USACE INSTITUTE FOR WATER RESOURCES

Vocabulary of Flood Risk Management Terms

Appendix A

Leonard Shabman, Paul Scodari, Douglas Woolley, and Carolyn Kousky

May 2014

2014-R-02

This is an appendix to: L. Shabman and P. Scodari. 2014. *From Flood Damage Reduction to Flood Risk Management: Implications for USACE Policy and Programs*. USACE Institute for Water Resources.

Vocabulary of Flood Risk Management Terms

This attachment presents a vocabulary of flood risk management (FRM) terms that are used throughout the main report. The development of the vocabulary began with a glossary of risk analysis terms used by the Department of Homeland Security. This was followed by reviewing the terms against the contemporary literature on risk analysis, and the terminology and definitions used by the Corps in uncertainty analysis and in the Corps Dam and Levee Safety Programs. These reviews were then used to develop a FRM-specific vocabulary.

This vocabulary is not an alphabetical glossary. Instead of listing terms alphabetically, the terms are listed in an order that allows each definition to follow logically from and build upon the definitions that precede it. Some definitions may be better understood after reading the brief explanatory text found in the endnotes that further elaborates on the definitions, and in some cases relates the definition to the most common use of the term in other contexts.

The need for a vocabulary structured in this way stems from the varied and inconsistent use of FRM-related terms in the literature and in policy discussions, which makes it difficult to have a coherent policy discourse on flood risk management. Too often words have multiple and ambiguous meanings across and sometimes even within FRM policy statements and other FRM writings. This is not a conclusion unique to this report. The diversity of terms and definitions found in the professional and policy literature has been widely recognized as a challenge for the development and evaluation of FRM policies and for risk communication.

One significant result of creating a vocabulary in this manner is that each term has to have a precise and logical connection to the terms that precede and follow it in the vocabulary. The result is that new FRM terms emerged, some common terms used in FRM were redefined within a risk analysis framework, and some common terms in the FRM literature do not appear in this vocabulary.

This report commits to consistent use of these terms and definitions, and readers are offered this vocabulary as a guide. It is not a recommendation of this report that the definitions in this vocabulary be adopted by the Corps or the other federal agencies; however, if an effort to develop standard terms and definitions were to be pursued, this vocabulary might serve as a useful resource.

Contents

Flood

A temporary condition of partial or complete inundation of normally dry land resulting from the overflow of inland or tidal waters, or from unusual and rapid accumulation of surface runoff from any source.

Floodplain

Any land area that is susceptible to floods, which includes but is not limited to lands subject to a 1% or greater chance of flooding in any given year.[1]

Flood Water Surface Elevation

The maximum height of waters resulting from a particular flood at a particular location in a floodplain, as measured in relation to a specified vertical datum.[2]

Flood Likelihood

The annual chance of a particular flood water surface elevation at a particular location within a floodplain.

Flood Hazard

The predicted probability distribution of flood water surface elevations [3] for different locations within a floodplain expected from all possible floods.

Exposure

The potential for people and assets to come into direct contact with flood water as a result of their location in a floodplain.[4]

Consequences

The categories of effects on people and assets, economies, communities**,** governments and natural environments from exposure to a flood hazard.[5] Consequences can include: [6]

Human Health Consequences

The change in individuals' health, including changes in illness, injury, and mental distress (including pre-flood anxiety and post-flood trauma) as well as prospective loss of life.

Economic Consequences

The change in the market value of public and private assets as well as the change in the incomes of households and businesses. At the community, regional, and national levels,

economic consequences include changes in employment and the productivity of capital, land, and labor.

Social Consequences

The change in physical or economic circumstances that affects the ability of a community to remain in a particular location and maintain its desired cultural and economic attributes.

Fiscal Consequences

The change in expenditures made by agencies of government.

