Corps Risk Analysis Gateway Training Module

Risk Assessment – Qualitative Methods

Series:
Corps Risk Analysis Online Training Modules

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Contents

Risk Assessment - Qualitative Methods

This module was originally developed as a web-based training on the Corps Risk Analysis Gateway. The content has been modified to fit this format. Additional modules are available for download on the IWR website.

Figure 1. Risk assessment is the analytical component of the Risk Analysis Framework.

As noted throughout the Risk Analysis Gateway, there are three key tasks of risk analysis, including the following:

- **Risk assessment:** defining the nature of the risk, its probability, and the consequences, either quantitatively or qualitatively (or a combination).
- **Risk management:** the actions taken to accept, assume, and manage risk.
- **Risk communication**: the multi-directional exchange of information to allow better understanding of the risk.

The goal of **risk assessment** is to identify and describe the risk(s) associated with a decision problem and to examine and evaluate the potential impacts of the risk.

Risk assessment procedures can include both qualitative and quantitative methods. The goal of the assessment is to identify and describe the risk(s) associated with a decision problem and to analyze the potential impacts of the risk. This module will expand upon qualitative risk assessments and the tools available to assist with this task. It is not the intent of this module to teach all of the possible methods for conducting qualitative analyses. Rather, the intent is to provide a broad understanding of the wide range of approaches and to provide resources to obtain more information about the various methods.

In **qualitative** assessments, the risk characterization produces non-numerical estimates of risk. Often times, qualitative risk assessments are undertaken due to lack of funding, time or expertise to tackle the problem quantitatively. Descriptive or categorical treatments of information are used in lieu of quantitative numerical estimates. Qualitative assessments can still be analytical evidence-based characterizations of risk that provide consistency and transparency in the way risks are handled.

There are two primary functions of **qualitative** risk assessment, including the following:

- **Risk identification**
- **Risk characterization and analysis**

Risk identification is the process of finding, recognizing and describing risks in a narrative fashion.

Qualitative **risk analysis** is risk characterization that produces non-numerical estimates of risk.

After completing this module you will be able to do the following:

- Describe the USACE model for qualitative risk assessment.
- Understand the processes for identifying risks.
- Identify the various approaches available to conduct a qualitative risk assessment.

You are encouraged to read through the examples, which look at specific concepts in more depth. Additional learning modules about risk assessment are available for exploration, including *Introduction to Risk Assessment* and *Risk Assessment – Quantitative Methods*.

This training is approximately one hour.

This course includes a self-assessment; it's recommended that you be able to achieve 70% for successful course completion.

Chapter 1 - Qualitative Methods for Risk Identification

1.0 Qualitative Methods for Risk Identification

Risk assessment can be described as the process of compiling, combining and presenting evidence to support a statement about the risk of a particular activity or event. There are a number of defined processes, techniques, tools, and models that can be used to support the assessment. Risk assessments can be qualitative, quantitative, or a combination of both.

In **qualitative** assessments, the risk characterization produces non-numerical estimates of risk. This course focuses on qualitative methods of risk assessment.

The starting point for any risk analysis (either qualitative or quantitative) should be a risk narrative. Simply, a risk narrative characterizes and describes an identified risk. It includes a narrative description of each of the four generic risk assessment steps: identify hazard or opportunity, consequence assessment, likelihood assessment and risk characterization.

There are qualitative tools that can be used to either identify risks or to analyze risks. As noted in Section 2.0 of the *Introduction to Risk Assessment* module, the **first formal step** in any risk assessment phase is to identify the risks of interest.

Risk identification is the process of finding, recognizing and describing risks in a narrative fashion. Informally, this is done by asking and answering the questions, "What can go wrong?" and "How can it happen?"

It is likely that a risk identification process will not be completed solely by one person. Therefore, some group process techniques might be beneficial to solicit group participation and feedback. A brief introduction to processes that can be used for risk identification is presented below. They include the following:

- 1.1 Brainstorming
- 1.2 Interviewing
- 1.3 Expert Elicitation

1.1 Brainstorming

Brainstorming may be useful for identifying hazards, risks, stakeholders, decision criteria and risk management options. Brainstorming is a conceptual approach for generating ideas from a group of participants, often for generating a large number of ideas in a short amount of time. The inputs for successful brainstorming include the following:

- A well-defined problem.
- A team of people with knowledge of the problem.
- A brainstorming technique.
- A facilitator.
- Means to both record and disseminate the results of the process.

The process itself can be formal or informal. Formal brainstorming is more structured. Facilitators prepare in advance and participants may be prepared as well. The formal brainstorming session has a defined purpose, structure and outcome. Informal brainstorming is less structured. It may be represented by the “let’s go around the table and see what everybody thinks” method.

The outputs of a brainstorming session might be a list of ideas. Generally the list of ideas will not be evaluated. However, some brainstorming techniques do provide for some degree of evaluation of the ideas. The strengths of brainstorming include some of the following:

- It encourages imagination.
- It identifies new risks and novel solutions.
- It involves key stakeholders and hence aids communication overall.
- It is relatively quick and easy to set up.

The weaknesses of brainstorming include some of the following:

- Failing to get the right mix of skills and knowledge in the group.
- Group domination by one or more strong personalities or bosses.
- Free-riding by group members.
- Social phenomena like "groupthink".[1]
- Difficulty verifying that the effort is comprehensive.

Some resources on the brainstorming technique include the following:

- Aiken, M., Sloan, H., Paolillo, J. & Motiwalla, L. (October 1997). *The use of two electronic idea generation techniques in strategy planning meetings*. Journal of Business Communication. 34(4): 370-382.
- Creighton, J. L. (n.d.) *Using group process techniques to improve meeting effectiveness*. Retrieved December 21, 2012 from: http://www.effectivemeetings.com/teams/teamwork/creighton.asp

- Mind Tools. (n.d.) *Brainstorming: Generating many radical, creative ideas.* Retrieved December 21, 2012 from http://www.mindtools.com/brainstm.html
- Mind Tools. (n.d.) *Mind Maps: A powerful approach to note-taking*. Retrieved December 21, 2012 from http://www.mindtools.com/pages/article/newISS_01.htm
- U.S. Army Corps of Engineers. (1996). *Identifying small group techniques for planning environmental projects: A general protocol*. Retrieved December 21, 2012 from: http://www.iwr.usace.army.mil/Portals/70/docs/iwrreports/96r29.pdf
- U.S. Army Corps of Engineers. (n.d.) *Collaborative planning toolkit: Tools and techniques for collaborative planning.* Retrieved December 21, 2012 from http://www.sharedvisionplanning.us/CPToolkit/Content.asp?ID=3.1

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[1] Groupthink: "A pattern of thought characterized by self-deception, forced manufacture of consent, and conformity to group values." Retrieved October 24, 2013 from: http://www.merriam-webster.com/dictionary/groupthink.

1.2 INTERVIEWING

Structured interviews or semi-structured interviews can be an important and useful technique for risk identification or addressing uncertainty. The basic idea is simple: individual experts are asked a set of prepared questions. Structured interviews adhere to the prescripted questions while semi-structured interviews allow the conversation to explore issues and topics that arise during the interview. Well-constructed interviews can encourage experts to see problems from new perspectives.[2]

Interviews are most useful when it is impractical or undesirable to get people together for brainstorming or more formal processes. The structure of an interview usually ensures more productive outcomes than a free flowing discussion in a group. Interviews can be used to identify risks or to assess the efficacy of risk management options.[3] The ease with which an interview can be conducted makes them a useful tool for gathering stakeholder input to a risk management process.

The set of questions used for an interview is the critical input. Open-ended questions are preferred when possible in qualitative research. The questions should be simple and each one should address a single topic or issue. The language should be appropriate to the interviewee. Use engineering jargon for engineers, but **not** for the public, for example. Interview questions should include follow up questions; the answer to one question may trigger the sequence of questions to follow. For example, if a person's home was flooded in the last flood, they will be asked different questions than a person that was not flooded. All questions should be pretested for clarity. The prepared questions are then asked of each interviewee. Care should be taken to use good interview techniques.

The output of the interview process is a documented record of the interviewees' views on the subject matter of the interview. The strengths of using an interview for risk identification include some of the following:

- It is useful for large groups.
- Structure ensures uniformity of coverage of an issue.
- One-to-one communication allows conversation to meander (semi-structured).
- There is a record of information obtained.

Its weaknesses include some of the following:

- Prior approval(s) may be required for conducting an interview survey.[4]
    - In order to interview or survey non-USACE employees, Office of Management and Budget approval must be sought.
- It is time-consuming and labor intensive.
- Benefits of group interaction are absent (bias is more likely than in group discussion, imagination is not triggered).

Some resources on interviewing techniques include the following:

- King, N. & Horrocks, C. (2010). *Interviews in qualitative research*. Sage Publications. https://us.sagepub.com/en-us/nam/interviews-in-qualitative-research/book228232
- Web Center for Social Research Methods. (2006). *Research methods knowledge base: Interviews.* Retrieved December 21, 2012 from: http://www.socialresearchmethods.net/kb/intrview.php

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[2] International Electrotechnical Commission (IEC)/International Organization for Standardization (ISO). (2009). *ISO 31000:2009, Risk management—risk assessment techniques.* Retrieved January 13, 2013 from http://www.iso.org/iso/iso31000.

[3] Ibid.

[4] Surveys conducted by the Federal Government are subject to the Paperwork Reduction Act of 1995 (Public Law 104-13), and must be approved by the Office of Management and Budget. For more information, see http://www.iwr.usace.army.mil/Library/OMBSurveys.aspx.

1.3 Expert Elicitation

The USACE is frequently required to make important decisions in the presence of uncertainty. Analysis of risk through risk assessment seeks to increase understanding of the implications of uncertainty for decision making. Expert elicitation is a useful technique for risk identification or for improving the characterization of uncertainty. It is a systematic process of formalizing and usually quantifying, often in probabilistic terms, expert judgments about uncertain quantities. It is discussed here among the qualitative methods because it has also been used to elicit qualitative judgments about matters of uncertain facts. The process frequently involves integrating empirical data with scientific judgment and identifying a range of possible outcomes and likelihoods. Thus, it can also be a quantitative technique. Documenting the underlying thought processes of experts is the essence of the process.

Many of the complex problems the USACE faces are characterized by a lack of direct empirical evidence for some aspect(s) of the problem. Most of these situations require judgment to help bridge the gaps in data, knowledge and theory. “Expert elicitation” is used to make subjective judgments as objective as possible; it is defined more narrowly than “expert judgment.” It is a method limited to characterizing the science (state of knowledge) in a decision problem. Expert judgment, as defined here, refers to characterizing the decision-relevant values and preferences that lead up to decision making. Thus, estimating a roughness coefficient for a model is a matter of expert elicitation, while trading off national economic development effects for national ecosystem restoration effects is an expert judgment. Elicitations may be group or individual efforts.

The inputs for an expert elicitation process include the following:

- Problem definition to include identification, selection and development of technical issues to be resolved.
- Formal elicitation protocol.
- Experts.
- Identification, summary and sharing of the relevant body of evidence with experts.
- Formal elicitation to encode the experts’ judgments.

