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Key USACE Flood Risk Management Terms

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14. ABSTRACT

Risk terminology has evolved since it was infused into the USACE culture in the early 1990s. This list attempts to capture this evolution and to present the current state of the language. All definitions in this list are taken directly from the documents referenced and are presented for information only. The terms are organized alphabetically, and then by date with the oldest definition first; the order of the terms is not meant to imply a recommendation for or endorsement of any given definition. The list only represents the basic core flood risk management terms that are used in USACE guidance and risk communication documents, and is not a compilation of all terms from the references.

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Key USACE Flood Risk Management Terms (CEIWR-HEC, 2014)

Introduction and Purpose

Risk terminology has evolved since it was infused into the USACE culture in the early 1990s. This list attempts to capture this evolution and to present the current state of the language. All definitions in this list are taken directly from the documents referenced and are presented for information only. The terms are organized alphabetically, and then by date with the oldest definition first; the order of the terms is not meant to imply a recommendation for or endorsement of any given definition. The list only represents the basic core flood risk management terms that are used in USACE guidance and risk communication documents, and is not a compilation of all terms from the references.

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Terms

Annual Chance Exceedance (ACE) (Flood)

1. The flood that has a (stated percent - %) chance of being exceeded in any given year, such as the 1% annual chance exceedance flood. (Reference 8; Reference 6)

2. The estimated mean probability that an event such as flooding will occur in any given year considering the full range of possible annual events (floods). (Reference 10)

Annual Exceedance Probability (AEP)

1. Expected annual exceedance probability (AEP) is a measure of the likelihood of exceeding a specified target in any year. (Reference 2)

2. The probability that a specified magnitude will be exceeded. Unless otherwise noted, this term is used herein to denote annual exceedance probability: the likelihood of exceedance in any year. (Reference 2)

3. The probability that flooding will occur in any given year considering the full range of possible annual floods. (Reference 3; Reference 5)

4. The probability that a random variable (e.g. flood discharge or stage) will occur in any given year considering the full range of annual possible flood discharges. (Reference 6)

5. The annual probability that the interior floodplain in an impact area will be inundated to any depth due to channel overflow, or in the case of a leveed area, due to levee overtopping or failure. In each case, the AEP is computed with HEC-FDA, considering the uncertainty in the hydrologic, hydraulic and if necessary levee fragility inputs. (Reference 10)

6. The annual probability that the interior floodplain in an impact area will be inundated to any depth due to channel overflow, or in the case of a leveed area, due to levee overtopping or failure. In each case, the AEP is computed with HEC-FDA, considering the uncertainty in the hydrologic, hydraulic and if necessary levee fragility inputs. (Reference 10)

7. The probability that flooding will occur at a given location (such as a consequence area index point, a specific grid cell, or a fragility curve location (also referred to as system response probabilities) in any given year considering the full range of possible annual floods and project performance. (Reference 13)

Annual Probability of Failure

1. For dams the combined estimated annual probability of failure from all failure modes associated with all loading or initiating event types that result in an unintentional release of the reservoir. (Reference 9)

2. Per-year chance of unintentional occurrence of an event such as flooding combined over all modes of failure; with due regard for non-mutually exclusive failure modes. (Reference 10)

Assurance (also see Conditional Non-Exceedance Probability)

1. An index of the likelihood that a specified target will not be exceeded, given the occurrence of a hydrometeorological event. (Reference 2)

2. The probability that a target stage will not be exceeded during the occurrence of a flood of specified recurrence interval. For example, USACE requires that for a levee system to be found in accordance with National Flood Insurance Program (NFIP) levee system evaluation requirements, it must have at least a 90 percent chance of not being overtopped when subjected to the estimated 1 percent annual chance exceedance flood. Term selected to replace "conditional non-exceedance probability". (Reference 6; and Reference 13)

3. This performance measure represents the probability that an index point will perform as expected when the system is loaded with a single selected flood. … In other words, this index of performance shows the probability that the target stage associated with each alteration plan will not be exceeded, given the occurrence of an event of specified annual chance exceedance probability. (Reference 14)

Capacity Exceedance

Capacity exceedance implies exceedance of the capacity of a water conveyance, storage facility, or damage-reduction measure. This includes levee or reservoir capacity exceeded before overtopping, channel capacity exceedance, or rise of water above the level of raised structures. (Reference 2)

Conditional Non-Exceedance Probability (CNP) - also see Assurance

1. An index of the likelihood that a specified target will not be exceeded, given the occurrence of a hydrometeorological event. (Reference 2)

2. The chance of containing the specific .10, .04, .02, .01, .004, and .002 exceedance probability event within the target stage, should that event occur. (Reference 5)

3. The probability that inundation will not occur if a specified event occurs. (Reference 10)

4. The probability of containing a specific annual chance exceedance flood event, should that event occur. (Reference 10)

5. The probability that a target stage will not be exceeded during the occurrence of a flood of specified recurrence interval. (Reference 13)

