WESTERN REGION TECHNICAL ATTACHMENT
NO. 87-48
December 1, 1987

WALLS OF WATER--DEADLY FENCES

[Editor's note: The following attachment recently appeared in the Southern Region staff notes. It is reprodoced here with permission of the Southern Region.]

TECHNICAL ATTACHMENT

WALLS OF WATER -- DEADLY FENCES

"I started to hear a sound like an airplane. Also, there were loud booms. It got louder and louder. I thought it was breaking the sound barrier. I kept looking for a plane, but couldn't see one. I got suspicious and started to look upstream. I saw trees crashing over and a wall of water coming down."

FACT OR FICTION?

A survivor of Colorado's Lawn Lake Dam failure tragedy in 1982 gave the above eyewitness account of the stupefying wall of water phenomenon -- a phenomenon the hydrologic community can likely agree occurs often with dam failures. In fact, it is largely this idea of a traveling wall of water that makes even the contemplation of a dam failure awesome. In this Lawn Lake Dam failure, several eyewitnesses estimated that wall to be 25 to 30 feet high. It looked like a brown cloud and sounded like a freight train.

Eyewitness accounts of traveling walls of water are not restricted to dam failure incidents alone, however. Through the decades there have been accounts of similar traveling walls of water associated with rain storm induced "natural" floods. There may be some skepticism among the hydrologic community concerning these events, however, for several reasons. Eyewitness accounts may grossly exaggerate the walls' verticality. Few photos have documented their occurrence. Such traveling "walls" are quite difficult to produce in laboratories paralleling natural conditions. Lastly, and sadly, many potential eyewitnesses to such events become hapless victims -- their testimony muted, best told merely by the floods' death toll. For study purposes, it must be honestly stated there is little in the literature to support the notion of traveling walls of water in "natural" flood events and a corresponding lack of any efforts to scientifically explain how such a phenomenon might occur. Nonetheless, mounting evidence, if not from eyewitnesses, then at least from undeniable occurrences of physical devastation, strongly suggests these things do happen and warrant a scientific examination.

The recent, widely publicized tragedy with the church camp bus and van on Texas' Guadalupe River (July 17, 1987), where nine or ten teenagers lost their lives after their stalled vehicles were swept away, probably represents just such a classic case. The bus driver, during a post-flood recounting, described a wall of water moving through the beleaguered group of stranded campers, and certainly the rapidity with which the stalled vehicles became water engulfed (just a handful of minutes) supports the notion of a traveling "wall."

How does such a phenomenon develop in nature? While it is becoming increasingly difficult to remain skeptical about its occurrence, it is probably a fact that these traveling water walls do represent rare natural events. Considering the randomness of storm movements and magnitudes, and the interplay with such a myriad of drainage features and patterns, these walls probably occur when some certain set of conditions, or requirements, are met. Is it possible to isolate these conditions, and to then, someday, through improved observing techniques, adequately foresee the approaching danger?

COLLAPSED DAMS OFFER CLUES

The dam failure case offers some strong clues to the conditions needed. A dam failure provides the *sudden* release of a *great volume* of water into a river channel. Almost intuitively, we can conclude that a rainstorm must also *suddenly* introduce a *great amount of runoff* into a river channel. These are necessary conditions, and not uncommon ones. They are probably not the only ones, however.

Since a traveling wall of water represents a discontinuous front, conditions must also provide for the development of this front. Most rainstorms probably do not accommodate the front's development. In the dam failure case, the dam itself provides this physical front -- i.e., a great depth of water is stacked vertically against the dam. Sudden failure of the dam allows this vertical stack of water to commence motion, and features of the discontinuity, or front, are retained. The water commences movement as a "wall", and retains this vertical characteristic for significant distances downstream. Such a discontinuity must also be developed in the case of the natural rainstorm induced flood if we are to see the moving wall of water. Developing this discontinuity represents the ticklish job in nature.

HYPOTHESIS

We can hypothesize two ways by which this front can be developed. One way is to have an intense and copious rainstorm remain stationary. If a near-stationary storm delivers a great deal of rainfall quickly, the condition for the discontinuity will be largely met -- the transition into the area producing runoff will be quite abrupt. Sometimes occurring in nature, this is, however, a rare event.

