Planning Quick Takes: Timely Topics for Risk-Informed Planning Studies

(Formerly Planning Mentor Handbook)

Version 2.0

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Cover Image:

Kissimmee River Restoration Project
The Kissimmee River Restoration project is a congressionally authorized undertaking sponsored by the U. S. Army Corps of Engineers and the South Florida Water Management District, the non-federal sponsor. The project encompasses the removal of two water control structures, filling approximately 22 miles of canal, and restoring over 40 square miles of the river channel and floodplain ecosystem, including approximately 27,000 acres of wetlands. Source: https://www.saj.usace.army.mil/Media/Images/igphoto/2001253871/

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Purpose of the Planning Quick Takes: Timely Topics for Risk-Informed Planning Studies

The first version of this document (June 2020) was titled the "Planning Mentor Handbook." The Handbook was envisioned as an aid to help planning mentors assist and advise Project Delivery Teams (PDTs) in conducting risk-informed planning for USACE feasibility studies. It was intended to remind trained mentors or make those new to the mentoring role aware of various concepts, tools, and techniques available to help guide PDTs in risk-informed decision making (RIDM), especially in the early phases of the iterative six-step planning process. However, from the outset it was recognized that the Handbook would have utility to all planners, not just planning mentors. The title was therefore changed in this second version to reflect the appeal and value to a broader planning audience.

The need for such a "Quick Take" on risk-informed planning topics was identified at a workshop of senior planners held in Kansas City, MO in August 2019. Participants brainstormed topics that would help planners rapidly iterate through the 6-step planning process and de-mystify novel or challenging concepts, often based on their own experiences and the types of questions they frequently encountered while advising PDTs in RIDM. While planners have access to extensive guidance and manuals when delving deeply into a particular technical topic, such investigations can be daunting and time consuming when all they need (at least initially) is a quick introduction to a concept and a general appreciation of its role or value. It was also recognized that real *examples* (from studies, reports, or presentations) often make abstract concepts more meaningful and can help planners better understand a topic and how it might apply in their situations. The idea of "Quick Takes" was to therefore offer condensed, high level summaries of risk-informed planning topics, and to provide the reader with links to examples in USACE reports, presentations, and other guides for more detail. For each of the topics covered in the Handbook, an explanation of the meaning of the concept, tool, or technique – in a feasibility study context -- is first provided. An explanation of *what is it?* is followed by who develops it and when it should occur in the planning process. Advantages of using the concept, tool, or technique (i.e., why do we do this? Why it is important?) are followed by actual examples from USACE feasibility studies. In several cases references to slide decks, guides, or reports with greater detail on a given example or topic are provided. A conclusion to each topic summarizes its utility in various settings or applications.

Finally, this Handbook is intended to be a "living document," with additional topics, actual examples, or references added as they become available.

Audience

The audience for Planning Quick Takes: Timely Topics for Risk-Informed Planning Studies is all USACE planners, whether novice, journeyman, or senior, who may benefit from learning about the various tools and techniques that can collectively facilitate the iterative six-step risk-informed planning process. This Quick Takes may therefore be viewed as a "primer" or summary of many risk-informed planning concepts, including examples and references to other sources for more detail.

Topic 1: Six Pieces of Paper

What is it?

The "Six Pieces of Paper" is one of the tools to assist PDTs in "Scoping," the first task in the USACE iterative planning process. According to the *Planning Manual Part II: Risk-Informed Planning*, "Scoping brings the purpose of the study into focus. During the scoping process, planners decide what is and is not included in the study. This determines the complexity and focus of the study. A good scope provides a road map for how the study will be accomplished. The scope of a study provides the first formulation of the risks to be managed. It is essential that the vertical team and their stakeholders agree on the scope of the planning study."

The six pieces of paper includes:

1. A written problems and opportunities statement
2. A narrative Future Without Project Condition (FWOP) scenario
3. A list of planning objectives and constraints
4. A list of decision criteria that will lead to the choice of a course of action
5. A list of unique questions to be answered in the investigation
6. A list of the most significant uncertainties

Who develops it and when is it developed?

The six pieces of paper should be developed at the very start of the study, as part of the first planning iteration which occurs ideally within the first 30 days of the study. The "six pieces" should initially be developed by USACE PDT members meeting together and brainstorming or discussing the problems, opportunities, objectives, constraints, etc., based on the knowledge they already possess about the study area. This discussion will of necessity entail the PDT making many assumptions, but identifying gaps in their data, knowledge, and understanding will serve the useful function of highlighting what uncertainties exist and where the PDT should focus their future investigations.

In terms of how this exercise may play out, a simple handout (which follows this topic) could be sent to PDT members in advance of the scoping meeting. They could fill out the form to the best of their ability based on personal knowledge, or the form could be filled out collectively during the meeting with all PDT members contributing.

Advantages

The "six pieces" form a foundation or a first scoping step providing direction to the planning process. It can also be used by the PDT to communicate (as a "read ahead" document) the study's initial scope with the non-Federal sponsor and other stakeholders at a subsequent charette. Problems, opportunities, objectives, constraints, etc., may of course be modified at the charette based on the knowledge and experience of charette participants, but the draft "six pieces" should be developed by PDT members in advance to help make the charette itself more productive, efficient and focused. Identifying key uncertainties may form the first draft of a subsequent risk register. Identifying unique questions may help the PDT anticipate future questions their decision-makers will ask.

Going further, the PDT will use the six pieces of paper developed in scoping during the next planning step, plan formulation, to complete a preliminary identification of measures or plan formulation strategies that could meet the planning objectives developed to solve the problems and realize the opportunities identified. Thinking about potential solutions may trigger additional questions and areas where evidence gathering should be focused. Non-federal sponsors may be particularly interested in proposing their potential alternatives (which may become a Locally Preferred Plan, or LPP) during initial plan formulation. This is important information for the PDT in developing the range of alternatives, the types of effects to be evaluated, evidence gathering priorities, etc.

Examples

An example of the six pieces of paper developed by the Florida Keys Coastal Storm Risk Management study (Figure 1) during the initial scoping (prior to charette) is presented here. Unique questions posed by the PDT from the outset included, "What are the hard constraints put on the plan formulation for the study because of the unique environment in the study area? For example, are there management measures that cannot be considered due to the presence of the National Marine Sanctuary?" An example of a significant uncertainty identified by the PDT included, "What actions will FLDOT or US Highway Administration take in the future (i.e., the FWOP) to protect or reduce potential damages to US Highway 1?"

Six Pieces of Paper for the Florida Keys Coastal Storm Risk Management Project

The following exercise was completed by the Florida Keys Coastal Storm Risk Management PDT with the non-Federal sponsor, Monroe County, FL, and other stakeholders during the study's first scoping meeting in October 2018.

Problems and Opportunities

Problems:

1. Roadway flooding, specifically flooding of U.S. Route 1, impedes evacuation during coastal storms, thereby posing a risk to human life and safety. Flooding also causes travel delays, and prevents timely return of residents after an evacuation for a storm event.
    a. U.S. 1 is the only route from to the mainland and is thus the only evacuation route for residents and tourists in the Florida Keys.
    b. The Route 1 corridor is where all of the critical county infrastructure and development is located because it is generally the highest elevation area on each Key.
    c. Any bridge collapse due to a storm event would be catastrophic for post-storm response and recovery.

2. Flooding due to coastal storm events causes damage to structures (commercial and residential), as well as such critical infrastructure features as roadways, bridges, airports, and hospitals.
3. Habitats are being lost (and transitioning from fresher or brackish to more saline) due to coastal storms, and exacerbated by sea level rise (SLR).

Opportunities:

1. Due to the rich environmental resources in the area and the surrounding Marine Sanctuary, there are various opportunities for the use of nature based features and/or restoration of the natural coastal system of defenses that are or were historically present in the study area:
    a. Mangroves—there is qualitative analysis that shows areas with established mangroves sustained less damage than areas without mangroves or in areas where mangroves have been reduced due to human activity and even performed better than areas with riprap shoreline protection structures.
    b. Coral reef

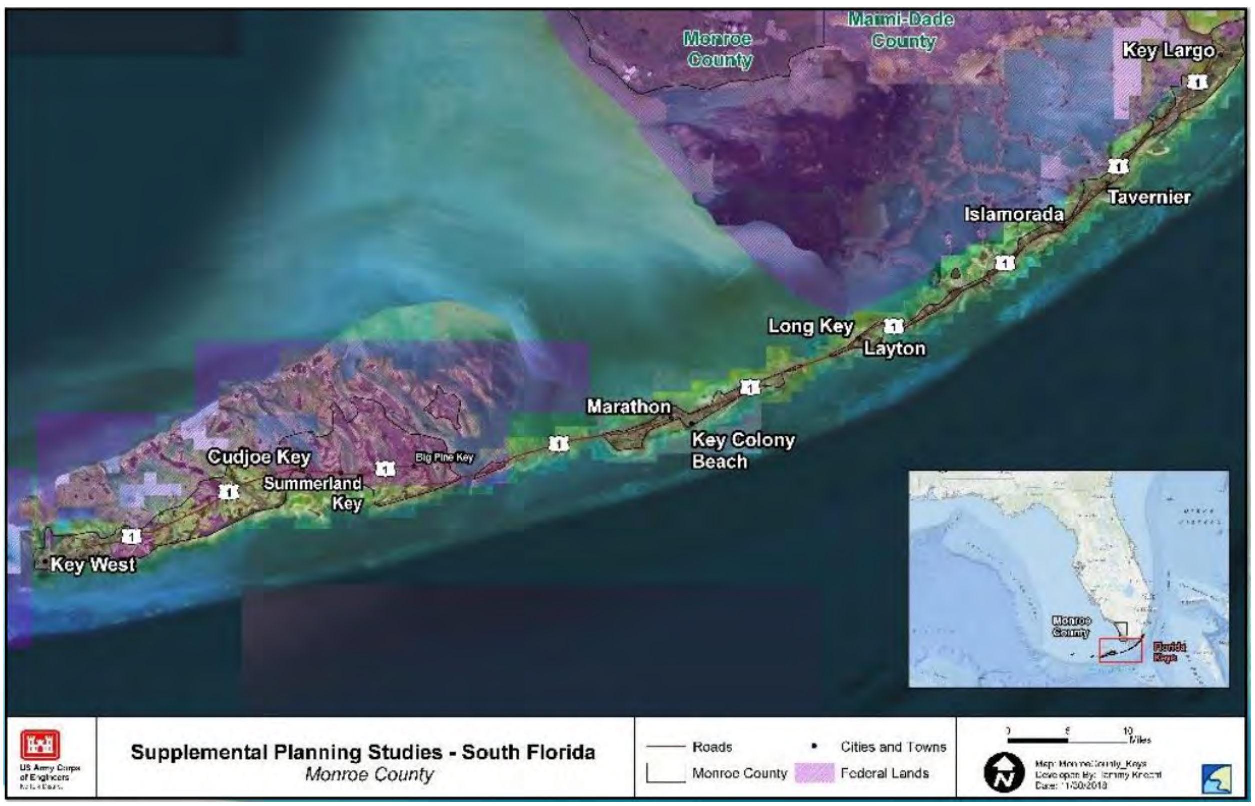


Figure 1 Map showing the location of the Florida Keys Coastal Storm Risk Management Feasibility Study.

Narrative Description of Future Without Project Condition

The study area is expected to remain vulnerable to the effects of coastal storms in the future and also experience more severe damage throughout the period of analysis due to sea level rise and increasing intensity and frequency of coastal storms due to climate change. The non-Federal sponsor has plans to complete some relatively small scale road improvement projects in areas that have been identified to be more vulnerable to sea level rise and storm damage, but does not have plans for a comprehensive coastal storm risk management effort that would reduce damages to infrastructure and human life and safety. Projects that will be implemented by the non-Federal sponsor include:

1. $17M, 5 year roadwork plan
2. Capital improvement plan projects
3. Some Federal Highways Administration maintenance of Route 1.

Objectives and Constraints

Objectives:

1. Reduce damages from coastal storms and coastal flooding to the natural and built environment in Monroe County over the period of analysis.
2. Reduce the risks to human life, health, and safety.
3. Reduce the vulnerability of Route 1, the primary and only evacuation route from the Keys, to the effects of coastal storms.
4. To increase the resilience of the Florida Keys to the impacts of coastal flooding. (Note: the USACE principles of resilience are Prepare, Absorb, Recover, and Adapt.)

Constraints and Considerations

Constraints:

1. There is a large amount of Federally owned land within the study area, including a National Marine Sanctuary and a Naval Air Station
2. There are a variety of unique and/or endangered species located within the study area
    a. Extensive coral reef
    b. Key deer
    c. Mangroves
3. Any project should not reduce evacuation capacity

Considerations:

1. County does not control the municipal water and wastewater infrastructure
2. The majority of the study area are protected lands, including a National Marine Sanctuary, State Parks, and some conservation easements held by NGOs
3. There are cultural/historic assets in the study area, ex. Indian Key

4. There are strict state and local codes that govern building and development within the study area, for example there is a local code that does not allow construction of riprap structures in open water within county boundaries
    a. Changing the code is possible but takes 8-12 months if it is approved

Decision Criteria

1. Damages prevented/reduced
2. Evacuation route protection/resilience
3. Critical infrastructure protected/damages reduced
4. Environmental impact or improvement/restoration
5. Estimated cost of measure/alternative
6. Regional Economic Development benefits/impacts
7. Resiliency (how do we measure this?) Potential metrics: improves evacuation times; improves ability of structure/ facility to absorb flood impacts; decreases time needed for recovery; “adaptability” of the measure to changing conditions.

Unique Questions

1. How can we economically justify natural and nature based features such as mangroves and coral reef vs. traditional measures such as hard structures for shore protection?
2. How do we plan with/around the Federal land within the study area?
3. What are the hard constraints put on the plan formulation for the study because of the unique environment in the study area? For example, are there management measures that cannot be considered due to the presence of the National Marine Sanctuary?
4. It has historically been very difficult to apply existing models to the Keys because of the unique environment, does one of the approved USACE models such as G2CRM work for this study?

Key Uncertainties

1. Sea Level projections, County would like us to consider the one they have been using for their own planning needs/studies.
2. Future population growth and development in the Keys – this affects the population at risk and economic assets at risk.
3. What is the expected trend for tourism in the Keys? This affects the potential population at risk and number of potential evacuees.
4. What actions will FLDOT or US Highway Administration take in the future to protect or reduce potential damages to US Highway 1?

Conclusion

In sum, developing the “six pieces of paper” helps PDTs make progress from the onset of the study. It helps PDTs document several planning steps, including identifying problems and opportunities, objectives and constraints; a narrative description of FWOP; formulating alternatives; and identifying what decision criteria will be important in plan evaluation and selection. All of this information can go into a draft "Report Summary," so it is not duplicative work. It can also help to populate a draft risk register with key uncertainties. The "six pieces of paper" helps the PDT think about and anticipate unique questions that decision-makers may pose at future milestone meetings, such as the Alternatives Milestone Meeting.

Topic 2: Charettes

What is it?

A charette (pronounced [*shuh*-ret]) is a structured, collaborative session in which a group comes together to develop a solution to a problem. It has been used in fields such as architecture, community planning, and engineering for years – bringing together a variety of different points of view to solve a difficult problem, often using the familiar six-step planning process as a key tool. The use of charettes was emphasized at the initiation of SMART Planning as a vehicle to convene the Project Delivery Team (PDT) and vertical team to make decisions critical to the study. Charettes are not required as part of Risk Informed planning, but they can be a useful tool and may provide a format for Planning Iterations or review meetings. Charettes are formal meetings with best practices that include a structured agenda (identifying the outcome/decision), facilitator, participants that include key decision makers, and readaheads to ensure preparation and common understanding. Guidance and tools for conducting a charette are available in the Planning Community Toolbox. A Charette Handbook was developed in 2013 and is available at:

https://planning.erdc.dren.mil/toolbox/library/smart/Charette%20Handbook.pdf

Who develops it and when is it developed?

Ultimately, the District is the “owner” and convener of the charette and the study team is responsible for ensuring the outcomes of the charette meet the needs of the study. A charette is an opportunity to have the full PDT and all levels of the vertical team – District management, PCXs, Division and Headquarters, and non-federal sponsor – work together in a focused and intensive workshop to advance the study, share information, and make decisions. The principles of the charette process are scalable and can also be applied to planning iterations, plan formulation workshops, scoping workshops, In-Progress Reviews, and more. The structure of the charette and its outcomes will be tailored to the decisions needed by the PDT and vertical team that will advance the study.

Advantages

A charette allows the convening of the Project Delivery Team (PDT), vertical team, non-Federal sponsor and sometimes resource agencies or other stakeholders to make decisions critical to the study. A charette has the potential to save the study team and vertical team time and money as it may enable more effective and efficient communications and review of study products. The organized approach with read aheads (e.g., risk register, decision management plan, report summary, six pieces of paper, etc.), detailed agenda, clearly defined participants (including facilitator, support team, and decision makers), and focus on delivering a decision or recommendation can be useful in assisting a PDT to get decisions and “buy in” on the process and outcomes.

Figure 2 A charette is a valuable tool for building consensus among the PDT, partners and stakeholders.

Examples of Charettes

Charettes can be used as a format for one or more of the Planning Iterations to gain vertical team buy-in on decisions related to key uncertainties, data/analysis to gather prior to next milestone, and decisions on screening of alternatives, etc. A charette can also be used as a way to fully explore the problems and options surrounding a potential need for rescoping to maintain 3x3x3 parameters or the need for an exemption to get all levels of the vertical team on board with the risks, need, options, and rationale for any modifications.

Wondering how a charette actually plays out? In addition to the Charette Handbook cited above, attached here is another example. This detailed agenda was for a virtual scoping charette, which took place over six sessions between April 21-23, 28, and May 5-6, 2020, is provided courtesy of the Yorkinut Slough Habitat Rehabilitation and Enhancement Project PDT (CEMVD-RPEDN). Virtual charettes have recently become more common, due to both health-related travel restrictions, as well as overall savings by reducing travel costs for in-person charettes. In addition to the agenda, the Yorkinut PDT provided a summary of the *Virtual Charette Tools used in the Yorkinut Slough HREP Virtual Scoping Charette, April-May 2020,* also attached here. The virtual tools covered include such lessons learned as 1) dry run of all technology; 2) sending read ahead materials; 3) Webex linked to audio; 4) separate facilitator, note-taker-timekeeper, and Webex manager; 5) logging in early; 6) sharing files; 7) setting ground rules using Poll Everywhere; 8) interactive maps; and 9) virtual site visits, among many others tips. Points of contact for the charette are also listed in the *Virtual Charette Tool* document.

Yorkinut Charrette FACILITATOR Agenda

Virtual Charrette Tools - Yorkinut Scopi

Conclusion

Charettes are not a required tool for risk informed planning, but they can be a valuable tool to organize an iteration, gain vertical team alignment on key planning issues, and advance to group decisions. It should be mentioned that some studies and PDTs have recently conducted less formal, smaller scale “study kickoff” meetings intended to cost less but still provide the basic functions of a charette for going through the initial iteration of the planning steps with brainstorming involving USACE, the non-Federal sponsor, and potentially resource agencies. In other cases these kick-off meetings are precursors to more formal charettes, whether in-person or virtual, which may include more participants and follow the more structured format described above. In either case, PDTs can use informal kick-off meetings and formal charettes as a way to reach decisions throughout the study process.

Topic 3: Engagement Techniques

What is it?

What is the best way for planning mentors and the PDTs they mentor to "connect" or engage? How can mentors be more effective in opening and maintaining dialogues with their PDTs? Because the experience of planning mentor interactions with PDTs has varied greatly (e.g., the frequency, value, and ease of those interactions), the intent of this section is to suggest engagement techniques that have been successfully employed by mentors. Several engagement techniques are summarized below.

- **Mentor calls in to PDT meetings.** Whether on a regular or subject-specific basis, by virtually participating via WebEx or using a call-in option for PDT meetings the mentor will gain familiarity with the feasibility study and the PDT will be able to ask questions or seek the mentor's advice during the call.
- **Product-oriented meetings.** The mentor may lead the PDT through a meeting (in person or virtual) and facilitate development of a product, such as the Six Pieces of Paper, a Risk Register, or even a Rapid Iteration of the planning process by the end of the meeting. Focusing on a product can give structure to the mentor/PDT relationship and advance the study process simultaneously.
- **Develop "cheat sheets"/ checklists/ "strawmen"** prior to a meeting that provide visualization. The mentor can provide a blank or partially filled out Six Pieces of Paper, Risk Register, or a checklist of plan formulation strategies, for example, in advance of a meeting with the PDT to initiate discussion on a given topic and to help the PDT visualize what the products look like or how they can be used. This can help the PDT think about the process or issues in advance of the meeting and lead to getting more accomplished during the actual mentor-PDT meeting.
- **Best practices to encourage dialogue from all.** The idea here is to avoid one or a few people dominating discussions at meetings by asking all PDT members to participate round robin style, or to ask for all participants to provide written responses on index cards so that all voices/ ideas may be considered. Another technique is to queue up a discussion topic and ask participants to bring their ideas to the next meeting. This allows team members that like to take their time to gather their thoughts before sharing with the group the opportunity to participate at a pace they are more comfortable with.
- **Use a "tech talk" to describe something of interest to the full PDT.** The mentor may develop and deliver a presentation or mini-webinar on a given topic of utility and interest to the PDT. This has the benefit of getting the entire PDT up to speed on a given topic (e.g., what is risk-informed planning? What is a risk register and how is it used? What are conceptual models and how can they help in risk identification?). In each case the tech talk could precede the mentor facilitating a rapid iteration of the planning process or an exercise in which the risk register or the conceptual model is developed collectively be the PDT. Other PDT members could also be asked to lead tech talks, such as how the engineering team developed fragility curves, which can then

provide the mentor an opportunity to help the PDT consider and document risk and uncertainty associated with that topic.

- **Charters.** When the Planning Mentor Program first kicked off in 2017, formal, signed "charters" were suggested to define the mentor's role vis-à-vis the PDT. A sample template of the agreement between a mentor and his/her PDT is provided below. Charters are not required, but can be useful in establishing the overall objectives for the mentor, delineating roles and responsibilities for the mentor and PDT, specifying resources and support, and establishing general standard operating procedures, such as frequency of communication, schedule of regular teleconferences, etc.

DRAFT_Planning Mentor Charter Agree

Who develops it and when is it developed?

Although either party may initiate the engagement, the role of the mentor is to encourage and assist the PDT in the concepts, practices, and application of risk-informed planning. The mentor therefore needs to take an active role in reaching out to the PDT, in letting the PDT know of his/her availability, and in seeking ways for their collaboration to be most beneficial to the PDT. In other words, the PDT may not know what to ask from their mentor, so the mentor should be proactive in offering various ways to help.

Advantages

The mentor can be more effective in communicating with the PDT and disseminating the concepts of risk-informed planning by adopting several of these engagement techniques. The mentor can help the PDT utilize the expertise and experience of the planning mentor to engage with them in a meaningful way.

Examples of Engagement Techniques

The attached presentation was used by a mentor to introduce the concepts of risk informed decision-making and the risk register. The attached risk register "cheat sheet" was developed by the same mentor to explain the content and use of the Risk Register to PDTs (e.g., how to fill it out, what the columns mean, how to think about things as risks — not just, "we don't have all the info/details we need") and serves as a reference as the PDT fills out the risk register.

Intro Risk Informed Decision Making.pdf

Risk Register cheat sheet.docx

Conclusion

PDTs can often benefit from mentoring in risk-informed planning, but they may not know what to ask for. It may therefore be up to the planning mentor assigned to a PDT to initiate dialogue and "meet the PDT where they are" in the planning process, offering a variety of areas of expertise, techniques, and tools to help advance the study. Several engagement techniques, described above, have been successfully employed by mentors. More examples will be added as they are developed.

Topic 4: Rapid Iteration(s)

What is it?

Rapid iteration(s) are a quick and intentional cycle **through all steps** of the Planning Process (see Figure 1) and repeated throughout the study process. A rapid iteration is completely faithful to the USACE six-step planning process and a critical aspect of risk-informed planning.

- An iterative process is one that is repeated as needed. Any portion of the process can be iterated, and the iteration can include the entire planning process, just a single step in the process, or a subset of the steps.
- With each iteration planners attempt to reduce uncertainty of the planning process. Iterations repeat, elaborate, refine, correct, or complete a part of the planning process.
- The primary reason the planning process is iterative is to address uncertainty. Uncertainty can increase or decrease with new information; you learn as you plan. As more information becomes available, your understanding improves, and it is often necessary to go back over something to make it better.

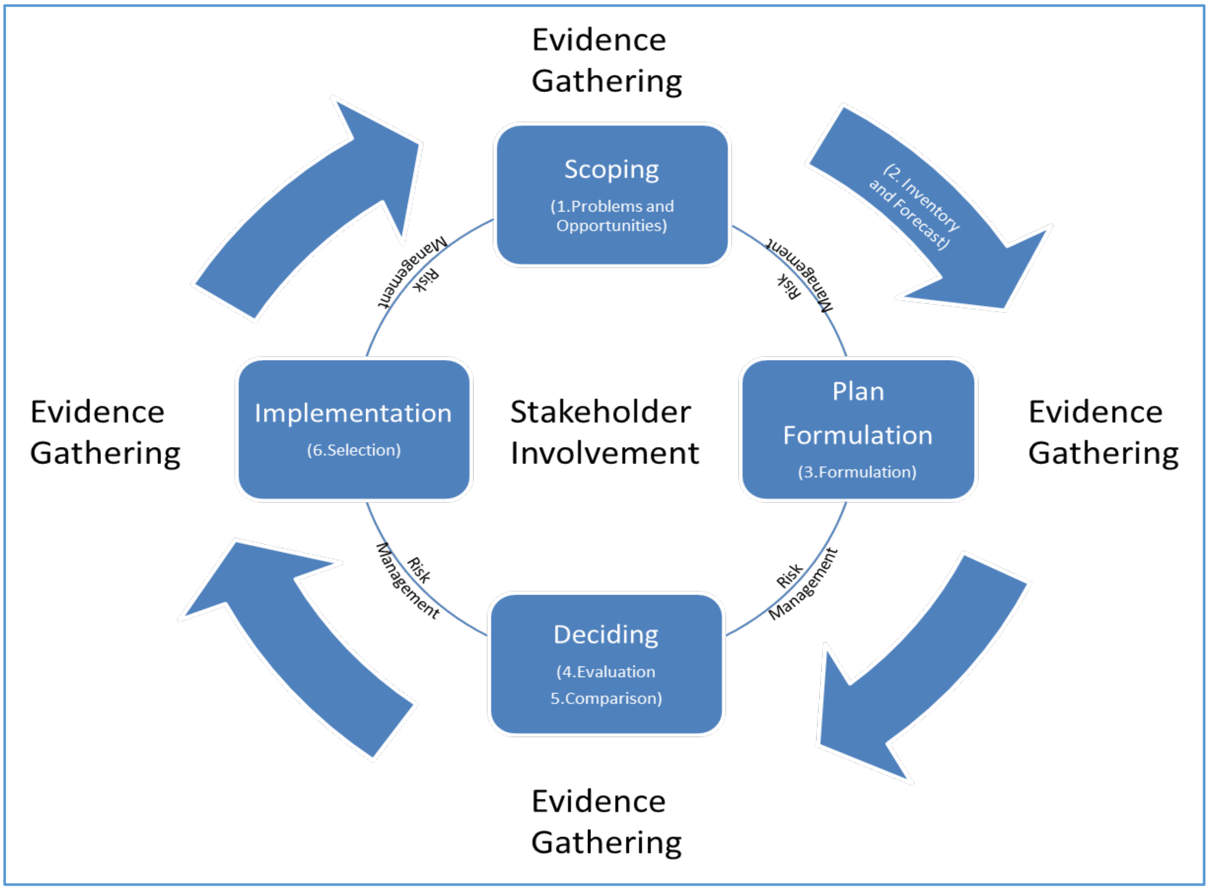


Figure 3. Risk-Informed Planning Cycle

Who develops it and when is it developed?

Rapid iterations can be carried out with any number of PDT members and participants from the vertical team, sponsors, stakeholders, and/or public. However, ideally it includes at least the key, core multi-disciplinary team members. A key aspect of rapid iterations is that they occur throughout the study process continuously refining the study scope, reducing and clarifying risk and uncertainties. The *Planning Manual Part II* prescribes at least three iterations in detail, followed by as many additional iterations as necessary to arrive at the best plan (see Figure 2).

- **1st iteration** – At the beginning of the scoping phase (first 30 days), document the information the team knows at that time and the information that is needed to be gathered to inform the Alternatives Milestone decision.
- **2nd iteration** – During the scoping phase, conduct a second iteration (first 90-100 days) prior to the Alternatives milestone (AMM) with information gathered to identify the needs identified from the first iteration; primarily existing available information.
- **3rd iteration** – During the alternatives evaluation phase (within 1 year) and prior to the Tentatively Selected Plan (TSP) milestone, develop the quantitative information necessary to compare the alternatives and select a TSP.
- **Additional iterations** – After TSP identification, there are iterations of individual steps or tasks, but not necessarily an iteration of the entire planning process. During the feasibility analysis phase, develop information needed to optimize the recommended plan, certify costs, and reduce instrumental risks to acceptable levels.

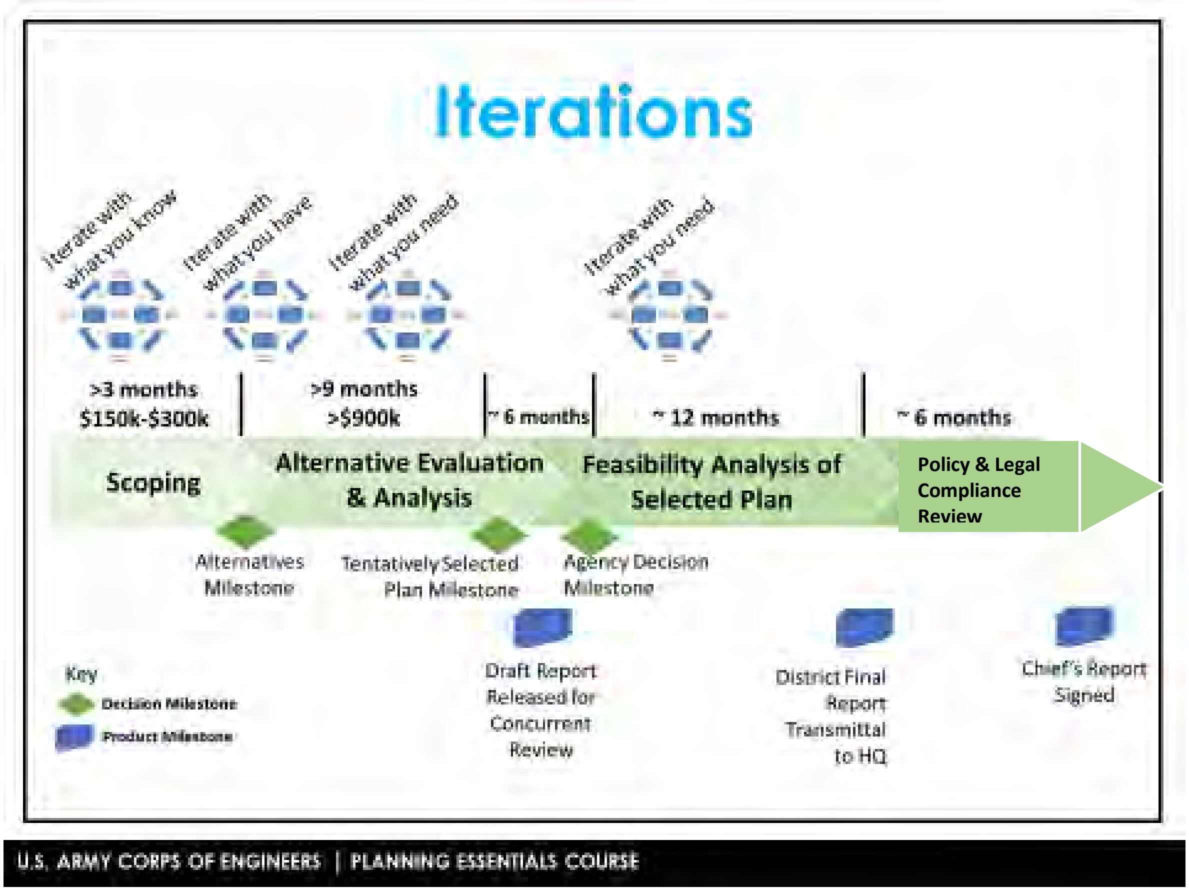


Figure 4. Rapid Iterations throughout the Planning Process

Advantages

Rapid iterations actively move the study forward by focusing on what data/analyses are needed to reduce uncertainty and make a decision. It encourages critical thinking and asking questions: Can we make a decision with what we know now? What risks would we face if we make decisions with what we know now? Do we need to address that risk now? Later? Iterations of the planning process can be used to reduce uncertainty strategically throughout the process and to gather data at the optimal time to make the next decision. This helps to keep the study moving forward and effectively and efficiently investing limited funds and time.

Examples of Rapid Iterations

One example of how to use the rapid iterations is to conduct a rapid iteration of the planning process using the six sheets of paper as part of the initial internal PDT kick-off meeting. Use the notes from that iteration to conduct a follow on more refined first iteration with the sponsor and vertical team, other stakeholders, etc. An example of a presentation delivered by a mentor in the first few months of the Los Angeles County Flood Risk Management Study to explain risk-informed planning and initiate a rapid iteration of the planning process with the PDT is attached here.

LACFCS Workshop
16 April 2019.pdf

Figure 5 A highly developed portion of Los Angeles River channel.

Conclusion

Multiple iterations of a risk-informed planning process focuses the team and decision makers on the additional information, data, and analyses necessary to reduce uncertainty and/or manage either study or project risk. It proactively moves the study forward, encourages critical thinking, provides a mechanism to strategically manage uncertainty, assists in gathering data at the optimal time to make the next decision, and allows teams to most effectively and efficiently invest limited funding and time.

Topic 5: Plan Formulation Strategies

What is it?

Planning can be defined as the deliberate organizational activity of developing an optimal strategy for solving problems and realizing opportunities in ways that achieve a desired set of objectives. It is a systematic way of combining measures into alternative plans based on a selected theme or focus. Using formulation strategies to guide and organize the creation of alternative plans is a sound method for logically progressing through the study process. Strategies can be employed to help group or combine measures, identify different ways to solve problems, and enable a rational, transparent process to more quickly develop an initial array of distinctly different alternatives. Strategies can take many forms limited only by the team's creativity. According to the *Planning Manual Part II (Sec. 8.5)*, "a formulation strategy is a disciplined way to produce one or more specific plans."

Who develops it and when is it developed?

Plan formulation is an ongoing creative group activity and plan formulation strategies are very helpful for identifying the Tentatively Selected Plan. Anyone on the Project Delivery Team (PDT) can play a role in developing formulation strategies; in fact, this is encouraged as different perspectives allow for different methods for addressing study objectives. The PDT can also solicit input from the public, stakeholders, or the sponsor. Strategies can be employed as early in the study as when management measures are developed and are carried through to guide alternative development and comparison. It is critical to document the basis for the strategy along the way, to define why it is proposed as a framework for alternative development, and what it will achieve towards addressing objectives. Planning typically is not a straight-forward, linear process, and new strategies can be developed as the PDT acquires more information or learns that certain measures or alternatives may not be effective.

Advantages

Using strategies to guide and organize the formulation of alternative plans can greatly improve the effectiveness of alternative comparison and evaluation. One of the biggest advantages for employing strategies is they help to create truly unique and independent alternatives. For example, considering flood risk management (FRM) from a nonstructural, detention basin, or levee perspective allows for a wide array of significantly different approaches to be considered. Besides organizing strategies around general types of measures, such as the previous example, strategies may be based on achieving different planning objectives or solving problems in different geographic areas. Using FRM again, strategies could be based on meeting certain objectives, like reducing risk to human health and safety, reducing property damage, and reducing risk to critical infrastructure; or geographically, such as reducing risk only to high damage or population centers, or reducing risk to the entire study area. An added benefit of employing strategies is the ability to more effectively convey information to the public and decision makers. Strategies are descriptively named and are more readily identifiable than the typically used alpha or numeric nomenclatures (such as Plan A4, etc.).

Examples of Plan Formulation Strategies

Strategies can originate from any number of sources including prior reports, the general public, conceptual models, stakeholder preference, or decision support tools. "A strategy usually consists of a set of tactics or approaches that shape and guide plan development; thus, strategies structure the *how to* of plan formulation[1]." Examples of plan formulation strategies may include but are not limited to the following:

- Maximize Environmental Outputs
- Ideal Scenario
- All Possible Combinations
- Something for Everyone
- Locally Preferred
- Nonstructural
- Cornerstone/Base Plan Strategy
- Resource Agency Preference

Two webinars offering examples of plan formulation strategies were presented to the PCoP in April and September 2016, respectively, for 1) all business lines (https://planning.erdc.dren.mil/toolbox/webinars/16Apr7-PlanFormStrategies.pdf); and 2) specifically for aquatic ecosystem restoration projects (https://planning.erdc.dren.mil/toolbox/webinars/16Aug26-EcoPlanFormStrategies.pdf).

Conclusion

Utilizing plan formulation strategies is the surest method for rationally and deliberately collecting management measures into distinct alternative plans. Strategies help ensure alternatives are designed to achieve objectives and they help identify distinctly different approaches towards solving study area problems. Plan formulation strategies should be provided to VT members at the Alternatives Milestone to document and demonstrate the various paths undertaken by the PDT to arrive at the focused array of alternative plans.

Topic 6: Screening Techniques & Criteria

What is it?

Criteria are the attributes, variables, and values associated with a decision problem that are important to decision makers. A criterion is something the decision makers care about and something that can influence the decision makers' choice. You should expect the screening/decision criteria for a USACE planning study to reflect the study's planning objectives and constraints. For example, if one of a study's planning objectives is to reduce flood risk in the study area, then a criterion related to measuring flood risk, such as the economic value of flood damages, will very likely be an important screening/decision criterion for that study. Criteria may vary from decision-to-decision and between milestone meetings during the planning process.

The *Planning Manual Part II* mentions benefits, costs, and environmental impacts of each plan as decision criteria that will almost always come into play for every USACE study. In addition, the four formulation and evaluation criteria of effectiveness, efficiency, acceptability, and completeness that are specified in the *Principles & Guidelines* (P&G Paragraph 1.6.2(c)) should be considered in the screening, evaluation, and comparison of alternative plans. Alternatives considered in any planning study should meet minimum subjective standards of these criteria in order to qualify for consideration and comparison with other plans.

Decision criteria are needed for the following key decision categories: scoping the study; management measures screening; evaluation of alternatives; comparison of alternatives; and selection of the TSP.

Who develops it and when is it developed?

One of the key tasks in any planning study and a significant component of your plan formulation strategy is to determine the appropriate screening/decision criteria that will be used at different points throughout the study to help the PDT eventually arrive at a TSP for recommendation. For this to be effective, the screening/decision criteria need to tie back to the study objectives and be developed early in the study process, preferably during scoping and in concert with establishing the Problems, Opportunities, Objectives, and Constraints. In fact, the PDT's identification of decision criteria for the study is one of the initial scoping tasks as part of the Six Pieces of Paper. It's important to identify decision criteria early to help the PDT determine what information or data *may already be available* to screen and evaluate alternatives, as well as what information, data, or analysis *will need to be collected and undertaken in the future* to screen and evaluate alternatives.

Can the decision criteria change throughout the course of the planning study? Yes. Generally decision criteria become more specific and quantitative as the study progresses, even when the criteria are evaluating the same attribute of an alternative plan. For example, a criterion related to ecosystem output for an AER project may progress from a subjective judgment that an alternative will yield a "positive, large" increase in wetland habitat at the management measure screening phase of the planning process; to an estimate of 2,500 intertidal marsh acres improved/ restored for that alternative during the deciding phase of the planning process; to an estimate of 1,780 habitat units using the Combined Habitat Assessment Protocol (CHAP) model for the same alternative at the stage of planning process when the TSP is identified.

Advantages

Employing screening techniques and criteria are essential tasks throughout the planning process, from helping to scope the study, through culling the myriad possible solutions, to ultimately recommending an alternative plan. Appropriately scaling the complexity of the technique and the specificity of the criteria allows the PDT to proceed efficiently through the planning process, making risk-informed decisions about what's in or out, what's screened or not, what's better or worse, using the knowledge, information and expertise available to the PDT at any given point in the study. The examples that follow help demonstrate the advantages of employing screening techniques and criteria appropriate to the stage of the study (i.e., from less complex/ specific to more complex/specific).

Example Screening Techniques and Criteria

Example #1

Let's take a hypothetical multi-objective AER/FRM planning study and show what screening/decision criteria might be employed and how they might be measured. The very simple conceptual model in Figure 3 below shows a river that is experiencing severe erosion and stream incision. In this example, aquatic and riparian habitat are degrading as a result of excessive erosion, which impacts water quality, and damages, by siltation, the structure of the benthic or bottom habitats. There is a loss of lateral connectivity between the stream and its floodplain (i.e., as the stream incises and deepens, it literally leaves its floodplain behind, or "strands" it, leading to loss of native riparian vegetation potentially impacting both riparian and other aquatic species). Our problem statement for this conceptual model might read: "Urbanization and other watershed alterations are changing the hydrology and hydraulics of Dry Creek, causing downstream channel incision, stream bank erosion and bluff failure, which in turn are causing: loss of natural riparian and floodplain vegetation; increased erosion and sedimentation of downstream habitats, leading to poor quality habitat for resident and migratory fish; increased risk of damages to nearby residential structures and critical infrastructure; and increased risk to public health and safety from collapse of structures and loss of functionality of a water treatment plant." Conceptual models have utility in portraying cause and effect relationships, which can help us identify the criteria important for decision-making.

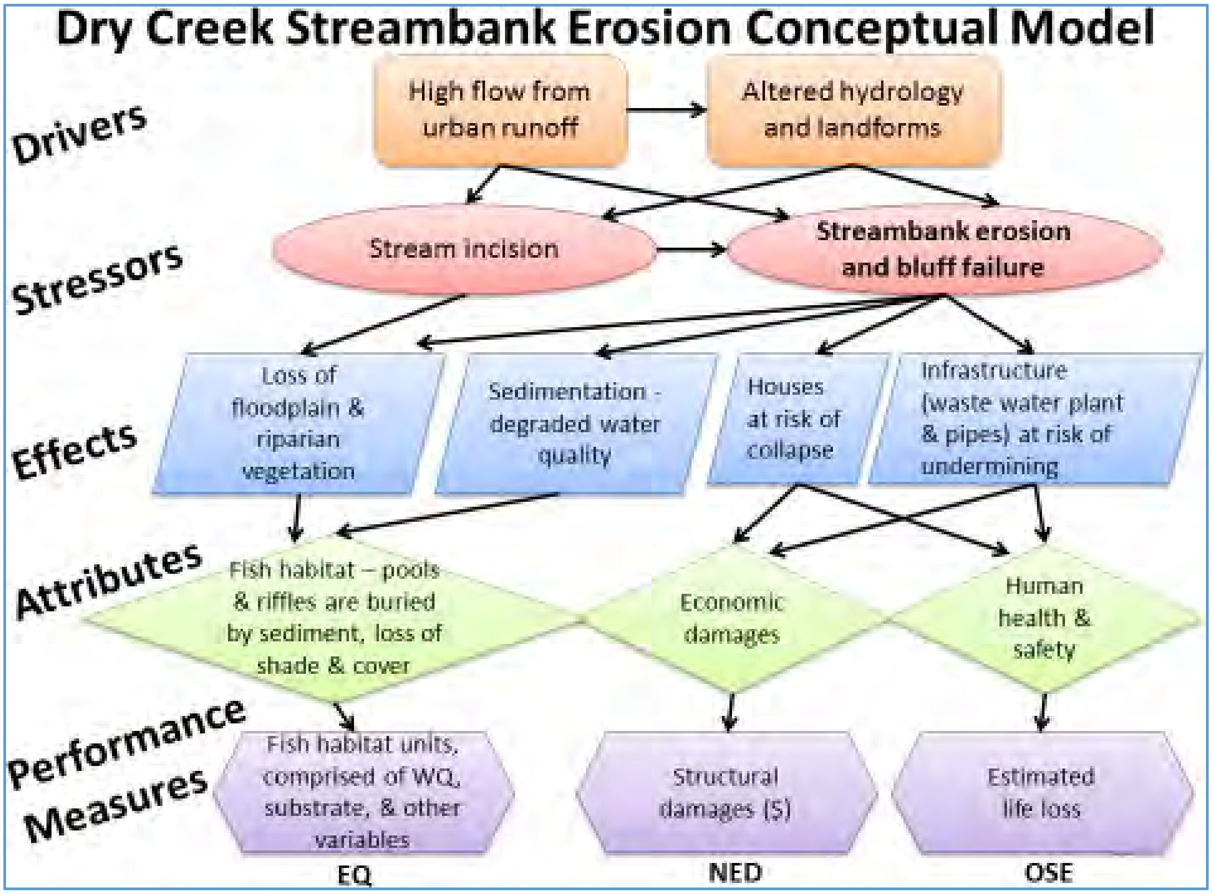


Figure 6. Hypothetical Conceptual Model as Basis for Screening/Decision Criteria

Going beyond the problem statement, our ecosystem-related planning objectives for this hypothetical study (we could also have flood risk management-related objectives) might focus on restoring both 1) the quality and quantity of degraded aquatic and riparian habitat; and 2) riverine-floodplain connectivity in the Dry Creek watershed over the period of analysis. Our management measures would be formulated to meet these objectives, and we might measure the effectiveness of our management measures or combinations of measures (i.e., alternatives) at the *evaluation/deciding step of the planning process* through their **predicted changes to such decision criteria as aquatic and riparian habitat units** (indicator species could be selected for each habitat type) using a certified or approved ecological model. Similarly, at the *evaluation/deciding step of the planning process* our alternatives might be evaluated for their effectiveness at reducing a flood risk objective through such decision criteria as either a **reduction in economic flood damages** or a **reduction in lives lost**, calculated using such certified models for NED and OSE benefits, respectively, as HEC-FDA and LifeSim. These decision criteria used at the *evaluation/deciding step of the planning process* (i.e., aquatic and riparian habitat units, economic damages prevented, and life loss) are labeled performance measures in the conceptual model diagram above.

Example #2

In the hypothetical Dry Creek study described above, the decision criteria were used to evaluate the effectiveness of alternatives, i.e., how well alternatives meet the planning objectives. But the metrics themselves (aquatic and riparian habitat units, economic damages prevented, and life loss) would likely not be available or developed until enough information had been collected and analytical models run during the evaluation/deciding step of the planning process. These metrics would likely be important decision criteria in TSP identification, along with such criteria as **costs, environmental impacts, acceptability**, and **completeness**.

But do we need such specificity in measuring the effectiveness of alternatives earlier in the planning process, say in the screening of management measures? The answer is “no.” We can still use “effectiveness” as a screening criterion earlier in the planning process, based on the professional judgment and experience of the PDT. We might measure effectiveness more qualitatively through such metrics as using color coding (green/amber/red), assigning nominal value (+, 0, -), using a numeric system, or even simply a “yes/no.”

When brainstorming management measures at a planning charette or at some point early in the planning process, our initial goal is creativity, to make sure we leave “no stone unturned” – what solutions could possibly solve the problems at hand? To make sense of the many management measures we might develop, however, we need to screen them to a manageable and realistic subset. One obvious screening criterion is effectiveness – will the management measure under consideration help achieve, and to what extent, a given planning objective? Early in the planning process, this evaluation of effectiveness may be qualitative – will a management measure a) highly, b) moderately, c) slightly, or d) not at all contribute to the achievement of a planning objective (and with what degree of confidence)? Later in the planning process, when we are evaluating alternatives, we are still very much concerned about effectiveness (along with costs, other impacts, resilience, etc.), but we will measure effectiveness quantitatively through, for example, such metrics as habitat units and biotic integrity. Whether qualitative or quantitative, our report documentation should include a table that shows, for each restoration management measure, which objective is likely to be addressed and how completely the measure is likely to address the objective. Figure 4 shows a simple example table using management measures developed for our “Dry Creek” conceptual model. Green cells denote a management measure highly contributes to the achievement of a planning objective. Similarly, yellow cells denote moderate contributions, amber cells denote slight contributions, and red cells denote no contribution to the achievement of a planning objective. Figure 4 below can also be used to show the results from screening management measures; i.e., whether measures are retained or dropped (in this example, based on their contributions to planning objectives). The PDT may decide to drop the management measure “place cobble/gravel instream” in Figure 4 from further consideration because of its lack of effectiveness in meeting most of the planning objectives.

Management Measures	Ability to Achieve Planning Objectives (Effectiveness)			
	Objective: Increase/Restore Aquatic Habitat	Objective: Increase/Restore Riparian Habitat	Objective: Increase River/ Floodplain Connectivity	Objective: Reduce Damages to Water Treatment Plant
Instream grade control structures	High	High	High	High/Moderate
High flow detention ponds	Moderate	Moderate	Moderate	Moderate
Terrace banks	Moderate	High	High	Low
Place cobble/ gravel instream	Low	None	None	None
Place armor/ rip rap on banks	Low	Low	None	High
Plant native vegetation on banks	High	High	Moderate	Moderate

Figure 7. Effectiveness as Screening Criterion (Using Color-Coding) for Dry Creek Management Measures

Example #3

In the following example from the Lower Santa Cruz River, Arizona, FRM Feasibility Study, the PDT used the four P&G criteria to evaluate and screen various management measures during early plan formulation using a score of 1-3, with "3" meaning the criterion would be fully met, "2" indicating the criterion would be partially met, and "1" indicating the criterion would not be met. Due to the limited ability to generate new data prior to the Alternatives Milestone, scores for each criterion relied principally upon existing data and professional judgment.

Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities (P&G Section VI.1.6.2(c) (2)). Measures or alternative plans that clearly make little or no contribution to the planning objectives should be dropped from consideration. Measures were scored for effectiveness based on the following:

3: The measure fully meets the objective(s).

2: The measure partially meets the objective(s).

1: The measure does not meet the objective(s).

Efficiency is the extent to which an alternative plan is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment (P&G Section VI.1.6.2(c)(3)). Benefits can be both monetary and non-monetary. Measures or alternative plans that provided little benefit relative to cost should be dropped from consideration. Measures were scored for efficiency based on the following:

> 3: The measure provides the most benefits for the least cost or provides desirable benefits (outputs that meet several objectives) for similar costs to measures that provide more limited benefits (outputs that meet only a few objectives).
>
> 2: The measure provides benefits that meet one or more objectives but these benefits are more limited or more expensive than other similar measures.
>
> 1: The measure is costly and provides minimal output.

<u>Acceptability</u> is the workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies (P&G Section VI.1.6.2(c)(4). Acceptability means a measure or plan is technically, environmentally, economically, and socially feasible. However, the PDT separated the Acceptability criterion into two dimensions to reflect both a) implementability (whether the plan is technically, environmentally, and economically feasible) and b) satisfaction (whether the plan is feasible or may pose a major "roadblock" from the perspectives of key stakeholders such as the non-Federal sponsor, resource agencies, and the general public). Measures were scored for these two dimensions of acceptability based on the following:

Implementability:

> 3: Easy to implement
>
> 2: There would be some institutional barriers to implementing the measure (e.g., the measure would require additional agency permissions or permits).
>
> 1: There are legal barriers to implementing the measure.

Satisfaction:

> 3: The measure is largely acceptable to all stakeholders.
>
> 2: There would be some political barriers to implementing the measure.
>
> 1: The measure would likely be totally unacceptable to major stakeholders.

<u>Completeness</u> is a determination of whether or not the plan includes all elements necessary to achieve the objectives of the plan. It is an indication of the degree that the outputs of a plan are dependent upon the actions of others. Completeness was not evaluated at this stage of the

planning process (screening of management measures) because even if measures are not deemed complete individually, they may be subsequently combined with other measures to form alternatives that do meet planning objectives.

In this study, the scoring results were compiled and averaged. After scoring, the PDT reviewed the results and confirmed that the highest scoring measures should be retained. The lower scoring measures were reviewed further, and some were indeed screened out. Results of this screening were documented in the feasibility report.

Conclusion

A criterion is something decision makers care about and something that can influence the decision makers' choice. You should expect the screening/decision criteria for a Corps planning study to reflect the study's planning objectives and constraints. Criteria may vary from decision-to-decision and between milestone meetings during the planning process.

Likewise, it is expected that the same criterion, for example "effectiveness," may be measured differently (qualitatively and quantitatively) throughout the planning process, with detail, specificity, and certainty increasing as the study progresses. While quantitative, objective decision criteria should be used for TSP selection and feasibility level optimization of the TSP, scoring metrics as simple as color-coding, H/M/L, numeric scoring, and yes/no may be acceptable for screening and initial evaluations. Another best practice is to use spreadsheets to keep track of the decision criteria used and how they were measured throughout the planning process. This record can then be included in summary or in detail as appropriate in the feasibility report or in a plan formulation appendix.

Topic 7: Level of Detail Needed Throughout the Planning Process

What is it?

The *Planning Manual Part II: Risk-Informed Planning* stresses the importance of collecting the appropriate level of detail to make the decision at hand while considering the risk of not gathering additional information. The greatest challenge is balancing the time, effort, and expense of gathering more evidence to reduce uncertainty versus the risk of making a poor decision. This section provides examples for Planning Mentors to use in assisting teams with determining the appropriate level of detail necessary throughout the planning process.

Who develops it and when is it developed?

As explained under Topic 4, rapid iterations are an essential process to enable risk-informed planning. Iterations of the planning process can be used to reduce uncertainty strategically throughout the process to gather data at the optimal time to make the next decision. Ideally, each iteration includes at least the key multi-disciplinary PDT members. Members from each discipline make the determination whether they have enough information available to make the next decision at that stage of the planning process (or iteration). Each iteration will include progressively higher levels of detail.

- **1st iteration** – at the beginning of the scoping phase (first 30 days), document the information the team knows at that time and the information that needs to be gathered
- **2nd iteration** – during the scoping phase (first 90-100 days), conduct a second iteration with information gathered prior to the AMM and to inform the Alternatives milestone decision
- **3rd iteration** – during the alternatives evaluation phase (within 1 year), develop the quantitative information necessary to compare the alternatives and select a TSP
- **4th iteration** – during the feasibility analysis phase, develop information needed to optimize the recommended plan, certify costs, and reduce instrumental risks to acceptable level

Advantages

During each iteration, the PDT should focus on reducing *instrumental uncertainties.* Instrumental uncertainty refers to things that could affect the decision. *Relevant uncertainty* refers to things people may care about but things that will not change the decision. While reducing relevant uncertainties can *feel* essential, focusing on reducing those instrumental uncertainties that can or will affect the next planning decision is a critical component of getting the right information at the right time and eliminating collection of data that is unnecessary. Note that Figure 5 below refers to “constraints” but these refer primarily to budget and schedule constraints as opposed to planning constraints.

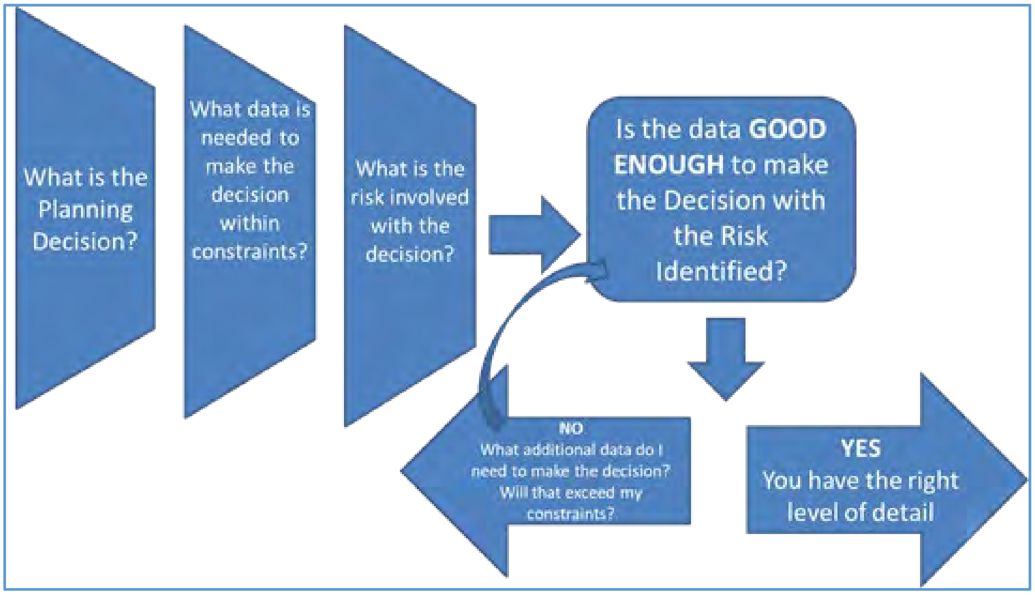


Figure 8. Risk-Informed Approach to Answering Level of Detail

Examples of Levels of Detail

Table 1 below offers examples of the appropriate level of detail necessary throughout the planning iterations for all studies in general and by select business lines.

Table 1. Examples of Level of Detail throughout Planning Iterations

Steps	**Scoping**	**Alternative Evaluation & Analysis**	**Feasibility Analysis of Selected Plan**
General	Qualitative data/ high uncertainty. Existing Information. General descriptions of measures/ alternatives, qualitative estimate of benefit (H, M, and L), order of magnitude cost estimates.	Quantitative data/ medium uncertainty. New information gathered. Conceptual level design, comparable analysis of benefits amongst alternatives, level 1 or 2 cost estimates, rough estimate of real estate costs.	Quantitative data/ low uncertainty. Higher level of detail for information. Feasibility (~10-30%) level design, optimized NED benefits, level 3 cost estimate to support certification; real estate cost estimate or appraisal as appropriate.
Examples	**Scoping**	**Alternative Evaluation & Analysis**	**Feasibility Analysis of Selected Plan**
Flood Risk Management	Existing maps, info on flooding, trends, census/ HAZUS data, levee safety. General categories of measures to be included (levees, floodwalls, detention basins, non-structural, nature-based) evaluated using qualitative screenings.	H&H info, structure inventories, geotech info, wetland/habitat surveys. Site-specific footprint of measures with conceptual design and assumptions related to size of structure that may be appropriate; evaluated using HEC-RAS and HEC-FDA. If low benefits are a concern, consider modeling max potential benefits and screening alternatives based on parametric cost estimates. Identify potential mitigation needs and costs of alts.	Detailed analysis of Recommended Plan (RP) to include multiple heights/sizes of structures in the RP in order to optimize NED benefits. Conduct life safety analysis of RP. Model habitat losses and mitigation options for optimized plan using eco models and CE/ICA.
Coastal Storm Risk Management	Existing coastal storm / storm surge / flooding hazard maps, records of coastal storms, sea level rise trends and projections, census / HAZUS data, records of shoreline movement and beach/dune erosion. General categories of measures to be included (beach nourishment, dune restoration, seawalls, jetties, shoreline stabilization, non-structural, nature-based) evaluated using qualitative screenings and combined into alternatives	Model inputs (meteorological data, coastal morphology, economic data, emergency management practices, etc.). Site-specific footprint of measures with conceptual design and assumptions related to size, length, width, and height of structure that may be appropriate; evaluated using Beach-FX or other appropriate software. If low benefits are a concern, consider modeling max potential benefits and screening alternatives based on parametric cost estimates. Identify potential mitigation needs and costs of alts.	Detailed analysis of Recommended Plan to include multiple heights of structures in the RP in order to optimize NED benefits. Conduct life safety analysis of RP. Model habitat losses and mitigation options for optimized plan using eco models and CE/ICA.

Table 1, continued.

Examples	Scoping	Alternative Evaluation & Analysis	Feasibility Analysis of Selected Plan
Ecosystem Restoration	Existing maps, info on species and habitats of concern, trends. General categories of measures to be included (wetlands, in-stream habitat, fish passage) evaluated using qualitative screenings.	H&H info, habitat surveys, information to feed eco model(s). Site-specific footprint of measures with conceptual design and assumptions related to size of features, eco modeling completed and CE/ICA conducted. Consider potential high-level adaptive management (AM) needs along with parametric costs. If AM vastly different amongst alternatives, include in analysis.	Detailed analysis of Recommended Plan to include specific alignment of features. Develop detailed monitoring and adaptive management plan and include costs in certified cost estimate.
Deep Draft/ Inland Navigation	Existing vessel traffic and commodity forecasts, information on species of concern, potential dredged material disposal sites. General categories of measures to be included (deepening, widening, lengthening, training walls, expansion/replacement of lock chambers, non-structural) evaluated using qualitative screenings and combined into alternatives.	Develop vessel traffic and commodity forecasts. Conduct sediment sampling and habitat/ species surveys. Specific footprint of measures and multiple depths/ widths analyzed as appropriate. Assumed quantities and disposal locations based on initial sampling results.	Feasibility level ship simulation of recommended plan to address safety concerns and inform design. Refined quantity estimates. Optimized depths/ widths/ lengths as appropriate.

Conclusion

Determining the appropriate level of detail at any given point in the planning process is often one of the most challenging questions for many PDT members to address. While having more information generally reduces uncertainty and gives planners and other PDT members greater confidence in their decisions, reducing that uncertainty usually comes with associated study costs in terms of time, effort, and expense. Focusing only on instrumental uncertainties (i.e., that can affect the decision at that stage or iteration of the planning process) can help PDTs strike that balance. Rather than collecting all the information that will eventually be needed upfront, PDTs should focus on reducing the instrumental uncertainties during each iteration.

Topic 8: Risk Informed Planning and Decision Making

What is it?

Risk-informed planning is basically the marriage of the USACE traditional six-step planning process (aka, the "beehive") and the USACE risk management framework. Just as Planning has always been about solving problems and making decisions under uncertainty, risk management is a decision making framework for making decisions under uncertainty. Risk-informed planning provides tools to efficiently reduce uncertainty by gathering only the evidence needed to make the next planning decision and to manage the risks that result from doing so without more complete information. Figure 6 below shows the blending of the six-step planning process and risk management framework to constitute Risk Informed Planning.

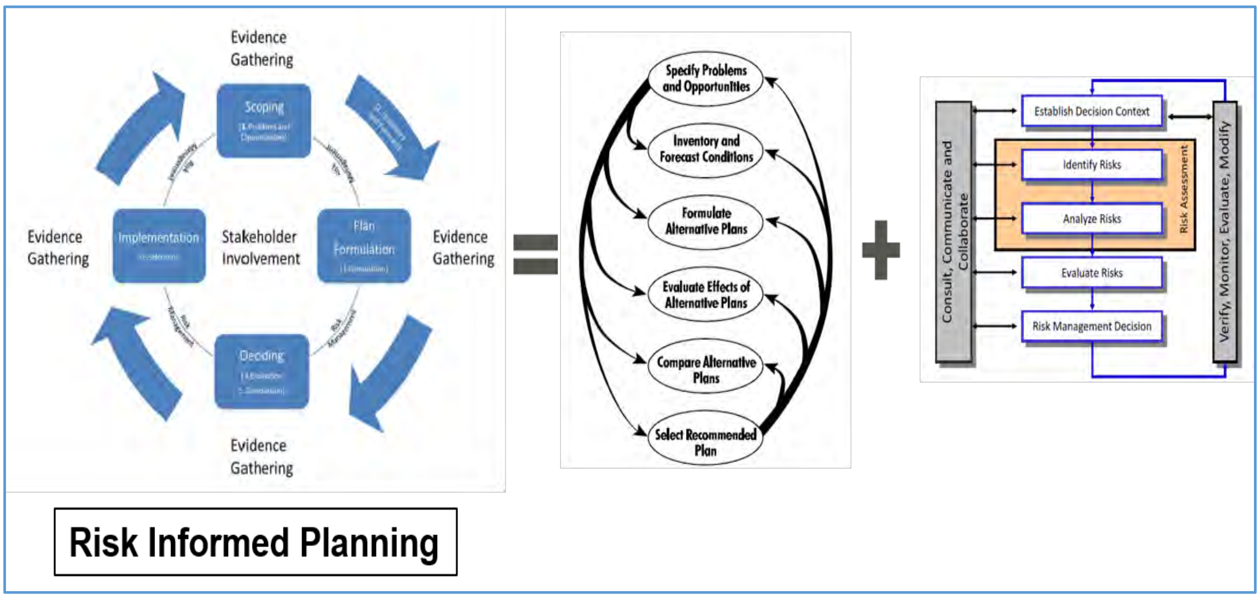


Figure 9. Risk Informed Planning in Relation to the Six-Step Planning Process and the Risk Management Framework.

What are these risk informed planning tools, who develops them, and when?

The *Planning Manual Part II: Risk-Informed Planning* offers many examples and tools of risk informed planning, some of which are highlighted in this Handbook: conducting several rapid iterations of the planning process as the study progresses; developing the six pieces of paper as part of scoping the study; conducting charette(s) to perform a rapid iteration(s); thinking about problem identification as "Risk Identification;" developing a risk register to identify study, implementation, and outcome risks, as well as options to manage those risks; thinking about the future without project condition as multiple future scenarios, and realizing that the level of detail associated with the FWOP will evolve as the study progresses; developing plan formulation strategies to think about various ways to tackle problems and meet planning objectives; identifying decision criteria of varying specificity and level of detail to be used for initial screening through evaluation of alternatives to optimizing the TSP; and a risk assessment of the TSP. These tools are usually developed collectively by PDT members throughout the feasibility study process, from the very first scoping meeting to the selection of the TSP and recommended plan.

Advantages

The chief advantage Risk Informed Planning or Risk Informed Decision-Making (RIDM) is to efficiently reduce uncertainty by gathering only the evidence needed to make the next planning decision and to manage the risks that result from doing so without more complete information. This allows studies to make progress from Day One, to streamline and economize data collection by using existing information and expertise to the greatest extent practicable, to advance even under time and budget constraints (through risk management), and to disclose to decision-makers and stakeholders, as well as proactively manage, implementation and outcome risks.

Examples

Figure 10 Heavy metal contamination of floodplain sediment, shown above, is addressed using RIDM in the St. Louis Riverfront-Meramec River Basin Ecosystem Restoration Feasibility Study, Missouri.

Many planners ask how Risk Informed Planning or RIDM plays out in feasibility studies. The easiest way to demonstrate what RIDM means for various business lines is simply to offer examples. Reducing uncertainty and instrumental risk for a FRM study may be achieved by the decision to spend significant time and money to gather geotechnical borings prior to screening the final array of alternatives and deciding on the TSP. Conversely, an Aquatic Ecosystem Restoration (AER) study may reduce instrumental risk and uncertainty very little after spending the time and money on geotechnical borings, and the RIDM process would lead the PDT to conclude that borings-related data is not necessary to make the TSP selection. Data gathering and analysis on sediment transport in a stream may be far more valuable for the AER study in reducing instrumental risk and uncertainty. For any study where data gathering and analysis is considered, part of RIDM includes the scale of data gathering analysis, and determining how much is needed to make a decision, even though that may be far less detail than needed for Preconstruction Engineering and Design of the recommended plan.

In terms of examples from specific studies, planners may ask what risk identification looked like, or how was the qualitative risk assessment of the TSP conducted? Examples of how RIDM was applied to both an AER project (St. Louis Riverfront - Meramec River Basin Ecosystem

Restoration Feasibility Study, Missouri) and a coastal storm risk management study (Florida Keys Coastal Storm Risk Management Feasibility Study, Florida) are summarized in the following PowerPoint presentations.

Skaggs RIDM for AER Mentors KC Aug 201

Skaggs PA 2019 CSRM Course Risk Pl

Conclusion

The *Planning Manual Part II: Risk-Informed Planning* offers many excellent "generic" examples and tools to conduct risk informed planning and RIDM. Planners and mentors should consult the Planning Manual Part II on a frequent basis. In addition to the two examples cited above, as specific examples of how RIDM has been successfully applied to various business lines or project purposes unfold across USACE, they can be added to this Handbook, presented as webinars, and offered as case studies in training courses.

Topic 9: TSP Risk Assessment

What is it?

The TSP Risk Assessment is a tool that will help teams better understand their TSP and potentially help identify risks that should be managed as the study moves into PED, construction, and monitoring. According to the *Planning Manual Part II: Risk-Informed Planning,* Section 10.4, "Following their choice of a TSP, the PDT should conduct at least a qualitative risk assessment of this plan in order to identify the residual risk that remains with the plan, if they were not included among the decision criteria, and to identify any new, transformed, or transferred risks generated by the new plan."

Also, Planning Bulleting (PB) 2019-04, *Incorporating Life Safety into Flood and Coastal Storm Risk Management Studies*, requires that for flood and coastal risk management studies a risk assessment be performed to evaluate life safety risks and the tolerability of any proposed dams, levees, or floodwalls. For those studies, greater coordination with their respective PCX and possibly the Risk Management Center (RMC), Dam Safety Modification MCX, or Levee Safety Center will be needed to identify the right level of detail.

For many studies, a qualitative risk assessment is probably sufficient to identify most risks, but particularly for flood and coastal risk management studies, some form of semi-quantitative or quantitative risk assessment may be more appropriate. This discussion focuses more generally on the TSP Risk Assessment, and not the specifics of PB 2019-04.

Who develops it and when is it developed?

The TSP Risk Assessment should be developed after the TSP milestone meeting. The PDT should develop the risk assessment and also seek input from those who have been outside the process and may not have been influenced by any biases developed by the team over time.

One tip to developing the risk assessment is to use "Inverse Brainstorming". Inverse brainstorming allows people to unleash the destructive energy we all hold back in ourselves. The concept is fairly simple – start with assuming that your TSP is satisfactory. Then start nitpicking it. Ask yourselves "What can go wrong?", "What could prevent us from achieving our benefits?", "Does our plan create new hazards or transfer existing ones to another area?"

The PDT is looking to both understand what the residual risks of the TSP are (i.e., the risk that remains after we implement the TSP) and what are the things that could prevent us from realizing the benefits of the TSP.

Advantages

The TSP Risk Assessment can help PDTs identify any "loose ends" they may need to clean up before a final report, but it will ideally serve as the primer for risk management as the study progresses into PED, providing a solid foundation for understanding the past and future risks associated with the project.

Examples of TSP Risk Assessments

The St. Louis Riverfront - Meramec River Basin Ecosystem Restoration Feasibility Study, Missouri, completed in July 2019, included a qualitative risk assessment of the TSP to identify the residual risk that remains with the plan. The PDT identified both 1) *implementation risks* (i.e., what can affect the efficacy, quality, timing, and budget of the built project?); and 2) *outcome risks* (i.e., what are the residual, new, transferred or transformed risks attributable to the recommended plan?). Two implementation risks were identified. 1) Potential CERCLA liability could result in unexpected clean-up costs or litigation (identified as a "medium" risk driven by low likelihood and high consequences). To mitigate for this risk, the PDT recommended continuing and consistently collaborating with USEPA, and that soils at the project sites would be tested for contaminants during PED. 2) Specific restoration sites could change during the PED phase (identified as a "medium" risk driven by high likelihood and low consequences). To mitigate for this risk, the PDT performed a sensitivity analysis on potential site location shifts and reduced scale scenarios to show continued Federal interest and that overall ecological benefits were not highly dependent on the exact location of sites. One outcome risk was identified, namely that constructed habitat restoration features could change during high river flows (identified as a "medium" risk driven by low likelihood and high consequences). To mitigate for this risk, the PDT followed the designs and monitored similar USEPA Pilot Project sites, and developed a robust adaptive management plan.

See the complete "St. Louis Riverfront - Meramec River Basin Ecosystem Restoration Feasibility Study, Missouri," July 2019, for more details on the qualitative risk assessment conducted on the TSP and recommended plan:
https://www.mvs.usace.army.mil/Portals/54/docs/pm/Reports/FS/MeramecFSFinalReport.pdf?ver=2020-01-03-092246-990

For reference, an example summarizing the qualitative risk assessment performed to evaluate life safety risks associated with a flood risk management study, as required by Planning Bulleting (PB) 2019-04, for the Lower Mud River Flood Risk Management Project, West Virginia, Validation Study (July 2019) is provided below.

Lower Mud River
FRM Risk Assessment

Conclusion

The TSP Risk Assessment is a tool that helps the broader life-cycle management of a project and takes advantage of the expertise the team has developed throughout the study, captures their concerns, and provides a solid foundation at managing risk as the study progress from planning, to PED, and through construction.

Topic 10: Life Risk Assessment

What is it?

Life risk is an element of "social effects." It is appropriately displayed in the Other Social Effects (OSE) account. Life risk is incorporated in project analysis from the beginning of the study process. As with all study elements, the level of effort in undertaking a life risk assessment will be based on its importance to the potential project. Both qualitative and quantitative approaches may be used depending on the nature of life risk.

The consideration of life risk in a feasibility study requires examination of concepts such as human behavior and societal and individual life risk. Factors that influence life risk analysis for a riverine or coastal flood risk management project include, but are not limited to, the depth and velocity of flooding, flood arrival time, infrastructure performance, socio-economic characteristics of the population, fatality rate thresholds, warning systems, warning time, warning effectiveness, evacuation plans, emergency response, and other physical and preparedness measures.

> ***Flood Risk*** is the measure of the probability (or likelihood) and consequence of uncertain future events. Flood Risk is determined by (Figure 7): the hazard (what can cause harm); the performance or response of the infrastructure to the hazard; the exposure of population to the risk; the vulnerability of the population at risk (PAR) to harm; and the consequences (probability and severity of adverse consequences).

Figure 11. Components of Flood Risk

> ***Life risk***, in the context of riverine or coastal flood risk management infrastructure, is the combination of likelihood and the extent of life loss because of a hazard or lack of system performance. This can include both direct life loss from the hazard (e.g., from the flood), as well as indirect life loss. In the case of considering life risk for flood or coastal storm risk management projects, an example of indirect life loss may occur from

a loss of essential services such as hospitals or fire departments as a result of the hazard occurring.