Conditional Probability

1. The probability of capacity exceedance, given the occurrence of a specified event. (see Conditional Non-Exceedance Probability (CNP) or Assurance). (Reference 2)

2. The probability of event occurrence based on the assumption that another event (or multiple events) has occurred, for example, the probability of an event-tree branch that is determined based on the fact (condition) that a previous event (or several events) has occurred. At any node of an event tree, the sum of the conditional probabilities associated with each of the events (branches) immediately following that node should equal one. (Reference 10)

Consequence(s of Inundation)

1. The effect, result, or outcome of inundation as reflected in the potential loss of life (paramount for levee safety), economic losses, and adverse environmental impacts. (Reference 8)

2. Consequence is the harm that results from a single occurrence of the hazard. It is measured in terms of indices such as economic damage, acreage of habitat lost, crop values damaged, and lives lost. (Reference 7; Reference 10)

3. The outcome of an event, including immediate, short- and long-term, and direct and indirect losses and effects. Losses may include human casualties, monetary and economic damages, and environmental impact, and may also include less tangible and therefore less quantifiable effects, including political ramifications, decreased morale, reductions in operational effectiveness, or other impacts. Less tangible effects, such as the changes in quality of life, should be quantified to the extent practicable, if needed. (Reference 10)

4. The categories of effects on people and assets, economies, communities, governments and natural environments from exposure to a flood hazard. (Reference 12)

5. The effect, result, or outcome of inundation as reflected in the potential loss of life (paramount for levee safety), economic losses, and adverse environmental impacts. (Reference 13)

Depth

1. Distance of the water surface straight down to the point of interest. Normally, refers to a value associated with corresponding damage from the depth of water. (Reference 5)

2. The term depth is used to refer to an incremental distance between the water surface elevation and some local datum, such as the ground surface at a particular floodplain location. (Reference 10)

Discharge

1. The volume of water passing a specific point for a given time interval. For example, 2,000 cubic feet per second or 1,000 cubic meters per second. (Reference 5)

2. The amount of water that passes a point in a given period of time. Rate of discharge is usually measured in cubic feet per second (cfs). (Reference 10)

Economic Consequences

1. Direct and indirect losses of the failure of a dam and other economic impacts on the regional or national economy. Part of the direct losses is the damage to property located downstream from the dam due to failure. Items in this category include ones commonly computed for the National Economic Development (NED) account in any USACE flood risk management study. (Reference 9)

2. The direct losses from a flood hazard such as failure of a flood risk management measure and other economic impacts on the regional or national economy. Items in this category include ones commonly computed for the National Economic Development (NED) account in any USACE flood risk management study. (Reference 10)

3. 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. (Reference 12)

Economic Damages (also see Consequences and Economic Consequences)

Damages to private and public buildings, contents of buildings, vehicles, public infrastructure such as roads and bridges, public utility infrastructure, agricultural crops, agricultural capital, and erosion losses to land. (Reference 9; Reference 10)

Economic Risk (also see Expected Annual Damage)

1. The weighted average of all flood damages that would be expected to occur yearly under specified economic conditions and development. Such damages are computed on the basis of the expectancy in any one year of the amounts of damage that would result from floods throughout the full range of potential magnitude. (Reference 10)

2. Economic risk is the result of integrating the damage-probability function to yield the mean or expected annual damage (EAD). (Reference 10; Reference 13)

Elevation

1. Indicates a vertical distance from a selected vertical datum; the datum should be constant throughout a study; used interchangeably with the term "stage". (Reference 10)

2. The distance that any point on the ground is above a certain point called a datum. (Reference 10)

Equivalent Annual Damage

The damage value associated with the without-or-with project condition over the analysis period (project life) considering changes in hydrology, hydraulics and flood damage conditions over the life. Expected annual damage is computed for each analysis year and discounted to present worth which is then annualized to obtain the equivalent annual damage value. (Reference 5)

Exceedance Probability

1. The probability that a specific event will occur in any given year. For example, the .01 exceedance probability event has one chance in a hundred or a one percent chance of occurring in any given year. (Reference 5)

2. The probability that a specified magnitude event will be exceeded. Unless otherwise noted, this term is used herein to denote annual chance exceedance probability, which is the likelihood of exceedance in any year. (Reference 2; Reference 10)

Expected Annual Damage (EAD) - also see Economic Risk

The integral of the damage-probability function. In risk-based analysis it is equal to the average or mean of all possible values of damage determined by exhaustive Monte Carlo sampling of discharge-exceedance probability, stage-discharge, and stage-damage relationships and their associated uncertainties. (Reference 5)

Exposure

1. Exposure occurs when a susceptible asset comes in contact with a hazard. (Reference 4)

2. People and property threatened by flood hazard. (Reference 10; Reference 13)

3. Exposure describes who and what may be harmed by the flood hazard. It incorporates a description of where the flooding occurs at a given frequency, and what exists in that area. Tools such as flood inundation maps provide information on the extent and depth of flooding; structure inventories, population data, crop data, and habitat acreage provide information on the population and property that may be affected by the flood hazard. (Reference 7; Reference 10; Reference 13)