Once a decision problem is defined and the technical issues have been identified, the experts have been identified, and the relevant evidence has been shared, it is common to have a facilitated discussion with the experts to refine the issues. Here the experts define the scope of the problem, clarify terminology and all contextual matters that will influence their ability to render judgment. At this point, the experts are trained for the elicitation process. For significant elicitations, this may include the calibration of experts. The elicitation process is facilitated according to a chosen protocol. A protocol provides for the elicitation of opinions, analysis, aggregation, revision of those opinions, and the development of a consensus when one is needed. The best processes may include a peer review. The outputs of the process include the expressed consensus, judgment or degree of belief expressed qualitatively or, at times, quantitatively (typically probabilistically).

The strengths of an expert elicitation process include some of the following:

- It can provide the carefully considered and fully described views of highly-respected experts affiliated with diverse institutions and perspectives. Such cross-institutional viewpoints may be preferable to relying on the views of an in-house expert.
- The process can be effective in bounding uncertainty and providing estimates of critical missing data and information.
- The technique can be useful for addressing emerging science challenges and scientific controversies, including such technical issues as model selection or use and data selection or use.
- The deliberation by a group of experts can help render complex problems tractable.

However, the process is not without its weaknesses, including some of the following:

- It is hard to find informed experts.
- Experts are not always well calibrated, that is to say they are not always statistically accurate for a wide variety of commonly recognized reasons. Primary among these reasons are the heuristics people use to think about probabilistic information.
- In the case of qualitative elicitations, problems frequently arise because the same words can mean very different things to different people. The same words can also mean very different things to the same person in different contexts.

Some resources on expert elicitation techniques include the following:

- Ayyub, B. (2000). *Methods for expert-opinion elicitation of probabilities and consequences for Corps facilitations*. IWR Report-00-R-10. Retrieved January 4, 2013 from: http://www.iwr.usace.army.mil/Portals/70/docs/iwrreports/00-R-101.pdf
- Slottje, P. Sluijs, J.P. van der, & Knol, A. B. (2008). *Expert elicitation: Methodological suggestions for its use in environmental health impact assessments.* Centre for Environmental Health Research, National Institute for Public Health and the Environment. Retrieved January 4, 2013 from: *http://www.nusap.net/downloads/reports/Expert_Elicitation.pdf*
- U.S. Environmental Protection Agency. (2009). *Expert elicitation task force: White paper*. Retrieved January 4, 2013 from: http://yosemite.epa.gov/sab/sabproduct.nsf/fedrgstr_activites/Expert%20Elicitation%20White%20Paper?OpenDocument ;
- http://www.epa.gov/osa/pdfs/elicitation/Expert_Elicitation_White_Paper-January_06_2009.pdf
- U.S. Environmental Protection Agency. (2009). *Expert elicitation white paper-Addendum of recent references*. Retrieved January 4, 2013

from: http://yosemite.epa.gov/sab/sabproduct.nsf/fedrgstr_activites/Expert%20Elicitation%20White%20Paper?OpenDocument

Chapter 2 - Qualitative Methods for Analyzing Risk

2.0 Qualitative Methods for Analyzing Risk

Once potential risks have been identified, the next step in the USACE risk management model is to move into analyzing the risk (see Figure 2), including the assessment of consequences and likelihoods and the characterization of risks.

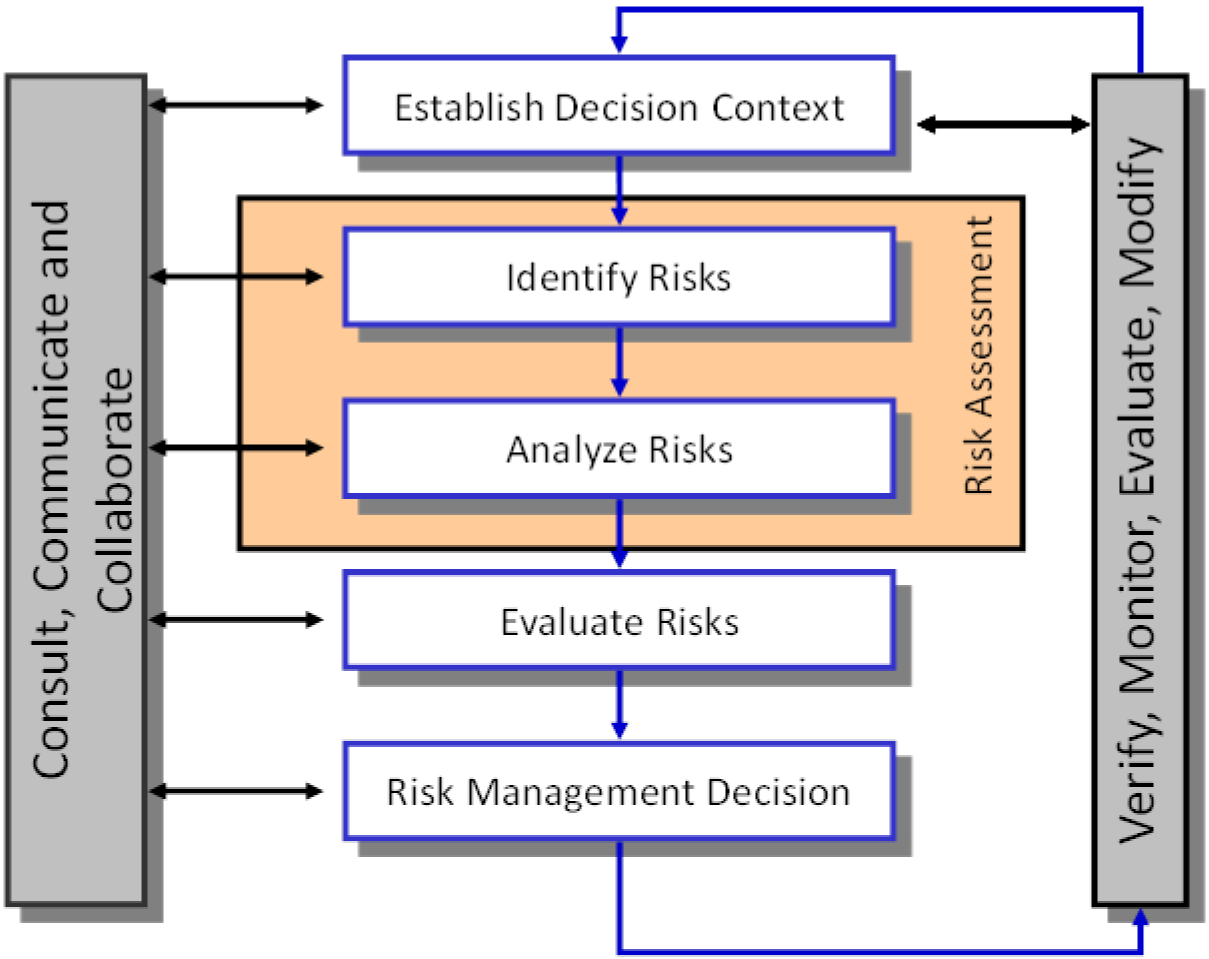

Figure 2. USACE Risk-Informed Decision Making Model

Risk assessment can be described in shorthand as the process of compiling, combining and presenting evidence to support a statement about risk. In **qualitative** risk assessment, the risk characterization produces non-numerical estimates of risk. Qualitative assessments are still analytical evidence-based characterizations of risk, but descriptive or categorical treatments of information are used in lieu of quantitative numerical estimates. Qualitative assessments are often most useful in situations where theory, data, time or expertise are limited. But they are also useful when decision makers only need a qualitative assessment of the risk. They can be useful for broadly defined problems where quantitative risk assessment may be impractical. For example, a qualitative assessment of the nation's systems of levees may be a useful way to identify the situations where a more detailed quantitative assessment is warranted.

Qualitative methods for risk analysis may be preferred in the following instances:

- Routine noncontroversial tasks.
- When theory, data, time or expertise is limited.
- Key uncertainties are highly unlikely to change the end result.
- When other methods are going to be cost prohibitive and have a low probability of successful analysis.
- When quantitative analysis is likely to result in inconclusive results.[5]

Some of the more useful qualitative risk assessment methods include the following:

- Risk narratives.
- Increase or decrease risk (due to changing conditions).
- Evidence mapping.
- Ordering techniques (screening, rating, ranking).
- Operational risk management (risk matrix).
- A generic process.

The following subsections provide a brief overview of these methods with a bit more emphasis on evidence mapping, a ranking method, the risk matrix and a generic process.

Table 1 is a snapshot of some qualitative tools for risk analysis.

Table 1. Qualitative tools for risk analysis.

Qualitative Methods	**Description**
Risk narrative	A risk narrative is a simple story that characterizes and describes an identified risk. It includes a narrative description of each of the four generic risk assessment steps: identify hazard or opportunity, consequence assessment, likelihood assessment and risk characterization. A risk narrative should be a starting point for any risk analysis, whether it is a qualitative or quantitative analysis.
Increase or decrease risk	Identify the parts of the risk and whether the surrounding uncertainty will increase or decrease the risk. For example, wetlands establishment is based on uncertain sea levels. The effect is a *decrease* in wetland establishment.
Evidence mapping	Evidence maps illustrate the evidence and logic experts use to derive tentative conclusions about a potential hazard or risk in the face of great uncertainty and/or conflicting evidence. An evidence map has three core elements: evidence, pro- and con- arguments, and conclusions about the risk. The evidence map approach does so in a way that identifies the consensus/disagreement that exists and the uncertainties that remain.
Ordering: chronological, screening, rating and rankings	• *Chronological*: The sequence and timing of events sometimes reveal cause and effect relationships, or they better enable us to see patterns, identify important events and see significant gaps in our understanding of cause-and-effect relationships. • *Screening*: One would carefully define categories, screening criteria, evidence for the criteria and if needed, an algorithm to synthesize information to make easier decisions. For example, “structures impacted by climate change” vs. “non-impacted structures” can be categories and sorted through more easily. • *Rating*: This is a screening done in advance that would expand categories and criteria to provide more evidence as to why certain categories are more or less important to consider. • *Ranking:* Ranking requires the same elements as a screening or rating process, but it may also include weighting the importance of the various criteria.
Operations risk management (risk matrices)	This tool uses the concepts of ratings and rankings within a matrix of probabilities and consequences.

[5] Lund, J.R. (2008). *A risk analysis of risk analysis.* Journal of Contemporary Water Research and Education. pp 53-60.

2.1 RISK NARRATIVE

The most basic type of qualitative tool is a ***narrative***. This is a written overview of the risk, its key uncertainties and their significance to the decision outcomes. It includes a narrative description of each of the four generic risk assessment steps: identify hazard or opportunity, consequence assessment, likelihood assessment and risk characterization. At minimum, the narrative should answer the four basic questions of the risk assessment and present any available evidence. This type of description is the most basic form of risk assessment and, if used alone, is best applied in situations where the uncertainties and risk level are considered modest. Although very simple, the importance of the narrative technique should not be overlooked as a starting point for any risk assessment. In fact, an effective narrative should accompany **every** risk assessment. Not everyone will need to understand the details of risk assessment, but all stakeholders and decision makers need an overview of the level of risk and the implications that a narrative can provide. The risk narrative should be included in the **risk register**.

