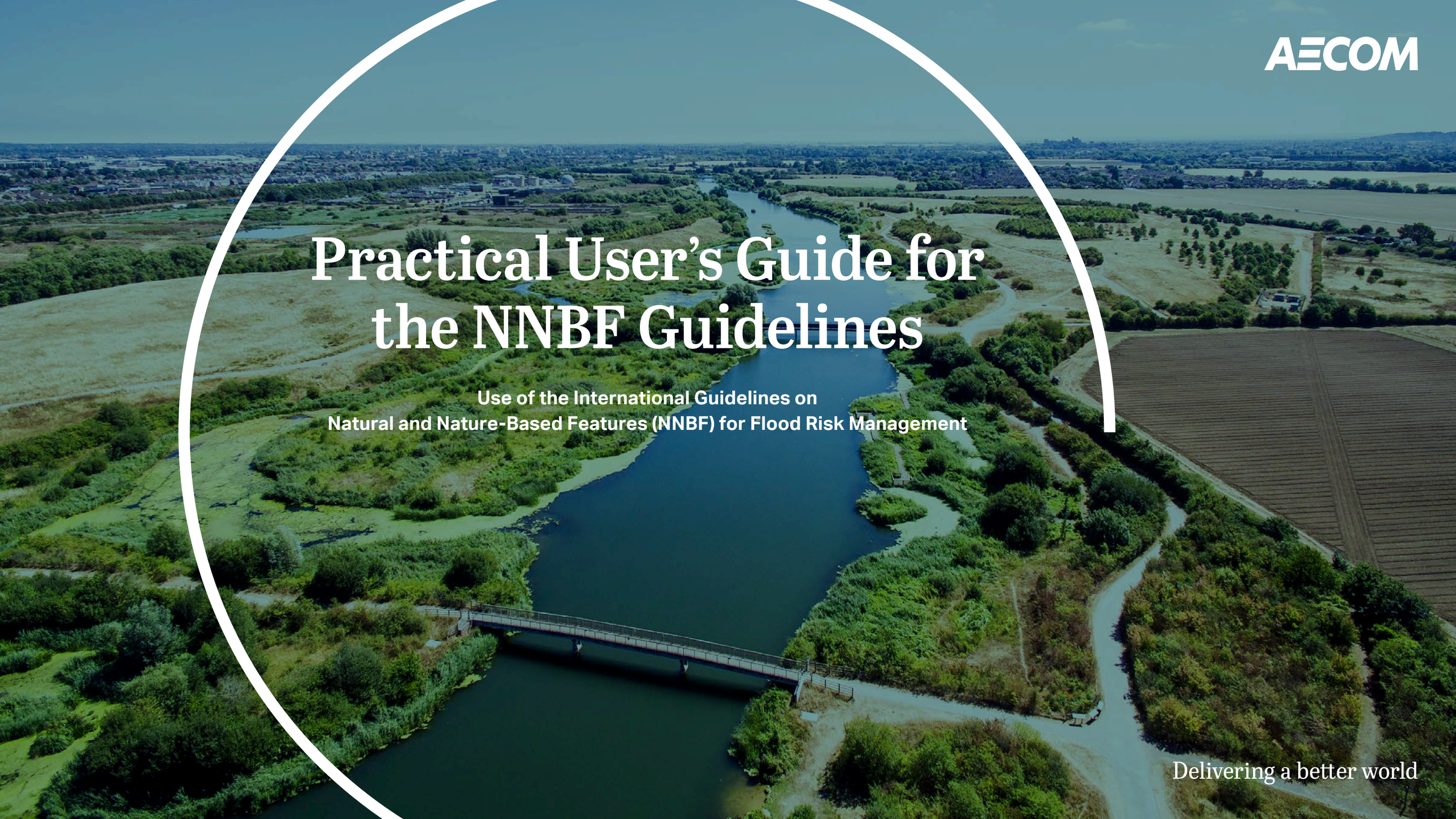
AECOM

Practical User's Guide for the NNBF Guidelines

Use of the International Guidelines on Natural and Nature-Based Features (NNBF) for Flood Risk Management



Delivering a better world

The NNBF Guidelines provide a wealth of information for flood risk management practitioners. AECOM's Practical User's Guide aims to highlight key findings based on the following two categories of information.