4. The potential for people and assets to come into direct contact with flood water as a result of their location in a floodplain. (Reference 12)

Flood Risk (also see Risk)

1. The risk associated with being flooded. Risk performance indicators used in the analysis are 1) the expected annual stage exceedance probability; 2) long-term risk (a .26 probability of the .01 exceedance probability event occurring over a thirty year period); and 3) conditional probability of non-exceedance (the project has a .95 probability of containing the .01 exceedance probability event should it occur). (Reference 5)

2. Measure of the probability and severity of undesirable consequences. (Reference 10)

3. The likelihood and consequences that may arise from inundation by flood water. Flood risk is determined by the following components: flood load (magnitude and likelihood of the hazard); the performance or response of any flood defense system (e.g., levee system - if such is present) to the flood load; the exposure to flood water of the item(s) at risk that might be harmed by flood water (population, property, infrastructure, etc); the vulnerability of the items at risk to harm from flood water; and the resulting measure of the harm, i.e., consequences that result from the flooding event (number of fatalities, dollar economic damages, environmental impacts, etc.). (Reference 11)

4. The likelihood and adverse consequences of flooding. 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". (Reference 12)

Flood Frequency

Technical reports should label flood frequency curves as "Percent Chance Exceedance". References to the frequency of a specific event should use the phrase "[x] percent chance exceedance flood". If the phrase is used several times in the text, it may be shortened to

"[x] percent flood". Information for public dissemination may use the short term with the full definition provided as a footnote: "The [x] percent flood has one chance in [100/x] of being exceeded in any given year". Highly technical reports such as research papers may have need to use the term "exceedance probability". Use of the terms "[x]-year flood", "recurrence interval", "exceedance interval", and "return period" are not acceptable in USACE reports. (Reference 1)

Flow

Referred to as discharge. (Reference 10)

Fragility Curve

A function that defines the probability of failure as a function of an applied load level. A particular form of the more general system response (Hartford and Baecher, 2004; see Reference 10 for citing). (Reference 10)

Freeboard

1. The increment of levee height added to the design flood height to increase the likelihood of the design event being contained without the levee overtopping. (Reference 6)

2. The increment of levee height added to the design flood height to increase the likelihood of the design event being contained without the levee overtopping. Freeboard is added primarily to provide a buffer in height to accommodate uncertainty in the estimated design flood level. At times, overbuild to account for long-term settlement and incrementing the height to ensure maintenance access during flood events is referred to as freeboard as well. (Reference 8)

3. Vertical distance between the design water level and the top of dam. (Reference 9)

Frequency

1. The rate of occurrence of an event measured in terms of the number of a particular type of event expected to occur in a particular time period of interest. The expected number of events within the period of interest may be less than or greater than one, and an annual period is commonly used. Thus, the resulting parameter represents an annual rate, typically referred to as annual frequency. (Reference 10)

2. In this document, frequency is referred to as probability. (Reference 10)

Hazard (Flood)

1. It is important to think broadly in terms of what a hazard is. All will be familiar with natural hazards like floods and water quality that destroys habitat, anthropogenic hazards like vessel operation or dam safety. These are only some of the hazards that present risks to be managed. The challenge to Corps personnel will be to see a broader range of hazards including cost overruns, budget shortfalls, negative net benefits, other financial risks, missed milestones, and the like. (Reference 4)

2. A potential source of harm (EPA 2003). (Reference 4)

3. A thing or action that can cause adverse effects (OMAF, 1997; see Reference 4 for citing). (Reference 4)

4. In a general sense, "hazard" is anything that is a potential source of harm to a valued asset (human, animal, natural, economic, social). It is important that one not limit the notion of a hazard to a natural hazard. A hazard can be thought of as an assumption about some uncertain value or parameter that, if incorrect, can result in the undesirable consequence of the failure to achieve the economic return anticipated. (Reference 4)

5. The hazard is what causes the harm, in this case, a flood. The flood hazard is described in terms of frequency, stage, velocity, extent, and depth. (Reference 7)

6. A potential source of harm (e.g. fire, earthquake, flood, etc.) to a valued asset (human, animal, natural, economic, or social) or a situation with a potential to cause loss. The hazard is what causes the harm, in this manual, is a flood. The flood hazard is described in terms of frequency, stage, velocity, extent, and depth. (Reference 7; Reference 9; Reference 10)

7. The predicted probability distribution of flood water surface elevations for different locations within a floodplain expected from all possible floods. (Reference 12)

8. An event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural loss, damage to the environment, interruption of business, and other types of loss or harm. The potential risk to life and limb and potential damage to property resulting from flooding. The degree of flood hazard varies with circumstances across the full range of floods. (Reference 13)

Level-of-Protection

1. Project performance will be described by annual exceedance probability and long-term risk rather than level-of-protection. (Reference 1)