It is important that the narrative consider the possible multiple dimensions of risk, as defined in Section 2.1 of the *Introduction to Risk Assessment* module. The risk narrative should address the risk story, the risk reduction story, and describe the effectiveness of the risk management options. It should also explore the possibility of residual, transferred or transformed risks. In qualitative risk assessments, the narrative may provide all that is needed for a risk management decision. Risk narratives are robust and flexible tools that can be used for any of the risk assessment tasks.

The information entered into a risk narrative answers the four risk assessment questions arranged in an effective story form. The outputs include a qualitative assessment of the risk evident in the nature of the narrative description. The strengths of the risk narrative include the following:

- A description of the risk as complete as possible given the available evidence.
- An account of the available evidence.
- A risk hypothesis that identifies the remaining uncertainty.

The narrative’s weaknesses include the following:

- Incomplete risk hypotheses when uncertainty is great.
- Discouragement of more complete quantitative risk assessments by appearing more complete than they are.

Risk narratives are suitable as a first step risk assessment in many situations. They can provide sufficient information for decision making and this makes them a valuable component of any risk profiling effort. A risk narrative is applicable to any stage of the risk assessment process and to any kind of risk.

2.2 Increase or Decrease Risk

The simplest way to assess the effect of any change in conditions on an identified risk is to consider the available evidence and judge whether the risk has increased, decreased or remained unchanged. It is helpful to use the "risk = probability x consequence" definition and to consider each parameter separately. For some simple decision problems, it may be enough to know if things are getting more or less risky. Being able to say the risk has increased or decreased and to present the evidence or rationale for why may be the simplest form of a qualitative risk assessment.

Has the risk increased or decreased?

- What has the storm done to the dunes along the coast?
- How was lock operation affected after the towboat hit the lock gates?
- How has the root network affected the levee's slope stability?

Figure 3. Increasing or decreasing risk?

This is not a technique to be used to evaluate changes in risk conditions or to identify risks. The inputs required include an identified risk, a clearly identified change in conditions that could affect the risk and a judgment about the effect of each changed condition and the evidence upon which that judgment is based.

Organize the supporting evidence and document the most significant uncertainty. Assess the effects of each change in conditions and then consider the overall effects of all the changes in conditions on the identified risk. If there are reasons and evidence to support the notion that a risk is more likely to occur and the consequences may be more severe, it is easy to conclude the situation is more risky. It is important to identify the elements of the judgment that are uncertain.

The outputs of this technique include enumerated changes associated with an identified risk, the effects of these changes on the risk, identification of key remaining uncertainties and, when possible, an overall assessment of all changed conditions on the risk. The strengths of this technique include the following:

- It is evidence based.
- It is easy to apply.
- It provides an initial characterization of an identified risk.

Because it is such a simple technique, it has significant limitations as well, including the following:

- The technique is not much good for netting out changes in risk factors.
- Substantial uncertainty usually accompanies this characterization of risks.

When some circumstances tend to increase a risk while others tend to decrease a risk, this technique will have limited value.

When the impacts of events are cumulatively aligned, this simple technique can be a useful tool. The evidence and rationale once again become the support for this judgment. Simply identifying the direction of change in a risk and the specific reasons for that change can be a positive step forward.

This method is useful for assessing changes in risk in the immediate aftermath of a change while uncertainty is greatest. It provides analysts with an opportunity to identify relevant risks and the likely changes in those risks while highlighting the critical uncertainties. For example, if a tow boat has hit the gates of a lock, there are several risks that are immediately obvious. They include such things as loss of pool, interruption of navigation traffic and costly gate repairs. It may be possible to assess each of these situations based on what was observed during the incident. Identifying critical uncertainties like conditions beneath the low water line help to identify the most fruitful first steps to further reduce uncertainty.

2.3 EVIDENCE MAPPING

Evidence maps are a tool for summarizing the scientific data about a potential hazard (Wiedemann et al., 2008). The method has been used primarily in situations when the evidence is unclear on whether or not a hazard actually exists.

For example, is sea level change a hazard for a specific project? Does woody vegetation on levees weaken or strengthen the levee? The notion can be readily extended to opportunity risks. Will channel deepening result in a net increase in cargo? Summarizing scientific evidence is a fundamental purpose of risk assessment.

Evidence maps are useful when the data are incomplete, inconsistent or even contradictory on significant matters of uncertainty. Evidence maps are useful in these situations because they assist with summarizing information that is certain or is uncertain, and then defining why.

The essential elements to an evidence map include the following:

- A well-defined decision problem, usually a potential hazard.
- The evidence basis—the number and quality of relevant scientific, engineering or economic studies.
- A panel of experts to review the evidence.
- The pro and con arguments related to the issue.
- The conclusions about the issue with any remaining uncertainties identified.

Figure 4 below shows a template for an evidence map.

The risk assessment process for the evidence map includes assembling relevant studies related to the issue from the available literature with input from an expert panel. The experts then extract the arguments for a hazard or risk (pro-argument) and the arguments against a hazard or risk (contra-argument). They carefully document evidence that either attenuates or supports these arguments, and then draw some tentative conclusions about the hazard or risk while carefully noting the remaining uncertainties about the issue.

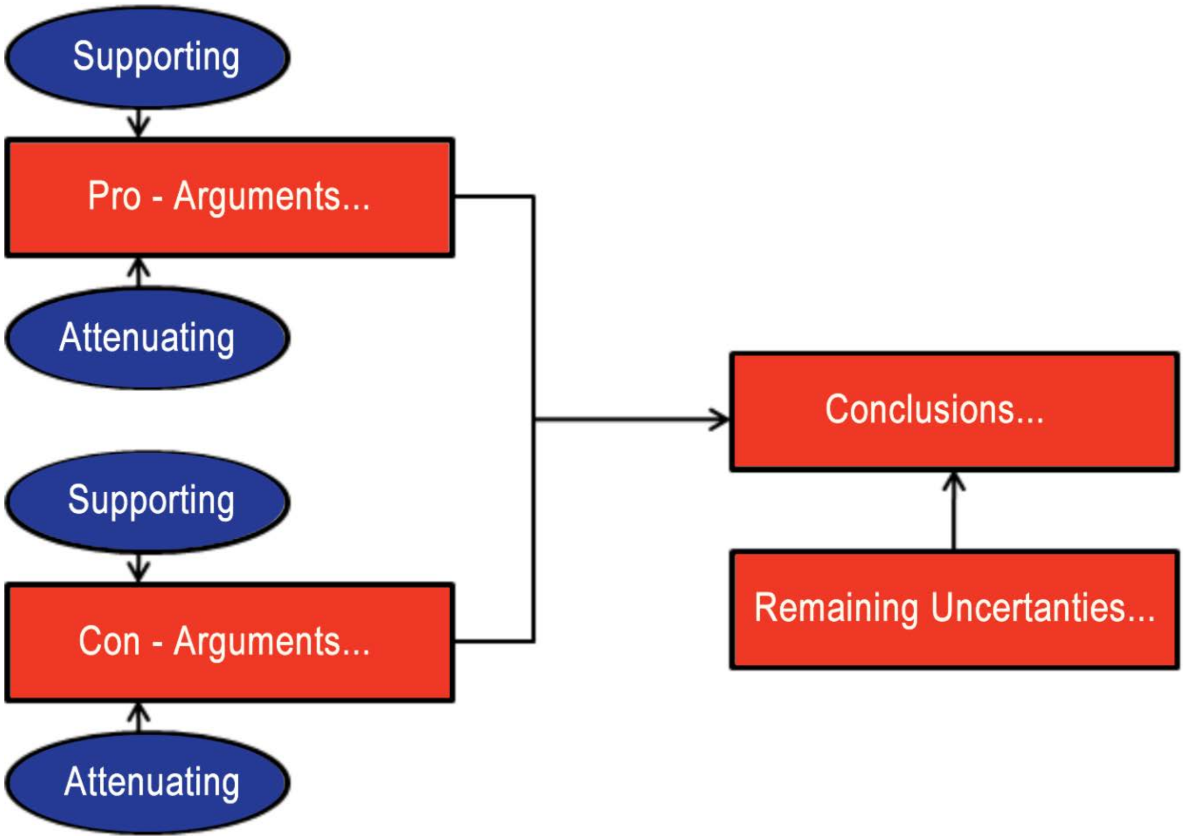

Figure 4. Example evidence map template. Source: Wiedmann, P.M., Schutz, H. & Spangenberg, A. (2008) *Evidence maps – a tool for summarizing and communicating evidence in risk assessment*. Research Centre Julich, Programme Group Humans, Environment, Technology. Julich, Germany. Available online, accessed April 4, 2012: http://www2.fz-juelich.de/inb/inb-mut/publikationen/preprints/evidence%20_maps.pdf. Also available from: http://onlinelibrary.wiley.com/doi/10.1002/9783527622351.ch13/summary

The output of the assessment process is a map of the pro and con arguments along with the remaining uncertainties. The map and its accompanying summary document should summarize what is and is not known about a hazard, risk or other topic being mapped. The strength of this technique is that it summarizes the current state of the scientific evidence and provides an unbiased summary of what is and is not known about the issue. It presents evidence-based arguments for all sides of an issue and notes evidence that either attenuates an argument or supports it. It is well suited to situations where there are contradictory views on an issue. The weakness of the process is that it cannot be applied unless a reasonable evidence base exists.

The method is also described in the following resources:

- Center for Advancing Correctional Excellence, Criminology, Law, & Society, George Mason University. Retrieved January 7, 2013 from: http://www.gmuace.org/tools/evidence-mapping.
- The Global Evidence Mapping (GEM) Initiative. Retrieved January 7, 2013 from: http://www.evidencemap.org/.
- The National Center for Evidence-Based Practice in Communication Disorders. Retrieved January 7, 2013 from: http://www.ncepmaps.org/Evidence-Maps-Background.php.
- Wiedmann, P.M., Schutz, H. & Spangenberg, A. (October 2005). *Risk evaluation of the health effects of mobile phone communication*. Retrieved January 7, 2013 from: http://www.emf-risiko.de/projekte/pdf/risikodialog_eng.pdf.
- Wiedmann, P.M., Schutz, H. & Spangenberg, A. (2008). *Evidence maps – a tool for summarizing and communicating evidence in risk assessment*. Research Centre Julich, Programme Group Humans, Environment, Technology. Julich, Germany. Available online, accessed April 4, 2012: http://www2.fz-juelich.de/inb/inb-mut/publikationen/preprints/evidence%20_maps.pdf. Also available from: http://onlinelibrary.wiley.com/doi/10.1002/9783527622351.ch13/summary.

2.4 Ordering Techniques

Screening, rating and ranking are useful ordering techniques that require increasing levels of detail and information. These techniques are used to identify hazards, risk potential, pathways, mitigation measures and the like that are of interest to decision makers.

Ranking

A ranking process, similar to a rating process, assigns a scale position of one thing relative to other things, and therefore does have an ordinal logic. The inputs for a ranking system are the same as those for screening or ratings, but it can also add the element of weighting the importance of various criteria.

Some resources for ordering techniques include the following:

- Arsham, H. (n.d.). *Tools for decision analysis: Analysis of risky decisions*. University of Baltimore. Retrieved January 4, 2013 from:
- http://home.ubalt.edu/ntsbarsh/opre640a/partix.htm#rintrodecisionanaly.
- National Regulatory Commission. (2003). Formal methods of decision analysis applied to prioritization of research and other topics. NUREG/CR-6833. Retrieved January 4, 2013 from: http://pbadupws.nrc.gov/docs/ML0330/ML033000339.pdf.
- U.S. Army Corps of Engineers. (n.d.) *Collaborative planning toolkit: Tools and techniques for collaborative planning (*see Tools at-a-glance link*).* Retrieved December 21, 2012 from http://www.sharedvisionplanning.us/CPToolkit/Content.asp?ID=3.1.