Planning

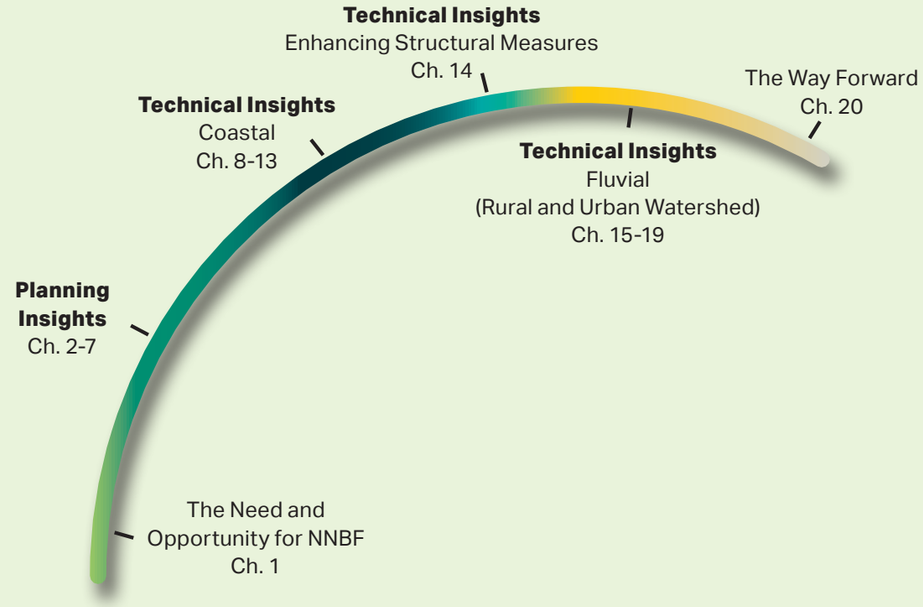
Chapters 1 through 7 of the Guidelines focus on planning concepts that can be advantageous to the development of NNBF solutions, understanding the complexities of partnerships, and capturing potential project benefits.

Technical

Chapters 8 through 19 of the Guidelines provide in-depth understanding of NNBF project types. These chapters lead users through understanding of coastal (Chapters 8-14) and fluvial, inland watershed (Chapters 15-19) systems, and the role of NNBF for hazard mitigation.

The Role of the Practical Guide

The NNBF Guidelines document is extensive and thorough; to complement this publication, AECOM has assembled this Practical User's Guide. This practical guide succinctly summarizes the Guidelines document and acts as a quick reference navigation tool. The NNBF Guidelines were developed through a consortium led by the U. S. Army Corps of Engineers (USACE), as part of the Engineering With Nature (EWN) Initiative, with partners contributing their unique insights from around the globe. This collaborative approach to authorship within the Guidelines results in each chapter or larger grouping of chapters having unique structures. For example, the Coastal collection of chapters is organized by feature type, while the Fluvial collection instead follows a framework of cause, effect, and approach. While collaborative authorship was undoubtedly the most practical and comprehensive approach to creating a collection of information on the topic of NNBF, the non-uniformity can be an obstacle to a first-time user. This practical guide aims to coalesce the Guidelines structure into a highly approachable format. AECOM has also developed six (6) key takeaways of guideline themes that are woven throughout.



The AECOM team has grouped the content into six topics and carried this organization throughout the Practical User's Guide, aligning with the overarching Planning and Technical categories. Chapters 1 and 20 are independent of the planning and technical categories, serving as bookends to the NNBF Guidelines. Additionally, each section of the Practical User's Guide refers back to the NNBF Guidelines chapters and page numbers for quick cross-referencing.

The Need and Opportunity for NNBF

Chapter 1
Pages 1-18

Chapter 1 of the NNBF Guidelines is an excellent resource to understand the role of NNBF in flood risk management. This chapter is helpful to determine if a stakeholder has an opportunity to link a nature-based solution with mitigating flood hazards, which is the first step for projects to utilize and potentially benefit from the remainder of the Guidelines. Given this connection, AECOM developed the following key takeaways.

AECOM's Six Key Takeaways from the NNBF Guidelines

#1 Natural and nature-based features aim to facilitate the function of natural systems

NNBF designs should aim to facilitate the function of natural systems, not simply mimic their aesthetic. Project designs should take advantage of the power of nature to provide resilient flood and erosion protection, while minimizing costs and taking advantage of NNBF's abilities to self-maintain and naturally adapt over time. NNBF should allow natural processes to occur and provide adequate space for natural variability (e.g., seasonal and annual changes and extreme events) considering existing conditions and future climate change.

#2 Natural and nature-based features have a decades-long track record of success

The use of NNBF has been growing and maturing for several decades within the engineering and environmental community; recently, NNBF have become more mainstream in planning and policy. While universal design guidelines do not exist because of the unique factors and conditions of each region and project site, there is more than enough evidence and experience to successfully design and implement NNBF with high levels of confidence to achieve a range of benefits, including improved flood risk management.