The second way is to have an intense, copious rainstorm move parallel and in the same direction to the *downstream* drainage channel for some significant distance, then have either the storm, or the channel, veer. Motion of the storm must be in the downstream direction to accommodate a "piling up" of the runoff entering the channel. Storm motion in any other direction will "spread the runoff out" and provide the "normally slow" transition into flood flow. (Normally slow is used in a relative sense here. Most floods are developed quickly from excessive rainfalls. That is not good enough to produce a flood wall, which must necessarily be a near instantaneous jump in river discharge and stage.) The effect of the veer will be similar to the effect of a dam failing, and the vertically developed stack of water will now flow with a wall front down the river channel in its new direction. This veering is probably required provided the traveling speed of the rainstorm is different from the concentration time of the catchment, by far the most likely situation.

This second case represents the more likely one, as practically all rainstorms exhibit some horizontal directional motion. At the same time, natural drainage patterns assume practically all possible directions of flow. Inevitably, match ups between storm movement and direction of flow will occur. These will represent the critical cases when walls might develop, provided the storm is also both sufficiently intense and copious.

DIAGRAMS HELP VISUALIZE

Diagrams may aid in visualizing some of the ideas expressed so far. Figure 1 represents a longitudinal section "snapshot" of a flood wave which has a vertical wall of water, "w", at its leading face. Note that the actual crest of the flood is found at some point upstream of the wall -- shown in the figure by "c."

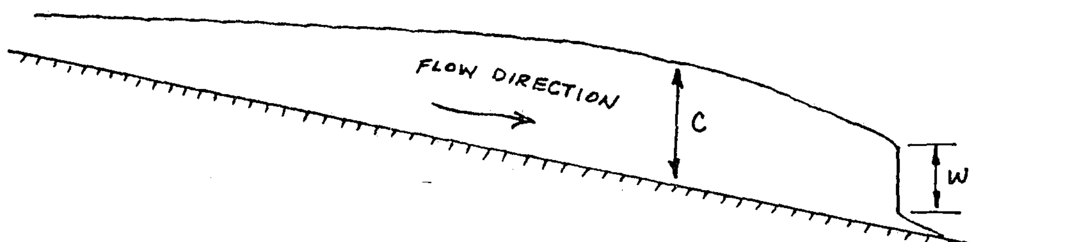

FIGURE 1

Figure 2 shows a developing flood wave from a just-failed dam. If the failure is truly instantaneous -- a near physical impossibility -- the flood's crest will be the lead wall. Because most dam failures occur over some finite time interval, the flood's crest occurs at some later time, just as in the "natural case.

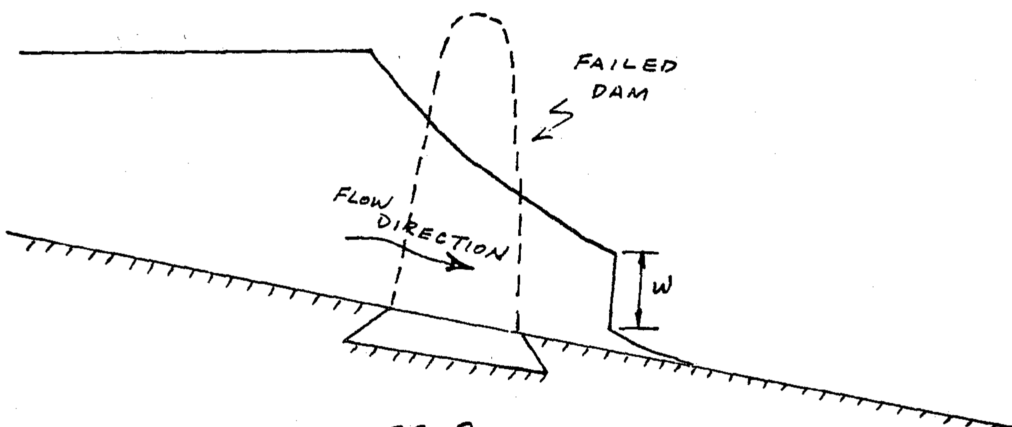

FIGURE 2

Figure 3 represents a map of a drainage channel flowing first to the northeast, then veering to the east-southeast. The storm's direction of movement is shown by the double arrow, paralleling the northeast drainage. The portion of the channel most susceptible to a flood wall is that portion just downstream of the channel veer. As depicted, magnitude of the wall should attenuate as the flood progresses downstream.