2. A levee design concept that is founded on the principle of providing a high degree of assurance that the levee system will neither breach nor overtop when loaded with a specific recurrence interval flood. The recurrence interval of the flood for this design

principle is then used as an expression of the performance of the levee system at the time of design. For the purposes of its use in levee safety documents, this terminology is restricted to applications when discussing design targets or design concepts; it is not to be used as a general expression of levee system performance. Other performance descriptors that are explicitly derived from the inundation scenarios defined above will be used instead, such as the probabilities of loading, breach, overtopping, and inundation. (Reference 8; Reference 10)

3. A levee design concept that is founded on the principle of providing a high degree of assurance that the levee system will neither breach nor overtop when loaded with a specific recurrence interval flood. The recurrence interval of the flood for this design principle is then used as an expression of the performance of the levee system at the time of design. For the purposes of its use in levee safety documents, this terminology is restricted to applications when discussing design targets or design concepts; it is not to be used as a general expression of levee system performance. (Reference 11)

4. Level-of-Protection (LOP) is a legacy performance index and a levee design concept that is founded on the principle of providing a high degree of assurance that the levee system component will neither breach nor overtop when loaded with a specific recurrence interval flood. The recurrence interval of the flood for this design principle is then used as an expression of the performance of the levee system. For example, a system could be deemed a 50-year LOP system if it can contain the 0.02 annual chance exceedance flood with a high degree of Assurance, e.g. 90 percent. (Reference 13)

Life Safety (Life Risk)

1. The threat to loss of life from failure of a flood risk reduction system or feature. Life risk is often expressed as an annual exceedance probability vs. incremental life lost function or expected value of that function (annual lives lost), sometimes referred to as 'annual statistical lives lost'. (Reference 6)

2. The threat of loss of life resulting from breach, overtopping, or malfunction of components of a flood risk reduction system. (Reference 8)

Likelihood (also see Probability)

1. Used as a qualitative description of probability and frequency (ICOLD; see Reference 9 for citing). A description of the occurrence chance of a particular event. (Reference 9)

2. Likelihood is a measure of the chance, or degree of belief that a particular outcome or consequence will occur. A probability provides a quantitative description of the likelihood of occurrence of a particular event. Probability is expressed as a value between zero (impossible) and one (certain). (Reference 8; Reference 10)

3. The annual chance of a particular flood water surface elevation at a particular location within a floodplain. (Reference 12)

Long-Term Exceedance Probability (also see Long-term Risk)

The probability of capacity exceedance during a specified period. For example, 30-year risk refers to the probability of one or more exceedances of the capacity of a measure during a 30-year period; formerly long-term risk. (Reference 10; Reference 13)

Long-term Risk (also see Long-Term Exceedance Probability)

The probability of capacity exceedance during a specified period. For example, 30-year risk refers to the probability of one or more exceedances of the capacity of a measure during a 30-year period. This term has been changed to "Long-term Exceedance Probability". (Reference 2)

Median Exceedance Probability

In a sample of estimates of exceedance probability of a specified magnitude, this is the value that is exceeded by 50 percent of the estimates. (Reference 2; Reference 10)

Parameter

A quantity in a function that determines the specific form of the relationship of known input and unknown output. An example is Manning's roughness coefficient in energy loss calculations. The value of this parameter determines the relationship between a specified discharge rate and the unknown energy loss in a specific channel reach. (Reference 2; Reference 10)

Parameter Uncertainty

Uncertainty in a parameter due to limited understanding of the relationship or due to lack of accuracy with which parameters can be estimated for a selected hydrologic, hydraulic, or economic function. (Reference 2; Reference 10)

Performance (also see System Performance)

1. The risk analysis will quantify the performance of all scales of all alternatives considered for final recommendation. The analysis will evaluate and report residual risk, which includes consequence of project capacity exceedance. This requires explicitly considering the joint effects of the uncertainties associated with key hydrologic, hydraulic, and

geotechnical variables. This performance will be reported in the following ways (Reference 3):

(1). the annual exceedance probability with associated estimates of uncertainty,
(2). the equivalent long-term risk of exceedance over 10-, 30-, and 50-years, and
(3). the ability to contain specific historic floods.

2. Ability to meet functional requirements. The performance of an item is described by various elements, such as flood risk management, reliability, capability, efficiency, and maintainability. Design and operation affect system performance. (Reference 10)

3. Performance is the system's reaction to the hazard. Performance refers to the system features and the capability to accommodate the flood hazard as a single event or load. In this manual, this would be termed "system performance" (also termed "engineering performance"). Performance also refers to the metric that describes the capability of the system to accommodate a single event (CNP) and the full range of events (AEP and LTEP). In that light, in addition to the levee failure probability functions, performance can also be described by the interior-exterior functions for leveed areas; unregulated-regulated transforms for reservoirs and diversions; and elevation-discharge functions (rating curves) for channels. These too would be considered "system performance". When the structural integrity of a system or system component is discussed, such as the fragility function, the reference would be termed "structural performance". When the economics of a system is discussed, the reference would be termed "economic performance". (Reference 10; Reference 13)