Residual life risk is often limited to situations describing the life risk that remains after a proposed flood or coastal storm risk management project has been implemented (in the past, present or future).

Incremental life risk is the risk of inundation posed by infrastructure, such as a levee or dam. A properly designed and constructed, well-maintained piece of infrastructure can perform well for the duration of its intended life. Incremental risk is attributed to situations when the infrastructure does not perform as intended, such as breaching prior to or during overtopping, malfunction, or mis-operation; and the subsequent consequences from that infrastructure malfunction. Generally, the potential for poor performance of a dam or levee should not appreciably increase the chance for someone to lose their life who resides or works behind or near that levee or downstream of that dam.

Tolerable risk, in the context of USACE flood risk management projects involving levee systems or dams, is the incremental risk that society is willing to accept to secure the benefits of living and working in the leveed or dammed area. To guide the understanding and significance of incremental risk USACE has developed tolerable risk guidelines (TRGs) for levees and dams. Tolerable risk guidelines address the questions: *Are the risks commensurate with the benefits (TRG-1)? Are risks being assessed, managed, and communicated (TRG-2)? Is the owner acting reasonably (TRG-3)? Is there more that should be done (TRG-4)?*

fN Plots/Charts (Probability Distribution of average annual Life Loss) are a way to summarize our quantitative understanding of INCREMENTAL life risk relative to USACE adopted societal and individual risk thresholds (see Figure 8 below). The *societal risk line (SRL)* represents the general tolerability of life risk by the population at large; as probability decreases, tolerable consequences (i.e., average life losses) increase. The *individual risk line (IRL)* represents the life risk that individuals, or groups of individuals, accept on a daily basis from all environmental factors (1 in 10,000 per year). The SRL and IRL have been adopted by USACE based on a broad spectrum of government and industry practices, including International Organization for Standardization (ISO). The purpose of assessing these risks relative to our FRM/CSRM projects is to ensure that our proposals are not unreasonably increasing these risks, while the general goal is to decrease risk down and to the left. There could also be exceptions where risk that plots above the SRL and/or IRL are deemed acceptable depending on how a plan is evaluated with respect to all four tolerable risk guidelines (TRGs).

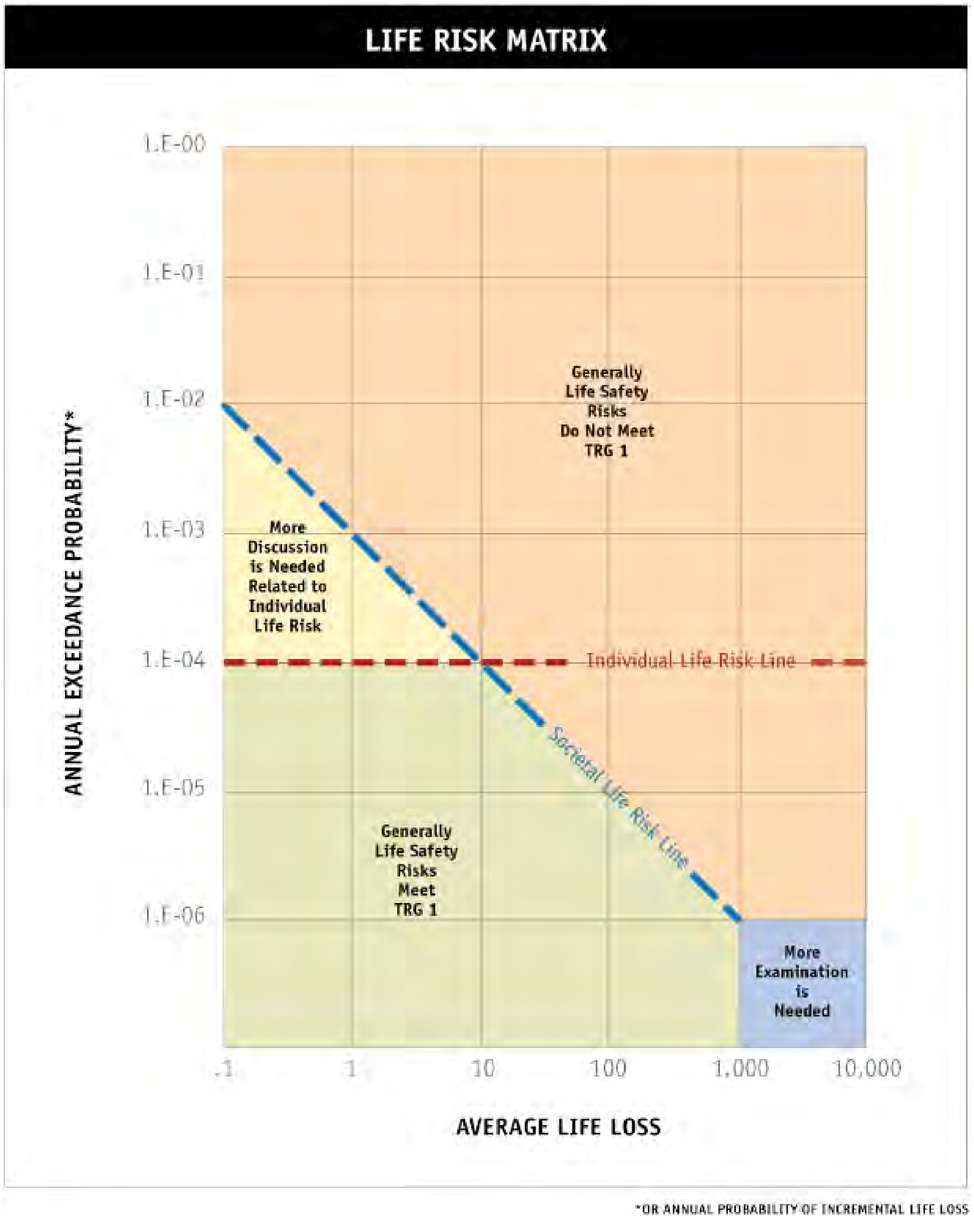


Figure 12. fN Plot/Chart

Who develops it and when is it developed?

Any life risk analysis is a true team effort and will require input from planners, engineers and economists. It is required to engage the district Dam and/or Levee Safety Officers (DSOs and LSOs) and Dam and/or Levee Safety Program Managers (DSPMs and LSPMs) when formulating plans that consider new dams and/or levees or modify existing dams and/or levees. As the complexity of the life risk analysis increases, as dictated by the influence of life risk on decision making, the responsibility and timing of the development of the analysis shifts. More complex analysis should be managed by personnel trained in developing and facilitating life risk assessments.

Qualitative and lower level detail analysis can and should be used early in the planning process and to support decisions that are not influenced by life risk (see "*Tips for Conducting Life Risk Assessments in the 1st 90 days of an FRM Study").* Semi-Quantitative risk analysis (SQRA) should be used when decisions in the study are influenced or driven by life risk (with full Quantitative risk analysis (QRA) generally not occurring until PED (if at all)). If a study requires a consideration of incremental risk, then the study team should seek to involve a Risk Management Center (RMC) approved risk assessment facilitator to help scope the risk analysis for the study. Regardless of the scope of the life risk assessment, it's imperative that teams can clearly communicate the sequence of events that happen (related to Hazard, Performance and Consequences) and lead to life risk for their particular study area.

If during scoping, the PDT believes life risk will play a large role in decision making and plan selection, early coordination with the appropriate Planning Center of Expertise (PCX) is also strongly encouraged.

Advantages

The consideration of life risk is a requirement for all FRM and CSRM studies (see PB 2019-04 for additional details) and is always an important piece of the puzzle in communicating flood risk. Life risk is also a subset of OSE and can meet the requirements of a four accounts evaluation for OSE. Reduction in life risk can also be part of the justification used to select a particular plan (which requires an NED exception to be approved by the ASA(CW) if not the NED plan).

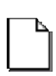
Examples and Resources

Even though the guidance laid out in PB 2019-04 is relatively new, there are some good resources and examples that teams can use to help them successfully incorporate and perform their life risk assessments at varying levels of detail.

Examples of Life Risk Assessments

Example 1: San Luis Rey Validation Study

This is a good example of a quick scaled semi-quantitative life risk assessment using available data from the Levee Screening Tool (LST) for existing/without project conditions and then making modifications to the LST to mimic with project conditions. This type of assessment would be most appropriate where there are existing levees as an initial assessment of life risk. If the initial assessment shows incremental or residual life risk to be very low, then this technique could be good enough. If life risk is shown to be moderate, then additional, more detailed life risk assessments may be necessary.



SanLuisRey_MFR_20
200327_SLRA_Smmr

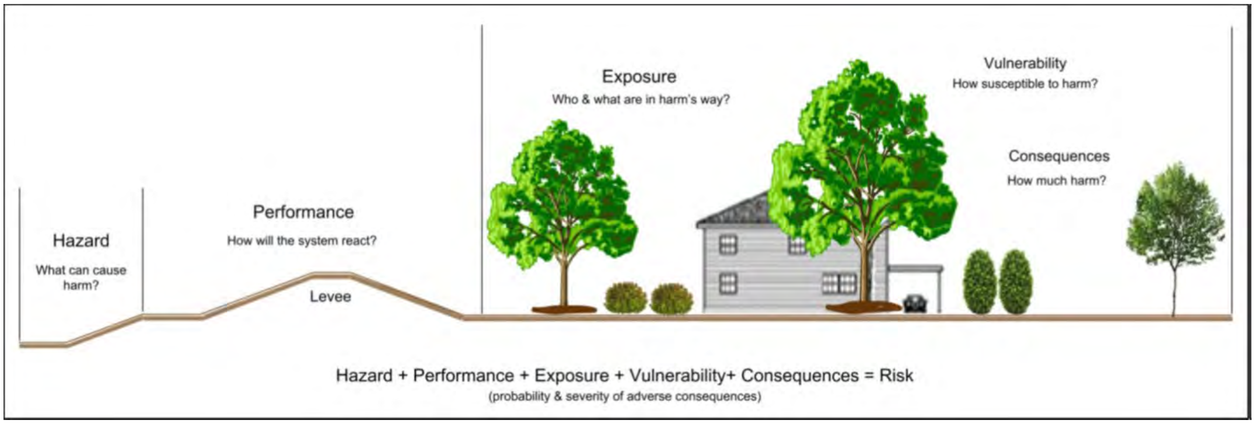


Figure 13 Components of flood risk, Portland Metro Levee System Feasibility Study.

Example 2: Portland Metro Levee System Feasibility Study

This is a good example of what you might see for a typical life risk assessment for an FRM Feasibility study with moderate to high incremental and/or residual life risk. Of particular note, Chapter 7 of the Life Risk appendix (attached) shows an effective way to describe and communicate order of magnitude (OoM) incremental life risk on an fN Chart for varying failure modes under FWOP and with-project conditions to clearly show how the alternatives impact life risk. Moving down and to the left on an fN Plot means life risk is decreasing.

PLMS_Appdx
Z_LifeLoss_PMLS_DFF

Resources

- *FRM-PCX Webinar 6: Incorporating Life Safety in FRM Planning Studies*: https://planning.erdc.dren.mil/toolbox/resources.cfm?Id=0&WId=491&Option=Planning%20Webinars
- *FRM-PCX Webinar 7: Life Safety Risk Assessments in FRM Planning Studies*: https://planning.erdc.dren.mil/toolbox/resources.cfm?Id=0&WId=491&Option=Planning%20Webinars
- *Tips for Conducting Life Risk Assessments in the 1st 90 days of an FRM Study*. Note that this document is a living document and is not meant to serve as formal requirements or guidance. This is solely meant as a resource giving PDT's helpful tips in scoping and conducting their life risk assessments. https://cops.usace.army.mil/sites/PLAN/pcx/FRMPCX/FRMPCX%20Documents/Best_Practices/Tips_for_Life_Risk_Assessments_in_the_1st_90_days-June_2020.pdf

Tips for Life Risk
Assessments in the 1s

Conclusion

While the formal requirements for evaluating life risk in FRM and CSRM planning studies is evolving, assessing and addressing life risk in conjunction with NED has always been a part of comprehensive and holistic Civil Works plan formulation. PDT's should be encouraged to utilize all resources available to them in order to seamlessly and efficiently integrate life risk with economic damage assessments. Hydrology, Hydraulics and Geotechnical inputs should be carefully scoped so that they can be leveraged by both the life risk and economic damage analysis for consistency and efficiency. LSPMs, LSOs, DSPMs, DSOs and PCXs are critical to the success of life risk assessments and must be involved from the beginning on studies with existing or new levees and/or dams.

Topic 11: Climate Change Assessment

What is it?

The climate change assessment is an evaluation of how the performance of a project alternative may change over the project's life cycle due to reasonably foreseeable changes to climate and hydrology in the project area (Figure 9). For example, by the late-21st century, more frequent, more intense rainfall in a watershed might result in increases in the frequency of the current 1% AEP (annual exceedance probability) flood so that flows of this magnitude become the 10% or 50% AEP flood, and the stage height of the 1% AEP flood increases. At that future timeframe, levees built to the current 1% AEP flood would no longer provide the same damage and life safety risk reductions that they do today. The project design needs to either take these projected changes in performance into account (e.g., build now so the desired performance is still achieved in 2085), or show benefits declining below the stated performance criteria over the analysis period and inform the non-federal sponsor of this estimated performance change so they can take action (e.g., use zoning to restrict development in the area of future flood inundation). The climate change assessment is the first step in understanding how project performance may evolve over time due to changes in hydrology.

Figure 14. Changes to both flood and drought frequencies and magnitudes are anticipated as a result of climate change.

Under the Risk-Informed Planning paradigm, the scope of the climate assessment should be targeted to the decision(s) being made and the measure(s) or alternatives under consideration. For example, the assessment for a flood risk study in the lower reaches of a major river with significant life-safety concerns may need to be more comprehensive, more detailed, and more quantitative than for a small watershed assessment project in a rural watershed with few assets or people at risk.

Who develops it and when is it developed?

A qualitative climate change assessment can be developed by any individual who has been through the Climate Preparedness and Resilience Community of Practice (CPR CoP) training (planner, hydrologist, or other PDT member) or has prior experience conducting climate assessments. However, quantitative assessments, if required, should be completed by the project's hydrologic or hydraulic engineer in collaboration with a subject matter expert identified by the CPR CoP. Online tools and information needed to complete these analyses are available at the CRP CoP Applications Portal (https://maps.crrel.usace.army.mil/projects/rcc/portal.html). Additional information and climate change assessment guidance can be found on the CPR CoP site at https://www.usace.army.mil/corpsclimate/.

A climate change assessment is required for all USACE hydrologic analyses. Because climate change may affect the future without project condition, and therefore future project performance, the assessment needs to be done early in the project and the results of the assessment should inform the evaluation and selection of management measures and alternative plans.

When keyed to planning milestones used for feasibility studies, the ideal timeline includes the following steps:

1. Prior to the Alternatives Milestone (AMM):
    a. Identify climate factors that currently contribute to the problems and opportunities.
    b. All inland hydrology analyses must follow the steps laid out in ECB 2018-14, "Guidance for Incorporating Climate Change Impacts to Inland Hydrology In Civil Works Studies, Designs, And Projects" (https://www.wbdg.org/ffc/dod/engineering-and-construction-bulletins-ecb/usace-ecb-2018-14). The PDT must also determine whether a quantitative hydrology assessment is needed, and within the study scope and budget. This will depend on the kinds of problems and opportunities identified for the study.
        i. If yes, the PDT must coordinate with the CPR CoP Lead before the Alternatives Milestone.
    c. If the elevation of the project area is ≤ 50 ft NAVD88 or is along a water body within the zone of tidal influence, the PDT should assess whether sea level change is likely to affect the project hydrology.
        i. If yes, plan to conduct analyses consistent with *ER 1100-2-8162, "Incorporating Sea Level Change in Civil Works Programs"* (https://www.publications.usace.army.mil/Portals/76/Users/182/86/2486/ER_1100-2-8162.pdf?ver=2019-07-02-124841-933) before the Tentatively Selected Plan (TSP) milestone.
        ii. For coastal projects, it is possible for changes in sea level to affect riverine flood elevations. The potential for such impacts should be evaluated for coastal projects and included in the assessment as warranted by location, scope, and budget.
2. Climate change analysis must inform identification of management measures, formulation and evaluation of alternatives, and identification of the TSP. Therefore, as

early as possible in the planning process (i.e., ideally before the AMM, but definitely before the TSP milestone), the following should be performed:

   a. Describe the existing conditions, including literature review and historic trends analysis using the USACE Climate Hydrology Assessment Tool (CHAT), Nonstationarity Detection Tool, and/or Time Series Toolbox. These and other tools can be accessed from the CRP CoP Applications Portal.
   b. Describe the future without project conditions, including literature review, and analysis of future conditions.
      i. A qualitative climate change assessment should be completed for all analyses. Online tools to assist with these analyses include using the CHAT and Civil Works Vulnerability Assessment tools.
      ii. If necessary, quantitative hydrologic and/or sea level change analyses should also be completed in coordination with the CPR CoP, and the results included as inputs to the hydrologic and/or hydraulic modeling for the project.
      iii. Online tools to assist with the sea level change analysis, the Sea Level Calculator and Sea Level Tracker, are available from the CRP CoP Applications Portal.
   c. Future with project climate conditions should be the same as the without project (in NEPA language, the impact of the action on the resource).
      i. A simple sentence to that effect should be included.
      ii. Exceptions to this are likely only in the case of large wetland and/or new reservoir construction (discuss with CPR CoP Lead and/or assigned ATR reviewer).
      iii. Because there is not currently an authoritative method for assessing greenhouse gas emissions and reductions as a result of USACE activities, greenhouse gas accounting should not be conducted as part of the climate change assessment. It is not currently required under the National Environmental Policy Act (NEPA).
      iv. The impacts of the project on future hydrologic conditions in the project area would still need to be discussed in the appropriate sections (e.g., if the project alters the stage-frequency relationship in a stream) per other USACE guidance.

3. Once the TSP has been selected, include a section in the feasibility report that describes residual risk associated with implementing the TSP and summarize the risks and uncertainties due to climate change for the TSP.
   a. Discuss whether and how climate change impacts were included to make the project more resilient.
   b. Any climate impacts that were not addressed in the project design are considered “residual performance risks.” Describe the residual performance risks resulting from changed climate conditions. This should be accompanied by a table that provides the following information: the measure being recommended for construction, the trigger (the changed climatic condition in the future), the hazard (hydrologic problem caused by the trigger), the harm (how this may

change project performance), and the qualitative likelihood (how likely is the harm to occur).

c. There may be other sources of residual risk, for example the 1% annual risk of overtopping a levee designed to provide protection from the 1% AEP flood. It may be helpful to the sponsor's understanding to have a section at the end of the description of the Recommended plan in the final feasibility report that discusses both climate and non-climate residual risks. This encourages the sponsor to think explicitly about other actions they might take locally to "buy down" this risk.
d. This information should be presented in the main document (it may also be included in the risk register).
    i. This information should also be repeated in other documents that go to the sponsor such as the Design Documentation Report, Monitoring Plans, and Operations, Maintenance, Repair, Rehabilitation and Replacement (OMRR&R) Manuals.
    ii. There are many opportunities for the sponsor to buy down future risk that are outside the scope of a USACE study. Inclusion of the residual risk information in these documents alerts the sponsor to the problem. If this information only exists in the project risk register, the sponsor is unlikely to see it and may fail to take actions they might otherwise have taken to reduce risks due to climate change.
e. Where uncertainty about the nature and timing of climate change impacts persists, there's an opportunity to establish a monitoring program that can identify critical performance thresholds that, once exceeded, trigger renewed planning or implementation of specific measures.

Advantages

Most of the infrastructure that USACE builds and operates has a life cycle of 50 years or more. Taking account of the impacts of climate change on project performance will allow USACE-built infrastructure to continue to provide valuable flood risk reduction, water supply, navigation, ecosystem restoration, and conservation services to the nation for the foreseeable future. Conducting a screening level, qualitative climate change assessment early in the study clarifies project performance risks, and along with the quantitative assessment (if required) provides a roadmap for buying down this risk through design changes and education of the sponsor and public.

Examples

The CPR CoP maintains a library of assessment examples on the CRP CoP Applications Portal (https://maps.crrel.usace.army.mil/projects/rcc/portal.html).

Conclusion

Climate change may alter the performance of water resources infrastructure. The USACE climate change assessment process provides a screening-level assessment of future risks to project performance and, where appropriate, quantitative data for adjusting project design to improve long-term project resilience. **A climate change assessment is a required input to all USACE planning studies and should be used to inform the selection of management measures and alternative plans.** As the climate data available to support decision-making matures in richness and accuracy, there will also be opportunities to revisit and revise climate change assessments for USACE projects.

Topic 12: Incorporating the Four P&G Accounts into Planning Studies

What is it?

The Economic and Environmental Principles and Guidelines for Water- and Land-Related Resource Implementation Studies (P&G) (U.S. Water Resources Council 1983) established four accounts to facilitate the evaluation and display the effects of alternative plans. The four accounts are National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ) and Other Social Effects (OSE). Furthermore, on 5 January 2021, the Assistant Secretary of the Army (Civil Works) (ASA(CW)) issued a directive for the U.S. Army Corps of Engineers (USACE) to provide comprehensive documentation of benefits in feasibility studies. Project delivery teams (PDTs) must identify and analyze benefits in total and equally across a full array of benefit categories. The four accounts as follows are defined in Table 2.

Table 2. Summary of the Four P&G Accounts

P&G Account	Description
National Economic Development (NED)	The **NED** account displays changes in the economic value of the national output of goods and services.
Regional Economic Development (RED)	The **RED** account registers changes in the distribution of regional economic activity that result from each alternative plan. Evaluations of regional effects are to be carried out using nationally consistent projections of income, employment, output, and population.
Environmental Quality (EQ)	The **EQ** account displays non-monetary effects on significant natural and cultural resources.
Other Social Effects (OSE)	The **OSE** account registers plan effects from perspectives that are relevant to the planning process but are not reflected in the other three accounts.

Table 3 provides examples of benefits that may be considered within each of the four accounts.

Table 3. Examples of Benefits Within the Four Accounts

NED Benefits* *(*always expressed in monetary units)* • Reductions in flood damages • Reductions in transportation costs • Prevention or reduction of emergency and flood clean-up costs • Increases in willingness to pay for improved quality of recreation • Power generation from a hydroelectric dam • Dollar value of M&I water supply	RED Benefits • Jobs and income generated/supported in a region from project construction expenditures • Jobs and income generated/supported in a region from waterborne transportation and support activities • Jobs and income generated/supported in a region from visitor spending on recreation and tourism related activities
EQ Benefits • Increase in habitat units within the study area • Identification and protection of threatened and endangered species • Mitigation of negative environmental impacts	OSE Benefits • Reduction of life loss or population-at-risk from flooding • Reduction in unemployment or poverty rates • Maintaining community cohesion • Changes in social vulnerability • Community resilience

Who develops it and when is it developed?

The four accounts are considered early in the planning process to ensure appropriate scoping and data gathering in addition to informing metrics that could be used for evaluation and comparison of alternative plans. The metrics are collaboratively developed by the PDT. Considerations related to the four accounts are addressed throughout the traditional six-step planning process and are presented below.

1. **Identify problems and opportunities** - The PDT should consider the relevance of the problems and opportunities to factors that may influence all four accounts. For example, the problem of high wave energy at a harbor may result in damage to infrastructure (NED), erosion of existing near shore habitat (EQ), a reduction in local recreational boater usage (RED), and increased risk to life safety (OSE).
2. **Inventory and forecast conditions** – PDTs may gather data directly pertinent to the NED and EQ accounts during this phase, however, data relating to RED and OSE factors should not be overlooked. For instance, information about the trends in regional jobs and income, social vulnerability, at-risk populations, and population growth may be useful in evaluating RED and OSE benefits.
3. **Formulate alternative plans** – Consideration of the four accounts in plan formulation will help the PDT develop solutions that better align with the needs of the local sponsor and community. The PDT should use this as an opportunity to be open-minded in their formulation by bringing forth measures and alternatives that can address RED, EQ, and OSE factors in addition to the typical NED factors.
4. **Evaluate alternative plans** – During plan evaluation, the PDT should connect evaluation criteria with the specific accounts. For instance, a quantification of life safety risk would be a representation of one factor in the OSE account, just as average annual cost is a representation of a component of the NED account. While quantitative evaluation criteria for the RED and OSE accounts is ideal, qualitative evaluation criteria (e.g. low, medium, high) can be useful in demonstrating consideration of all four accounts and supporting plan selection, especially in early iterations.
5. **Compare alternative plans** – The previously developed evaluation criteria should be used to compare the relative benefits and impacts to the four accounts resulting from the alternative plans. This assessment is often best summarized using a table to depict a side-by-side comparison of the alternative plans and their impact on the four accounts. In most cases, PDTs will want to determine how the evaluation criteria will be used in plan comparison, such as weighting of factors or tradeoff analysis, prior to beginning plan comparison.
6. **Select a plan** – The PDT should clearly demonstrate how consideration of the four accounts were used to support screening and selection of the recommended plan.

Advantages

At times, budget and time constraints have prompted PDTs to focus primarily on the NED account or the EQ account (for example, to identify the NED or NER plans, respectively) while minimally addressing the remaining accounts. However, it is important to consider project benefits and impacts across all four accounts; this supports comprehensive formulation and evaluation of alternatives and leads to optimal Civil Works investment decisions.

Consideration of the four accounts throughout the planning process also supports the Agency's initiative to develop and evaluate holistic plans. On 5 January 2021, the Assistant Secretary of the Army (Civil Works) (ASA(CW)) issued a policy directive for the U.S. Army Corps of Engineers (USACE) to provide comprehensive documentation of benefits in feasibility studies. PDTs must identify and analyze benefits in total and equally across a full array of benefit categories.

Examples

The examples below provide a summary of how the four accounts were applied in a flood risk management study and aquatic ecosystem protection study, respectively.

Study Example 1: Incorporating the Four Accounts in the Río Guayanilla, Puerto Rico (PR) Flood Risk Management (FRM) Study

This study analyzed problems and opportunities regarding life safety, economic sustainability, and the ecosystem. NED benefits were the primary focus for selecting an alternative as the recommended plan, but the other categories were considered in the discussions that led to the final decision. For example, life safety (OSE) considerations guided decisions on which nonstructural measures to recommend and impacts to wetlands and T&E species (EQ) guided decisions related to important aspects of alternative implementation, such as sourcing borrow material. The evaluation metrics considered for each of the four accounts are presented in Table 4.

Table 4. Four Accounts Evaluation Metrics from the Rio Guayanilla, P FRM Study

NED	RED
• Flood damages to the community • Flood cleanup costs • National Flood Insurance Program (NFIP) operating costs • Emergency costs related to Public Assistance (PA) and Other Needs Assistance (ONA) Programs • Unemployed and underemployed labor resources	• A quantitative RED evaluation was not conducted since USACE's certified regional economic impact model does not encompass Puerto Rico. However, flood impacts to local businesses were addressed within the context of social vulnerability (OSE).
EQ	**OSE**
• Qualitative impacts to threatened and endangered species • Qualitative impacts to wetlands	• Life Loss and population-at-risk • Social vulnerability • External community investment • Impacts to total population and community cohesion • Unemployment and poverty rates

Overall, when the PDT began the feasibility study, there was a large amount of uncertainty regarding the magnitude of NED benefits; consequently, the PDT wanted to ensure that benefits from the other accounts were fully evaluated and documented. The comprehensive evaluation and documentation of benefits ultimately helped the PDT, vertical team, stakeholders, and the public understand the variety of ways that this project would benefit and protect the Guayanilla community. The feasibility report is available at the following link:

https://www.lrc.usace.army.mil/Portals/36/docs/projects/Rio%20Guayanilla/2020/02_RG_FRMReport_FinalReport_FINAL.pdf

Study Example 2: Incorporating the Four Accounts in the Great Lakes and Mississippi River Interbasin Study at Brandon Road (GLMRIS-BR)

The Great Lakes and Mississippi River Interbasin Study – Brandon Road (GLMRIS-BR) Report (2019) provides an example of involving stakeholders and applying the four accounts and screening criteria within the context of an ecosystem protection study.

Based on the 2014 GLMRIS Report, the ASA(CW) directed USACE to focus on the upstream transfer of Mississippi River Basin aquatic nuisance species (ANS), which includes Asian Carp, into the Great Lakes (GL) Basin. The PDT developed alternatives with consideration of stakeholder interests. USACE ultimately recommended installing a control point at Brandon Road Lock and Dam (BRLD) in Joliet, Illinois, to protect the GL from Mississippi River Basin ANS invasion. The control point would safeguard the health of the GL ecosystem and its numerous dependent industries as well as the nation's investment in inland navigation.

The plan’s selection and justification were not based solely on NED metrics or NER analysis. Rather, the recommended plan maximized project effectiveness while reducing NED and RED impacts associated with project implementation and minimized potential negative NED, RED, OSE and effects of Mississippi River Basin ANS establishment in the GL Basin. A subset of the metrics utilized to evaluate, compare, and display the effects of alternative plans are presented in Figure 10.

GLMRIS-BR Specific Evaluation Criteria		Stakeholder Interests	Rating Method for Evaluation Criteria	4 Accounts
Relative life safety risks		Navigation	Low, Intermediate, or High	OSE
Sociopolitical consequences of ANS establishment (Chapter 5)		Great Lakes States	Qualitative description	OSE and EQ
Economic consequences of ANS establishment (Chapter 5)		Great Lakes States	Changes in Economic Value	NED
			Changes in Regional Employment, Labor, Income, Output and Value Added	RED
Impacts to Commercial Cargo Navigation		Navigation Community & State of Illinois	Average Annual Costs,	NED
			Changes in Regional Employment, Labor, Income, Output and Value Added.	RED
Probability of ANS establishment		All	Percentage of Occurrence (%)	OSE and EQ
System performance robustness	Ability to cycle in Nonstructural	State of Illinois Federal Agencies	Yes (indicated by symbol) or No (indicated by lack of symbol)	The alternative differences which are displayed by these metrics informed the Elicitation of Probability of ANS Establishment (EQ and OSE)
	Ability to cycle in Structural	State of Illinois Federal Agencies	Yes (indicated by symbol) or No (indicated by lack of symbol)	
	Number of Structural Control Points	State of Illinois Federal Agencies	Number (indicated with corresponding number of symbols)	
	Modes of Transport	Federal Agencies	Swimmer Floater Hitchhiker	

Figure 15. Examples of GLMRIS-BR Evaluation Criteria Metrics, Interested Stakeholders, and the Four Accounts

It is important to consider alternative plans, their impacts, and issues that are most important to stakeholders are well defined and understood throughout the planning process. PDTs may be able use this information to identify NED, OSE, RED and EQ metrics to display the differences among alternatives on these issues.

The feasibility report is available at the following link:
https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll7/id/11394

Conclusion

USACE guidance and policies establish a foundation for PDTs to develop, evaluate and display the effects of alternative plans. Specifically, the P&G (U.S. Water Resources Council 1983) established four accounts to facilitate the evaluation and display the effects of alternative plans: NED, RED, EQ and OSE. In addition, the ASA(CW) Policy Directive, dated 5 January 2021, directs the Agency to comprehensively assess and document benefits in water resources development planning. This policy updates current procedures and emphasizes and expands upon policies and guidance to ensure the USACE decision framework considers, in a comprehensive manner, the total benefits of project alternatives which include equal consideration of economic, environmental and social categories. Studies such as the Rio Guayanilla PR FRM Study and the GLMRIS-BR Report offer examples as to how the four accounts are utilized throughout the planning process. When all project benefits and impacts are considered, the formulation and evaluation of alternatives is more complete, leading to more holistic Civil Works investment decisions.

April 21-23, 28, and May 5-6, 2020 Scoping Charrette
Yorkinut Slough Habitat Rehabilitation and Enhancement Project
Detailed Facilitator's Agenda

Location: Webex: https://usace.webex.com/meet/janet.i.buchanan
Audio: "Call Me" from the webex meeting
Not preferred: If unable to use webex, call in: 1-866-434-5269, Access code: 4536297#, Security code: 1234#.
Backup webex: https://usace.webex.com/meet/megan.b.mcguire

Poll Everywhere: https://www.pollev.com/stpauldistri511

Interactive site map: \https://usace-mvs.maps.arcgis.com/apps/webappviewer/index.html?id=bc3858f8012c4917a7fae7380751fc6f

Purpose: A series of intensive discussions that provide an opportunity for the study team, sponsor, and stakeholders to consult and collaborate on the study scope.

Objectives/Outcomes:

1) Resource significance – what is the significance of this Refuge in location, habitat type, etc.
2) Inventory existing conditions and forecast the future without project condition over the 50-year period of analysis.
3) Discuss and document the study problems, opportunities, objectives, and constraints.
4) Identify potential restoration measures and formulation strategies.
5) Identify and discuss the key areas of uncertainty and associated risks potentially impacting the study and plan formulation.

Participation (N=20-25): USACE St Louis District Study Team (16), US Fish and Wildlife Service (6), Upper Mississippi River Basin Association (UMRBA) (1), Natural Resource Conservation Service (NRCS) (1)

Text in red and purple for internal/facilitator use only; will be deleted from participant agenda.

Overview:

Session #1: Intro, Study Area, Problems, & Opportunities (Tuesday April 21) – 4 hours

Session #2: Objectives & Constraints (Wednesday April 22) – 2 hours

Session #3: Resource Significance & Conceptual Model (Thursday April 23) – 2 hours

Session #4: Existing Conditions & Forecasting Conditions (Tuesday May 5) – 2 hours

Session #5: Measures & Plan Formulation Strategies (Wednesday May 6) – 2 hours

Session #6: Alternative Evaluation & Comparison (Thursday May 7) – 2 hours

All sessions led and facilitated by Megan McGuire. Other speakers presenting on specific sections named in orange and highlighted: Brandon, Ken, Monique, Ben/Lane.

<u>MONDAY, APRIL 20</u>

0930 Send participants all readahead materials including agenda, slides (as PDF), Heitmeyer report, presenter bios, how to get into Webex, have it Call Me so that phone and acct on screen are linked.

1100 Full tech. run-through, including testing chatbox, Poll Everywhere, etc.

Telecon Hot Keys - some are only available to Host, others are available to all:

Will probably use:
- *33 Silent Entry/Exit
- *5 Participant Count
- *78 Mute All Lines Except Host (participants can unmute/mute by pressing *6)
- *70 Unmute all Lines (when *78 used)
- *6 Mute/Unmute

<u>TUESDAY, APRIL 21</u> - Session #1: Intro, Study Area, Problems, & Opportunities – 4.5 hours (incl. 1h lunch)

0915 Janet, Lane, Megan get on Webex, prep everything

0930 Have people who are new to Webex technology to log in ahead of time

1000 Welcome and Introductions

- Introductions, including roles during the charrette sessions. Include photos on slides. Use video?
  - Megan – facilitator overlord
  - Monique – planning guru (plan formulation supervisor)
  - Brandon – project manager
  - Ben – environmental planner
  - Janet – webex manager
  - Lane – notetaker
  - Everyone else
- Icebreaker – Something interactive on webex that also works in chat. Test everyone's annotation.
  - What would you spend $100k on?

1015 Charrette Purpose and Ground Rules

- Why are we here? What do we hope to accomplish? Overall goal.
  - Outputs: POOCs, resource significance, conceptual model, data needed for existing and future conditions, measures, alternatives
- Review the structure of the charrette sessions. (Short description of the in-person charrette we were going to have…)
  - Overall schedule
  - Materials provided ahead of time (slides, webmap link, etc)
  - Presentations – 5-10 minutes
  - Discussion, via voice, annotation, [whiteboard], chatbox – 5-20 minutes

            - How to mute line, raise hand, and annotate. Introduce self before speaking.
        - Documentation – 5-10 minutes
        - Notes – notes will be taken and shown on screen
        - Parking lot – for anything not related to Yorkinut but wish to record
    - Poll Everywhere: Setting ground rules. Have the group brainstorm them first, then suggest options.
        - Example ground rules:
            - Avoid multitasking (unless you need to/during Brain Breaks)
            - Let the group know if you have to leave early
            - Actively participate.
            - Be fully present. Avoid multi-tasking.
            - Balanced participation: If you are introverted, challenge yourself to speak more. If you tend to dominate conversations, challenge yourself to make space for others. Even the playing field.
            - Be brave: share your creative and "out-there" ideas, take risks, keep an open mind.
            - Acknowledge differences and value dissenting views while working toward consensus.
            - Respectfully challenge one another by asking questions.
            - [For charrettes specifically] Focus on creativity rather than perfection.

1020 Tips for communication on the call, & annotation practice

- Check that everyone is using the Webex app, not just their browser.

1030 Overview of UMRR and HREP (Brandon)

1035 Yorkinut Slough Fact Sheet and preliminary project schedule (Brandon)

1040 Brain Break slide – trivia question, doodle opportunity, etc.

1045 'Your Experience with This Stuff' – so we can get a general idea of attendees's background, to better meet their needs/speak to their levels

- Annotate on slide in boxes for experience with UMRR & NWRs
- Prompt to be answered in chatbox: What's the most important thing you'd like the study team to know or consider about this project?

1050 Study Area: Overview of the Refuge (FWS – Ken and/or Sabrina)

- Virtual site visit:
    - Slides showing photos from the site with big numbers on them.
    - Numbers correspond to numbers on pins on map slide
    - Participants may individually scroll around in the webmap in their own browsers
- Current management
- Habitat Management Plan overview
- Habitat types

1135 Lunch

1230 Planning process overview (Monique)

1235 Describe Planning Step 1: Identify Problems (Monique)

1240 Problems

- Presentation – 10 minutes (Monique)
- Poll Everywhere –problem statements. ENTER & REVIEW BEFORE VOTING – 15 minutes
  - Review key words only rather than reading all statements in full (otherwise takes too long)
- Discussion – 15 minutes
- Vote on agreement to move forward with top 5 – 5 minutes

1325 Opportunities

- Presentation – 10 minutes (Monique)
- Poll Everywhere –opportunities statements. ENTER & VOTE AT SAME TIME – 15 minutes
- Discussion – 20 minutes

1410 Wrap up, round robin to check in on how things are going, ask for uncertainties, risks, and assumptions, and due outs

1430 Adjourn.

1435 Janet/Lane/Megan finalize items for Poll Everywhere in next session, summarize uncertainties/risks/assumptions from the day

WEDNESDAY, APRIL 22 - Session #2: Objectives & Constraints – 2 hours

0930 Janet, Lane, Megan get on Webex, prep everything

1000 Roll call & Webex functions recap – 5 minutes

1005 Recap of Study Area, Problems and Opportunities – 10 minutes

1015 Objectives

- Presentation – 5 minutes (Monique)
- Poll Everywhere – objectives. Enter and vote at same time. – 15 minutes
- Discussion – 15 minutes
- Vote on agreement to move forward with top 5 – 5 minutes

1055 Brain Break slide

1100 Constraints & Considerations

- Presentation – 10 minutes (Monique)
- Poll Everywhere – constraints. Enter and vote at same time. – 10 minutes
- Discussion – 25 minutes

1145 Wrap up, round robin, and due outs

1200 Adjourn

1205 Janet/Lane/Megan finalize items for Poll Everywhere in next session, summarize uncertainties/risks/assumptions from the day

THURSDAY, APRIL 23 - Session #3: Resource Significance & Conceptual Model – 2 hours

0930 Janet, Lane, Megan get on Webex, prep everything, and record audio

1000 Roll call & Webex functions recap

1005 Recap of Objectives and Constraints

1010 Resource Significance

- Presentation – 10 minutes (Monique)
- Poll Everywhere – public significance. Enter & upvote– 5 minutes
- Poll Everywhere – institutional significance. Enter & upvote– 5 minutes
- Poll Everywhere – technical significance. Enter & upvote – 5 minutes
- Discussion – 20 minutes

1055 Brain Break slide – Add Resource Significance slide to start of Conceptual model slides

1100 Conceptual Model discussion – will be filled in as the charrette moves forward (Megan)

- Presentation – 10 minutes
- Build/Populate blank model (or start with half-filled-in model) – 40 minutes

1150 Wrap up, round robin, and due outs

1200 Adjourn

1205 Janet/Lane/Megan finalize items for Poll Everywhere in next session, add resource significance statements to slide in following session, clean up conceptual model, summarize uncertainties/risks/assumptions from the day

TUESDAY, APRIL 28 - Session #4: Existing Conditions & Forecasting Conditions – 2 hours

0930 Janet, Lane, Megan get on Webex, prep everything. Send instructions for session #5.

1000 Roll call & Webex functions recap

1005 Describe Planning Step 2: Inventory & Forecast Conditions – 10 minutes (Monique)

1015 Inventory Existing Conditions discussion – Environmental, Cultural, Other Social Effects

- Presentation – 10 minutes (Lane)
- Poll Everywhere – What information do we have already? – 5 minutes

- Discussion & draw on map slides – 25 minutes

1055 Brain Break slide

1100 Forecasting Conditions discussion

- Presentation – 10 minutes (Ben)
- Poll Everywhere – enter data sources – 5 minutes
- Discussion – 20 minutes
- Poll Everywhere – most & least important data sources. Enter and vote – 10 minutes

1145 Wrap up, round robin, and due outs

1150 Describe format of Session 5 (incl. small group breakout discussions); ask who will attend.

1200 Adjourn

1205 Janet/Lane/Megan finalize groups for small group discussions in next session, send out slides for small group discussions to facilitators, summarize uncertainties/risks/assumptions from the day

TUESDAY, MAY 5 - Session #5: Plan Formulation: Measures & Alternatives – 2 hours – INCL SMALL GROUPS

0930 Janet, Lane, Megan get on Webex, prep everything

1000 Roll call & Webex functions recap

1005 Review the existing and forecasted conditions methods & data sources – 5 minutes

1010 Conceptual Model update – as needed – 5 minutes

1015 Describe Planning Step 3: Formulate Alternatives (Plan Formulation) (Monique)

1020 Measures (Monique)

- Presentation – 5 minutes
- Poll Everywhere - Brainstorming Measures. Enter (no voting) – 10 minutes

1035 Plan Formulation Strategies (Monique)

- Presentation – 5 minutes

1040 Check everyone is clear on what happens next

1045 Adjourn from main call

1100 Small Group Discussions begin.

- Each group has a facilitator already appointed (with a Webex account)
    - Megan - https://usace.webex.com/meet/megan.b.mcguire, 1-866-434-5269, Access code: 858 646 9, Security: 1234#

- Janet - https://usace.webex.com/meet/janet.i.buchanan, Call in: 1-866-434-5269, Access code: 453 629 7 #, Security: 1234#
- Monique - https://usace.webex.com/meet/monique.e.savage , Telecon: 1-877-873-8017 / Access Code: 8105693 / Security Code: 1234
- Brandon - https://usace.webex.com/meet/brandon.m.schneider , 888-363-4735, Access code: 3324128, Security Code, if required: 1234

- Groups choose someone to report out tomorrow.
- Groups choose someone to take notes to send to Janet.

1105 Small Groups discuss measures.

1135 Small Groups discuss alternatives & develop 1 alternative.

- Strategies for organizing measures into alternatives – least O&M, minimum plan, kitchen sink plan

1200 Small Groups adjourn.

1500 Janet/Lane/Megan compile notes from small group discussions, prepare slides for presentations tomorrow, summarize uncertainties/risks/assumptions from the day

TUESDAY, MAY 6 - Session #6: Alternative Evaluation & Comparison (Thursday May 7) – 2 hours

0930 Janet, Lane, Megan get on Webex, prep everything

1000 Roll call & Webex functions recap

1005 Check in – how did Small Group discussions go

1010 Small Groups report out on measures and alternatives

- Small Group 1 – 5 minutes
  - Poll Everywhere: Favorite thing about Group 1's alternative – 3 minutes
- Small Group 2 – 5 minutes
  - Poll Everywhere: Favorite thing about Group 2's alternative – 3 minutes
- Small Group 3 – 5 minutes
  - Poll Everywhere: Favorite thing about Group 3's alternative – 3 minutes
- Small Group 4 – 5 minutes
  - Poll Everywhere: Favorite thing about Group 4's alternative – 3 minutes
- Poll Everywhere: Vote on best/favorite 3 measures – 11 minutes

1050 Brain Break slide

1055 Describe Planning Steps 4 & 5: Evaluate and Compare Alternatives – 5 minutes (Monique)

1100 Alternative Evaluation and Comparison discussion

- Presentation on Criteria, ER benefits, & comparing alternatives – 20 minutes (Ben/Lane)
  - Criteria: Benefits and costs
  - What are ER benefits and how are they developed

    - Comparing alternatives
    - Criteria: Environmental quality, other social effects, other criteria
- Poll Everywhere – Evaluation criteria for Yorkinut Slough – 5 minutes
- Discussion – 5 minutes

1125 Key Uncertainties, Risks, Decisions, and Assumptions – 10 minutes (Monique)

1135 Next Steps/Schedule/Wrap-up – 10 minutes

1150 Final Wrap Up & Round Robin to check in with everyone – 10 minutes

- In addition to charrette feedback questions on slide, we can also add Poll Everywhere feedback questions as needed, and leave the session open.
    - Eg Do you have a better understanding of how to scope this project?
    - Can you identify an area that really helped your understanding?

1200 Adjourn

LATER – Janet/Lane compile notes for Charrette Report, upload minutes & annotated slides to ProjectWise

Virtual Charrette Tools used in the Yorkinut Slough HREP Virtual Scoping Charrette, April-May 2020

"This was the best run webinar I have been a part of." - Sabrina Chandler, USFWS (UMRR project partner)

As part of the Yorkinut Slough HREP project, under the UMRR program, the planning team began preparing for a Scoping Charrette in early 2020. The initial plan was to hold a three-day charrette including a half-day site visit to the site, the Two Rivers National Wildlife Refuge. Then came the lockdown due to COVID-19.

In deciding whether to postpone the meeting or change to an online format, we considered how important it was to hold the charrette in-person, and whether some attendees would not be comfortable participating remotely. We decided to move ahead with re-structuring the charrette in a virtual setting. The project planner reached out to seven USACE personnel with experience in virtual facilitation and participative technology (listed at the end of this document), to help make the charrette as interactive as possible.

The charrette was divided into six sessions, held over three weeks. The first session was four hours in length with a lunch break in the middle, and the other sessions were two hours in length. This schedule was chosen so that each session was not too long, and so that the planning team had some time to adjust the material between sessions. Participant feedback: "I think the shorter duration helped keep everyone focused and involved. Having it over a couple of weeks allowed for additional information gathering and refinement of products." Twenty-three (23) attendees were expected, the majority of whom were from federal agencies (primarily USACE and USFWS). In the end, approximately 18 participants attended each session.

Elements that worked well:

BEFORE THE CHARRETTE SESSIONS

- **Dry run of all technology.** All the different tools were tested the day before the first session.
- **Sending readahead materials.** The slides, agenda, and other readahead materials were attached to the meeting invite the day before each session.

AT THE CHARRETTE SESSIONS

- **Webex linked to audio.** Participants were encouraged to enter the Webex meeting and use 'Call Me' to get audio. This linked names and audio so speakers were identified when they spoke.
- **Separate facilitator, note-taker-timekeeper, and Webex manager.** These roles were divided so that more attention could be paid to each. The Webex manager was tasked with monitoring the chat box, the participant list, and her own email to track any issues with the technology.
- **Logging in early.** Day of, the facilitator and Webex manager logged into the Webex meeting early to test the technology.
- **Share File.** Sharing the file, and not just the Powerpoint application, worked best. It allows the presenter to see the Participant and Chat panes alongside the slides without having attendees see any grey boxes where content is not being shared. Share File also allows annotation on the slides that can be saved to a PDF (see Annotation, below).

- **Starting the call with small talk.** Those on the call ahead of time would talk with each other a little bit to create a positive atmosphere as others joined the call. The *33 function was used to silence entry and exit tones.
- **Introduction slide with photos.** To start each session, a slide showing all attendees' names and organizations was shown. For USACE personnel, photos were included. The facilitator referred to this slide to take a roll call and check everyone's audio was working.
- **Slide on 'Tips for Communication on the Call'.** This slide was shown near the beginning of each session, showing the following tips:
    - Identify yourself when you speak – eg "This is Shane, …"
    - Mute line unless speaking – The host did not mute all lines, so that attendees could chime in at any time. This worked well.
    - Type questions in the chat box – If participants did not want to interrupt the conversation, or had additional information or links, they could comment in the chat.
    - Raise hand – In the end, no-one used this feature, but it was listed as an option.
- **Annotation.** In every session, we re-introduced the annotation tools & kicked off with annotation practice on the introductions slide. Attendees wrote in their answers to a fun 'question of the day' such as "What is your favorite bird?" with the Text tool. The host allowed all participants to annotate at Participant > Assign Privileges > Participants > Annotate.
- **Setting ground rules using Poll Everywhere.** Attendees were directed to a link where they could suggest ground rules. The facilitator reviewed these with the group and compiled an edited list to be presented at the start of each session. One of our favorite rules: "Patience with technology."
- **Allowing others to present.** Several attendees presented images, slides, or documents on their own screens in the charrette sessions. Some of these transitions were planned, but others were spontaneous when participants wanted to quickly display something on their own screen to the group. The host set this permission at Participant > Assign Privileges > Participant > Meeting > Control shared applications, web browser, or computer remotely.
- **Posting important links upfront in the chat box.** We posted the map link and Poll Everywhere link in the first chat comment, for easy reference.
- **Allow participants to navigate slides.** We decided that for this group, permission should be granted for attendees to navigate between slides if they wished. The host can bring everyone back to the same slide by changing the slide. This permission is set at Participant > Assign Privileges > View Any Page. Then, toggle over the left side menu and click the button with the 4 little squares to switch to slide overview and move between slides.
- **Interactive map.** The GIS member of the PDT developed a webmap showing important data layers related to the site. This map is publicly accessible and can be accessed by all stakeholders.
- **Virtual site visit.** In lieu of an in-person site visit, the charrette planning team did the following:
    - Show slides with numbered photos from the site, and a map showing the numbered locations. Fortunately most of the photos had already been taken on a previous site visit.
    - Display the interactive web map, scrolling and zooming to key features and clicking on the pins for geotagged photos to pull them up. Attendees were also encouraged to view the map between charrette sessions to familiarize themselves with the site.
    - Display aerial imagery from previous helicopter flight surveys (aerial video) and/or Google aerial imagery. Our partner (FWS) presented these slides.
    - Also considered, but not chosen, were: a Google Earth 'flyover' video, a Facebook Live site visit where one person presents while walking around the site and taking questions;

a pre-recorded video of a presenter giving a site visit; and a pre-recorded narrated video of drone footage over the site (not possible over National Wildlife Refuges).

- **Poll Everywhere.** Poll Everywhere (www.polleverywhere.com) was used for interactive group exercises. It allows anonymous input, which may have been helpful in encouraging attendees to generate ideas. It offers the following response options:
    - Up- and down-vote (used most often), resulting in a ranked list
    - Open-ended (used second-most often)
    - Multiple choice
    - Word cloud
    - Clickable image
    - Survey

  The Webex manager was logged into Poll Everywhere and displayed the results as they came in. The facilitator had Poll Everywhere open in participant mode. Some participants were not able to access Poll Everywhere the first time. The participants who couldn't connect to the site entered their ideas into the chat, and the facilitator entered them into Poll Everywhere to display them alongside the other responses.
  In the follow-up survey, Poll Everywhere was ranked joint first as a charrette tool. Participant feedback: "Poll everywhere was helpful in getting everyone's input without talking over each other."
- **Fist to Five.** For key portions of the charrette such as problem formulation, the group first used Poll Everywhere to enter and rank responses. Then, a 'Fist to Five' slide was used to determine the level of consensus on the statements formulated. The 'Fist to Five' method asks that participants rank their agreement using annotation on a scale from 0 ("No way, I'll block this") to 5 ("I love this! I will champion it"). Because annotation was used, this feedback could be done anonymously. Participants who indicated agreement of less than 3 were invited to explain their concerns. If the group was not largely at 5, as happened with the first iteration of the problem statements, the statements were revisited, re-worked, and voted on again on another 'Fist to Five' slide in the final charrette session.
- **Variety of presenters.** The charrette planning team scheduled several presenters to speak on their subject matter, to vary the voices heard and give participants a better understanding of who does what in USACE's planning process. USFWS, the project partner, was invited to present on the site visit and potential measures, among other things. The presentations covered subjects including objectives, and how they are defined; then, the group was asked to brainstorm objectives in Poll Everywhere.
- **Small group discussions.** This classic feature of an in-person charrette was tried virtually via appointing four USACE personnel with Webex accounts to host their own meetings for the second hour of the session focusing on alternative formulation. The disciplines and organizations represented were divided into different groups. Each group nominated a notetaker and a presenter to present on their findings in the next session.
- **'Brain breaks'.** A small break was scheduled in the middle of each 2-hour session, to allow participants to stretch, check email, or use the bathroom. A fun, interactive slide was displayed during this time, such as 'spot the camouflaged animal' or a 'what do you see' optical illusion.
- **Due outs slide.** Towards the end of each session, a 'due outs' slide was shown, with due outs requested or completed from previous sessions shown in gray text and new due outs in black text.
- **Feedback slide.** A feedback slide was included as the penultimate slide in each session. The slide included:

    - A ‘scale’ bar for people to annotate between ‘No’ and ‘Yes as the answer to: “Was this session helpful in formulating [subject of today’s session] for the project?”
    - Space for annotation beneath the questions, “What did you take away from this session that you liked a lot?” and “What would make this virtual charrette session better?”
- **Round Robin slide.** The last slide of each session was a round robin. Attendees were encouraged to give feedback, ask questions, or share final thoughts from the session. Attendees from the partner organization (FWS) were listed first, then other organizations in attendance, then USACE. Not all of the USACE personnel on the call were listed/called on (to save time and not overpower the call).

AFTER THE CHARRETTE SESSIONS

- **Stay in the Webex meeting.** Save out the key information before leaving the meeting.
- **Save a PDF of the annotated slides.** If annotations were made, save the slide deck as a PDF with File > Print > Adobe PDF.
- **Save chat box comments.** If important information was shared in the chat box, a transcript of the comments can be saved with File > Send Transcript, then No, then open the transcript .txt file from the draft email that is created. Send Transcript is a host-only function. Alternatively, highlight and copy the text from the chat and paste it into a Word doc.
- **Save email addresses of participants.** To save the email addresses of everyone who logged into the Webex meeting, go to File> Send Transcript , then No, then copy the email addresses from the ‘To’ line of the draft email that is created. Paste them into an Excel document, or check off attendees from the list of invites.
- **Adapt and adjust between sessions.** After each session, the charrette planning team touched base and made adjustments and additions for the next session.
- **Follow-up survey.** At the end of the last session, a survey was posted in Poll Everywhere to elicit anonymous feedback on the charrette sessions. Excerpts from this feedback are noted in blue text in this document.

Elements that didn’t work perfectly:

- **Time taken to address technology problems.** It took much longer for attendees to join and familiarize themselves with Webex in the first charrette session than was scheduled on the agenda.
- **Participants not able to edit slides together.** During the small group discussions, it was difficult to collaboratively write suggestions and edit the slides they were to present in the next session. A program or app like Google Slides that allows simultaneous group editing would have been useful in this exercise. Because the slides were shared with Share File, the presenter could not edit the slides in Powerpoint, e.g. typing on the slide. There were times where it would have been nice to draw on a map and then type notes on a slide visible to all, but these two functions were not available at the same time.
- **Participants not able to draw on maps together.** Webex annotation has limited functionality; participants missed being able to draw and point on a physical map. Participant feedback: “[What could be improved?] In this setting it is really hard to understand without someone being able to draw or visualize things. In a classroom setting they can draw on maps etc.”
- **Some sessions felt too short.** We received comments that the 2-hour session on developing measures and alternatives (Session #5) was too short. The first hour of presentations and

discussion had to be cut short, and during the second hour, several groups doing the small group discussions went over their time. This session would have taken a half-day in an in-person charrette; perhaps this should remain a longer session in a virtual charrette. Participant feedback: "[What could be improved?] Add a little additional time to the break out groups." Participant feedback: "[What could be improved?] More time devoted to Measure development, then more time devoted to Alternative development."

- **Session break between brainstorming and small groups.** The large group brainstormed measures and then broke into small groups to develop alternatives. A session break in between would have allowed the facilitators to format the measures that were brainstormed by the large group into a more useable format for the small groups, e.g. a spreadsheet or Word doc list. The large group could have sorted and grouped measures before breaking into small groups. This might have given the small groups a better set of measures to work with.
- **Overall schedule could be improved.** Five out of seven respondents to the follow-up survey said that "seven short sessions was a good format". However, two others voted for "Fewer and longer days would be better" or "Several short sessions but in one week rather than across several weeks." There are pros and cons to the scheduling options; a condensed schedule means keeping better track of what was just discussed and finishing sooner, while a more spread out schedule allows for more time to digest and collect new information between sessions.

Recommendations:

- Allow for 10 minutes at the beginning of each session for people to get phone working, get connected, and go through the ground rules and technology reminders.
- Allow for 10 minutes at the end to review, capture due outs, document assumptions, uncertainties, and risks.
- Allow for 15 minutes for the round robin at the end of each session (assuming about 15-20 people). Combined with the above, this requires about 25 minutes at the end of each session.
- Have a backup plan if annotation or Poll Everywhere does not work. Ask participants to enter their comments in the chat box, for example.

Contacts on the Yorkinut Slough HREP project:

Janet Buchanan, MVP Plan Form – janet.i.buchanan@usace.army.mil
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Brandon Schneider, MVS Project Manager – Brandon.m.schneider@usace.army.mil
Lane Richter, MVS Wildlife Biologist – lane.a.richter@usace.army.mil

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Enable & Operationalize Risk Informed Decision Making through SMART Planning

Planning Mentor – NAME
Charter for XXX Supplemental study
Date:

A. CONTEXT:

The Planning Mentor program has been established as a resource to ensure PDT success in delivering of a project to solve a water resources related problem.

A trend analysis of the current Planning portfolio identifies that teams are struggling to meet early milestones time and cost commitments. The goal is for studies to reach the Alternatives Milestone within the first 2-3 months from signing of FCSA and the Tentatively Selected Plan Milestone within a year. Planning Mentors will assist teams apply risk-informed decision making and aligning the level of detail with the areas of uncertainty that must be reduced to make the decision at hand. Planning Mentors will train PDTs and support their ability to improve project delivery.

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B. MISSION/OBJECTIVE

The mission of the Planning Mentor program is to provide a short-term boost to help coach, mentor and train Lead Planners and PDTs on risk informed decision making, emphasizing the 'R' in SMART, and utilizing the techniques and principles in the Planning Manual Part II: Risk Informed Planning (IWR Report 2017-R-03).

The overall objectives of a Planning Mentor are to:

- Coach and mentor lead planners on *all* SMART Planning principles and procedures.
- Coach and mentor PDTs through early iterations of risk-informed planning process and rapid risk analysis, applying the methodologies in the Planning Manual Part II: Risk Informed Planning.
- Coach lead planners & PDTs on risk management (assessment, communication, and mitigation).
- Build capacity and risk management competence by assisting PDTs to emphasize the 'R' in SMART Planning, empowering them to make risk-informed decisions.
- Mentor PDTs on how to tell the risk story.
- Share lessons learned to ensure the Planning and allied Communities of Practice continually improve.
- Support new start studies and high profile projects.

For the <study name>, the <District> Planning Chief and <MSC> Planning Chief have identified the following specific tasks for <the Planning Mentor name>, the Planning Mentor (this list has tasks that all Planning Mentors are required to participate in shown in bold and examples of other tasks, edit to fit particular study needs) to be accomplished with xx hours provided by the District:

- **Hold a conference call to discuss study status and issues with the District Planning Chief and lead planner to reach alignment on Mentor role and engagement within one week after receiving mentor funds.**
- **Work with the lead planner and core members of the PDT to complete an iteration of the risk-informed planning process within the first 60 days after signing of the FCSA.**
- **Utilize tools and techniques in the Risk Informed Planning Manual to advance the study to reach the Alternatives Milestone, currently scheduled for XX XXX XXXX and follow-on milestones as needed.**
- **Work with the core planning team to develop and articulate risk management strategies in the team's risk register.**
- **Assist the PDT in telling the risk story for the study in the IPR/milestone meeting(s) scheduled for XX XXX XXXX.**
- <specific issues that need resolution>
- <specific issues that need resolution >
- **Complete a short final report of Planning Mentor engagement, documenting and sharing lessons learned with the District Planning Chief, MSC Planning Chief, and other Planning Mentors.**

C. COMPOSITION AND ROLE

For the <study name> the following team is being formed to accomplish the aforementioned objectives.

<NAME> is the Planning Mentor. In this role they are responsible for:
- Managing the budget they were given for this effort.
- Providing support and assistance to the PDT..
- Providing status reports to the District Planning Chief and MSC Planning Chief on a regular basis.

<NAME> is the Lead Planner. In this role they are responsible for:
- Managing the day-to-day operations of the team and the team's deliverables.

<NAME> is the District Planning Chief. In this role they are responsible for:
- Providing the resources and interacting with district management as needed.

<NAME> is the Risk Champion. In this role they are responsible for:
- Ensuring this Team Charter is abided by.

- Planning Mentor, contact information
- Lead Planner, contact information
- District Planning Chief, contact information
- Risk Champion, contact information

D. AUTHORITY AND EMPOWERMENT

The Planning Mentor works at the request of the <MSC NAME> Planning Chief who will also serve as the Risk Champion for the <NAME District> and the <STUDY NAME>. The Planning Mentor works in an advisory capacity and has the authority in conjunction with the Risk Champion to discuss issues or challenges with anyone in the vertical chain as needed for advancement of the study.

The Planning Mentor will virtually interact with the <study name> PDT, the District Planning Chief, and the Risk Champion. The Planning Mentor will tailor the communication to best fit the need of the study and PDT. The Planning Mentor and Risk Champion will keep the PCoP informed of progress via email and highlight lessons learned for sharing.

E. RESOURCES AND SUPPORT

The Planning Mentors will generally be provided <XX> hours to work on the <xxx> study and must carefully consider how best to use those funds. Additional funds may or may not be available. Project funds may be used to continue / extend Planning Mentor support.

The Risk Champion will fully support the Planning Mentor. Any issues, concerns or challenges should be discussed as soon as they occur.

F. OPERATIONS

The Planning Mentor and the lead planner will communicate in the manner best determined to work for them and with the PDT, whether webinar, email, written communication or during a face-to-face meeting (which is expected only in rare instances).

The Planning Mentor and Risk Champion will discuss study progress during <bi-weekly teleconference calls – set the frequency and mode of communication that makes sense for this engagement>. The District Planning Chief and Lead Planner may also be invited to participate.

G. NEGOTIATION AND AGREEMENT

I hereby agree that I will help operationalize risk informed decision making to improve planning program delivery for the <xxx> study as described in this Charter.

Signed

____________________	____________________
<Name> Planning Mentor	<Name> Lead Planner
____________________	____________________
<Name> Risk Champion	<Name> District Planning Chief

OBJECTIVE 3: IMPLEMENTING RISK INFORMED DECISION MAKING IN PLANNING

Objective: *Ensure participants understand how Risk Informed Planning execution enables USACE to deliver on its commitments.*

Presenter: *Valerie Ringold (Planning Mentor)*

BLUF: DCW MEMO SIGNED 03 MAY 2018

- Subject: Improving Efficiency & Effectiveness in USACE CW Project Delivery (Planning Phase and Planning Activities)
- Mandates risk-informed decision making in planning phase of CW project development **and throughout project lifecycle**
- The memo:
  - Directs teams to apply Risk Informed Planning approaches and techniques
  - Reframes Decision Milestone Meetings around decision making under uncertainty
  - Delegates Authority for feasibility milestone decision making
  - Reduces Redundant Review Roles; One-Headquarters policy review approach
  - Provides guidelines in resource management and efficient allocation of personnel and funds
- Requires all USACE elements with role in planning to examine and update guidance

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ENTERPRISE RISK INITIATIVE

Enterprise Risk Management

- LoE #1 - Embrace & Operationalize Risk Informed Decision Making
- LoE #2 - Make, Justify & Document Decisions at the Most Appropriate Levels
- LoE #3 - Synchronize HQ functions to Support MSC and District Project Delivery
- LoE #4 - Integrate & Synchronize Agency Policy & Guidance
- LoE #5 - Incorporate Social & Environmental Benefits into Project Formulation, Design, and Implementation

Key PCoP Activities:

- **Delegate milestone decision making to MSCs** Update Appendix H – put PB guidance into our guiding ER
- Communicate expectations in light of no Civil Works Review Board (*it's not replaced by any other senior panel meeting or milestone*)
- Equip SMA**R**T Planning Milestone decision makers and PDTs to discuss risk and uncertainty with common terms

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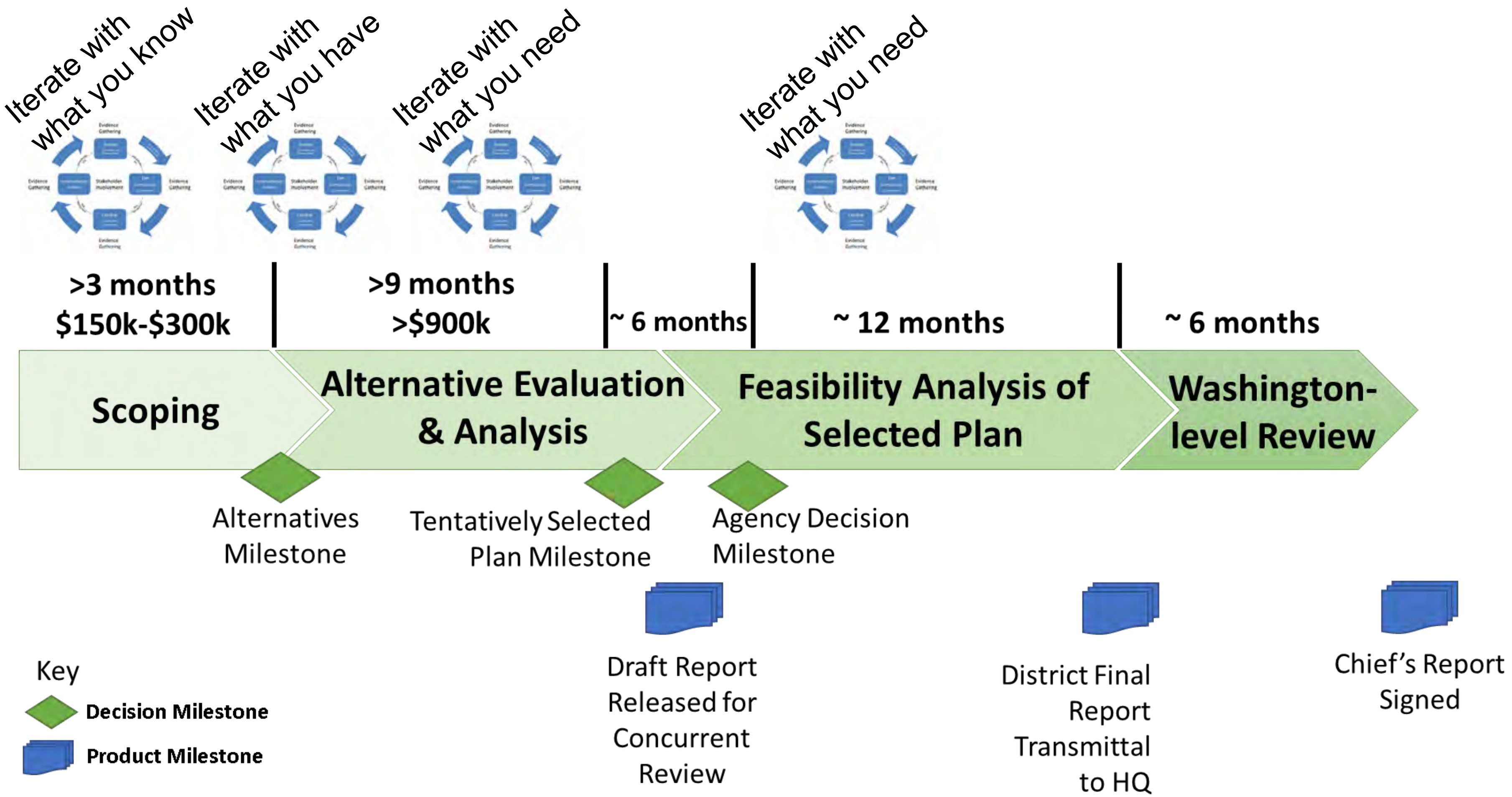
ITERATE THE SIX-STEP PLANNING PROCESS AND GATHER EVIDENCE TO REDUCE UNCERTAINTY AND MANAGE STUDY AND PROJECT RISK



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MILESTONE DECISIONS IN A RISK CONTEXT

Discussions and decisions at the ADM focus on the TSP/Recommended Plan and the risks that could affect the decision and outcomes.

- Risks to the affected human and environmental community: existing risks and risk reductions realized by the recommended plan. *Are there any public, agency, technical, or policy concerns that may change the recommended plan?*
- Study Risks: what can affect the accuracy, quality, timing, and budget of the study? *Is the level of mitigation planning, engineering, cost engineering, etc. sufficient? Too much? Not enough?*
- Implementation risk: what can affect the efficacy, quality, timing, and budget of the built project? *Is "budgetability" of PED or Construction a concern of decision makers? Will that impact the corporate decision about the level of effort to complete the feasibility report and Chief's Report?*
- Outcome risks: residual risks and how to manage them; new, transferred or transformed risks attributable to the recommended plan.

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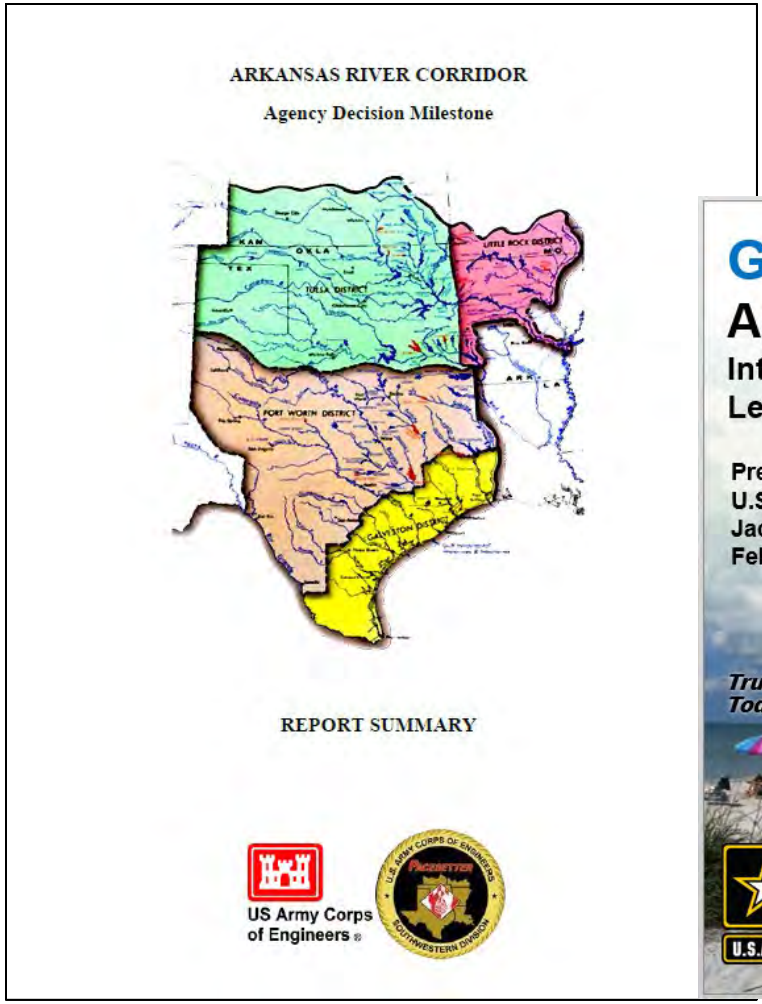
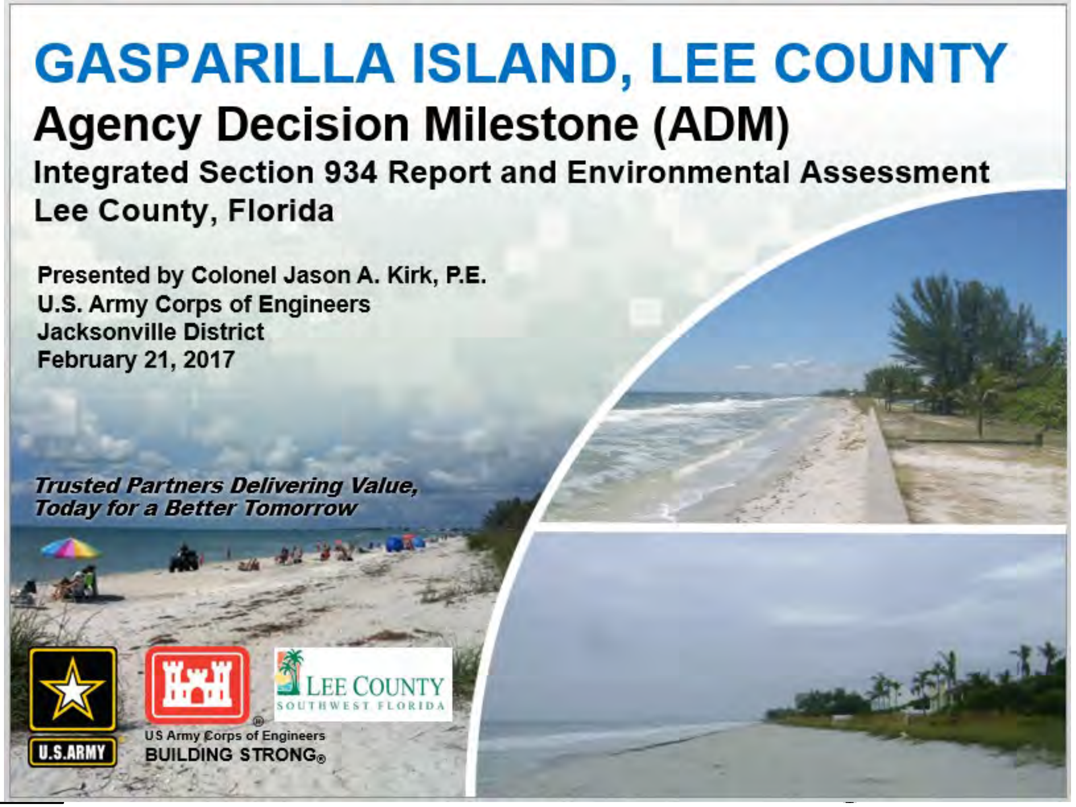
TELLING THE RISK STORY AT MILESTONES

PDTs tell the risk story at each milestone meeting – study risk, implementation risk, project risk – and how the PDT is managing those risks.