#3 Natural and nature-based features provide a broad range of co-benefits

NNBFs can achieve the risk reduction benefits of traditional infrastructure (e.g., flood protection and erosion control) while also increasing long-term resilience and providing a broader suite of socioeconomic and environmental co-benefits that may not be typically considered by project designers (including benefits to habitat, fisheries, climate change mitigation, tourism and recreation, human health, water quality, and sediment supply).

#4 Consider the broader context of the system

NNBF projects don't exist independent of their surroundings and need to consider the broader context of the systems that they are a part of. These systems should include the natural system, but also the developed, social, and economic components as well. NNBF elements can exist as large-scale, standalone projects or as smaller components of a larger flood risk management effort that cumulatively provides the desired benefits. Providing system connectivity along and across NNBF sites is critical, as well as connectivity to and functional redundancy with other habitats in the system.

#5 Open the door for stakeholder collaboration and funding streams

NNBF projects provide unique opportunities for community and stakeholder engagement and access to multiple sources of funding. Because NNBF projects provide a broad range of co-benefits to multiple beneficiaries, they necessitate early, inclusive, and professional engagement. While this can be challenging and may require larger up front collaboration investments, those costs are often offset by supportive contributions from stakeholders interested in long-term project success.

#6 Embrace uncertainty and manage natural and nature-based feature projects adaptively

Natural systems are dynamic and will evolve over time. Like structural measures, NNBFs may be damaged or deteriorate over time and require maintenance; however, unlike structural measures, NNBFs are able to adapt to changing conditions or events that exceed design conditions. As such, expectations and performance criteria for NNBFs need to be flexible and adaptable. Adaptive management is a key strategy to address data gaps, reduce project uncertainties, and improve outcomes and performance over time in a controlled way to ensure desired project performance and benefits.

Chapters 2-7

Pages 19-318

Planning Insights

Project Lifecycles

Chapters 2, 5, and 6 provide an understanding of project planning concepts that define the project lifecycle. These are the primary components to conceptualizing a project and setting realistic expectations and performance criteria.

Reviewing these chapters is recommended if you are formulating the foundational components of your NNBF project.

CHAPTER 2. PRINCIPLES, FRAMEWORKS, AND OUTCOMES

Often overlooked or skipped over, this covers developing the full NNBF project vision from concept through monitoring. Unique insights are provided to understand risks and uncertainties. It also discusses how to understand project lifecycles through a comprehensive framework, including how to think through desired outcomes for all phases of the project.

CHAPTER 5. PERFORMANCE

Provides an emphasis on project performance which should consider desired outcomes from ecological, social, and economic perspectives. Performance should be considered over the entire project life cycle, considering all possible scenarios (e.g., two simultaneous flood events), including chronic (e.g., sea level rise) and acute (e.g., rainfall event) hazards. A source-pathway-receptor-consequence conceptual model is outlined as a baseline and performance assessment method. Ultimately, defining project performance metrics early in the planning process is key, especially because understanding these metrics is an evolving science that can increase uncertainty when not well defined.

CHAPTER 6. BENEFITS AND COSTS

Often times, project viability hinges on the ability to demonstrate that its benefits outweigh the costs; however, this can be highly complex and data intensive with multiple assessment methodologies (most typically cost-benefit analyses). This chapter takes the user deep into methods for assessing benefits, including the performance of NNBF projects. For flood mitigation, project performance primarily relies on (1) risk reduction and resilience benefits and (2) co-benefits, which are highly specific to each type of NNBF. Incorporating co-benefits can be influential in differentiating NNBF from traditional flood risk solutions. This chapter also dives into development of costs for NNBF, including costs of design, permitting, acquisition, creation/protection/restoration, maintenance, and monitoring.

Understanding the Natural System

Chapters 3, 4, and 7 are integral to understanding and leveraging the natural system in the project approach. At their core, NNBF projects are about how natural systems can be used as a foundation upon which to build value.

Reviewing these chapters is recommended to learn about the strategies that are most beneficial to users looking to understand natural systems.