Performance Uncertainty

Lack of certainty in the prediction of system response probabilities within each applicable failure mode. (Reference 10)

Probability (also see Likelihood)

1. The values ranging from zero to one of the number of outcomes in an exhaustive set of equally likely outcomes that produce the event divided by the total number of outcomes (Frequency divided by 100). (Reference 5)

2. A measure of the chance or degree of belief that a particular outcome or consequence will occur. A probability provides a quantitative description of the likelihood of occurrence of a particular event. Probability is expressed as a value between zero (impossible) and one (certain). (Reference 8; Reference 14)

3. A measure of the likelihood, chance, or degree of belief that a particular outcome or consequence will occur. A probability provides a quantitative description of the likelihood of occurrence of a particular event. This is expressed as a value between zero and one. (Reference 6; Reference 8; Reference 9)

4. The statistical probability that a flood of a given size will be equaled or exceeded in a given period of time. (Reference 10)

5. Subjective probability; quantified measure of belief, judgment, or confidence in the likelihood of an outcome, obtained by considering all available information honestly, fairly, and with a minimum of bias. Subjective probability is affected by the state of understanding of a process, judgment regarding an evaluation, or the quality and quantity of information. It may change over time as the state of knowledge changes (HSE, 2001; see Reference 10 for citing). (Reference 10)

6. Frequency or fraction; the outcome of a repetitive experiment of some kind, such as flipping coins. Such a number is called an "objective" probability because it exists in the real world and is in principle measurable by doing the experiment (ICOLD, 2005; see Reference 10 for citing). (Reference 10)

7. A measure of the degree of confidence in a prediction, as dictated by the evidence, concerning the nature of an uncertain quantity or the occurrence of an uncertain future event. This measure has a value between zero (impossibility) and 1.0 (certainty) (Hartford and Baecher, 2004; see Reference 10 for citing). (Reference 10)

Redundancy

The duplication of critical components of a system with the intention of increasing reliability of the system, usually in the case of a backup or fail-safe. (Reference 9; Reference 10)

Reliability

1. For gate and mechanical systems reliability is defined as the likelihood of successful performance of a given project element. It may be measured on an annual basis or for some specified time period of interest or, for example, in the case of spillway gates, on a per demand basis. Mathematically, Reliability = 1 – Probability of unsatisfactory operation. (Reference 9)

2. The likelihood of successful performance of a given project element over a specified time period. It may be measured on an annualized basis or for some other specified time period of interest. Mathematically, reliability equals one (probability of unsatisfactory operation). (Reference 10)

Residual Risk (Flood/Inundation)

1. Residual risk is the flood risk that remains if a proposed flood damage reduction project is implemented. Residual risk includes the consequence of capacity exceedance as well. (Reference 3)

2. The likelihood and consequences of occurrences that exceed the stresses that can be met by the project. (Reference 4)

3. Flood risk that remains if a proposed flood damage reduction project is implemented. Includes the consequence of capacity exceedance. (Reference 5)

4. The flood risk (probability of capacity exceedance or failure and the associated consequences) that remains after the levee system is implemented. (Reference 6)

5. The inundation risk in the leveed area at any point in time (i.e., prior to, during, or after implementation of risk reduction measures) is herein referred to as 'residual inundation risk', i.e. the risk that remains and is a candidate for management by other means. (Reference 8)

6. The remaining level of risk at any time before, during or after a program of risk mitigation measures has been taken. (Reference 9)

7. The risk (probability of failure and the associated consequences) that remains after an event hazard occurs, such as the probability of flood risk remaining after a flood risk management measure is implemented. (Reference 10)

8. 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". 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. (Reference 11)

9. 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". (Reference 12)

10. The flood risk that remains in the floodplain after a proposed flood risk management project is implemented. Residual risk includes the consequence of capacity exceedance as well as consideration of project performance. (Reference 13)

Resilience/Resiliency

1. The ability to avoid, minimize, withstand, and recover from the adverse effects of a flood. (Reference 11)

2. The ability to avoid, minimize, withstand, and recover from the effects of adversity, whether natural or man-made, under all circumstances of use. (Reference 9; Reference 13)

3. The ability of people and assets to return to pre-flood conditions and functionality in the aftermath of realizing flood damage. (Reference 12)

Risk

1. In a hydrologic context, risk is the probability that one or more events will exceed a specified value that has an estimated "true" percent chance exceedance, during a specified number of years. Note that this narrow definition includes a time specification. Risk evaluation enables a probabilistic statement to be made about the chances of a particular location being flooded within a specified number of years. (Reference 1)

2. Risk involves exposure to a chance of injury or loss. (Reference 2)

3. The probability an area will be flooded, resulting in undesirable consequences. (Reference 3)

4. A measure of the probability of undesirable consequences. (Reference 4)

5. The probability that an area will be flooded resulting in undesirable consequences. (Reference 5)

6. A measure of the probability and severity of undesirable consequences. (Reference 6; Reference 8; Reference 9)

7. Generally, the probability and severity of undesirable consequences. In the context of flood risk, the probability that an area will be flooded, resulting in undesirable consequences. As used in this manual, risk is the function of five factors: hazard, performance, exposure, vulnerability and consequences. Risk involves exposure to a chance of injury or loss. (Reference 10)