DECISION MAKERS ARE RISK MANAGERS

- Understand and manage decision risks. What will affect your decision or the outcomes of your decision?
  - What can go wrong?
  - How can it happen?
  - What are the consequences?
  - How likely are they?
- How does uncertainty affect your decision or the outcomes of your decision?
  - What is uncertain?
  - Why is it uncertain?
  - How uncertain is it?
  - Why is the uncertainty important?

THE BOTTOM LINE: RE-FOCUSING MILESTONE MEETINGS

Four things we are going to do differently – starting now.

1. Decision Makers: Come prepared to decide
2. PDT: Tell the risk story of the plan and the study
3. MSC Planning Chiefs: Champion risk; engage and keep focus on managing the risks that affect the decision and the project outcomes
4. All: Milestone discussions need to go beyond review and compliance to include discussion of risk and uncertainty

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Refresher on Risk Register: What it is, Why we should use it, How to fill it out

The risk register collects information about:

- Risks and their causes.
- Consequences of risk.
- Likelihood of the risk occurring.
- Confidence of the risk consequences and likelihood of its occurring.
- PDT recommendation about the risk.

What is it? The Risk Register (RR) is an important risk management tool for USACE. The RR is a log (spreadsheet) in which you record the relevant details of the risks that could result from actions taken or not taken during each stage of a project's life cycle. The Project Delivery Team (PDT) and all levels of the vertical team have input and joint ownership of the RR.

Why is it used? It is a tool for identifying risks throughout the study's iterative planning process. The risk register should be used as a guide for decision-making in a timely manner, making and accepting decisions based on information available to the PDT at that time. The risk register is also a read-ahead for the study's Decision Milestone meetings.

The risk register:

- Identifies the risks the PDT and the Corps is willing to tolerate.
- Identifies ways the PDT will manage risks that are not tolerable.
- Documents risk mitigation strategies being pursued in response to the identified risks.
- Grades risk mitigation strategies in terms of likelihood and consequence.
- Provides the vertical team with a documented framework to report risk status.
- Represents an actionable document prepared early in the study.
- Helps ensure the communication of risk management issues to key stakeholders.
- Provides a mechanism for seeking and acting on feedback.

Why Should the PDT Use a Risk Register?
The utilization of a risk register during a study to document and evaluate the risk associated with decisions helps the PDT anticipate the *potential effects of uncertainty* on both the quality of their study decisions and project outcomes.

Uncertainty and the Level of Detail
Throughout the Study, the PDT must ask how added detail will affect the next decision:

- Where is the uncertainty?
- Does the uncertainty affect the decision?
- What are the consequences of a poor decision?

The risk register compiles the data needed to answer these questions. Multiple strategies can be used to collect and analyze the data. The PDT can prioritize data gathering and analyses in areas critical for differentiating among alternatives and selecting a recommended plan.

Using the Risk Register throughout the Study

The register is a living document that should be maintained and kept current throughout the study. The risk register will evolve with the study and the recommended actions. The register should be prepared as early in the process as possible, but only when the PDT assesses what data it has and what data it truly needs. Ideally, an initial risk register would be completed early in the study and aligned with a Decision Management Plan

New risks may be identified from time to time. The risk register will also change regularly as previously identified risks are reassessed in light of new information, or based on the effectiveness of the mitigation strategy. *Risks that are identified in the study will continue to be evaluated, monitored, and managed through the life-cycle of the project, from planning to design, construction and operations.*

A Closer Look at the Risk Register

Properly maintained, the risk register is a valuable tool to communicate risk management issues to the PDT, the Sponsor, the USACE Vertical Team and key stakeholders.

A risk register generally includes:

- Grading risks in terms of their likelihood of occurring and seriousness of impact on the study/project.
- Initial plans for mitigating each high level risk, the costs and responsibilities of the prescribed mitigation strategies and subsequent results.

The risk register includes the following columns on each of the tabs:

Column	Value Described
SMART Milestone or IPR	List the milestone or major decision. Use this column for summary page only, as the tabs in the spreadsheet are already organized by Decision Management Plan.
Risk number	A unique identifier for each risk. Identifiers can be associated with the discipline / area of risk (e.g., 1 Eng; 1 H&H)
Date	Date entry was last updated
Scoping Choice or Event	This is the scoping choice (task, decision, problem, question, issue) or event (action, hazard or opportunity) that is to be managed.

Risk and its cause	Briefly identify the risk associated with the action. Considering the Action, what can go wrong and how can it happen?
Risk Type	Study Risk (Analytical error, study delays, study cost increase, poor planning decision), Implementation Risk (schedule and cost of implementation, redesign), or Outcome Risk (hazard risk and project performance risk) Consequence Describe the consequence of the risk. If things do "go wrong" in the way described what is the specific consequence for the study or project outcomes? (List the most significant consequence first if more than one.)
Consequence rating	If the most significant consequence occurs what is its potential magnitude? (High, Medium, Low)
Evidence for consequence rating	Specific evidence used to support the consequence rating. If relying on an event from a previous study, list study and date.
Likelihood rating	What is the likelihood that the most significant Consequence will occur? (High, Medium, Low) Evidence for likelihood rating Specific evidence used to support the likelihood rating. If relying on an event from a previous study, list study and date.
Uncertainty rating	How great is the uncertainty about either the consequence or likelihood of the risk identified? (High, Medium, Low)
Risk rating	Qualitative risk rating based on Consequence and Likelihood from lookup table on "Risk Rating Tab" (High, Medium, Low)
Risk management options	Enter options for reducing the risk and estimate time/cost impacts associated with the management option. Be specific. If you can identify the cost or schedule impacts of implementing these instead actions of the chosen action, please do so to help inform PMP options.
Conclusion / Recommendation	Identify the preferred course of action for managing the risk you have identified in previous column. Tolerate the risk is the default option.
Point of Contact	Name(s) of person(s) assessing the task and responsible for the task.
Affected Study Component	What other analyses of the study are affected by this risk? For example, what other analyses use outputs from the scoping choice as their input.

Outcome	Describe the result of the risk management action.
Notes	Make note of any significant information not otherwise provided.

Confidence Rating Terms

- High—the consequence of this risk is unacceptable
- Medium—the consequence of this risk can be tolerated
- Low—the consequence of this risk is a relatively insignificant concern

Likelihood Rating Terms

- High - the probability of undesirable result is unacceptable based on evidence. A significant deviation from the expected value is more likely than not.
- Medium - the probability of undesirable result is borderline tolerable/unacceptable based on evidence. A significant deviation from the expected value is as likely as not.
- Low - the probability of undesirable result is tolerable or acceptable based on evidence. A significant deviation from the expected value is less likely than likely.

Uncertainty Rating Terms

- High - there is little to no concrete evidence available. There is very broad range of possible outcomes that include extremes.
- Medium - there is some good evidence and some significant data gaps. Extreme outcomes are not possible.
- Low - good evidence is available, data gaps are not significant. There is a limited range of possible outcomes.

Resources

- Risk Register Template (Excel) – Blank risk register for team adaptation and use
- IWR-APT (Assistance to Planning Teams)
  IWR-APT is an online software tool to help project delivery teams (PDTs) create, edit, analyze and manage their study materials. Modules currently within APT include: Risk Register, Decision Management Plan (DMP), Decision Log, Study Issue Checklist, and SMART Planning Deliverable Workflow.
- Example Urban Ecosystem Restoration Risk Register (PDF) - updated in June 2014 to better align with the language and approach of the Cost Schedule Risk Register
- Example Wetland Ecosystem Restoration Risk Register (PDF) - Urban ecosystem restoration on an existing flood control project, early in the study process. NOTE: This risk register is provided as an example. It should NOT be used for any other study except as an example of how other real studies characterized and chose to manage risks associated with the study. Please do not cut and paste information.

- Sample Draft ER Risk Register 3 (XLS) - Wetland restoration with high resource significance, early in the study process. NOTE: The format of this risk register does not follow the standard template so please discuss pros and cons of this approach with your vertical team prior to using it. This risk register is provided as an example. It should NOT be used for any other study except as an example of how other real studies characterized and chose to manage risks associated with the study. Please do not cut and paste information.
- Example HSDR Risk Register for St. Johns County, FL (PDF) - This example Risk Register was developed to prepare for vertical team alignment on St. Johns County, FL, Hurricane and Storm Damage Reduction (HSDR) study's 3x3 scoping. NOTE: This risk register is provided as an example. It should NOT be used for any other study except as an example of how other studies characterized and chose to manage risks associated with the study. Please do not cut and paste information.
- Example HSDR Risk Register for St. Lucie County, FL (PDF) - This example Risk Register was developed to prepare for vertical team alignment on St. Lucie County, FL, Shore Protection Project study's 3x3 scoping. NOTE: This risk register is provided as an example. It should NOT be used for any other study except as an example of how other studies characterized and chose to manage risks associated with the study. Please do not cut and paste information.
- Example Coastal Hurricane Storm Damage Reduction study Risk Register, prior to the TSP milestone (PDF). NOTE: This risk register is provided as an example. It should NOT be used for any other study except as an example of how other real studies characterized and chose to manage risks associated with the study. Please do not cut and paste information.
- Example Deep Draft Navigation Risk Register (PDF) - Example of a risk register developed by a Deep Draft Navigation study. NOTE: This risk register is provided as an example. It should NOT be used for any other study except as an example of how other real studies characterized and chose to manage risks associated with the study. Please do not cut and paste information

LOS ANGELES COUNTY FLOOD CONTROL SYSTEM FRM FEASIBILITY STUDY

RAPID ITERATION OF PLANNING PROCESS WORKSHOP

Leigh Skaggs, Planning Mentor
Office of Water Project Review, HQUSACE

Los Angeles District
16 April 2019

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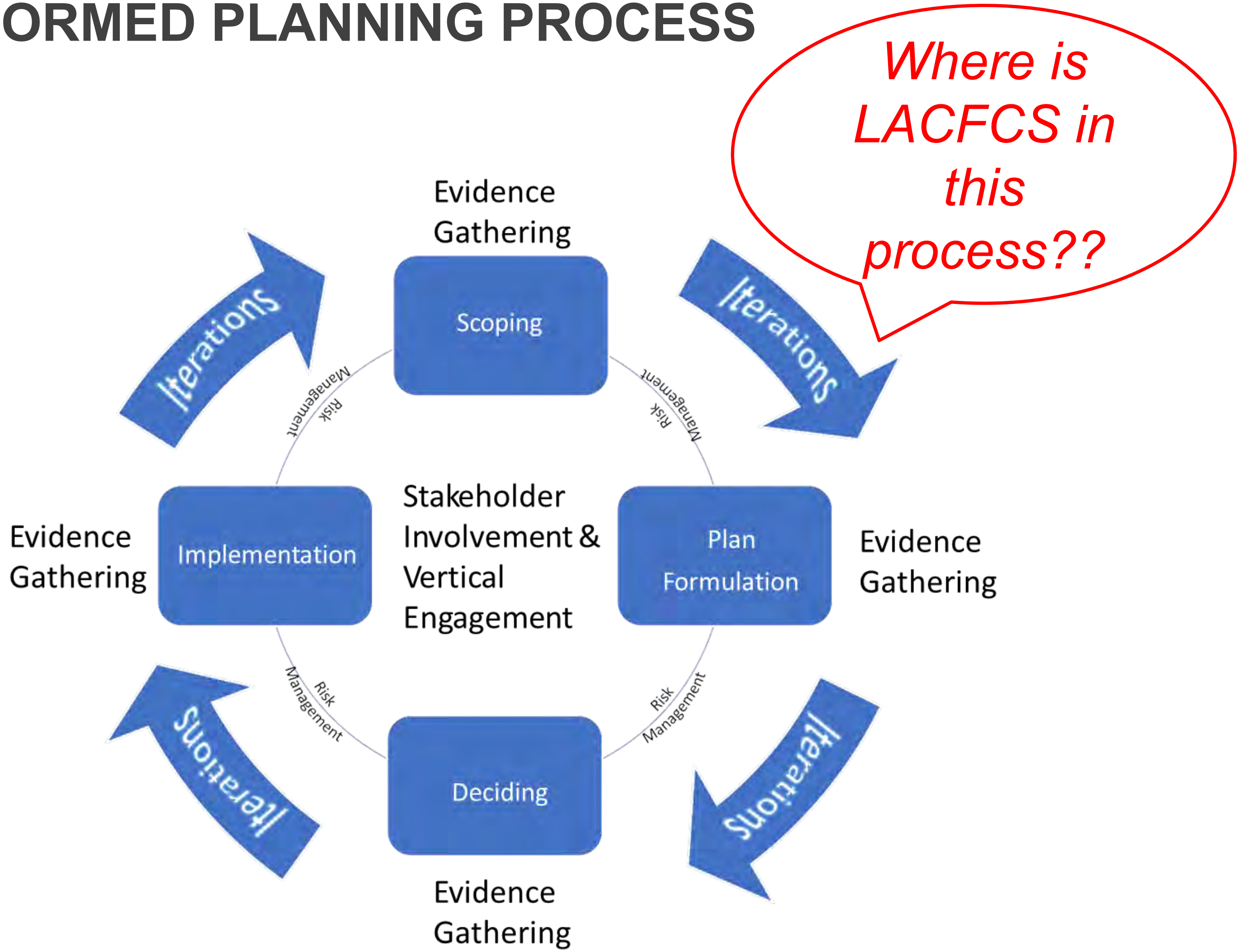
RISK INFORMED PLANNING PROCESS



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WHY ARE WE DOING THIS?
WHAT DO WE HOPE TO ACCOMPLISH?

1. **Getting through an iteration in the first 90 days is one of the Alts Milestones goals (see PB 2018-01)**
   – *"Conduct at least 1 iteration of risk-informed planning process (six steps); scoping and plan formulation activities resulting in screened array of alternatives, including developing preliminary future without project alternative."*
2. **Trying to make a decision with the information we have now**
3. **Will the selected plan change between now and TSP milestone? Very likely**
4. **Then why go through an iteration?**
   – To confirm what we know and what we don't know
   – To close data gaps
   – To give direction to our investigations
   – To avoid unnecessary data collection & investigations

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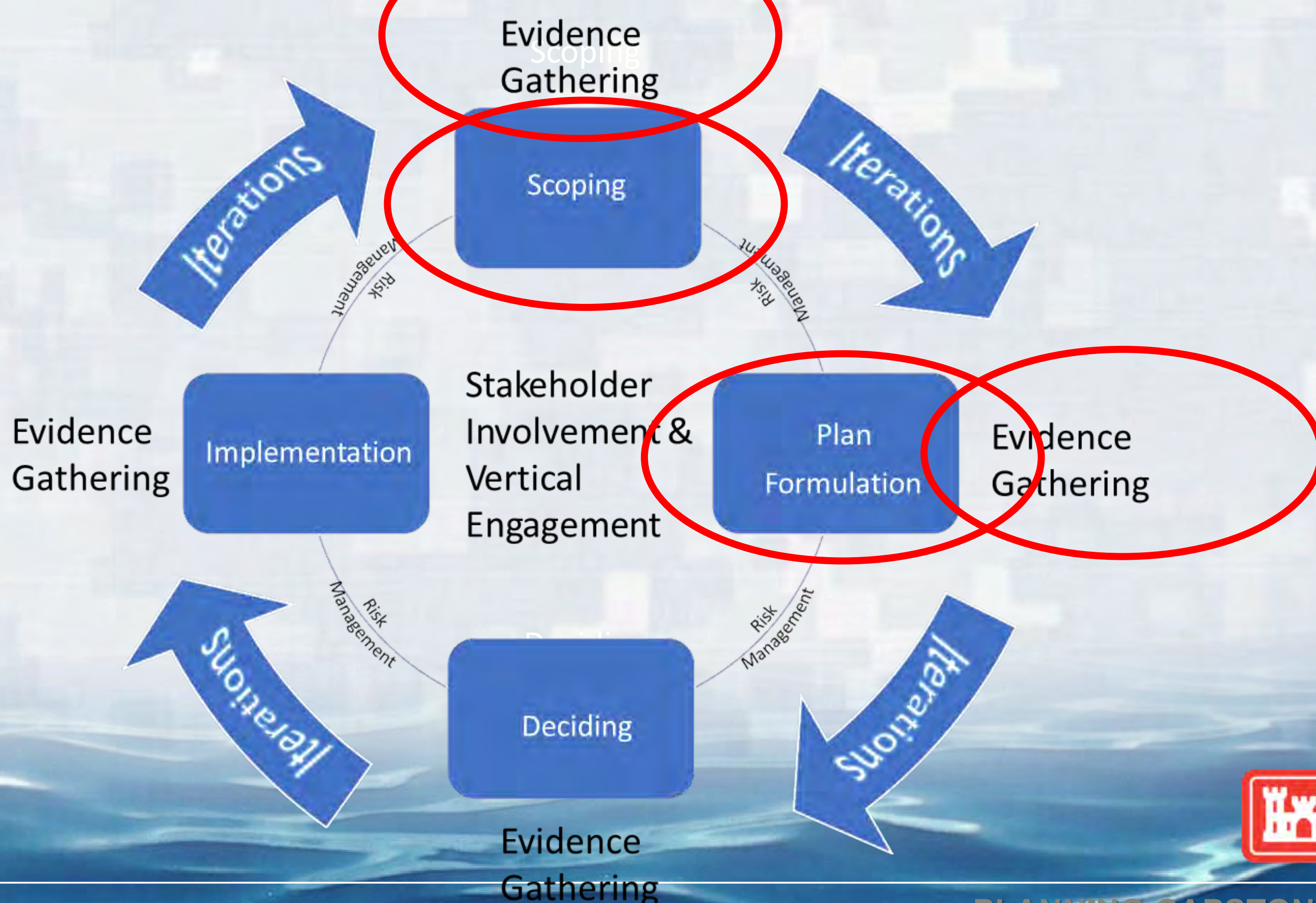
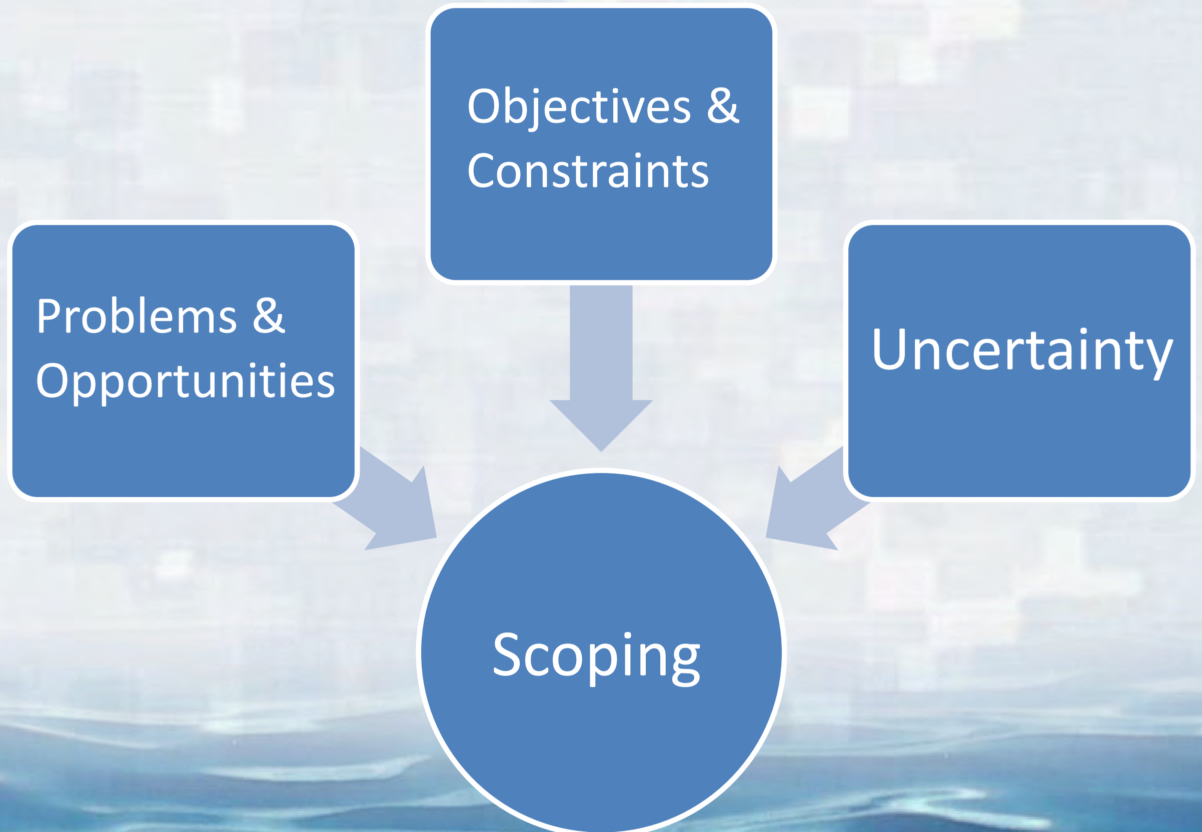
Quick recap – What has LACFCS already accomplished?



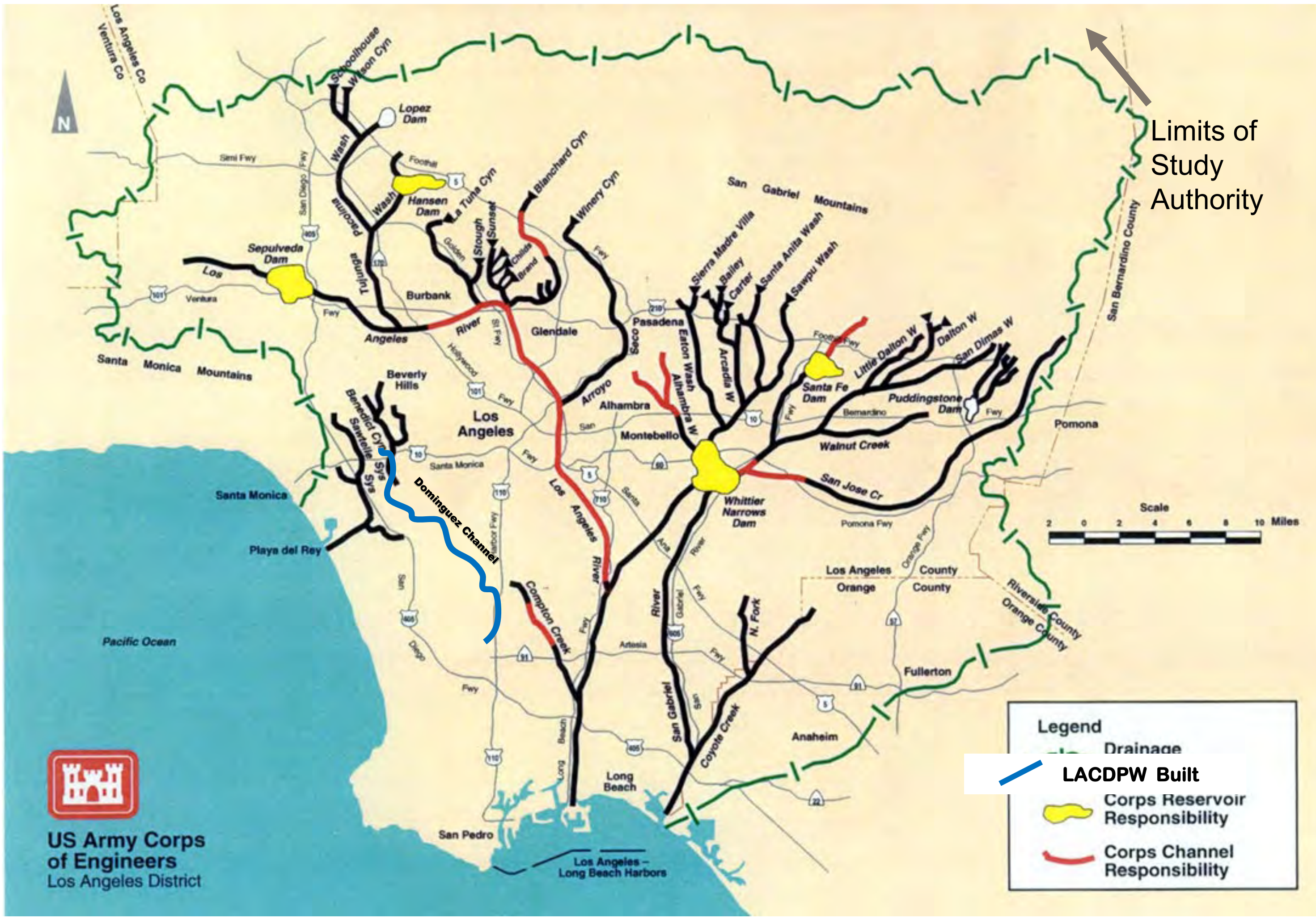
What is Scoping?

Task 1 of Risk-Informed Planning Process



LOS ANGELES COUNTY DRAINAGE AREA AND SYSTEM

The PDT has already scoped/ re-focused both the study area and the existing assets to be evaluated… definitely document this process!



PRELIMINARY SCOPING OF FRM BY ASSET TYPE

Asset Type	Categorical Screening
Dams (USACE or LACDPW)	Existing dams present concerns related to dam safety. Identified concerns are related to low probability/high consequence events that would not provide likely justification for a GI study recommendation.
Debris Basins	Primary concerns are related to greater than expected sediment yields that require more frequent basin cleanouts. Being addressed through ongoing O&M by LACDPW.
Channel/Levee Reaches	Levee safety program evaluations and FEMA certification studies identify residual FRM risks appropriate for further study

<u>Conclusion: Focus screening on existing levee/channel reaches in the study area.</u>

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FLOOD RISK & CONSEQUENCES: CHANNEL/LEVEE REACHES

System Component	San Gabriel River/ Coyote Creek 1	Coyote Creek/ CCC 1	Carbon Creek 1/ CCC1	Coyote Creek 2	Coyote Creek 3	San Gabriel River/ Coyote Creek 2	San Gabriel River 1	San Gabriel River 2a	San Gabriel River 2b	San Gabriel River 4	San Gabriel River 6
Overtop probability	0.0005	0.001	0.005	N/A	0003	0.005	0.005	0.0002	0.002	0.002	0.0002
Pop @ Risk	785	16,589	24,760		14,317	99,190	203,817	60,539	3,722	662	57,763
LSAC	4	$4	3	3	3	2	2	3	4	4	4
Prop. Damage ($M)	$42	$880	$1,319	N/A	$645	$3,574	$7,414	$1,337	$82	$43	$1,467

System Component	San Gabriel River 7	Rio Hondo Upper 3	Rio Hondo Upper 4a	Rio Hondo Upper 4b	Los Angeles River/ Rio Hondo 1	Los Angeles River/ Rio Hondo Diversion 2	Los Angeles River/ Compton Creek 1	Los Angeles River/ Compton Creek 2	Los Angeles River 3	Los Angeles River 5	Los Angeles River 6	Los Angeles River 7	Dominguez Channel
Overtop probability	0.002	0.002	0.002	0.01	0.01		0.01	0.005	0.05	0.005	0.05	0.05	0.02
Pop @ Risk	9,145	5,527	5,895	2,781	192,468		1,455	275,895	104	1,766	5,662	4,359	37,200
LSAC	4	3	3	3	2		3	4	2	4	2	3	N/A
Prop. Damage ($M)	$413	$102	$168	$90	$3,892		$1,455	$110	$8	$37	$341	$73	$760

Dominguez Channel has higher consequences (Pop@risk, $ damages) for ACE >0.01

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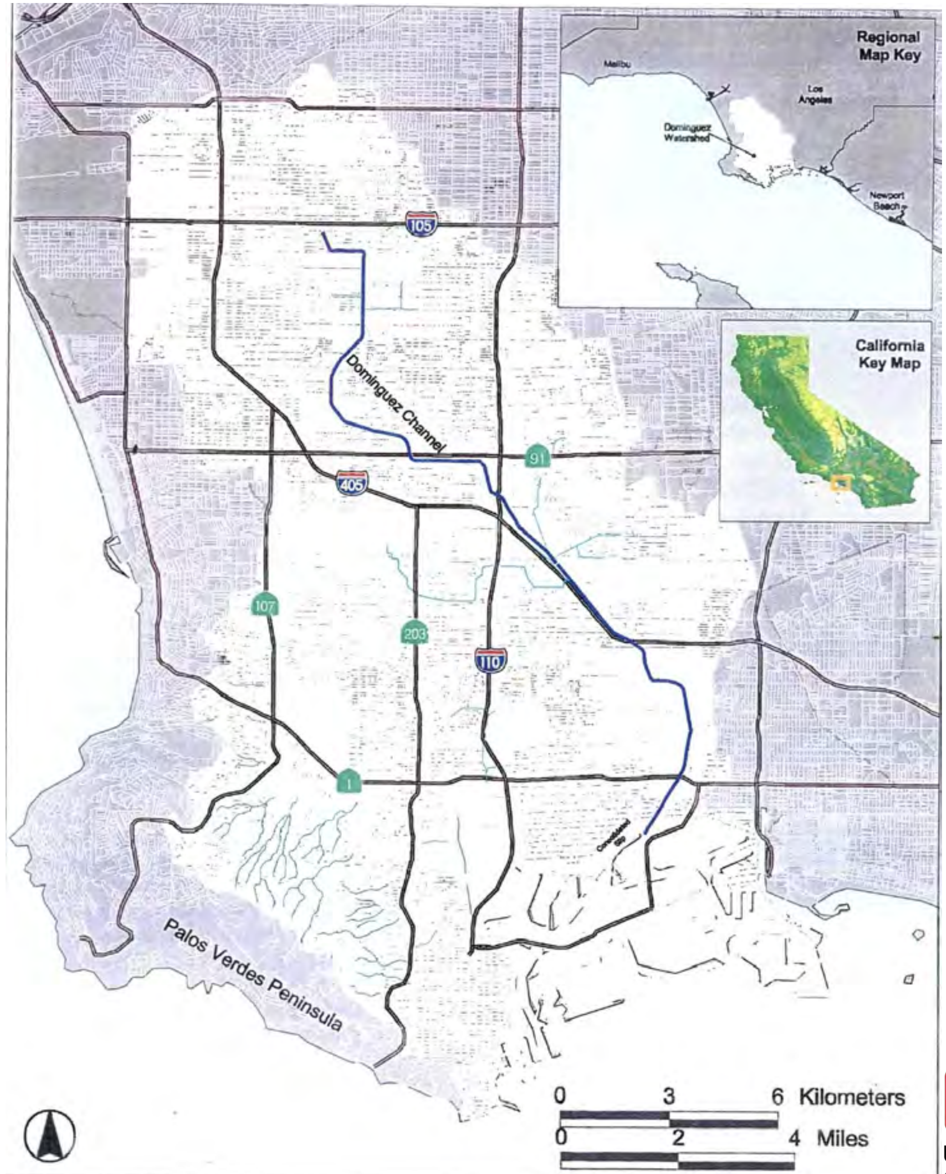
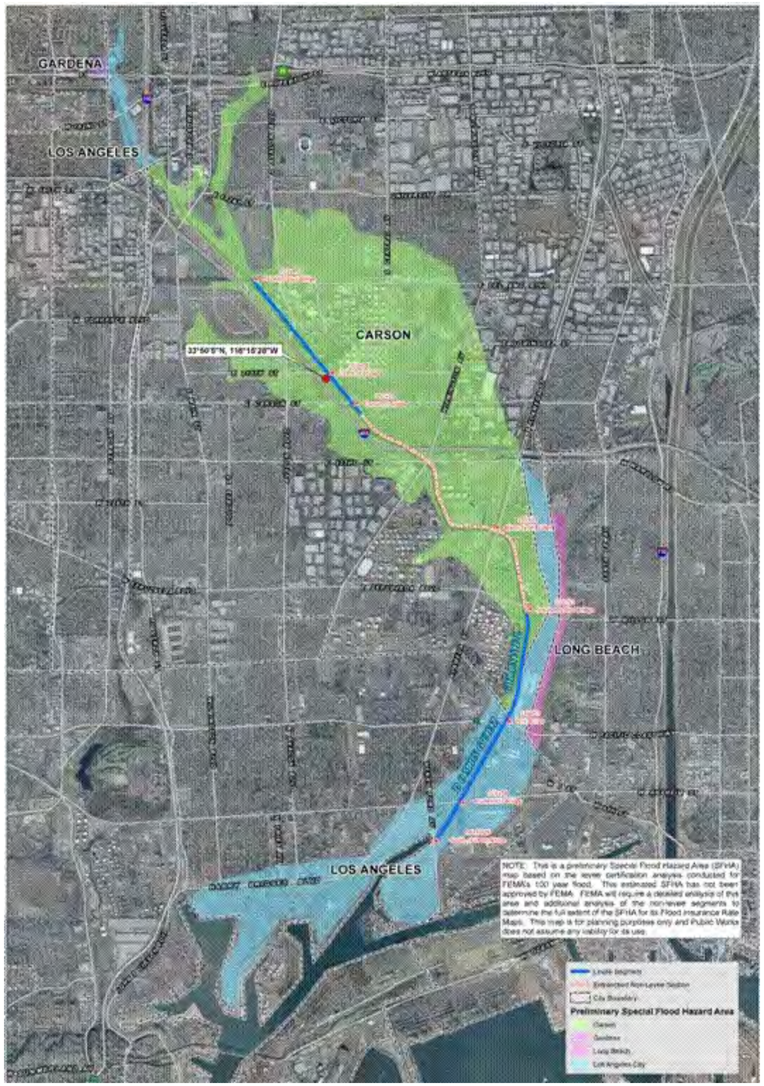
DOMINGUEZ WATERSHED



CURRENT ESTIMATED FLOODPLAIN



1% ACE Floodplain (estimated)
Overtopping & Topography

- 30,000 residents living in floodplain; 11,000 housing units
- Floodplain includes light/heavy manufacturing industries, petroleum/chemical storage tank farms; public infrastructure
- Drains to Port of Los Angeles - largest/busiest container port in country. Over 8M containers pass through port annually. Containers loaded on to freight trains and transported nationwide
- *We care about other floodplains as well, correct?*

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DOMINGUEZ CHANNEL BACKGROUND

- Channel constructed in 1950s by LACFCD to provide flood protection in southwest Los Angeles County (South Bay area).
  - Drains 110 sq.mi subwatershed
  - 15.7- mile long channel
  - Drains densely populated cities Inglewood, Hawthorne, El Segundo, Redondo Beach, Gardena, Torrance, Lawndale, and Carson
- Channel is concrete entrenched in upper reaches; becoming riprap banks and soft-bottom in middle to lower reaches
- Urbanization over last 60 years has reduced flow conveyance from 1% annual chance of exceedance (100-yr) to 2% ACE (50-yr)
- Opportunities to decrease flood damages to homes, commercial and industrial enterprises resulting from 2% ACE storm event or greater

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SCOPING TASK - WHAT ARE THE 6 PIECES OF PAPER?

Has the PDT developed all these?

- ✓ **Problems & opportunities**
- **Future without project conditions – narrative description**
- ✓ **Objectives & constraints**
- **Decision criteria**
- **Unique questions**
- ✓ **Key uncertainties**

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PROBLEMS – FROM AMM

- There is significant flood risk in the Dominguez Channel floodplain that would result in flood related damages to residential properties, commercial and industrial properties and infrastructure such as highways and port facilities; as well as significant threats to life and safety.
- Underlying causes of increased flood risks include:
  - Increased runoff due to urbanization
  - Overtopping of channel/levees that will inundate structures and critical infrastructure
  - Sea level rise will decrease flow capacity and discharge of floodwaters to the East Basin, Port of Los Angeles

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Risk Identification = Problem Identification

Risk Identification

Trigger
- An event
- Accumulation of information

Hazard
- The thing that can cause harm
- Or the opportunity for a potential gain

Harm
- Identify the specific harm(s) of interest
- Identify the specific gain(s) that could be achieved

Sequence of events
- Sequence of necessary events from hazard to harm
- Sequence of events from opportunity to gain

Uncertainty
- Identify key uncertainties
- Reduce uncertainty

OPPORTUNITIES – FROM AMM

- *Increase channel capacity* to reduce flood damages and risks to public safety associated with overtopping of the Dominguez Channel.
- Reduce impacts to traffic and emergency vehicle flow throughout the floodplain and affected areas and maintain access to the Ports.
- Decrease peak discharge of storm events in the watershed caused by short duration, high intensity storms.

- *Should we change (or add to) any of these?*

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OBJECTIVES FROM AMM

- Reduce flood hazards along Dominguez Channel, including risks to life safety and damages to private and public property and infrastructure.

- Improve water conservation, impaired water quality and ecosystem degradation by addressing watershed conditions that also contribute to flood risk reduction.

Note on last objective: these conditions (e.g., degraded ecosystem) are good candidates as "opportunities." Then if we are going to formulate to meet them, they become "objectives."

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CONSTRAINTS

- The project *cannot induce flooding* in other parts of the drainage area.
- The project must not cause an increase in response time from emergency responders, nor cause an increase in flood risk to critical facilities, such as police stations, fire departments, hospitals, or schools.
- The project must comply with all applicable federal, state, and local laws and policies.
- The project must comply with applicable executive orders (EOs).

- *Should we change any of these?*

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CONSIDERATIONS

- Existing Infrastructure: channel crossings, (pipelines in sub-surface; sewer crossings; rail lines; power lines) -- physical conflicts/cost considerations
- Barriers to real property acquisition: cost and political/institutional opposition
- Contaminants in existing channel bottom will affect costs and safety requirements for channel modification
- HTRW sites along channel (plumes; delineated areas) physical hazards, liability, disposal requirements, water quality impacts of construction
- Tidal influence makes channel deepening ineffective

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KEY UNCERTAINTIES

Uncertainty	Consequence	Strategy
Floodplain based on topographic analysis	Damages and benefits may go up w H&H model development	Track model development and assess impacts on viability of measures/alternatives.
Extent of HTRW	Additional construction requirements, elevated construction costs	Consider land use and regulatory data to estimate probability of contamination and adjust costs accordingly
Sea Level Rise	Underestimate damages	Focus on medium and high SLR scenarios, identify resilient measures
Large/Rare Event	Catastrophic Damages	Estimate probabilities, exclude scenarios with no feasible solutions
Future Drainage Modification	Under or over estimate measure performance	Coordinate with NFS to include watershed strategies in H&H and combine with plans in analysis

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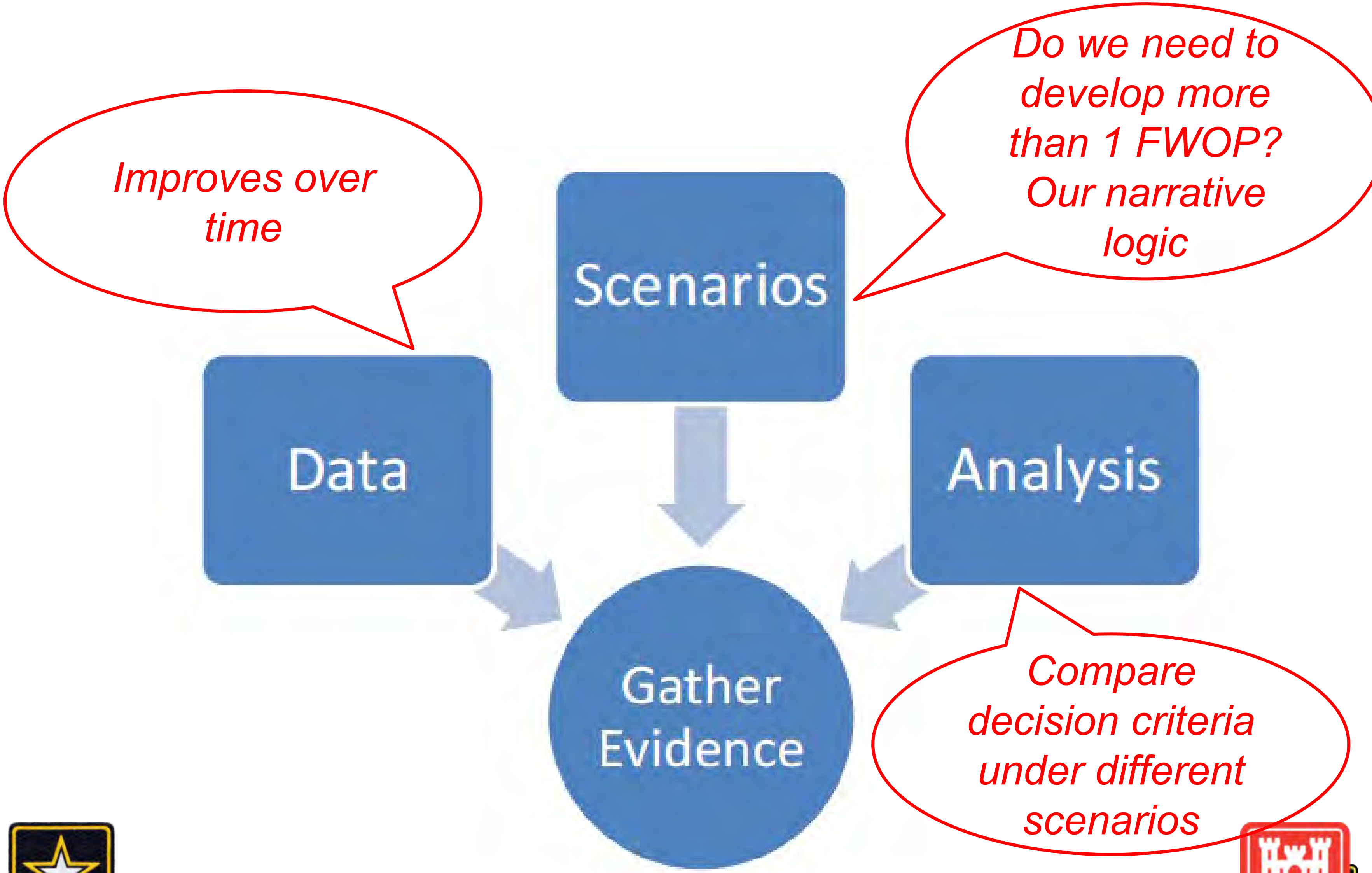
EVIDENCE GATHERING



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FWOP CONDITION – NARRATIVE DESCRIPTION
CAN WE FLESH OUT ANY OF THIS?

In general:

- Assumptions?
- Trends?
- Actions by others?
- Will FRM problems get better or worse over time without Federal action?

Typical Forecasts:

- H&H
- Climate change (ECB 2018-14)
- Sea level change (ER 1100-2-8162)
- Structure value
- Population change
- Exposed/vulnerable population
- Local development plans
- Land use changes
- Habitat changes/ WQ changes
- Infiltration/ conservation
- State/ local actions

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WHAT DECISION CRITERIA WILL WE USE?

Some candidates:

- Costs (including construction, LERRD's)
- Damages – how large are damages in a reach/area, and how effective is alternative in reducing damages?
- Population at risk – how large is population in reach/area, and how effective is alternative in reducing risk to population?
- What critical infrastructure is present in reach/area, and how effective is alternative in reducing damage or risk?
- Can alternative also address water conservation?
- Can alternative also address WQ?
- Can alternative also address ecosystem degradation?
- What are the environmental effects of the alternative – negative or positive?
- Are there cultural resources effects?
- Are there other potential benefit categories besides flood damage reduction and life safety – e.g., environmental benefits, recreation benefits?
- Resilience (principles are: prepare, absorb, recover, adapt)
- 4 P&G criteria
- Others?

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WHAT ARE UNIQUE QUESTIONS TO THIS STUDY? (THAT DECISION MAKERS WOULD LIKE TO KNOW)

Some candidates:

- What is history of flooding in this area? Has there been historical loss of life?
- Is population in reach/ area particularly vulnerable to flooding?
- What is the nature of the critical infrastructure present in study area that is at risk of flooding? What would the consequences of damage to that infrastructure be?
- What is the nature of HTRW contamination in study area? Could we worsen HTRW situation through our alternatives?
- Besides costs, what factors affect land acquisition?
- Besides costs, what factors affect channel improvements?
- How does SLC impact the effectiveness of drainage/conveyance system? How far upstream are the effects evident?
- What actions is the Sponsor/ LA County taking to manage flood risk in study area (existing and future)?

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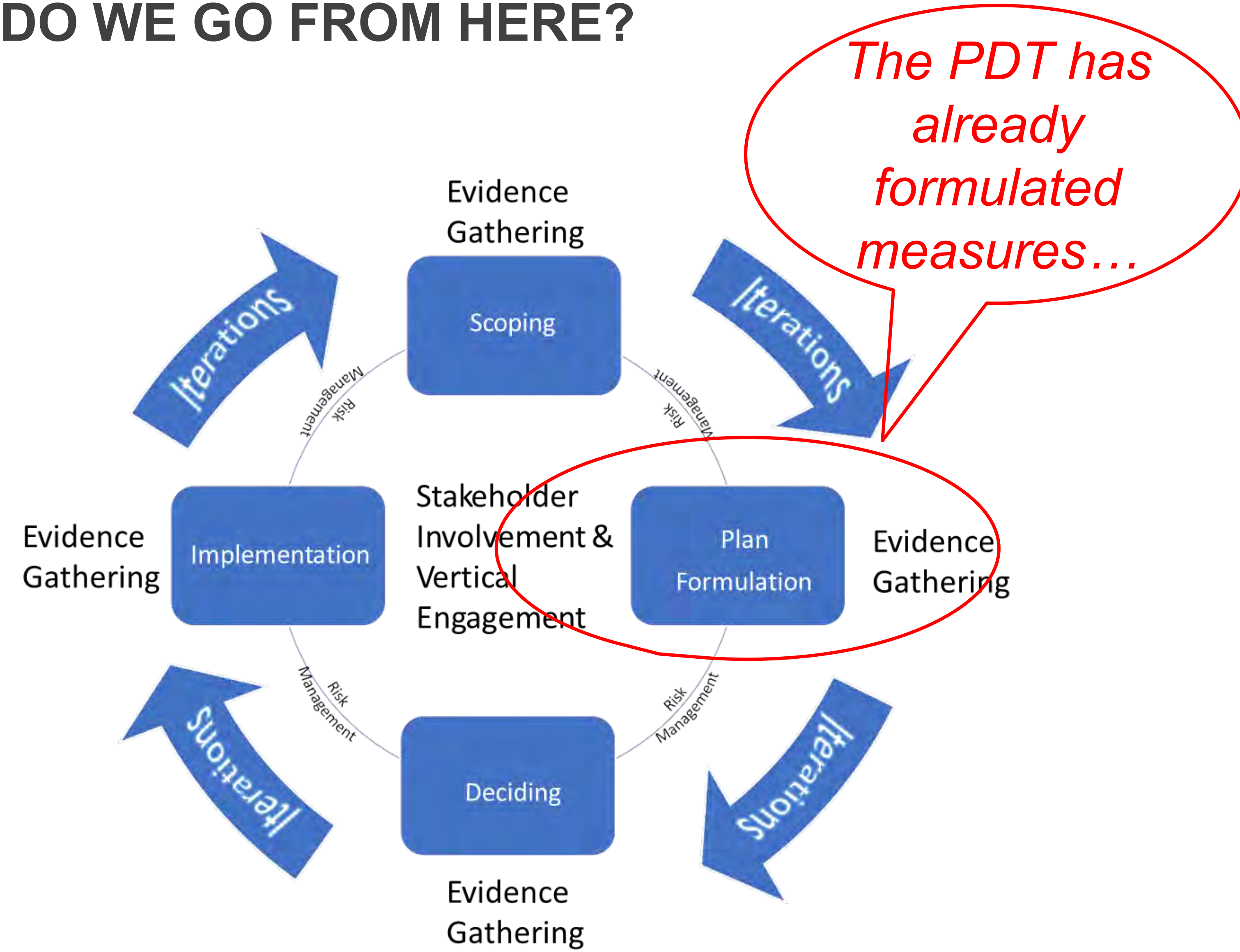
WHERE DO WE GO FROM HERE?



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PLAN FORMULATION

- PDT has developed measures and formulation strategies
  - Detention basins
  - Channel mods
  - Parapet walls
  - Parcel level flood detention
  - Relief drain/ bypass channel

- Bypass channel
- Structure to reduce tidal influence
- Nonstructural – must include
- Nature-based features - must show we considered

- Formulation strategies:
  - Improve conveyance
  - Detention/ retention off-channel storage
  - Nonstructural to reduce consequences
  - Provision of other benefits – water conservation & ecosystem
  - Combinations of the above

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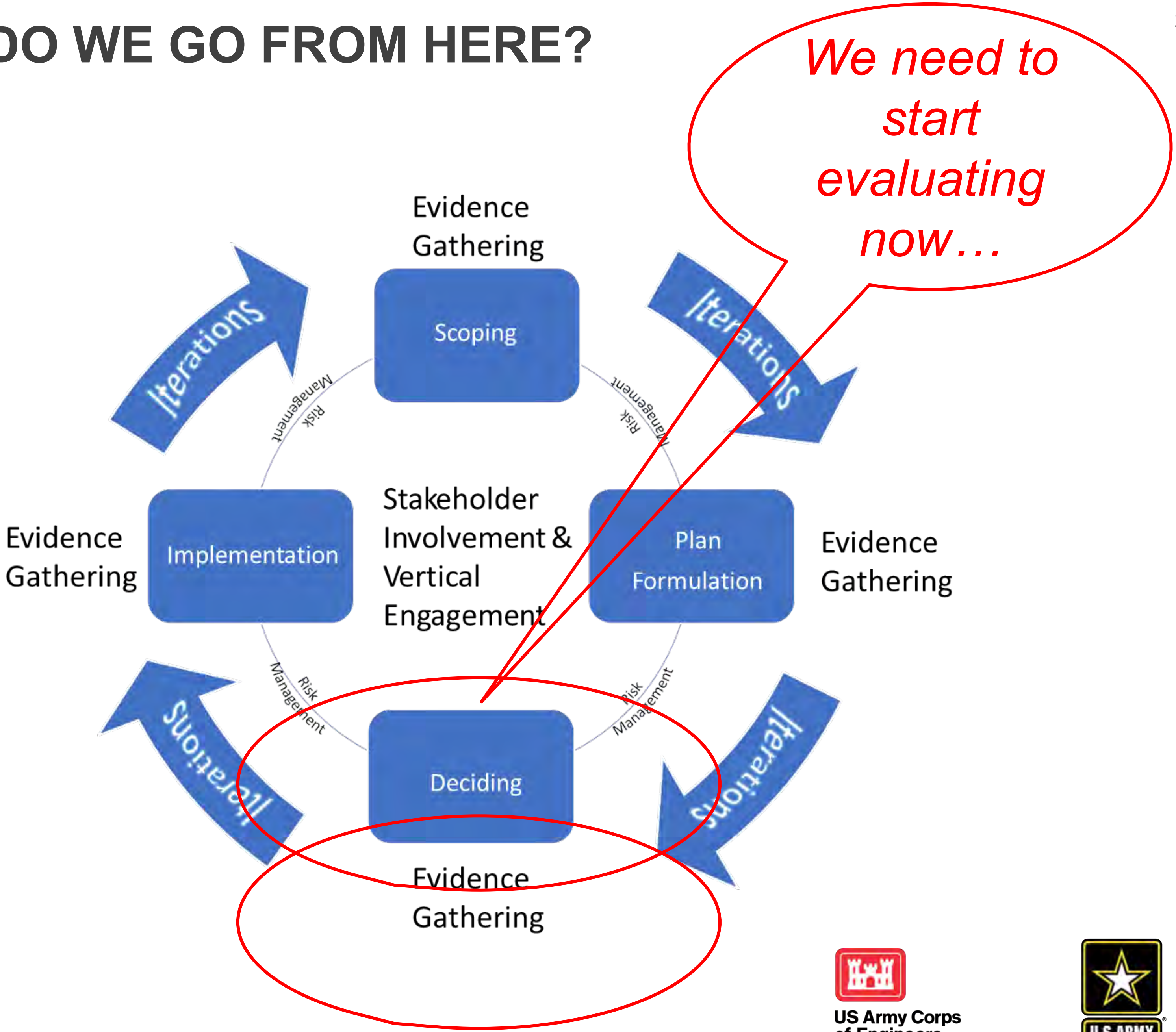
WHERE DO WE GO FROM HERE?



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WHERE DO WE GO FROM HERE?

- Let's focus on the technical steps to get to the TSP milestone
- Let's tackle each discipline with a focus on:
  - Do we have enough info now to evaluate the alternative?
  - Doesn't have to be the "final answer" or analysis – better, more refined data can come later – but can we make some decisions now?
- Examples:
  - Economics – can we use the FEMA 500-year floodplain as the boundary for our structural inventory?
  - Geotechnical engineering – do we need to develop fragility curves now to be able to assess current performance of levees and performance of alternatives?
- Process:
  - Discuss each task/activity on Gantt chart
  - Emphasis on shortening schedule, doing analysis now with what we have

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THE FOLLOWING SLIDES ARE FROM AMM PRESENTATION FOR REFERENCE

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MEASURES LIST DEVELOPMENT

1) Detention/Retention Basins (u/s and d/s– LACDPW has developed an open area inventory in the drainage area, open parcels, golf course, parking areas could be diked and excavated for off-channel capacity).
2) Channel modifications: considered d/s – a) change in geometry - trapezoidal to rectangular concrete (Vermont to d/s to tidal – big issue having hard bottom close to the ocean – pressure; soft bottom cantilevered walls – costs are significant), c) widening with respect to available to ROW (take out one access road – evaluate costs)
3) Parapet walls: road modifications – evaluate crossings, d/s – levee (8.3 miles), depending on topography – but most probably both sides. Concerns – geotech, foundation condition. Increased loading. (general review of existing of data – settlement problems). H&H – interior drainage issue would need to be evaluated – so not effected and making flooding worse. (Physical conflicts with infrastructure, esp. bridge crossings and rail lines.)
4) Parcel Level Flood Detention – LACDPW is evaluating PLFD systems throughout the watershed to provide 50% detention of peak flow, while also contributing to the county’s water quality goals.
5) Relief Drain – An underground relief drain could be constructed along a new alignment to push the flows out to the ocean through a separate drainage system, preventing 14,075 cfs peak flow from entering the channel.

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MEASURES LIST DEVELOPMENT

6) Bypass: diversion along the channel (box culvert), draining to the bay. Likely to be high cost and susceptible to SLR. Some parts of it underground, and other sections daylighted. Start of line (to reduce the peak), to the bay. HTRW. UP – big yard in this area; Port; Kinder Morgan; Refineries.
7) Structure(s) to reduce tidal influx – tide gate, barrier, pumping, diversion/spillway to East Basin Port of Los Angeles
8) Non-structural: flood proofing structures, flood warning system, evacuation and communication practices – supplementary to structural measures.

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ALTERNATIVES DEVELOPMENT

Strategies for Alternatives

- Methods of conveyance: measures to augment existing channel capacity, add additional conveyance
- Retention/detention to reduce peak flows: Off-channel storage (open area locations for basins), PLFD.
- Provision of incidental benefits: water conservation, habitat/ecosystem restoration
- Non-structural measures to reduce consequences of overtopping.

COMBINATIONS OF MEASURES AND ALTERNATIVES

Determine conflicts, compatibilities, dependencies and redundancies among measures.

Exclude combinations that induce flooding, have costs unlikely to justify benefits, or result in unacceptable impacts.

Combine compatible elements of thematic plans to include hybrid plan

PLAN COMPARISON AND SELECTION

Perform H&H and estimate value of damage reduction: derive net benefits

Determine plan with maximum net benefits for NED Plan

Characterize incidental benefits, consider for tie-breaker or trade-off analysis

Consider SLR analysis and likelihood of plan benefits in later part of period of analysis.

Consult with sponsor on TSP, determine interest in LPP if a justified increment is identified that meets NFS objectives in addition to NED plan benefits.

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POST ALTERNATIVES MILESTONE

- PDT will **proceed with reducing uncertainties** and **identifying the TSP**.
- Feasibility study activities will include, but are not limited to:
  - **Initiation and continuing environmental and cultural compliance** documentation and activities (NEPA, FWCA, ESA, NHPA, etc.);
  - Conducting **further analyses of the Future Without Project Condition** to enable appropriate comparison with alternatives;
  - **Evaluating and comparing the focused array of alternatives,** including NEPA analysis;
  - **Selection of a TSP**;
  - **Identification of a LPP**, if applicable;
  - **Developing the draft feasibility repor**t in preparation for concurrent review.

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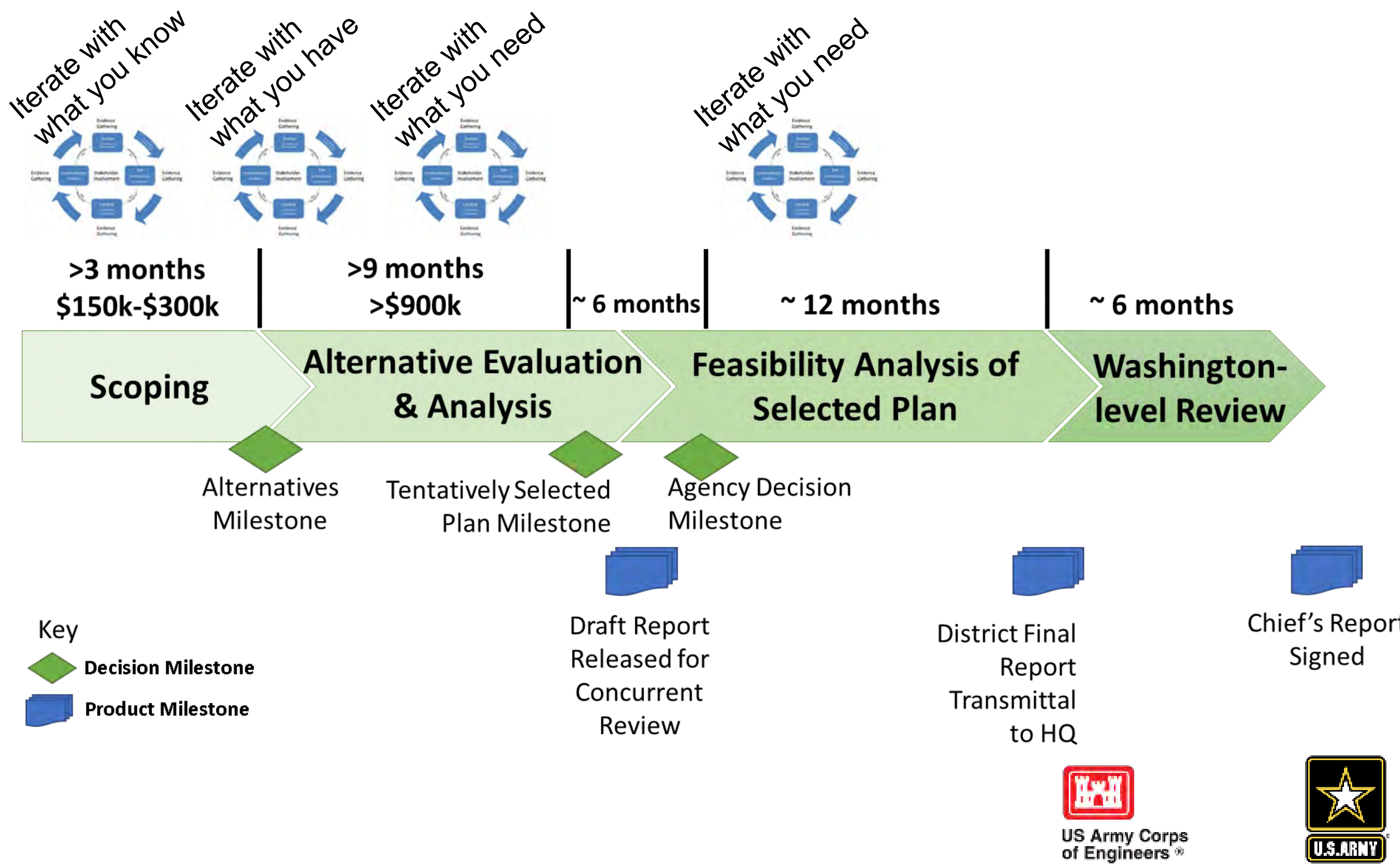
RISK-INFORMED DECISION-MAKING FOR AQUATIC ECOSYSTEM RESTORATION

Leigh Skaggs, HQUSACE
Kansas City Mentoring Workshop
29 August 2019

Disclaimer:
Credit to MVS Project Delivery Team for doing all the hard work!!
I'm just presenting their study with a different spin

TAKE THE SIX-STEP PLANNING PROCESS AND ITERATE SEVERAL TIMES! GATHER EVIDENCE TO REDUCE UNCERTAINTY AND MANAGE STUDY AND PROJECT RISK



USING ITERATIONS OF THE PLANNING PROCESS AND LOOKING AT OUTCOMES THROUGH A RISK LENS IS NOT NEW

Knowledge based – get experienced input

Iterate through the 6-step planning process at least once before making many judgments about the scope

Then -

- Start with what you know
- Challenge your assumptions
- Use a risk register or similar tool to organize and communicate your thoughts

From 2014 webinar, "Strategies for Scoping 3x3x3 Studies"

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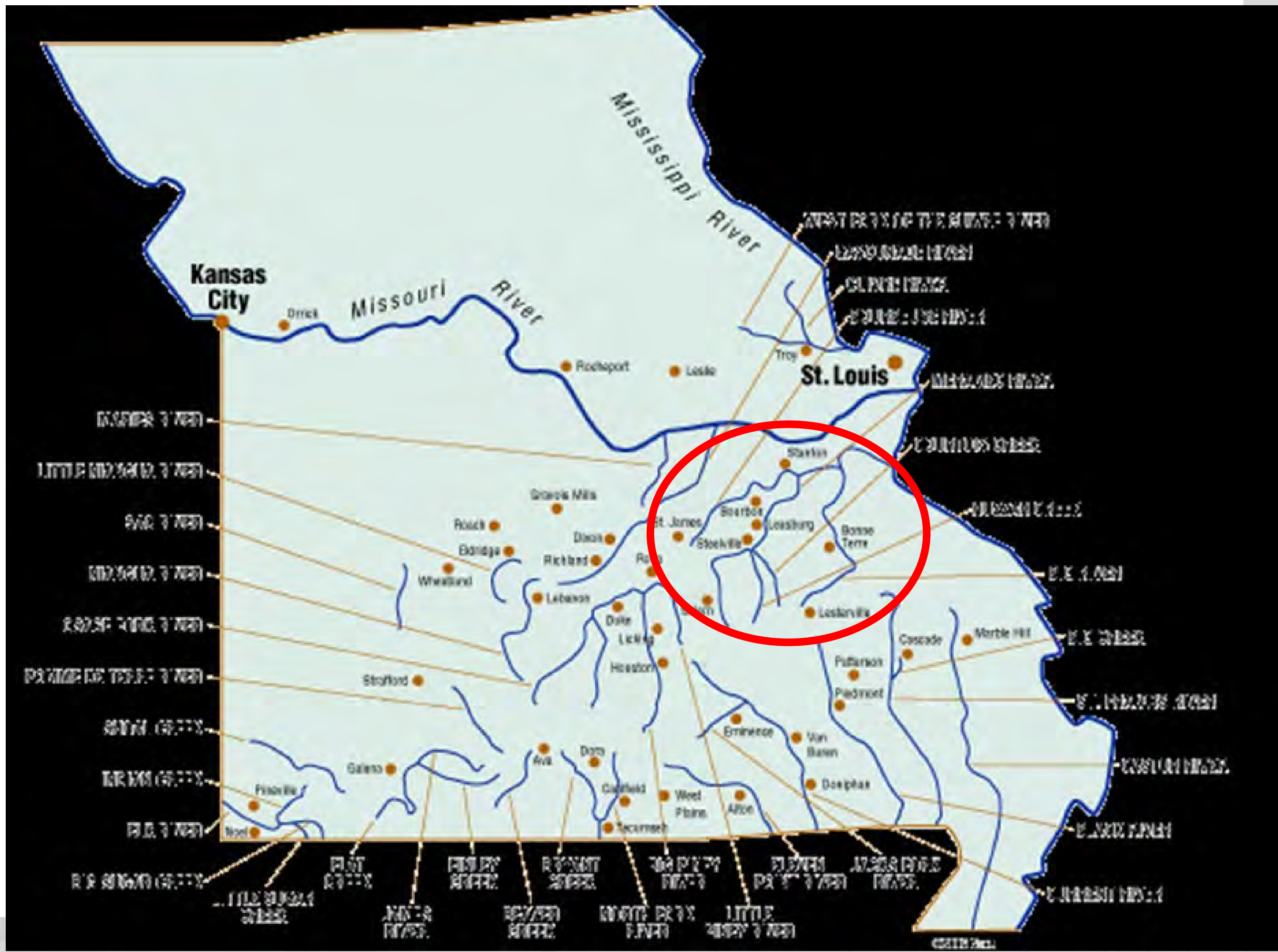
LET'S APPLY RIDM TO AN ONGOING USACE AQUATIC ECOSYSTEM RESTORATION STUDY –

ST. LOUIS WATERFRONT/ MERAMEC RIVER, MISSOURI



LET'S APPLY RIDM TO AN ONGOING USACE AQUATIC ECOSYSTEM RESTORATION STUDY –

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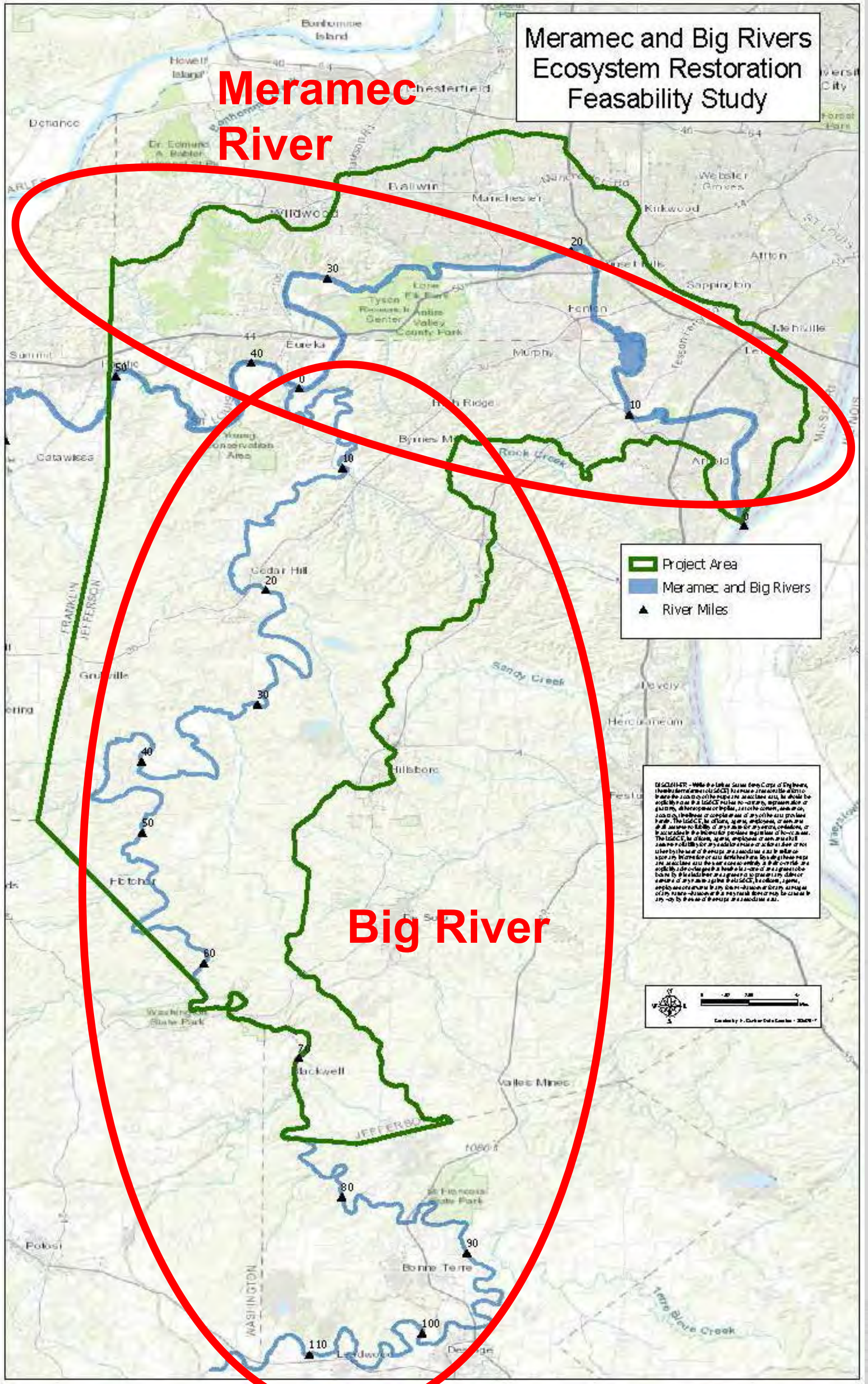

YOU CAN CONDUCT THE 1ST ITERATION WITH KNOWLEDGE ON THE TEAM!

In a feasibility study, this iteration will be within first 30 days.