CHAPTER 3. ENGAGEMENT

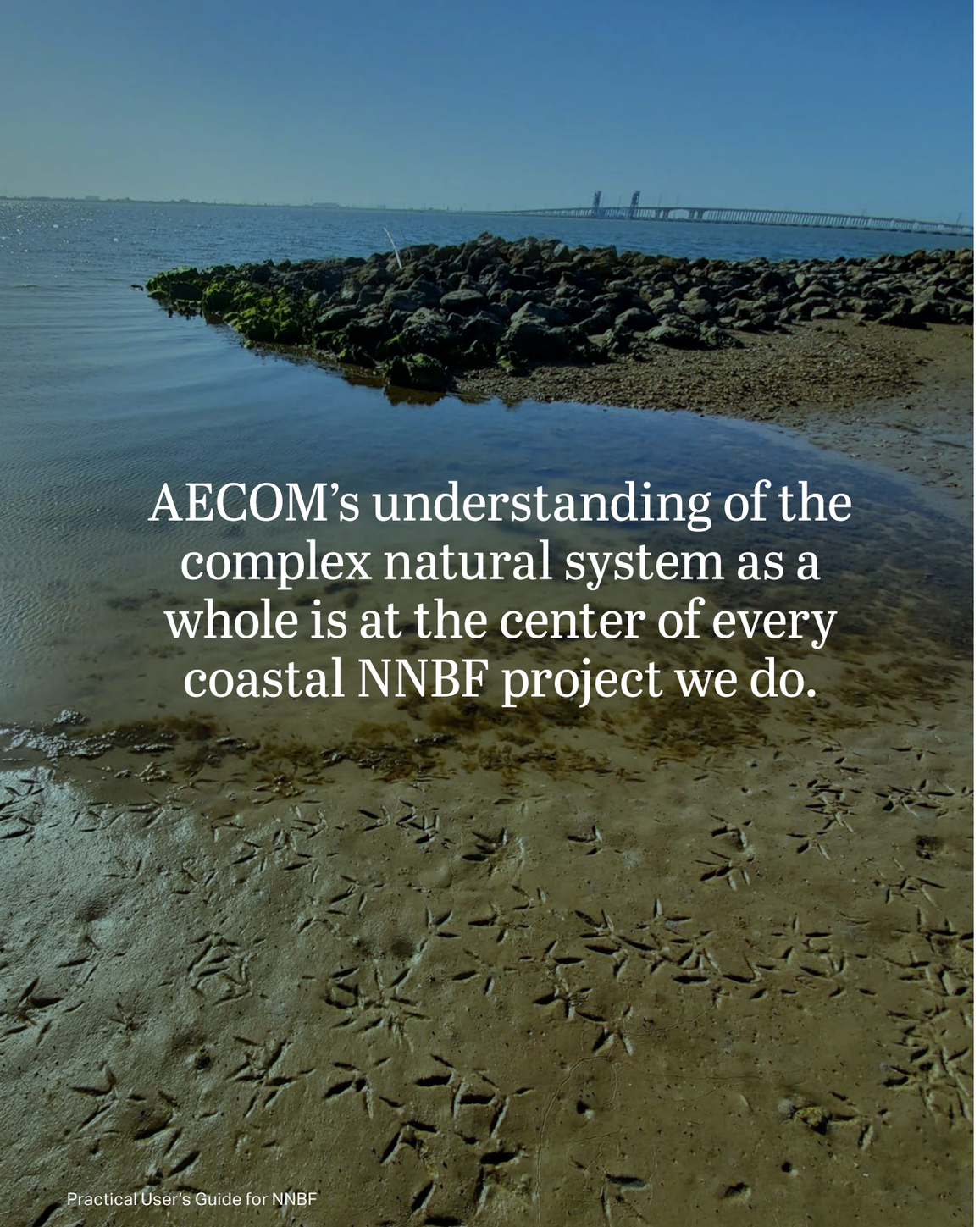
Beyond traditional stakeholder engagement, this explores the broader facility that NNBF projects provide to engage local communities. Because NNBF projects tend to require more diverse stakeholder groups, there are greater opportunities to foster community spirit and empower stakeholders. Furthermore, this type of engagement often leads to more expansive benefits, as discussed in Chapter 6. Importantly, the Guidelines provide pathways to build trust with stakeholders, including a quick guide to a phased breakout of three different levels of engagement. Users should remember that, in most cases, the more diverse the project's stakeholder group, the more informed the project will become through deeper understanding of the natural system and its functions.

CHAPTER 4. SYSTEMS APPROACH

While it can be daunting to think of projects at a systems scale because of challenges such as political boundaries or potential cost, doing so can lead to greater likelihoods of success and expanded benefits. Often, the realization that the natural system provides hazard mitigation occurs after a disaster, but this chapter pushes the idea of being proactive in approaching hazard mitigation needs with NNBF. Under this systems mindset, realizing environmental, social, and economic project benefits increase project feasibility; likewise, improves temporal and spatial project considerations. Finally, this chapter complements the Chapter 3 engagement discussion as a systems approach is a driver for broader stakeholder groups early in the project process.