Ratings

This is a systematic process of separating elements into multiple categories of varying degrees of interest. Items with like ratings are gathered into like groups where the groups usually, but not always, have an ordinal logic to them. Individual items may be rated high, medium, low or no risk, for example.

The National Dam Safety Program's Dam Safety Action Classes (DSAC) (http://www.usace.army.mil/Missions/CivilWorks/DamSafetyProgram/ProgramActivities.aspx) I to V provide an example of a rating system. Ratings can be used for a wide variety of risk elements. For example, hazards may be rated high, medium or low. Probabilities of risks may be rated from rare to common. Consequences could range from negligible to catastrophic.

USACE Dam Safety Action Classification Table				
Dam Safety Action Class		**Characteristics of dams in this class**	**Actions for dams in this class**	
I **URGENT AND COMPELLING** (Unsafe)		**ACTIVE FAILURE** Progressive failure is confirmed to be taking place under normal load. Almost certain to fail under normal load within a few years without immediate action. **AND/OR EXTREMELY HIGH RISK** Combination of life or economic consequences with probability of failure is extremely high.	Validate classification through an external peer review. Take immediate action to avoid failure. Implement interim risk reduction measures, including operational restrictions, and ensure that emergency action plan is current and functionally tested. Expedite investigations, design and construction using all resources and funding necessary. Initiate intensive management and situation reports.	EMERGENCY – dam failure is imminent or has occurred – initiate emergency action plan
II **URGENT** (Unsafe)		**FAILURE INITIATION LIKELY** Dam is expected to fail or an active failure is expected to be initiated as the result of an event (e.g. flood or earthquake) that is reasonably expected to occur prior to remediation although dam safety issues may require confirmation. **AND/OR VERY HIGH RISK** For confirmed and unconfirmed dam safety issues, the combination of life or economic consequences with probability of failure is very high.	Implement interim risk reduction measures, including operational restrictions as justified, and ensure that emergency action plan is current and tested. Expedite investigations to confirm classification. Give very high priority to design and construction funding.	
III **HIGH PRIORITY** (Conditionally Unsafe)		**SIGNIFICANTLY INADEQUATE WITH MODERATE TO HIGH RISK** For confirmed and unconfirmed dam safety issues, the combination of life or economic consequences with probability of failure is moderate to high.	Consider interim risk reduction measures, including operational restrictions as justified, and ensure that emergency action plan is current for initiating event. Conduct heightened monitoring and evaluation. Prioritize for investigations, design and construction funding considering consequences and other factors.	
IV **PRIORITY** (Conditionally Safe)		**INADEQUATE WITH LOW RISK** For confirmed and unconfirmed dam safety issues, the combination of life or economic consequences with probability of failure is low but not tolerable.	Conduct elevated monitoring and evaluation. Give normal priority to investigations to validate classification, but no plan for risk reduction measures at this time.	
V **NORMAL** (Safe)		**ADEQUATELY SAFE** Dam is considered safe, meeting all essential USACE guidelines with no unconfirmed dam safety issues. **AND RESIDUAL RISK IS CONSIDERED TOLERABLE.**	Continue routine dam safety activities, normal operation and maintenance.	

Figure 5. USACE Dam Safety Action Classification Table

The inputs for a rating system are essentially the same as those for a screening system, these include the following:

- Items to be rated.
- Carefully defined rating categories.
- Evidence-based criteria to use for rating.
- Evidence.
- A synthesis algorithm (a defined method) for rating the items.

The process is to compile the list of elements to be rated, and then carefully define the rating categories. This means more than simply saying items will be rated high, medium or low. It means objectively defining the criteria for rating an item high, medium or low. This, of course, requires analysts to identify the evidence-based criteria that will be used in the rating. If the rating of high, medium or low cannot be determined on the basis of objective evidence, then the rating system will be of limited utility in risk assessment.

The output is a rating for each item in the list of things to be rated. The strengths of this process are that it is flexible, evidence-based and reproducible, and that it provides a finer degree of discernment than simple screening. Its greatest weakness is that the process is sometimes abused and the ratings are assigned subjectively without tying the rating explicitly to any objective evidence.

Screening

Screening, or sorting, is the process of separating elements into one or more categories of interest through a systematic evidence-based process. For example, screening criteria can be chosen to either screen items onto the short list of interest (allowing new components *in*) or to screen items off of the long list (by weeding undesirable criteria *out*). Screening can be used to identify hazards of potential concern or of no concern. For example, screening techniques can be used to say which concrete monoliths, rumble mound jetties or tainter gates are of potential concern. Another example is that USACE operations and maintenance (O&M) projects can be screened for funding this year, next year or not at all. Screening is a tool to use to create *groups of things;* it is not the tool to use to find the best item among or within the *groupings*.

Inputs for screening include the following:

- Items to be screened.
- Carefully defined categories (or groupings) into which they are to be separated.
- Evidence-based criteria to use for separating items into categories.
- Evidence.
- A synthesis algorithm (a defined method) for using the criteria and your measurements to separate a long list of items into discrete and separate categories of items.

Given a list of items to be screened and the chosen categories, measurements of the screening criteria are obtained for each item to be screened. If there is more than one criterion, an algorithm for considering the evidence and sorting the items is needed.

There are several common procedures for separating items into categories, including the following:

- A **domination** procedure requires an item to be better or worse on all criteria than all other items. This could be used to separate the best or worst from the rest of a population of items.
- A **conjunctive** procedure requires item to meet all predetermined criteria thresholds for inclusion in a category.
- A **disjunctive** procedure requires an item to meet at least one criterion threshold.

- Elimination by aspects begins by identifying the most important criterion from a set of criteria.
  - A cut-off value is set for it and all items that do not meet the cut-off value are eliminated or screened out. Then the next most important criterion is identified, a cut off is set for it and all items that do not meet it are eliminated. This process continues until the desired subsets of screened-in items are identified.

The output of a screening process is a list of elements that has been successfully sorted into the mutually exclusive and collectively exhaustive categories of interest. The advantages of this technique are its simplicity, its reliance on evidence and its ease of documentation. The principle limitation is that items in the piles cannot be differentiated from one another; only the grouping of items is differentiated.

EXPLORE: Enhanced Criteria-Based Ranking

The following is a specific example of a ranking technique that is referred to as an *enhanced criteria-based ranking*. The basic ranking concept is enhanced by including evidence-based criteria and an enhanced evaluation structure. There are eight steps in the example ranking process including the following:

1. Criteria
2. Rating
3. All possible combinations of ratings
4. Ranking
5. Evaluate reasonableness of ranking
6. Add criteria
7. New combinations of ratings
8. New ranking

Problem/Opportunity Statement

Any good risk assessment must begin with a question or questions that define the management problem or opportunity. For this hypothetical example, the question pertains to the USACE navigation business line:

Which lock gates within the USACE Division present the greatest potential risk to health and safety and therefore should be repaired first?

The following descriptions address each of the eight steps of the enhanced criteria-based ranking technique risk assessment to respond to the question above.

Step One: Criteria

The first step in this technique is to identify the criteria that reflect the most important aspect of the risk. For simplicity in this example, it is assumed that all criteria are equally important (although they do not have to be when you are using this technique). Given the *risk = probability x consequence* definition, the criteria should reflect both the risk and the consequence of the risk. For this example, three criteria are identified, including the following:

1. Age of the lock.
2. Frequency of its use.
3. Consequence of failure.

The first two criteria relate to the probability of the risk and last one relates to the consequence.

Gates
Criteria #1: Age H = Twenty and above years of age. M = Ten to twenty years of age. L = Zero to ten years of age.
Criteria #2: Frequency of Use. H = Daily use - approximately 365 times a year. M = Greater than one and less than 365 times a year. L = Annual use - once a year.
Criteria #3: Consequence of Failure. H = Loss of life and/or property. M = Structure damage. L = Minimal loss of property and/or damage.

Figure 6. STEP ONE: Criteria

In addition to the criteria, three scenarios are defined for each of them. In this example, the three scenarios include the following:

- A high risk potential (H).
- A medium risk potential (M).
- A low risk potential (L).

For example, with age, if a lock is 20 years older or above, that would be high risk potential for lock gate failure. If it is 10 years up to 20 years of age, that is a medium risk potential. If the lock is less than 10 years old, that would be considered a low risk potential for failure of the lock gate.

For the frequency of use criteria, if a lock is used daily, that is a high risk potential for failure. If the lock is used once per year or less, that would be a low risk potential, and if it is in-between those two extremes, that would be medium risk.

And finally, if a consequence of failure of a lock gate is the potential loss of life and/or property, this would be considered a high risk consequence. If there is just the possibility of structure damage (no life loss), this would be considered a medium consequence. If there is the possibility of a just minimal loss of property and/or damage, that would be considered a low consequence.

Ordinarily not more than three or four such evidence-based criteria would be used. If more criteria were necessary, this might indicate that a more sophisticated quantitative process may be necessary.

Step Two: Rating

Step Two involves rating the lock gates within the Division using the scenarios for the three criteria. If possible, evidence should be collected to complete the ratings. However, when there is some uncertainty, expert judgment might be necessary to evaluate the ratings (see the expert elicitation process).

In this example, it is supposed that the locks are the potential hazard and that something could go wrong to cause them to fail. For the rating, letters are used instead of numbers because there is not an absolute measurement of the risks, only a relative means for comparison. So although a three, two, one scheme might work just as well, using letters has the advantage of not implying a higher level of accuracy than exists.

Table 2. STEP TWO: Rating

Gate	**Criteria 1**	**Criteria 2**	**Criteria 3**
Knightsbridge	H	L	M
Steadly	H	M	M
Redwood	M	H	L
Jackflash	M	H	L
Cantget	L	L	L
Roughjustice	H	M	L
IORR	L	M	H
19	L	H	L

Step Three: All Possible Combinations

Step Three is to identify all the possible combinations of ratings. With three criteria and three scenarios for each of the criteria, the lock with greatest potential risk would be one that has a rating of HHH (i.e., it gets a high risk potential for each of the three criteria). The least risky lock rating would be a rating of LLL, a low risk potential for each of the criteria.

Table 3. STEP THREE: All Possible Combinations

Risk Level	**Combination of Ratings (assuming equally weighted criteria)**
Greatest Risk	HHH
	HHM, HMH, MHH
	HHL, HLH, LHH, HMM, MMH, MHM
	HLM, MHL, HML, LMH, MLH, MMM, LHM
	HLL, LHL, LLH, MML, LMM, MLM
	MLL, LML, LLM
Least Risk	LLL

However, the issue to be addressed is the ratings that fall between the two extremes. In this example, a relatively transparent method is used where essentially a 3 is assigned to the *H*, a 2 to the *M*, and a 1 to the *L,* and then simply add the number values. So given this method, the second highest risk grouping would be two *H*'s and an *M* (*HHM*) (because in this example, there are equal weights given for each criteria).