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THE SETTING: NATURAL STATE

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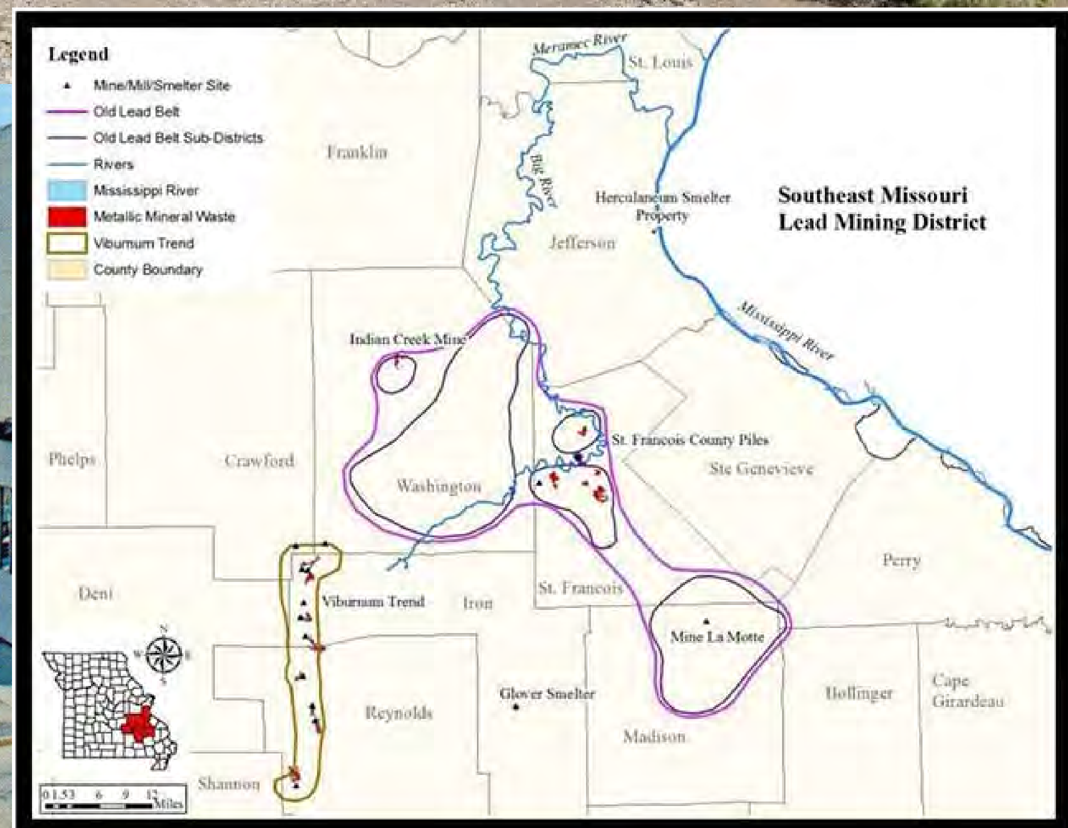
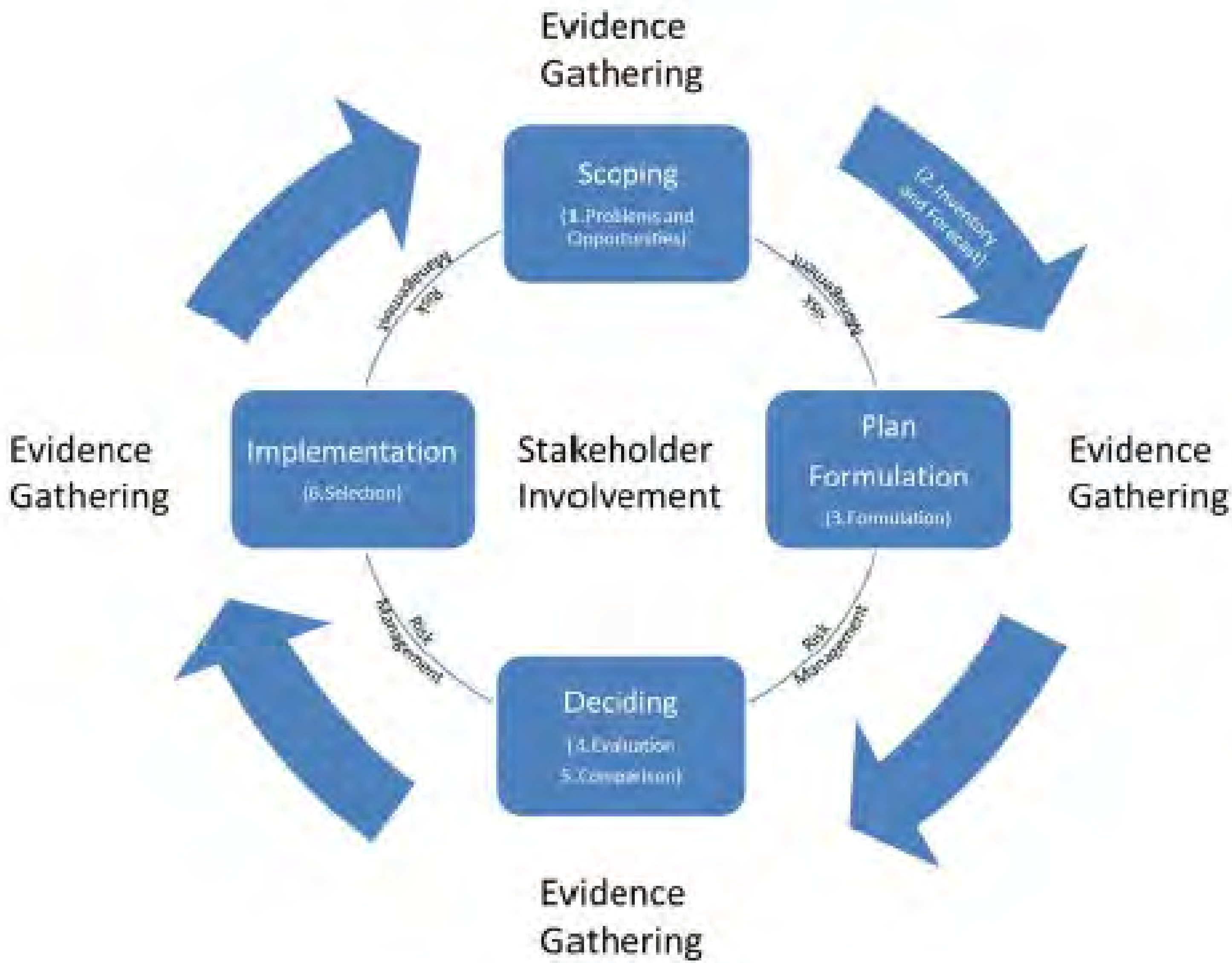
THE SETTING: DEGRADED STATE



RISK INFORMED PLANNING PROCESS



TASK 1: SCOPING

Scoping can be summarized on 6 Pieces of Paper:

1) Identify problems and opportunities
2) Forecast "future without" condition
3) Identify objectives and constraints
4) Identify decision criteria
5) List unique questions
6) Identify key uncertainties

Figure 6.1: Three main tasks comprising the scoping task

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Problem Identification = Risk Identification

Trigger
- An event
- Accumulation of information

Hazard
- The thing that can cause harm
- Or the opportunity for a potential gain

Harm
- Identify the specific harm(s) of interest
- Identify the specific gain(s) that could be achieved

Sequence of events
- Sequence of necessary events from hazard to harm
- Sequence of events from opportunity to gain

Uncertainty
- Identify key uncertainties
- Reduce uncertainty

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PROBLEM/ RISK ID EXAMPLE – MERAMEC RIVER, MO

Trigger: Continued loss of freshwater mussel habitat (indicator species), losses are migrating downstream, listing of T&E species, loss of biodiversity & aquatic connectivity

Hazard: Excessive sediment loads, contaminated sediments, streambank erosion, stream blockage (mill dams)

Harm: Loss/degradation of aquatic / mussel habitat, actual "dead zones," loss of riparian habitat, loss of recreation, potential human health effects, loss of land

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PROBLEM/ RISK ID EXAMPLE – MERAMEC RIVER, MO

Sequence of Events:

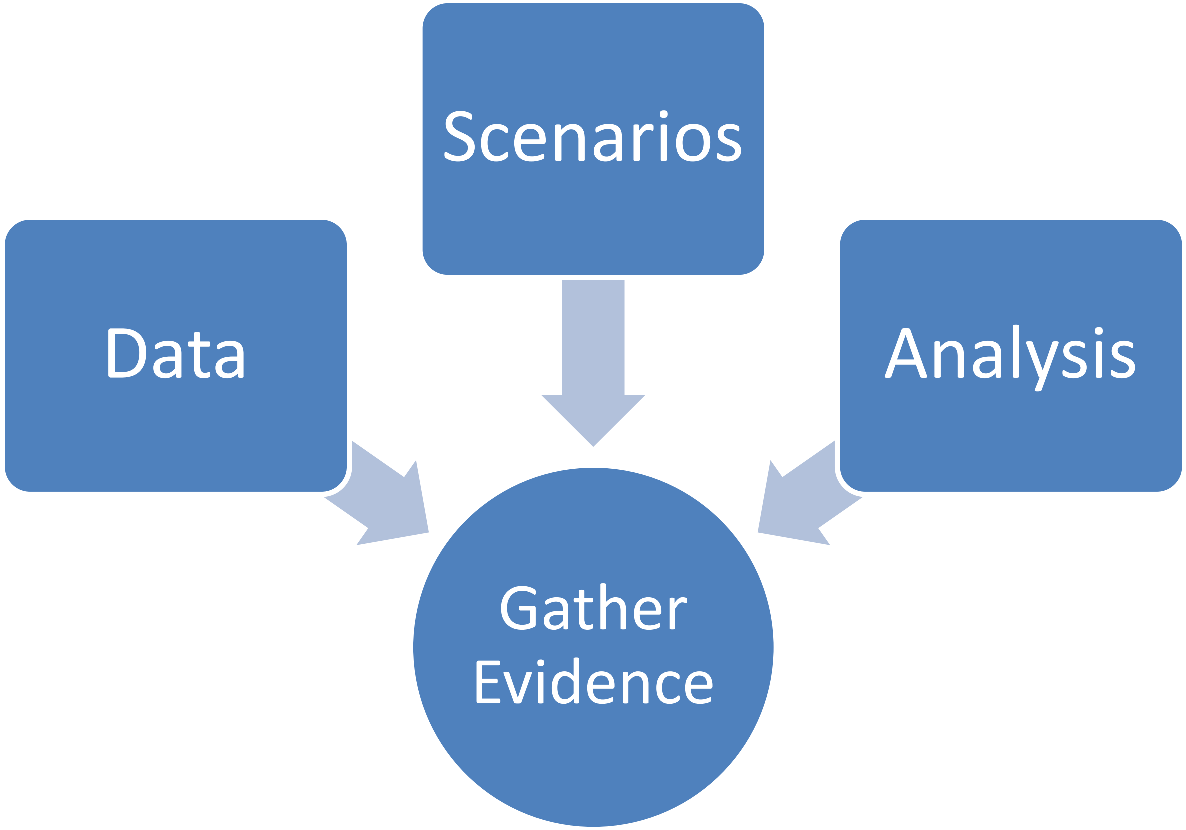
Historic lead mining + tailing mounds + land use changes → sediments mobilized during precip/floods → increased sediment bedload → disrupted stream geomorphology → bank erosion + buried substrate → degraded/ loss of aquatic + riparian habitat → fewer mussels, fewer mussel species, fewer species in general

PROBLEM/ RISK ID EXAMPLE – MERAMEC RIVER, MO

Key uncertainties (early on):

1) What factors most affect mussel habitat?
2) Will sediment mobilization continue?
3) Distance/ rate of downstream sediment progression?
4) Do mill dams really affect connectivity?
5) What will EPA's Remedial Investigation/ ROD result in?
6) Should we limit formulation to "clean" areas?

ONGOING ACTIVITY: GATHER EVIDENCE



What do you need to reduce instrumental uncertainty, manage intolerable risk, and make the next decision?

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NARRATIVE FWOP CONDITION – MERAMEC ("+" = IMPROVEMENT, "-" = DECLINE, "~" = UNCHANGED)

+ Assumed that USEPA will move forward with an independent Feasibility Study (Remedial Investigation) and remediation of sites where human health and safety are at risk.
+ Other groups and agencies addressing problems within the watershed will continue to move forward.
– Existing tailings/sediments that have already made their way into the Big River system are expected to continue their downstream migration.
– Erosion from the floodplain is expected to continue to reintroduce mining sediment into the system.

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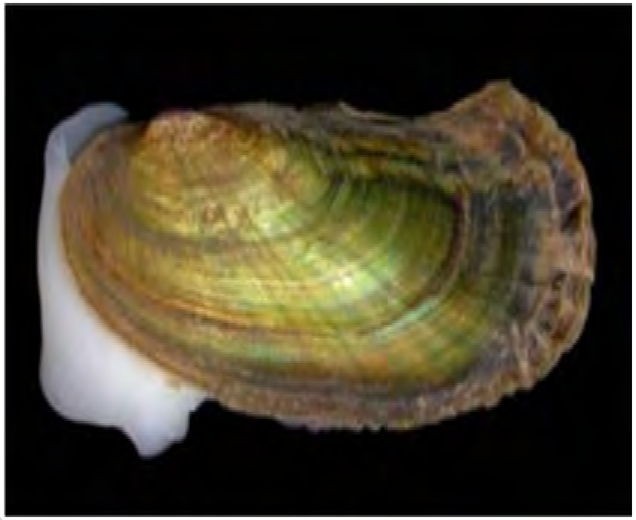
NARRATIVE FWOP CONDITION - MERAMEC

- Existing & future sediments expected to continue to have negative effects on local mussel populations, including five federally endangered mussel species (Pink Mucket, Scaleshell, Sheepnose, Snuffbox, and Spectaclecase).
- The decline in the Big River mussel community's distribution, diversity, and abundance seen over the last 30 years is likely to continue to expand down the Big River and into the Meramec River.

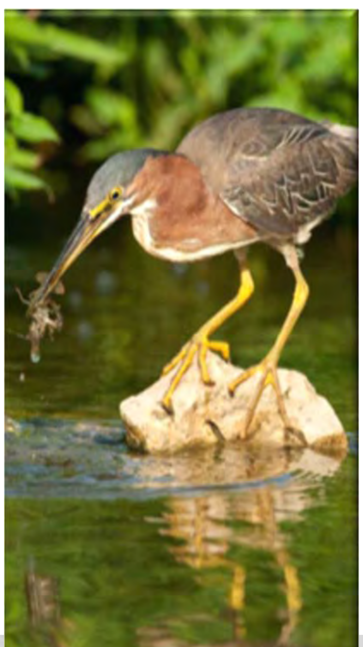


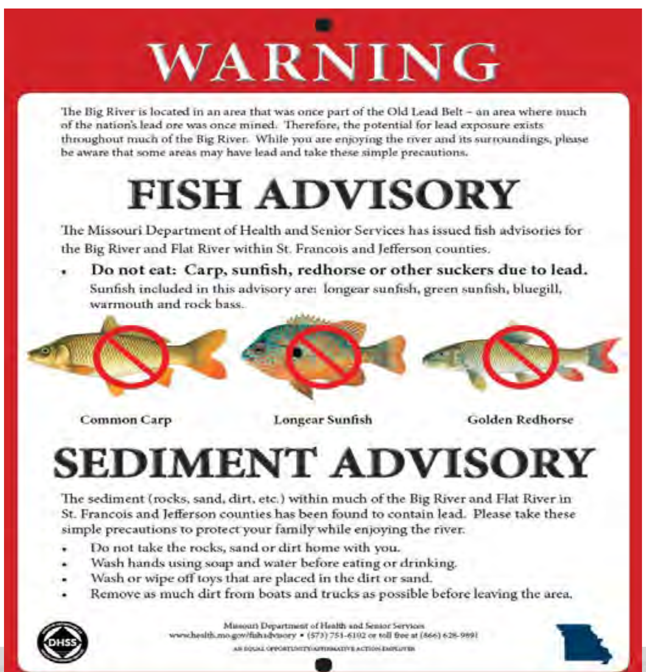
NARRATIVE FWOP CONDITION - MERAMEC

– Other biota in the lower Meramec River system would likely be adversely affected by the Big River sediment bed load.

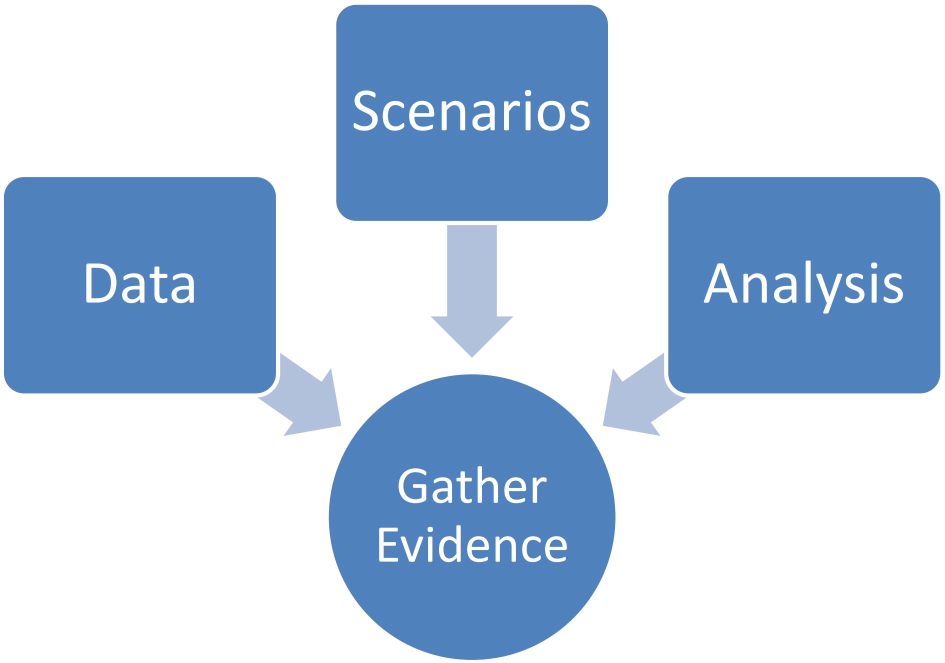
~ Current land use trend will continue and a minimal increase in urbanization and agriculture will occur.

~ Climate change will not have a significant impact on the hydrology of the project area.





FWOP: WHAT ABOUT SCENARIOS?



- What remediation efforts will USEPA undertake?
- Until ROD, definitive remediation levels (HTRW) are unknown.
- Potential for USACE project/site overlap w/ USEPA
- RIDM Solution: Scenarios! Establish alternative (upper & lower bounds) clean-up levels – what are impacts on benefits?
- In addition: develop plan formulation strategies that can adjust to potential EPA actions

STILL CONTINUING WITH 6 PIECES OF PAPER UNDER SCOPING… ID OBJECTIVES - MERAMEC

Objective 1: Reduce the downstream migration and quantity of excessive sediment from the upper reaches of the Big River in order to protect, enhance, and restore degraded aquatic and mussel habitat.

Objective 2: Reduce the quantity of sediment entering the Big River, Meramec River, and tributaries from bank erosion, floodplain sediments, and other sources.

Objective 3: Increase riparian habitat connectivity, quantity, diversity, and complexity within the Project Area.

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6 PIECES OF PAPER… ID CONSTRAINTS & CONSIDERATIONS - MERAMEC

- Project features will not increase the distribution or migration rate of contaminated sediments.
- Avoid features that are not compatible with other restoration or remediation efforts.
- Avoid features that could permanently affect the function of surrounding infrastructure.
- Avoid features that could increase flood elevations or potential flood damages.
- Recreation designs on public property should avoid inadvertent access to private property.

6 PIECES OF PAPER… ID KEY DECISION CRITERIA - MERAMEC

- For initial array of alternatives: High (3)/ Med(2)/ Low(1)
- Effectiveness
  - Reduce migration of sediment
  - Reduce quantity of sediment
  - Increase aquatic connectivity
  - Increase riparian habitat
- Efficiency
  - Minimizes cost relative to benefit
- Acceptability
  - Minimizes USACE policy concerns
  - Acceptable to state & local entities
  - Acceptable to communities
- Completeness
  - All features/actions (including by others) considered

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6 PIECES OF PAPER… ID KEY UNCERTAINTIES - MERAMEC

- Actions to be undertaken by EPA
  - Definitive remediation (clean up) levels unknown
    - Assumed 400 ppm (residential yards) - 1200 ppm (existing upstream) lead concentration
  - See sensitivity analysis below
- Locations of remediation/ clean-up

ID KEY UNCERTAINTIES - MERAMEC

- – Real estate interest
- – Sediment transport and riverine processes – affects benefits, alternatives, costs:
  - Bank erosion rates
  - Spatial distribution of legacy sediments
  - Bed load transport rate and frequency
  - Sediment capture basin fill rates
  - Tributary sediment contributions
  - Land use and resulting overland flow
  - Mill dams
  - Bed stability
  - Lead reduction

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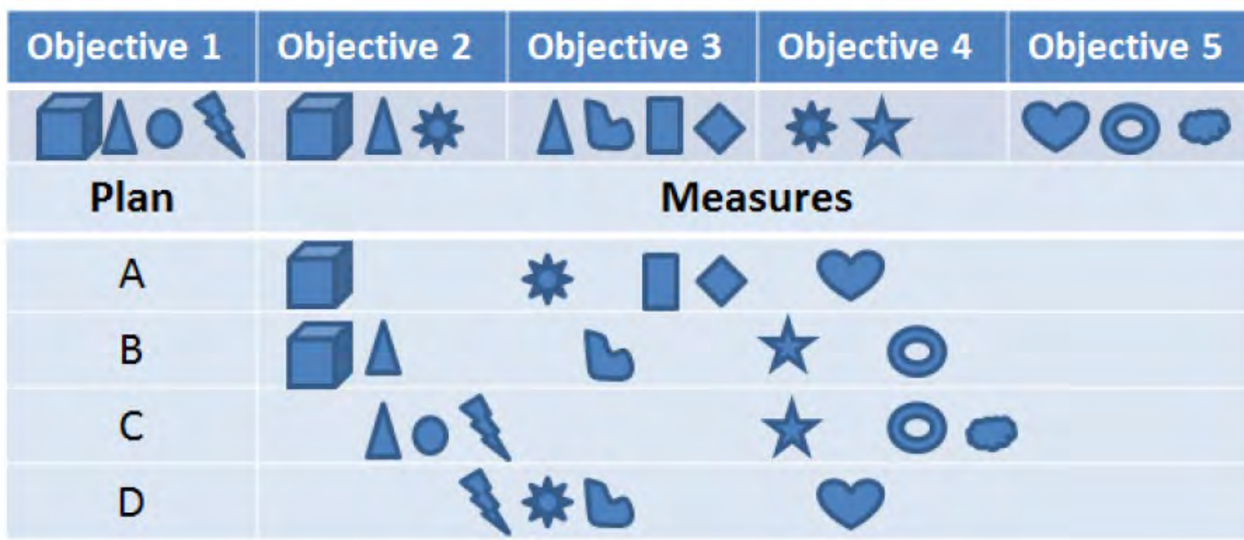
TASK 2: PLAN FORMULATION

Identify measures

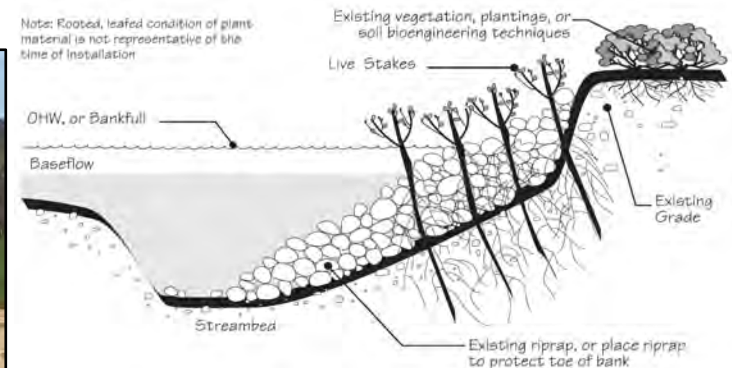
Screen measures

Formulate plans

Reformulate plans



BANK STABILIZATION MEASURES - LPSTP



Post Construction

4 months

BANK STABILIZATION MEASURES - BIOENGINEERED

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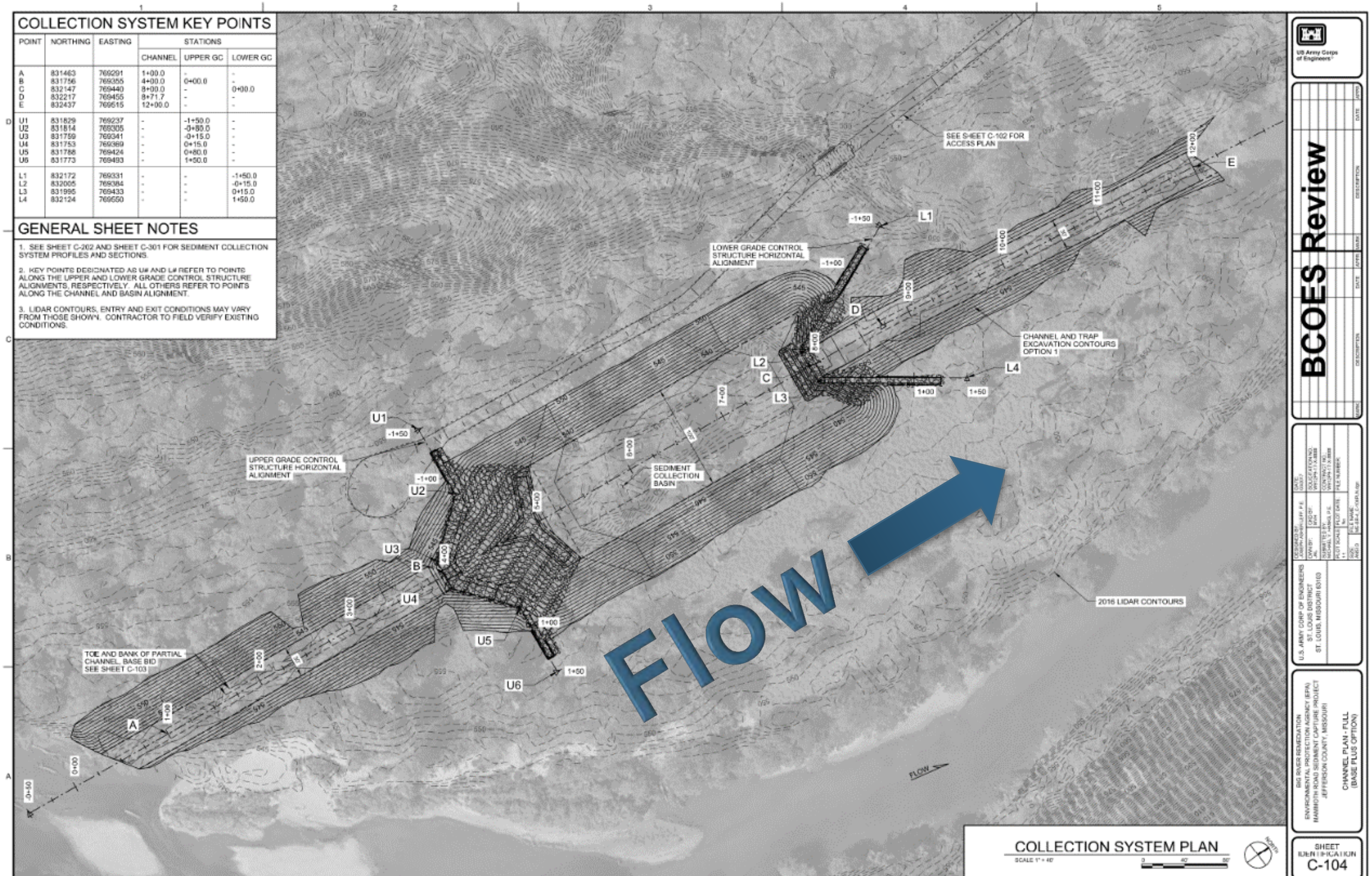
PASSIVE SEDIMENT COLLECTION BASIN



POINT	NORTHING	EASTING	STATIONS: CHANNEL	STATIONS: UPPER GC	STATIONS: LOWER GC
A	831463	769291	1+00.0	-	-
B	831756	769355	4+00.0	0+00.0	-
C	832147	769440	8+00.0	-	0+00.0
D	832217	769455	8+71.7	-	-
E	832437	769515	12+00.0	-	-
U1	831829	769237	-	-1+50.0	-
U2	831814	769305	-	-0+80.0	-
U3	831759	769341	-	-0+15.0	-
U4	831753	769369	-	0+15.0	-
U5	831788	769424	-	0+80.0	-
U6	831773	769493	-	1+50.0	-
L1	832172	769331	-	-	-1+50.0
L2	832005	769384	-	-	-0+15.0
L3	831995	769433	-	-	0+15.0
L4	832124	769550	-	-	1+50.0

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ROCK RIFFLE STRUCTURE

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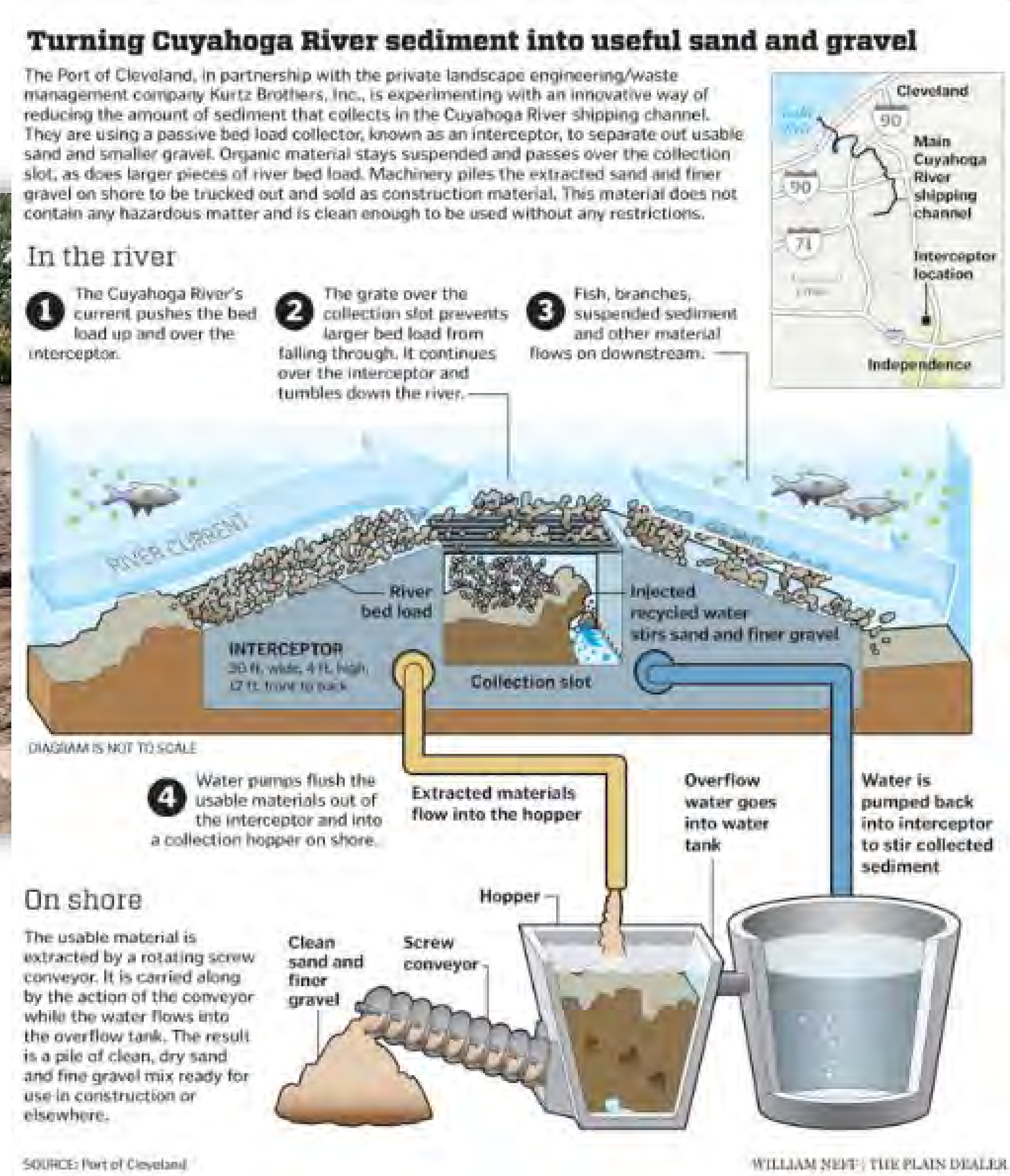
BEDLOAD SEDIMENT COLLECTOR



TASK 2: PLAN FORMULATION STRATEGIES - MERAMEC

- Maximize efficiency in Big River (priority area)
- Maximize benefits in Big River
- Maximize benefits in Meramec River (“cleaner”, less impacted by sediments) *(response to uncertainty in FWOP scenario)*
- Minimize impacts to OSE
- Maximize ecosystem benefits across study area
- Maximize fish passage
- Maximize bank stabilization
- Maximize sediment capture
- LPP

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TASK 3: DECIDING

Verify plans
- Are they complete, effective, efficient, and acceptable?

Evaluation
- Do plans meet evaluation criteria?

Comparison
- How do plans compare using defined criteria?

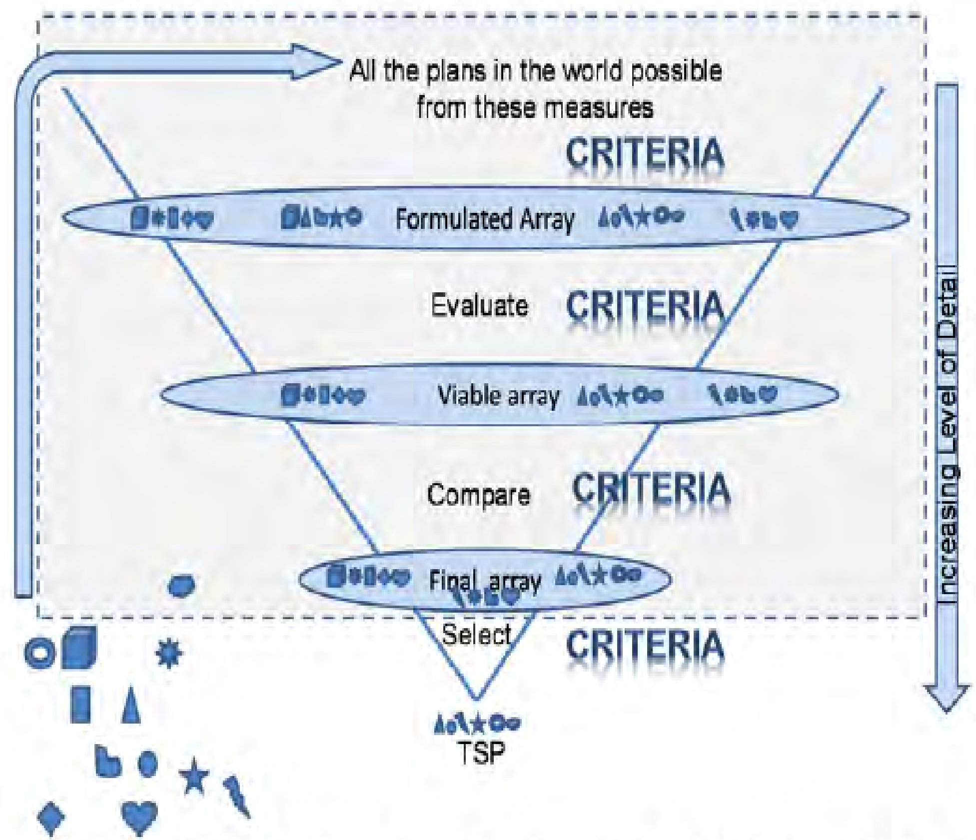
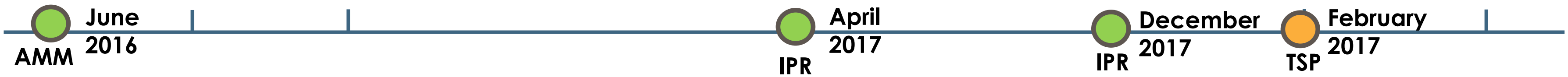


Figure 9.3: Shaded rectangle shows component parts of the deciding task of the planning process

SUMMARY OF SCREENING & EVALUATION



Measures Screening

- 49 measures were identified as possible solutions
- Evaluated using the 4 P&G criteria
- 23 were eliminated from further evaluation

Alternatives Formulation

- 12 Formulation Strategies were identified
- 2 were eliminated from further evaluation
- 10 Initial Alternatives were identified

Initial Array

- Evaluated using 4 P&G criteria
- 6 - focus array of alternatives

Final Array

Results

Focused array of alternatives

- No Action
- Maximizes efficiency in priority areas
- Maximizes ecosystem benefits in priority areas
- Maximizes ecosystem benefits in Meramec River
- Maximizes ecosystem benefits in project area
- Maximize Bank Stabilization

Decision

- Concurrence on schedule waiver request
- Concurrence on focused array of alternatives

Path Forward

- Continue regional mussel model certification for benefit calculation
- Develop parametric cost estimates
- Develop real estate needs for alternatives
- Continue USEPA coordination

REMEMBER 6 PIECES OF PAPER… ID KEY DECISION CRITERIA?

- For initial array of alternatives: High (3)/ Med(2)/ Low(1)
- Effectiveness
  - Reduce migration of sediment
  - Reduce quantity of sediment
  - Increase aquatic connectivity
  - Increase riparian habitat
- Efficiency
  - Minimizes cost relative to benefit
- Acceptability
  - Minimizes USACE policy concerns
  - Acceptable to state & local entities
  - Acceptable to communities
- Completeness
  - All features/actions (including by others) considered

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FOCUSED ARRAY OF ALTERNATIVES (AMM)

INITIAL ALTERNATIVES SCREENED OUT	REASON
Maximize efficiency in Meramec	Ranked among the lowest for effectiveness and has the potential not to be distinctly different from Alternative 4.
Minimize impacts to OSE	Not distinctly different from Alternative 2
Fish passage only	Is not efficient or acceptable to solely address fish passage without addressing sediment into the system
Sediment capture only	Would not be efficient or effective to solely address sediment capture if the source of sediment (bank erosion) into the system is not addressed
Agency/sponsor preferred	Not distinctly different from Alternative 7
FOCUSED ARRAY OF ALTERNATIVES	**DESCRIPTION**
No Action	
Maximizes efficiency in priority areas (Big River)	12 bank stabilization, 6 sediment captures basins, 9 excavation sites, 6 bed collectors, 6 grade control, 18 riparian planting
Maximizes ecosystem benefits in priority areas (Big River)	24 bank stabilization, 6 sediment captures basins, 18 excavation sites, 6 bed collectors, 6 grade control, 18 riparian plantings
Maximizes ecosystem benefits in Meramec River	5 bank stabilization sites
Maximizes ecosystem benefits in project area	30 bank stabilization, 6 sediment captures basins, 18 excavation, 6 bed collectors, 6 grade control, 8 riparian plantings
Maximize bank stabilization in project area	30 bank stabilization sites

TASK 4: IMPLEMENTATION

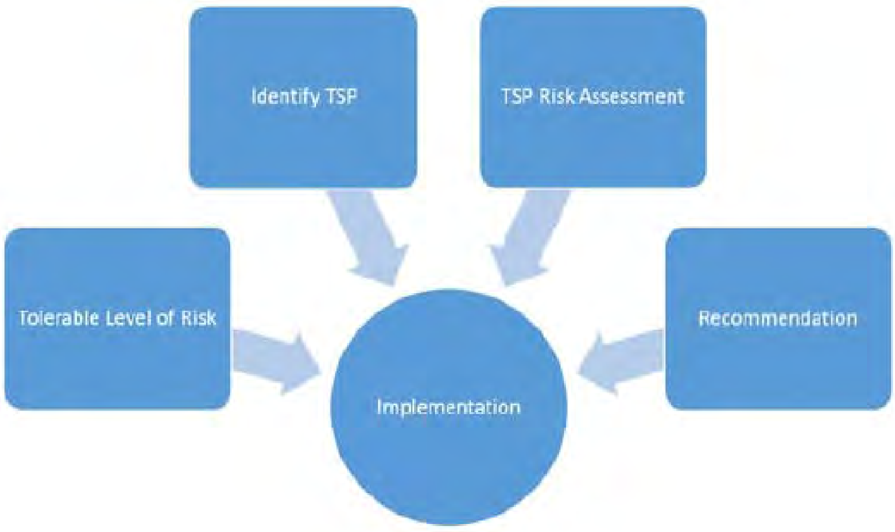
Determine a tolerable level of risk

Identify candidate Tentatively Selected Plan

TSP Risk Assessment

Story-telling:

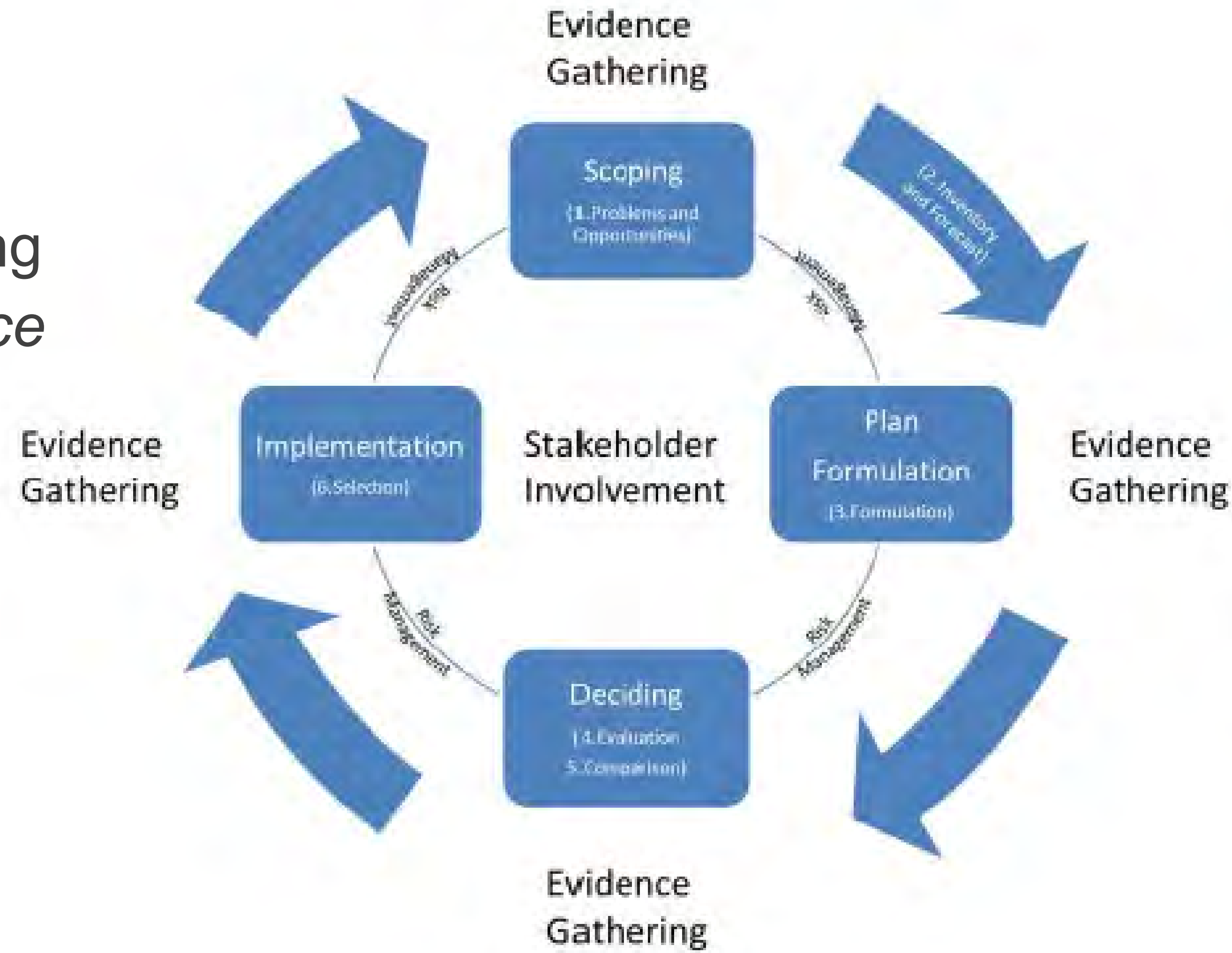
- Resource significance
- Why us?
- Why here?
- Why now?



WHAT'S NEXT?

Repeat!

Confirm Scoping
Gather Evidence
Formulate
Decide
Implement



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2ND ITERATION: WHAT DO OTHERS KNOW

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AVAILABLE DATA

- County-wide LiDAR and additional location-specific LiDAR
- Land use/land cover data
- Aerial imagery dating back to the 1930s
- Extensive biological data (fish, mussels, invertebrate, etc.)
- Previous geomorphic studies by Missouri State University
- Flow and water quality data from USGS
- Extensive sediment data from multiple sampling events by USEPA and others
- Channel cross sections from multiple points in time (most recent was 83 new cross sections from 2017).
- Soil and Water Assessment Tool (SWAT) modeling by St. Louis University and TNC
- Data/information from completed pilot projects with USEPA (grade control, sediment capture, and bank stabilization)

River has been studied extensively for 40+ years

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EXISTING CONDITIONS

FUTURE CONDITIONS

- USEPA will move forward with remediation effort
- Groups and agencies will continue to be active in the area
- Existing tailings will continue downstream migration
- Bank erosion will continue to reintroduce legacy sediment into the system
- Decline in the Big River mussel community's is likely to expand
- Current land use will not change
- Climate change will not have a significant impact on the hydrology of the project area

TOOLS

- Land use - analyzed SWAT, LULC maps, and contacted local govt.
- Climate change analysis
- Created an approved for single use freshwater mussel model
- Bankline analysis – 3 imagery sets, Lidar, existing literature
- Characterize habitat - Rapid bio-assesment and existing data
- Extrapolation of existing data to calculate sediment capture rates
- Extrapolation of existing data to calculate sediment budget
- Analysis of existing mussel data
- Gage analysis to understand bed stability
- Elicited expert advice on interaction of tributaries with Big River

3RD ITERATION: WHAT MUST WE LEARN?

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TASK 3: DECIDING - MERAMEC

- Aquatic and floodplain benefits
  - HSI for black-capped chickadee (floodplain forest) 3 parameters:
    - average height of overstory trees, tree canopy cover, density of snags
  - HSI for Meramec River Freshwater Mussel (aquatic-riverine) 6 parameters:
    - TSS, Substrate, Lead, channel change, aquatic cover, fish species richness
- Costs
  - Parametric costs to estimate construction costs
  - Abbreviated risk analysis to inform contingency for each alternative
  - Parametric costs to estimate monitoring, adaptive management, and OMRRR items
  - LERRDS cost estimate - District real estate office

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FINAL ARRAY

ALTERNATIVE	DESCRIPTION
1. No Action	
2. Subset Maximize Ecosystem Restoration in Big River RM 0-10.2	3 bank stabilization sites, 1 sediment capture basin, 2 riffle structures, 2 excavation sites, and 149 acres reforestation
3. Subset Maximize Ecosystem Restoration in Big River RM 0-35	12 bank stabilization sites, 5 sediment capture basins, 2 excavation sites, 5 riffle structures sites, 2 bed collectors, and 443 acres reforestation.
4. Maximizes ecosystem benefits in Meramec River	6 bank stabilization sites, 19 acres of reforestation
5. Maximizes efficiency in priority areas (Big River)	12 bank stabilization sites, 6 sediment captures basins, 8 excavation sites, 6 bed collectors, 5 riffle structures sites, 675 acres of reforestation
6. Maximizes ecosystem benefits in priority areas (Big River)	24 bank stabilization sites , 6 sediment captures basins, 20 excavation sites, 6 bed collectors, 5 riffle structures sites, 680 acres of reforestation
7. Maximizes ecosystem benefits in project area	30 bank stabilization sites sites, 6 sediment captures basins, 20 excavation sites, 6 bed collectors, 5 riffle structures sites, 699 acres of reforestation
Maximize bank stabilization in project area	30 bank stabilization sites

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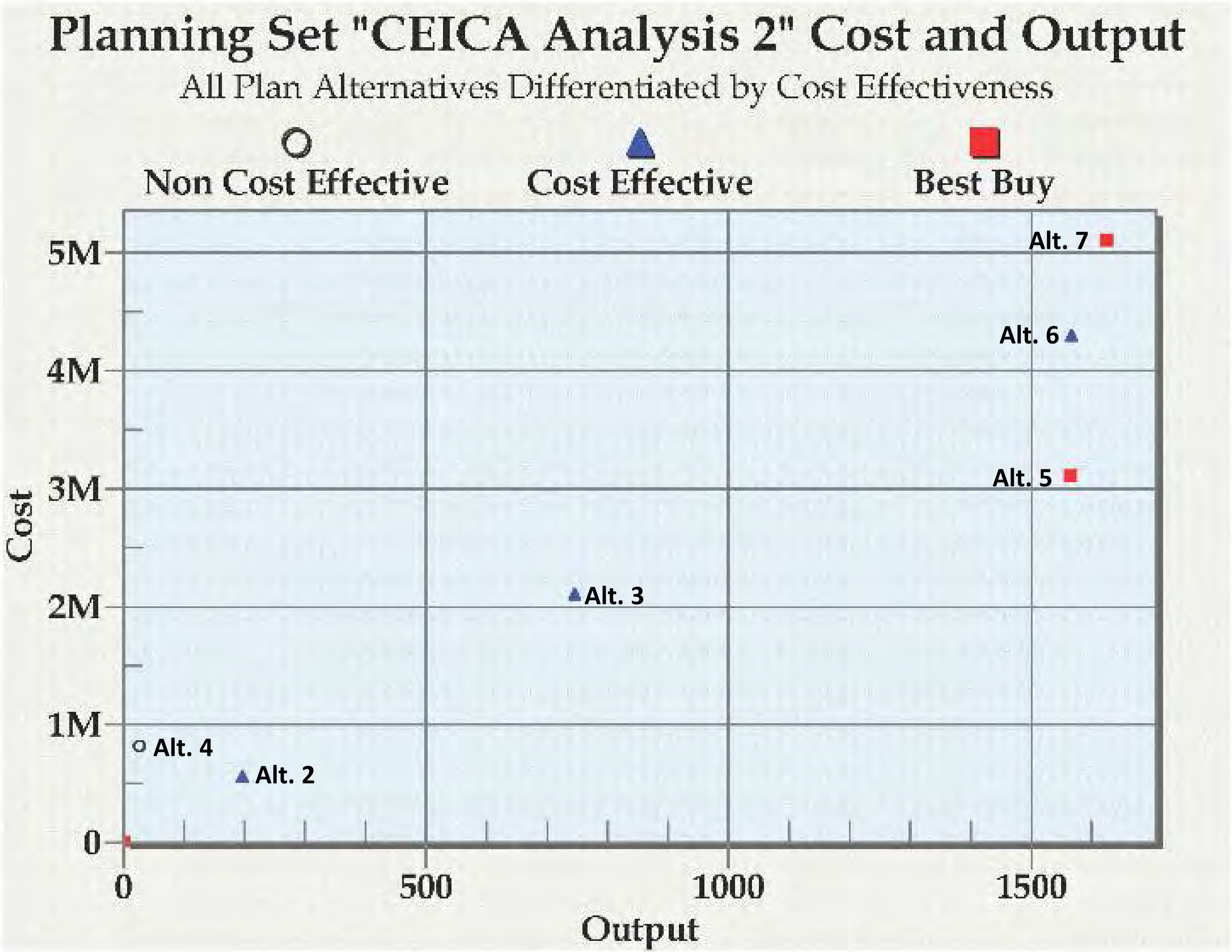
NER ANALYSIS

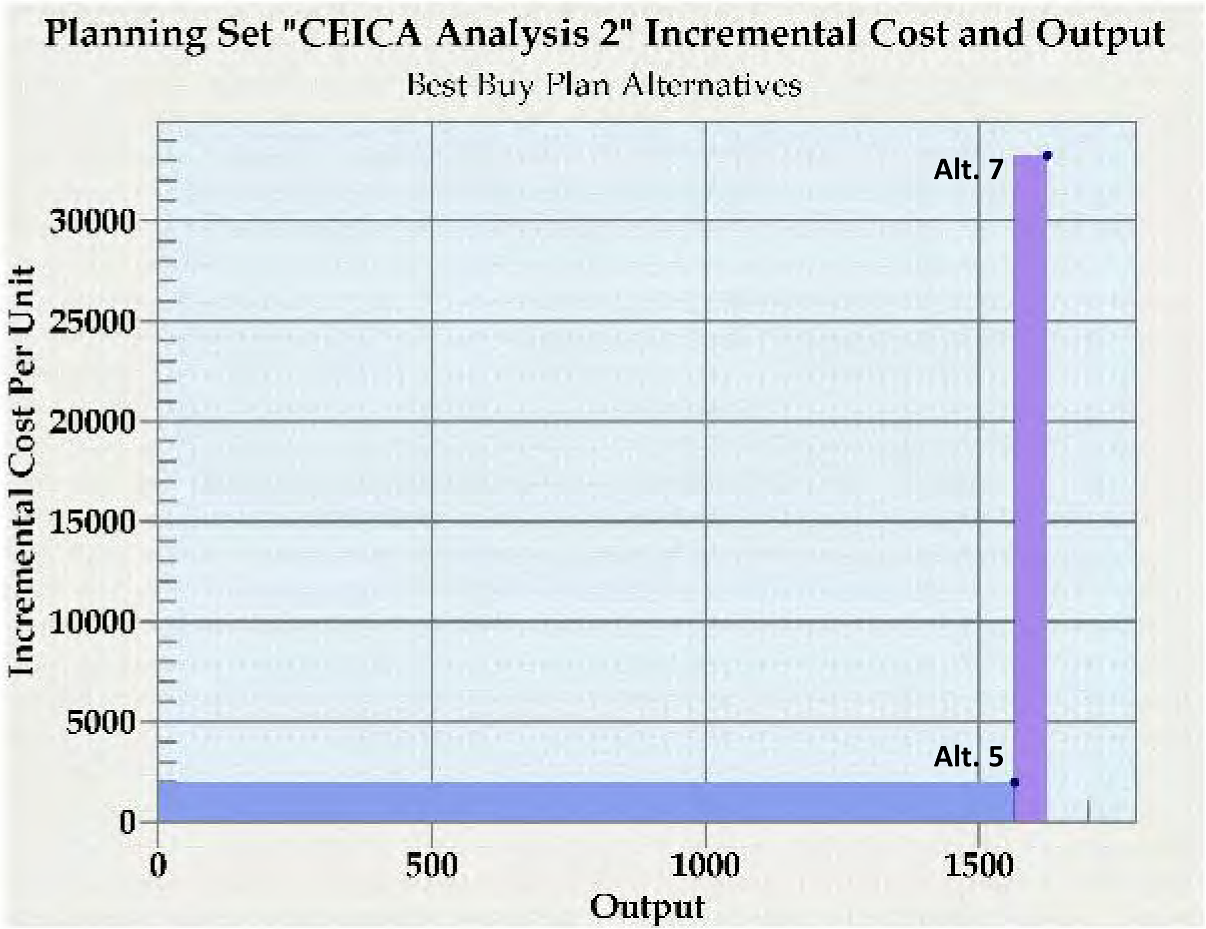
- Habitat suitability index model for the black-capped chickadee
  - Inputs include average height of over story trees, tree canopy cover, and density of snags
- Meramec River Freshwater Mussel habitat suitability index model
  - Inputs include TSS, lead, substrate, channel change, aquatic cover, and fish species richness
- Habitat analysis included representatives from USFWS, MDNR, MDC, TNC
- Net benefits of floodplain forest and aquatic habitat are additive
- Parametric quantities and costs were applied to construction, OMRRR and AMM measures; unit costs when avaialable
- Costs below are displayed in Millions

	Construction	AM	PED/S&A	Contingency	OMRRR	LERRDS	IDC	Annualized	AAHU
Alt 2	$8.3	$0.8	$2.2	$2.7	$0.7	$0.8	$0.2	$0.6	197
Alt 3	$30.0	$2.8	$7.9	$9.7	$7.9	$3.0	$0.8	$2.1	745
Alt 4	$11.8	$1.3	$3.1	$3.8	$6.4	$0.3	$0.3	$0.8	26
Alt 5	$43.7	$5.0	$11.7	$14.1	$13.4	$3.5	$1.2	$3.1	1565
Alt 6	$60.5	$8.4	$16.6	$19.9	$17.8	$3.7	$1.7	$4.3	1567
Alt 7	$72.4	$9.5	$19.7	$23.5	$24.2	$4.0	$2.0	$5.1	1625

COST EFFECTIVE ANALYSIS



NER ANALYSIS



Alternative	Outputs (HU)	Annualized Cost ($)	Average Cost ($)	Incremental Cost ($)	Incremental Output (HU)	Incremental Cost/Output ($/HU)
No Action Plan	0	0	0	0	0	0
5. Maximizes efficiency in priority areas (Big River)	1565	$3,110,235	$1,987	$3,110,235	1565	**$1,987**
7. Maximizes ecosystem benefits in project area	1625	$5,105,813	$3,142	$1,995,578	60	$33,260

EVALUATION CRITERIA

Criteria	Metric	Metric used	Methods/Models
NER	Annual Net benefits	The plan that reasonably maximizes net benefits was identified	Chickadee and Mussel model used to identify net benefits High: scored high in 2 of 3 objectives and cost effective Medium: scored medium in 2 of 3 objectives and cost effective Low: All other plans
EQ	Air/Noise/Water Quality, T&E, Cultural, etc.	Environmental impacts quantified for each plan	Coordination with resource agencies and Net Benefits
OSE	Reduced health safety, reduced flood benefits	Reduced sediment used to capture ancillary health and flood reduction benefits	Mussel model annual benefits, same rating as objective 2
Completeness	Includes all actions (including those of others) to achieve outputs	Plans ranked by the potential need for additional actions by others to achieve benefits	PDT discussion determined no additional actions are needed to achieve benefits
Effectiveness	Annual Benefits	Plans ranked by how well they meet project objectives	Objective 1. High: over 1000 AAHUs Medium: over 100 AAHU Low: less than 100 AAHU Objective 2. High: 1000 AAHU and 5 or more bank sites Medium: over 100 AAHU and 5 or more bank sites Low: all other plans Objective 3. High: over 500 floodplain AAHU Medium: 100 – 499 floodplain AAHU Low: less than 100 AAHU
Efficiency	Annual Net benefits (NER analysis)	Plans evaluated based on cost and benefits	IWR Planning Suite Output
Acceptability	Implementable	Plans evaluated based on degree of potential barriers during implementation	Alternatives were evaluated on whether an EPA ROD was needed to be within policy High – implementable independent of ROD Low – implementable dependent on ROD
Opportunities	Lead Reduction	Plans evaluated based on potential to reduce ecological effects of lead on mussels	Lead levels High: below 128 PPM Medium: below 200 PPM Low: above 200 PPM

ALTERNATIVE EVALUATION

#	Alternative	P&G CRITERIA						P&G ACCOUNTS			OPPORTUNITIES
		EFFECTIVENESS			EFFICIENCY	ACCEPTABLE	COMPLETE	NER	EQ	OSE	Lead Concentration
		Reduces migration sediment	Reduce quantity of sediment	Increase riparian habitat	Minimizes cost relative to benefit	USACE minimize policy concern	All items considered complete	Reasonably maximizes benefits	Effects on natural and cultural resources	Other perspectives	Big River Lead Concentrations (PPM) after 50 years
1	No Action	Low	Low	Low	Low	High	High	Low	Low	Low	Low
2	Maximizes ecosystem benefits RM 0-10.2	Low	Low	Low	Med	Low	High	Low	Low	Med	Low
3	Maximizes ecosystem benefits RM 0-35	Med	Med	Med	Med	Low	High	Med	Med	Med	Low
4	Maximizes ecosystem benefits in Meramec	Low	Low	Low	Low	High	High	Low	Low	Low	Low
5	Maximizes efficiency in priority area	High	High	High	High	Low	High	High	High	High	Med
6	Maximizes ecosystem benefits in priority area	High	High	High	Med	Low	High	High	High	High	Med
7	Maximizes ecosystem benefits in project area	High	High	High	High	Low	High	High	High	High	Med

REVISIT KEY UNCERTAINTIES – DOES THE TSP CHANGE?

- Actions to be undertaken by EPA
  - Definitive remediation (clean up) levels unknown
    - Assumed 400 ppm (residential yards) - 1200 ppm (existing upstream) lead concentration
  - See sensitivity analysis below
- Locations of remediation/ clean-up

TASK 4: IMPLEMENTATION

Determine a tolerable level of risk

Identify candidate Tentatively Selected Plan

TSP Risk Assessment

Story-telling:

- Resource significance
- Why us?
- Why here?
- Why now?

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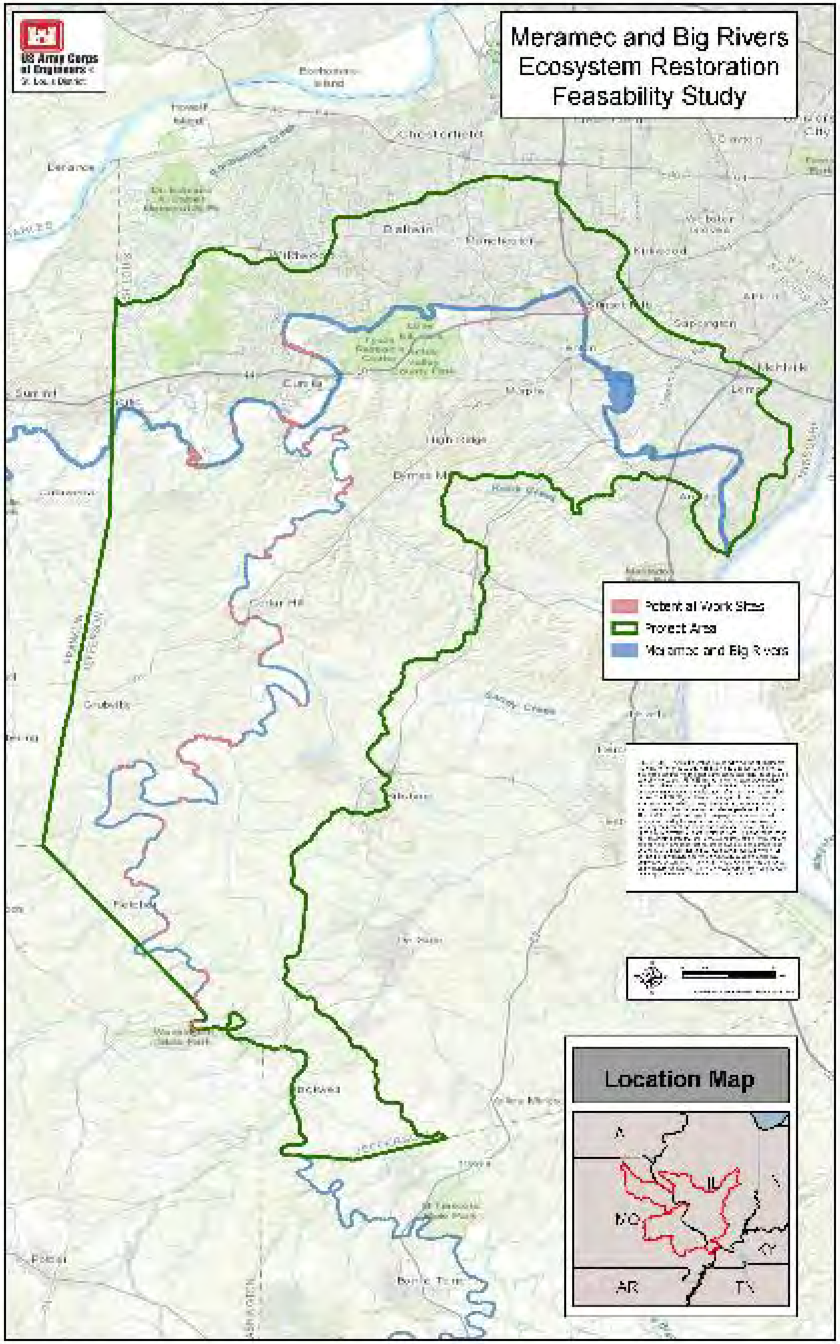
TENTATIVELY SELECTED PLAN

- 1,565 net AAHU’s
- Average annual cost of $3.11 Million (FY18, 2.75%)
- $1,987 per habitat unit
- 675 acres benefitted riparian habitat
- 1310 acres benefitted aquatic habitat
  - 12 bank stabilization locations
  - 6 sediment capture locations
  - 6 bed collector locations
  - 5 rock riffle structures
  - 9 excavation structures
  - 18 reforestation areas

Items	Cost
Fish & Wildlife Construction	$43,694,000
Preconstruction Engineering & Design (PED)	$7,793,000
Construction Management (S&A)	$3,897,000
Monitoring & Adaptive Management	$5,032,000
Contingency (24%)	$14,114,000
Lands & Damages	$ 3,472,000
Total First Cost	**$ 78,002,000**
OMRRR	$ 13,353,225



TASK 4: TSP RISK ASSESSMENT

Implementation risks:

- CERCLA liability results in unexpected clean-up costs or litigation (medium risk)
  - Risk is driven by low likelihood and high consequences
  - Mitigation actions: Consistently collaborating with USEPA, soils will be tested during PED
- Sites could change during the PED phase (medium risk)
  - Risk is driven by high likelihood and low consequences
  - Mitigation actions: Sensitivity analysis on site locations shifts, reduced-scope scenarios to show Federal interest, benefits not highly dependent on exact location of sites

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TSP RISK ASSESSMENT - MERAMEC

Outcome risk:

- Habitat restoration features may change during high flows (medium risk)
  - Risk is driven by low likelihood and high consequences
  - Mitigation actions: Designed and Monitored similar USEPA Pilot Projects, robust adaptive management plan

MILESTONE DECISIONS IN A RISK CONTEXT

Discussions and decisions at the TSP and ADM focus on the TSP/Recommended Plan and the risks that could affect the decision and outcomes.

- Risks to the affected human and environmental community: existing risks and risk reductions realized by the recommended plan. *Are there any public, agency, technical, or policy concerns that may change the recommended plan?*
- Study Risks: what can affect the accuracy, quality, timing, and budget of the study? *Is the level of mitigation planning, engineering, cost engineering, etc. sufficient? Too much? Not enough?*
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- Outcome risks: residual risks and how to manage them; new, transferred or transformed risks attributable to the recommended plan.

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RIDM AND MERAMEC RIVER ECOSYSTEM RESTORATION STUDY BLUF

From the Meramec River PDT:

“This study would likely not have been completed (certainly within the 3x3x3 rule) under USACE’s former former method of planning and decision-making.

SMART Planning and Risk-Informed Planning came along at just the right time!”

Team members to contact:

Monique Savage, Lead Planner

Greg Kohler, PM

Joe Collum, Lead H&H

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QUESTIONS AND DISCUSSION

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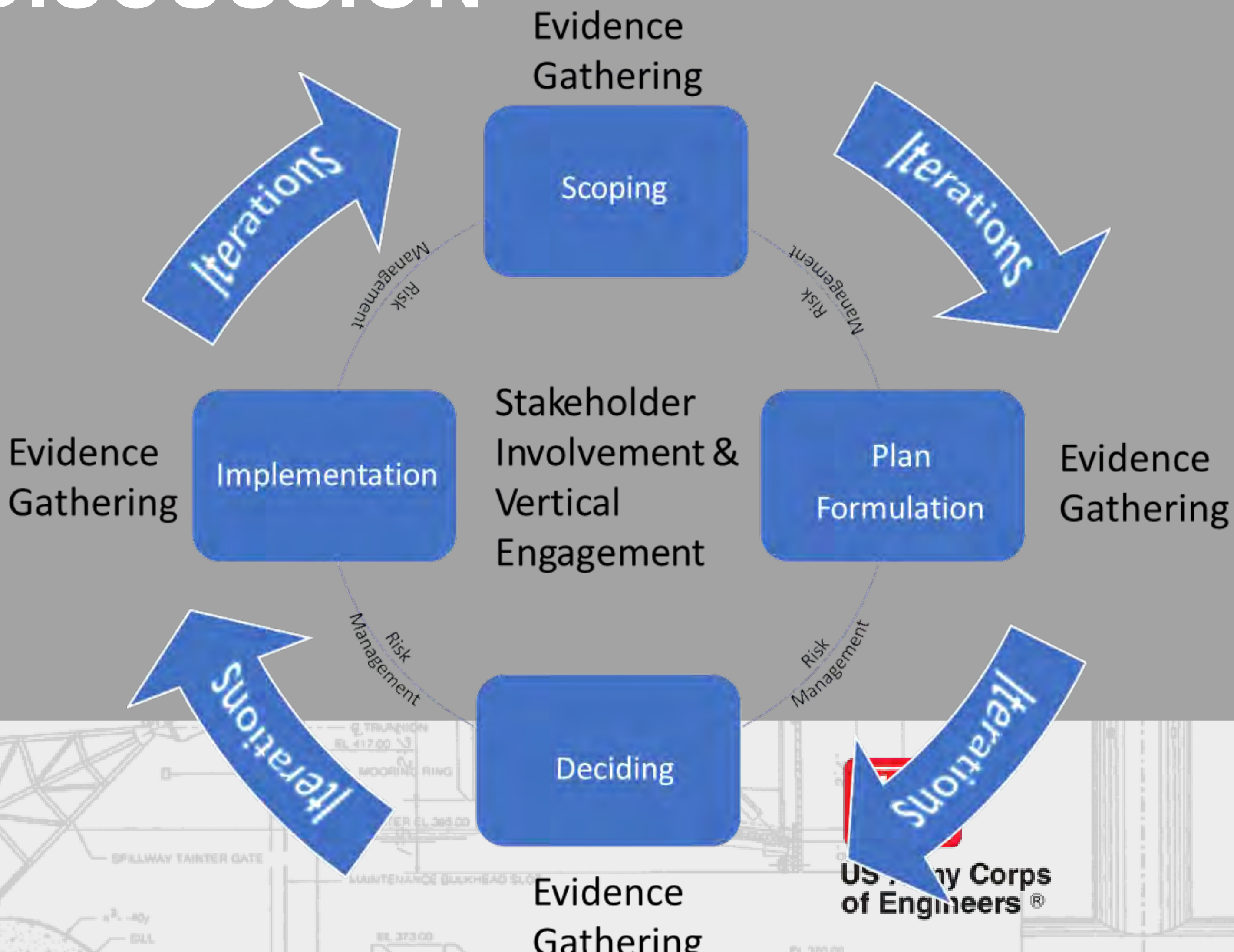

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HQUSACE PERSPECTIVE: COASTAL STORM STUDY RISK-INFORMED PLANNING EXAMPLE

Leigh Skaggs, OWPR

Planning Associates – CSRM Course
Sausalito, CA
16 May 2019

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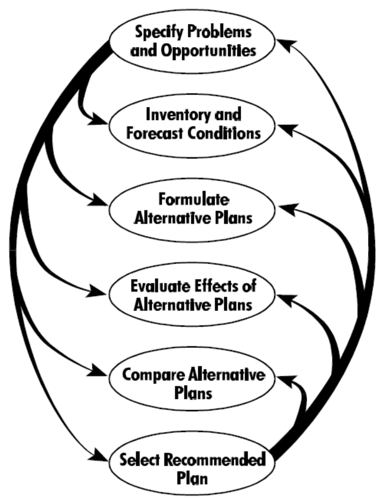
RISK INFORMED PLANNING =

SIX-STEP PLANNING PROCESS + RISK-INFORMED DECISION MAKING

=



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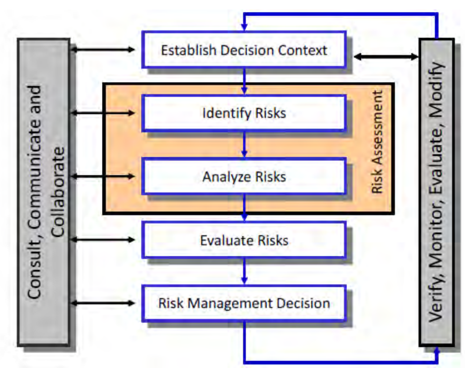

Risk Informed Planning

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IN A NUTSHELL…

At every step think critically – Can we make a decision with what we know now? What risks would we face if we make decisions with what we know now? Do we need to address that risk and potential consequences now? Later?

- Engage early and often with vertical team and with SMEs across disciplines to gauge and manage risk
- Identify and elevate policy issues
- Communicate throughout process, not just at Milestones or during review
- Document and share decisions made

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THE BOTTOM LINE: WHAT'S DIFFERENT?

1. Through entire CW project lifecycle, actively manage risk (study risk, project risk, implementation risk, outcome risk)
2. Acknowledge and intentionally manage uncertainty
3. Use risk informed planning tools, including rapid planning iterations to inform study scope and tasks
4. TSP in 12 months/$1.2M – Supplemental is an opportunity
5. Prepare for milestone meetings DIFFERENTLY. The emphasis of the decision briefing at the milestone meeting should be on the risk story and the path ahead to the next milestone.

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RISK CHAMPIONS & PLANNING MENTORS – EVOLVING ROLES, SAME PEOPLE!

PLANNING MENTORS

Short-term boost to help coach, mentor & train Lead Planners & PDTs on Risk Informed Decision Making. Emphasizing the 'R' in SMART. Utilizing Planning Manual II.

RISK CHAMPIONS

Advocates for Risk Informed Decision Making by driving Culture Change in the PCOP and the enterprise.