CHAPTER 7. ADAPTIVE MANAGEMENT

Concluding the planning discussion is a chapter on adaptive management. In the case of NNBF, adaptation is more important than for traditional engineering projects for two main reasons. Firstly, NNBF projects are adaptive by nature, meaning they will evolve and change over time, ideally in a way that better promotes resilience to mitigate climate change and other changing hazards. To improve how we respond, we need to reflect on potential future environmental changes and develop adaptive projects from the onset. Secondly, there is still significant uncertainty regarding NNBF project performance, leading to a need for continuous learning, improvement, and broad communication.



Chapters 8-13

Pages 319-700

Technical Insights - Coastal

The NNBF Guidelines provide significant technical resources and insights organized by coastal feature in chapters: 8-13 as noted below. AECOM recommends navigating these chapters by considering the hazard(s) you are looking to mitigate and considering your options accordingly. For coastal scenarios, the hazards are primarily captured as:

- Wave propagation and related exposure to coastal assets;
- Rising water levels: low-frequency storm surge and/or long-term sea level rise; and
- Shoreline erosion and sediment transport, including natural- and built-system exposure.

After understanding the potential hazards at the project site and other characteristics of the local coastal system, users can select from the list of chapters given below based on the feature(s) that are most appropriate to the project site. It is relevant to note that most coastal systems include multiple of these features and that many of the most effective coastal NNBF projects will include multiple components. Key chapter considerations for each type of feature are noted below.

CHAPTER 8. NNBF IN COASTAL SYSTEMS
Introduces the role of NNBF in coastal systems broadly and introduces the various potential benefits to be captured through coastal NNBF.

CHAPTER 9. BEACHES AND DUNES
Beaches and dunes are important to flood risk management because they can dissipate wave energy, trap sediments, and potentially accrete above sea level. These are temporal systems with geometries and shoreline locations that vary seasonally. Understanding past, present and future system dynamics are critical for understanding sediment budgets and the interactions with ecological and human systems.

CHAPTER 10. WETLANDS AND TIDAL FLATS
Most NNBF projects under this category will focus on wetlands, as there is extensive knowledge in that field, meaning wetlands are more readily able to provide direct benefits compared to tidal flats. Wetlands provide an adaptive component to shoreline management. Wetlands primarily reduce erosion, but can also provide wave attenuation, floodwater storage, and even surge mitigation when implemented at large scales.

CHAPTER 11. ISLANDS
The potential flood management benefits of islands are heavily tied to project footprints. In general, islands are often the product of opportunity from beneficial use of dredged material near navigation channels. Because of this, islands are often highly dynamic and may have higher construction costs relative to the benefits without cost reduction measures, such as cost sharing with project partners. These costs are dependent on scale and whether the island is new construction or enhancement of an existing island.

CHAPTER 12. REEFS
Reefs are frequently NNBF candidates, so there is significant industry knowledge about their benefits. The primary benefit of reefs is mitigating wave energy. Shoreline stability is a secondary benefit, but is largely dependent on reef elevation and width which dictates wave attenuation capabilities.

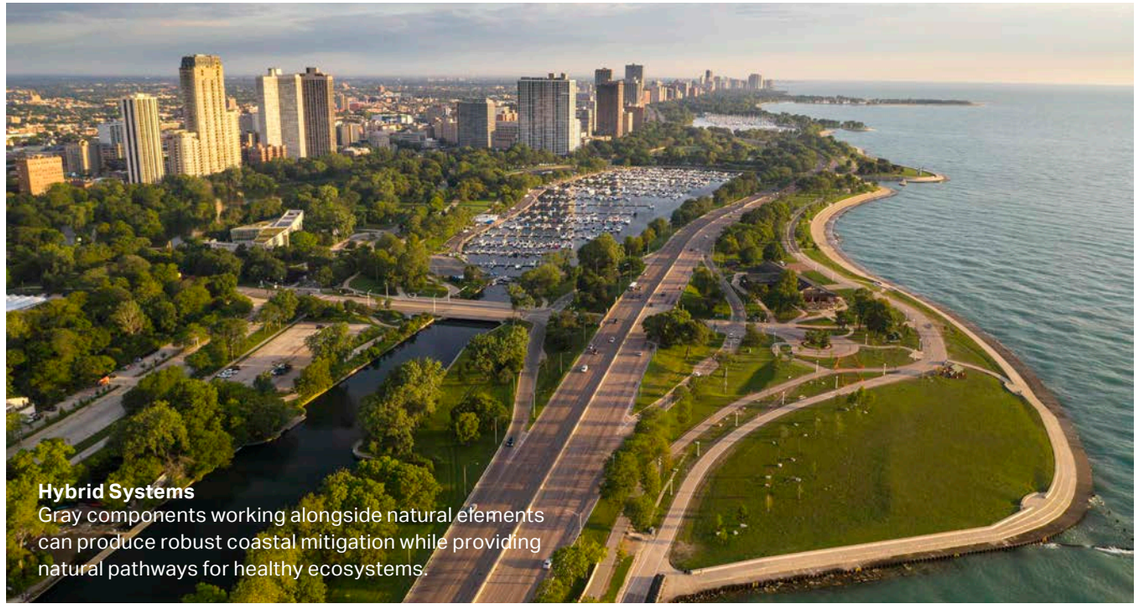
CHAPTER 13. PLANT SYSTEMS
Submerged aquatic vegetation (SAV) can provide sediment stabilization and wave attenuation, but in most cases this vegetation will be complementary to other features for flood management efforts. SAV can provide significant ecological benefits, expanding project potential. SAV is also highly dynamic, and for success requires suitable conditions which should include consideration of future conditions.

