recovery, provide residents returning to their homes information on safety precautions associated with:

- Sanitary conditions.
- Unsafe drinking water.
- Use of utilities.
- Electric fields created in water by downed power lines.

Evacuation

If fast- and slow-developing floods are possible in a jurisdiction, protective action decisions must be based on the estimated time necessary for evacuation and the availability of shelter space above the estimated flood elevation. When complete evacuation is not feasible, citizens need to know where high ground is; when evacuation is feasible, planning should have accounted for routes facing possible inundation. In evacuation planning for floods, consideration must be given not only to critical facilities and custodial institutions but also to recreational areas prone to flooding, whether because the site is physically isolated or because visitors isolate themselves from communication.

Particular attention should be paid to critical facilities that are low-lying or in the path of projected debris flows. Transportation routes subject to flooding should also be noted, given the potential impact on evacuation and relief efforts.

The following planning considerations should be addressed, if appropriate, in one or more appendices to an evacuation annex:

- Maps that detail probable flood inundation areas and designated evacuation routes.
- Pickup points and government provided transport to move evacuees.
- Provisions for moving the residents of custodial facilities (hospitals, jails, mental health facilities, nursing homes, retirement homes, etc.).
- Coordination and implementation of mutual aid agreements with adjacent jurisdictions to facilitate evacuation.

Mass Care

The following planning considerations should be addressed, if appropriate, in one or more appendices to a mass care annex:

*Space/
Capacity*

Relevant considerations include:

- Identification of a sufficient number of mass care facilities to accommodate the estimated number of people that may be evacuated.

- Availability of shelter space for a prolonged (up to 90 day) period.

*Safe Location
of Facilities*

This involves designating shelters for use that are located on high ground (beyond the worst case inundation estimates).

**Health and
Medical**

The following planning considerations should be addressed, if appropriate, in one or more appendices to a health and medical annex:

- Provisions to keep people informed of the health and sanitary conditions created by floods: flood waters may carry untreated sewage, dead animals, disinterred bodies, and hazardous materials.
- Monitoring water quality and sanitary conditions.

**Resource
Management**

The following planning considerations should be addressed, as appropriate, in one or more appendices to a resource management annex:

- Provisions for purchasing, stockpiling or otherwise obtaining essential flood fighting items such as sand bags, fill, polyethylene sheeting, and pumps (of the right size and type, with necessary fuel, set-up personnel, operators, and tubing/pipes).
- Resource lists that identify the quantity and location of the items mentioned above, as well as points of contact (day, night, and weekend) to obtain them.