Given the equally weighted criteria and the numeric assignments to the ratings, the row for the greatest risk, the rating of *HHH* would be equal to a nine, the next row would be eight, then seven, six, five, and so on. So in this particular example, all possible ratings are combined into similar rating groups.

If different weights were assigned to the criteria, this would result in a different list of all possible combinations. This is discussed in the learning module about quantitative analysis in the section about multi-criteria decision analysis.

Step Four: Rank Subjectively

Step Four is to rank the criteria subjectively. In the table of ratings, there are subjective lines with the greatest risk as the top category, putting the least risk as the lowest category. In this particular example, there is very little difference between gate number ***19*** and gate ***Roughjustice***; in fact, the HML ranking is done arbitrarily. However, there is no basis for discriminating further and the middle group is ranked as a moderate risk. So, this step establishes a rank according to a descending relative risk and by identifying subjective clusters of risk.

Table 4. STEP FOUR: Rank Subjectively

Gate	Rating	Ranking
Steadly	HMM	Greatest Risk
Roughjustice	HML	
Jackflash	MHL	
Knightsbridge	HLM	Moderate Risk
Redwood	MHL	
IORR	LMH	
19	LHL	
Cantget	LLL	Least Risk

Step Five: Assess Reasonableness of Ranking

Step Five is essentially a reality check on the qualitative technique. If the rankings do not make logical sense, then the issue and the chosen criteria should be reconsidered.

Step Six: Add Criteria

One option, Step Six, is to identify additional criteria with evidence for consideration.

If there was a belief that rankings seem unreasonable from field expectations, another criteria for the example that could be considered is the cost of emergency repair. With this criterion, the three rankings include the following:

- A high risk potential (H), major disruptions to navigation or power, much higher costs to repair.
- A medium risk potential (M), much higher costs to repair, without major disruptions.
- A low risk potential (L), same a schedules repair cost and disruption.

Step Seven: New Ratings

With the additional criterion, evidence for the criteria would need to be collected and rated, and the combined ranking revised.

Table 5. STEP 7: New Ratings

Gate	Criteria #4 Rating	New Combined Ranking
Steadly	H	HMMH
Jackflash	H	MHLH
Knightsbridge	H	HLMH
Redwood	M	MHLM
IORR	M	LMHM
19	H	LHLH
Roughjustice	L	HMLL
Cantget	H	LLLH

Step Eight: New Ranking

Continuing with the assumption that all four of the criteria are equally important and have equal weights, the ranking becomes fairly simplistic. The new list of all possible combinations would be led by four H’s, which is equal to a 12, and the lowest risk would be four L’s, which is equal to a four. As shown in Table 6 below, the result in the example is groupings of 12, 11, 10, nine, and so on, all the way down to four.

In this example, there are two sets of lock gates that have moved up into the greatest risk category, but the line where the greatest risk, the moderate risk, and the lowest risk is entirely subjective. In this case, the justification is going to depend on the criteria used and the evidence gathered.

This example demonstrated a qualitative tool to determine the three locks with the set of gates with the highest risk potential as defined in the initial question and the defined criteria. At this point, a more detailed risk assessment of the highest risk locks may be warranted. That additional analysis could be a more refined, detailed, and analytical qualitative risk assessment. Alternatively, depending on the risks and consequences, a quantitative risk assessment for those three locks could be considered.

Table 6. STEP 8: New Ranking

Gate	New Combined Ranking	Criteria #4 Rating
Steadly	HMMH	Greatest Risk
Jackflash	MHLH	Greatest Risk
Knightsbridge	HLMH	Greatest Risk
Redwood	MHLM	Moderate Risk
IORR	LMHM	Moderate Risk
19	LHLH	Moderate Risk
Roughjustice	HMLL	Moderate Risk
Cantget	LLLH	Least Risk

2.5 The Risk Matrix

The risk matrix, sometimes known as operational risk management (ORM), is another qualitative technique based on the *risk = probability x consequence* definition. The probability dimension of a risk forms one dimension of the matrix and is broken into qualitative segments or categories. Although the segments could be defined quantitatively, they are usually not. Categories like improbable, remote, occasional, probable and frequent are used, and they are usually defined in a narrative manner.[6] Likewise, the continuum of consequences is broken into a number of qualitative categories such negligible, marginal, critical and catastrophic.[7] These categories comprise the other dimension of the matrix. A sample is shown below.

Consequences	**Probabilities**				
	Improbable	**Remote**	**Occasional**	**Probable**	**Frequent**
None					
Negligible					
Marginal					
Critical					
Catastrophic					

Figure 7. Example risk matrix

When the probability and consequence categories are given evidence-based definitions, it is possible to examine the evidence and assess the risk. For example, the risk of levee failure can be assessed for a list of non-federal levees. Each levee would be slotted into a cell in a matrix like the one above based on the definitions of the probability and consequence categories, and the available evidence.

The risk matrix technique requires a well-defined risk to be assessed. Specifically, the question to answer must be clearly specified. Also, the following is needed to summarize the technique:

- A list of items to assess.
- Carefully constructed evidence-based definitions of a limited number of probability categories.
- Carefully constructed evidence-based definitions of a limited number of consequence categories.
- Evidence for categorizing each item by its probability and consequence.

The process is critical to the value of this technique. Carefully defining a set of mutually exclusive and collectively exhaustive evidence-based probability and consequence categories is the most critical aspect of the process. Then, gathering evidence to support the rating for the probability and consequence of each potential risk becomes the basis for this evidence-based assessment technique. The output of this process is a list of potential risk items, each of which has a probability and consequence rating that has been documented on the basis of the available evidence.

Consider that every item on the list of risks to be assessed will have been placed in one of the cells in the risk matrix. Usually the cells are grouped into subjective ordinal clusters of cells like red, yellow or green. Red typically indicates cells with an acceptable risk, yellow identifies cells to be carefully monitored, and green cells indicate items of no immediate concern. The strength of this technique is that it systematically addresses both the consequence of a potential risk and its probability of occurring based on the available evidence. The technique is easy to explain and understand.

The weakness of the risk matrix is that it is one of the most easily abused risk assessment tools (see Cox, 2008). Ratings of consequence are often assigned arbitrarily and without direct regard for the available evidence. Consider a hypothetical case where the risk matrix is used to establish budget priorities. If items with frequent and catastrophic consequences are the items that are most likely to be funded, the winning strategy may be to assign the highest possible rating to each potential budget item rather than to objectively assess the evidence. This destroys the value of the technique and the integrity of the decision making process resulting from it; it can also produce faulty analysis along the way.

Risk matrices have many different applications in addition to the one above. The Risk Institute (http://www.riskinstitute.org/peri/images/file/RiskIdentification_and_Analysis_62006.pdf) offers guidance on creating a risk matrix and provides an example (see slides 17-19 of the pdf file).

Another example of a risk matrix is from the Department of Treasury (http://www.treasury.gov/resource-center/terrorist-illicit-finance/Documents/charity_risk_matrix.pdf) for risk factors for charities disbursing funds or resources to grantees.

Additional information about risk matrices can be found in the following sources:

- Cox, L. (2008). *What's wrong with risk matrixes?* Risk Analysis (28, 2) pp 497-521.
- RuleWorks. (n.d.). The *risk management guide: information resources—risk profit matrix*. Retrieved January 7, 2013 from: http://www.ruleworks.co.uk/riskguide/risk-profile.htm.

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[6] U.S. Department of Defense. (February 2000). *Standard practice for system safety*. MIL-STD-882D. Retrieved January 14, 2013 from: https://acc.dau.mil/CommunityBrowser.aspx?id=255833.

[7] Ibid.

EXPLORE: DEVELOPING CONSEQUENCE CATEGORIES

Here is an example of the consequence categories developed for the Department of Defense, Standard Practice for System Safety.[8] Figure 7 illustrates mishap severity categories for managing a military installation. The range of categories for consequences goes from catastrophic to negligible with narrative definitions of each category.

TABLE A-I. **Suggested mishap severity categories.**

Description	Category	Environmental, Safety, and Health Result Criteria
Catastrophic	I	Could result in death, permanent total disability, loss exceeding $1M, or irreversible severe environmental damage that violates law or regulation.
Critical	II	Could result in permanent partial disability, injuries or occupational illness that may result in hospitalization of at least three personnel, loss exceeding $200K but less than $1M, or reversible environmental damage causing a violation of law or regulation.
Marginal	III	Could result in injury or occupational illness resulting in one or more lost work days(s), loss exceeding $10K but less than $200K, or mitigatible environmental damage without violation of law or regulation where restoration activities can be accomplished.
Negligible	IV	Could result in injury or illness not resulting in a lost work day, loss exceeding $2K but less than $10K, or minimal environmental damage not violating law or regulation.

Figure 7. Suggested mishap severity categories. Source: U.S. Department of Defense. (February 2000). *Standard practice for system safety*. MIL-STD-882D. Retrieved January 14, 2013 from: https://acc.dau.mil/CommunityBrowser.aspx?id=255833.

In a similar fashion, probability levels or categories are then defined. They range from frequent to improbable, and have been defined for both an individual item as well as for a fleet or inventory. For example, a frequent probability for an inventory or fleet of vehicles is something that is continuously experienced. An improbable probability is something that is unlikely to occur, but is still possible. However, for a single, individual item, the “frequent” description becomes redefined as noted here as likely to occur often in the life of an item with a probability of occurrence greater than 10^{-1} in that lifetime. An improbable event is something that has a probability of occurring less than one in a million in that lifetime. What is important and what is critical to the success of a risk matrix is that the categories are defined in a way that enables the collection of evidence.

TABLE A-II. **Suggested mishap probability levels.**

Description*	Level	Specific Individual Item	Fleet or Inventory**
Frequent	A	Likely to occur often in the life of an item, with a probability of occurrence greater than 10^{-1} in that life.	Continuously experienced.
Probable	B	Will occur several times in the life of an item, with a probability of occurrence less than 10^{-1} but greater than 10^{-2} in that life.	Will occur frequently.
Occasional	C	Likely to occur some time in the life of an item, with a probability of occurrence less than 10^{-2} but greater than 10^{-3} in that life.	Will occur several times.
Remote	D	Unlikely but possible to occur in the life of an item, with a probability of occurrence less than 10^{-3} but greater than 10^{-6} in that life.	Unlikely, but can reasonably be expected to occur.
Improbable	E	So unlikely, it can be assumed occurrence may not be experienced, with a probability of occurrence less than 10^{-6} in that life.	Unlikely to occur, but possible.

Figure 8. Suggested mishap probability levels. Source: U.S. Department of Defense. (February 2000). *Standard practice for system safety*. MIL-STD-882D. Retrieved January 14, 2013 from: https://acc.dau.mil/CommunityBrowser.aspx?id=255833.

Continuing with managing a military installation, Figure Ex-3 below is an example of a matrix used to assess risk. Notice that the rows are identified by the probability categories and the columns are identified by the consequence categories. It is easy to identify the greatest risk potential: an event that is frequent and catastrophic. The least risky is an event that is negligible and improbable. So assigning a *one* as the most risky is an easy decision, as is assigning a 20 to the least risky. The problem with this matrix and many others is the determination of the second riskiest item. Notice that this matrix has 20 different cells and they are ranked from the most risky to the least risky. However, is something that is probable and catastrophic identified as the second riskiest item? Is that indeed a greater risk than something with frequent critical consequences? The problem with operational risk management matrices when practiced is that numbers cannot just arbitrarily be assigned.