Chapter 14

Pages 701-771

Technical Insights - Enhancing Structural Measures

While it is often preferable to develop NNBF projects from the ground up, there are often situations where significant structural flood management measures are already in place that need to be considered. This chapter provides insights on how to work with existing structural systems and introduce NNBF to them, both as part of a new project or as retrofits. In these cases, the structural measures are likely providing robust, engineered mitigation for flood hazards and natural features could be added to diversify the project benefits. The added function generated by introducing NNBF would provide ecological benefits, creating an environmental asset in addition to an engineered one, as well as quality of life improvements for the surrounding community.



Hybrid Systems
Gray components working alongside natural elements can produce robust coastal mitigation while providing natural pathways for healthy ecosystems.

NNBF can unite communities more closely to their surrounding natural systems while helping manage flood risk at all levels.

1

As an example, living shorelines can be constructed to include bird nesting areas, so projects maintain engineered functionality while adding habitat value.

2

Community pocket parks are valuable ways to enhance quality of life while also increasing water storage to mitigate potential flood events.

3

Creating small, repeated green spaces throughout a community can lead to increased local investment in the natural system while also providing urban habitat areas.

Chapters 15-19

Pages 772-966

Technical Insights - Fluvial (Rural and Urban Watershed)

The fluvial portion of the NNBF Guidelines is organized in a different manner than the coastal portion. The fluvial chapters are not divided by feature type, but rather by fundamental concepts contributing to development and implementation of watershed-based NNBF. The five fluvial chapters walk through a concept introduction, the relationship of NNBF to flood risk management, benefits and challenges, fluvial NNBF applications, and case studies. AECOM recommends referencing these chapters based on the user's project role and experience.

CHAPTERS 15 AND 16. HOW WE GOT HERE

Much of an area's fluvial flood risk is the result of centuries of human development in watersheds by building in floodplains, modifying riverine systems, and changing hydrologic flow patterns. Chapters 15 and 16 are deep and insightful resources to better understand this historical and current dynamic. Understanding this context of the current situation of flood risk management allows stakeholders to better conceptualize NNBF projects, and for users that have little exposure to these concepts, these chapters are valuable resources. These chapters can provide an understanding of residual impacts, or how a change at one location can impact another upstream or downstream. Likewise, they can also help enlighten users to unintended consequences. This is information that has historically not been considered, as in most cases, watersheds were engineered for specific solutions, while not always realizing the system-wide impacts resulting from a localized viewpoint.