Eventually, all Planning Leaders – at all levels of the Enterprise - embrace being Risk Champions & Planning Mentors

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SO HOW ARE PLANNING MENTORS SUPPOSED TO HELP?? WITH OUR RISK INFORMED PLANNING TOOLS THAT ARE *ALREADY* FAMILIAR TO PLANNERS

- Six-step planning process is heart of planning
- Storytelling is key – not just in the report, but in presentations, meetings, internal and external
- Risk register tools to assess and document risk and risk management strategies and engage full PDT
- Ensure vertical engagement via IPRs, decision meetings, milestone meetings

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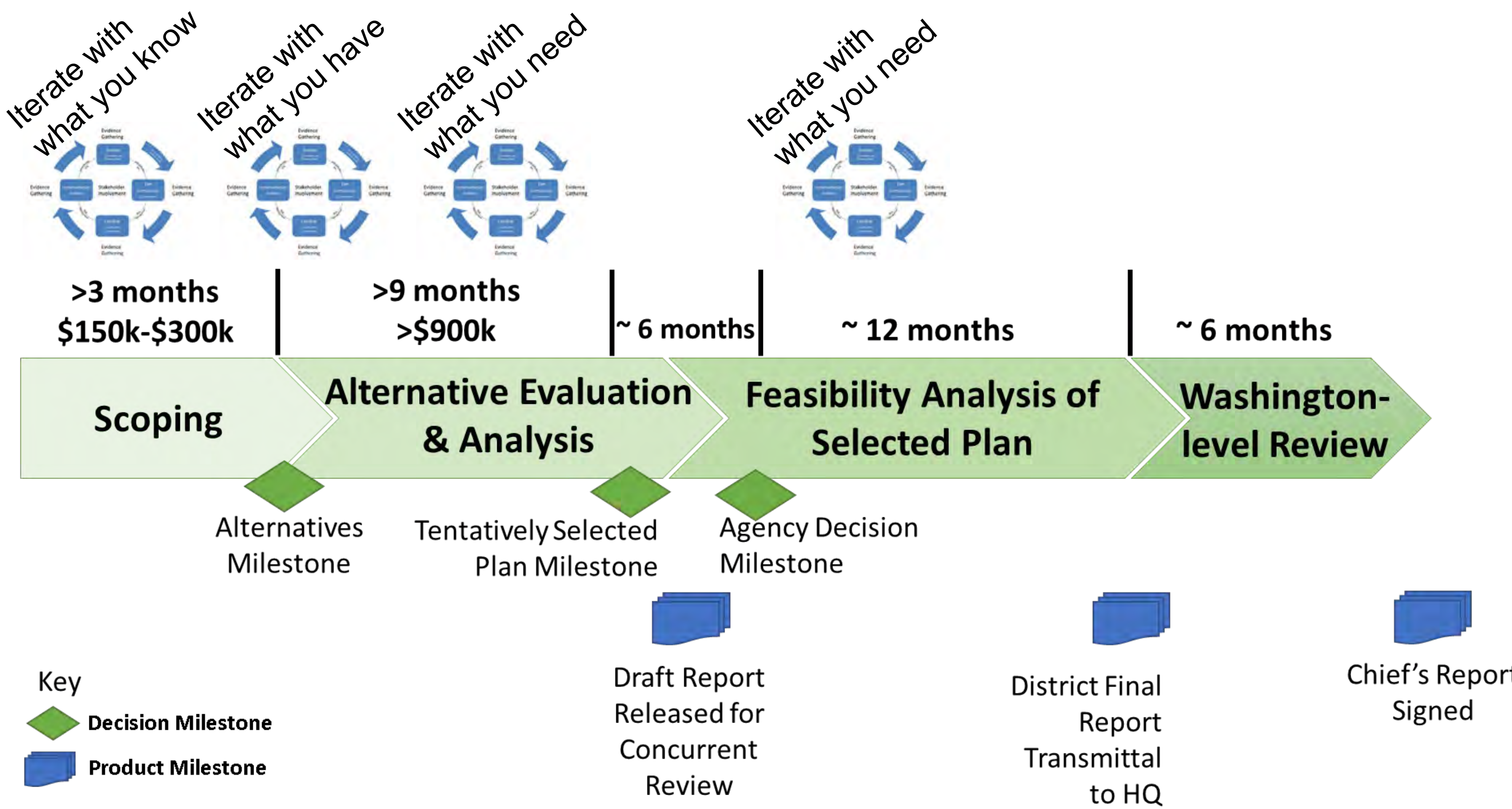
TAKE THAT SIX-STEP PLANNING PROCESS AND ITERATE SEVERAL TIMES!! GATHER EVIDENCE TO REDUCE UNCERTAINTY AND MANAGE STUDY AND PROJECT RISK



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USING ITERATIONS OF THE PLANNING PROCESS AND LOOKING AT OUTCOMES THROUGH A RISK LENS IS NOT NEW

Knowledge based – get experienced input

Iterate through the 6-step planning process at least once before making many judgments about the scope

Then -

- Start with what you know
- Challenge your assumptions
- Use a risk register or similar tool to organize and communicate your thoughts

From 2014 webinar, "Strategies for Scoping 3x3x3 Studies"

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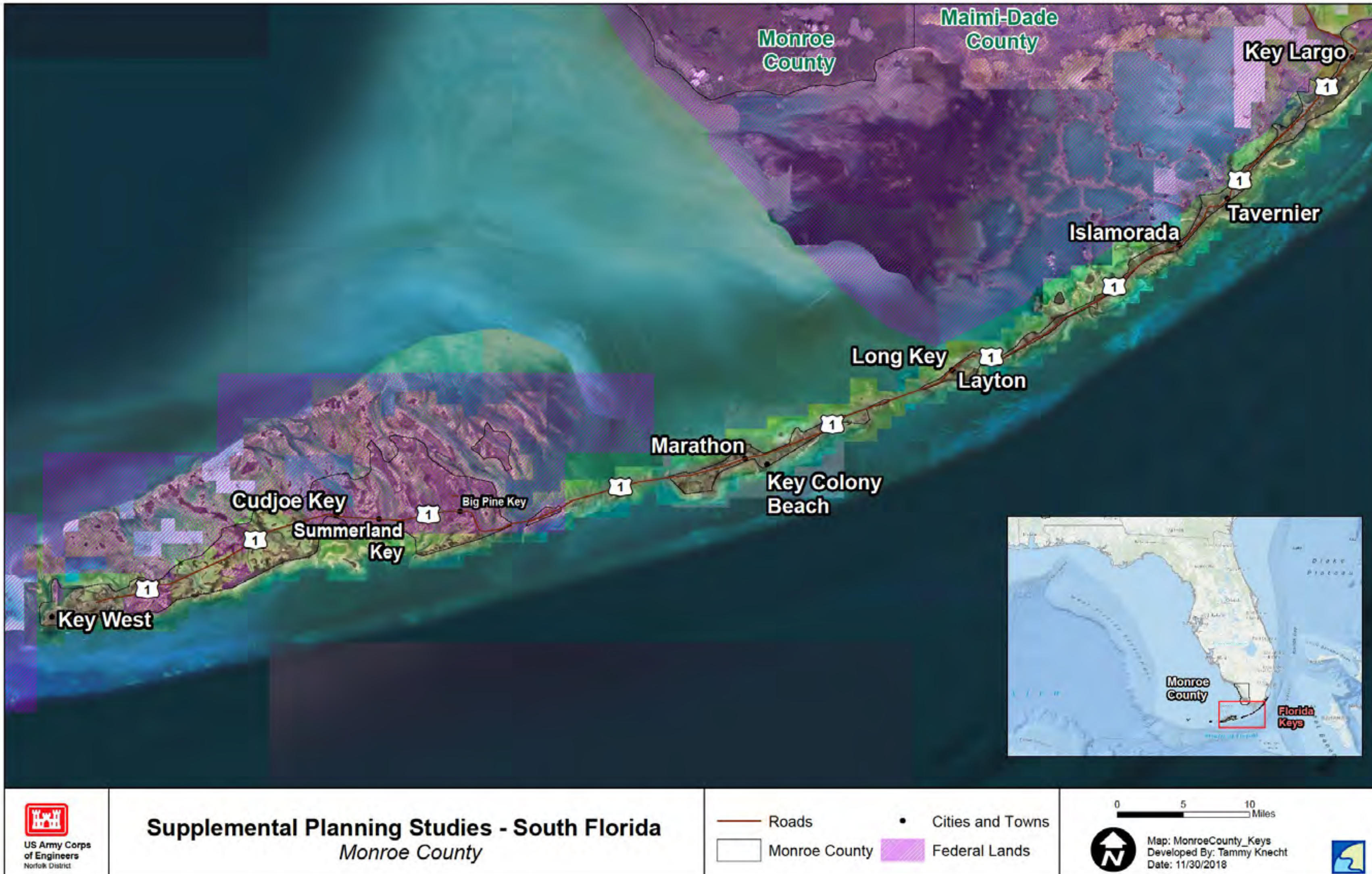
RISK INFORMED PLANNING PROCESS

EXAMPLE: FLORIDA KEYS CSRM STUDY



YOU CAN CONDUCT THE 1ST ITERATION WITH KNOWLEDGE ON THE TEAM!

We'll id our biggest data gaps, plug 'em, then do it all again.

Planning is iterative. We'll do the entire process.

In a feasibility study, this iteration will be within first 30 days.

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TASK 1: SCOPING

Scoping can be summarized on 6 Pieces of Paper:

1) Identify problems and opportunities
2) Forecast “future without” condition
3) Identify objectives and constraints
4) Identify decision criteria
5) List unique questions
6) Identify key uncertainties

Figure 6.1: Three main tasks comprising the scoping task

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Problem Identification = Risk Identification

Trigger
- An event
- Accumulation of information

Hazard
- The thing that can cause harm
- Or the opportunity for a potential gain

Harm
- Identify the specific harm(s) of interest
- Identify the specific gain(s) that could be achieved

Sequence of events
- Sequence of necessary events from hazard to harm
- Sequence of events from opportunity to gain

Uncertainty
- Identify key uncertainties
- Reduce uncertainty

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PROBLEM/ RISK ID EXAMPLE – FLORIDA KEYS STUDY

Trigger: Hurricanes, coastal storms, sea level rise

Hazard: Coastal storms, exacerbated by rising sea levels, can flood entire 150-mile study area and isolate it from mainland

Harm: Loss of human life, potential threats to human health and safety, economic damages, damage to infrastructure, loss of coastal habitats, loss of recreation, loss of land

PROBLEM/ RISK ID
EXAMPLE – FLORIDA KEYS STUDY

Sequence of Events:

Coastal storms + rising sea levels →

Storm surge + wave attack + erosion →

Flooding/ inundation of entire study area + loss of land + loss of transportation access via US Highway 1 →

Isolation of study area from mainland + damage to property & critical infrastructure + loss of life, human health effects + environmental losses →

Measured as NED damages, OSE effects, EQ losses, RED losses

PROBLEM/ RISK ID
EXAMPLE – FLORIDA KEYS STUDY

Key Uncertainties:

- What actions will others (FL DOT) take? (affects FWOP)
- Can we include benefits to transportation infrastructure (US 1)?
- Impacts of SLR on damages/ benefits
- Unique geology, topography, and hydrology limits effectiveness of some types of structural measures
- Extensive protected marine resources limit some types of structural measures
- Ability to measure effectiveness of NNBF's
- Challenge to incorporate life safety benefits into evaluation & selection

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WRAPPING UP 6 PIECES OF PAPER – FL KEYS

PROBLEMS

- Critical infrastructure features including fire stations, airports, hospitals, etc. are at risk to the effects of coastal storms.
- Critical transportation routes, specifically U.S. Route 1, is at risk to coastal storms and there have been instances of storm surge and erosion affecting evacuation before/during storms and the timely return of residents after the evacuation is lifter post-storm.
- Structures (commercial and residential), are at risk to the effects of coastal storms
- Utilities including water, wastewater, electricity, phone, etc. are at risk to the effects of coastal storms and are essential for human health and safety.
- There are rich environmental resources that are unique to the study area that are being lost due to coastal storms and exacerbated by climate change and sea level rise (SLR). Some of these resources, mangroves for example, provide a reduction in the effects of coastal storms on the study area and their loss increases the risk to the built environment and life safety.

OPPORTUNITIES

- Reduce economic damages from coastal storms and coastal flooding to the natural and built environment
- Reduce the risks to human life, health, and safety
- Reduce the vulnerability of Route 1, the primary and only evacuation route from the Keys, to the effects of coastal storms
- Increase the resilience of the Florida Keys to the impacts of coastal storms and flooding (Note: the USACE principles of resilience are Prepare, Absorb, Recover, and Adapt)
- Utilize nature based features and/or restoration of the natural coastal system of defenses that are or were historically present in the study area
- Regulate new development (and rebuilding efforts from previous storms) so that it is more resilient
- Better manage existing canal system and post storm debris removal
- Sediment management and erosion control (sand displaced during storms)
- Possible benefits to the Department of Defense facilities located in the vicinity (ex. the Naval Air Station in Key West)

OBJECTIVES

- Reduce economic damages from coastal storms and coastal flooding to the natural and built environment in the Florida Keys.
- Reduce the coastal storm risk to human life, health, and safety to the population in the Florida Keys.
- Increase the resilience of the Florida Keys to the impacts of coastal storms and flooding.

CONSIDERATIONS

- Avoid creating or exacerbating flooding within the project area and to local military installations
- Avoid impacts to environmental and cultural/historic resources in the study area and nearby (e.g. National Marine Sanctuary)
- There is a large amount of protected, state owned, and Federal land within the study area
- Porous limestone geology limits structural measures
- Strict state and local building codes are in place that regulate structures and development in the study area
- Water management activities outside of the study area could affect the hydrology within the study area

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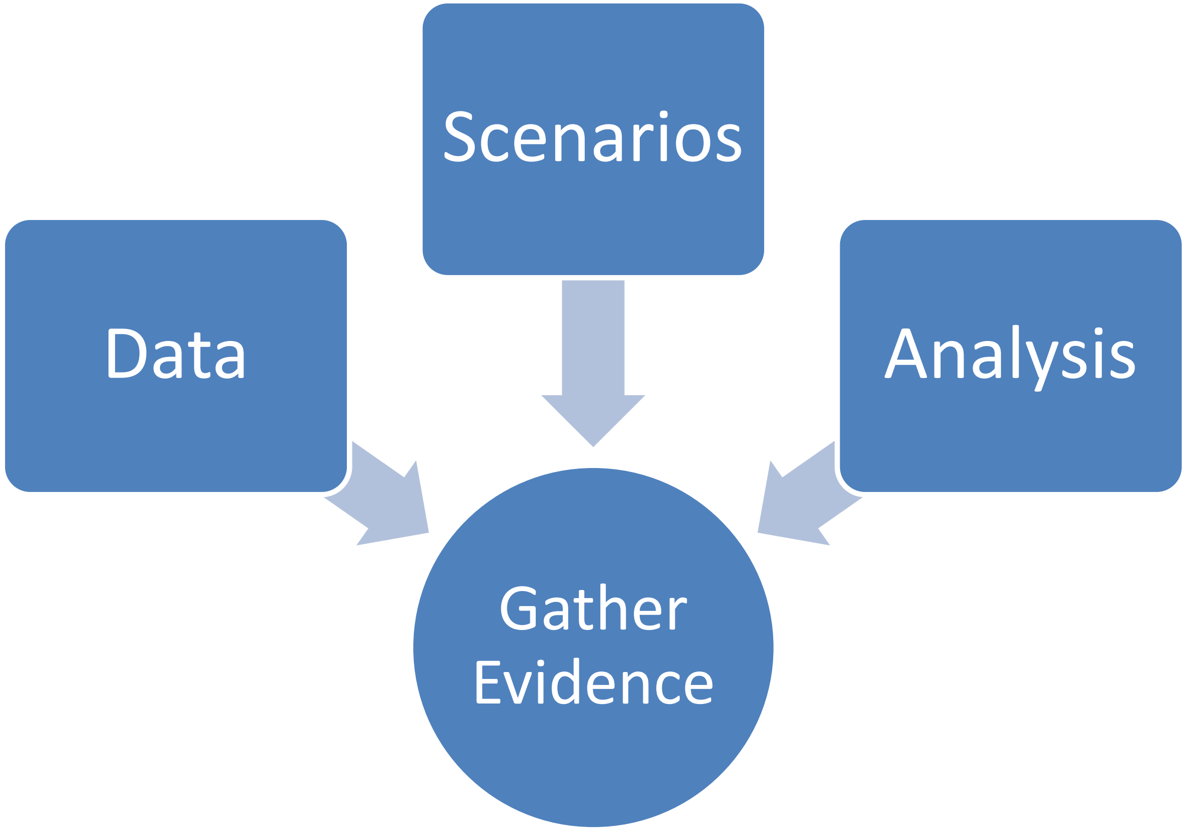
ONGOING ACTIVITY: GATHER EVIDENCE



What do you need to reduce instrumental uncertainty, manage intolerable risk, and make the next decision?

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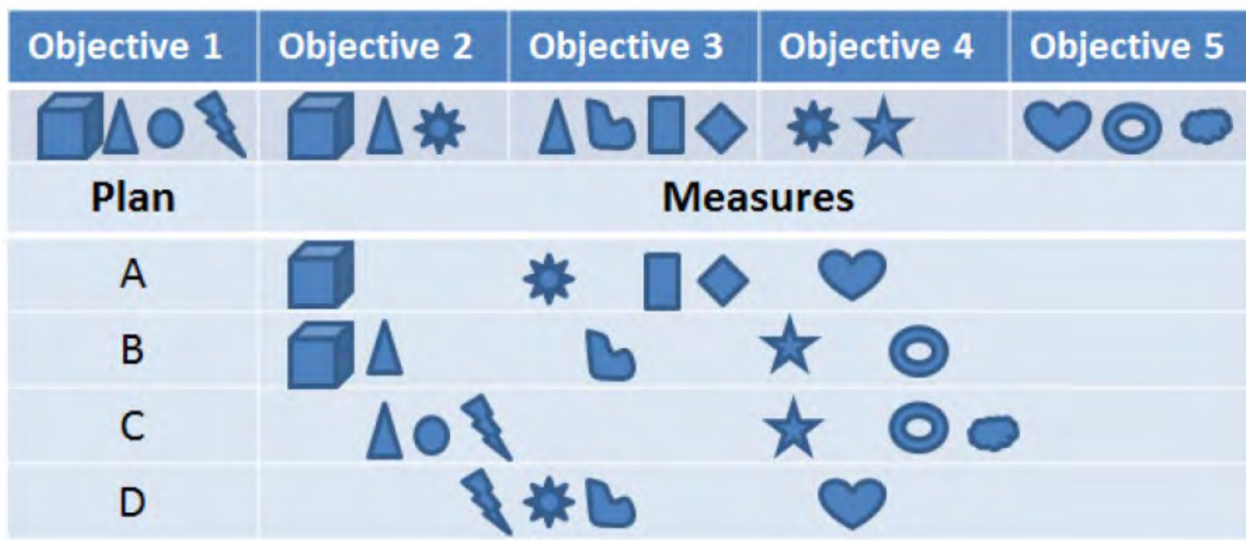
TASK 2: PLAN FORMULATION

Identify measures

Screen measures

Formulate plans

Reformulate plans



TASK 2: PLAN FORMULATION STRATEGIES – FLORIDA KEYS STUDY

- Reduce coastal storm risk along the Route 1 corridor. Specifically, reduce damage to the roadway and address portions of the roadway that are inundated during coastal storms. The goal of this plan formulation strategy is to reduce the risk to life safety by improving the functionality of the singular evacuation route from the Keys.
- Reduce coastal storm risk to critical infrastructure. Critical infrastructure includes emergency services (fire, police, EMS), key utilities (communications, power, water, wastewater/sewer), emergency shelters, etc.
- Reduce coastal storm risk to population and development centers. Specifically, reduce life loss and damage to structures in vulnerable areas.

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TASK 2: MEASURES ASSOCIATED WITH FL KEYS PLAN FORMULATION STRATEGIES

Reduce risk to US 1 Strategy:

- Road elevation
- Floodproofing
- Breakwaters

Shoreline stabilization
Beachfill/Dunes
NNBF

Reduce risk to critical infrastructure strategy:

- Floodproofing
- Elevation
- Breakwaters

Shoreline Stabilization
Storm surge barriers
NNBF

Reduce risk to population & development centers strategy:

- Buyout/Acquisition
- Elevation
- Dry/Wet Floodproofing
- All Other Nonstructural Measures
- Breakwaters

Shoreline Stabilization
Storm Surge Barriers
Beachfill/Dunes
NNBF

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TASK 3: DECIDING

Verify plans
- Are they complete, effective, efficient, and acceptable?

Evaluation
- Do plans meet evaluation criteria?

Comparison
- How do plans compare using defined criteria?

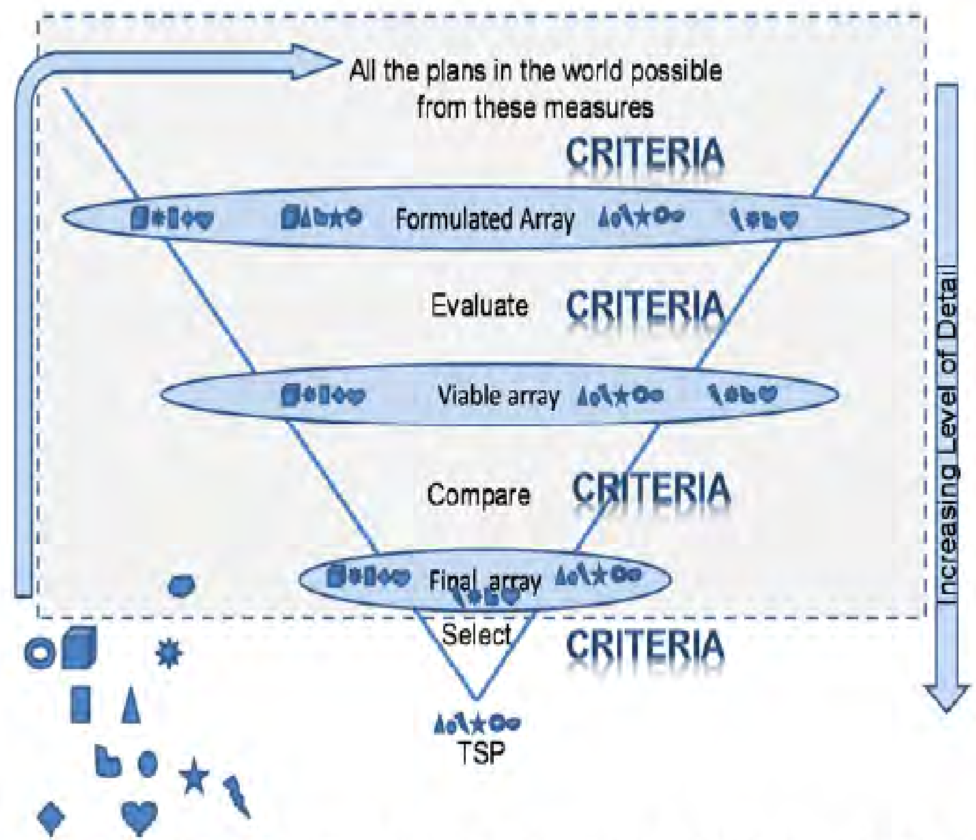

Figure 9.3: Shaded rectangle shows component parts of the deciding task of the planning process

TASK 3: FL KEYS DECISION CRITERIA

- Damages prevented/reduced
- Estimated cost
- Life safety benefits
- Environmental impact or improvement
- Regional Economic Development benefits/impact
- Recreation benefits
- Other Social Effects

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TASK 4: IMPLEMENTATION

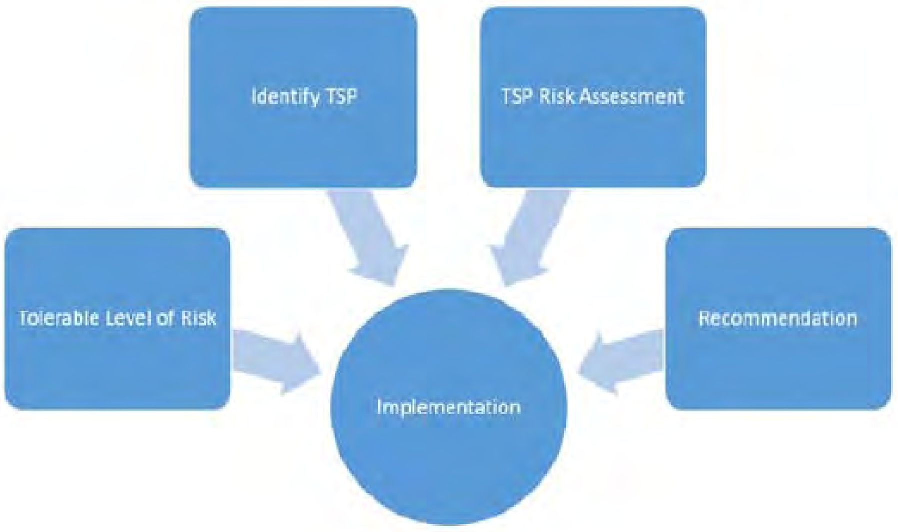
Determine a tolerable level of risk

Identify candidate Tentatively Selected Plan

TSP Risk Assessment

Story-telling:

- Resource significance
- Why us?
- Why here?
- Why now?



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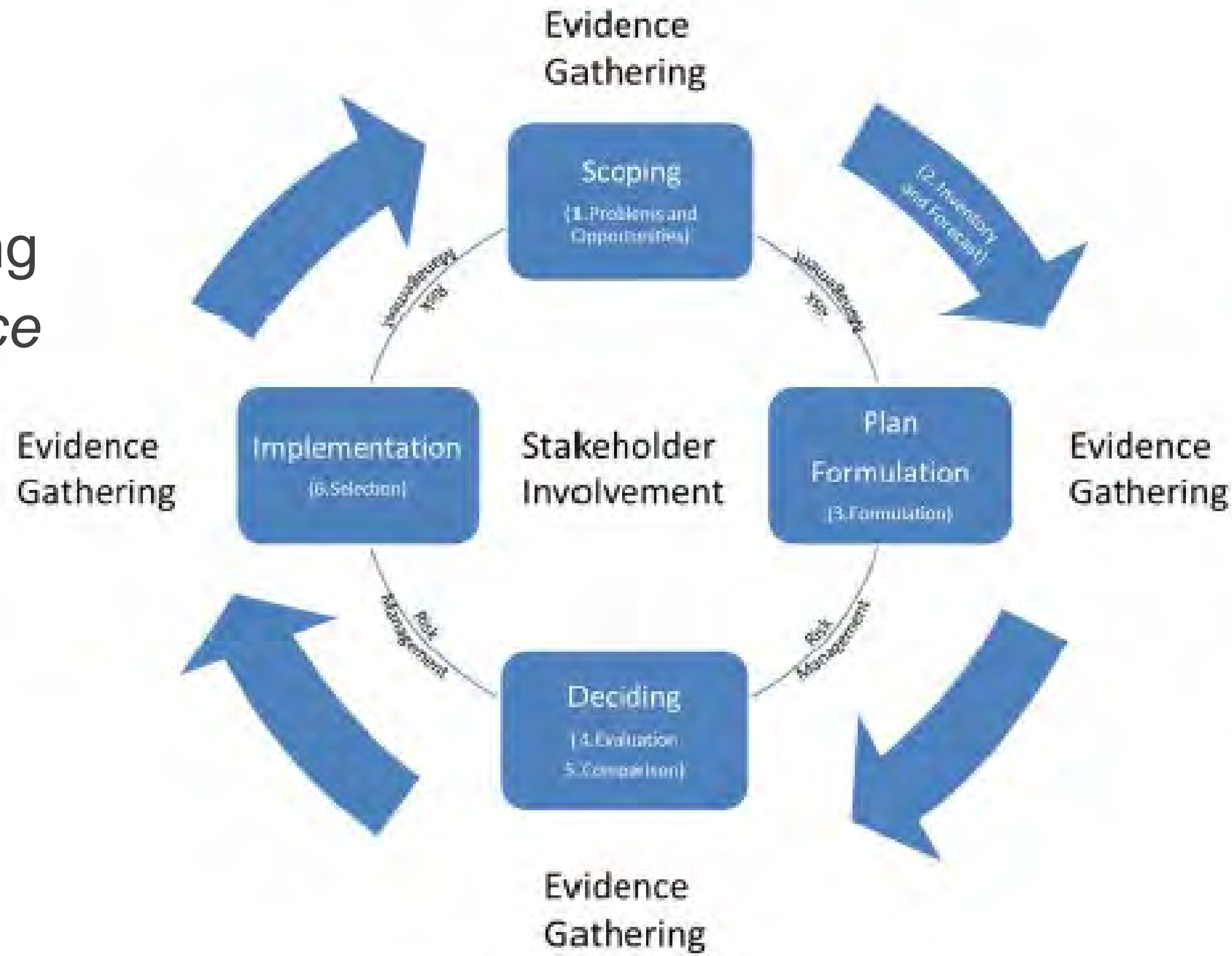
WHAT'S NEXT?

Repeat!

Confirm Scoping
Gather Evidence
Formulate
Decide
Implement



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2ND ITERATION: WHAT DO OTHERS KNOW

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KEY UNCERTAINTIES – FL KEYS REVISITED

Model Assumptions and Economics:

- ❑ Some assumptions will have to be made to complete the structure inventory where there are not elevation certificates for first floor elevations (Low)
- ❑ Using the high USACE SLR curve could increase the cost of some measures/alternatives (Medium)
- ❑ There have been issues in the past applying models to the Keys due to the unique geology/hydrology (Medium)
  - Model will be adapted as much as possible and highest quality input data available will be used
- ❑ It may be challenging to quantify NNBF benefits in terms of damage prevented (dollars) (Low)
  - Will work with ERDC and other experts to quantify NNBF benefits and also will utilize OSE account for non-monetary benefits
- ❑ It may be challenging to quantify benefits to life safety vs. damages prevented (low)
  - G2CRM captures life safety benefits, evacuation route importance will be stressed narratively

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KEY UNCERTAINTIES – FL KEYS REVISITED

- ❑ Significant unique environmental resources present in the study area vicinity will likely impose additional design considerations for structural measures (Low)
  - There will need to be a high level of coordination with environmental resource agencies throughout the plan formulation process
- ❑ Alternatives addressing Route 1 will have to be coordinated with FDOT and checked for USACE policy compliance (Low)
- ❑ Public outreach will be critical to manage potentially contentious issues throughout the study (Low)

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SCREENING OF MEASURES DURING SECOND ITERATION

- ❑ Measures carried forward from pre-AMM screening were reevaluated with new information
  - Refined structure damage data
  - Updated cost estimates for measures
  - Refined technical analysis of suitability
  - Input from relevant agencies (FDOT, FKNMS, environmental resource agencies)
- ❑ Seawalls/levees – screened out due to ineffectiveness (no high ground to tie into) + porous limestone geology
- ❑ Surge barriers screened out due to ineffectiveness (no high ground to tie into)
- ❑ Road elevations screened out due to cost and lack of RE
- ❑ Canal improvements screened out due to cost in relation to effectiveness (little reduction in storm damage)

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SCREENING OF MEASURES DURING SECOND ITERATION

- Beachfill/dunes – screened out due to low benefit: cost ratio (<1)
  - Parametric cost estimates for material from nearby, recent project ($76/ CY)
  - Minimum width (50’) and “other feature” assumptions
  - Potential damages based on GIS-tool showing structures + depth inundation for FEMA floodplains
  - Assumed damages eliminated for first 1000’ inland from shore; assumed assessed values of structures
  - Did not use Beach-fx model – screened out measure based on method above (avg. ann. costs = $32M; avg. ann. benefits = $4M)

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3RD ITERATION: WHAT MUST WE LEARN?

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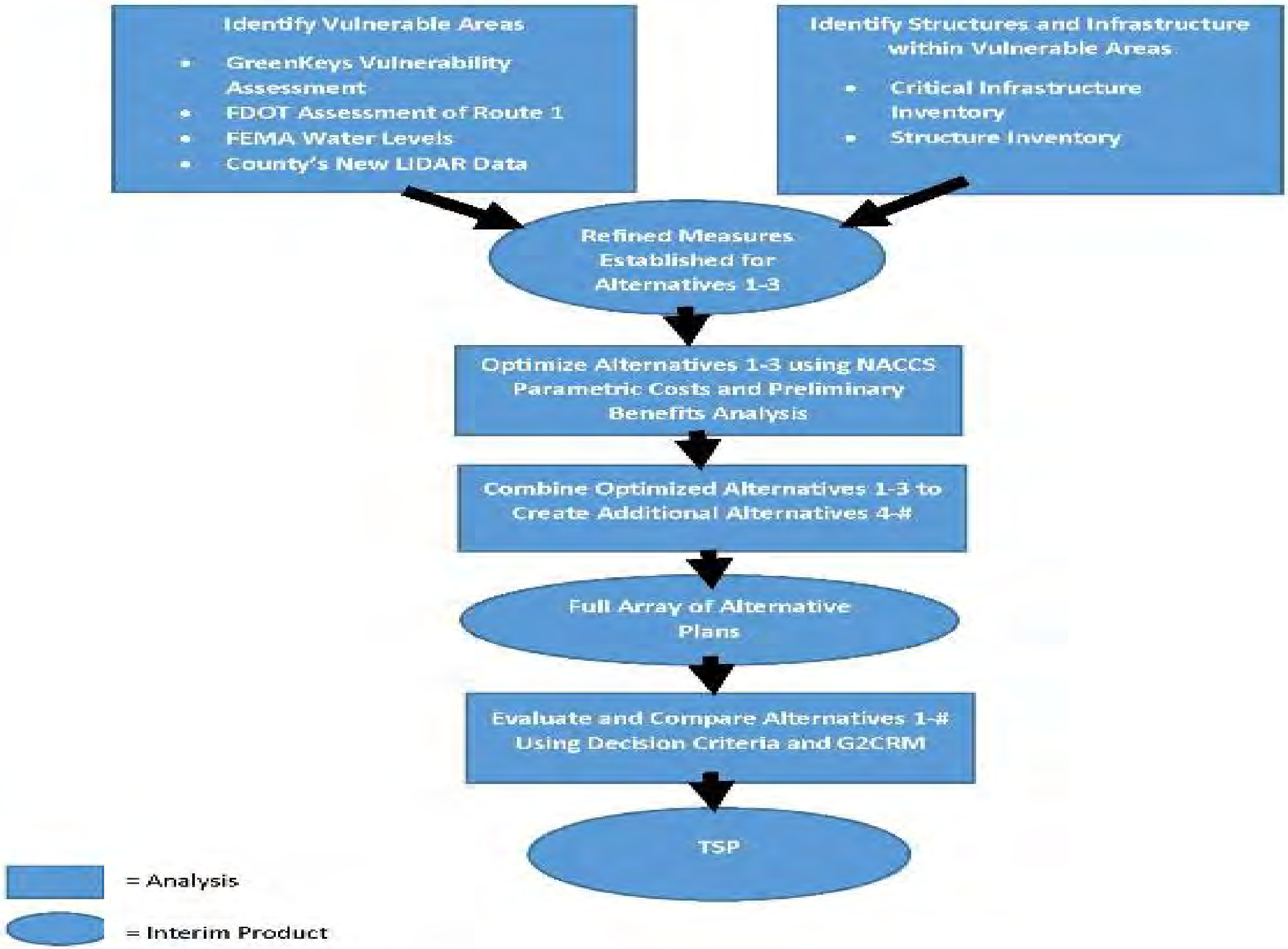
PATH TO TSP – FL KEYS



MILESTONE DECISIONS IN A RISK CONTEXT

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- Outcome risks: residual risks and how to manage them; new, transferred or transformed risks attributable to the recommended plan.

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QUESTIONS AND DISCUSSION

-

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
502 EIGHTH STREET
HUNTINGTON, WEST VIRGINIA 25701-2070

REPLY TO
ATTENTION OF

CELRH-DSPC 07/31/2019

MEMORANDUM FOR RECORD

SUBJECT: Documentation of the 22-23 April 2019 Risk Assessment Meeting for the 2019 Lower Mud River Flood Risk Management Project, Validation Study

BACKGROUND: The subject meeting was held in order to incorporate life safety risk principles in the study phase of the Lower Mud River project. USACE recognizes that risks to human life are a fundamental component of all flood risk management studies, and must receive explicit consideration in the planning process. For the Lower Mud River study, this consideration was accomplished as part of the Cost and Schedule Risk Analysis (CSRA) for the recommended plan. The life safety risk assessment portion of the CSRA was conducted in approximately a day and half following the completion of the standard CSRA.

PARTICIPANTS:
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SCOPE: The process used to consider life safety risk was qualitative in nature and used primarily existing information. A simplified consequence analysis was conducted prior to the meeting. The team consisted of a facilitator from the Dam Safety Modification Mandatory Center of Expertise (DSMMCX), consequence and H&H experts, and a majority of the PDT. The team was focused on identifying potential failure modes (PFMs) which may potentially not meet tolerable risk guideline 1 (TRG 1) as outlined in Section 12.6 of EC 1165-2-218 (March 2018 draft) and using the CSRA as a way to capture any potential cost increases from scope changes needed to address the PFMs. TRG 1 applies to "incremental risk", or risk associated with the levee system itself, which includes breach prior to overtopping, overtopping with breach, and malfunction or improper operation of levee system components. Levee overtopping without breach is "non-breach" risk, and was not considered for this exercise.

PROJECT SUMMARY: The proposed features described in the 2019 Decision Document for the Lower Mud River Flood Risk Management (FRM) Project include approximately 8,000 linear feet of earthen levee, one stoplog roadway closure with adjacent I-wall transitions to the levee embankment, two pump stations with associated gravity outfall conduits and gatewells, and a relocation of a portion of the Mud River channel. Below are some key data and assumptions the team used for some of the PFM evaluations:

- Roadway closure sill: 6-8 feet Below Top of Levee
- Mud river rate of rise: Several Hours (12+) for installation of roadway closure
- Duration of levee loading: 2-3 days assumed

BRAINSTORMING PFMs: The team began by brainstorming a list of PFMs. The brainstorming session identified 28 PFMs, spanning the following categories of performance: embankment and foundation internal erosion, embankment stability, embankment erosion, closure systems, interior drainage, and floodwall stability. For the brainstorming effort, the team was asked to consider the current design described in the Decision Document, existing knowledge of the subsurface, likely levee materials, locations of potential construction difficulties, and likely operations and maintenance issues that could occur over time. The chart below lists these brainstormed PFMs sorted by the affected feature:

	PFM Description	Feature	Location
1	Mis-operation/malfunction of closure	Roadway Closure	at Bill Blenko Drive
2	Malfunction of closure due to seismic loading	Roadway Closure	at Bill Blenko Drive
3	I-wall instability at earthwork/structural transition	Roadway Closure	at Bill Blenko Drive
4	Mis-operation/malfunction of pump station	Pump Station	at Newman's Branch
5	Mis-operation/malfunction of pump station	Pump Station	at John's Creek
6	Malfunction of structure due to seismic loading	Pump Station	at John's Creek
7	Malfunction of structure due to seismic loading	Pump Station	at Newman's Branch
8	Overtopping (OT) with breach due to unarmored levee slope at transition to I-wall	Earth Embankment Levee	at Bill Blenko Drive
9	Internal Erosion (IE) of foundation material exiting at low spot in old channel	Earth Embankment Levee	at old Mud River channel crossings
10	IE of embankment due to differential settlement	Earth Embankment Levee	at Fill Areas (Sta. 0+00 to Sta. 16+00)
11	Slope instability during sudden drawdown (with dual crested event)	Earth Embankment Levee	along entire levee alignment
12	OT with breach at unplanned OT location due to debris blockage at bridge	Earth Embankment Levee	upstream of Bill Blenko Drive Bridge
13	IE of embankment due to differential settlement	Earth Embankment Levee	at old Mud River channel crossings
14	OT with breach at unplanned OT location due to excessive settlement	Earth Embankment Levee	at downstream swampy area (Sta. 70+00 to Sta. 80+00)
15	IE of embankment or foundation due to unknown flaw in existing highway embankment	Earth Embankment Levee	upstream Route 60 tie-in

	PFM Description	Feature	Location
16	IE of embankment due to woody vegetation and/or animal burrows (from poor O&M)	Earth Embankment Levee	along entire levee alignment
17	IE of foundation due to encroachment by adjacent property owners	Earth Embankment Levee	along entire levee alignment
18	IE of embankment due to current "thin" impervious zone design	Earth Embankment Levee	along entire levee alignment
19	IE of embankment due to work stoppage during flooding or work stoppage between construction seasons	Earth Embankment Levee	along entire levee alignment
20	IE of embankment or foundation due to utility crossing leaks	Earth Embankment Levee	along entire levee alignment
21	Slope instability due to seismic loading	Earth Embankment Levee	along entire levee alignment
22	Mis-operation/malfunction of gate(s)	Gatewells	at either pump station
23	Interior flooding due to interior drainage conveyance issues	Interior Drainage Features	along downstream levee section (Sta. 62+00 to Sta. 83+00)
24	IE of embankment along or into conduits due to poor compaction or conduit defect	Gravity Outlet Conduits	at either pump station
25	Overtopping and breach due to inadequate erosion protection	Designed OT Section	at downstream levee section
26	IE of foundation due to defect in barrier wall	Seepage Barrier	along entire levee alignment
27	Slope instability due to river erosion of foundation	Riprap Sections	at existing outside Mud River bends
28	Slope instability due to uncontrolled river erosion of man-made channel	Relocated Mud River Channel	at proposed outside Mud River bends

EVALUATING PFMS: The team then began the evaluation of the brainstormed PFMs and attempted to narrow down the list to those that may not meet TRG 1. This was done qualitatively, with discussions of the likelihood of the initiating event, likelihood of the flaw, likelihood of failure, and magnitude of resulting life loss. The life loss was bracketed by the simplified consequence analysis, but with each PFM the team considered the amount of warning expected, since the consequences were particularly sensitive to warning time.

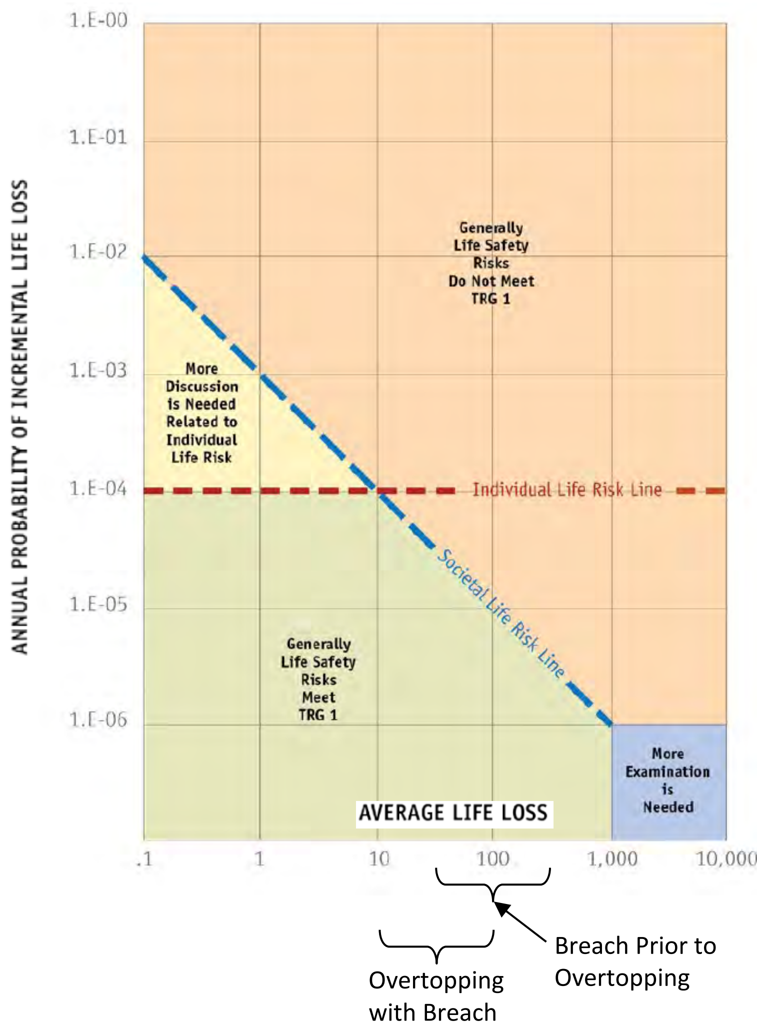
The consequence analysis (fully described in Attachment A), employed a simplified approach to create depth grids in ArcGIS rather than using HEC-RAS hydraulic breach modeling. A structure inventory was developed using the USACE National Structure Inventory and the arrival time was set at one hour for the entire study area. Two warning time scenarios were used in the LifeSim model to bracket the consequences: minimal and ample warning, with incremental life loss estimates in the approximate ranges below:

- Minimal warning: 30 to 300
- Ample warning: 3 to 30

This level of potential life loss requires a more robust design than many levee systems would necessitate. It means the level of risk for this project will be measured against the Societal Life Risk Line (shown on the life risk matrix below), so that the annual chance of incremental life loss must be lower as consequences become higher. Additional results of the consequence analysis that were considered by the team are given below:

- Very low chances of life loss below an elevation 585 ft. NAVD88 water surface
- Life loss was approximately double if the breach occurs in the daytime versus nighttime
- During a large flood commercial buildings and schools may be empty, which would reduce life loss for daytime breaches to closer to the nighttime breach numbers
- Overtopping first occurs at an approximate annual exceedance probability of 4E-03

With input from the consequences team member, the team decided to assume the PFMs involving breach prior to overtopping would correspond to the minimal warning scenario and the PFMs involving overtopping would likely fall between the two warning scenarios. This is illustrated on the below life risk matrix used to assess TRG 1. This helped the team in the evaluation of the 28 PFMs, which is summarized in the table below. The right column of the table gives a qualitative assessment by the team of the likelihood that the risk from the PFM will fall in the green region of the life risk matrix.



	PFM Description	Evaluation	Potential to not meet TRG 1
1	Mis-operation/malfunction of closure	Likely hesitation to execute roadway closure due to traffic needs, little warning if mis-operation/malfunction occurs during flood event. ~1/100-year flood event	**High**
2	Malfunction of closure due to seismic loading	Odds of concurrent flood and earthquake event are remote. Will inspect and repair.	Low
3	I-wall instability at earthwork/structural transition	Problematic configuration – pre-IPET design concept, little warning if failure occurs during flood event	**High**
4	Mis-operation/malfunction of pump station	Not usually concurrent events, low life loss consequence, three pumps need to fail (Motor Control Center is critical case)	Low
5	Mis-operation/malfunction of pump station	Not usually concurrent events, low life loss consequence, three pumps need to fail (Motor Control Center is critical case)	Low
6	Malfunction of structure due to seismic loading	Odds of concurrent flood and earthquake event are remote. Will inspect and repair.	Low
7	Malfunction of structure due to seismic loading	Odds of concurrent flood and earthquake event are remote. Will inspect and repair.	Low
8	Overtopping (OT) with breach due to unarmored levee slope at transition to I-wall	Known PFM from IPET, if not armored	**High**
9	Internal Erosion (IE) of foundation material exiting at low spot in old channel	Since there is a barrier wall here, IE is not an issue	Low
10	IE of embankment due to differential settlement	Relatively short (8 feet) levee section, issues can be detected during inspections, current zoned section design has filters incorporated to combat any cracks in the impervious layer	Low
11	Slope instability during sudden drawdown (with dual crested event)	Little time available to saturate levee fill, requires unlikely second crest, any slide would most likely be shallow	Low
12	OT with breach at unplanned OT location due to debris blockage at bridge	Bridge deck and parapets are right near the top of the levee elevation, flow funneled to bridge, several hours of OT needed to fail, Feasibility Report apparently included two overtopping locations (one being upstream of bridge)	Low
13	IE of embankment due to differential settlement	Current zoned section design has filters incorporated to combat any cracks in the impervious layer developed from differential settlement, likely to detect in inspections	Low
14	OT with breach at unplanned OT location due to excessive settlement	Requires at least twice the predicted settlement, likely to detect in inspections	Low

	PFM Description	Evaluation	Potential to not meet TRG 1
15	IE of embankment or foundation due to unknown flaw in existing highway embankment	Under or through seepage at Route 60 embankment. Low spot just north of highway, little information on embankment materials.	**High**
16	IE of embankment due to woody vegetation and/or animal burrows (from poor O&M)	Includes roots, downed root-balls, or animals burrows. Through seepage concern, vulnerable spot at riverward toe could be compromised (current design includes "thin" impervious zone)	**High**
17	IE of foundation due to encroachment by adjacent property owners	Foundation seepage concern, barrier wall for full alignment will combat under seepage, access road along the landward toe would mitigate	Low
18	IE of embankment due to current "thin" impervious zone design	This assumes none of the flaws of 10, 16, and 19 – therefore less likely	Low
19	IE of embankment due to flaw from work stoppage during flooding or work stoppage between construction seasons	Work stoppages are likely due to multiple construction seasons. Flooding is also possible.	**High**
20	IE of embankment or foundation due to utility crossing leaks	Utility crossings would be cased with link seals	Low
21	Slope instability due to seismic loading	Odds of concurrent flood and earthquake are remote	Low
22	Mis-operation/malfunction of gate(s)	Early detection (Gates closed when WSE is low), should be tested by city, intervention likely before consequences realized	Low
23	Interior flooding due to interior drainage conveyance issues	Very low consequences, but doesn't need an exterior event to cause damages	Low
24	IE of embankment along or into conduits due to poor compaction or conduit defect	Current design incorporates 8'x 8' cast-in-place box culverts at Pump Stations, easy to inspect, but this is very common PFM and we have no designed filter.	**High**
25	Overtopping and breach due to inadequate erosion protection	Current cost estimate does not include erosion protection	**High**
26	IE of foundation due to defect in barrier wall	Flaw would only allow a small amount of flow, localized high gradients.	Low
27	Slope instability due to river erosion of foundation	No riprap or bench at bend near up-stream tie-in, so here there is high likelihood to not meet TRG 1. But other locations have designed riprap and a bench above allowing for detection. Expect end-treatments to be incorporated into design.	**High**
28	Slope instability due to uncontrolled river erosion of man-made channel	Would have to erode land in between to impact levee and may be time to detect and remediate. But little in the current design to prevent erosion/channel migration.	**High**

The ten PFMs that were identified as having a greater potential to not meet TRG 1 were carried forward for consideration in the CSRA. The identified scope changes and cost and scheduled risks are summarized in the table below.

	PFM Description	CSRA Consideration
1	Mis-operation or malfunction of stoplog roadway closure	Risk assessments supports change to a quick-closure design. Already has been considered and included in CSRA.
3	I-wall instability at transition from levee to roadway closure	High likelihood of changing the proposed I-wall to T-wall. T-wall costs from Marlinton LPP used in CSRA.
8	Overtopping and breach at transitions from I-wall to levee	Added cost for riprap protection in this location to Base Estimate because this is now standard of practice
15	Internal erosion at upstream tie-in to Route 60	Too early to know exact scope change required. Cost added to CSRA to cover anticipated solutions – less than $40,000.
16	Internal erosion of embankment due to vegetation and/or animal burrows from poor maintenance	CSRA already includes the potential for converting to an essentially homogeneous levee cross section, which will lessen the impact of unwanted vegetation and animal burrows
19	Internal Erosion of embankment due to construction-related flaw (from work stoppage/flood)	Scope of potential homogeneous section (already in CSRA) includes landward filter zone which will arrest IE from flaws. Consider ways to minimize flaw development in construction phasing (don't let phasing be based only on Real Estate) and when resuming after a work stoppage.
24	Internal Erosion of embankment along or into conduits	Filters meeting current state of practice will be added around conduit penetrations. Added this cost to Base Estimate.
25	Overtopping and breach at designed overtopping section	Added cost for erosion protection to Base Estimate to prevent erosion at OT section
27	Slope instability of levee embankment at outside river bend near upstream tie-in due to erosion of riverbank	Added cost for riprap to Base Estimate to prevent erosion at outside channel bend near upstream tie-in
28	Slope instability of levee embankment along channel relocation due to erosion of riverbank	Added cost for riprap to Base Estimate to better prevent erosion at outside channel bends

ADDITIONAL RECOMMENDATIONS: In addition to the scope changes listed above, a few recommendations have resulted from the discussions in this meeting.

- Install a Flood Warning System. The risk assessment assumed no Flood Warning System and fairly limited evacuation and warning plans. As mentioned above, the consequences were found to be particularly sensitive to warning time; therefore the team believes a Flood Warning System and robust evacuation and warning plans could greatly reduce life safety risk in a cost-effective manner. In addition, nearby residents outside of the leveed area, such as those on the opposite side of the river on Georgia Avenue, would also benefit.

- Construct and maintain an access road along as much of the landward toe as practicable. Although encroachments by adjacent property owners was not identified as a major driver of risk, this is a common issue with urban levees that could be mitigated by an access road which creates a visible boundary.
- Consider phasing construction based on concerns other than Real Estate availability. Consider earlier construction for reaches with anticipated higher settlement, such as from approximate Station 70+00 to Station 80+00, and/or ways to minimize embankment flaws created from work stoppages.

It is also recommended that when more rigorous and quantitative risk assessments are conducted in the Pre-Construction Engineering and Design (PED) phase, the full list of 28 PFMs be consulted as part of the process, not just the ten highlighted with the potential for greater risk. One reason this is important is that future design changes will likely affect the risk from one or more PFMs identified here (such as changes to the levee zoning or the seepage control measures). Another reason is the qualitative nature of this assessment. In addition, during the evaluation process, the team recognized that for some PFMs that were not carried forward, meaningful risk reduction could still be achieved with modest scope changes that are worth considering in the PED phase. Further brainstorming of PFMs should also occur in future risk assessments since new design or geological issues may develop in the meantime.

KEY LIMITATIONS / LESSONS LEARNED:

- The methodology for the simplified consequence analysis seems appropriate for the level of risk assessment conducted and phase of the project. Life loss consequences were able to be reasonably bracketed in a very short timeframe, and additional refinement would likely not have affected the evaluation of PFMs.

- Risk concepts were not fully understood by all PDT members that participated, which affected their ability to contribute to some parts of the discussion. Time constraints did not allow for a much of an introduction of these concepts during the meeting.

- Some hydrologic questions arose during the risk assessment, including the river's rate of rise and the duration of loading, which could not be immediately answered with much certainty. Anticipating these needs prior to the meeting may have reduced uncertainty in some of the PFM evaluations.

- Following brainstorming, the Levee Safety Tool was used to ensure all common levee PFMs were considered by the team. Although no new PFMs were added, it provided some assurance that none had been missed.

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Attachment:
Analysis of Potential Levee Breach Consequences in Support of the Lower Mud River Feasibility Study

CF:
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Analysis of Potential Levee Breach Consequences
In Support of the Lower Mud River Feasibility Study

In April of 2019, a simplified consequence analysis was performed to estimate potential consequences of a levee breach in support of the Lower Mud River Feasibility Study. The recommended plan includes a levee system to protect the town of Milton, WV along with a river channel realignment.

Instead of using HEC-RAS hydraulic breach modeling, a simplified approach was used to create depth grids in ArcGIS software using a USGS 3 meter resolution terrain grid. The resulting depth grids represent a single water surface with no slope, with depth being based on the underlying terrain. An assumed arrival time grid was created to represent a single arrival time of 1 hour over the entire study area. A structure inventory was developed using the USACE National Structure Inventory version 2, which is based on parcel data, building footprints, census data, and several other sources. The structure inventory was clipped so that it only included structures within the proposed levee area.

A HEC-LifeSim 2.0 model was developed using the above data inputs. The LifeSim parameters were selected to match the MMC Levee Breach Modeling Standard Operating Procedures, which include using mostly unknown uncertainty parameters and two warning time scenarios: minimal warning and ample warning. Minimal warning represents a uniform distribution of warning time between 3 hours prior to breach and 30 minutes after breach, while ample warning represents a warning approximately 24 hours prior to breach. These times were each extended by one hour to account for arrival time uncertainty that would not be included in the uniform arrival grid. The model was run with 2,000 iterations using depth grids representing depths at 597, 594, 590, 585, and 580 feet NAVD88. The difference between NAVD88 and NGVD29 is approximately 0.6 feet (594 NAVD88 is 594.6 NGVD29). The approximate crest of the levee at its downstream overtopping section is currently expected to be 594.12 NGVD29, or 593.58 NAVD88.

Water Elevation (NAVD88)	Structures Inundated	Daytime PAR	Nighttime PAR	Property Damage
597	573	1,986	1,216	$184,531,590
594	529	1,929	1,107	$153,146,210
590	458	1,801	938	$95,494,390
585	215	1,160	526	$15,016,826
580	23	19	38	$309,165

Table 1: Consequences data by Water Elevation

The life loss estimated with uncertainty for the two warning scenarios is shown in the following tables.

Water at El. 597 NAVD88				
Statistic	Minimal Warning		Ample Warning	
	Day	Night	Day	Night
95th Percentile	241	123	52	28
75th Percentile	225	104	38	19
Median	**212**	**96**	**26**	**12**
25th Percentile	181	84	13	6
5th Percentile	66	38	2	1
Water at El. 594 NAVD88 (594.6 NGVD)				
Statistic	Minimal Warning		Ample Warning	
	Day	Night	Day	Night
95th Percentile	161	85	35	20
75th Percentile	148	73	25	13
Median	**138**	**67**	**16**	**8**
25th Percentile	119	58	8	4
5th Percentile	43	26	1	0
Water at El. 590 NAVD88 (590.6 NGVD)				
Statistic	Minimal Warning		Ample Warning	
	Day	Night	Day	Night
95th Percentile	88	30	19	7
75th Percentile	78	21	13	4
Median	**68**	**18**	**8**	**2**
25th Percentile	51	14	3	1
5th Percentile	20	7	0	0
Water at El. 585 NAVD88 (585.6 NGVD)				
Statistic	Minimal Warning		Ample Warning	
	Day	Night	Day	Night
95th Percentile	1	1	0	0
75th Percentile	0	0	0	0
Median	**0**	**0**	**0**	**0**
25th Percentile	0	0	0	0
5th Percentile	0	0	0	0

Table 2: Life Loss Estimates

Life loss is significantly higher during the daytime due to the commercial nature of the area development, along with a school and a preschool. Minimal warning scenarios would generally fit within the 30 to 300 order of magnitude range, while ample warning scenarios would generally fit within the 3 to 30 range, approximately one order of magnitude lower than the minimal warning scenarios.

The selection of which warning scenario to give more weight to would depend on the type of potential failure mode. Overtopping failure modes might be closer to the ample warning scenario if forecasting and modeling allowed for early warning. Breach observation likelihood and progression time, as well as the potential for intervention, would also impact the warning time.

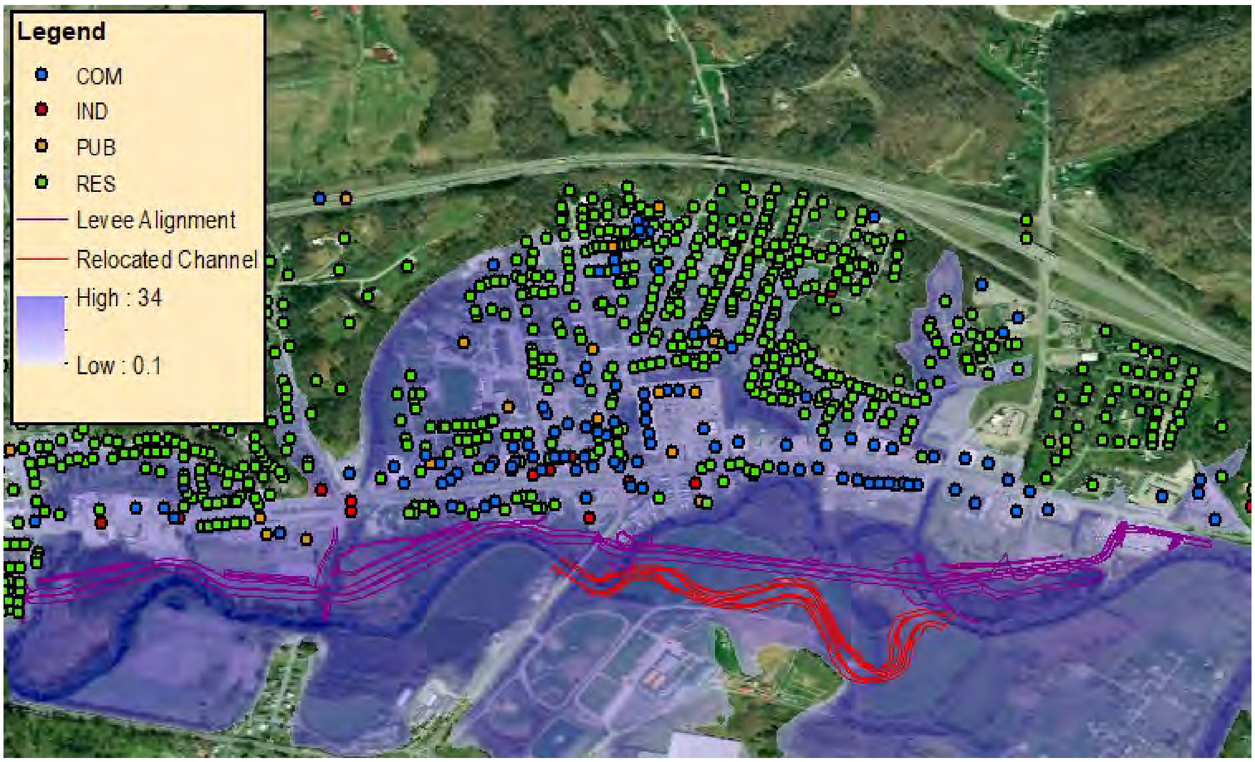

Figure 1: Structure Inventory with El. 597 NAVD88 Depth Grid

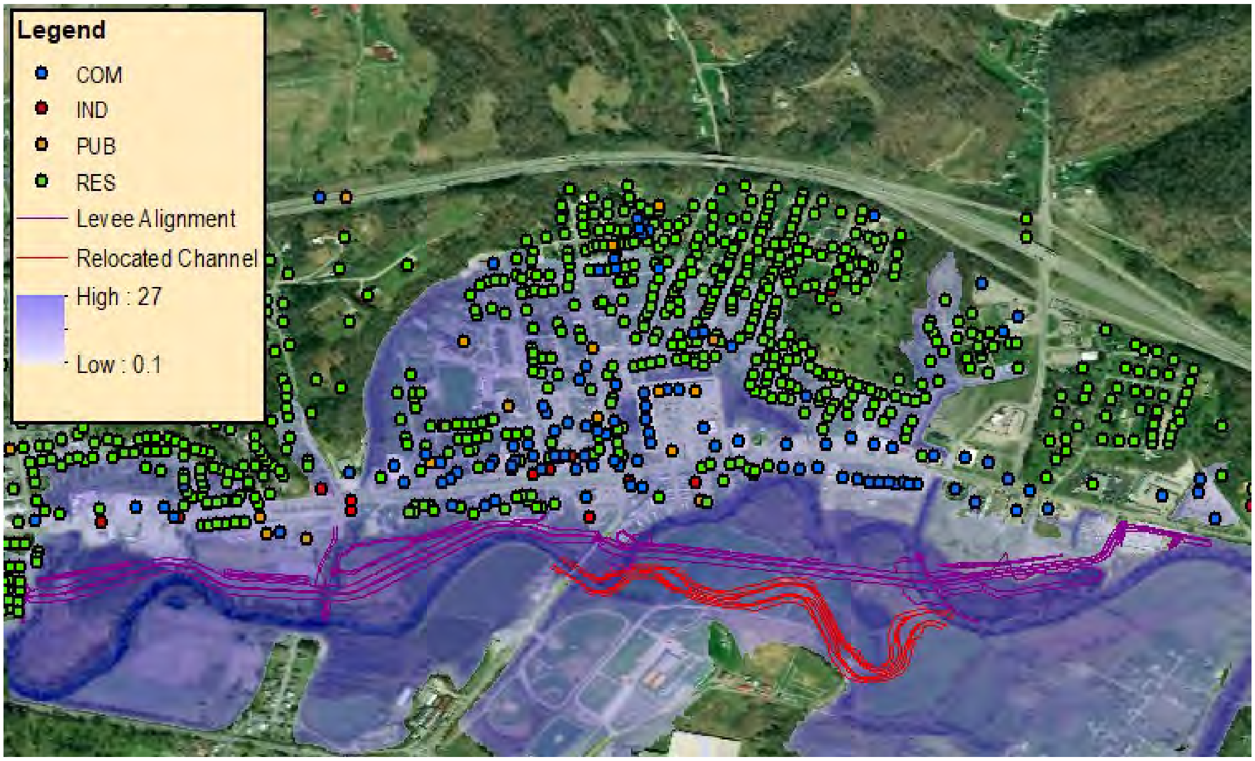

Figure 2: Structure Inventory with El. 590 NAVD88 Depth Grid

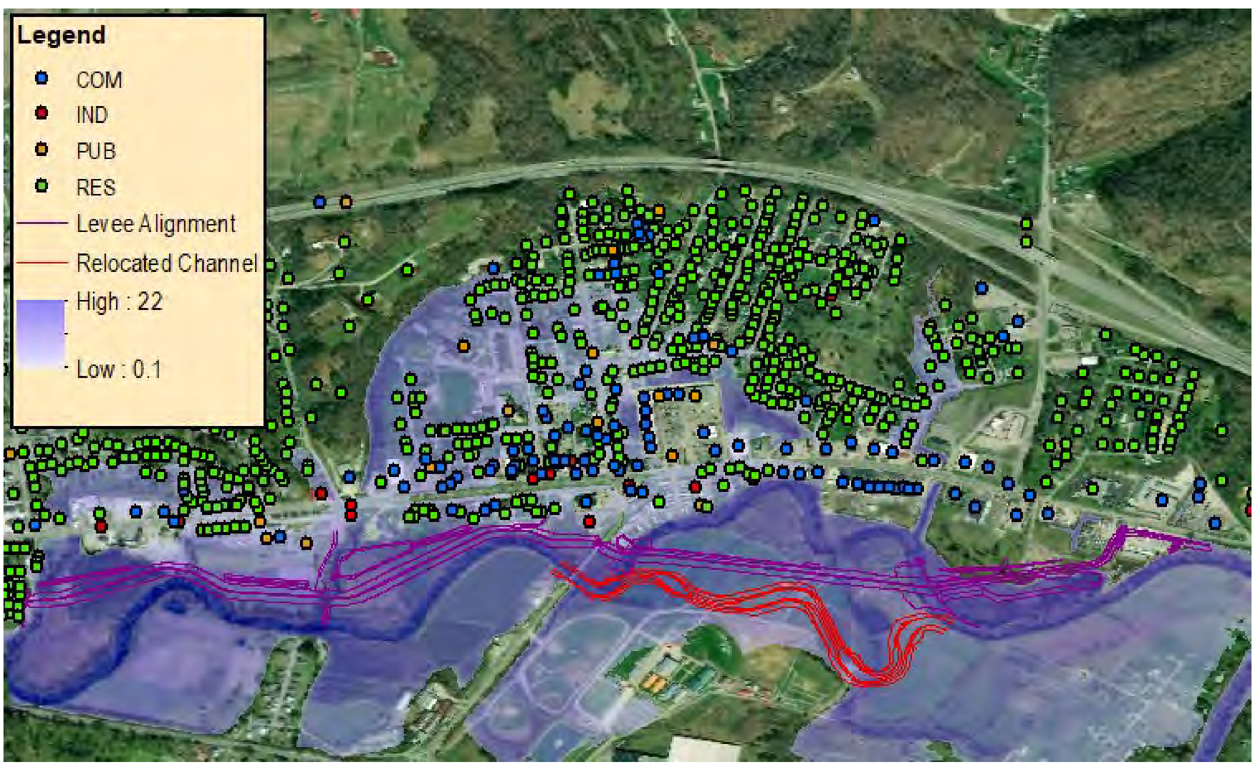

Figure 3: Structure Inventory with El. 585 NAVD88 Depth Grid

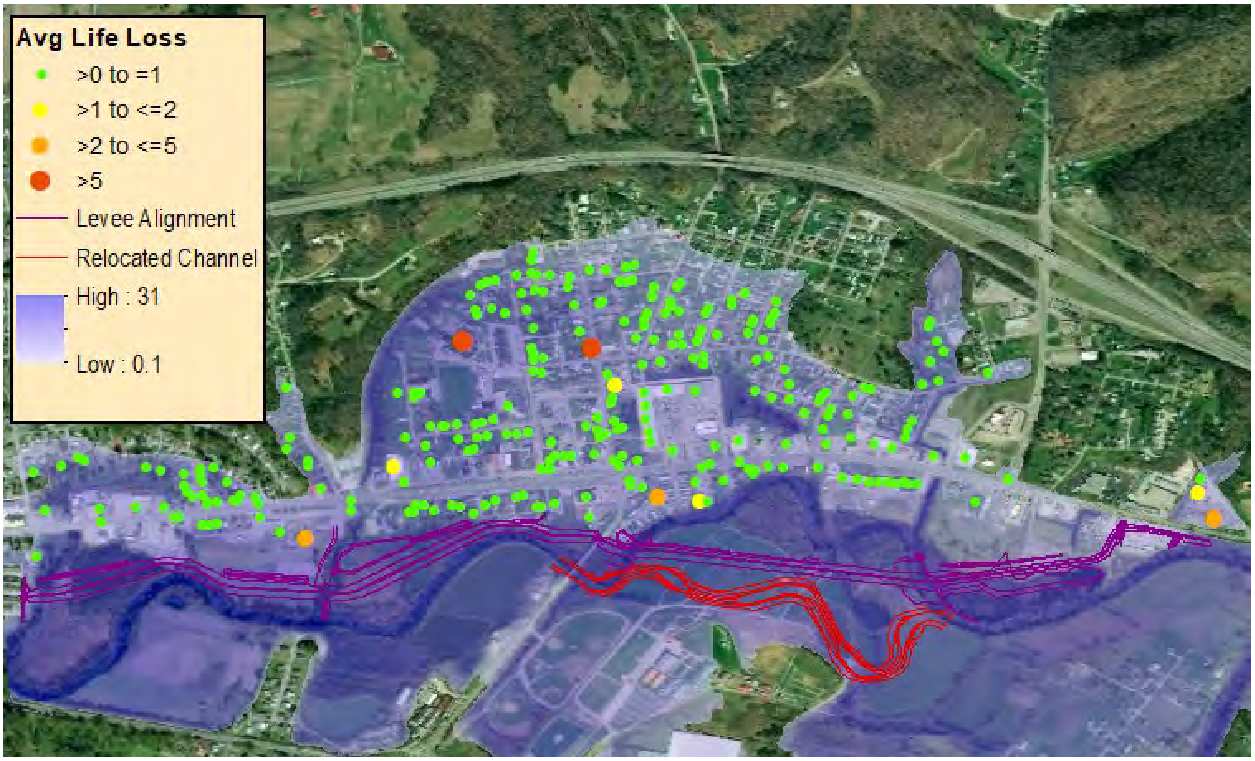

Figure 4: Average Life Loss Estimate per Structure at El. 594 Depth, Minimal Warning, Daytime (138 median life loss)

It should be noted that the highest life loss structure is the Milton Elementary School (average potential life loss of around 41). The school is one of the main reasons that life loss is higher during the day than at night.

Methodology Notes:
This analysis does not incorporate actual hydraulic breach modeling, meaning it does not account for breach progression, arrival time progression, velocity damage, or water slope.

Technical POC:
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CESPL-EDG 27 March 2020

MEMORANDUM FOR RECORD

SUBJECT: San Luis Rey River 1, 3, 4, 5, & 6 Levee Systems Risk Assessment Summary for use with the Post Authorization Change Report

1. References:

a. USACE Headquarters (HQ) Levee Safety Officer (LSO) approved risk characterization for San Luis Rey River 1 Levee System (SLR1), San Luis Rey River 3 Levee System (SLR3), San Luis Rey River 4 Levee System (SLR4), San Luis Rey River 5 Levee System (SLR5), and San Luis Rey River 6 Levee System (SLR6). May 2019.

b. San Luis Rey River 1 Levee System Routine Inspection. 2015.

c. San Luis Rey River Levee System Periodic Inspection No. 1 Reports for SLR 3, SLR 4, SLR 5, and SLR 6. Various dates.

d. Planning Bulletin No. PB 2019-04, Incorporating Life Safety Into Flood and Costal Storm Risk Management Studies, Issued: 20 June 2019.

e. Engineering and Construction Bulletin No. 2019-15, Interim Approach for Risk-Informed Designs for Dam and Levee Projects, Issued 08 October 2019

2. Background. The San Luis Rey River Levees were constructed by the U.S. Army Corps of Engineers between 1991 and 1994; however, the projects were not turned over to the partnering sponsor, the City of Oceanside. Vegetation has grown in the river channel and endangered species are utilizing the newly formed habitat. Performance deficiencies have been noted during recent Periodic and Routine Inspections. The project has reached its Section 902 limit for funding and must request a Post Authorization Change Report (PACR) to perform the necessary repairs, and turn the project over to the local sponsor, City of Oceanside. Presented below are the results of the screening level risk assessments and risks associated with the subject levees. It also describes potential risk reduction if the improvements to the project outlined in the PACR are approved. This memorandum is intended to be included as an attachment to the PACR.

3. Periodic Inspections of SLR3, SLR4, SLR5, and SLR6 were performed between 2013 and 2016 as shown in Table 1, and the reports were finalized between 2015 and 2017. Enclosure 1 is a Leveed Area and Location Map of the levee systems. A routine

inspection was performed in 2015 for SLR1. The most serious of deficiencies overall are:

a. Extensive vegetation, consisting of large-diameter trunk trees and shrubs, have grown in the river channel, and in the stone along the levee toe (‘knee’ and ‘toe’ stone, which are part of the functioning levee) inhibiting inspection of the levee. The vegetation also violates the vegetation-free zone described in EP 1110-2-18 (formerly ETL-1110-2-583). There is also concern that the vegetation may interfere with the performance of the stone, preventing it from “launching” that may lead to scour during large river flows.

b. Sediment that has accumulated in the channel upstream of the I-5 Freeway will be scheduled for removal after the PACR is approved, and anticipated to convey the 1% annual exceedance probability (100-year event) plus acceptable assurance. However, the capacity downstream of I-5 Freeway is not sufficient for the National Flood Insurance Program (NFIP) on the right (north) bank of SLR4. Increasing the capacity may be complicated because this area was not included in the environmental consultation. The PACR includes further details with respect to this concern.

c. Culverts have not been inspected and some levees have flap gates that cannot be inspected or exercised to assess their expected performance during a storm event. Environmental constraints limited access to and inspection of the riverside of these drains and needs to be part of a maintenance plan with environmental access authorization.

4. Levee screening level risk assessments were performed after the completion of the inspections. These screenings were reviewed at the National Rollup, and presented to the Levee Safety Oversight Group. The Levee Safety Action Classification (LSAC) ratings were approved by HQ LSO, and the results from the screenings are presented in Table 1. Note that all of the levees will experience two feet of overland flow following an overtopping or levee breach and not experience deep ponding in developed areas.

a. The levee of most concern (highest risk) is SLR3, which runs for 5.68 miles along the left (south) bank of the river between College Boulevard and Canyon Drive. Based on the screening results for SLR3, an expected statistical life loss of seven people is estimated due to a breach prior to overtopping during a 1/100 Annual Exceedance Probability (AEP) storm event.

b. Concerns related to embankment erosion and seepage have been noted. The screening level risk assessment determined that there is a High Likelihood potential of seepage-induced failure and embankment erosion at SLR3.

TABLE 1. Risk Properties of San Luis Rey River Levee Systems

DESCRIPTION	SLR 1	SLR 3	SLR 4	SLR 5	SLR 6
Last Periodic Inspection (year)	Not applicable(1)	2013	2016	2016	2013
Periodic Inspection Rating (A/M/U(4))	Not applicable(1)	U	U	U	U
Levee Length (mi.)	0.13	5.68	0.48	1.46	2.42
Leveed Area (sq. mi.)	0.01	3.15	0.10	0.16	1.64
Population At Risk Per Screening	152	14,956	61	417	3,414
Levee height on Land Side Avg. / Max. (Ft.)	2/2	20/21	8/9	11/24	19/21
High Likelihood Risk Drivers that Contribute to Breach (2)	Not applicable	Riprap Revetments, Revetments other than riprap, Localized Settlement, Culvert/Discharge Pipes, Erosion	Unwanted Vegetation, Closure System,	Not applicable	Riprap Revetments, Revetments other than Riprap, Erosion
Channel Design Flow Velocity (fps) Per Screening	8 to 15	6.4 to 17.2	14.1 to 22.4	7 to 10.7	8.6 to 17.2
Annualized Probability of Inundation, Breach Prior to overtopping	1.01E-04	1.35E-02	1.09E-03	8.92E-05	2.29E-03
Anticipated Life Loss Prior to overtopping	0.09	7	0.03	0.19	3
AEP for Overtopping	1.99E-02	9.22E-03	1.94E-02	4.94E-03	0.005
Anticipated Life Loss with Overtopping	0.06	10	0.01	0.11	5
System Levee Safety Action Classification (LSAC)	4	2	4	4	3

(1) Routine inspection was performed in 2015.
(2) Levee Screening Tool (LST) Performance Modes that were Rated HL (high likelihood) to contribute to a breach when the levee is loaded to the crest.
(3) A = “Acceptable”, M = “Minimally Acceptable", U = “Unacceptable”

5. Risk Management Measures in relation to Tolerable Risk Guidelines

a. Understanding the Risk: Are there any recommendations that would reduce uncertainty of the risk estimate or change the risk estimate based on new information?