8. The likelihood and severity of adverse outcomes; for this ER (Reference 13) the focus is on the risk from flooding. Risk is often measured as potential or mean loss-of-life, property damage, and/or ecosystem losses and may also include uncertainty over the benefits to be gained from a proposed or actual action taken. Usually, both the likelihood and the consequence are to some degree uncertain. (Reference 13)

Risk Analysis

1. Risk analysis is an approach to evaluation and decision making that explicitly, and to the extent practical, analytically, incorporates considerations of risk and uncertainty in a flood damage reduction study. (Reference 3)

2. A decision-making framework that explicitly evaluates the level of risk if no action is taken and recognizes the monetary and non-monetary costs and benefits of reducing risks

when making decisions. Risk analysis comprises three tasks: risk assessment, risk management, and risk communication. (Reference 8; Reference 10; Reference 11)

3. Risk analysis, more specifically engineering reliability assessment and risk cost assessment, explicitly accounts for the uncertainties and vulnerabilities that accompany any project, and then identify the performance and design changes and their costs to reduce the risk of project failure. This directed assessment of critical vulnerabilities differentiates risk analysis from the application of uniform standards. (Reference 4)

4. The process of separating the whole of risk into its component tasks by assessing the risk and related uncertainties for the purpose of efficacious management of the risk, facilitated by effective communication about the risks. (Reference 4)

5. Approach to evaluation and decision making that explicitly, and to the extent practical, analytically, incorporates consideration of risk and uncertainty. (Reference 5)

6. Risk analysis is a framework that comprises three tasks: risk assessment, risk management, and risk communication. (Reference 6; Reference 8; Reference 10)

7. Risk analysis is a systematic way of identifying decision problems then gathering and evaluating evidence that can lead to recommendations for a decision or action in response to an identified hazard or opportunity for gain. It is a process that has evolved specifically for decision making under uncertainty. (Reference 11)

8. A decision-making framework that comprises three tasks: risk assessment, risk management, and risk communication. (Reference 13)

Risk Assessment

1. An update of the traditional definition of risk assessment taken from the 1983 National Research Council's *Risk Assessment in the Federal Government: Managing the Process* (the so-called "Redbook") includes the following steps (Reference 4):
   (1). Hazard Identification
   (2). Exposure Assessment
   (3). Risk Characterization

2. Risk assessment has a somewhat different meaning than the Corps' terminology of "risk-based' or "risk-informed" or "risk and uncertainty." It may be characterized as a more formal and focused effort to describe and define the impacts of a risk to facilitate their effective management. The proposed and subsequently withdrawn (2007) OMB Risk Assessment bulletin defined the "risk assessment" as a "means a scientific and/or technical document that assembles and synthesizes scientific information to determine whether a potential hazard exists and/or the extent of possible risk to human health, safety, or the environment". (Reference 4)

3. A broad term that encompasses a variety of analytic techniques that are used in different situations, depending upon the nature of the risk, the available data, and needs of decision makers. It is a systematic, evidence based approach for quantifying and describing the nature, likelihood, and magnitude of risk associated with the current condition and the same values resulting from a changed condition due to some action. (Reference 4; Reference 9)

4. Risk assessment is a systematic, evidence-based approach for quantifying and describing the nature, likelihood, and magnitude of risk associated with the current and most likely future condition and the same parameters resulting from a changed current and most likely future condition resulting from some action. Risk assessment includes explicit acknowledgment of the uncertainties in the risk. (Reference 10; Reference 11; Reference 13)

5. 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. (Reference 12)

6. A risk assessment considers explicitly the performance of the structural flood risk management measures and the consequences of exposure of people and property to the entire range of likely flood events. (Reference 14)

Risk Communication (Flood)

1. Risk communication is the open, two-way exchange of information and opinion about hazards and risks leading to a better understanding of the risks and better risk management decisions. Risk communication is integrated into the assessment and management processes. It is not a task that occurs only after decisions have been made. Risk communication ensures that the decision makers, other stakeholders and affected parties understand and appreciate the process of risk assessment and in so doing can be fully engaged in and responsible for risk management. (Reference 4)

2. Risk communication is the open, two-way exchange of information and opinion about hazards and risks leading to a better understanding of the risks and better risk management decisions. (Reference 9)

3. Risk communication is the open, two-way exchange of information that begins with information about how stakeholders can participate in the multi-stakeholder risk management process. The information exchanged includes: 1) characterization of current and possible future risks, including information concerning the uncertainty in the risk assessment; 2) the feasible life safety risk management measures, and 3) the monetary and non-monetary benefits and costs of alternative actions, with emphasis on life safety. (Reference 10)