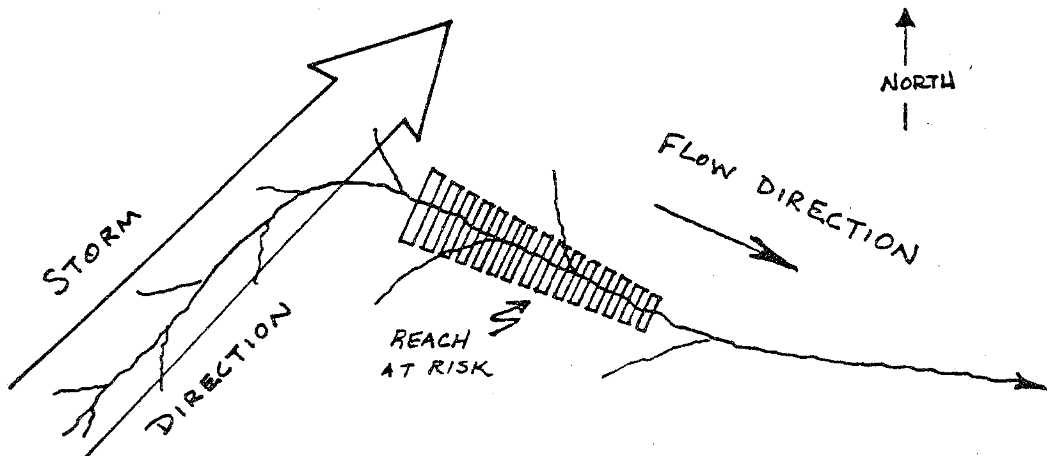

FIGURE 3

The state of the river just prior to the flood must also be considered. Dry river channels, or those flowing but nearly dry, present the best opportunity for spectacular wall development. Since dry channels, or those with exceedingly low flows, are largely a warm season phenomenon, most of the cases of interest here probably occur during summer or early autumn. The reason why channels at low flow have the greatest wall effect are shown by Figure 4. The summer, or low flow case, is shown on the left. Any sudden increase in flow represents a sizable increase in stage, or river depth. Continuity considerations, on the other hand, show a similar sudden increase in flow when the river is already flowing full will increase the stage, or depth, much less, as shown on the right. This is the normal winter-spring case.

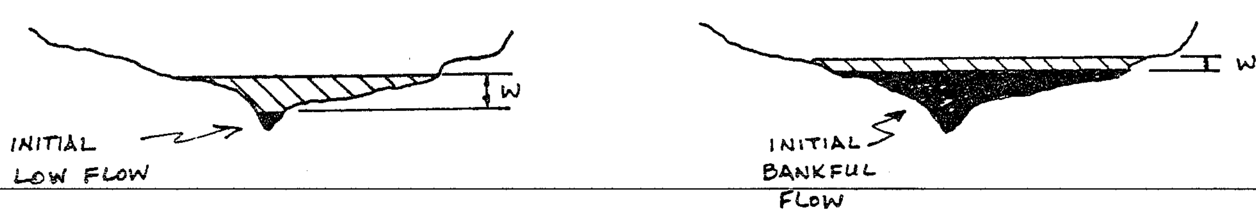

FIGURE 4

CONCLUSIONS

Too much evidence supports the notion of traveling walls of water during rainstorm-induced flash flood events to deny their existence. At the same time, such events, which represent true killer flash floods because of the magnitude and rapidity of their inundation, are rare, probably depending upon a particular match up of random conditions. Improved methods of hydrometeorological observation may someday provide the means for adequately warning for these events. At the present time, neither observation methods nor a fundamental understanding of the walls' development provide an opportunity for realistically targeted warnings.

The following is known about these flash flood walls.

- Their occurrence is an immediate threat to life for anyone directly in the flood plain.
- They can only occur with intense and copious rainfalls over a drainage.
- Their occurrence is most notable when stream beds are initially dry or at very low flow.

A hypothesis has been presented in this article.

- The discontinuity, or front, which is the traveling wall, may likely be developed one of two ways. A nearly stationary intense rainstorm may initiate it, as may an intense rainstorm moving parallel to the downstream direction of the river channel. The second condition is probably the more common. In this second instance, a veering of the river channel away from the storm's direction of movement likely enhances the wall's development.

The hypothesis needs to be examined against documented cases.