Measures	**Feature In PACR**
<u>Culvert/Discharge Pipe</u> Pipes have not been inspected since construction. The uncertainty of condition is contributing to the low rating for the seepage performance mode, Inspection of system side drain structures to verify current condition of the features. SLR3 LST Rating: HL	Pipe inspections of all side drains is included in the PACR. Conditions will no longer be uncertain and repairs will proceed where need on damaged pipes. The LST rating associated with this item are anticipated to improve to a low likelihood of contributing to poor performance. Updated SLR3 LST Rating: LL
<u>Closure System</u> Many of the flap gates were not inspection or exercised during the last Periodic inspection due to environmental restrictions. The uncertainty of condition is contributing to the low rating for the seepage performance mode. SLR3/6 LST Rating: ML	Inspection and exercise of all flap gates is included in the PACR. Conditions will no longer be uncertain and repairs will proceed where need on damaged flap gates. The LST ratings associated with this item are anticipated to improve to a low likelihood of contributing to poor performance. Updated SLR3/6 LST Rating: LL
<u>Riprap Revetments, Revetments other than riprap, Localized Settlement, Erosion</u> There are deficiencies noted during the last Periodic Inspection, including settlement of grouted stone on the riverside of the levee. The poor condition of the grouted stone and the uncertainty in embankment condition is contributing to the low rating for the erosion performance mode. SLR3/6 LST Ratings: HL	The PACR includes geotechnical investigations of areas that exhibited poor performance. Including areas outlined in Sections 5.d.(1) below. Following investigations, appropriate repairs will be made. The LST ratings associated with this item are anticipated to improve to a low likelihood of contributing to poor performance. Updated SLR3/6 LST Rating: LL

b. Building Risk Awareness: Are there any recommendations related to risk communication and public engagement?

Measures	**Feature In PACR**
The City of Oceanside participated in the screening level risk assessment with SPL.	No additional feature in PACR needed. The City will continue to be included in Levee Safety Related matters related to the project.
An updated system specific Emergency Action Plan should be developed for each	The PACR does not include specific measures to address this item, but it will

Measures	Feature In PACR
levee system, in coordination with the City of Oceanside.	include recommendation to the local sponsor for assessment/improvement in these areas.
Community flood risk awareness should be improved, in coordination with City of Oceanside, through public engagement activities, media stories, or community website.	The PACR does not include specific measures to address this item, but it will include recommendation to the local sponsor for assessment/improvement in these areas

c. Fulfilling Daily Responsibilities: Are there recommendations related to O&M, monitoring, or emergency planning?

Measures	Feature In PACR
Interior condition of side drain structures needs to be determined via video recording. Replace/repair pipes that have reached end of serviceable life or are in poor condition.	Pipe inspections of all side drains is included in the PACR.
All flap gates need to be opened and closed to confirm they operate correctly.	Inspection and exercise of all flap gates is included in the PACR.
An updated system specific Emergency Action Plan should be developed for each levee system, in coordination with the City of Oceanside.	The PACR will not address this item.
Settlement should be monitored and subsurface investigations should be performed to determine the extent.	This item is included in the scope of the PACR.

d. Actions to Reduce Risk: Are there any recommendations related to reducing the risk drivers?

(1) The levee repairs outlined in the PACR are intended to address the risk drivers and areas of poor performance. The full extent of the proposed levee repairs is dependent on the findings of the periodic inspections and geotechnical evaluation. An interim scope of work for levee repairs has been provided by the Geotechnical Branch based on a 2008 levee inspection and subsequent site visits. The project costs and contingencies account for unknown repairs that may be needed. Additional detail regarding the cost estimates can be found in the PACR. The scope includes but is not limited to:

Measures	**Feature In PACR**
Culvert/Discharge Pipe SLR3 LST Rating: HL	Outlet Works Upstream of Douglas Drive Bridge – Replacement of outlet works headwall and surrounding grouted stone due to settlement and voids; Updated SLR3 LST Rating: LL
Revetments other than riprap SLR3 LST Ratings: HL	Foussat Road Bridge – Repair and replacement of damaged grouted stone bank protection at the southern bridge abutment; Douglas Drive Bridge - Repair and replacement of damaged grouted stone bank protection at the southern bridge abutment; Unknown Repairs – Additional unknown defects may be present in the levee driving the existing defects. Repair of large sections of grouted stone may be required and a percentage of the length of the south levee where damages are observed potentially requiring repair has been included in the estimate. Updated SLR3 LST Rating: LL
Localized Settlement SLR3 LST Ratings: HL	Maintenance Road Repairs – Surface drainage along the maintenance road was not constructed properly causing voids under the grouted stone and roadway surface, repairs are required to fix voids and correct construction defects;

(2) To assist in characterizing the impact of actions proposed in the PACR will have on the incremental risk associated with the Levee Systems, Screenings of the San Luis Rey River 3, 4, and 6 Levee Segments were cloned in the Levee Screening tool. The cloned screening ID's are 7300 (SLR3), 7302 (SLR4), and 7301 (SLR6). The new screenings were cloned with all the input from the original screenings and the performance ratings associated with the primary risk drivers were updated. For this exercise, the existing condition is represented by original screening results. The cloned screenings represent the condition following completion of the actions outlined in the PACR, or a "with project" condition. Figure 1 below shows the life safety risks associated with the SLR3, SLR4, and SLR6 levees as identified by the original and "with project" risk assessments. The results are displayed as boxes representing order-of-magnitude estimates, in order to visually display the uncertainty associated with the risk estimates generated by the LST. The Annual Exceedance Probability (AEP) of the Average Life Loss (ALL) associated with the updated SLR3 and SLR6 with project screenings was approximately two orders of magnitude lower than those of the existing conditions. The AEP associated with the updated SLR4 with project screening was lower, within one order of magnitude, than the screening results associated with the

existing conditions. Notably, the with-project life loss plots below the societal life risk line for all three of the levee segments.

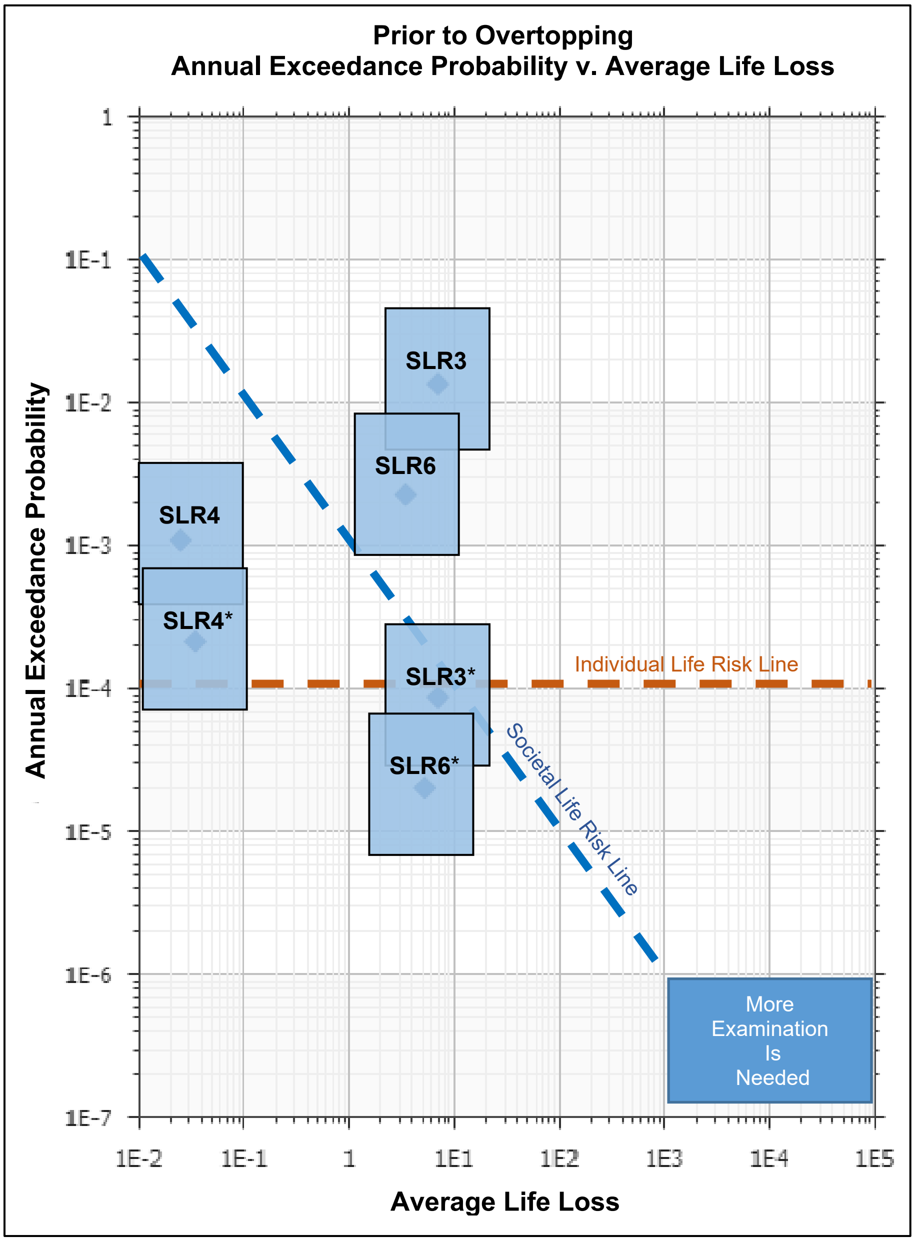


Figure 1. San Luis Rey River Levee Segments, Prior to Overtopping: Annual Exceedance Probability v. Average Life Loss. (Levee Screening Level Risk Assessment, Levee Screening Tool ID's: SLR3 – 5955, SLR4 – 5797, SLR6 – 909, SLR3* – 7300, SLR4* – 7302, SLR6* – 7301)

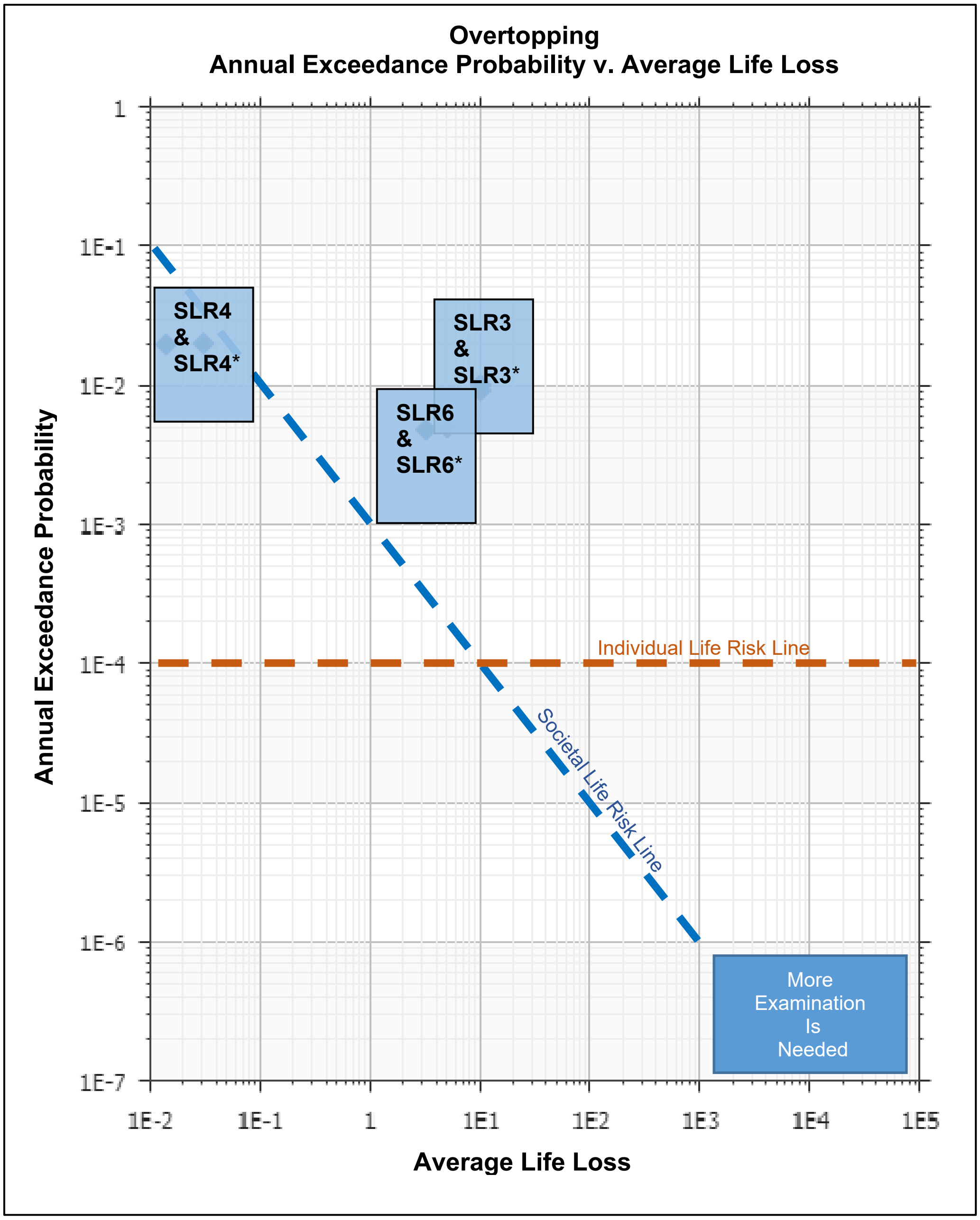


Figure 2. San Luis Rey River Levee Segments, Overtopping: Annual Exceedance Probability v. Average Life Loss. (Levee Screening Level Risk Assessment, Levee Screening Tool ID's: SLR3 – 5955, SLR4 – 5797, SLR6 – 909, SLR3* – 7300, SLR4* – 7302, SLR6* – 7301)

(3) Figure 2 above shows the Overtopping life safety risks associated with the SLR3, SLR4, and SLR6 levees as identified by the original and "with project" risk assessments. The results are displayed as boxes representing order-of-magnitude

estimates, in order to visually display the uncertainty associated with the risk estimates generated by the LST. The Annual Exceedance Probability (AEP) of the Average Life Loss (ALL) associated with the updated SLR3, SLR4 and SLR6 with project screenings did not change significantly compared to those of the existing conditions. The statistical life loss plots above the individual life risk line for all three of the levee segments for both the updated and existing condition screenings. The statistical life loss plots above the societal life risk line for both the updated SLR3 and SLR6 with project screenings and the existing condition.

6. Recommendations. Levees pose a unique risk to life loss during flooding because failure of the structure causes sudden, sometimes unexpected, high velocity flows in areas, and as such can lead to life loss that may not occur from local runoff or channel spill. Table 1 indicates that the SLR3 poses a High (LSAC 2) risk to the population living behind this levee. In addition, four other levees pose a Moderate to Low risk. In considering the Annual Probability of Inundation versus Average Life Loss plots in the screening presentations, a 1/100 AEP has been computed to result in a total anticipated life loss of 10 people for a breach prior to overtopping. The recommendations below are intended for inclusion into the PACR.

a. Recommendations for repairs to the levee were provided in the referenced Periodic Inspection Reports, including (but not limited to) removal of non-compliant vegetation, inspecting/repairing culverts and pipes, repairing voids and settlement within the levee, repairing maintenance roadways, replacing grouted stone and revetment, and performing relief well maintenance. By making the recommended repairs, the life loss risk is anticipated to be reduced. A positive NFIP finding may be attained for the levee systems, with the exception of SLR4. However, NFIP certification is subject to future geotechnical investigations and findings. Key engineering considerations from discussions with FEMA can be summarized by the following points:

(1) Meet the requirements of 44 CFR 65.10 as certified by a registered professional engineer.

(2) The hydraulic analysis must be completed assuming existing conditions (no assumption of future scour is allowed).

(3) Vegetation meets the criteria set by USACE Vegetation Free Zone (VFZ) requirements.

(4) Analyses must meet USACE design criteria.

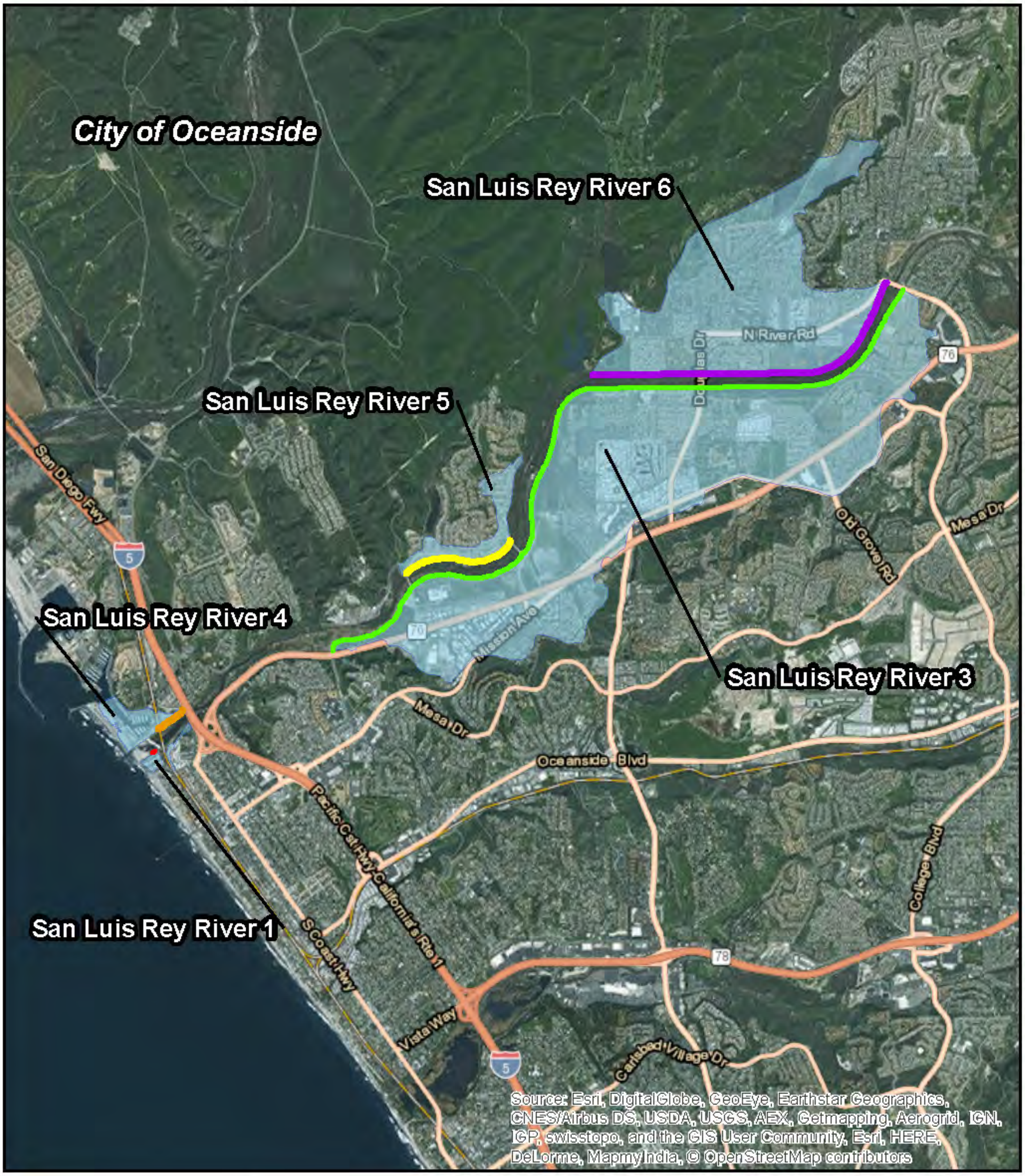
b. As previously discussed, SLR4 does not have sufficient capacity for NFIP purposes. To obtain a positive NFIP finding for SLR4, the following are required: levee repairs, increased capacity, and sand berm removal. Increased capacity can be provided through the removal of sedimentation, vegetation, and the sand berm. Environmental consultation with resource agencies is required for removal of the sedimentation, vegetation, and the sand berm due to potential disturbance of endangered species. NFIP certification will also depend upon the levee condition, and is subject to future geotechnical investigations and findings.

c. In order to facilitate inspection of the ‘knee’ and ‘toe’ stone, remove trees with and shrubs within the vegetation-free zone.

7. This memorandum presents a summary of the San Luis Rey River Levee Systems as they relate to loading frequency, physical condition, and consequences. By the approval of a PACR, the risk that these levees pose is anticipated to be reduced as described in paragraph 5. Executive Summaries of the Periodic Inspections may be found on the National Levee Database, and Screening Risk Assessments may be found on the Levee Screening Tool or upon request to the Dam and Levee Safety Section of Los Angeles District.

GARY J. LEE, P.E.
District Levee Safety Officer
Chief, Engineering Division

Encl



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Legend

- San Luis Rey River 1
- San Luis Rey River 3
- San Luis Rey River 4
- San Luis Rey River 5
- San Luis Rey River 6
- Leveed Areas

0 1 2 Miles

SAN LUIS REY RIVER LEVEE SYSTEMS
SAN DIEGO COUNTY, CA

Location and Leveed Area Map

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

ENCLOSURE 1

Portland Metro Levee System Feasibility Study

Draft Feasibility Report and Environmental Assessment

Appendix Z – Life Loss

Preliminary Draft Pre-Decisional / Deliberative Materials. For U.S. Army Corps of Engineers Use Only / Do not Distribute / Do not release under FOIA

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CCDD
Columbia Corridor Drainage Districts

January 2020

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1. Purpose

The U.S. Army Corps of Engineers (Corps), Portland District, is preparing the Portland Metro Levee System Feasibility Study with its local sponsor, the Columbia Corridor Drainage District Joint Contracting Authority (CCDD). The purpose of the study is to identify and evaluate flood risk management alternatives for a 27-mile levee system along the lower Columbia River in the Portland Metropolitan Area.

This appendix includes assessment of life safety risks. This appendix is not intended for public review due to the sensitive nature of the estimates. An abbreviated, qualitative summary of the findings of this appendix is included in the Other Social Effects (OSE) section of the Economic Appendix. The Economic Appendix is available for public review, and the discussion in the OSE section stems from the analysis presented here.

2. Background

2.1. Study Area

The study area lies along the Columbia River within Multnomah County, Oregon. The study area includes 27 miles of levees along the lower Columbia River within the Portland Metropolitan Area, running from just west of I-5 to the Sandy River (River Mile (RM) 105.9 to 121.8). Large portions of North and Northeast Portland, City of Gresham, City of Fairview, and City of Troutdale are natural floodplains. Beginning in 1917, a system of levees and pump stations was constructed to provide critical flood protection and storm-water management functions for the CCDD. Figure 2-1 provides a study area map.

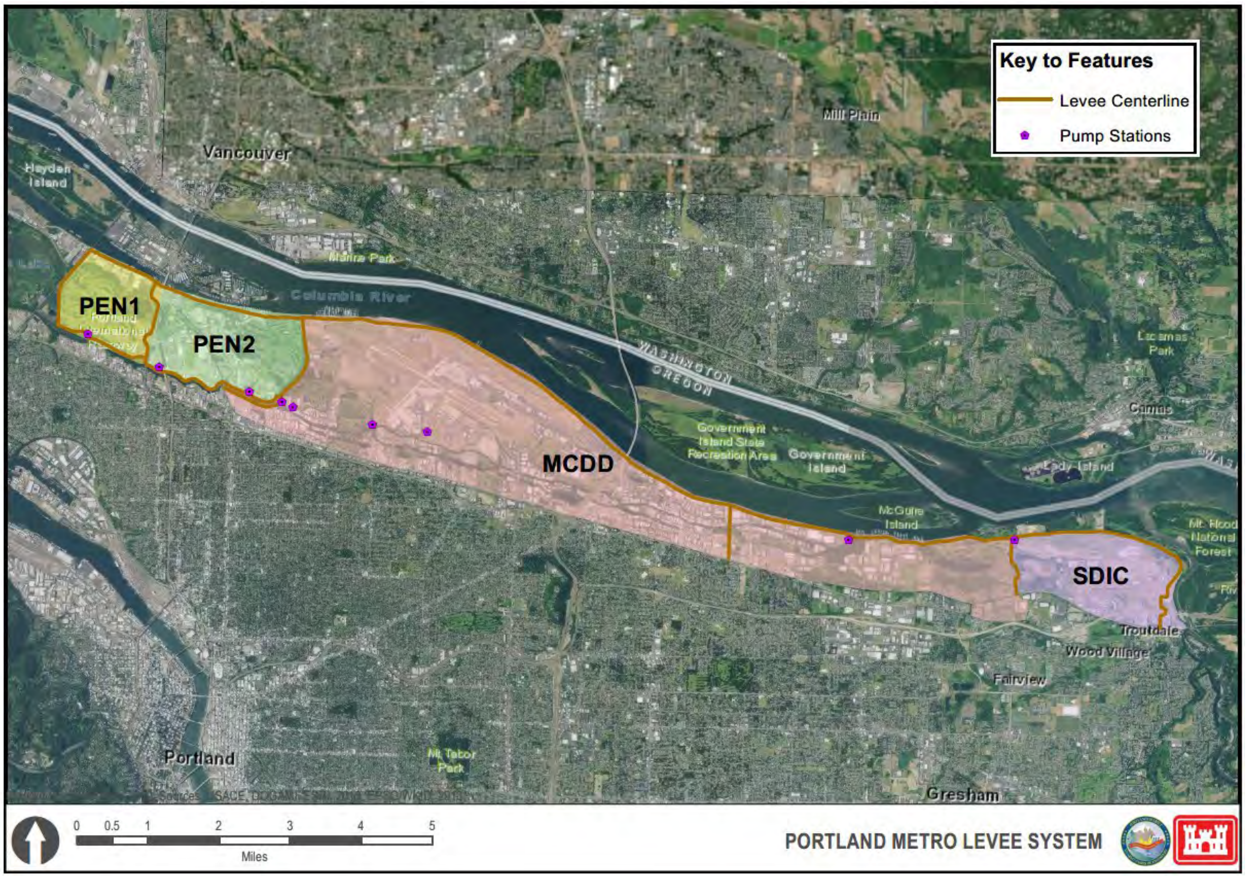


Figure 2-1: PMLS Study Area Overview Map

The Portland Metro Levee System (PMLS) is comprised of four drainage districts: Peninsula Drainage District #1 (PEN1), Peninsula Drainage District #2 (PEN2), Multnomah County Drainage District #1 (MCDD), and Sandy Drainage Improvement Company (SDIC). These four districts are responsible for managing the 27 miles of federally authorized levees encompassing more than 12,000 acres.

The 142nd Avenue cross levee divides MCDD into two smaller levee systems, which are commonly referred to as MCDD-East and MCDD-West. These 5 leveed areas in the PMLS system are connected by cross-levees. The cross levees are redundant features designed to limit damage in the event of a breach during a flood event.

2.2. Population

For a full description of the population in the study area, refer to the Economic appendix. Some relevant details for the life loss are summarized here.

Data for population, demographics, and housing were taken from the American Fact Finder, which provides statistics prepared by the American Community Survey (USCB 2019). The residential population of the study area is 8,860 people. Over 70 percent of the population is between 20 and 64 years of age, with the second largest population falling between the ages of 5 to 19 years.

Of the total population, minorities include black, Asian, and individuals who reported two or more races or some other race. No Native American, Alaskan, Hawaiian, or Pacific Islander residents were reported to live in the study area. The study area has 3,155 housing units, with occupancy ranging from 2.11 to 2.78 people per home.

There are additional populations in the MCDD that are not categorized by the American Community Survey. Dignity Village is an intentionally developed community for homeless men and women, where 43 basic dwelling structures provide shelter to approximately 60 residents (Dignity Village 2019). Incarcerated populations in the study area include up to 595 inmates at the Columbia River Correctional Institution and up to 1,074 inmates at Multnomah County Inverness Jail (Appleby and Bauer 2018).

The population within the PMLS system has grown substantially through the years. Population peaked in the leveed areas during World War 2, as the community of Vanport was formed in the PEN1 area. At its height, residential population in the leveed area exceeded 40,000 people (Geiling 2015). This population was drastically reduced after the 1948 flood, but population has increased since this date. The PEN2 area has the most residential population, followed by MCDD-East and MCDD-West. While residential population is minimal in SDIC and PEN1, they have significant industrial areas that include 24/7 facilities. The number of people in the levee system is greatly increased during the day, due to the high amount of employment in the levee system. Total population in the leveed areas is approximately 43,000 people during the day (working in the area) and 18,000 at night, some of whom may be unable to effectively evacuate (homeless transition project, transient camping areas, etc.).

Figure 2-2 and Figure 2-3 show the estimated population by structure in the leveed areas at 2AM and 2PM respectively. For estimating life loss using current HEC-LifeSim modeling software, populations within study area census blocks are distributed into buildings located within that census block using algorithms developed by USACE programmers and economists working at the Louisville, KY District (LRL).

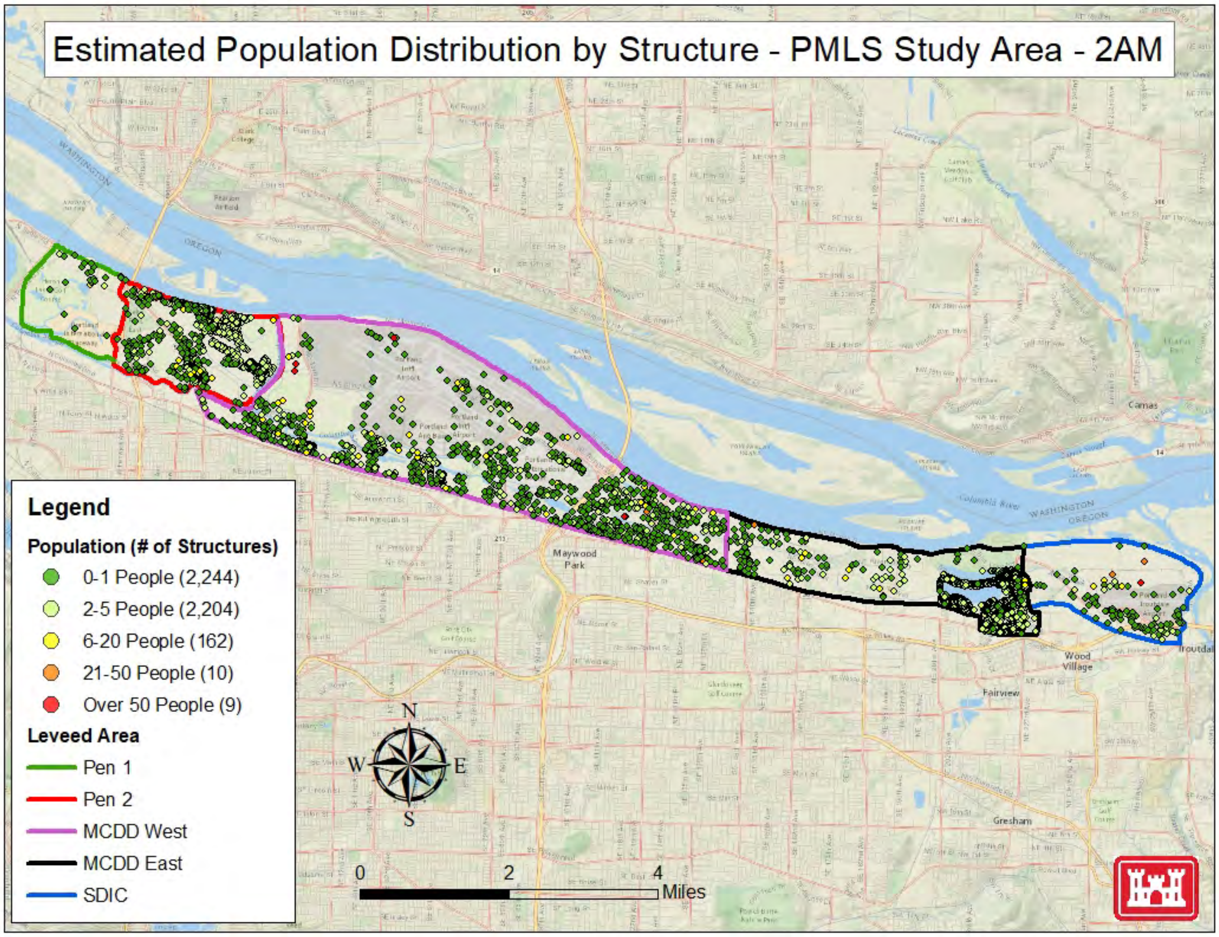


Figure 2-2: Estimated Population by Structure in the PMLS – 2AM

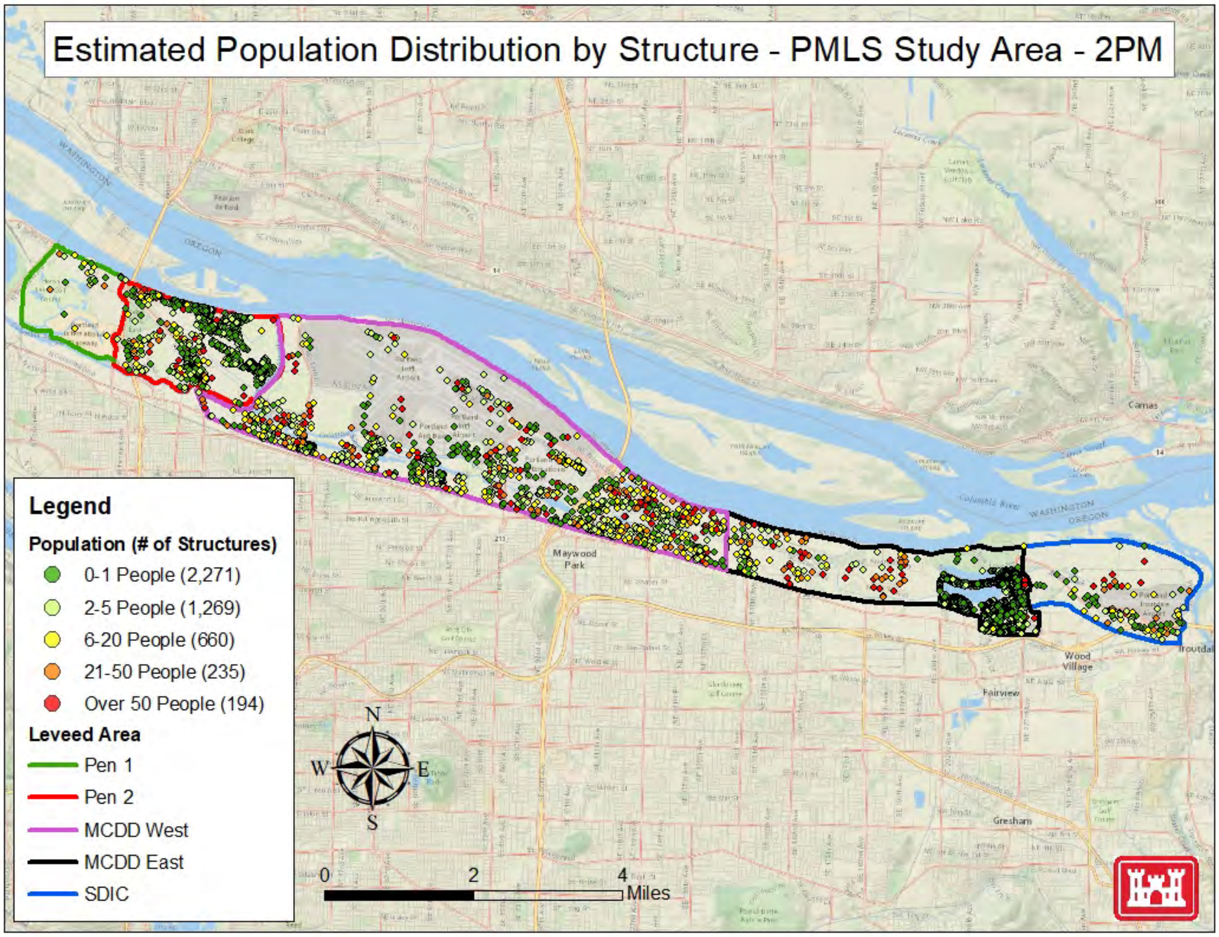


Figure 2-3: Estimated Population by Structure in the PMLS – 2PM

2.3. Past Life Loss

There has been one catastrophic failure of the levees in the past, during the May-June 1948 event. This flood caused a breach in the railroad embankment, completely inundating the PEN1 area, where the city of Vanport had been located. At least 15 fatalities resulted from this levee breach, and it the consequences could have been more severe if the breach had not occurred on a fair weather Sunday afternoon on Memorial Day weekend. This flood also caused failures of the PEN1/PEN2 cross-levee and inundated MCDD-West via the Columbia Slough. The only fatality from these other two breaches was an employee performing levee inspections who was caught in a developing levee breach (USACE 1949).

2.4. Levee Screening Tool

The Levee Screening Tool (LST) includes an approximate assessment of life loss risk for all levees in the nationwide USACE portfolio. Levee screenings were completed in 2013 for MCDD-West, MCDD-East, and SDIC. The PEN1 and PEN2 screenings were not finalized, and are currently being updated. In addition, the upstream segment of SDIC along the Sandy River is being revisited, as are the Columbia Slough and Peninsula Drainage Canal segments of MCDD-West. Updated levee screenings for PEN1, PEN2, and the segments in MCDD-West and SDIC are anticipated in late 2019. Draft results from these levee screenings in progress are available for comparison. The analysis methods used in the levee screening tool are fundamentally different than methods (HEC-LifeSim) applied in this feasibility study. Levee screening methods are intended to be uniform throughout the nation's portfolio of levees, so that fair comparisons can be made. While the results will not match exactly, differences between the levee screening and the feasibility study will be discussed throughout the appendix. While the levee screening results provide context, the methods used in this appendix are a level of detail beyond the screening results.

2.5. Incremental Risk

Flooding in a levee system can occur from four generalized mechanisms, as shown in Figure 2-4:

1. Breach prior to overtopping
2. Overtopping with breach
3. Component malfunction or improper operation
4. Overtopping without breach

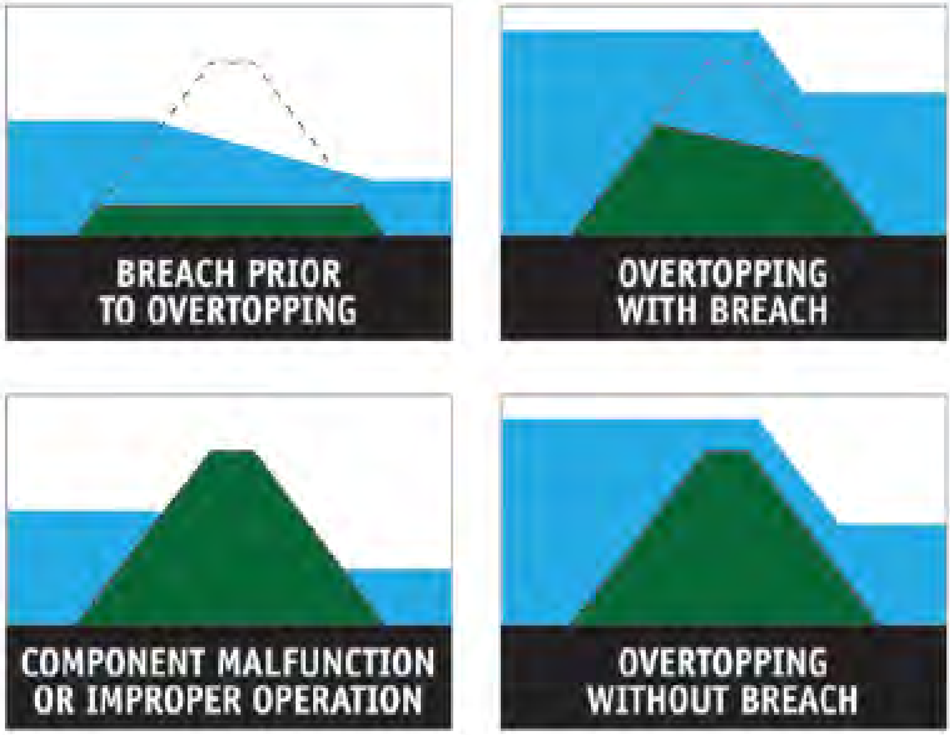


Figure 2-4 Generalized flooding mechanisms for levee system

Incremental risk for an existing levee system is defined in ECB 2019-15 as the risk of inundation posed by a levee system for the following three inundation scenarios: prior to overtopping, overtopping with breach, and component malfunction/mis-operation. In other words, the incremental risk is the risk associated with non-performance of the levee. It is the risk to the floodplain occupants that can be attributed to the presence of the levee. Total flood risk includes both incremental risk (scenarios 1-3) and the non-breach risk (scenario 4: overtopping without breach). In the PMLS, the existing levee system is not designed to withstand overtopping flows, and the sand-silt materials are not competent in the event of overtopping (refer to Levee Appendix B for more details). Therefore, the overtopping without breach scenario (non-breach) is not credible for the PMLS. This means that for the PMLS, there is no difference between total risk and incremental risk. ECB 2019-15 and Planning Bulletin 2019-04 state that incremental risk is to be used when evaluating the Tolerable Risk Guidelines.

2.6. Tolerable Risk Guidelines

One goal of planning studies of existing levee systems is to achieve all four Tolerable Risk Guidelines (TRG) (USACE 2019a). Where TRGs are not currently met, measures and alternatives can be formulated to reduce risk and achieve all four TRGs. USACE considers risk to life safety related to the TRGs from two perspectives, societal life risk and individual life risk.

1. Societal life risk is the risk of widespread or large-scale catastrophes from the inundation of a leveed area that would result in a negative societal response. In general, society is

more averse to risk if multiple fatalities were to occur from a single event. In contrast, society tends to be less averse to risks that result from many events resulting in only one or two fatalities, even if the total losses from the small events is larger than that from the single large event.

2. Individual life risk is represented by the probability of life loss for the identifiable person or group by location that is most at risk of loss of life due to a levee breach. Individual life risk is influenced by location, exposure, and vulnerability within a leveed area.

The four TRGs are provided below, with some discussion of how the local sponsor meets the TRGs:

- **TRG 1 – Understanding the Risk**. The first tolerable risk guideline involves considering whether society is willing to live with the risk associated with the levee system to secure the benefits of living and working in the leveed area. In other words, it answers a basic question: are the risks commensurate with the benefits? The life risk matrix is used to evaluate compliance with TRG 1. Risks that plot above the societal life risk line are considered unacceptable except in exceptional circumstances.
  The alternatives considered in this study have different performance related to TRG1. The assessments of probability of failure and life loss estimates detailed in the remainder of this appendix are used to judge compliance with TRG 1. See Section 0 for the life risk matrix evaluation.
- **TRG 2 – Building Risk Awareness**. The second tolerable risk guideline involves determining that there is a continuation of recognition and communication of the levee risk, because the risk associated with levee systems are not broadly acceptable and cannot be ignored. The rationale for meeting TRG 2 will be determined qualitatively and may be met through USACE levee safety program activities and/or levees sponsor activities, which includes risk communication.
  The non-federal sponsor is very active in building risk awareness, and the levee system meets TRG2. The sponsor is a key planning member of the annual Vanport Mosaic festival, which serves as a reminder of the 1948 levee breach. The sponsor has a booth at community events, such as Sunday Parkways, where they provide information about the levee system. The sponsor has teamed with the Columbia Slough Watershed Council to develop a curriculum for 5th grade classes to educate them about flood risks and the levee system. This includes a tabletop model for students to experiment with floods and levee configurations. While many people working and traveling in the metro area remain unaware of the levee system, the public outreach of the levee sponsor is active in trying to build awareness.
- **TRG 3 – Fulfilling Daily Responsibilities**. The third tolerable risk guideline involves determining that the risks associated with the levee system are being properly monitored and managed by those responsible for managing the risk. The rationale for meeting TRG 3 will be determined qualitatively and may be met through USACE levee safety program

activities and/or levees sponsor activities. TRG 3 can be met through demonstrated monitoring and risk management activities. This would include an active operation and maintenance program, visual monitoring (documented regular inspections), updated and tested emergency plan, instrumentation program, and interim risk reduction measures plan.

The non-federal sponsor meets TRG3 through their day-to-day operations. The sponsor conducts a full-day exercise at least every other year with the participation of USACE levee safety staff and other response partners. This exercise includes real-world examples, including an emergency operations center, levee patrols, and use of machinery to fill sandbags and HESCO barriers. According to the levee safety program manager's experience, the sponsor is one of the most active and responsive in the Portland District portfolio. They have continuously maintained good status in the Rehabilitation and Inspection Program. When concerns are noted in periodic inspections that might push the rating to unacceptable, the sponsor is very quick to respond to them.

- **TRG 4 – Actions to Reduce Risk**. The fourth guideline is determining if there are cost effective, socially acceptable, or environmentally acceptable ways to reduce risks from an individual or societal risk perspective. If it is determined that there are no cost effective or acceptable ways to further reduce risks, USACE may consider this an exceptional circumstance and therefore might consider the levee risk to be tolerable even if the life safety risk exceeds the associated tolerability guideline under TRG 1.

  The non-federal sponsor meets TRG4 to the extent practicable with limited funding. The sponsor has spent years building a coalition of partner agencies and non-profits that have a stake in the levee system. This coalition is known as Levee Ready Columbia, and the sponsor has been the main engine bringing this group together. They have funded levee evaluation studies, assessments of economic impacts of levee failure, and studies of the vulnerability of the system to climate change. The sponsor is currently working with the Port of Portland to raise a known low spot in the levee in PEN2. Other, more major projects to reduce risk in the levee system are not within the normal operating budget of the sponsor. The sponsor was instrumental in initiating this feasibility study to help reduce risk further in the system.

3. Approach

There are many ways that life loss can occur in the PMLS system. For instance, flooding may occur from overtopping of levees during a spring snowmelt flood on the Columbia, or flooding could occur from a slope stability failure during a winter storm. These different scenarios are termed potential failure modes. Each potential failure mode has a different risk of occurring, where risk is defined as the combination of the probability of occurrence and the life loss consequence of the failure.

For the feasibility study, the life loss analysis is detailed enough to support the evaluation of alternatives and their effect on life safety. A full potential failure mode analysis (PFMA) on existing conditions is not being pursued during this feasibility phase in consideration of schedule and budget constraints. Existing levee screening results were reviewed to ensure major potential failure modes were identified. A limited PFMA on the new proposed project features in the selected plan will be pursued after the Tentatively Selected Plan milestone. To mitigate risks, a Type II IEPR SAR will be conducted during Preconstruction, Engineering, and Design (PED), as documented in the review plan.

In the interest of meeting schedule constraints, the life loss analysis will consider only the most critical life loss scenarios, rather than assessing a full range of scenarios. Two main failure modes will be considered: overtopping with breach and breach prior to overtopping. For each failure mode, a single most critical flooding scenario will be assessed in HEC-LifeSim. While there may be other risks to the system, additional failure modes would provide diminishing benefits to the alternative selection process of the feasibility study. Additional analysis is planned to be performed when the selected alternative moves forward to design after the feasibility phase.

This approach of only evaluating the most critical life loss scenario implies that the only measures that are effective at reducing damages are those that target the failure mode with the highest risk. Under this approach of only considering the most critical life loss scenarios, measures that address issues in other “non-critical” locations will have no effect on life loss estimates, unless they are paired with measures that drastically reduce the worst failure mode. This approach is most appropriate if there is a single failure mode that has significantly higher risk than the other modes.

The failure prior to overtopping (FPTO) scenarios are run separately for each of the 5 leveed areas, while the overtopping simulation (OT) is run with all 5 leveed areas at once. The FPTO scenarios are heavily influenced by the geotechnical fragility curves, which are assumed to be independent between the leveed areas. In contrast, the overtopping scenario is more straightforward—there is very little variability in the shape of the water surface profile for a winter event. The order of sequential overtopping of the leveed areas is not expected to change.

All FPTO simulations use the same hydraulic loading. For the FPTO simulations, the most critical case occurs at water levels just below the threshold to issue evacuation warnings. In this event, most of the population is still present in the leveed area at the time of a breach. Scenarios with FPTO where the river water levels have already exceeded the evacuation thresholds are not as critical, and are not included.

The trigger to issue evacuation orders occurs at water levels well before overtopping. Therefore, the OT scenario is expected to be governed by those people who never evacuate. A sensitivity analysis was performed through manipulation of the protective action initiation curve (described further in Section 4.2) to verify that only those who do not heed a 72-hour advance hazard warning are driving the life loss estimations in the OT simulations.

After defining the scenarios, the HEC-LifeSim simulations are run through the Monte Carlo MMC consequence tool. This quickly outputs Monte Carlo iteration percentile tables, whisker plots, and a tornado chart showing life loss correlation to parameter uncertainty (sampling from curves). Finally, the probability of the failure mode is plotted with the life loss consequences on the life loss risk matrix.

4. LifeSim Model Setup

A USACE Hydrologic Engineering Center (HEC) HEC-LifeSim 2.0 model was developed to assess life loss consequences. HEC-LifeSim is designed to simulate the entire warning and evacuation process for estimating potential life loss resulting from catastrophic floods. The software can help identify where people are most at risk of losing their lives, whether it is on roads or in structures.

HEC-LifeSim life loss estimate computations rely on a timeline of emergency response personnel and population at risk actions that are expected to occur. This timeline begins with the identification of an imminent hazard through avenues such as a river forecast predicting water surface elevations to rise above emergency action thresholds leading to a levee overtopping situation. Another example of identification of an imminent hazard is a levee safety patrol noticing a wet area below the levee crest that may indicate underseepage or boils leading to a failure prior to overtopping situation. The timeline ends when a person exposed to the hazard decides to take protective action either by remaining in the structure and moving vertically upward onto the roof or exiting the structure to seek higher ground. This timeline is illustrated in Figure 4-1.

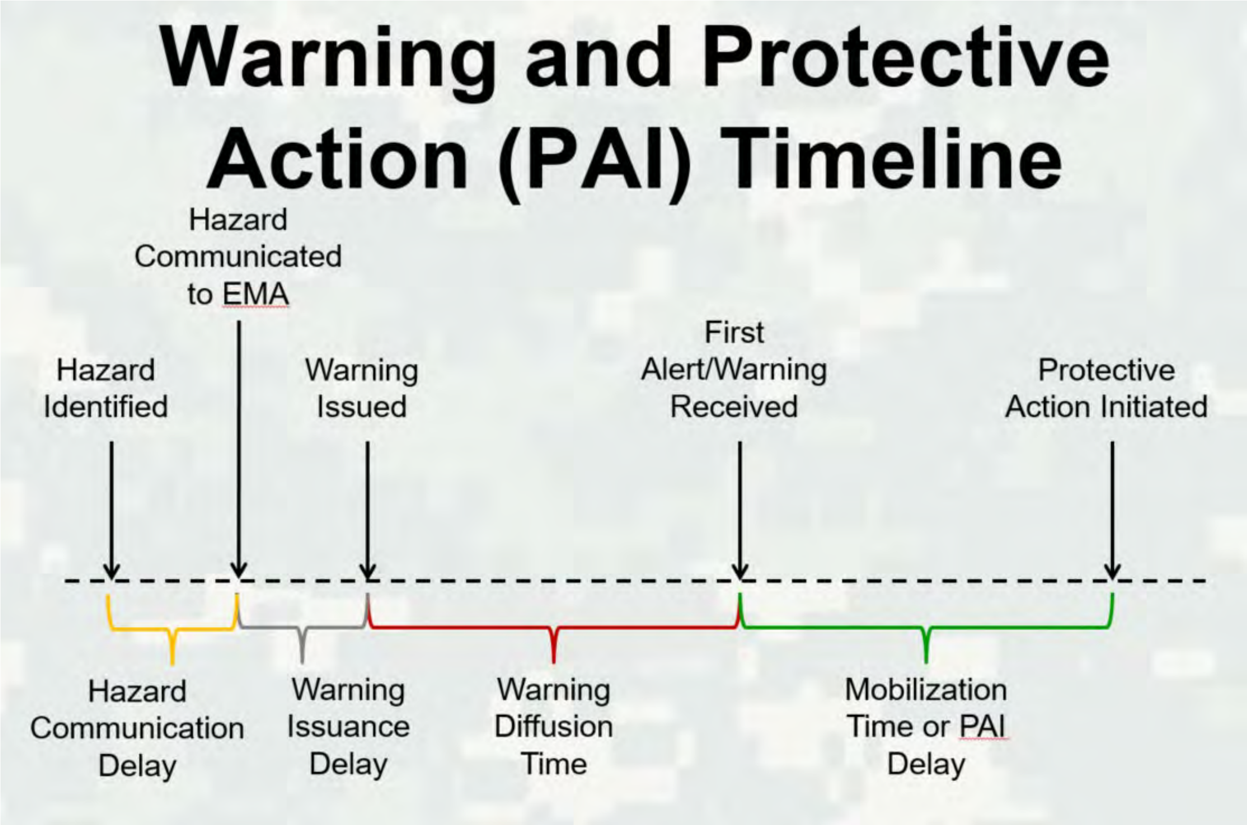


Figure 4-1: HEC-LifeSim Warning and Protective Action Timeline

4.1. Assumptions

The HEC-LifeSim model has the following assumptions:

- All leveed areas are included, rather than having a separate model for each leveed area.
-
- The population inventory is primarily based on U.S. Census Bureau information. People located within a census block are distributed through the use of algorithms into structures within that census block using Longitudinal Employer-Household Dynamics (LEHD) data.
- Industrial, public, and commercial structure populations are assumed to comply with evacuation warnings. Residential populations may not fully heed evacuation warnings.
- Hazard identification occurs 72 hours prior to the overtopping failure mode (with no uncertainty) and between -2 and + 6 hours (uniformly distributed) for the failure prior to overtopping failure mode.
- The Hazard Communication Delay (time from when someone sees a potential problem until they notify an emergency manager) is uniformly distributed between .01 and .5 hours.

4.2. Input Emergency Action and Public Response Curves

HEC-LifeSim software comes preloaded with 3 default time series curves:

1. Warning issuance delay: how long it takes for emergency managers to issue warning after being made aware of a problem
2. Warning diffusion: how fast warning is received by the population at risk
3. Protective action initiation: how long it takes for a person to decide to take protective action

These three curves are used in Monte Carlo simulations that model the probability of different outcomes in processes that are difficult to accurately predict when random variables are present. In the context of predicting loss of life during a flood hazard, the random variables include natural variability in how people will react to warnings and the actions they will take, if any, upon receiving the warning. Examples of these time series curves are shown in Figure 4-2 below.

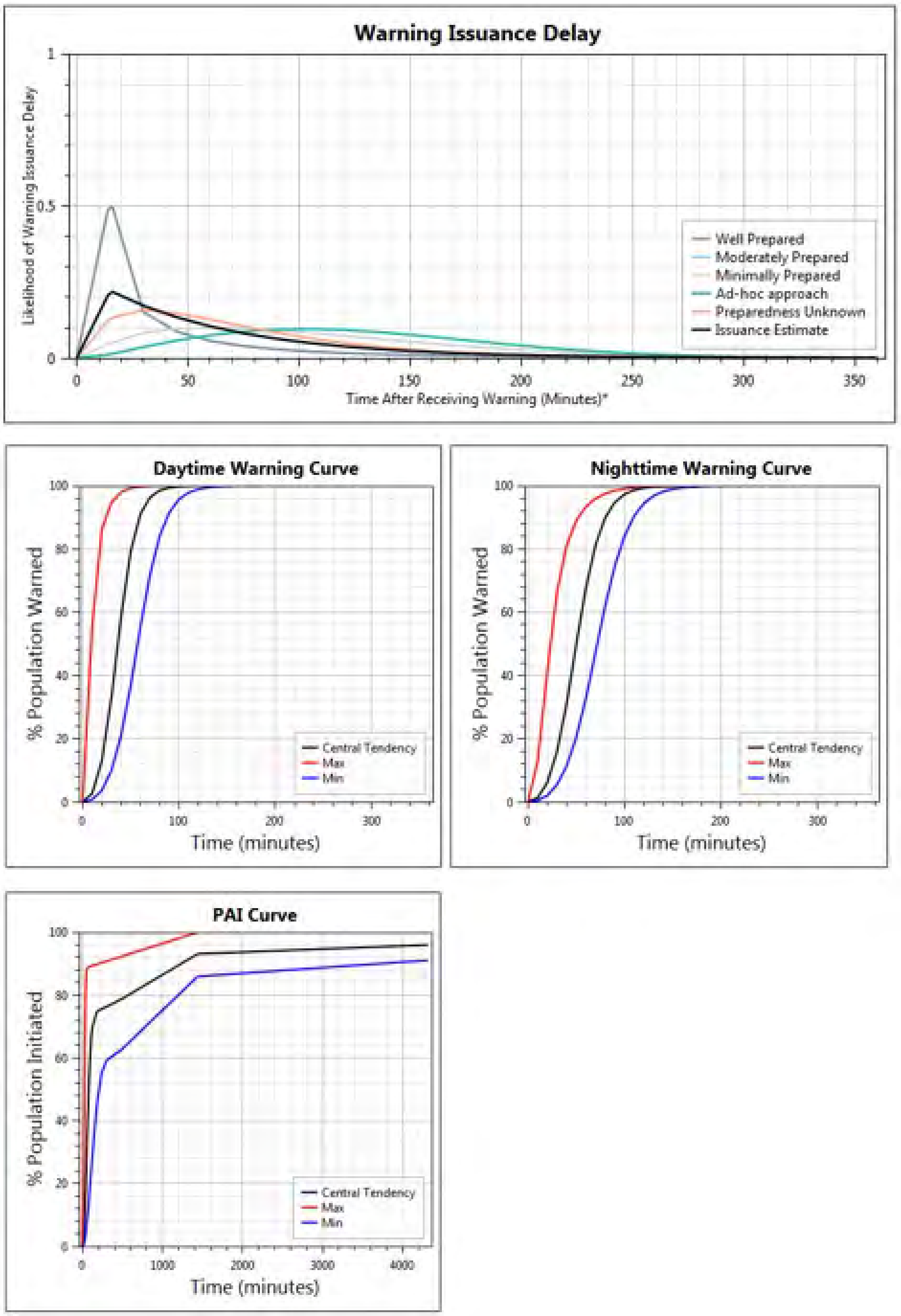
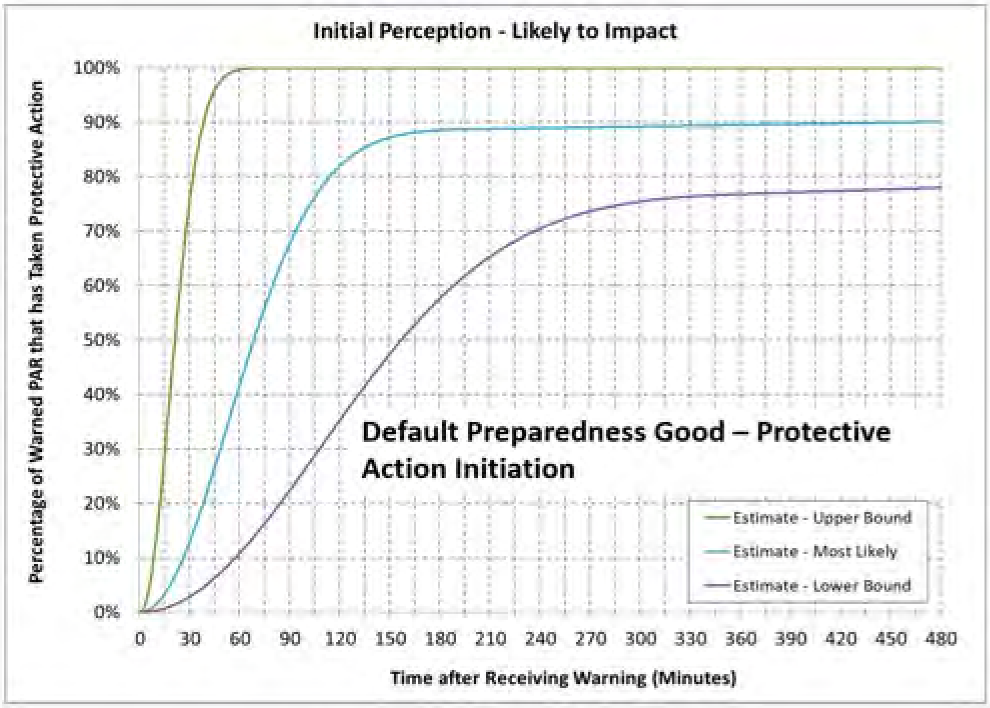


Figure 4-2: Example of HEC-LifeSim Warning and Protective Action Curves

The Corps engaged with social scientists in the areas of warning and evacuation to better understand how flood warnings spread through a community and what causes an individual to delay their decision to take protective action based on those warnings. Dr. Dennis Mileti (Professor Emeritus of Sociology, University of Colorado at Boulder) and Dr. John Sorenson (Researcher Emeritus, Oak Ridge National Laboratory, Oak Ridge TN) wrote three white papers that cover the areas of warning issuance delay, warning diffusion, and protective action initiation delay. These actions are illustrated in Figure 4-2. The professors developed a facilitator guide that describes how to interview local emergency managers and gain an understanding of the existing evacuation potential in their area in the event of a major flood event (USACE 2016).

The PMLS PDT technical team used an interview schedule developed through the Mileti-Sorenson research and subsequently revised by the USACE Risk Management Center (RMC) to interview emergency managers from Columbia Corridor Drainage District, Multnomah County, and the Portland Bureau of Emergency Management. This interview allowed for the generation of localized warning issuance, warning diffusion, and protective action curves (with uncertainty) to be used in the LifeSim model rather than the default curves. While the interview resulted in curves that are different from the default curves, there was no significant difference found in curves between the five leveed areas. In other words, the interview revealed that there is enough redundancy in local emergency action plans and communication tools to assume that no areas with known populations of people will be forgotten in the case of imminent flood hazard exposure warnings. An exception to this would be the unknown whereabouts of transient populations. However, emergency managers expressed knowledge of some known transient camps in the study area to which warning attempts would be made. The following paragraphs detail an example of how communications to the houseless populations has evolved over the last few years. Figure 4-3 shows an example of how the locally developed PMLS protective action initiation curve compares to the broader area based default curve.

During high water events, there is a vacant property in the southeast corner of PEN 2 on a small peninsula that projects into the Columbia Slough that begins to inundate much earlier than other locations with the system. In 2017, the local sponsor did not have any formal systems in place to warn houseless communities encamped in the managed floodplain. Although the District staff did visit the site to warn campers that the peninsula would become inundated, not everyone heeded the warning, and a group of people had to be rescued via boat once the peninsula became an island. This experience and others prompted the sponsor to initiate a houseless outreach program in coordination with Cascadia Behavioral Health, a local nonprofit organization that provides mental health services, addiction recovery support, primary care, wellness programs, permanent housing solutions and affordable housing to people of all ages. The primary purpose of the program is to provide education to the houseless individuals to minimize impacts on levee system and to the sponsor’s ongoing operations and maintenance activities. The secondary benefit of the program is that houseless individuals get connected with social services in the field. During a small high water event in early 2019, Cascadia's trained outreach staff were deployed to the peninsula in order to educate and warn campers that the area would soon inundate. These efforts were repeated multiple times per day as the water continued to slowly rise. Once the encampment was cleared, signs were placed around the entrance to warn newcomers to avoid the area due to flood risk. The campers did heed the warnings in 2019 and no emergency rescues were required.



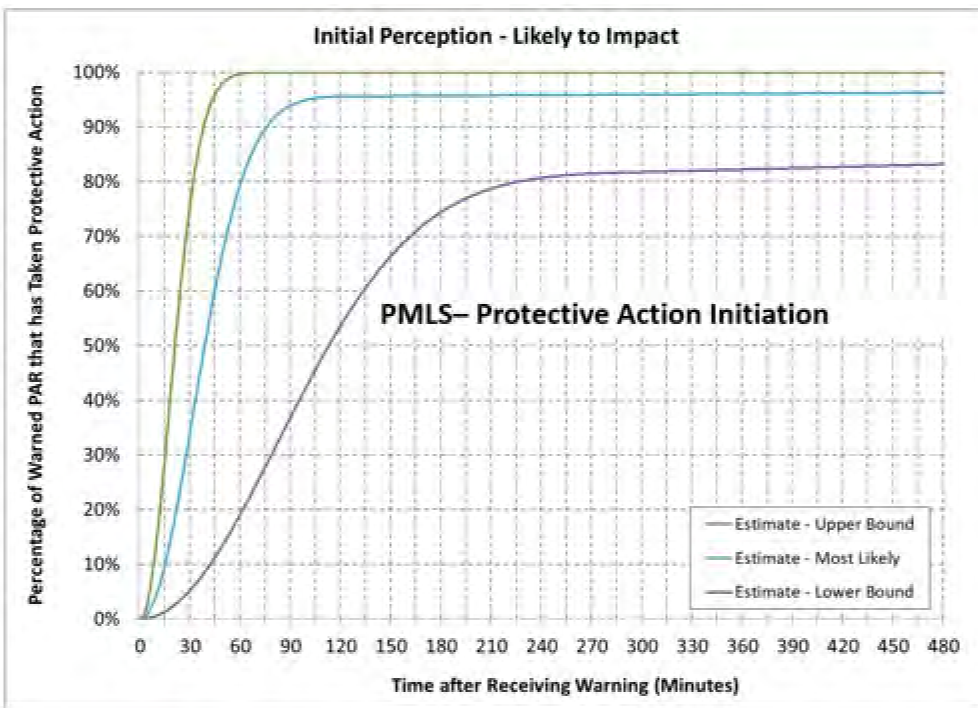


Figure 4-3: Comparison of Protective Action Initiation Curves

In the example curve comparison in Figure 4-3, 60 minutes after receiving warning of an imminent flood hazard, ~80% of people in the PMLS study area are predicted to take action to remove themselves from the hazard compared to ~40% with the default curve. The LifeSim Monte Carlo process samples from the area between the upper and lower uncertainty bounds over the course of 1,000 iterations (aka "realizations"). At the 60-minute time step, the upper bounds (best case) are ~99% for both curves while the lower bounds (worst case) are ~20% and ~10% for the PMLS and default curves, respectively. It is the central tendency line (blue) that was affected the most through the interview with emergency managers.

4.3. Hydraulic inputs

The inputs to the HEC-LifeSim model are detailed in full in the H&H Appendix B, and a brief summary is provided here. Refer to the Levee Appendix D for more background on the development of levee breach parameters. Since the levees are primarily sand/silt material, they are expected to progress from initiation to breach relatively quickly (within a few hours).

A 2-d HEC-RAS model was used to produce inputs to HEC-LifeSim. The breach prior to overtopping runs use the highest water surface elevation possible before the mandatory evacuation trigger. The Emergency Action Plan for the City of Portland requires mandatory evacuation at river stage of 32.5 feet NAVD88 at the Vancouver gage. This is modeled as a winter event, which is more likely to produce these peak stages and has shorter warning times, making it a more critical flooding scenario for life risk.

For the overtopping runs, the water surface elevation slowly increases through the simulation. Breach is initiated when the water surface elevation rises just above the low point of the levee. One model run is performed that increases river levels until all systems have overtopped (various times).

To avoid confusion with modeling of historic events, all levee breach scenarios are modeled in February 2099. For the breach scenarios prior to overtopping, breach initiation is set to 2400 hours on February 5.

The location of breach was selected where the highest risk to life loss is anticipated. Life loss risk is a combination of the probability of failure and the consequence of lives lost. Probability of failure is maximized at the weakest fragility curve location for a given leveed area. Life loss consequences are maximized at levee breach locations nearest population centers, since evacuation time is minimized. Cross-levee failures are not evaluated in these simulations, since they are not assumed to be critical life loss scenarios. It is assumed that if one leveed area were to fail, the populations in neighboring levee systems would take notice and evacuate. Potential breach locations leading to highest risk were discussed and agreed upon with staff from the levee districts. A summary of the hydraulic inputs is given in Table 4-1. Maps showing the breach locations, inundation maps, and arrival time maps can be found in the H&H Appendix B.

Table 4-1: Hydraulic model levee breach scenarios

Type	Drainage Area	Breach Location	Water Surface Elevation at Vancouver (feet NAVD88)
Breach prior to overtopping	PEN1	Columbia Slough Station 174+08	32.5
Breach prior to overtopping	PEN2	Levee Plug 175+00	32.5
Breach prior to overtopping	MCDD-West	Columbia River 361+00	32.5
Breach prior to overtopping	MCDD-East	Columbia River 11+50	32.5
Breach prior to overtopping	SDIC	Columbia River 22+00	32.5
Overtopping with breach	All	Low point (levee control location)	Increasing from 30' to 45' in two days

5. Probability of Failure

5.1. Breach prior to overtopping

The breach prior to overtopping failure mode assumes water levels are just below the threshold that would trigger an evacuation warning (32.5 ft NAVD88). The probability of this event occurring is not as simple as extracting the desired annual exceedance probability (AEP) from the stage-frequency curve. If an event larger than 32.5 ft NAVD88 were to occur, the life loss consequences would be less due to issuance of evacuation orders. Therefore, the probability of being within a small range of elevations just below this threshold is required. The annual chance of reaching a stage two feet below the trigger elevation is used (30.5 ft – 32.5 ft). Rather than a single estimate of this probability, a range representing the 5% and 95% bounds on uncertainty is more useful for risk assessments. To calculate the probability of the peak water surface elevation falling between 30.5 and 32.5 feet, the annual exceedance probability of 32.5 feet is subtracted from the AEP of 30.5 feet. To get a range of the probabilities, the process is repeated for the 5% upper confidence limit line and the 95% confidence limit line. Table 5-1 shows the estimates of probability—these estimates were sourced using the winter stage-frequency curve in the H&H Appendix B.

The annual probability of hydrologic loading between 30.5-32.5 feet ranges from 0.4% to 1.3%, with a best estimate of 0.8%. This is consistent for all alternatives, since no alternatives modify the riverine hydrologic loading. The levee performance changes by alternative, and is explored in the following sections. In some cases, the probability of failure is shown as 0 (negligible). This does not mean that there is actually no chance of failure, since there is always a small chance of failure when the levee is loaded above the toe. In cases where 0 (negligible) is shown, the probability was so low that it would plot well below the tolerable risk guidelines on the life risk matrix, so no further effort was taken to quantify a remote probability.

Table 5-1: Probability of hydrologic loading at various water levels

Water Surface Elevation (ft NAVD88)	Best Estimate Probability	5% uncertainty	95% uncertainty
30.5	1.5%	0.7%	3%
32.5	0.7%	0.3%	1.7%
Range between 30.5 and 32.5	0.8%	0.4%	1.3%

5.1.1. FWOP

The fragility curve analysis detailed in the Geotech Appendix to the feasibility study provides information on the chances of levee failure at various water levels. The results for the FWOP are shown in Table 5-2. PEN2, MCDD-West, and MCDD-East were shown to have a negligible chance of failure at a Vancouver stage of 32.5 feet from the Taylor Series analysis.

Table 5-2: FWOP Probability of breach prior to overtopping

Drainage Area	Breach Location	Probability of failure if loaded with Vancouver stage between 30.5 and 32.5 feet
PEN1	Columbia Slough Station 174+08	20%
PEN2	Levee Plug 175+00	0 (negligible)
MCDD-West	Columbia River 361+00	0 (negligible)
MCDD-East	Columbia River 11+50	0 (negligible)
SDIC	Columbia River 22+00	2%

5.1.2. Alt 3

In alternative 3, the only portion of exterior-facing levee with proposed improvements to levee performance are in PEN1 along the railroad embankment and the Columbia Slough. It is assumed that improvements to the levee would be in accordance with current design standards, which would result in a remote chance of failure prior to overtopping at these hydrologic loading levels. The probability of breach at all other locations remains consistent with the FWOP.

Table 5-3: Alt 3 probability of breach prior to overtopping (changes from FWOP)

Drainage Area	Breach Location	Probability of failure if loaded with Vancouver stage between 30.5 and 32.5 feet
PEN1	Columbia Slough Station 174+08	0 (negligible)

5.1.3. Alt 4

Alternative 4 is similar to alternative 3 in the improvements to exterior-facing levees. One difference between alternative 3 and alternative 4 is that the improvement to the west end of PEN1 is a setback levee in alternative 4 rather than improvement to the railroad embankment. This improvement is assumed to result in equivalent performance to alternative 3. The other modification is improvement to the northwest corner of SDIC, which will improve levee performance.

Table 5-4: Alt 4 probability of breach prior to overtopping (changes from FWOP)

Drainage Area	Breach Location	Probability of failure if loaded with Vancouver stage between 30.5 and 32.5 feet
PEN1	Columbia Slough Station 174+08	0 (negligible)
SDIC	Columbia River 22+00	0 (negligible)

5.1.4. Alt 5

Alternative 5 includes a large-scale levee raise in PEN1 and PEN2, which is anticipated to improve levee performance. The northwest corner of SDIC is also improved.