TABLE A-III. **Example mishap risk assessment values.**

SEVERITY PROBABILITY	Catastrophic	Critical	Marginal	Negligible
Frequent	1	3	7	13
Probable	2	5	9	16
Occasional	4	6	11	18
Remote	8	10	14	19
Improbable	12	15	17	20

Figure 9. Example mishap risk assessment values. Source: U.S. Department of Defense. (February 2000). *Standard practice for system safety*. MIL-STD-882D. Retrieved January 14, 2013 from: https://acc.dau.mil/CommunityBrowser.aspx?id=255833.

In completing this example, the following is a description of how the Defense Department document uses that information. The 20 risk matrix cell values ranked one to 20 are summarized Figure Ex-4 in a table that identifies who is responsible for making decisions at that level of risk. Any mishap risk with a value between one and five is considered in the high risk category, and only a high level authority (e.g., the Component Acquisition Executive) can make those risk management decisions. Events with a rating from six to nine are serious and the Program Executive Officer is authorized to make those decisions, and so on. Mishap risks of 18, 19 or 20 are low risk and those decisions can be made by anyone as directed by the standard operating procedures.

TABLE A-IV. **Example mishap risk categories and mishap risk acceptance levels.**

Mishap Risk Assessment Value	Mishap Risk Category	Mishap Risk Acceptance Level
1 – 5	High	Component Acquisition Executive
6 – 9	Serious	Program Executive Officer
10 – 17	Medium	Program Manager
18 – 20	Low	As directed

Figure 10. Example mishap risk categories and mishap risk acceptance levels. Source: U.S. Department of Defense. (February 2000). *Standard practice for system safety*. MIL-STD-882D. Retrieved January 14, 2013 From: https://acc.dau.mil/CommunityBrowser.aspx?id=255833.

The Defense Department example is a rather unique one. The more common use of a risk matrix is to define the probability categories, define the consequence categories, and then to group them.

[8] Ibid.

2.6 A Generic Process

A generic process can be used for any risk. It begins with the familiar conceptual model of *risk = probability x consequence*. There is no risk without one or more consequences, and some series of events is required for an undesirable consequence to occur. A generic process simply identifies the sequence of events necessary for the undesirable or desirable consequence(s) to occur, and assesses the likelihood of each of the necessary events as well as the consequence should they all occur.

The strengths of the generic process include that it is comprehensive and can be applied to a wide variety of situations. Almost any risk can be decomposed into a reasonable number of probability and consequence elements. It is logically sound when the key elements are identified and the process is supported by evidence. The technique is practical in that it can be performed with varying levels of resources and degrees of uncertainty. The method is conducive to learning. Repeated applications of a generic model inevitably result in a better understanding of the problems and their potential solutions. The model is easily documented and, therefore, conducive to evaluation.

However, its greatest weakness stems from its strength. Once developed, there may be a tendency to rely on this qualitative method when a quantitative assessment is warranted.

EXPLORE: Consideration of Effects of Aquatic Nuisance Species Being Introduced to New Waterways (GLMRIS)

This example is based upon a USACE authorized study to consider the effects of aquatic nuisance species being introduced to new waterways, an example based on the Great Lakes Mississippi River Inter-Basin Study (http://glmris.anl.gov/) (GLMRIS).

There are two areas of focus. The first is on the Chicago Area Waterway System. Each number on the map indicates a potential pathway for non-indigenous aquatic species to move from the Mississippi River basin into the Great Lakes. The second focus area is the very long divide between the Mississippi River basin and the Great Lakes Basin where, again, each number shows the pathways of greatest potential concern. This is an existing issue for USACE and the region. It is an issue that is likely to occur in other parts of the country as well.

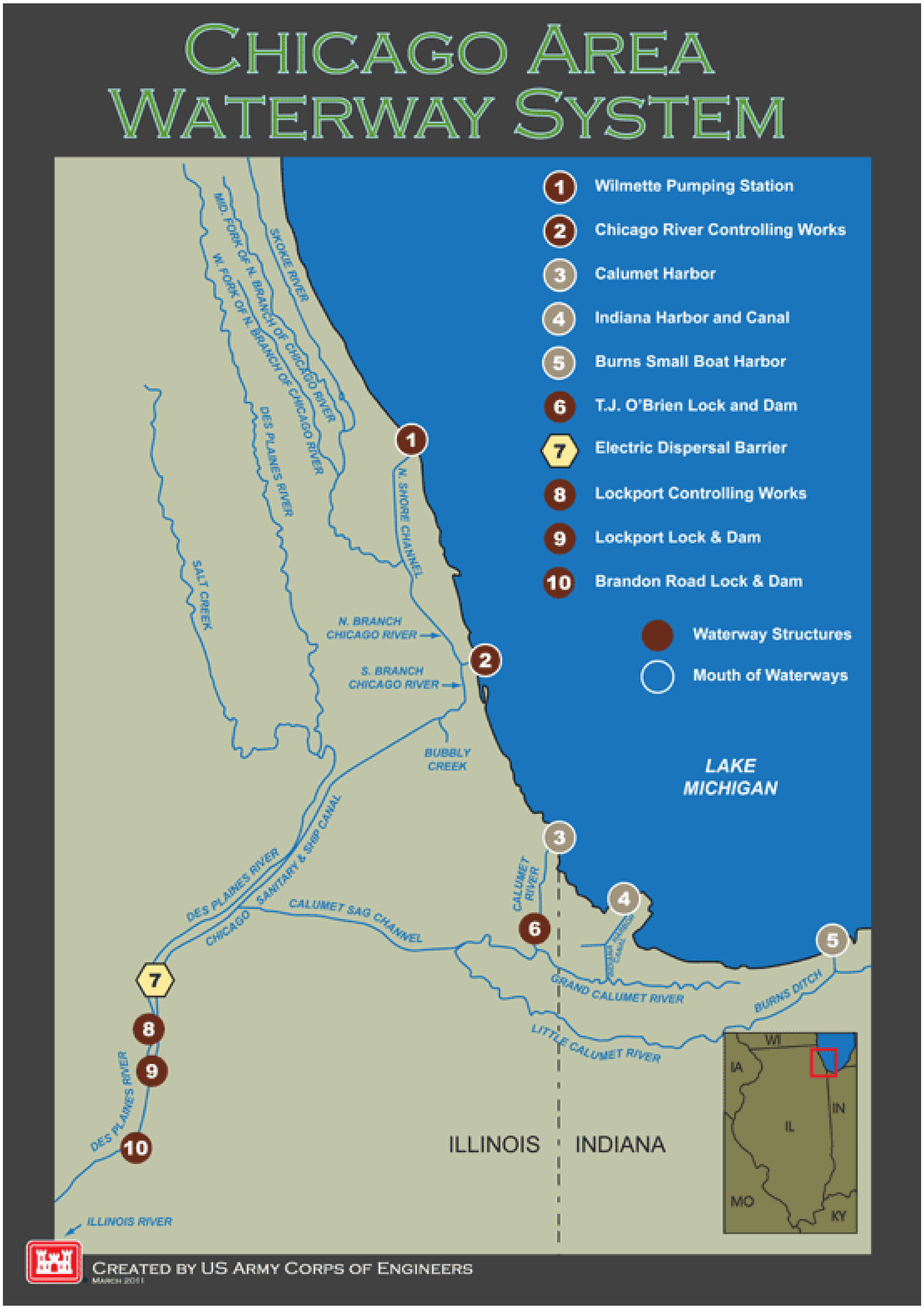

Figure 11. Chicago Area Water System

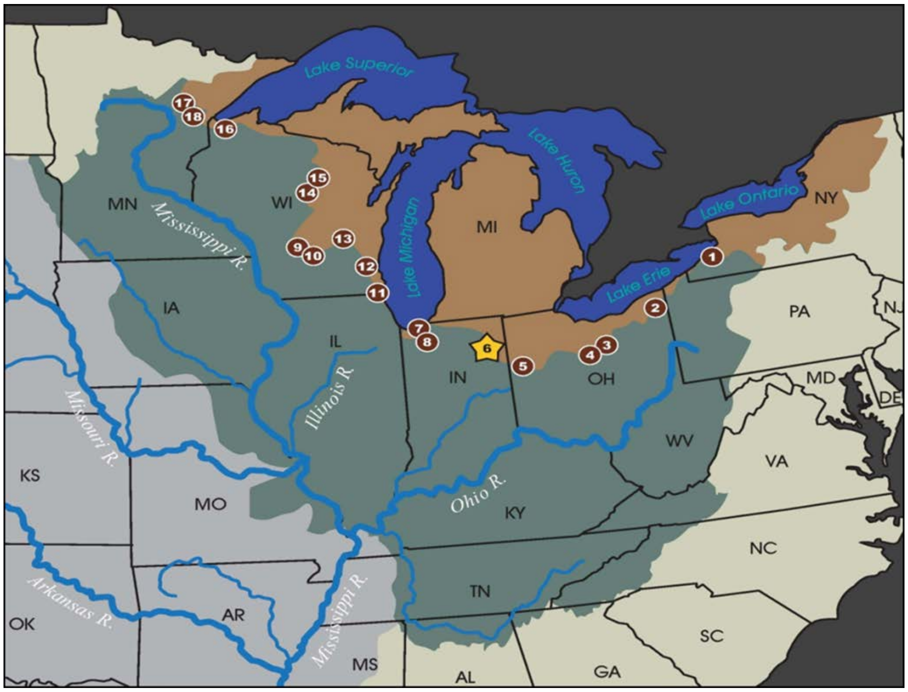

Figure 12. Great Lakes Mississippi River Inter-Basin Study (GLMRIS)

Problem/Opportunity Statement

As previously described, all risk assessments need a clearly focused question to answer. In this example, the question is the following:

> **What is the risk that an aquatic nuisance species (ANS) can spread into a new waterway and cause harm?**

Harm (i.e., the consequence) is a very important part of this question.

A generic process works with the two elements of risk probability and consequence. This example also addresses the idea of a risk hypothesis. A risk hypothesis requires the construct of a conceptual model that describes how aquatic nuisance species may cause harm. In other words, the necessary conditions for harm to occur will be investigated. That means the sequence of a chain of events will be identified. It is recognized that this chain of events may differ from one pathway to another.

The risk hypothesis should be developed in small steps. The risk of aquatic nuisance species spread to new waterways is defined as the following:

Probability of the spread to new waterway x consequence of spread to new waterway

The probability of the spread of an aquatic nuisance species (ANS) to a new waterway also needs to be addressed. This is the risk hypothesis, the conceptual model that identifies the probability (P) and sequence of necessary events:

Probability of the spread to new waterway =

$P_{athway\ exists} \times P_{ANS\ access\ to\ pathway} \times P_{ANS\ transits\ pathway} \times P_{ANS\ colonizes\ in\ new\ waterway} \times P_{ANS\ spreads\ in\ new\ waterway}$

First, a pathway has to exist. Then, the aquatic nuisance species has to have access to the pathway; it has to be close enough and be able to get into that pathway. Then the aquatic nuisance species must successfully transit through the pathway, overcoming any obstacles there. The fourth event in the sequence that needs to occur is when the aquatic nuisance species reaches the new waterway, the species has to reach high enough numbers and find the life requisites in sufficient abundance to be able to colonize and establish a breeding colony in the new waterway. Even that event is not enough yet for harm to occur because the aquatic nuisance species must spread throughout the new waterway.