Environmental Consequences

The change in the structure, function, and services provided by water and related land resources in the watershed and realized by people located in the floodplain, in the region, and in the nation. [7]

Vulnerability

The characteristics of people and assets that affect the likelihood that they will realize adverse consequences from exposure to the flood hazard. [8]

Resiliency

The ability of people and assets to return to pre-flood conditions and functionality in the aftermath of realizing flood damage.[9]

Floodplain Management

Policies and programs of federal and non-federal government directed to actions taken in advance of a flood that are intended to limit the exposure and vulnerability of people and assets to flooding. [10] [11]

Flood Damage

The adverse consequences to people and assets expected (or realized) from their exposure and vulnerability to the flood hazard or a portion of the hazard (that is, one or more possible floods).[12]

Flood Risk

The likelihood and adverse consequences of flooding.[13] Flood risk for assets and people at any location in a floodplain is a function of flood hazard at that location and their exposure and

vulnerability to the flood hazard. In areas served by flood hazard reduction infrastructure, the remaining risk is often referred to as “residual risk” (see below).[14]

Flood Risk Reduction Actions

Actions that are intended to reduce the likelihood or the potential adverse consequences of a future flood. They include actions to reduce the hazard, reduce exposure, and reduce vulnerability, as outlined below. [15] [16]

Reduce the Hazard

Reduce the likelihood of flood water inundating a location, for a given duration, through:

- New investments to increase upstream flood water storage (dams, wetlands and floodplain restoration, runoff controls for pervious surfaces) and to secure flowage easements.
- New investments in channels, levee systems, walls, and culvert sizing to keep flood water away from an area of the floodplain.
- Proper O&M, inspection for structural integrity, and rehabilitation of past investments.
- Temporary flood-fighting.

Reduce Exposure to the Hazard

Reduce the potential for people and assets to come into direct contact with flood waters that inundate the floodplain through:

- Information programs intended to affect floodplain location and use decisions.
- Regulation intended to direct and limit new floodplain land occupancy and use decisions.
- Payments made to relocate assets and associated populations that are currently in the floodplain in order to change floodplain land settlement patterns and use.
- Payments made by landowners (occupancy fees or mandatory insurance premiums) that can influence their floodplain occupancy and use choices. [17]

Reduce Vulnerability to the Hazard

Reduce the likelihood that people and assets will realize adverse consequences from their exposure to the flood hazard through:

- Building codes, flood proofing and elevation of structures, ring levees, etc. and technical assistance and subsidies to encourage the adoption of such measures.
- Local emergency warning systems, evacuation plans and transportation equipment, and shelters combined with:
    - Information programs to encourage individual preparedness planning.
    - Strategies for enforcing and executing mandatory evacuation, including evacuation assistance.

Residual Risk

The level of flood risk for people and assets located in a floodplain that remains after implementation of flood risk reduction actions. Residual risk includes "transformed risk" (see below). [18]

Residual Risk Management Actions

Actions that increase the ability of people and assets to return to pre-flood conditions and functionality in the aftermath of a flood,[19] including:

- Planning and program design to assure rapid and effective execution of post disaster assistance programs, including:
    - Post flood counseling.
    - Rebuilding of public infrastructure.
    - Emergency aid and recovery assistance.
- Increased availability and subsequent purchase of insurance (NFIP/commercial, crop) to assure larger and more immediate post-flood payouts.[20]

Lawful Location In and Use of Floodplains

Floodplain location and use decisions of communities, households, and businesses that comply with federal and non-federal flood risk management programs as well as environmental and other regulatory programs and policies in effect at the time that the decisions are made.

Transformed Risk

The change in the nature of flood risk for some area associated with the presence of flood hazard reduction infrastructure.[21]

Transferred Risk

A change in flood risk (or financial costs) in one location due to a floodplain location and use choice and/or implementation of a risk reduction or residual risk management action in another location. [22]

Flood Risk Assessment

A systematic, evidence-based approach to qualitatively and/or quantitatively describe one or more determinants or elements of flood risk for assets and people, and the expected effects of flood risk reduction actions on flood risk. [23]

Flood Risk Communication

The process by which flood risk assessment results are disseminated to floodplain occupants and agencies of government for their consideration in decision-making relating to floodplain location and use as well as the choice of actions to reduce flood risk and manage residual risk. [24]

Flood Risk Management

The mix of federal and non-federal government policies and programs that influence the decisions made by communities and individuals relating to floodplain location and use and their choice of actions to reduce flood risk and manage residual risk. The term also covers the decisions actually made by all levels of government and by individuals to implement actions to reduce flood hazard, exposure, and vulnerability as well as to increase resiliency.