Drainage Area	Breach Location	Probability of failure if loaded with Vancouver stage between 30.5 and 32.5 feet
PEN1	Columbia Slough Station 174+08	0 (negligible)
PEN2	Levee Plug 175+00	0 (negligible)

SDIC	Columbia River 22+00	0 (negligible)

5.2. Probability of Overtopping

The stage-frequency curves provided in the H&H Appendix B are used to calculate the probability of overtopping. The low spot of the levee in relation to the water surface profile is identified (levee control location), and the probability of overtopping is interpolated from the curves. To provide an estimate of the uncertainty in the probability of overtopping, the 5% and 95% confidence limits are provided as well. The winter season completely dominates the spring season for overtopping failures. The results for each alternative are provided in the following sub-sections.

5.2.1. FWOP

The overtopping scenario considered is a winter flood that rises to a high enough level to overtop all areas. PEN2 overtops first at the northeast corner, followed shortly afterward by PEN1. MCDD-West is the next to begin overtopping from the Columbia River, followed by SDIC. MCDD-East is the last to be overtopped, with failure occurring at the SDIC cross-levee rather than from the Columbia River.

Table 5-5: FWOP Probability of overtopping

Drainage Area	Overtopping Location (Levee Control Location)	Minimum Levee Elevation (ft NAVD88)	Annual Probability of overtopping (best estimate)	Annual Probability of overtopping (5% uncertainty)	Annual Probability of overtopping (95% uncertainty)
PEN1	Columbia River 36+00	37	0.14%	0.05%	0.4%
PEN2	Columbia River 85+00	35	0.32%	0.12%	0.8%
MCDD-West	Columbia River 512+00	40.5	0.05%	0.01%	0.2%
MCDD-East	MCDD-SDIC Cross Levee L 37+00*	44	0.02%	0.005%	0.1%
SDIC	Sandy River 180+00	42.5	0.04%	0.01%	0.14%

*MCDD-East cross-levee overtops after SDIC

5.2.2. Alt 3

No major levee raises are proposed for Alternative 3. A few measures include a levee raise, but this is typically converting a temporary closure structure (sandbag/HESCO closure) to a permanent levee feature. The northeast corner of PEN2 does include a modest raise to an elevation of 36.4 feet NAVD88. Therefore, the probability of overtopping for Alt 3 is identical to FWOP except for PEN2. In this alternative, the sequence of overtopping is the same as FWOP.

Table 5-6: Alt 4 Probability of Overtopping

Drainage Area	Overtopping Location (Levee Control Location)	Minimum Levee Elevation (ft NAVD88)	Annual Probability of overtopping (best estimate)	Annual Probability of overtopping (5% uncertainty)	Annual Probability of overtopping (95% uncertainty)
PEN2	Columbia Slough 229+00	36.4	0.19%	0.067%	0.55%

*MCDD-East cross-levee overtops after SDIC,

5.2.3. Alt 4

No significant levee raises are proposed for Alternative 4 other than the raise in PeEN2 (present in Alternative 3) and a small raise in SDIC. A few measures include a levee raise, but this is typically converting a temporary closure structure (sandbag/HESCO closure) to a permanent levee feature. Therefore, the probability of overtopping for Alternative 4 is identical to FWOP except for PEN2, SDIC, and MCDD-East. In this alternative, the sequence of overtopping is the same as FWOP. However, the overtopping location in PEN2 shifts from the northeast corner to the south near MLK Jr Blvd.

Table 5-7: Alt 4 Probability of Overtopping

Drainage Area	Overtopping Location (Levee Control Location)	Minimum Levee Elevation (ft NAVD88)	Annual Probability of overtopping (best estimate)	Annual Probability of overtopping (5% uncertainty)	Annual Probability of overtopping (95% uncertainty)
PEN2	Columbia Slough 229+00	36.4	0.19%	0.067%	0.55%
MCDD-East	MCDD-SDIC Cross Levee L 37+00*	44	0.01%	0.001%	0.04%
SDIC	Columbia River 10+00	47	0.01%	0.001%	0.04%

*MCDD-East cross-levee overtops after SDIC, uses equal probability of overtopping as SDIC.

5.2.4. Alt 5

Alternative 5 includes significant levee raises throughout PEN1 and PEN2 to 40 feet NAVD88, and it also includes a small levee raise at the low spot in MCDD-West and SDIC. In this alternative, overtopping still occurs in PEN2 and PEN1 first, and the remaining sequence of overtopping is the same as FWOP.

Table 5-8: Alt 5 Probability of overtopping

Drainage Area	Overtopping Location (Levee Control Location)	Minimum Levee Elevation (ft NAVD88)	Annual Probability of overtopping (best estimate)	Annual Probability of overtopping (5% uncertainty)	Annual Probability of overtopping (95% uncertainty)
PEN1	Columbia River 36+00	40	0.05%	0.014%	0.18%
PEN2	Columbia Slough 229+00	40	0.06%	0.016%	0.20%
MCDD-West	Columbia River 512+00	42	0.03%	0.007%	0.11%
MCDD-East	MCDD-SDIC Cross Levee L 37+00*	44	0.01%	0.001%	0.04%
SDIC	Columbia River 10+00	47	0.01%	0.001%	0.04%

*MCDD-East cross-levee overtops after SDIC, uses equal probability of overtopping as SDIC.

5.3. Comparison to Levee Screening Tool

Table 5-9 compares the results from the levee screening tool to the future without project results from this study. In general, the results of probability of failure are within an order of magnitude, which is fairly similar considering the different methods applied. The most critical levee segment was used from the LST for comparison to the feasibility study results.

Table 5-9: Comparison of probability of failure study results to levee screening tool

	Annual Probability of Overtopping			**Annual Probability of Breach Prior to Overtopping**		
Drainage Area	**Feasibility Study**	**Levee Screening Tool**	**Difference (orders of magnitude)**	**Feasibility Study**	**Levee Screening Tool**	**Difference (orders of magnitude)**
PEN1	0.14%	0.1%	0.2	0.16%	0.1%	0.2
PEN2	0.32%	0.2%	0.2	0 (negligible)	0.006%	N/A

MCDD-West	0.05%	0.1%	-0.3	0 (negligible)	0.4%	N/A
MCDD-East	0.02%	0.1%	-0.7	0 (negligible)	0.1%	N/A
SDIC	0.04%	0.2%	-0.7	0.016%	0.15%	-1.0

A few discrepancies merit further explanation. The probability of overtopping is fairly consistent between the LST and the feasibility study, with differences within an order of magnitude for all systems. The breach prior to overtopping scenarios show more noticeable differences. As previously discussed, the feasibility study only considered the most critical case for a breach prior to overtopping: the situation where the levee breaks before evacuation warnings have been issued. Warnings are issued well before water is close to the top of the levee. The details of the emergency action plan and evacuation orders are not included in levee screening, which considers breach prior to overtopping for loading up to the top of levee. Therefore, the estimates for the feasibility study tend to have less probability of breach prior to overtopping than the screening tool. A noticeable exception is PEN1, where the feasibility study shows a higher likelihood of failure than LST. In the feasibility study, detailed geotechnical models (GeoStudio) and a Taylor Series approach were used to calculate fragility curves. In contrast, the levee screening tool includes a qualitative assessment of risk for various failure mechanisms, then uses generalized relationships to estimate the probability of failure. The results from the feasibility study modeling were used to inform the qualitative estimates in levee screening, but an exact match between the feasibility study and the LST is not possible.

6. Life Loss Consequence Results

The results from the HEC-LifeSim simulations are provided in the following sections for each alternative. 1,000 Monte Carlo iterations were performed with HEC-LifeSim—the best estimate is shown using the mean values from the simulation. To provide an estimate of the uncertainty in these estimates, confidence bands from the 1,000 Monte Carlo simulations are also shown in the tables.

6.1. Population at Risk

Population at risk (PAR) describe the number of people that would experience any level of flooding if no protective action were taken. The HEC-LifeSim model estimates the distribution of population throughout the study area based on the USACE National Structure Inventory version 2 (NSI-2). PAR is a function of both inundation extents (spatial) and warning issuance time (temporal). If the inundation area is static, the PAR changes based on time of day when a warning is issued. Figure 6-1 shows the concept of the interpolation scheme used by HEC-LifeSim. For the PMLS system, the daytime population is larger than night-time, but is assumed constant from 10:00 am to 5:00 pm, and from 12:00 am to 4:00 am.

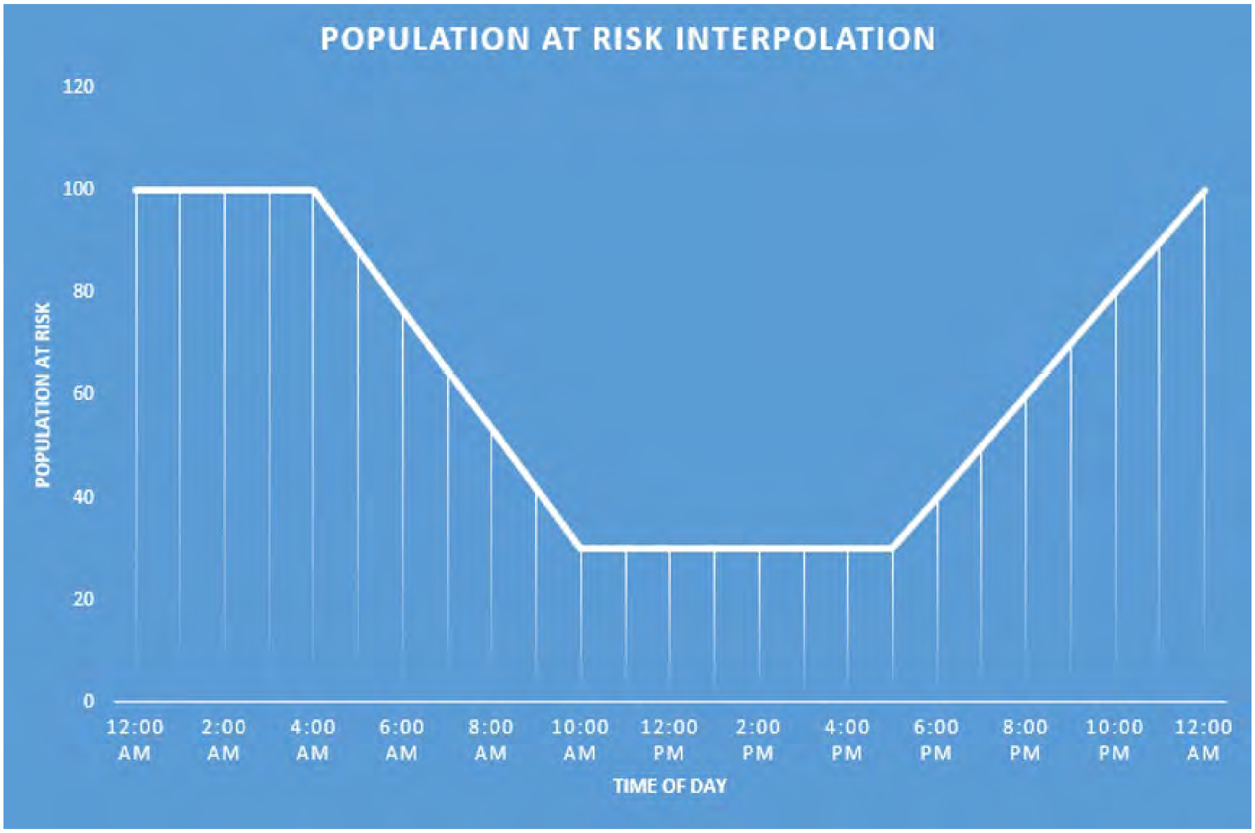


Figure 6-1: Example schematic of Population at Risk fluctuations

The population at risk results do not change significantly from alternative to alternative, since the inundation areas are similar. Table 6-1 shows PAR results for the PMLS applicable to the failure prior to overtopping inundation extents. The PAR is over six times higher during the day than at night, due to the large amounts of commercial and industrial activities that only operate during the day. During the day, MCDD-West has the largest PAR, since it is the largest geographic area and has the most industrial and commercial activity. At night, PEN2 has the largest PAR, since it has the highest number of residences out of the five areas. The proportion of the PAR above the age of 65 is larger at night (12%) than during the day (10%).

Table 6-1: Population at Risk results

	Day (2pm)		Night (2am)	
	PAR (under 65)	PAR (over 65)	PAR (under 65)	PAR (over 65)
MCDD-E	938	51	120	12
MCDD-W	23,283	2,827	2,233	298
PEN1	181	10	21	1
PEN2	4,186	438	2,336	327
SDIC	2,187	109	145	8
Total	**30,775**	**3,435**	**4,855**	**646**

6.2. FWOP

Table 6-2 provides the life loss estimates for the FWOP. In general, the life loss results are higher when there is a failure prior to overtopping, since it is assumed evacuation warnings have not been issued prior to the breach. However, uncertainty of warning issuance for both the overtopping and failure prior to overtopping scenarios are taken into account in the LifeSim model during Monte Carlo simulations through sampling of the Warning Issuance Delay time curve as well as uncertainty in the Hazard Communication Delay time.

MCDD-West and PEN2 show the largest life loss, since these areas contain the most population. Even in an overtopping scenario with days of warning, significant life loss is still expected at PEN 2. As previously shown in the modeling results, PEN 2 is also the area where overtopping is most likely in the system since it has the lowest levee elevations. Therefore, life loss at PEN 2 poses the highest risk in the system. Other areas also show high potential for life loss, but PEN 2 is the most critical area when considering both probability of a failure and the consequence of a flood together. MCDD-West has a large population in the leveed area, but the residential population is smaller than PEN 2. However, the uncertainty bounds are larger on MCDD-West since it is a much larger area. Non-residential populations are more likely to evacuate, reducing the life loss consequence in MCDD-West despite the large populations. The flooding pattern in MCDD-West is also less severe, allowing for more successful evacuation. The MCDD-West area is much larger than PEN 2 and a levee breach opening would be smaller, which means that floodwaters take longer to spread through MCDD-West than PEN 2.

The FPTO simulation for MCDD-East does not show much life loss because floodwaters from the breach directly enter the Blue Lake area at first, providing additional time for populations to move to safety. In general, the life loss estimates are higher during the day than at night for the FPTO simulations. This result stems from the fact that much of the leveed area is commercial and industrial uses rather than residences, and there are more people in the leveed areas during the day. However, the overtopping scenarios show larger life loss at night, since these estimates are primarily governed by the residential populations rather than other users. The overtopping life loss estimates are primarily controlled by that portion of the population that decides to ignore evacuation warnings, since there is ample warning time for overtopping failures.

Table 6-2: FWOP HEC-LifeSim results (1000 Monte Carlo simulations)

	Day (2pm)			**Night (2am)**		
	Life Loss (best estimate)	**Life Loss (minimum estimate)**	**Life Loss (maximum estimate)**	**Life Loss (best estimate)**	**Life Loss (minimum estimate)**	**Life Loss (maximum estimate)**
Failure Prior to Overtopping						
MCDDE	0	0	5	0	0	7
MCDDW	245	3	804	24	0	681
PEN1	4	0	22	1	0	7
PEN2	116	0	324	90	1	401
SDIC	8	0	55	1	0	50

Overtopping (72-hour warning)						
MCDDE	2	0	13	5	0	20
MCDDW	4	0	55	6	0	67
PEN1	0	0	3	0	0	2
PEN2	5	0	20	12	0	47
SDIC	0	0	1	0	0	1

Note: Best Estimate life loss values are the mean values from 1,000 LifeSim Monte Carlo simulations.

Table 6-3 provide an estimate of the probability distribution of the life loss estimates. This table is developed by taking the maximum of the life loss estimates from the day and night. The 5% and 95% percentile values are used to plot the results on the life risk matrix in Section 0.

Table 6-3: FWOP HEC-LifeSim probability distribution

	Life Loss Estimates						
	Min	5th percentile	25th percentile	Most Likely (mean)	75th percentile	95th percentile	Max
Failure Prior to Overtopping							
MCDDE	0	0	0	0	0	1	7
MCDDW	3	27	74	245	413	630	804
PEN1	0	0	1	4	6	12	22
PEN2	0	31	80	116	150	194	324
SDIC	0	0	3	8	9	27	55
Overtopping (72-hour warning)							
MCDDE	0	0	2	5	7	12	20
MCDDW	0	0	0	6	9	19	67
PEN1	0	0	0	0	0	0	3
PEN2	0	2	7	12	17	27	47
SDIC	0	0	0	0	0	0	1

Life loss consequences increase as the depth and velocity of flooding increase. When depth and velocity of floodwaters are very high, structures can collapse under the flood loading. Collapsed structures pose a high risk, as it assumed people in structures that collapse do not survive. In the PMLS, the portion of life loss generated by collapsed structures is fairly small compared to the total life loss. In most areas, the floodwaters do not have sufficient depth and velocity to collapse structures. In the FWOP overtopping scenario, 312 structures collapse, accounting for an estimated 8 lives lost. Most people in these structures have had time to evacuate before the structures collapsed, but have chosen not to. The majority of collapsed structures are manufactured homes, though a few additional single family homes collapse as well.

In the failure prior to overtopping scenario at PEN2, 134 structures collapsed, accounting for an estimated 7 lives lost. The highest concentration of collapsed structures considering both the overtopping and failure prior to overtopping scenarios are manufactured homes in the park near the Columbia Slough, which experience more than 8 feet of inundation. Figure 6-2 shows the collapsed structures in the overtopping and breach prior to overtopping scenarios.

The relatively small amount of life loss from collapsed structures suggest that measures targeting slower fill of the leveed area in the event of a flood are unlikely to have significant life loss benefits. Most life loss occurs because some residents in more stable structures decide not to evacuate to higher ground and are then either unable to climb to safety to avoid rising floodwaters, or are able to climb to safety but are then overcome by water rising above the highest point in the structure..

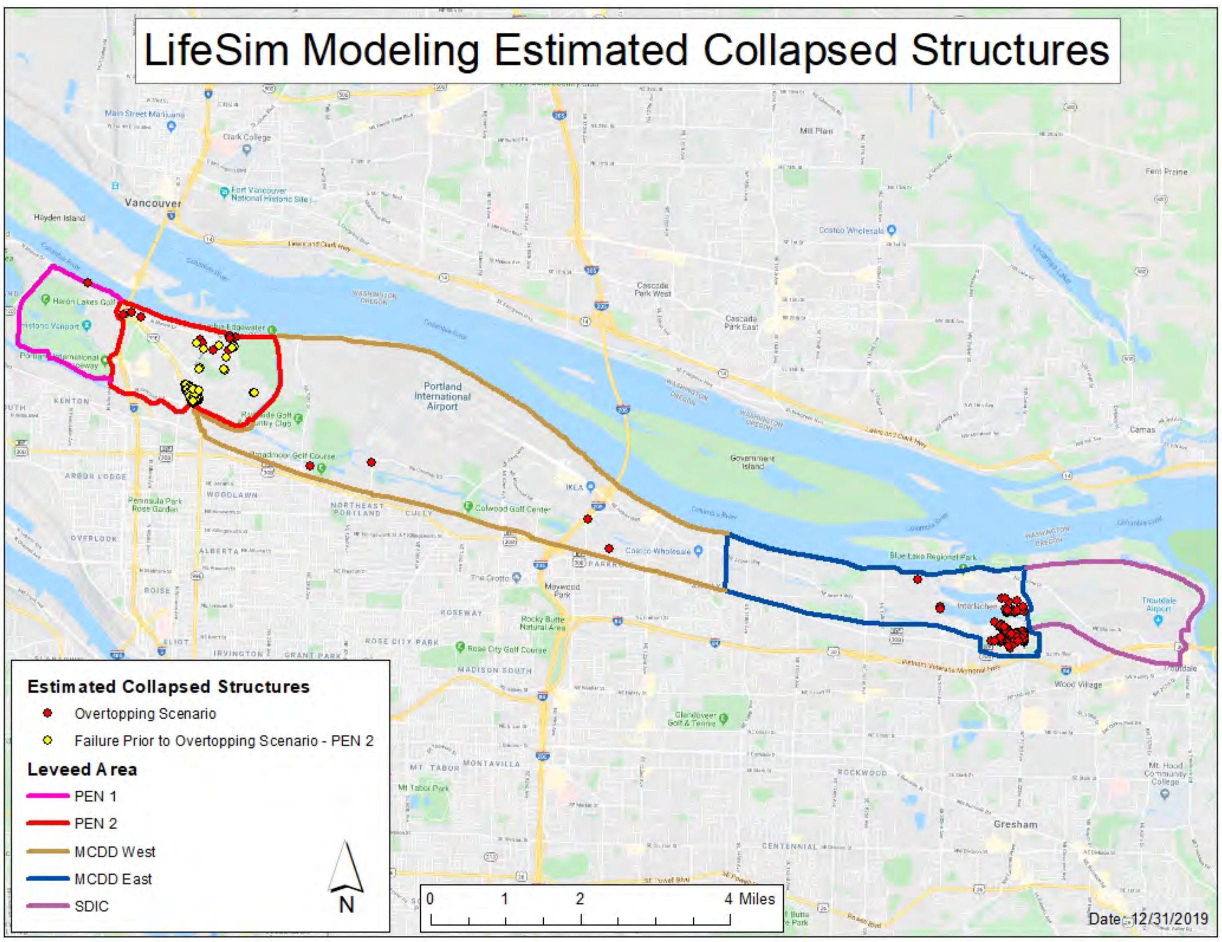


Figure 6-2: LifeSim Modeling Estimated Collapsed structures

6.3. Alt 3

Alternative 3 contains non-physical nonstructural measures that are intended to improve evacuation effectiveness, thereby reducing the life loss in the event of a levee failure. These measures include improvements/additions to existing flood warning systems, implementation of flood risk and seismic education programs in coordination with the USGS, improve signage throughout designated emergency evacuation routes, and the development of safe zones at the Expo Center, Airport, 142nd Ave. cross levee, and the Amazon and Fed-Ex facilities.

The most pertinent model adjustment made to compare with and without project life loss estimations for the safe zone measure listed above is the changing of population at risk counts. For example, for the development of safe zones measure, people within a certain distance of the proposed safe zone are assumed to use the safe zone and are therefore considered safe and removed from the without project population at risk. The distance is determined by approximate travel time from their current location to the safe zone in relation to the timing of the inundation.

To estimate the benefit of the improvements/additions to existing flood warning systems measure, adjustments are made to the daytime and nighttime first alert time-series curves to reflect more people getting warning at a faster pace. This is accomplished through changes made to the emergency manager elicitation-based Mileti-Sorenson curve generator discussed in Section 4.2 of this appendix. Uncertainty is taken into account with this curve during the Monte Carlo process using a triangular distribution.

The life safety benefits of implementing flood and seismic education programs are estimated through adjustments to the without project protective action initiation curve that reflect an increased willingness to evacuate to safety when a hazard warning is received. Uncertainty is taken into account with this curve during the Monte Carlo process using a triangular distribution.

Table 6-4 provides the life loss estimates for Alternative 3. The reductions in life loss consequences due to the non-structural measures are relatively modest. The non-structural measures provide roughly a 9% decrease in expected life loss compared to the FWOP.

Table 6-4: Alt 3 HEC-LifeSim results (1000 Monte Carlo simulations)

	Day (2pm)			Night (2am)		
	Life Loss (best estimate)	Life Loss (minimum estimate)	Life Loss (maximum estimate)	Life Loss (best estimate)	Life Loss (minimum estimate)	Life Loss (maximum estimate)
Failure Prior to Overtopping						
MCDDE	0	0	7	0	0	7
MCDDW	221	2	747	0	22	588
PEN1	4	0	20	1	0	7
PEN2	108	0	332	81	1	367
SDIC	7	0	58	1	0	44
Overtopping (72-hour warning)						
MCDDE	2	0	11	4	0	24

MCDDW	3	0	55	5	0	70
PEN1	0	0	2	0	0	3
PEN2	4	0	19	11	0	43
SDIC	0	0	1	0	0	1

Note: Best Estimate life loss values are the mean values from 1,000 LifeSim Monte Carlo simulations.

Table 6-5: Alt 3 HEC-LifeSim probability distribution

	Life Loss Estimates						
	Min	5th percentile	25th percentile	Most Likely (mean)	75th percentile	95th percentile	Max
Failure Prior to Overtopping							
MCDDE	0	0	0	0	0	2	7
MCDDW	2	20	62	221	377	602	747
PEN1	0	0	1	4	5	12	20
PEN2	0	22	72	108	143	184	332
SDIC	0	0	2	7	8	23	58
Overtopping (72-hour warning)							
MCDDE	0	0	1	4	6	12	24
MCDDW	0	0	0	5	9	18	70
PEN1	0	0	0	0	0	0	3
PEN2	0	2	6	11	15	26	43
SDIC	0	0	0	0	0	0	1

6.4. Alt 4

The life loss results for Alternative 4 are equal to Alternative 3. The same non-structural measures are applied, and none of the structural measures significantly change the life loss consequences.

6.5. Alt 5

Alternative 5 includes some significant levee raises, but these changes are not anticipated to change the life loss consequences in the event of a failure. While the probability of a failure is reduced in Alternative 5, no major changes to the flood depths or velocities are anticipated with Alternative 5. Therefore, the life loss consequences for Alternative 5 are equal to Alternative 3 since the same non-structural measures are applied.

6.6. Comparison to Levee Screening Tool

Table 6-6 shows a comparison of life loss results from the current study to the levee screening tool. Most estimates of life loss are within an order of magnitude, which is fairly similar considering the different techniques used. The feasibility study results use HEC-LifeSim model results with custom inputs developed from expert elicitation with emergency managers. The levee screening tool estimates life loss in a more simplified manner, assigning a qualitative rating to three categories: evacuation planning, community awareness, and flood warning effectiveness. The levee screening tool uses this information in conjunction with a transportation system congestion factor to estimate life loss. The population estimates between the feasibility study and the levee screening tool are consistent—both are based off the National Structure Inventory (version 2). Neither account for transient populations (such as the houseless) or recreation users (such as golfers).

In general, the PMLS life loss estimates are slightly lower than the levee screening tool. This is likely due to the custom parameter curves input into HEC-LifeSim from the expert elicitation. Furthermore, the overtopping scenario in the feasibility study assumes that evacuation orders have been issued, and that industrial and commercial property owners comply with these orders. The levee screening tool assumes these populations may still be at risk in the overtopping scenario. HEC-LifeSim takes into account individual structure heights and stability, which the levee screening tool does not consider. The only failure mechanism that shows a difference more than an order of magnitude is the failure prior to overtopping scenario at MCDD-East. The estimates in the feasibility study are lower for 2 main reasons:

1. The breach prior to overtopping in PMLS accounts for the attenuation of the flooding that Blue Lake and Fairview Lake provide in the hydraulic simulations. This provides additional time for populations to evacuate.
2. The residences in MCDD-East are all at relatively high elevations that do not experience great depths of flooding. The greater resolution of the feasibility study captures this, while the LST does not.

Table 6-6: Comparison of life loss results from current study to levee screening tool

	Average Life Loss (Overtopping)			Average Life Loss (Breach prior to overtopping)		
Drainage Area	**Feasibility Study**	**Levee Screening Tool**	**Difference (orders of magnitude)**	**Feasibility Study**	**Levee Screening Tool**	**Difference (orders of magnitude)**
PEN1	0.1	1	-1.0	4	3	0.1
PEN2	12	17	-0.2	116	46	0.4
MCDD-West	6	25	-0.6	245	53	0.7
MCDD-East	5	10	-0.3	0.1	6	-1.8
SDIC	0.1	0.5	-0.7	8	3	0.4

7. Life Risk Matrix

To evaluate system performance related to TRG 1, a life safety risk matrix (Figure 7-1) is used with societal and individual risk criteria. Consideration of uncertainty in the risk estimates will be a factor in determining if life safety risk meets TRG 1, especially for those risk estimates that plot on or around the individual and/or societal risk lines. When the life safety risk has average loss of life of 1,000 or more with an annual exceedance probability of breach of 1.E-06 or less, those situations will be closely scrutinized prior to deciding if the risks are tolerable due to limitations with methods to estimate probabilities that low. For those situations where TRG 1 is met for societal life risk but not individual life risk, further considerations related to identifying the most at risk individuals in the leveed area; verifying the potential for life loss; and considering whether individuals exposed consider the benefits worth the levee risk will be taken into account for TRG 1.

For PMLS, each failure mode is plotted on the risk matrix and evaluated using the TRG 1 criteria. The probability of failure is sourced from Section 5, and is a combined probability of hydrologic loading and geotechnical performance. The consequence of failure is sourced from the HEC-LifeSim simulations in Section 6. Generally, nonstructural measures affect the consequences of a flood, and have the effect of shifting the failure mode to the left on the plot. Structural measures typically reduce the probability of a failure, and shift the failure mode point downwards.

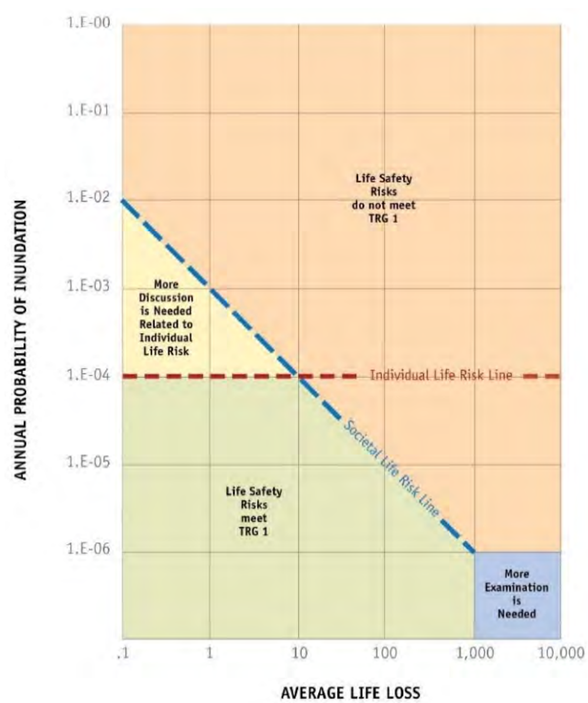


Figure 7-1: Life Risk Matrix for evaluating TRG 1

7.1. FWOP

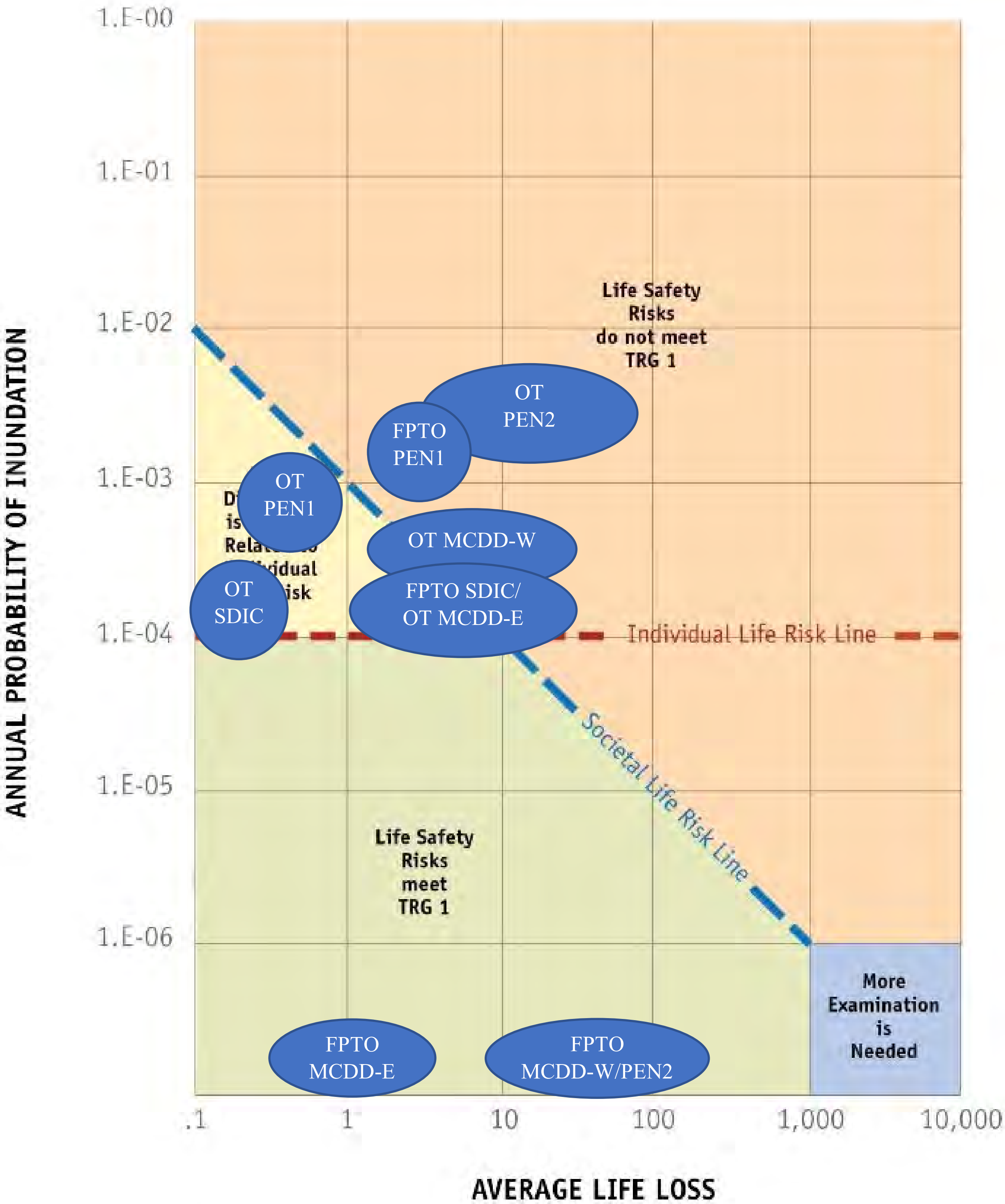


Figure 7-2: FWOP Life Risk Matrix

7.2. Alt 3

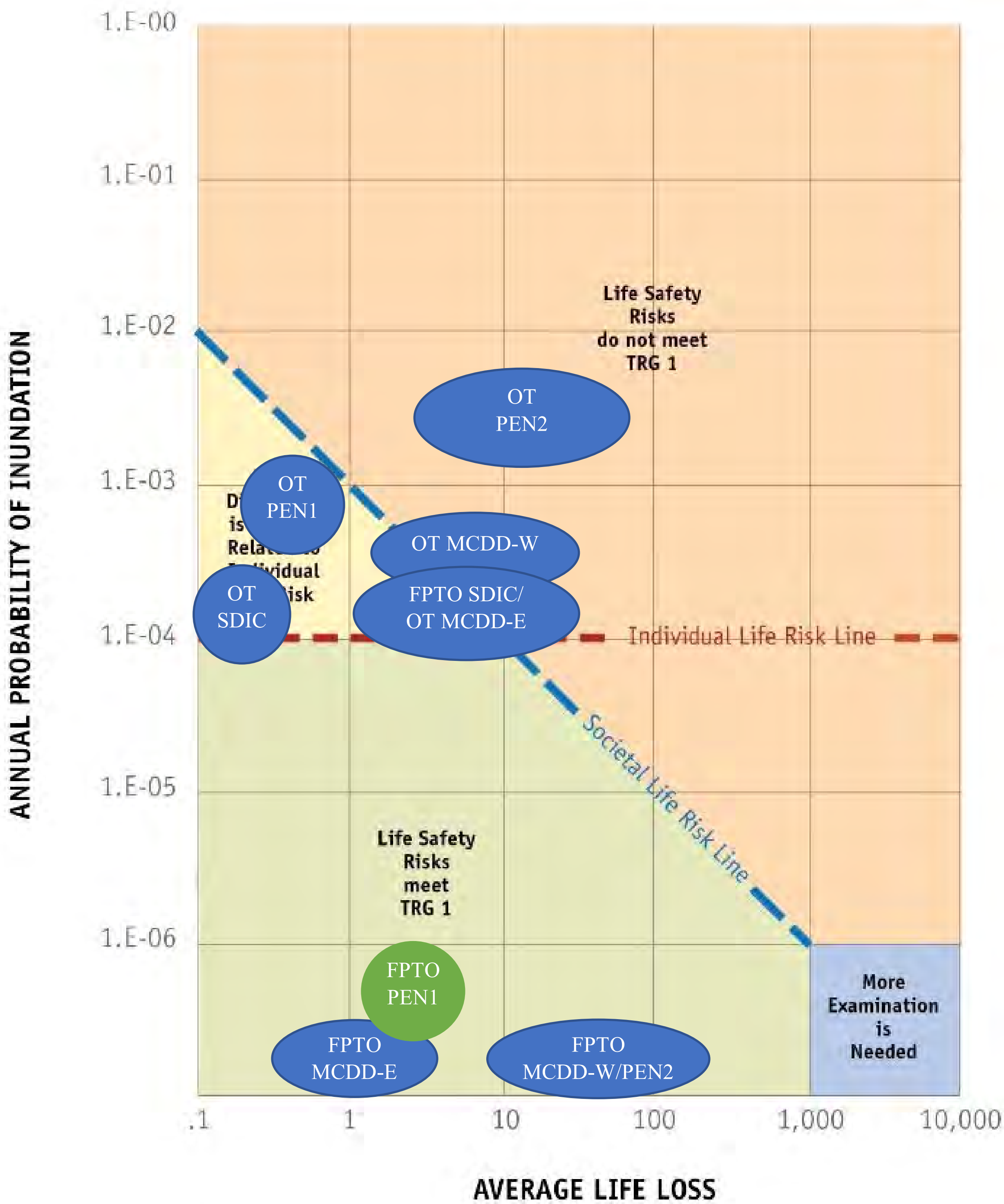


Figure 7-3: Alt 3 Life Risk Matrix (green shading is changed from FWOP)

7.3. Alt 4

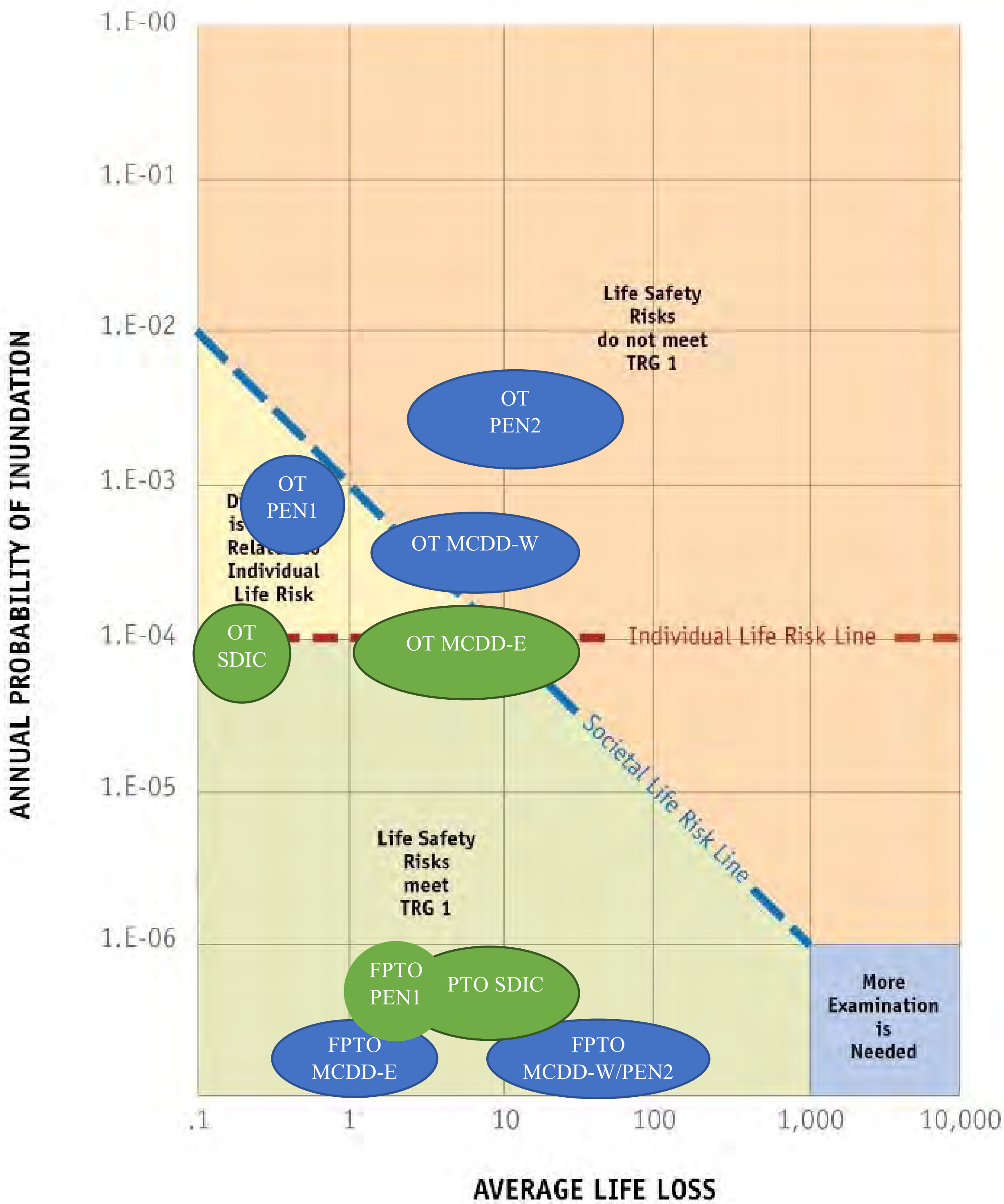


Figure 7-4: Alt 4 Life Risk Matrix (green shading is changed from FWOP)

7.4. Alt 5

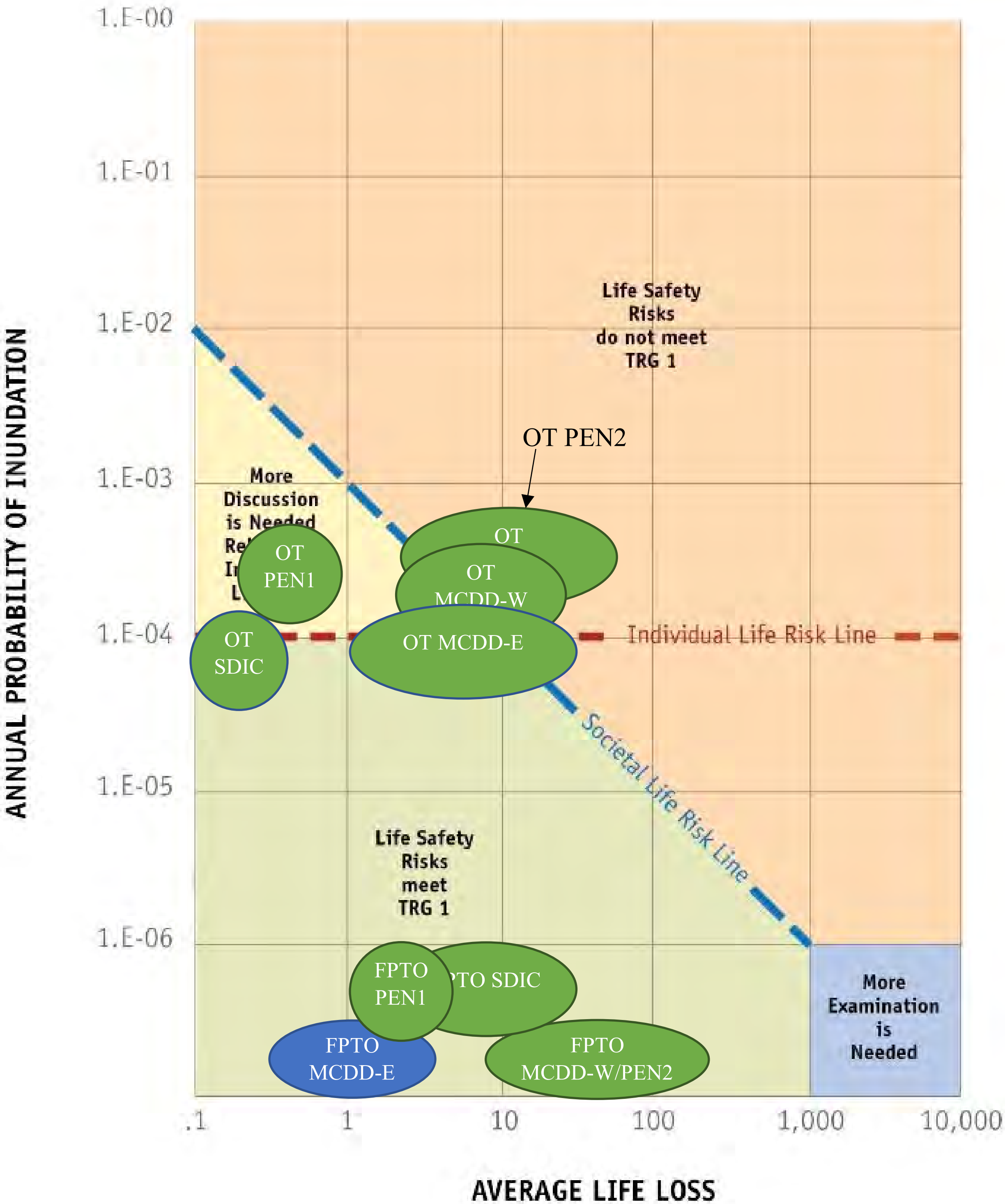


Figure 7-5: Alt 5 Life Risk Matrix (green shading is changed from FWOP)

7.5. Discussion of TRG1

Planning Bulletin 2019-04 states that "At a minimum, one alternative that addresses TRG 1 and TRG 4 must be identified. In cases where evaluation reveals the formulated alternatives do not reduce risk below the societal life risk line or individual risk line, the PDT must describe what factors drive the remaining risk for the societal or individual life risk, whether revisions to the formulated alternatives can be made to lower the societal or individual life risk, or if additional formulation is required".

In the FWOP, there are 5 failure modes that plot above both the individual risk line and the societal risk line:

1. Overtopping at PEN 2
2. Failure Prior to Overtopping at PEN 1
3. Overtopping at MCDD-West
4. Failure Prior to Overtopping at SDIC
5. Overtopping at MCDD-East

All alternatives provide improved life safety compared to the future without project scenario. The results of the life loss analysis show that none of the alternatives fully reduce all potential failure modes below the individual and societal life risk lines. Alternative 5 reduces the risk to levels well below the TRG1 thresholds for PEN 1, SDIC, and MCDD-East. Alternative 5 also includes measures to address overtopping at PEN 2 and overtopping at MCDD-West, which reduces life loss risk for these critical failure modes. However, these two failure modes continue to plot above the guidelines in Alternative 5, as shown in Figure 7-6.

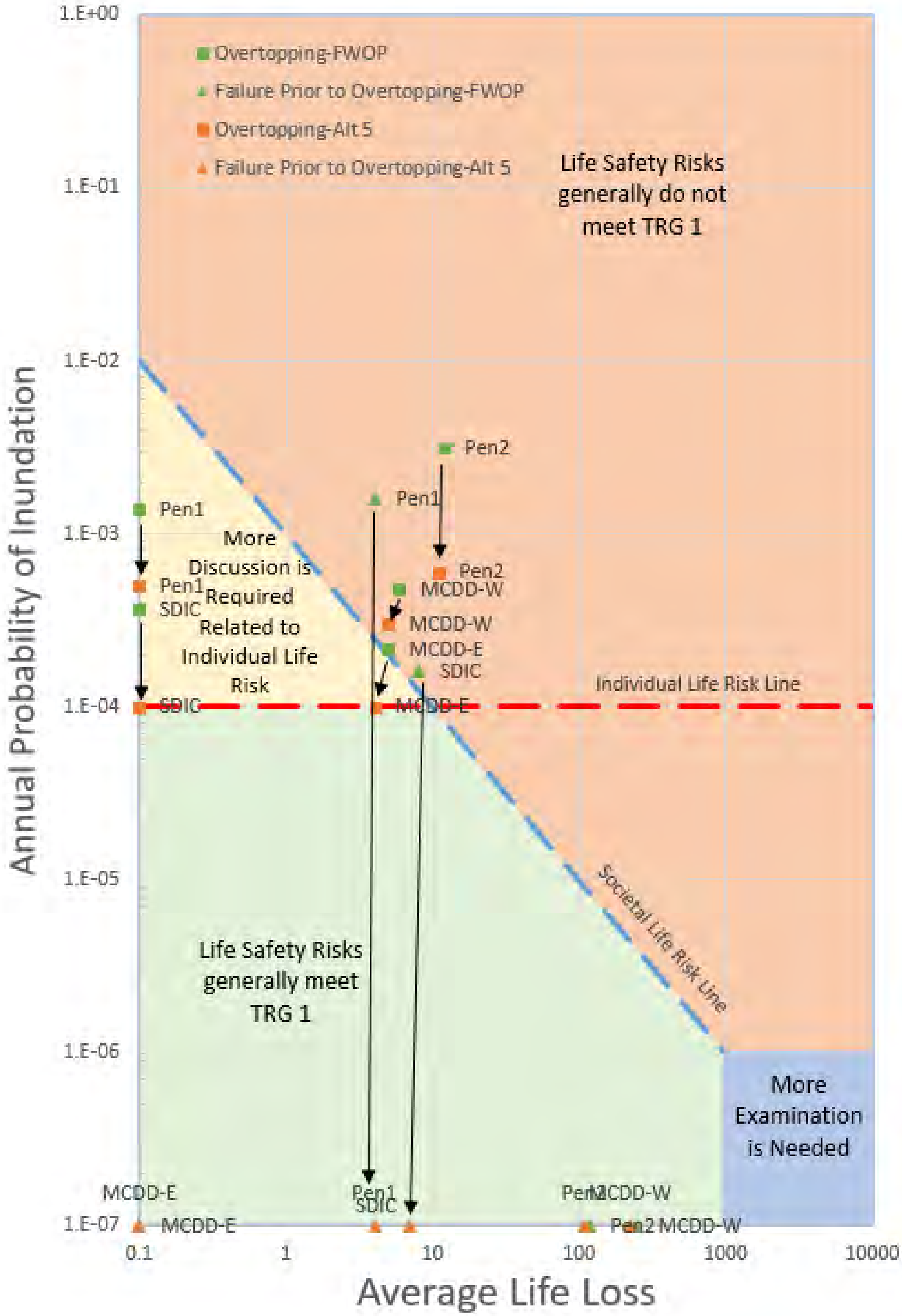


Figure 7-6: Life Loss Benefits from Alternative 5

In order to reduce risk to below the individual and societal risk lines, the probability of inundation could be reduced, or the life loss consequences in the event of a flood could be reduced.

1. Reducing Life Loss Consequences.

Reducing the life loss consequences does not appear feasible. The alternative already includes non-structural measures to boost flood risk awareness and evacuation. There is adequate flood warning time to evacuate for the overtopping scenario, so the life loss estimates are primarily driven by those residents who do not heed evacuation warnings. Collapsing structures from the velocity and depth only account for a small amount of life loss. The life loss is governed by those who cannot climb to safety and have very large inundation depths. Therefore, measures such as floodproofing are ineffective. The only remaining options are not feasible. For instance, life loss would be reduced if residents were forcefully evacuated, but this is not possible. Elevating structures is impracticable, since most homes would need to be elevated by about 20 feet. Buyouts would reduce life loss risk, but it would be tremendously expensive to buyout all residences in the leveed areas. Another option to reduce life loss consequences is to implement managed overtopping measures, which are discussed in the next paragraph

ECB 2019-8 calls for consideration of managed overtopping of levees, which can include overtopping reaches or superiority. Superiority is defined as "providing higher levees at all points except where initial overtopping is desired". The intent of managed overtopping is to initiate overtopping in the least hazardous location in order to provide some warning/evacuation time before total system exceedance. This measure was considered during plan formulation (measure 43), but was screened out and not carried forward into any of the alternatives. It was screened for the following reasons:

1. **System Loading**. If implemented, managed overtopping would have negligible impact on river water levels. In some levee systems, the overtopping flows into a levee system are significant enough that they reduce the water levels of the river, providing some relief of hydraulic loading for the rest of the system. In the PMLS, the leveed areas are very small comparable to the Columbia River, and hydraulic simulations in the H&H Appendix have shown that opening up the leveed areas to flooding has a minimal effect on river levels. This potential benefit of managed overtopping does not exist for PMLS.
2. **Hydraulic Profile**. The water surface profiles of the Columbia River that load the PMLS system are relatively flat, with only a few feet of difference from the downstream end at PEN1 to the upstream end at SDIC. The ECB suggests initiating overtopping at a downstream location to allow for more gradual fill of the leveed area. Since the PMLS area is relatively flat, there is not an obvious area with lower ground elevations than the rest of the system.
3. **Hydrograph shape**. The most likely flooding scenario from PMLS stems from a short-duration, rainfall-driven winter storm. These types of events produce hydrographs that increase very rapidly, rather than a slower rise that would be experienced during a

snowmelt event. For instance, during the February 1996, stage increased by over 14' in two days. A rapidly rising hydrograph allows less time for managed overtopping to produce a beneficial effect, since the overtopping section is engaged for a short period of time before the system is overwhelmed in a flood.

4. **Stage-Frequency curve**. The stage-frequency curve for winter events at PMLS has a positive skew. This means that as events get rarer, the magnitude of stage increase continues to grow. In other words, peak stage accelerates as events get rarer. This reduces the effectiveness of managed overtopping. Managed overtopping is most effective when water levels exceed the managed overtopping section, but do not overwhelm the system. The probability of this scenario is much smaller with a positive skew than with a neutral or negative skew. In a situation where the frequency curve had a neutral or negative skew, it is much more likely that managed overtopping will be effective.
5. **Evacuation**. The emergency action plan calls for evacuation orders to be issued well in advance of overtopping. One of the primary benefits of managed overtopping is to provide more warning/evacuation time before total system exceedance. This benefit would not be realized in this system due to the evacuation orders being issued multiple days before overtopping. The life loss from overtopping in the system is not generated from having minimal warning time, but rather from residents who choose to take no protective action.
6. **Economic Benefit Reduction**. Implementing a section with managed overtopping would decrease the amount of economic benefits in a given alternative. An intentional low section would cause flooding of structures more often.
7. **Other levees in Portland District**. No other levees in the Portland District inventory along the Lower Columbia River have managed overtopping sections. While this is not necessarily a reason that managed overtopping could not work in PMLS, it provides context that overtopping sections are not standard practice along the Lower Columbia River.
8. **Cost**. If an overtopping section were constructed with intentionally lower levee heights, the cost would be fairly limited, but it would provide only minor life loss benefits. Larger life loss benefits would be realized if the whole system were retrofitted to be able to withstand overtopping flows. However, such an improvement to approximately 27 miles of levee with significant development near the landward toe would be extremely costly. Such a solution would likely encounter significant opposition as surfaces currently vegetated with grasses would likely be replaced with an engineered solution.
9. **Equity Issues**. If managed overtopping were pursued, the PDT could attempt identify areas to intentionally flood before other areas. It is likely that the populations in these areas would raise equity concerns and raise resistance to the concept from a social equity standpoint.

To test the effect of managed overtopping, test LifeSim models were computed to determine the effectiveness of such a measure.

1. The first trial run tested the location of overtopping. The PEN2 area of overtopping is currently the northeast corner, with low-lying homes nearby that are inundated rapidly. A less critical overtopping scenario where the southwest corner overtops first was tested. The life loss results were identical between these two scenarios. This is because residents have already had ample warning time to evacuate, and the only life loss is occurring from residents who choose not to heed the warnings.
2. The second trial run assumed that the entire system was armored on the landward side such that overtopping occurs without breaching. This simulation shows the benefit of a slower overtopping scenario that can result in a smaller level of inundation in the interior areas. The life loss simulations showed minor reductions of approximately 2 people in PEN2, which is the most critical failure mode. While this reduction is not negligible, it is not significant enough to meet TRG1. In this run, less property was inundated, but since most of the residences are in low elevation areas, the benefit is limited.

2. Reducing Probability of Inundation.

The critical life loss scenarios are overtopping at PEN2 and MCDD-West. The only option to reduce the chance of overtopping is to raise the levee. Alternative 5 already contains a sizeable levee raise of 3 to 4 feet. A larger raise of 7 feet was evaluated early on in the study, but it was estimated to cost roughly $600 million, about four times the cost of Alternative 5. As the amount of levee raise increases, the cost increases exponentially. Furthermore, a raise of 7 feet to elevation 43 feet NAVD88 for PEN2 still would not reduce the probability of overtopping to below the societal risk line. The levee raise would have to be approximately 9 feet to elevation 45 feet NAVD88 to fall below the line. Such a raise would vastly alter the entire levee system and road network, requiring a realignment of I-5, which is not practicable solely for the benefit to life risk.

While Alternative 5 does not strictly satisfy the individual and societal risk line requirements, it meets the criteria of being as low as reasonably practicable (ALARP). Additional measures reducing life risk or formulation of a new alternative is not required.

7.6. Comparison to Levee Screening Tool

Figure 7-7 compares the life risk matrix for the future without-project condition to the results from the levee screening tool. Comparable failure modes between the two analyses are circled in red to highlight the differences in the estimates. Detailed explanations of differences in the probability of inundation were described in Section 5.3, and difference in life loss estimates were described in Section 6.6. The life risk matrix combines this information and provides a visual comparison of the two approaches. The most obvious differences are the probability of inundation for the breach prior to overtopping scenario in MCDD-East, MCDD-West, and PEN2. The detailed geotechnical modeling applied in the feasibility study showed a lower risk of breach prior to overtopping than the levee screening tool. Furthermore, the feasibility study evaluated breach prior to overtopping only for the scenario where evacuation orders have not yet been issued as a function of the Vancouver gage. This hydraulic loadings for these scenarios is a lower water level than loading to the top of levee. While those three scenarios show the most difference, the results from the other scenarios and levee areas are fairly similar—typically within an order of magnitude. In particular, the PEN2 overtopping results are quite close, which is the highest life risk scenario for the feasibility study. The levee screening tool shows a breach prior to overtopping at MCDD-West has a higher total life risk than overtopping at PEN2. The levee screening tool suggests that MCDD-West is the highest risk failure mode, but this is likely due to incomplete geotechnical information in MCDD-West available at the time. The levee screening for MCDD-West was completed for the Columbia River segment in 2013, and is not being revisited in the current round of levee screening updates. For instance, the Columbia River segment had seepage and stability rated as a "medium likelihood" of failure, which is not consistent with the feasibility study findings. It assumed a worse geotechnical performance than the feasibility study, which had the advantage of detailed boring information. It is expected that if additional information were incorporated into the levee screening for MCDD-West Columbia River segment, it would show much lower probability of inundation.

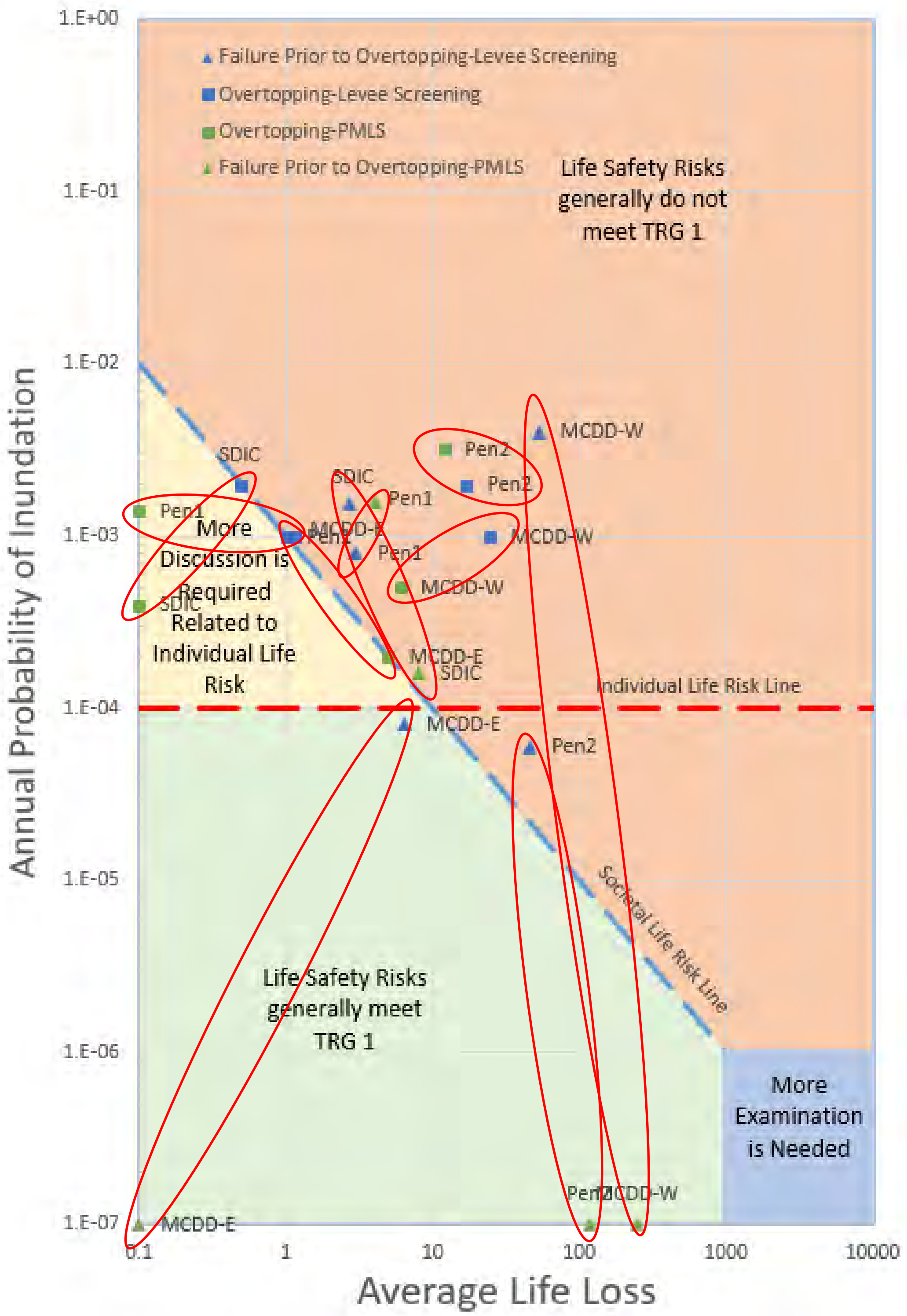


Figure 7-7: Life Matrix comparison of FWOP to Levee Screening Tool

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Tips for Conducting Life Risk Assessments in the 1st 90 days of an FRM Study – Cover Page

This guide was written to help teams think through how to incorporate life risk evaluation into their studies. It is designed to provide Project Delivery Teams (PDTs) with tips for considering potential impacts to life safety in the first 90 days of the planning process. It is aligned with the guidance provided by PB 2019-04 and ECB 2019-15. It is also important that PDTs consider the ASA(CW) Policy Directive "Comprehensive Documentation of Benefits in Decision Documents" 5 JAN 2021 as they consider how to evaluate life risk in their studies.

Teams can use this guide to assist in critically thinking through the best ways to evaluate life risk in the first 90 days of the planning process and to scope any future efforts to improve their understanding of potential life safety impacts across the various alternatives and project conditions. It includes examples of how to evaluate life risk qualitatively; discussion on how to leverage existing data to understand existing life risk in the study area; how to incorporate flood characteristics and potential infrastructure response into the risk assessment process; and how to display life risk on a risk matrix and discuss the four Tolerable Risk Guidelines (TRGs).

This guide is a tool PDTs can use to help inform what level of analysis is appropriate for the decision being made as they move through the planning process. The guide is not policy guidance and does not replace or supersede official guidance. PDTs are responsible for ensuring full compliance with applicable policies.

This guide was developed by the Flood Risk Management Planning Center of Expertise (FRM-PCX). The POC for this guide is Jesse Morrill-Winter, National Technical Specialist, Economics and Risk Analysis, Jesse.E.Morrill-Winter@usace.army.mil.

Tips for Conducting Life Risk Assessments in the 1st 90 days of an FRM Study

1. **Purpose:** The purpose of this document is to provide tips to PDTs for conducting life risk assessments in the first 90 days of an FRM Study leading up to the Alternatives Milestone Meeting (AMM) in accordance with PB 2019-04, ECB 2019-15 and all other relevant planning policy (e.g. ER-1105-2-100).

2. **Timing:** The AMM phase is essentially the first 90 days of a study after the Feasibility Cost Sharing Agreement is signed. Ideally, this phase will consist of one full iteration of the 6-step Planning Process during the first 30 days using available data and a second full iteration in the next 60 days using additional data gathered[1]. Two full iterations might not always be possible, but that's the goal teams should strive for.

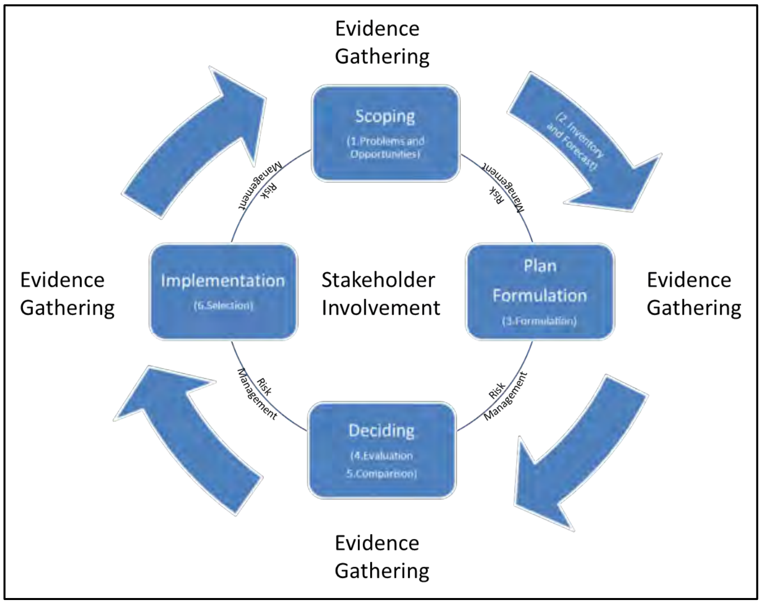
   There are a lot of moving parts for a newly formed PDT in the first 90 days of a study and time can go by very quickly. What's most important for a new PDT to focus on in terms of life risk is critically thinking (qualitatively) about what's driving the study area's life risk. What are the general flood patterns in the area and how do they create different scenarios that could cause people to lose their lives? How can we utilize existing and available data and information to better understand what key factors might be driving the life risk? By the time the AMM arrives, the PDT should be able to clearly communicate qualitatively the most likely flood patterns, the sequence of events that could lead to life loss and the key drivers of that life loss risk.

   For review, the 6-step Planning Process is shown in the figure below. While all six steps of the process involve consideration of life risk, it's really the first four steps where most of the life risk assessment work will be done.

   i. Step 1: Identify Problems and Opportunities (and Objectives/Constraints)
   ii. Step 2: Inventory and Forecast Conditions
   iii. Step 3: Formulate Alternatives
   iv. Step 4: Evaluate Alternatives
   v. Step 5: Compare Alternatives
   vi. Step 6: Select an Alternative

[1] Refer to Section 2.5.2 of USACE Planning Manual II, https://planning.erdc.dren.mil/toolbox/library/Guidance/PlanningManualPartII_IWR2017R03.pdf

Figure 1 – 6-Step Risk Informed Planning Process



3. Life Risk Considerations:

The following are very simplified, but major considerations in life risk characterization:

Figure 2: The Flood Risk Equation

- <u>**Hazards**</u>:
  - Flood Frequency: Generally, more frequent flooding can impact annualized life loss more than less frequent flooding. However, the less frequent (larger) floods will tend to have higher event life loss.
  - Warning time: Shorter warning times have higher life risk than longer warning times.
  - Flood Velocities: Higher velocities usually result in higher life risk.
  - Flood Arrival Times: Shorter flood arrival times usually result in higher life risk.
  - Flood Depths: Greater depths are typically associated with higher life risk.

- **<u>Performance</u>**:
  - FRM features that have less reliable performance have higher life risk than more reliable features.
- **<u>Consequences</u>**:
  - Highly developed areas have higher potential life risk consequences than undeveloped areas.
  - Older populations tend to be more vulnerable than younger populations.
  - Economically disadvantaged communities tend to be more vulnerable than economically advantaged communities.
  - Critical infrastructure (Fire, Police, Hospitals), and how they are impacted in a flood event can plan a key role in life risk.

4. Available Data:

The following table lists potentially available data that the PDT can obtain while assessing the life risk in the first 90 days. The "Likely Available" data should be gathered and utilized in the first 30 days, while the "Maybe Available" should be a focus of the 2nd iteration for more detail if possible. Teams should not delay iterating though the Planning Process just because they don't have particular information in better detail. Early in a study, you need to use what you have and document uncertainties. This data will inform Section 6 (Qualitative Assessments) below.

Table 1 – Available Data to Inform Early Life risk Assessments[2]

Hazard, Performance or Consequences?	Likely Available	Maybe Available
Hazard	• FEMA Floodplains / Reports/FIRM's/etc. (incl. non-Fed levees) • Terrain Data (low res) USGS, IFSAR • USGS National stream-flows statistics program	• Levee Screening Tool (LST) • FPM's, EAP's, etc. • CWMS Models (H&H) • Terrain Data (high res) GRID, Local Sponsor • Historical Flooding • Water Control Manuals • Prior flood studies
Performance	• National Levee Database • National Inventory of Dams • Levee Incident Database	• LST • Recent Periodic Assessments, SQRA's, PFMA's • Historical system performance • State or local Dam Safety studies
Consequences	• National Structure Inventory (NSI), includes population • HAZUS, HSIP 1.0	• LST • NSI (OCONUS) • Historical Damages • HIFLD (HSIP 2.0) • CWMS Models (FIA)

[2] See "Data Sources" Attachment for where/how to find this data.

5. Critical Thinking: While iterating through the planning process in these early stages, the PDT should consider the following questions to help guide critical thinking in assessing their study area's potential life risk.

Planning Process Steps 1 and 2 Questions:

i. What's driving the study area's existing life risk? Develop a narrative of the sequence of events leading to life loss risk, with discussion of hazard, performance and consequences (see Attachment #4 for ideas on how to get started).
   i. For example: Floodwaters rise to the toe of the existing levee to the north of City XYZ at around a 1/20 AEP event and overtopping would occur at a much more infrequent event, around 1/200 AEP (if you don't have specifics, you can say "frequent or infrequent." Flood-fighting history in the area tells us that there is high likelihood of levee breach prior to overtopping. If a levee breach were to occur, a high velocity of floodwater at the breach location ranging from 5-10 feet deep would enter the City of XYZ from the north end first and then spread throughout the city in a matter of hours. Because levee breaches can happen with little warning, there's a reasonable chance that the 30,000 people living within the flooded area would have very little warning time and chance to escape prior the arrival of floodwaters. There could also be many people caught evacuating trying to find high ground, who would be exposed to very high mortality. Those that don't attempt evacuation (probably the majority of the population) would have to shelter in place. Depending on the depth of floodwater, much of the population may have to evacuate through their attics to their roofs and be highly exposed to the elements. Those that are not able to evacuate vertically are would be at risk of hypothermia from floodwater ranging from 55-60 degrees Fahrenheit. Generally speaking, the incremental life risk from flooding in City XYZ is appears high and key risk drivers are high velocities, low warning time, deep flooding, fast flood arrival times and hypothermia from exposure. Geographically, risk is likely decreased as you move from north to south in City XYZ.

ii. What is the team's initial qualitative characterization of life risk (both residual and incremental[3])? Why has the PDT arrived at this characterization? Start thinking about how it will be measured for the existing and without project conditions (and for comparison of alternatives later).
   i. Low, medium, high
   ii. Green, Yellow, Red
   iii. Etc.

iii. What are the study's life risk objectives?
   i. When conducting an FRM study, life risk should almost always be an objective, but it's important to try and understand and categorize the nature of the life risk to inform the objectives.

[3] See "Residual vs. Incremental Risk" Attachment for definitions of different types of risk

ii. If incremental risk is a problem, then addressing the four Tolerable Risk Guidelines (TRG's)[4] will be an objective. TOLERABLE RISK GUIDELINES APPLY TO INCREMENTAL RISK ONLY!

iii. If incremental risk is not a problem, then reducing residual life risk associated with key risk drivers could be an objective.

Planning Process Steps 3 and 4 Questions:

i. How do the alternatives impact life risk identified above? (describe qualitatively using a similar "sequence of events" narrative used in Planning Steps 1 and 2 above)
   a. How would the sequence of events and impacts be changed by each alternative?

ii. Do any alternatives introduce incremental risk? (describe qualitatively)
   a. Incremental Risk is introduced when we are modifying or proposing new FRM infrastructure that has the potential to fail (e.g. dams, levees, floodwalls, closure structures, etc.).

Planning Process Steps 5 and 6 Questions:

i. What is the likelihood of recommending a life risk plan that's different than NED? Things to look for might include:
   a. Infrequent probability of flooding causing monetary damages, but significant life risk if and when it does occur.
   b. Flood patterns with very little warning time.
   c. Flooding of low value structures in high population areas.
   d. The most economically efficient solutions appear to not improve life risk.

ii. What is the anticipated scope of Life risk Assessment moving forward?
   a. Start with the qualitative characterization of life risk from Planning Steps 1 and 2 above. The higher the risk, the more likely the need for a larger life risk assessment scope moving forward.
   b. For quantitative data, always start with available Levee Screening Tool (LST) or Dam Safety data in your study area (check with your Levee/Dam Safety Officer and integrate them into the PDT from day one!). In many cases, especially early in a study, the LST data can be leveraged to get a rough quantitative assessment of life risk in your study area.
   c. Will the study focus on residual risk, incremental risk or both?
   d. If there's potential for a life risk plan that could differ from NED, then a more robust life risk assessment will probably be necessary in the future (LifeSim and Probable Failure Mode Analysis).
   e. What are the key uncertainties? Identifying key uncertainties (or instrumental uncertainties) that the PDT believes will drive decision making will help focus scoping efforts to reduce them.
      1. Are the uncertainties under the Hazard, Performance and/or Consequences part of the equation?