CHAPTER 17. THE CHALLENGING PATH FORWARD

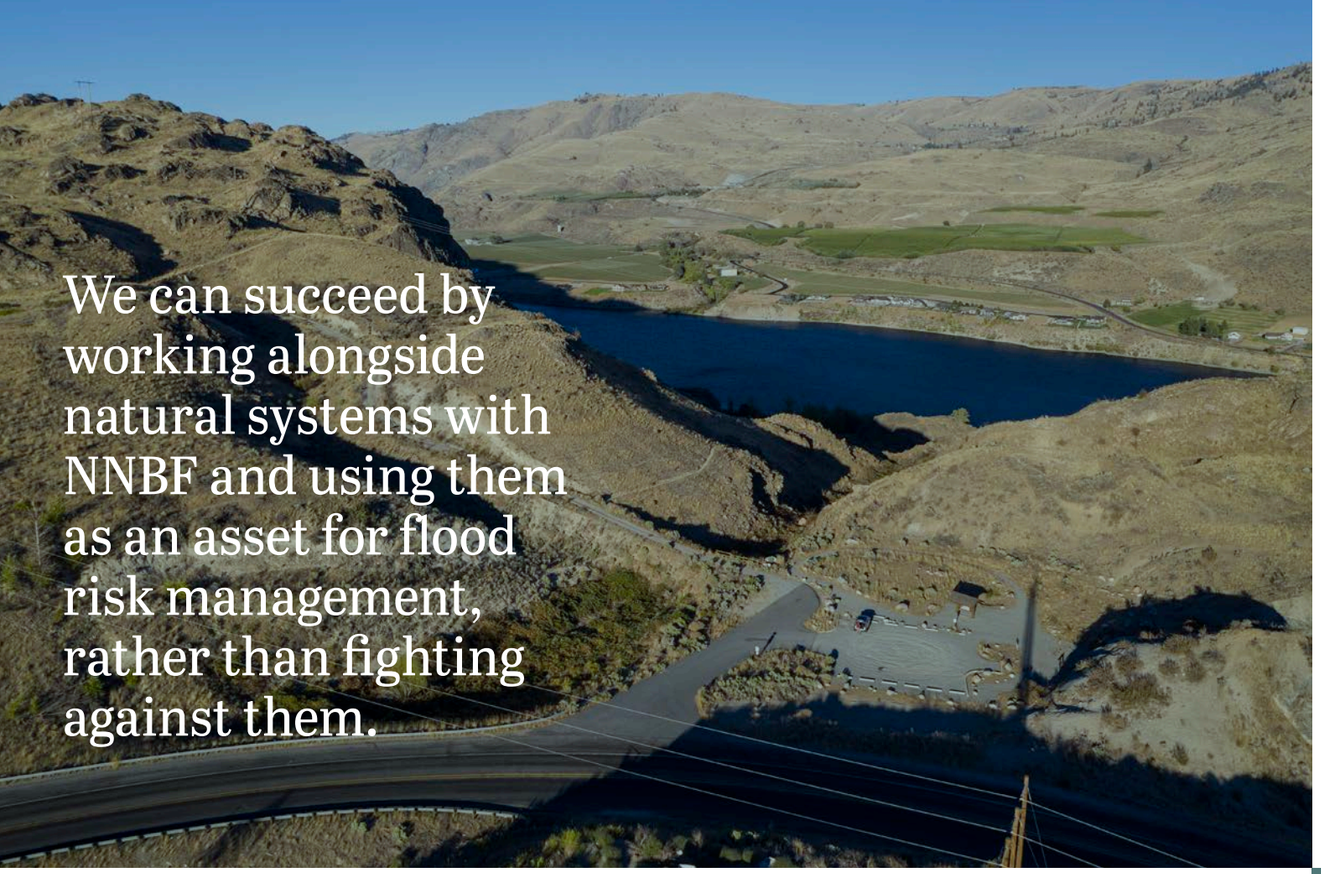
Building off of the previous chapters, this explores the significant systemic challenges we face from the approaches in developed watersheds and how past decisions have enacted barriers to NNBF in urban development. It delves into how existing conditions can limit desired modifications within the watershed, but also highlights how they can create opportunities through widespread benefits. Restoring the natural system functionality of watersheds is most viable through storage and conveyance NNBF.

CHAPTER 18. FLUVIAL NATURAL AND NATURE-BASED FEATURE APPROACHES

This chapter focuses on specific approaches to NNBF in fluvial scenarios. In most cases, approaches are divided into rural and urban scenarios, as there are significant differences, in most cases, between the two. In rural settings, preserving and restoring a large-scale floodplain may be possible. Risk may be reduced with development limitations or with the reduction or slowing of runoff in a widespread area to benefit downstream urban areas. As NNBF move into more urban settings, often they will need to be paired with traditional engineered solutions in hybrid formats to achieve a broader set of project goals and provide significant flood risk management. Co-benefits are also covered, illustrating how to achieve and recognize secondary, but important, benefits.

CHAPTER 19. FLUVIAL CASE STUDIES

Valuable fluvial NNBF case studies are presented. Often, having a specific example to give evidence for a concept is one of the most valuable tools available to stakeholders. The Guidelines include a range of case studies covering rural and urban fluvial projects from across the globe. It is likely that users can find a relevant example that is similar to their future project concepts.



Chapter 20

Pages 967-972

The Way Forward

The final chapter of the Guidelines serves as call to realize the vision of NNBF globally. Specifically, it covers the need to consciously promote natural and nature-based projects, including development of analyses and information that will make them viable to the masses. It speaks to the ability for NNBF to be a bridge for a more inclusive toolkit of engineered flood risk management solutions. Because NNBF projects can engage broad groups of stakeholders, decision makers, and the public as a whole, we should be compelled to take advantage of this. Finally, we must collaborate. Sharing knowledge and educating one another is the pathway for NNBF projects to become common place and create a truly systemic approach to resilience.