So, in essence, there are five events that are necessary for harm to occur and they are outlined by the risk hypothesis as shown in the conceptual model. The model expresses these events as probabilities, so the probability that the pathway exists multiplied by the probability that the aquatic nuisance species has access to the pathway. These are expressed in a multiplicative way because if any one of those elements is a zero, then the probability of spread to a new waterway is a zero. If any of those element probabilities are very low, then the probability is low, leading to the overall probability being low.

These probabilities are then compared to the consequences of spread:

Consequence of spread to new waterway = Economics + Environmental + Political + Other

The consequences would be economic, environmental and political, as well as other variables. The consequences are expressed as additive, because if any one of them is zero, that does not preclude one of the other consequences from being a non-zero element.

This is a generic process where the essential elements of the probability and the consequence are defined and calculated in such a manner that represents the math of the situation with the probability being multiplicative and the consequences being additive. This conceptual model expresses the risk hypothesis.

Table 7. Risk hypotheses for aquatic nuisance species (ANS)

Conceptual Model Scenario	Risk Hypothesis
A viable pathway exists.	A viable pathway does not exist.
ANS can access the pathway.	ANS cannot access the pathway.
ANS survives transit through pathway.	ANS does not survive transit through pathway.
ANS colonizes in new location.	ANS does not colonize in new location.
ANS spreads from colony.	ANS does not spread from colony.
ANS cause harm.	ANS does not cause harm.

The Conceptual Model Scenario can be expressed differently from the Risk Hypothesis. Table 7 illustrates this as it shows the conceptual model scenarios down the left column. The right column shows the related risk hypotheses.

The task of the risk assessment is to find evidence to disprove the risk hypothesis. Take, for example, the hypothesis that a "viable pathway does not exist." If one can point to the Chicago Area Waterway System map and show clearly how one point on the Mississippi river leads to the Great Lakes, this is strong enough data to disprove the hypothesis that a viable pathway does not exist. If evidence cannot be found that disproves it, then the hypothesis has been corroborated. Again, because the probabilities are multiplicative, it is only necessary to disprove any one of the risk hypotheses in order to argue that there is establishment of the aquatic nuisance species.

Table 8 below is a mockup of a template that would be used to evaluate the risk of a given aquatic nuisance species (e.g., Asian carp) spreading into a specific pathway (e.g., the Chicago Area Waterway). On the left are the probability elements. Each one of these elements would be rated high, medium, low or none. Each one of these elements (e.g., the pathway exists) would have an uncertainty rating that accompanies its element. So, if it is stated that there is a high probability that a pathway exists and there is no uncertainty that would be an example that can be pointed to on a map that a clear, consistent, year-round connection between the two waterways exists. In other areas, the existence of a pathway might be a much lower probability or there could be much greater uncertainty surrounding it. For every element of the conceptual model, there would be a rating and there would be an uncertainty judgment for the rating. That would be true for every probability element and for every consequence element. About halfway down this template mockup is a place for evidence for the ratings. Next to that is an area to define significant remaining uncertainties.

The key to executing a qualitative risk assessment in a generic process like this example is the **evidence**. This risk assessment would involve gathering evidence (gathering the facts that point to the existence of the pathway or the lack of existence of a pathway) and entering that evidence into the template form. That evidence would form the basis for the ratings. The assessment begins with the evidence, not with the ratings. Once all of the evidence has been acquired and accumulated, then the rating can be provided. This would be completed for every element of the conceptual model.

Date	Click here to enter a date.		***Assessment Leader***	Click here to enter text.	
Pathway	Click here to enter text.		***ANS***	Click here to enter text.	
Probability element	***Likelihood Element rating***	***Uncertainty rating***	***Consequence element***	***Element rating***	***Uncertainty rating***
P(pathway exists)	Choose an item.	Choose an item.	*Economic consequences*	Choose an item.	Choose an item.
P(access to pathway)	Choose an item.	Choose an item.	*Environmental consequences*	Choose an item.	Choose an item.
P(transits pathway)	Choose an item.	Choose an item.	*Political consequences*	Choose an item.	Choose an item.
P(colonizes)	Choose an item.	Choose an item.	*Social consequences*	Choose an item.	Choose an item.
P(spreads)	Choose an item.	Choose an item.	*Other consequences*	Choose an item.	Choose an item.
P (establishment)	Choose an item.	Choose an item.	*Overall consequences*	Choose an item.	Choose an item.
Overall ANS risk potential			Choose an item.	Choose an item.	
Evidence for Ratings			***Significant Uncertainty***		
P(pathway): Click here to enter text.			Click here to enter text.		
P(access): Click here to enter text.			Click here to enter text.		
P(transits): Click here to enter text.			Click here to enter text.		
P(colonizes): Click here to enter text.			Click here to enter text.		
P(spreads): Click here to enter text.			Click here to enter text.		
Economic consequences: Click here to enter text.			Click here to enter text.		
Environmental consequences: Click here to enter text.			Click here to enter text.		
Political consequences: Click here to enter text.			Click here to enter text.		
Social consequences: Click here to enter text.			Click here to enter text.		
Other consequences: Click here to enter text.			Click here to enter text.		
References					
Click here to enter text.					

Figure 13. Template to evaluate the risk that an aquatic nuisance species can spread into the waterway

The evidence is the key to the success of this generic model or any other. Here are some definitions of likelihood element ratings:

- High

  This event will certainly or almost certainly occur (the risk hypothesis has been rejected convincingly).

- Medium

  This event is more likely to occur than not, but it is not certain (the risk hypothesis has been rejected).

- Low

  This event is more likely not to occur than to occur, but it is not impossible (the risk hypothesis is weakly corroborated).

- No

  This event is impossible and will not occur (the risk hypothesis is strongly corroborated).

Here are some definitions of **uncertainty** ratings for likelihoods:

- High

  There is little to no concrete evidence available.

- Medium

  There is some good evidence and some significant data gaps.

- Low

  Good evidence is available, data gaps are not significant.

- None

  All relevant facts are known.

It might be said that the rating for likelihood has high uncertainty if it was made with little to no concrete evidence. If all the relevant facts are known, then there is no uncertainty attributed to the likelihood.

In a similar fashion, the consequence elements would have to be rated. A high consequence might be defined as being of a magnitude that is clearly unacceptable. No consequence might be that there are no undesirable consequences. The definitions of consequences and of likelihood elements might vary from one generic model to another. Definitions of consequences used in this example include:

- High

  The magnitude of these consequences is clearly unacceptable (the risk hypothesis has been rejected convincingly).

- Medium

  The magnitude of these consequences is tolerable but not yet acceptable (the risk hypothesis has been rejected).

- Low

  The magnitude of these consequences is acceptable (the risk hypothesis is weakly corroborated).

- No

  There are no undesirable consequences (the risk hypothesis is strongly corroborated).

Uncertainty ratings are also provided for the consequence elements. A high uncertainty rating might mean there is little to no concrete evidence available, or it might be cast in a different way. If there is a very broad range of possible outcomes that might include extreme events, then it might be said that these are consequences that have a high uncertainty.

- High

  There is little to no concrete evidence available, or there is very broad range of possible outcomes that include extremes.

- Medium

  There is some good evidence and also significant data gaps, or there is a broad range of outcomes that does not include extreme values.

- Low

Good evidence is available, data gaps are not significant, or there is a limited range of possible outcomes.

There are a number of elements for the probability of harm; in fact there are five shown in Table 8. The question is then how an overall likelihood rating is assigned.

Table 8. Overall Likelihood of a Probability Element

Overall Likelihood of Probability Element					
Exists	**Access**	**Transit**	**Colonize**	**Spread**	**Overall**
M	**L**	**H**	**H**	**L**	**L**
H	**H**	**H**	**L**	**H**	**L**
M	**H**	**H**	**M**	**M**	**M**

In this case, find the lowest of all the likelihood elements; that rating is the overall likelihood for that condition. Here are three examples from the table above:

- In the first rated row, there is an M, an L, two H's, and an L. If all those elements were present, what would the result look like? Keep in mind that these are probabilities and they are numbers between zero and one (i.e., a fraction). If there are five numbers between zero and one and they are multiplied, the resulting number is always going to be smaller than the smallest number of the five. To emulate the math with the qualitative rankings and ratings, one would simply look at this row, find the lowest rated element (in this case it is an L), and that becomes the overall rating. The probability of establishment would be low for that first rated row.
- Looking at the second rated row, there are four high probability elements and one low probability element. If the probability that the species can colonize is low, then the probability that it is going to cause harm is low because it cannot colonize (i.e., it cannot spread). Each element is a conditional "one". For example, high probability of spread that follows the low probability of

colonization in the current example is indeed high. It is saying, "If this species can colonize, if it does colonize, then the probability of spreading is high." However, it is not likely to colonize; so the overall rating is low.

- In the last row, the medium likelihood rating is the lowest. That becomes the overall rating.

Table 9. Overall Consequence

Overall Consequence				
Environmental	**Economic**	**Social**	**Political**	**Overall**
H	**H, M, L, N**	**H, M, L, N**	**H, M, L, N**	**H**
H, M, L, N	**H**	**H, M, L, N**	**H, M, L, N**	**H**
M, L, N	**M, L, N**	**H**	**H**	**H**
M	**M**	**M**	**M**	**H**
L, N	**L, N**	**M**	**M**	**L**
L	**L, N**	**L, N**	**L, N**	**L**
L, N	**L**	**L, N**	**L, N**	**L**
N	**N**	**L**	**L**	**L**
N	**N**	**L**	**N**	**L**
N	**N**	**N**	**L**	**L**
N	**N**	**N**	**N**	**N**

The overall consequence rating is more subjective. Here are two examples from Table 9 above:

- The first row indicates that if the environmental consequence is high, then the economic, social or political consequences do not matter; thus, the overall consequence is also going to be high.
- The second row suggests that if economic consequence is high, the other consequences do not matter; thus, the overall rating will be high for consequences.

The table shows that there are four scenarios that lead to a high consequence; there are six scenarios that lead to a low consequence. There is only one scenario that leads to no consequence; any scenario that is not listed in this table will lead to a medium consequence. However, that is a subjective determination, and one that could certainly be debated.

The following provides a summary of this example:

- The conceptual model has been developed.
- The sequences of events (elements) that lead to harm have been identified.
- The risk hypotheses have been defined.
- Evidence has been gathered.
- Each element has been rated as high, medium, low or none for likelihood of occurrence.
- Uncertainties have been developed around the likelihood of events (probability of the likelihood).
- The consequences of the events have been estimated.
- The probability and consequence of events together identify the risk potential for the aquatic nuisance species and the event that is being evaluated.

If an aquatic nuisance species has a high probability of establishment and a high consequence, then its risk potential is also high. If it has a high probability of establishment and medium consequences, then its risk potential is high. This is illustrated in Table 10 below.