Federal Flood Risk Management Agencies

Agencies of the federal government with primary missions and supporting authorities designed to promote the public's understanding of flood risk; plan and implement flood risk reduction actions, residual risk management actions (e.g., provide insurance), and post-flood recovery actions; as well as influence decision-making by communities and individuals relating to floodplain location and use and their choice of actions to reduce flood risk and manage residual risk. [25]

Non-federal Flood Risk Management Agencies

Non-federal agencies of state and local government and special purpose agencies (e.g., levee and flood control districts) that alone or in partnership with federal flood risk management agencies have primary missions and supporting authorities to promote the public's understanding of flood risk, plan and implement flood risk reduction actions, residual risk management actions, and post-flood recovery actions as well as regulate or influence decision-

making by community households and businesses relating to floodplain location and use and their choice of actions to reduce flood risk and manage residual risk.

Tolerable Risk Guideline

A flood risk management goal defining a desired maximum level of transformed risk posed by flood hazard reduction infrastructure.[26]

Flood Risk Management Agency Policy & Program *Communication*

The intentional and structured sharing of information within and among agencies of governments with flood risk management missions about goals and implementation strategies at the program level and in specific places, with the intention of finding opportunities for policy and program coordination and collaboration.

Flood Risk Management Agency Policy & Program *Coordination*

Parallel or mutually supporting policy and program execution within and among agencies, while each agency retains discretion about its program policies and implementation procedures. Coordination may require a specific MOU/MOA within the discretionary limits of some agency to make the agency's actions interdependent with those of another agency.

Flood Risk Management Agency Policy & Program *Collaboration*

Modifications made to individual agency program authorities and implementation procedures in order to achieve a mutually agreed-to goal. The term "integration" is sometimes uses a synonym.

Endnotes

[1] For example, the National Flood Insurance Program (NFIP) uses the term "base floodplain," which is defined as the area that would be inundated by the flood that has a 1% chance of occurring in any year. As this suggests, the term "floodplain" should be associated with an adjective (e.g., base) or a more detailed description of the area being discussed if the area being referred to is less than the total land area that is subject to potential flooding.

[2] This definition is for a particular flood event at a particular floodplain location, but any location within the boundary of a floodplain is subject to floods of different possible magnitudes and thus variable possible flood water surface elevations. Flood hazard, defined elsewhere in this vocabulary, describes the whole distribution of possible flood water surface elevations across each location in a floodplain (as well as their chance of occurrence).

[3] Other possible dimensions of flood hazard include rate of rise, flow velocity, and duration of inundation associated with the water surface elevation.

[4] Exposure is the mirror image of the Corps' term "degree of protection." It includes concepts such as "population at risk" and "assets at risk."

[5] The most proximate adverse consequences from flooding are experienced by assets and the people associated with those assets.

[6] These categories of flood consequences are interdependent (and overlapping). For example, the direct effects of flooding on human health may bear on affected individuals' ability to work, which can exacerbate the economic consequences of flooding. As another example, the direct economic consequences of flooding, such as people losing their homes or livelihoods, can in turn affect the physical and mental health of affected individuals.

[7] A flood event may result in unintended releases of pollutants into the water from inundation of private enterprises (e.g., manufacturing plant) and public facilities (e.g., sewage treatment plants, CSO and SSO, landfills) or loss of environmental improvement projects such as created and restored wetlands. However, environmental consequences of flooding may also refer to a change in the "natural and beneficial functions" of floodplains.

[8] For example, characteristics relating to mobility (such as age and income in the case of people) can bear on the susceptibility of people and assets to adverse consequences from exposure to the flood hazard by affecting their ability to be evacuated from the floodplain location in advance of a flood, or escape or minimize harm if they cannot or do not evacuate (e.g., movement of automobiles and mobile homes, elevated or flood-proofed structures, people retreating to roofs or swimming to safety). This definition as it relates to people only is

consistent with the term "social vulnerability." Note: the term vulnerability also is used in some literature to refer to the ability of flood hazard reduction infrastructure to withstand stress on the structures from flood flows.

[9] This definition is narrower than some found in the FRM literature. For example, a 2012 report by the National Research Council defines resilience as "the ability to prepare and plan for, absorb, recover from or more successfully adapt to actual or potential adverse events."

[10] Some definitions describe floodplain management as the collective flood risk reduction and residual risk management actions taken by all levels of government as well as by floodplain occupants.

[11] Floodplain management is more limited than flood risk management and is focused on limiting the exposure and vulnerability of people and assets to flooding. Floodplain management, while important, is subsumed in flood risk management. As the term is defined here, floodplain management does not include other aspects of addressing our nation's flood risk that are encompassed within flood risk management, such as hazard reduction and post-flood disaster assistance. Sub-federal levels of government have significantly more control over floodplain management than federal agencies, although federal agencies may try to alter floodplain management decisions through incentives created by federal programs and information provision programs (e.g., NFIP).