4. 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. More generally risk communication is the open, two-way exchange of information and opinion about hazards and risks leading to a better understanding of the risks and better risk management decisions. (Reference 11; Reference 12)

5. The open, two-way exchange of information and opinion about hazards and risks, leading to a better understanding of the risks and better risk management decisions. (Reference 13)

Risk Management (Flood)

1. Risk management is the process of problem finding and initiating action to identify, evaluate, select, implement, monitor and modify actions taken to alter levels of risk, as compared to taking no action. The purpose of risk management is to choose those technically sound integrated actions to reduce risks after consideration of the costs of each increment of risk reduction. Environmental, social, cultural, ethical, political and legal considerations all factor into the decision made on how much cost will be incurred for each increment of risk reduction (how safe is safe enough?) . (Reference 4)

2. The objective of Federal and non-Federal policies and programs in managing the nations flood risk. This includes structural and non-structural measure taken to reduce the chance or magnitude of flood damage. These may include implementation of reservoirs, detention storage, channels, diversions, levees, interior drainage systems, floodproofing, levee raising, relocation of buildings, and flood warning and emergency preparedness actions. It also includes policies and programs intended to inform and to influence the decisions made by Federal, state, and local government agencies, individuals, businesses and communities in their choice of flood risk reduction measures and to locate assets in floodplain. (Reference 8)

3. The process of problem finding and initiating action to identify, evaluate, select, implement, monitor, and modify actions taken to alter levels of risk, compared with taking no action. The purpose of risk management is to choose and prioritize work required to reduce risk. (Reference 9)

4. Risk management is the process of evaluation, assessment by management of available options, prioritization of recommendations, selection of options, implementation, and monitoring and reviewing of actions taken. The risk management choice should acknowledge the need to manage the residual risk and the effectiveness and acceptability of options available to do so. (Reference 10)

5. 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 their choice of actions to reduce flood risk and manage residual risk. The term also includes the decisions 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. More generally risk management is the process of problem finding and initiating action to

identify, evaluate, select, implement, monitor and modify actions taken to alter levels of risk, as compared to taking no action. The purpose of risk management is to choose and prioritize work required to reduce risk. (Reference 11; Reference 12)

6. The process of problem finding and initiating action to identify, evaluate, select, implement, monitor, and modify actions taken to alter levels of risk, compared with taking no action. (Reference 13)

Robustness:

1. The ability of a system to continue to operate correctly across a wide range of operational conditions, with minimal damage, alteration, or loss of functionality, and to fail gracefully outside of that range.; the wider the range of conditions, the more robust the system. (Reference 10)

2. The ability of a system (physical, social, cultural or economic) to continue to operate correctly across a wide range of flood conditions, with minimal harm, alteration or loss of functionality, and to fail gracefully outside of that range. The wider the range of conditions included, the more robust the system. (Reference 11)

3. The ability of a system to continue to operate correctly across a wide range of operational conditions, with minimal damage, alteration, or loss of functionality, and to fail gracefully outside of that range.; the wider the range of conditions allowing good performance, the more robust the system. (Reference 9; Reference 13)

Sensitivity Analysis

1. Computation of the effect on the output of changes in input values or assumption. (Reference 2)

2. An analysis to determine the rate at which an output parameter varies, given unit change in one or more input parameters (ICOLD, 2005; see Reference 10 for citing). (Reference 10)

Stage (see also Water Surface Elevation)

1. The vertical distance in feet (meters) above or below a local or national datum (N.G.V.D. for elevations). (Reference 5)

2. Water height measured as the vertical distance in feet (meters) above or below a local or national elevation datum. (Reference 6)

3. For consistency […], the terms *stage* and *water surface elevation* are used to refer to the position of the water surface with reference to a regional or national geodetic datum (i.e., NAD27 (North American Datum of 1927), NAV88). (Reference 10)

Superiority

Superiority simply means providing higher levees at all points except where initial overtopping is desired. Superiority is an increment of the levee height that increases the likelihood that when the system approaches capacity, controlled flooding will occur at a specified overtopping section. (Reference 13)

System Performance

1. System performance is the system's reaction to the hazard. Performance is described by levee fragility curves and interior/exterior functions for leveed areas; unregulated/ regulated transforms for reservoirs and diversions; and rating curves for channels. (Reference 7)

2. The capability of the system to accommodate the flood hazard as a single event or load. (Reference 10)

Transferred Risk

1. 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 action in another location. Transferred risk occurs when floodplain location and use and/or risk reduction actions result in: 1) financial costs for risk reduction 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). (Reference 11)

2. 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. (Reference 12)

3. Similar to Transformed Risk, a result of an action taken in one region of a system to reduce risk, where that action shifts the risk burden to another region in the system. For example, if a levee is raised in one reach of a system, thus containing more flow and thereby reducing risk in that reach, that action then results in increased flow downstream to another reach of the system. Risk has been "transferred" from one location to another. (Reference 13)

Transformed Risk

1. The change in the nature of flood risk for some area associated with the presence of hazard reduction infrastructure. 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. (Reference 11)