6. Qualitative Assessments:

The data gathered above can be used in conjunction with other PDT discussions and professional judgment to complete a qualitative life risk matrix similar to what's

[4] See "Tolerable Risk Guidelines" Attachment for more detail about TRG's

shown in Table 2 or Table 3 below (can be completed for existing/FWOP conditions during Step 2 of the Planning Process and can be completed for with-project conditions during Steps 3, 4 and 5). Not all metrics in the example tables would necessarily be applicable for all studies, and other relevant metrics can also be used. Metrics should be chosen carefully based on key risk drivers identified in the PDT's particular study area during the Life Risk Considerations and Critical Thinking sections above. Metrics can be measured in many different ways (e.g. low, medium, high), but they must be clearly defined, consistently applied and normalized (e.g. a "low" rating is always good and a "high" rating is always bad no matter the metric).

An important aspect of comparing alternatives qualitatively is describing relative differences between them. For example, all other things being equal, if Alternative 1 includes erosion protection and Alternative 2 does not, then Alternative 1 is likely to have higher performance and less life risk.

Table 2 – Qualitative Life Risk Matrix (Example #1 for AMM)

Measure/Alternative	Metric						
	Probability		Consequences			Residual Life Loss Risk Characterization	Incremental Risk Characterization
	Likihood of Flooding	Likihood of Failure/Non-Performance	Flood Depth	Warning Time LLR	Evacuation LLR		
No Action	High	High	High	Medium	High	High	High
Alternative 1	Low	Low	Low	Low	Low	Low	Low
Alternative 2	High	High	High	Medium	High	High	High
Alternative 3	Medium	Medium	Medium	Low	Medium	Medium	Low
Alternative 4	Medium	Medium	Medium	Low	Medium	Medium	Medium
Alternative 5	High	Low	High	Medium	High	High	High
Alternative 6	High	High	High	Low	Medium	High	Medium
	Low =	Low =	Low =	Low =	Low =	Low =	Low =
	Med =	Med =	Med =	Med =	Med =	Med =	Med =
	High =	High =	High =	High =	High =	High =	High =

Table 3 – Qualitative Life Risk Matrix (Example #2 for AMM)

Measure/Alternative	Metric						
	Probability		Consequences			Residual Life Loss Risk Characterization	Incremental Risk Characterization
	Likihood of Flooding	Likihood of Failure/Non-Performance	Flood Velocity Life Loss Risk (LLR)	Warning Time LLR	Flood Arrival Time LLR		
No Action	High	High	High	Medium	High	High	High
Alternative 1	Low	Low	Medium	Low	Low	Low	Low
Alternative 2	High	High	High	Medium	High	High	High
Alternative 3	Medium	Medium	Medium	Low	Medium	Medium	Low
Alternative 4	Medium	Medium	Medium	Low	Medium	Medium	Medium
Alternative 5	High	Low	High	Medium	High	High	High
Alternative 6	High	High	Medium	Low	Medium	High	Medium
	Low =	Low =	Low =	Low =	Low =	Low =	Low =
	Med =	Med =	Med =	Med =	Med =	Med =	Med =
	High =	High =	High =	High =	High =	High =	High =

7. Extra Credit and Looking Towards TSP! Scaled Semi-Quantitative Assessments (SQRA):

Although not expected for an Alternatives Milestone Meeting, it's good to start thinking about how the PDT will quantify life risk through a Scaled Semi-Quantitative Risk Assessment.

In rare cases (where life risk it identified as very low), a matrix similar to what's shown in Table 2 may be all that is needed for beyond the AMM and to inform scoping of what's necessary for the TSP Milestone Life risk Assessment; however, teams who are addressing incremental risk (existing levees/dams and/or new levees/dams) should attempt to conduct a scaled SQRA (or use existing SQRA data) to provide an order of magnitude plot on an fN Chart as shown below as a potential first step in quantifying life risk.

If your study has existing levees, you likely have an existing rough quantitative assessment that's been conducted in the LST and that's a great place to start! Figure 3 shows an example from the LST and can be adjusted by your Levee Safety Officer (LSO) or Levee Safety Program Manager (LSPM) to simulate with project conditions.

If LST is not available, utilizing data collected from Table 1 and best professional judgment, teams are encouraged to plot Order of Magnitude (OoM) Incremental Risk on an fN Plot[5] as show in Figure 4 below. Figure 4 shows a whiteboard example that can be done by having the appropriate expertise in a room together (RMC approved Risk Facilitator, Dam/Levee Safety Officer, H&H, Geotechnical Engineer, Planner, Economist) with relevant information on potential probability and consequences of failure or non-performance. PDT's should always coordinate with their Dam/Levee Safety Officer to help them in scoping their quantitative risk assessment. The LSO/Dam Safety Officer (DSO) can also work with the Risk Management Center (RMC) to identify a trained risk facilitator to guide the study.

An OoM plot is essentially an order of magnitude box instead of a more refined point on the fN Plot which would need a more refined SQRA. The OoM box can be whatever size is reasonable given the uncertainty in the underlying data. The bigger the box, the more uncertain the team is with the results. For example, instead of saying that we estimate 37 lives would be lost in a levee overtopping failure scenario (which would require detailed LifeSim modeling), we can say that we think there would be somewhere between 10-100 lives lost (which instead provides an OoM box, as shown in Figure 3).

While these plots will continue to be refined throughout the study with more robust analysis, it's good for the team to understand and begin communicating the potential life risk as early in the process as possible. This information will help inform how critical life risk may be to the plan formulation process and eventually to decision making on plan selection.

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[5] See "Tolerable Risk Guidelines" Attachment for more detail about fN Plots

Figure 3 – Order of Magnitude Incremental Risk fN Plot (LST example)

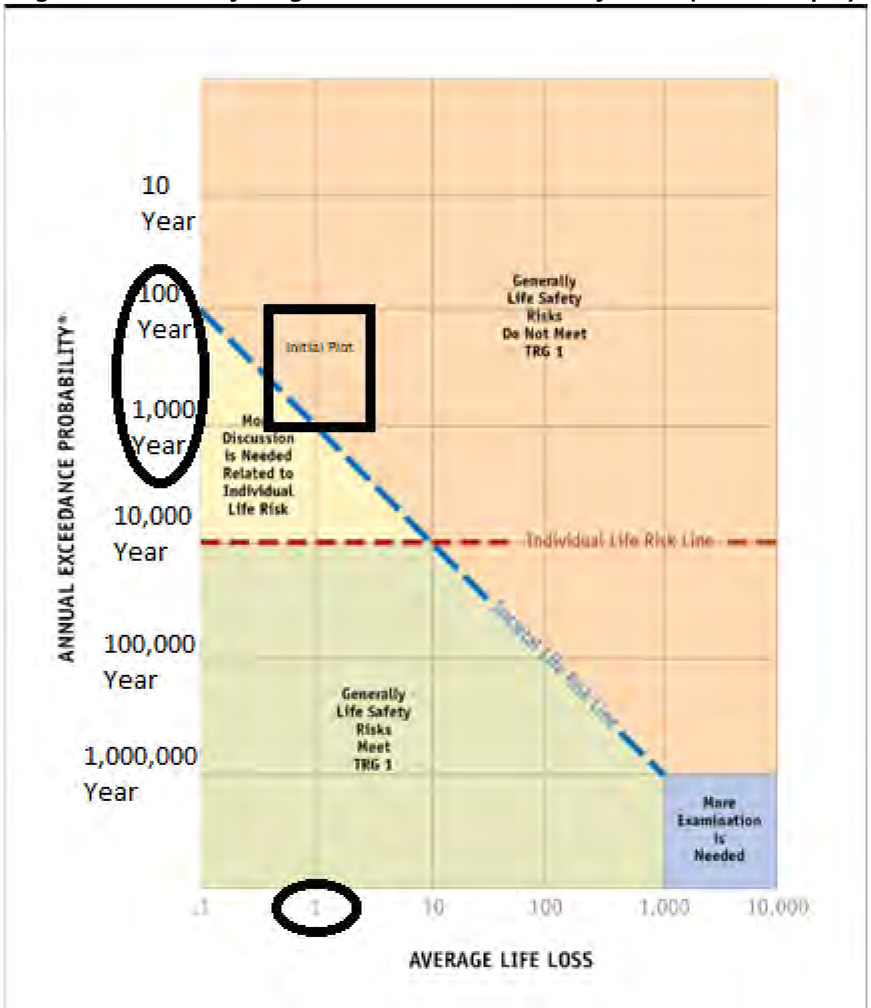
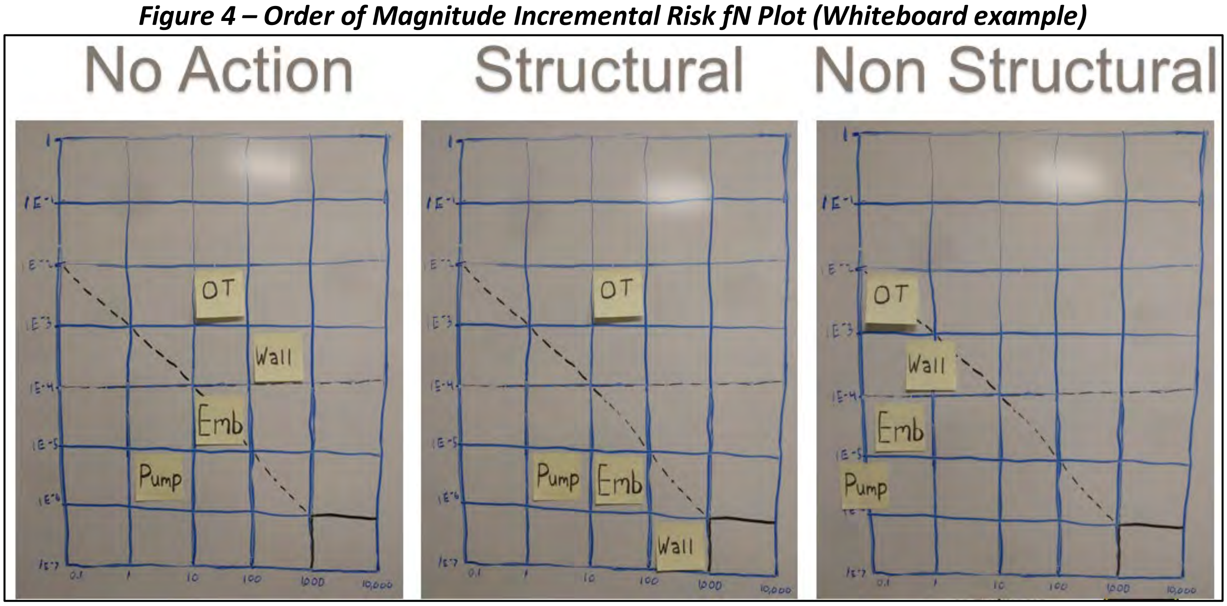


Figure 4 – Order of Magnitude Incremental Risk fN Plot (Whiteboard example)



Attachment #1 – Residual vs. Incremental Risk

Residual Risk (aka "Flood Risk") – The risk at any point in time (incl. incremental and non-breach). There are no "targets" to meet for residual risk. Just try to do some good! Consider as other non-monetary benefits for formulation, evaluation and comparison.

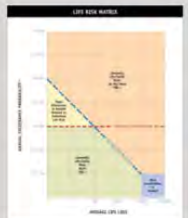
Incremental Risk – Risk to the floodplain/downstream occupants that can be attributed to the presence of the levee or dam. Difference between Breach and non-breach risk. Have predetermined agency guidelines that any USACE structure should meet, known as the "Tolerable Risk Guidelines (TRGs)."

Non-breach Risk – The risk in the floodplain/downstream area even if the levee or dam functions as intended

Attachment #2 – Tolerable Risk Guidelines (TRG’s)

TOLERABLE RISK GUIDELINES APPLY TO INCREMENTAL RISK ONLY!

Below is a brief overview of Tolerable Risk Guidelines (TRG’s). For a more complete description, please refer to Planning Bulletin 2019-04, Attachment A: (https://planning.erdc.dren.mil/toolbox/library/PB/PB2019-04.pdf).

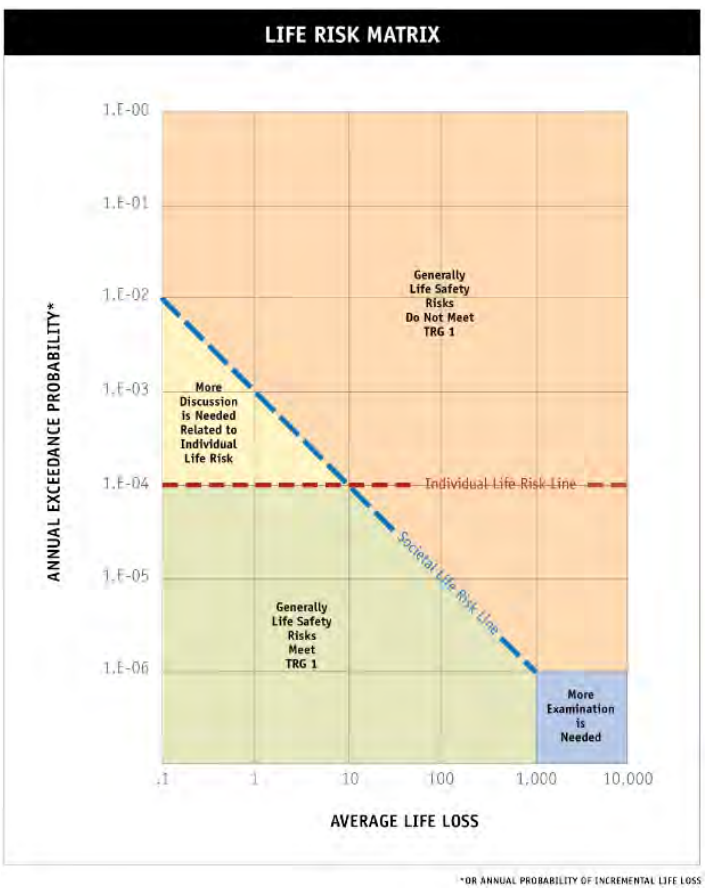
TRG	Description	Evaluation Method
1	Understanding the Risk	 Evaluation of Societal Life Risk Evaluation of Individual Life Risk Evaluation of Economic Risk Evaluation of Environmental Risk
2	Building Risk Awareness	will be determined qualitatively
3	Fulfilling Daily Responsibilities	determined qualitatively
4	Actions to Reduce Risk	(1) Have appropriate actions been taken to reduce risks? (2) Could any action reasonably be taken that would reduce risks further? (3) What is the cost to reduce the risk and how much is the risk reduced? (4) Should action be evaluated in a detailed study? (5) Is there demonstrated progress towards implementing risk reduction measures?

For planning purposes and conducting life risk assessments in FRM studies, the two most important TRG's are #1 and #4.[6] TRG 1 is about understanding your incremental risk (risk of failure or non-performance of FRM infrastructure) as it relates to the societal and individual risk lines on the fN plot.

(1) Evaluation of Societal Life Risk. The societal tolerable risk line shown reflects that society becomes more adverse to risk as the number of life loss increases. Risks that plot above the societal life risk line are considered undesirable except in extraordinary circumstances. Extraordinary circumstances refers to a situation when USACE, acting on behalf of society, may determine that the life risks can be considered meeting TRG 1 based on special benefits that the levee system brings to society at large. Risks that plot below the societal life risk line are considered to have met TRG 1 for life risk.

(2) Evaluation of Individual Life Risk. USACE has chosen to use 1 in 10,000 per year for the probability of life loss for an individual or group of individuals most at risk. The goal is to keep the risks associated with USACE program levees from increasing the probability of death for an individual above the background levels any individual would typically be exposed to over their life-time.

TRG 1: Understanding Incremental Risk related to Societal and Individual Risk Lines



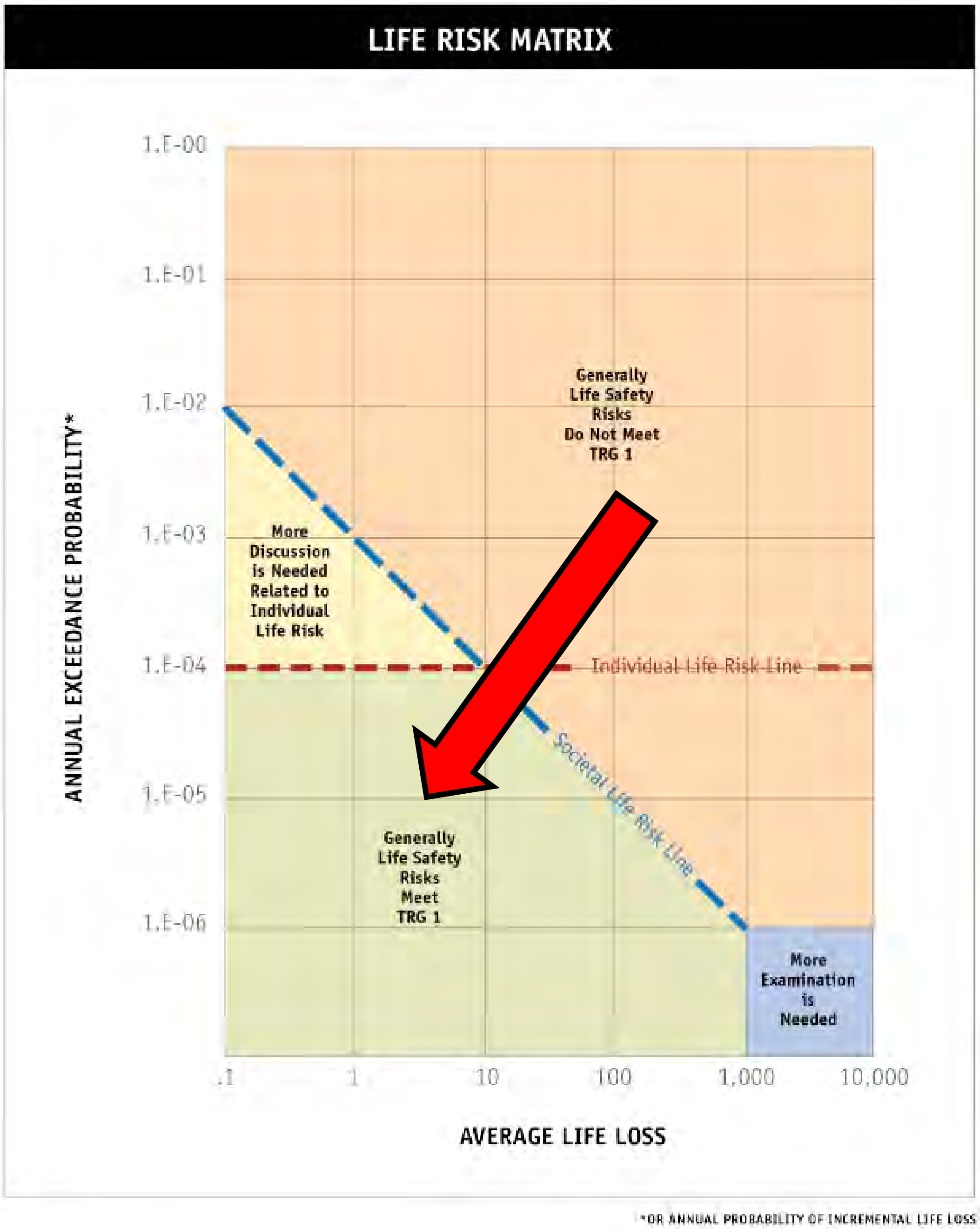
Notation Cheat Sheet

Ratio	Decimal	Scientific
1	1	1.00E+00
1/10	0.1	1.00E-01
1/100	0.01	1.00E-02
1/1,000	0.0001	1.00E+03
1/10,000	0.00001	1.00E+04
1/100,000	0.000001	1.00E+05
1/1,000,000	0.0000001	1.00E+06

[6] TRG's as they relate to FRM Planning studies are also discussed further in two FRM-PCX webinars available here:
https://planning.erdc.dren.mil/toolbox/resources.cfm?Id=0&WId=491&Option=Planning%20Webinars
https://planning.erdc.dren.mil/toolbox/resources.cfm?Id=0&WId=508&Option=Planning%20Webinars

TRG 4 is essentially about what measures can be taken to reduce our identified risk. Even if the risk is identified in the green area, then you can still consider any potentially efficient and effective solutions to reduce that risk further. Outputs will not necessarily be measured by dollars. The goal is to move our risk down and to the left.

TRG 4: Reducing Risk As Low as Reasonably Practicable



Attachment #3 – Data Sources

Hazard:

- FEMA Floodplains / Reports/FIRM's/etc. (incl. non-Fed levees)
  - Available from FEMA at: https://msc.fema.gov/portal/advanceSearch
- Terrain Data
  - Standard Quality Data: https://www.usgs.gov/core-science-systems/national-geospatial-program/national-map
  - High Detail often available from GRID or Local Sponsor
    - Inquire with H&H or GIS
- USGS National stream-flows statistics program
  - https://www.usgs.gov/software/national-streamflow-statistics-program-nss
- FPM's, EAP's, Water Control Manuals, etc.
  - Project owners typically prepare EAPs and may conduct their own investigations
  - Inquire with Dam and Levee Safety Office and H&H
- CWMS Models (H&H, FIA)
  - Models have been prepared for many basins across the country
  - Models are often stored on ProjectWise servers
    - Inquire with H&H

Performance:

- Levee Screening Tool (LST)
  - LSPM may grant access to https://lst.sec.usace.army.mil/
- National Levee Database
  - https://levees.sec.usace.army.mil/#/
- National Inventory of Dams
  - https://nid.sec.usace.army.mil/ords/f?p=105:1::::::
- Levee Incident Database (Geotech fragility estimates)
  - In development as part of LST improvement, but still currently usable data. Contact RMC for data (Jason Needham or David Schaaf).
- Recent Periodic Assessments, SQRA's, PFMA's
  - Inquire with Dam and Levee Safety Offices
- Historical system performance
  - After Action Reports, or Periodic Inspections

Consequences:

- National Structure Inventory (NSI)
  - Background information: https://github.com/HydrologicEngineeringCenter/NSI
  - Have Econ PDT member contact Nicholas Lutz, LRL or Michael (Alex) Ryan, LRH for access
- HAZUS
  - https://www.fema.gov/hazus
- Historical Damages
  - Inquire with Econ PDT Member

- HIFLD (HSIP 2.0)

Critical Infrastructure and other GIS Data: https://gii.dhs.gov/hifld/

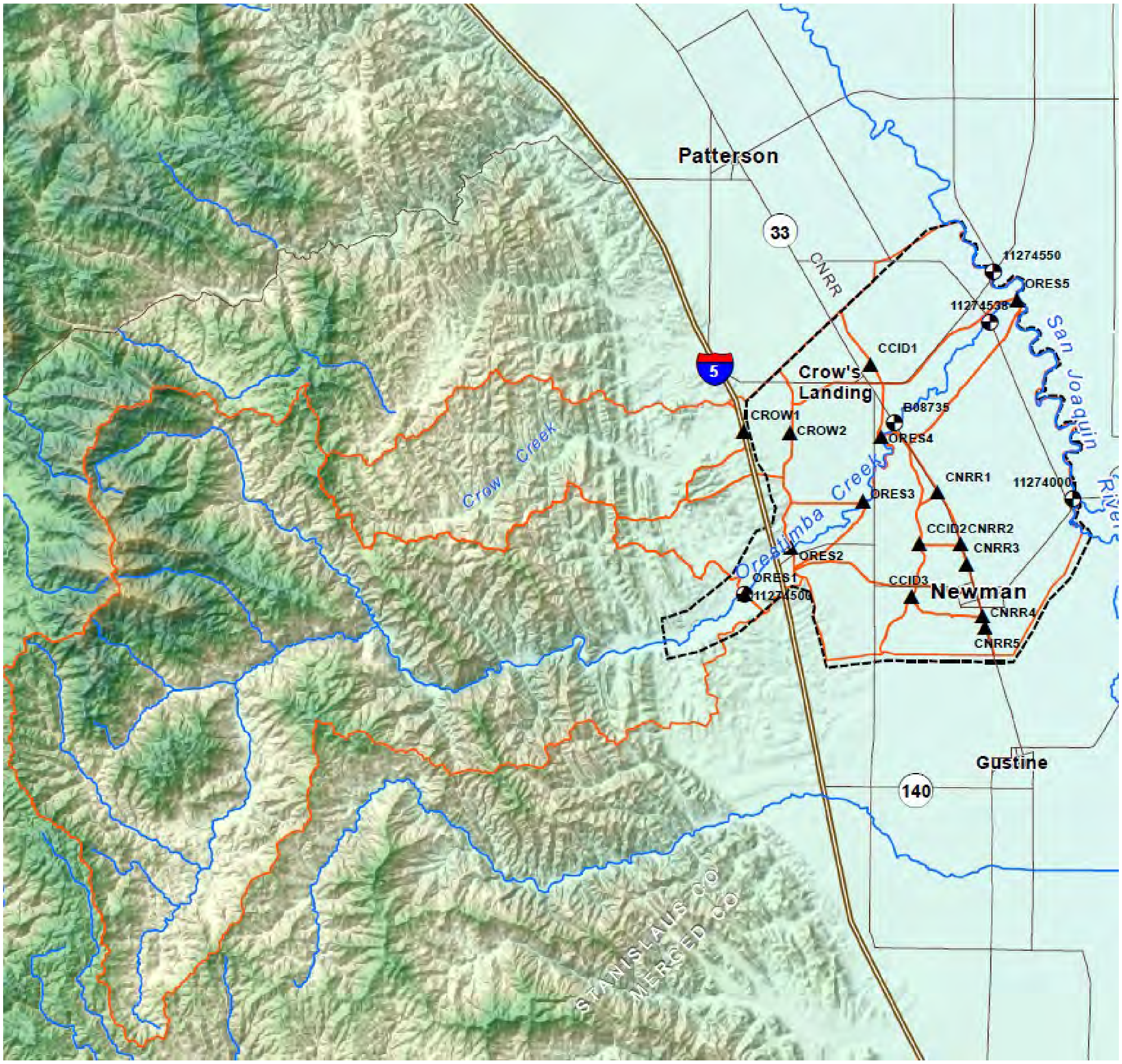
Attachment #4 – An Example "First Cut" Qualitative Life Risk Assessment

1. Input from Project Sponsor.

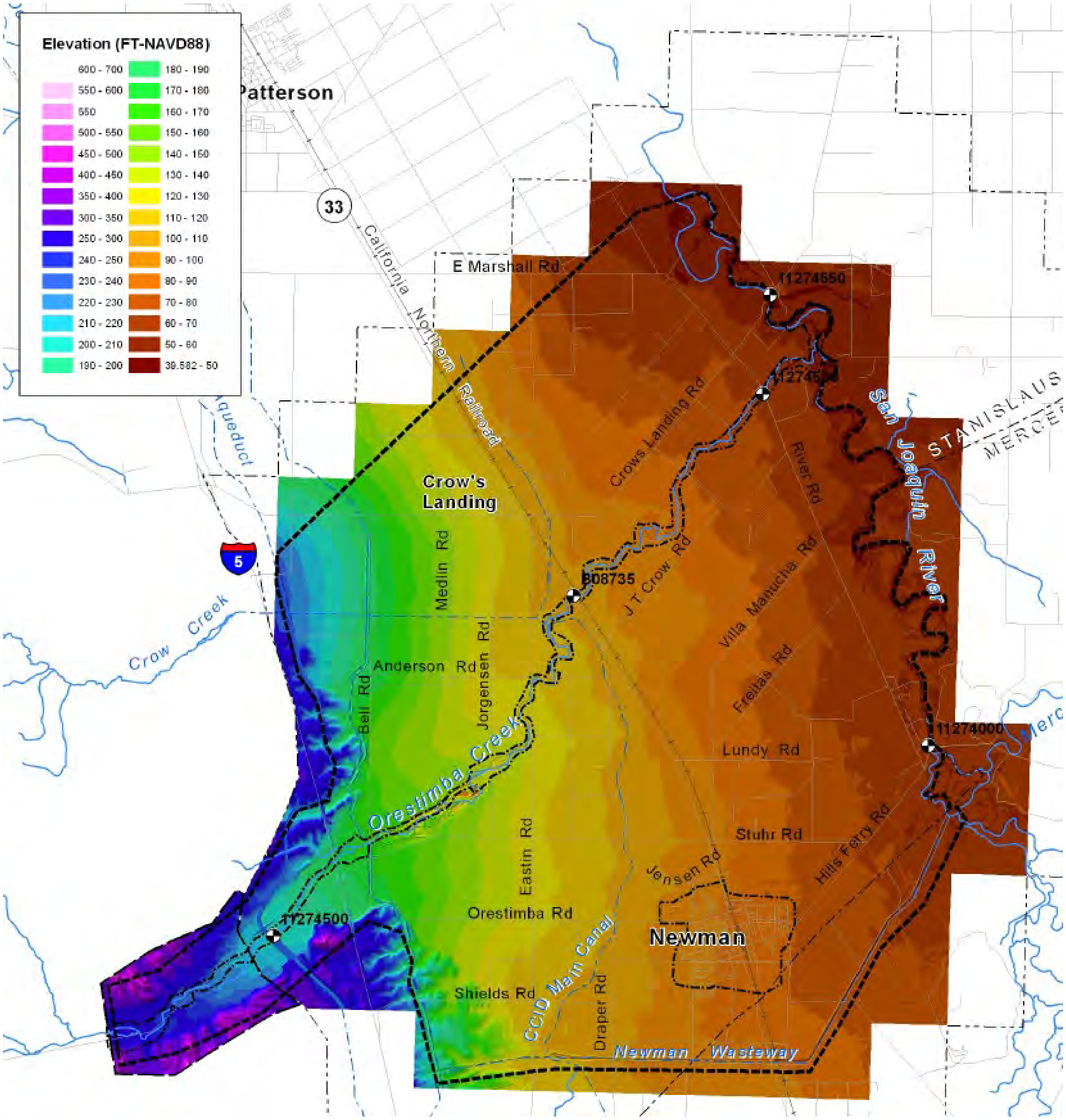
Sponsor is primarily interested in reducing flooding in the City of Newman because of recent flood events. They also mentioned that several lives were lost when a car tried to cross a low water crossing and was swept away. Need to be careful about using recent events as an indication of flood risk because they could have been very rare. Need to figure out the frequency of those events. Sponsor is really interested in an upstream reservoir. We will need to include that in the list of potential measures and probably not going to be able to just screen based on professional judgment. Will need to look into more detailed methods of evaluation and screening.

2. Review Topographic Maps

Topographic mapping is the single most important data set in the evaluation of flooding. Topographic maps should be one of the first things reviewed during an FRM assessment and building terrain models that can be viewed in GIS and RAS-Mapper should be started on the first day of a study. The National Elevation Dataset is a good place to start and is accurate enough to evaluate the watershed. However, a more detailed set of topography like LiDAR or 2-foot contour mapping is critical to understanding channel dimensions, levee locations, and features like embankments that can impact the flow depth and direction of shallow floodwater. Note that the examples provided are final versions and show road labels, etc. that are not needed for an initial assessment. HEC-RAS mapper has very good terrain viewing capabilities for on-the-fly viewing and assessments.



The terrain model of the watershed area (based on the National Elevation Dataset) indicates there are several potential sources of flooding within the study area, including Crow Creek, Orestimba Creek, and San Joaquin River. The map above indicates there may be suitable locations in the watershed to construct flood detention.



The detailed topographic map shows that floodwaters would initially be confined by mountain slopes but once it opens up to the valley, the terrain mapping has an alluvial fan shape that usually means the channel loses capacity and floodwaters will spread out. The apex of the alluvial fan will be an important consideration in understanding hydraulic uncertainty in the downstream floodplain areas. Changes in channel geometry at the apex could result in redirection of floodwaters in the downstream area. In other words, flooding in the town of Newman may not appear likely based on hydraulic model results, but a slight shift in the upstream topography near the fan apex could change the floodplain delineation. The more detailed mapping indicates that the town of Newman is significantly higher than the Joaquin

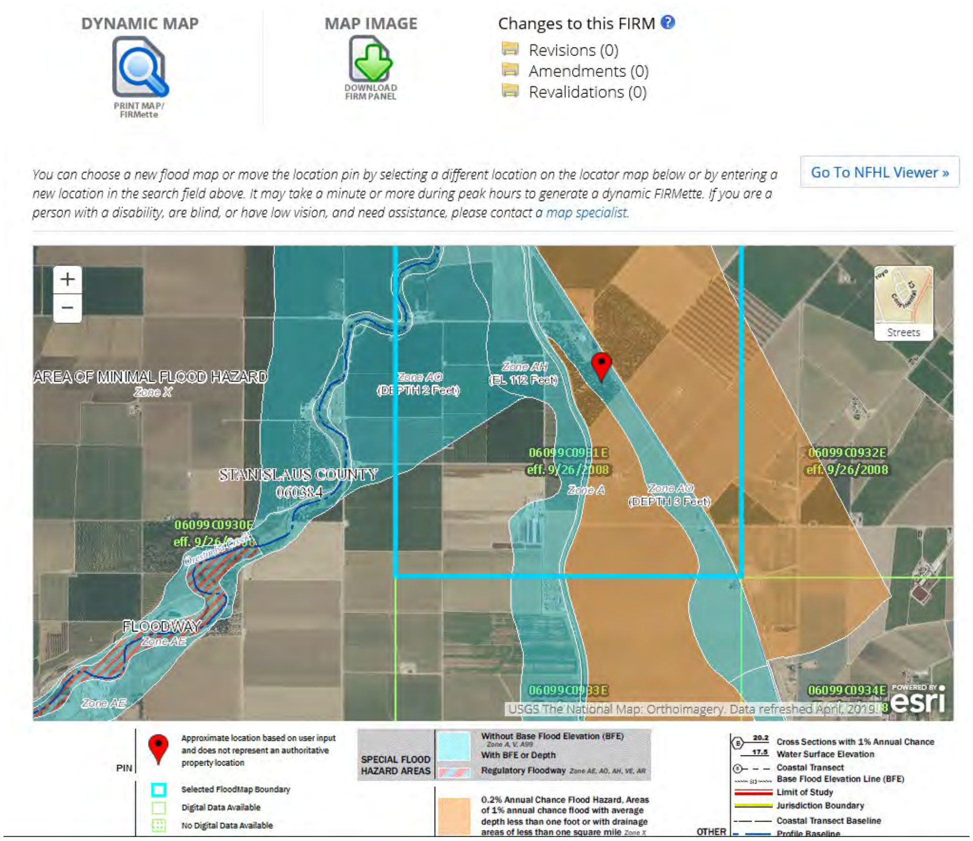
River. However, the San Joaquin River might need to be considered when looking at benefits and possible impacts of a project in comingled flooding locations.

3. Review FEMA NFIP Maps and Flood Insurance Study Reports

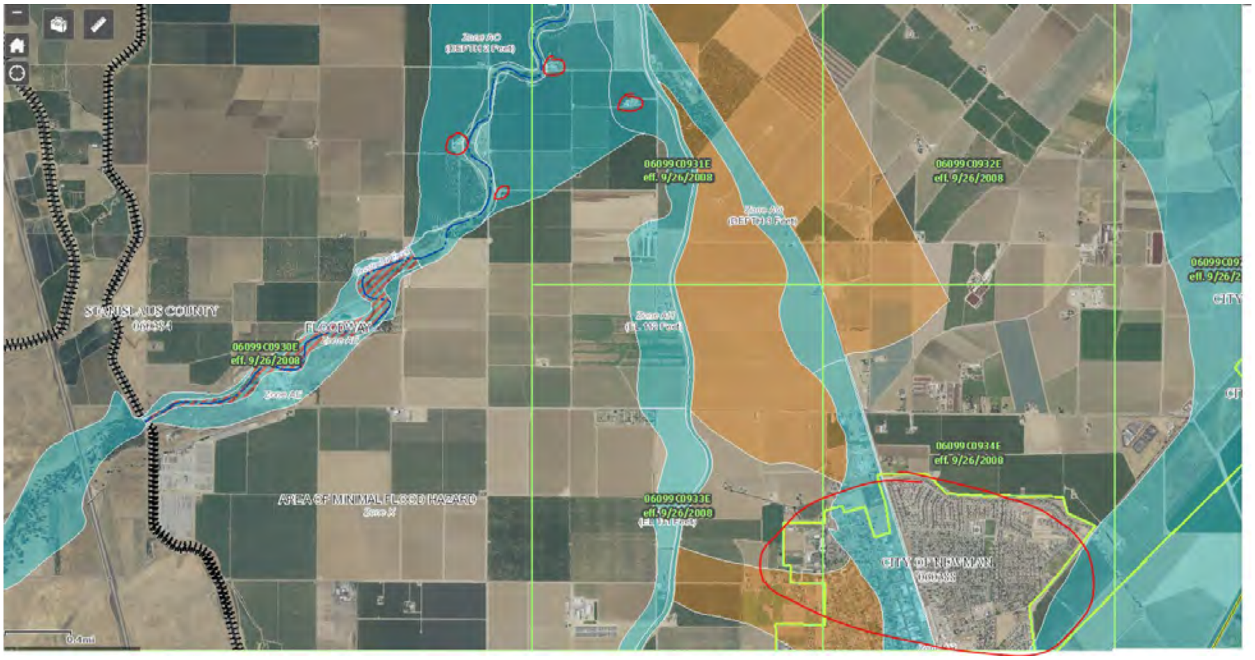
FEMA National Flood Insurance Program (NFIP) mapping is usually available for any area that has a potential for federal FRM interest.

Go to the FEMA map portal.

https://msc.fema.gov/portal/search?AddressQuery=orestimba%20ca#searchresultsanchor



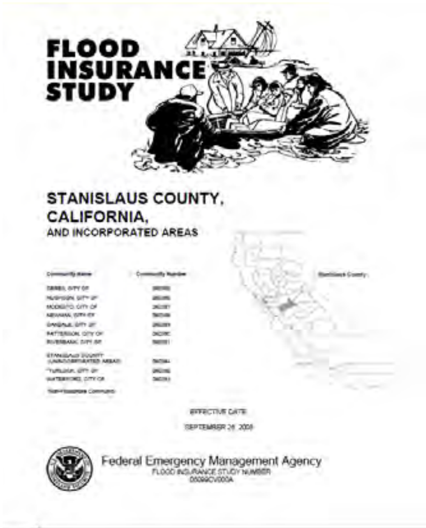
Click on link to go to FEMA map viewer and pan around to look at 1% floodplain extents. Compare them to the detailed topographic mapping of the study area.



Maps indicate that the 1% flood comes out of the mountains where it is confined by the hillsides. Further downstream, the floodplains expand greatly indicating that the channel capacity decreases and the floodwaters are less confined and more likely to be shallow. Flows in the confined channel reaches are likely to have higher velocities, and the aerial photography indicates the channel bed is actively scoured which also confirms that the velocities could be high. The downstream floodplain is wide and likely to have shallow depths and low velocities. The aerial photographs does not show any evidence of active scour in the wide floodplain area which confirms the low velocities. The floodplain maps combined with the aerial photographs and terrain map indicate there are embankments or levees that are impacting the direction of floodwater. The embankment west of Newman is a significant distance upstream from Newman and appears unlikely to pose a significant life risk. Significant damage areas are circled in red and likely federal interest will be focused on reducing flood risk to Newman. Implementation of flood risk measures in the other areas are unlikely to be cost effective.

Flood Insurance Study report.

Select map area and download the Flood Insurance Study (FIS). The FIS provides flood history, description of analysis, flow frequency, and flood profiles. Sometimes it will also provide average channel velocities in AE zones with floodways.



Flood Insurance study report cover.

Newman, City of

The hydrologic and hydraulic analyses for the initial FIS were prepared by the USGS, for the Federal Emergency Management Agency (FEMA), under Inter-Agency Agreement No. IAA-H-8-76, Project No. 14. That study was published in march 1978.

The hydrologic and hydraulic analyses for the January 3, 1990 FIS were prepared by the U.S. Army Corps of Engineers (USACE), Sacramento District, for FEMA, under Inter-Agency Agreement No. EMW-86-E-2226, Project Order No. 3. This work was completed in November 1987.

Description of study in the Newman Area. Wow, looks like Sacramento District did the work. Maybe I can find additional information in the archives if I had time.

2.2 Community Description

Stanislaus County, situated approximately 80 miles east of San Francisco, is bounded by San Joaquin, Calaveras, Tuolumne, Mariposa, Merced, Santa Clara, and Alameda Counties. The estimated 2006 population was 512,138 (Reference 2). Of these persons, 205,721 live in the City of Modesto, the county seat, and 193,897 live in the incorporated cities of Turlock, Ceres, Riverbank, Oakdale, Patterson, Newman, Waterford, and Hughson (listed largest to smallest) (Reference 2). The total population in the unincorporated areas was 112,520 (Reference 2). The economy of the county is based primarily on agriculture and related industries.

The county straddles the main trough of the San Joaquin Valley and extends from the western foothills of the Sierra Nevada on the east to the crest of the Diablo Range section of the Coast Range Mountains on the west.

Native Americans originally inhabited the western portion of Stanislaus County. Then, in 1806, Gabriel Moraga led a Spanish expiation into the region and discovered and named the Stanislaus River. He later commanded two other expeditions through the area in 1808 and 1810. Spanish settlement started in the region soon after, some beginning as early as 1820. John C. Freemont traveled the region in early 1844 during his explorations in the far west. In 1849, a ferry across the San Joaquin River (called Hill's Ferry) at a site about 5 miles northeast of Newman was begun by a man named Thompson. Greater settlement began in the early 1850's when the Gold Rush era began to decline and more American pioneers started entering the area. Stanislaus County was organized in 1854 after being partitioned off from Tuolumne County. The City of Newman was founded in 1887 and incorporated in June 1908. the City of Patterson was founded and incorporated in December 1919.

History of the area. This could be useful for the feasibility study report…

2.3 Principal Flood Problems

Large floods occurred along the Stanislaus River in 1939, 1950, and 1955 before the New Melones Dam was constructed. Since the New Melones Dam and its related flood-control project were completed in 1979, floods of near record size have occurred in the San Joaquin Valley on the Stanislaus River in 1995, 1996, and 1997. The worst of these floods came in January of 1997. portions of the Towns of Ripon, Riverbank, and Oakdale were flooded. The New Melones Dam upstream of these cities on the Stanislaus provides a high level of protection, and the uncontrolled spillway of the dam did not spill during the January 1997 flood. However, large controlled outlet releases were required from the dam during these floods and affected a significant number of structures located in the floodplain.

Major damage resulted from the flood events of January 1997. The areas where flooding occurred have been identified as flood hazard mitigation projects areas. The large rainfall events that occurred in 1995, 1996, and 1997 shifted the flood frequency curves for the study reaches and significantly increased flood hazard areas.

Large floods occurred along the Stanislaus River in 1938, 1950, and 1955 before the New Melones Dam was constructed. Since construction of the New Melones Dam and its related flood control were completed in 1979, floods of near-record size have occurred in the San Joaquin Valley on the Stanislaus River in 1995, 1996, and 1997. The worse of these floods occurred in January 1997. Portions of the Cities of Ripon, Riverbank, and Oakdale were flooded. However, upstream of these cities, the New Melones Dam provided a high level of protection during the floods, and the uncontrolled spillway of the dam was not overtopped. In spite of

History of flood problems. Might be old but this is good information for the report.

General rainstorms over the region can produce flood conditions over a widespread area that, consequently, can cause either high flows on just one of the streams or concurrent high flows on two or all three of the streams.

The drainage areas for Del Puerto and Orestimba Creeks (upstream of Interstate 5) are 72.6 and 134 sq. mi., respectively.

Cloudburst storms are rare but can occur anytime from late spring to early fall, sometimes taking place in an extremely severe sequence within a general rainstorm. Cloudbursts are high intensity storms, yet in the vicinity of Patterson/Newman, they do not have the peak flows, duration, or volume of general rainstorms. Although they usually cover small areas, cloudburst storms can cause minor flooding on the comparatively flat valley floor in the county.

The flows for all three west-side streams are constricted at the DMC by either a siphon (Del Puerto and Orestimba Creeks) or an overchute (Salado Creek), thus forcing the ponding of floodwaters to the west of the canal. The Salado Creek ponding is diverted southeasterly for a few miles, and eventually, a substantial quantity of floodwaters flow into Little Salado Creek and then under the canal, adding significantly to floodflows in the vicinity of the Naval Auxiliary Landing Field just northwest of Crows Landing.

Looks like economic damages are probably more sensitive to the general rainstorm events. However, we should probably consider that a cloudburst (aka thunderstorm) could catch people off guard and be a life risk consideration in the upper confined reaches.

Floodwater is directed southward through Newman by the railroad embankment. This floodwater ponds in the southeastern part of the city before overtopping the railroad and continuing eastward.

Floods in 1955, 1958, and 1980 have followed this flooding pattern, with shallow floodflows entering Newman from the north and west (References 8 and 9). There has been very little structural damage in Newman because flooding is shallow, with relatively slow velocities.

This confirms the map assessment. Floodwaters in Newman are relatively shallow. The railroad embankment appears to be a major factor and we should consider how to address that.

TABLE 2 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-percent annual chance	2-percent annual chance	1-percent annual chance	0.2-percent annual chance
DEL PUERTO CREEK					
At Interstate 5	72.6	*	*	7,960	*
DRY CREEK					
At Modesto	192.3	4,730	9,300	11,800	18,100
ORESTIMBA CREEK					
At Interstate 5	134.0	*	*	15,590	*
SALADO CREEK					
At Interstate 5	25.3	*	*	2,820	*
Below DMC	25.3	*	*	710	*
STANISLAUS RIVER					
At Oakdale	1,020	7,600	8,000	8,000	41,300
TUOLUMNE RIVER					
At Modesto	1,884	10,500	32,000	70,000	154,000
At Waterford	1,640	9,000	10,000	42,000	225,000

*Data Not Available

Discharges are only available for the 1% AEP event. Might need a detailed hydrology study as part of the feasibility study.

Orestimba Creek								
A-N[1]								
O	49,790[3]	560	3,238	4.1	135.5	135.5	136.5	1.0
P	53,760[3]	503	2,386	6.1	140.7	140.7	141.3	0.6
Q	57,490[3]	414	3,193	4.7	149.4	149.4	150.4	1.0
R	59,750[3]	275	1,784	8.8	156.5	156.5	156.5	0.0
S	61,680[3]	148	1,593	10.2	166.2	166.2	167.2	1.0
T	62,200[3]	335	5,259	3.1	168.4	168.4	169.3	0.9

[1]No floodway computed
[2]Feet above mouth
[3]Feet above confluence with San Joaquin River

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

STANISLAUS COUNTY, CA AND INCORPORATED AREAS

FLOODWAY DATA

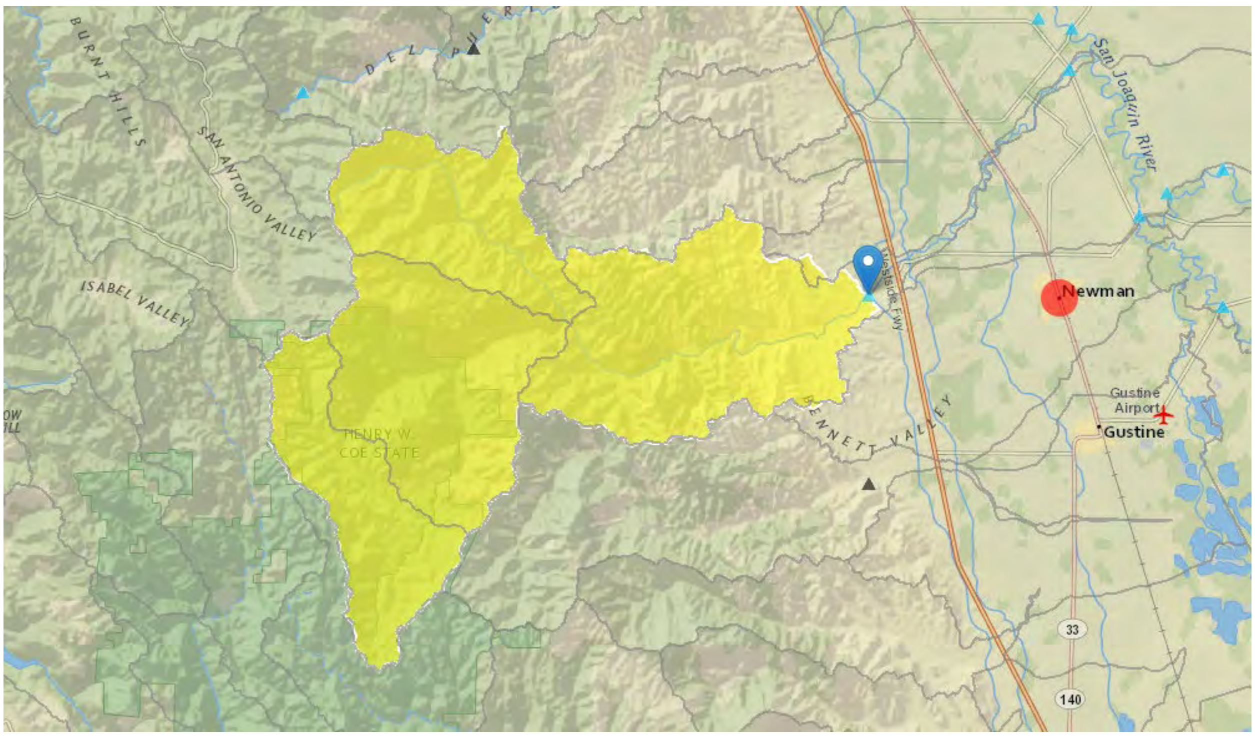
DRY CREEK – ORESTIMBA CREEK

The floodway table confirms the map assessment. Velocities in the upper channel around Section S are 10 feet per second.

4. Review Output from USGS National Streamflow Statistics Program

https://streamstats.usgs.gov/ss/

This is a great tool for a quick delineation of a watershed upstream of a user defined point. Peak flow estimates should not be used if the study area has storage regulation (ie reservoirs) because regional equations are based on natural unregulated watersheds and do not account for regulation of stream flow. The map used for delineation showed that the gage "Orestimba Creek near Newman" was located on the creek. Therefore the gage location was used as the point to delineate the upstream basin.



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
BASINPERIM	Perimeter of the drainage basin as defined in SIR 2004-5262	98	miles
BSLDEM30M	Mean basin slope computed from 30 m DEM	34.4	percent
CENTROIDX	Basin centroid horizontal (x) location in state plane coordinates	-2197390.2	meters
CENTROIDY	Basin centroid vertical (y) location in state plane units	1877506.5	meters
DRNAREA	Area that drains to a point on a stream	135.3	square miles
EL6000	Percent of area above 6000 ft	0	percent
ELEV	Mean Basin Elevation	1552	feet
ELEVMAX	Maximum basin elevation	3802	feet
FOREST	Percentage of area covered by forest	14	percent
JANMAXTMP	Mean Maximum January Temperature	54.7	degrees F
JANMINTMP	Mean Minimum January Temperature	37.49	degrees F
LAKEAREA	Percentage of Lakes and Ponds	0.00539	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	0.4	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	0	percent
LFPLENGTH	Length of longest flow path	33	miles
MINBELEV	Minimum basin elevation	205	feet
OUTLETELEV	Elevation of the stream outlet in thousands of feet above NAVD88.	206	feet
PRECIP	Mean Annual Precipitation	17.6	inches
RELIEF	Maximum - minimum elevation	3596	feet
RELRELF	Basin relief divided by basin perimeter	36.7	feet per mi

Peak-Flow Statistics Parameters[2012 5113 Region 4 Central Coast]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	135.3	square miles	0.11	4600
PRECIP	Mean Annual Precipitation	17.6	inches	7	46

Peak-Flow Statistics Flow Report[2012 5113 Region 4 Central Coast]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SEp
2 Year Peak Flood	501	ft^3/s	77.5	3230	162
5 Year Peak Flood	1830	ft^3/s	478	7000	97
10 Year Peak Flood	3410	ft^3/s	1090	10700	79.4
25 Year Peak Flood	6190	ft^3/s	2190	17500	69.9
50 Year Peak Flood	8880	ft^3/s	3330	23700	66.2
100 Year Peak Flood	11700	ft^3/s	4380	31400	66.9
200 Year Peak Flood	15000	ft^3/s	5570	40200	67.6
500 Year Peak Flood	19700	ft^3/s	6850	56400	71.5

Peak-Flow Statistics Citations

Gotvald, A.J., Barth, N.A., Veilleux, A.G., and Parrett, Charles,2012, Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012–5113, 38 p., 1 pl.

Note that peak flow from USGS regional equations is less than the FEMA NFIP value. However, it does provide an indication of the percent difference between frequency quintiles. The basin is very rural and does not appear to be rapidly developing.

The flow statistics computed for the gage were obtained by clicking on the gage in the webviewer.

Streamflow Statistics

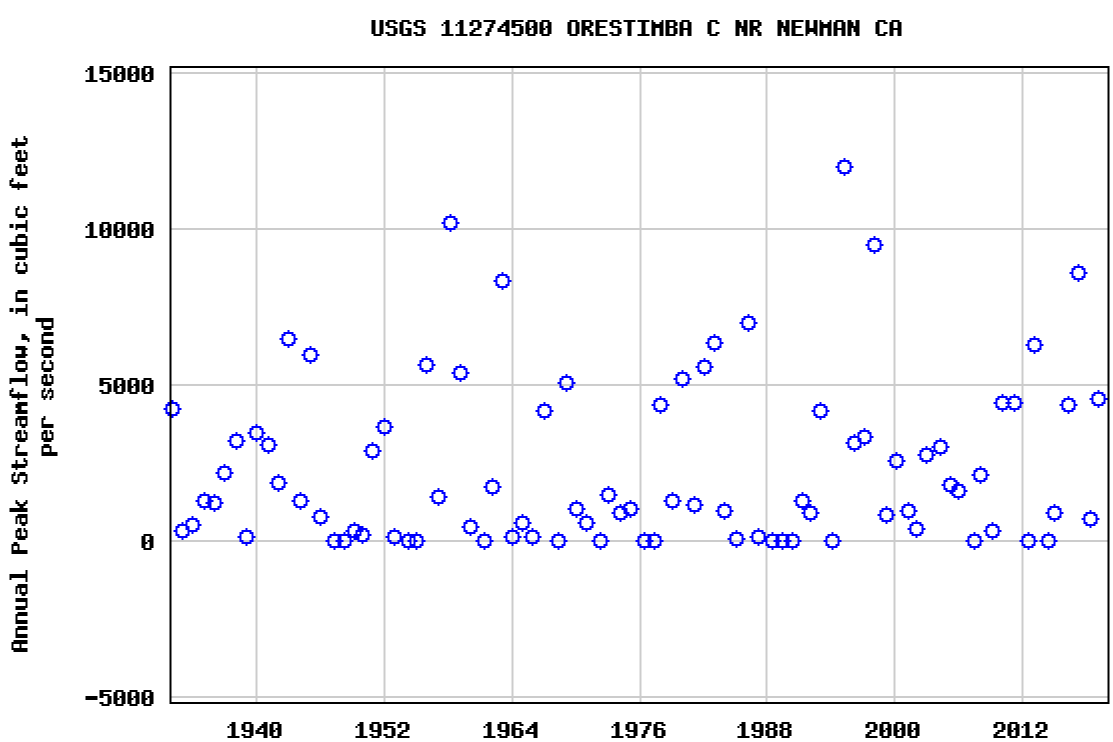
Statistic Name	Value	Units	Citation Number	Preferred?	Years of Record	Standard Error, percent	Variance log-10	Lower 95% Confidence Interval	Upper 95% Confidence Interval	Start Date	End Date	Remarks
Peak-Flow Statistics												
Mean_Annual_Flood	288.000	cubic feet per second	31	Y								
2_Year_Peak_Flood	1310	cubic feet per second	230	Y	75	17.04	0.00539699988			10/1/1931	9/30/2006	The complete lower tail was censored.
5_Year_Peak_Flood	3800	cubic feet per second	230	Y	75	16.02	0.00478029996			10/1/1931	9/30/2006	The complete lower tail was censored.
10_Year_Peak_Flood	6170	cubic feet per second	230	Y	75	17.36	0.00560100004			10/1/1931	9/30/2006	The complete lower tail was censored.
25_Year_Peak_Flood	9850	cubic feet per second	230	Y	75	21.34	0.00839610025			10/1/1931	9/30/2006	The complete lower tail was censored.
50_Year_Peak_Flood	13000	cubic feet per second	230	Y	75	25.46	0.0118490001			10/1/1931	9/30/2006	The complete lower tail was censored.
100_Year_Peak_Flood	16300	cubic feet per second	230	Y	75	30.18	0.0164379999			10/1/1931	9/30/2006	The complete lower tail was censored.
200_Year_Peak_Flood	19900	cubic feet per second	230	Y	75	35.27	0.0221159998			10/1/1931	9/30/2006	The complete lower tail was censored.
500_Year_Peak_Flood	24800	cubic feet per second	230	Y	75	42.41	0.0311900005			10/1/1931	9/30/2006	The complete lower tail was censored.

The values are much closer to the values provided in the FEMA NFIP study report.

5. Review USGS Gage Records

USGS gage records in combination with the stream stats data can be used to evaluate the frequency of historical events.

https://waterdata.usgs.gov/nwis



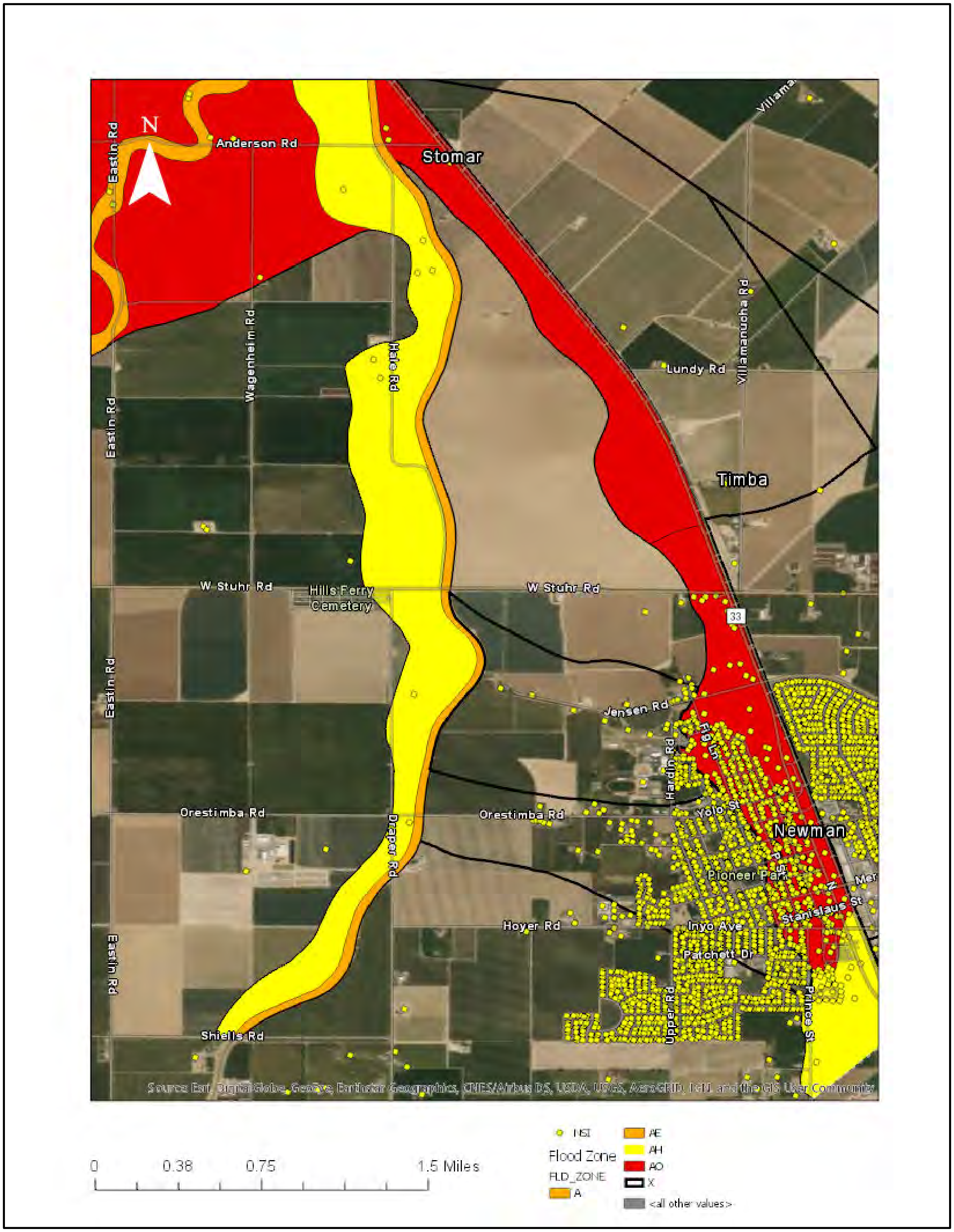
The stream gage record indicates that the recent flooding experienced in February 2017 was the fifth largest peak flow since records began in 1932. The next largest occurred in February 1998 and the largest occurred in March 1995. The May 1958 was the second largest but probably too far back for locals to remember vividly. The March 1995 peak flow was less than the peak discharge of a 1% Annual Exceedance Probability flood based on the USGS frequency evaluation.

5. Gaining an Understanding of the Vulnerability, Exposure and Potential Consequences within the Study Area

Now that there's a general understanding of the flood patterns and geographic locations within the study area, we can begin to gather information about the affected areas that will drive the life risk consequences.

i. Use Levee Screening Tool (LST) if you have it. If your study area has existing levees, chances are some level of life risk assessment has already been completed. Talk with your Levee Safety Officer in your district to find what data exists.
ii. If no LST data is available or you don't have existing FRM infrastructure in your study area, the USACE National Structure Inventory Database (NSI2) is a great place to start. Begin with the FEMA floodplain polygon (identified in Section 3 above), or any other study area delineation that you may have available. In GIS, overlay the polygon and the NSI Inventory which will give you information about the structure makeup in your study area.

National Structure Inventory and Flood Zones in Study Area



iii. When looking at this data, you'll want to take special note of a few things and how they may relate to potential life risks:
   a. What is the Population at Risk?
   b. What are the general land uses in the study area (rural vs. urban)?
   c. What are the distributions/geography of different occupancy types? Focus on where the residential structures are, because that's usually where the majority of life loss with originate from.
   d. What are the typical foundation heights? In the case of Newman, with relatively shallow flood depths, the foundation heights of structures could be critical with respect to life loss (and damages).
   e. What is the socioeconomic population makeup (is part of the population more elderly, economically disadvantaged or otherwise increasingly vulnerable to life loss in a flood event)? Data here can be supplemented with Census data as needed.
   f. Where are the critical infrastructure located in the study area (Police, Fire, Hospitals)?

By counting the number of structures within the study area, summing the populations and structure values of those structures, and examining other relevant fields, we can begin to understand who is at-risk of flooding and how vulnerable those populations are to flooding.

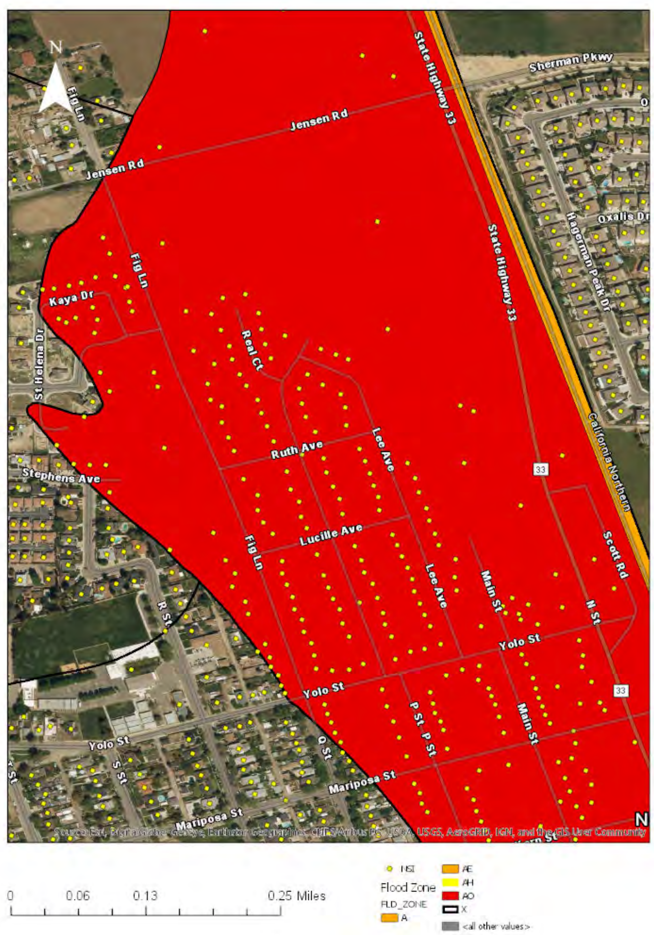
The table below suggests that there are roughly 10,000 individuals within the study area, however, the vast majority of those populations are within the "X" flood zone, which is a low-risk category for those within 500-year flood zones, behind existing levees, or are otherwise not yet analyzed at being at a high risk of inundation. The next largest group of Population At-Risk (2,000) are those within the "AO" zone, which is reserved for those mapped in shallow flooding zones, although, these zones can occasionally include high velocities. Along with those in other "A" zones, which are any areas within the traditional "100-year" boundary, this suggests that there may be upward of 2,000 PAR in frequently flooded areas that may face hazardous conditions if exposed.

The NSI also gives best estimates for the percent of the PAR that is older than 65 (~13%), has a disability that limits their mobility (30% of those over 65, 4% of those under 65), and how many stories each of the structures possesses. Each of these variables are used in models such as LifeSim to estimate the likelihood that PAR may vertically evacuate within their structures to avoid being exposed to floodwaters. In the absence of LifeSim modeling, this information may still be useful to qualitatively assess the vulnerability of PAR to floodwaters.

Table of NSI Data Summarized by Flood Zone[7]

Flood Zone	Structures	Night Population	Day Population	Structure Value	Average Number of Stories
A	5	20	10	$ 1,650,000	1.8
AE	10	60	50	$ 2,130,000	1.3
AH	40	230	130	$ 29,640,000	1.1
AO	530	1,520	1,810	$ 221,000,000	1.1
X	2,960	9,620	7,460	$ 851,780,000	1.4
Grand Total	3,550	11,450	9,460	$ 1,106,200,000	1.4

NSI and Flood Zones within Newman, CA



7 https://snmapmod.snco.us/fmm/document/fema-flood-zone-definitions.pdf

The table below shows what a qualitative risk matrix might look like for Newman, CA:

Measure/Alternative	Metric							Residual Life Loss Risk Characterization	Incremental Risk Characterization
	Probability		Consequences						
	Likelihood of Flooding	Likelihood of Failure/Non-Performance	Economic Damage	Flood Depth	Flood Velocity Life Loss Risk (LLR)	Warning Time LLR	Evacuation LLR		
No Action	High	N/A	Medium	Low	Low	Medium	Medium	Low	N/A
Ring Levee	Low	Medium	Low	Low	Medium	Medium	Medium	Low	Low
Upstream Reservoir	Low	Medium	Low	Low	Medium	Medium	High	Low	Medium
Levees along Channel	Medium	Medium	Low	Low	Low	Low	Medium	Low	Low
Relocations	Low	N/A	Low	Low	Low	N/A	Medium	Low	N/A
Flood Proofing	Medium	Low	Low	Low	Low	Low	Medium	Low	N/A

You'll notice that Flood Depth and Economic Damage don't seem to be key risk drivers for this area, so they should probably not be presented here. Instead it looks like the probability of flooding and the potential for introducing incremental life risk to an area that currently doesn't have any will need to be considered. While the likelihood of high velocities will probably be small on an annual basis, if there was a malfunction under the Upstream Reservoir or the ring levee option, the study area could be subject to higher high velocity flows.

A more helpful matrix would remove non key risk drivers and might look like this:

Measure/Alternative	Metric					Residual Life Loss Risk Characterization	Incremental Risk Characterization
	Probability		Consequences				
	Liklihood of Flooding	Liklihood of Failure/Non-Performance	Flood Velocity Life Loss Risk (LLR)	Warning Time LLR	Evacuation LLR		
No Action	High	N/A	Low	Medium	Medium	Low	N/A
Ring Levee	Low	Medium	Medium	Medium	Medium	Low	Low
Upstream Reservoir	Low	Medium	Medium	Medium	High	Low	Medium
Levees along Channel	Medium	Medium	Low	Low	Medium	Low	Low
Relocations	Low	N/A	Low	N/A	Medium	Low	N/A
Flood Proofing	Medium	Low	Low	Low	Medium	Low	N/A

iv. If you wanted to go for a quantitative risk estimate, you can utilize some generic assumptions about warning times, evacuation rates and fatality rates to come up with an OoM range of life loss for given flood events. General rules of thumb might be:

a. The LST assumes an evacuation range of 52 to 98% of the Population At-Risk. Overtopping scenarios, or other breaches where significant warning time might be expected, would be near the higher end of the range. Scenarios with little warning opportunity time or communities with generally unprepared Emergency Management Agencies are more likely to be on the lower end of the range.

b. Apply fatality rates to any remaining exposed PAR. The LST generally assumes fataility rates ranging from 0.2% for shallow overland flow to roughly 2% as flood depths approach roof tops. However, LifeSim assumes fatality rates as high as 75% on average if structures are modeled as being destroyed by high velocities or being completely submerged by floodwaters.

c. Consider any other relevant sources of life loss, such as those who may be caught on roadways, or indirect life loss due to the loss of critical infrastructure. Also, consider if life loss represents breach, non-breach, or incremental risk.

d. Using your estimates of the relevant ranges, multiply the initial PAR by the percent unable to evacuate and the fatality rate.

For example, if we expect 2,000 PAR are at risk within the wider Newman, CA area and that 90-98% would evacuate, then that would leave 40 to 200 who may be exposed to floodwaters. Assuming a fatality rate of 0.2% to 2%, then life loss would range from 0.08 to 4. This initial wide range may be useful for framing the degree to which life loss may be a concern for the study, but the PDT should be aware that future RAS and LifeSim modeling may shift, narrow, or expand the range depending on how much more detailed analysis differs from the initial assumptions.

6. Assessment Summary:

Existing Conditions:

Highest economic flood risk in the study area is the town of Newman. Flooding in Newman would result from a general rain storm in the upper watershed. As floodwaters flowed out of the upper watershed they would overtop the channel banks where they are directed south towards the town of Newman by several embankments.

Highest life risk is probably the channel due to high velocities. This is supported by the life loss at low water crossing during a flood event. However, it is not a populated area so the overall life risk is considered low. Life risk within the town of Newman is also likely to be low because the depths and velocities are likely to be low and the amount of time it would take for floodwaters to travel downstream would allow for evacuation.

Future Without Project Conditions:

The watershed is very remote and is not very close to any urbanizing areas. Therefore it does not appear likely that it would change significantly within the next 50 years. It is possible that topographic changes could occur due to farming practices and land leveling which is common in the area and this translates to uncertainty in the floodplain mapping. There is a potential for inland climate change but uncertainty in topographic aspects appears to be much greater.

Potential Alternatives:

1) Ring levee to direct the shallow floodwater around the town. Low Cost.

2) Upstream reservoir to store floodwater and release at non-damaging flow. Highest Cost.

3) Levees along Channel. High Cost.

4) Relocations: Moderate Cost.

5) Flood proofing. Low Cost.

All alternatives should include an emergency action plan that includes road closures and signage at low water crossings.

Considerations for Technical Analysis:

1) Hydrology: Hydrology analysis will probably need to use HEC-HMS because hydrographs would be needed to look at potential reservoir site. In addition, broad alluvial fan flooding is highly dependent on flood hydrograph volumes. Need to make sure the storm duration is long enough to simulate reservoir storage and antecedent events that could impact capacity of reservoir prior to event. Will probably need HEC-ResSim analysis to evaluate the operation of the reservoir alternative. Will need Probable Maximum Flood estimate to size spillway for reservoir alternative. The hydrology model will also need to provide local runoff from the alluvial fan surface. Look into modeling local runoff as direct rainfall in the hydraulic model. Will need to estimate the peak flow frequency of the San Joaquin River in order to account for residual flooding in the comingled area. Hydrographs are probably not needed for the San Joaquin River because it is a large river and the study could assume steady state conditions.

2) Hydraulics: Recommend a HEC-RAS 2-D model because the floodplain is unconfined and flow direction may vary by flood event. The model would need to extend upstream to the where the flows are contained by the mountain slopes. Might need to broaden area to account for local runoff on alluvial fan surface. Need to make sure the model incorporates topographic definition of the embankment features which appear to significantly impact the shallow flows. Might need to model the channel in 1-D in order to evaluate levee alternative. However, 2-D might be sufficient for channel for initial screening and switch to 1-D after ADM if channel modifications are part of the TSP. Will need to simulate several embankment failures to support life risk modeling of the ring levee alternative. Channel stability might be an issue for the levee alternative and need for grade control and bank protection will need to be assessed. Managed overtopping will also need to be assessed for the levee alternative.

3) Economics: Economic damage areas should be delineated based on comingled sources of flooding and location of ring levee. Need to determine logical selection of flood proofing and relocation alternatives.

4) Life risk models will be needed to evaluate incremental life loss for the reservoir and levee alternatives. Residual risk appears to be relatively low and will probably be reduced even further in line with alternatives being considered. Nonstructural measures such as Emergency Action Plans and Evacuation Plans could also reduce life loss.