[12] Flood damage is functionally related to the magnitude and characteristics of a realized flood and to the exposure and vulnerability of people and assets to flooding.

[13] A national accounting stance would define flood risk in terms of likelihoods and adverse consequences for all floods possible in all locations over time and across the nation. However, communities, households, and businesses would define flood risk over time for their specific locations. Flood risk will change over time as a result of changes in watershed characteristics affecting the hazard, as driven by development and environmental change (non-stationarity), and the implementation of flood risk reduction actions affecting the hazard, exposure, or vulnerability.

[14] The term flood risk may be defined differently across government agencies. Also, households, businesses, and communities who make decisions relating to floodplain location and use as well as the choice of actions to reduce flood risk and manage residual risk may describe flood risk in different ways. Among the different definitions of flood risk are the following:

- The likelihood and severity of adverse consequences resulting from a full range of flood events (expected value). The term flood damage reduction as used by the Corps and others can be reinterpreted to fit with this definition of flood risk. By this definition,

what some Corps programs do is reduce expected flood damages. It would be consistent with this definition to term the purpose of some Corps programs as "expected flood damage reduction."

- The severity of adverse consequences resulting from a particular water surface elevation, where the consequences are deemed unacceptable (manifested as a tolerable risk guideline). The location of people or assets where the return frequency (annual likelihood) of a specified flood event is deemed "unacceptable." This is a performance standard (e.g., no development in the base floodplain; no critical facilities where there is a 0.2% annual chance of flooding).

- The likelihood that a flood hazard reduction structure (e.g., levee system) cannot withstand the stress of a flood event and will thus breach, resulting in a sudden release of flood waters into floodplain areas where there are exposed people and assets (see: "Transformed Risk").

[15] Flood risk reduction actions are often categorized as structural or nonstructural, with the distinction being that structural actions alter the flood hazard, while nonstructural actions alter exposure and vulnerability to the hazard. All the categories of actions that can be found in such lists are included here, but they are organized according to the means by which they reduce flood risk.

[16] The term "mitigation" is often used in the literature to denote actions for flood risk reduction as well as the management of residual risk (see: "Transformed Risk").

[17] Actions to reduce exposure will also reduce vulnerability; however, actions to reduce vulnerability will not necessarily reduce exposure.

[18] Residual risk is often defined as the risk beyond the "level of protection" provided by hazard reduction infrastructure. However, level of protection refers only to the return frequency of a specific flood elevation, and so does not include all of the determinants of residual risk.

[19] Residual risk management actions do not reduce risk, but rather minimize the long term consequences of flood damage to people and assets.

[20] The focus here is on the insurance payouts, not insurance premiums paid.

[21] For example, the presence of a levee system can result in a more sudden inundation of a floodplain location if the levee breaches (with or without overtopping), thus increasing the vulnerability of exposed populations in that location. Generally, the following are sources of transformed risk:

- A flood event does not exceed the current performance capability of a flood hazard reduction structure, but the structure breaches or otherwise fails nevertheless.
- Intentional releases of reservoir storage to prevent dam failure.
- Drainage pumps fail to operate correctly, leading to internal flooding during a rainfall event.

[22] Transferred risk occurs when floodplain location and use or risk reduction actions or risk management actions result in: 1) financial costs for risk reduction or management actions paid by another entity, such as from general tax revenues of a higher level of government instead of by the floodplain occupants; 2) induced flood hazard in another location, and; 3) diminution of natural functions of floodplains that adversely affect the well-being of others (e.g., reduction in recreational fishing success). Transferring of costs may be lawful (See: Lawful Location In and Use of Floodplains).

[23] Risk assessment can be accomplished for the nation, a region, a community or a specific location in the floodplain. Ideally, flood risk assessments should report analytical *uncertainty* related to conceptual, data, and modeling limitations.

[24] Risk communication can be for the nation, a region, a community or a specific location in the floodplain.

[25] There are two principal federal flood risk management agencies—Corps and FEMA, while several other federal agencies, including USDA, NWS, NOAA and USGS, have a lesser focus on FRM.

[26] Tolerable risk guidelines describe a framework now being used to guide the portfolio risk management process of the Corps Dam Safety Program. The guidelines provide the means for evaluating whether transformed risks to human life associated with Corps dams are too high and thus should be reduced, and for prioritizing risk reduction actions across the portfolio of Corps dams.