Table 10. Risk Potential

Risk Potential Lookup		
Establishment Probability	**Establishment Consequence**	**Risk Potential**
H	**H**	**H**
H	**M**	**H**
H	**L**	**H**
H	**N**	**H**
M	**H**	**H**
M	**M**	**M**
M	**L**	**M**
M	**N**	**N**
L	**H**	**M**
L	**M**	**M**
L	**L**	**L**
L	**N**	**N**
N	**H**	**N**
N	**M**	**N**
N	**L**	**N**
N	**N**	**N**

Chapter 3 - Summary

3.0 SUMMARY

This learning module has explored qualitative methods for risk assessment. There are a wide variety of qualitative approaches that can be tailored and utilized for an identified risk problem.

Concepts introduced in this learning module include the following:

- Brainstorming, interviews, expert elicitations and other process techniques can be effective methods for identifying risks and addressing uncertainty by filling in data gaps.
- Evidence maps, a new tool, can be very helpful in sorting out the disparate opinions about the existence of a hazard or risk found in the literature.
- Ordering tools that include screening, rating and ranking methods are among the most frequently used and robust qualitative risk assessment tools.
- Developing a generic risk assessment process is a valuable approach to problems that recur or for risk issues where many different assessments will have to be conducted.[9]

Sometimes qualitative risk assessments provide the information needed for a risk analysis or provide sufficient information to make decisions regarding the risk. However, the results may also indicate that a more detailed analysis is warranted, such as that presented in the *Risk Assessment - Quantitative Methods* learning module.

[9] The USACE risk register (https://planning.erdc.dren.mil/toolbox/smart.cfm?Section=8&Part=4) is one such tool that can be used to summarize the findings of the risk assessment.

Chapter 4 - Resources

4.0 Resources

The following are additional resources available regarding risk assessment approaches and qualitative methods.

Risk Assessment

Information Systems Audit and Control Association (ISACA). (n.d.). Risk assessment tools: a primer. Retrieved May 16, 2013 from: http://www.isaca.org/Journal/archives/2003/Volume-2/Pages/Risk-Assessment-Tools-A-Primer.aspx.

International Electrotechnical Commission (IEC)/International Organization for Standardization (ISO). (2009). *ISO 31000:2009, Risk management—risk assessment techniques.* Retrieved January 13, 2013 from http://www.iso.org/iso/iso31000.

Moser, D., Bridges, T., Cone, S., Haimes, Y., Harper, B., Shabman, L. & Yoe, C. (2007 unpublished). *Transforming the Corps into a risk managing organization*.

U.S. Army Corps of Engineers. (2012) *Planning community toolbox, Using a risk register in feasibility studies.* Retrieved January 13, 2013 from: http://planning.usace.army.mil/toolbox/smart.cfm?Section=8&Part=4.

U.S. Environmental Protection Agency. (No date). *Risk assessment home: basic information.* Retrieved January 2, 2013 from http://www.epa.gov/risk_assessment/basicinformation.htm#a1).

U.S. Food and Drug Administration. (December 18, 2012). *Risk analysis at FDA: food safety*. Retrieved January 2, 2013 from:

http://www.fda.gov/Food/ScienceResearch/ResearchAreas/RiskAssessmentSafetyAssessment/ucm243439.htm.

Yoe, Charles. (2012). *Principles of risk analysis: decision making under uncertainty.* CRC Press: Boca Raton, FL. http://www.crcnetbase.com/doi/pdf/10.1201/b11256-1.

Risk Identification

Aiken, M., Sloan, H., Paolillo, J. & Motiwalla, L. (October 1997). *The use of two electronic idea generation techniques in strategy planning meetings*. Journal of Business Communication. 34(4): 370-382.

Ayyub, B. (2000). *Methods for expert-opinion elicitation of probabilities and consequences for Corps facilitations*. IWR Report-00-R-10. Retrieved January 4, 2013 from: http://www.iwr.usace.army.mil/Portals/70/docs/iwrreports/00-R-101.pdf.

Creighton, J. L. (n.d.) *Using group process techniques to improve meeting effectiveness*. Retrieved December 21, 2012 from: http://www.effectivemeetings.com/teams/teamwork/creighton.asp.

King, N. & Horrocks, C. (2010). *Interviews in qualitative research*. Sage Publications. http://www.sagepub.com/books/Book228232.

Mind Tools. (n.d.) *Brainstorming: Generating many radical, creative ideas.* Retrieved December 21, 2012 from http://www.mindtools.com/brainstm.html.

Mind Tools. (n.d.) *Mind Maps: A powerful approach to note-taking*. Retrieved December 21, 2012 from http://www.mindtools.com/pages/article/newISS_01.htm.

Slottje, P. Sluijs, J.P. van der, & Knol, A. B. (2008). *Expert elicitation: Methodological suggestions for its use in environmental health impact assessments.* Centre for Environmental Health Research, National Institute for Public Health and the Environment. Retrieved January 4, 2013 from: *http://www.nusap.net/downloads/reports/Expert_Elicitation.pdf*.

U.S. Army Corps of Engineers. (1996). *Identifying small group techniques for planning environmental projects: A general protocol*. Retrieved December 21, 2012 from: http://www.iwr.usace.army.mil/Portals/70/docs/iwrreports/96r29.pdf.

U.S. Army Corps of Engineers. (n.d.) *Collaborative planning toolkit: Tools and techniques for collaborative planning.* Retrieved December 21, 2012 from http://www.sharedvisionplanning.us/CPToolkit/Content.asp?ID=3.1.

U.S. Environmental Protection Agency. (2009). *Expert elicitation task force: White paper*. Retrieved January 4, 2013 from: http://yosemite.epa.gov/sab/sabproduct.nsf/fedrgstr_activites/Expert%20Elicitation%20White%20Paper?OpenDocument; http://www.epa.gov/osa/pdfs/elicitation/Expert_Elicitation_White_Paper-January_06_2009.pdf.

U.S. Environmental Protection Agency. (2009). *Expert elicitation white paper-Addendum of recent references*. Retrieved January 4, 2013 from: http://yosemite.epa.gov/sab/sabproduct.nsf/fedrgstr_activites/Expert%20Elicitation%20White%20Paper?OpenDocument.

Web Center for Social Research Methods. (2006). *Research methods knowledge base: Interviews.* Retrieved December 21, 2012 from: http://www.socialresearchmethods.net/kb/intrview.php.

Qualitative Risk Methods

Arsham, H. (n.d.). *Tools for decision analysis: Analysis of risky decisions*. University of Baltimore. Retrieved January 4, 2013 from: http://home.ubalt.edu/ntsbarsh/opre640a/partix.htm#rintrodecisionanaly.

Center for Advancing Correctional Excellence, Criminology, Law, & Society, George Mason University. Retrieved January 7, 2013 from: http://www.gmuace.org/tools/evidence-mapping.

Cox, L. (2008). *What's wrong with risk matrixes?* Risk Analysis (28, 2) pp 497-521

National Regulatory Commission. (2003). *Formal methods of decision analysis applied to prioritization of research and other topics.* NUREG/CR-6833. Retrieved January 4, 2013 from: http://pbadupws.nrc.gov/docs/ML0330/ML033000339.pdf.

RuleWorks. (n.d.). *The risk management guide: information resources—risk profile matrix*. Retrieved January 7, 2013 from: http://www.ruleworks.co.uk/riskguide/risk-profile.htm.

The Global Evidence Mapping (GEM) Initiative. Retrieved January 7, 2013 from: http://www.evidencemap.org/.

The National Center for Evidence-Based Practice in Communication Disorders. Retrieved January 7, 2013 from: http://www.ncepmaps.org/Evidence-Maps-Background.php.

U.S. Army Corps of Engineers. (n.d.) *Collaborative planning toolkit: Tools and techniques for collaborative planning (*see Tools at-a-glance link*).* Retrieved December 21, 2012 from http://www.sharedvisionplanning.us/CPToolkit/Content.asp?ID=3.1.

U.S. Department of Defense. (February 2000). *Standard practice for system safety*. MIL-STD-882D. Retrieved January 14, 2013 from: https://acc.dau.mil/CommunityBrowser.aspx?id=255833.

Wiedmann, P.M., Schutz, H. & Spangenberg, A. (October 2005). *Risk evaluation of the health effects of mobile phone communication*. Retrieved January 7, 2013 from: http://www.emf-risiko.de/projekte/pdf/risikodialog_eng.pdf.

Wiedmann, P.M., Schutz, H. & Spangenberg, A. (2008) *Evidence maps – a tool for summarizing and communicating evidence in risk assessment*. Research Centre Julich, Programme Group Humans, Environment, Technology. Julich, Germany. Available online, accessed April 4, 2012: http://www2.fz-juelich.de/inb/inb-mut/publikationen/preprints/evidence%20_maps.pdf. Also available from: http://onlinelibrary.wiley.com/doi/10.1002/9783527622351.ch13/summary.

Chapter 5 - Self-Assessment

5.0 Self-Assessment

1. Which of the following is NOT a qualitative method for risk identification?
    a. Brainstorming
    b. Interviewing
    c. Expert elicitation
    d. Evidence mapping

2. Ordering tools that include screening, rating and ranking methods are among the most frequently used and robust qualitative risk assessment tools. T/F

3. A risk narrative is used only in a qualitative risk assessment. T/F

4. The simplest way to assess the effect of any change in conditions on an identified risk is to consider the available evidence and judge whether the risk has increased, decreased or remained unchanged. T/F

5. Which of the following is not a screening input?
    a. Evidence
    b. Items to be screened
    c. Carefully defined rating categories
    d. Algorithm or method for using criteria

6. Any good risk assessment must begin with a question or questions that define the management problem or opportunity. T/F

7. The following is an example of which tool:
    a. Risk register
    b. Risk matrix
    c. Risk communicator
    d. Risk narrative

Consequences	**Probabilities**				
	Improbable	**Remote**	**Occasional**	**Probable**	**Frequent**
None					
Negligible					
Marginal					
Critical					
Catastrophic					

5.0 Self-Assessment - Answers

1. Which of the following is NOT a qualitative method for risk identification?
    a. Brainstorming INCORRECT
    b. Interviewing INCORRECT
    c. Expert elicitation INCORRECT
    d. Evidence mapping **CORRECT**. Evidence mapping is a tool for summarizing the scientific data about a potential hazard.

2. Ordering tools that include screening, rating and ranking methods are among the most frequently used and robust qualitative risk assessment tools. T/F

    True. **CORRECT**

3. A risk narrative is used only in a qualitative risk assessment. T/F

    False. **CORRECT**. A risk narrative should be included in every risk assessment.

4. The simplest way to assess the effect of any change in conditions on an identified risk is to consider the available evidence and judge whether the risk has increased, decreased or remained unchanged. T/F

    True. **CORRECT**

5. Which of the following is not a screening input?
    a. Evidence INCORRECT
    b. Items to be screened INCORRECT
    c. Carefully defined rating categories **CORRECT**. Carefully defined rating categories are part of a Rating tool.
    d. Algorithm or method for using criteria INCORRECT

6. Any good risk assessment must begin with a question or questions that define the management problem or opportunity. T/F

    True. **CORRECT**

7. The following is an example of which tool:
    a. Risk register INCORRECT
    b. Risk matrix **CORRECT**
    c. Risk communicator INCORRECT
    d. Risk narrative INCORRECT

Consequences	**Probabilities**				
	Improbable	**Remote**	**Occasional**	**Probable**	**Frequent**
None					
Negligible					
Marginal					
Critical					
Catastrophic					