AECOM Corporate Initiatives are Supporting NNBF in Action

SUSTAINABLE LEGACIES

Sustainable Legacies, AECOM's Environmental, Social, and Governance (ESG) strategy, is our commitment to embed sustainable development and resilience across our work, improve social outcomes, achieve net zero, and enhance governance in all that we do.

AECOM has developed long-standing relationships with a diverse suite of clients working in the climate resilience and nature-based solutions space. We are leveraging our capacity to meet our Sustainable Legacy commitments to deliver projects for clients that align with their climate goals while benefiting the natural environment and local communities, including environmental justice and underserved communities.

Our AECOM team recognizes that there is work ahead for all of us to make NNBF more common in mitigating hazards, particularly flood risks. In alignment with the USACE EWN led efforts, AECOM is leading the way through multiple global initiatives that are promoting technical excellence and project implementation in this space. AECOM is committed to actionable Environmental, Social, and Governance (ESG) commitments. These initiatives span beyond flood risk management, bringing a comprehensive approach to addressing the needs of natural systems on a global scale.

Our AECOM values, projects, and commitments enable us to provide tested planning, engineering, design, implementation, and monitoring of NNBF to our clients.

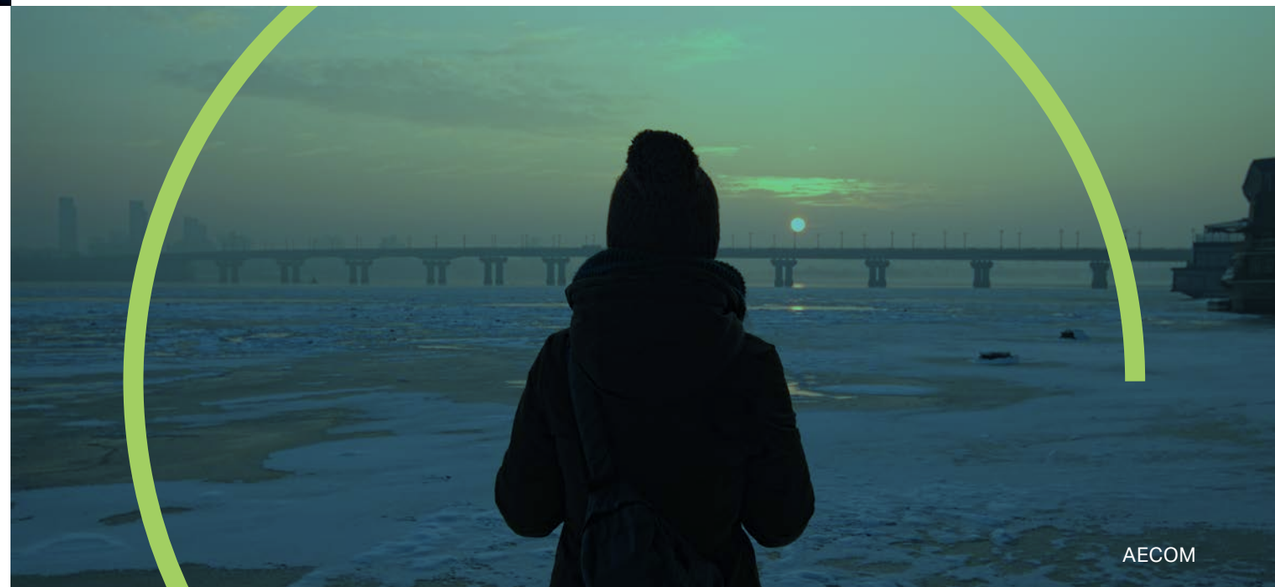


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Image Captions (AECOM Project Photographs)

1. Jubilee River, England (Photo Credit: Chris Coupland)
2. Morgana Bluffs Nature Preserve, OH (Photo Credit: Robb Williamson)
3. San Francisquito Creek Restoration, CA (Photo Credit: Robb Williamson)
4. Buffalo Bayou, TX (Photo Credit: Robb Williamson)
5. Virginia Point Living Shoreline, TX (Photo Credit: Chris Levitz)
6. Moses Lake Living Shoreline, TX (Photo Credit: Robb Williamson)
7. Fullerton Theater Shoreline, IL (Photo Credit: Robb Williamson)
8. Bonifacio Global City, Philippines (Photo Credit: Robb Williamson)
9. Springfield Dam Regeneration, Northern Ireland (Photo Credit: AECOM)
10. Beebe Springs Natural Area, WA (Photo Credit: Robb Williamson)
11. California Bay-Delta, CA (Photo Credit: AECOM)

Check out the full online version of the Engineering with Nature document titled *International Guidelines on Natural and Nature-Based Features for Flood Risk Management*

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