2. The change in the nature of flood risk for some area associated with the presence of flood hazard reduction infrastructure. (Reference 12)

3. A new risk that emerges or increases as a result of mitigating another risk. The magnitude and nature of the risk of flooding are different with a levee compared with conditions without a levee. A levee reduces the likelihood that originally protected property will be flooded but may set the stage for development that puts new property at risk. A levee transforms the flood risk from one that may be gradual and observable before emergency action would be necessary for the originally protected properties to flood risk that may be sudden and catastrophic. (Reference 10; Reference 13)

Uncertainty

1. Uncertainty refers to the fact that the true statistics of the total population of occurrences of a particular phenomenon, e.g. annual peak stream flow, are not known. (Reference 1)

2. Uncertainty is a measure of imprecision of knowledge of parameters and functions used to describe the hydraulic, hydrologic, geotechnical, and economic aspects of a project plan. (Reference 3)

3. The result of imperfect knowledge concerning the present or future state of a system, event, situation, or (sub) population under consideration. Uncertainty leads to lack of confidence in predictions, inferences, or conclusions. Uncertainty occurs because of a lack of knowledge. Here we distinguish it from variability, although many consider variability a specific source of uncertainty. (Reference 4)

4. Measure of imprecision of knowledge of parameters and functions used to describe hydraulic, hydrologic, geotechnical and economic aspects of a project plan. (Reference 5)

5. A measure of the imprecision of knowledge of variables and functions used in the risk analysis. Uncertainty may be represented by a specific probability distribution with associated parameters, or sometimes expressed simply as standard deviation. (Reference 6)

6. Uncertainty is the result of imperfect knowledge concerning the present or future state of a system, event, situation, or (sub) population under consideration. The level of uncertainty governs the confidence in predictions, inferences or conclusions. (Reference 9)

7. Function uncertainty (also referred to as distribution uncertainty and model uncertainty): Lack of complete knowledge regarding the form of a hydrologic, hydraulic, or economic function to use in a particular application. This uncertainty arises from incomplete scientific or technical understanding of the hydrologic, hydraulic, or economic process. (Reference 2; Reference 10)

8. A measure of knowledge incompleteness and inconsistency due to inherent deficiencies in acquired knowledge. Also, a characterization of the degree to which the state of a system is unsettled or in doubt, such as the uncertainty of the outcome. In a quantified risk assessment, uncertainty is a representation of the confidence in the state of knowledge about the models and parameter values used. The two general categories of uncertainty are epistemic and aleatory. Epistemic uncertainties are associated with a lack of knowledge; while aleatory uncertainties are attributable to randomness. (Reference 10)

9. Used to describe any situations without sureness, whether or not described by a probability distribution. In the context of levee safety, uncertainty can be attributed to (i) inherent variability in natural properties and events, and (ii) incomplete knowledge of parameters and the relationships between input and output values. (Reference 8; Reference 11)

10. Lack of knowledge regarding the true value of a quantity. It is a consequence of reliance on limited data and on conceptual and mathematical models. This category of uncertainty is formally labeled epistemic uncertainty. Uncertainty is a measure of imprecision of knowledge of parameters and functions used to describe the hydraulic, hydrologic, geotechnical, and economic aspects of a project plan. (Reference 13)

Variability

1. One of two components often thought of as comprising 'uncertainty'. Epistemic or 'knowledge uncertainty' that is possible to reduce with additional data and study; aleatory or 'natural variability' that reflects a process that is random but uncertainty in its magnitude and values may not be reduced with additional data and study. Annual stream flow is an example of 'natural variability'. (Reference 9)

2. The heterogeneity of values within a population; the inherent randomness of natural or social systems (aleatory uncertainty). (Reference 10)

3. The distribution or spread of values within a natural "population" or data set. This array of possible values in a population is caused by the inherent randomness of natural or social systems, and is formally labeled aleatory uncertainty. The values in the statistical population have some probability distribution, and only limited knowledge of the entire statistical population and the probability distribution may exist. Sometimes variability is classed as a type of uncertainty although generally it should not be confused or interchanged with uncertainty as defined above. Variability is the notion that there is a range of possible values that will occur and not the lack of knowledge about that range or the distribution of those values. (Reference 11; Reference 13)

Vulnerability

1. Vulnerability is the susceptibility to harm of human beings, property, and the environment exposed to the hazard. Depth-damage functions, depth-mortality functions, and other similar relationships describe vulnerability. (Reference 10; Reference 7)

2. The characteristics of people and assets that affect the likelihood that they will realize adverse consequences from exposure to the flood hazard. (Reference 12)

3. The susceptibility to life, property, and the environment to damage if a hazard manifests its potential. (Reference 13)

Water Surface Elevation (also see Stage)

1. For consistency […], the terms *stage* and *water surface elevation* are used to refer to the position of the water surface with reference to a regional or national geodetic datum ((i.e., NAD27 (North American Datum of 1927), NAV88). (Reference 10)

2. 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. (Reference 12)