WORKSHOP 6 PROCEEDINGS // MARCH 22ND, 2023

THE NATURE-BASED EXCHANGE

Design Standards for Natural and Nature-Based Solutions, Part 1

The Nature Conservancy · SURCULUS · School of Architecture Resilient Urban Design · Biohabitats Southeast Atlantic Bioregion · Robinson Design Engineers

Cover photo: Stream daylighting and restoration project done at Hyatt Park in collaboration with the City of Columbia, Robinson Design Engineers, and KBS Landscape Architecture and Planning. This photo showcases in-progress construction of the stream channel and bank stabilization methods including choir matting, plant plugs, and live stakes. Construction started in early 2021 and finished in the fall of 2021.

Acknowledgments

Planning Team: This workshop series would not have been possible without the time, effort, and expertise of the planning team. Their countless hours of work led to the formation of a robust workshop series that Increased knowledge, spurred discussion, and produced tangible outcomes for South Carolina.

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Contributors: The successful execution of each workshop was due to our amazing contributors, including our speakers, panelists, and facilitators as well as those who worked behind the scenes to help us with planning and logistics, funding, and agenda-shaping.

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Host venue

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ACE Basin NERR/SCDNR Coastal Training Program
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Continuing education credits

Robinson Design Engineers
Nature-Based Exchange compendium

Amy Nguyen
Nature-Based Exchange compendium design

Workshop Series Timeline

There is often a gap between conceptualizing ideas for natural and nature-based solutions (NNBS) and developing practical and solution-oriented plans using them. To close this gap, The Nature Conservancy, Clemson's Resilient Urban Design Program, and the City of Charleston conducted a series of practical and outcome-based workshops that brought together a variety of local partners to discuss and develop NNBS. The goal was to synthesize existing knowledge and information on NNBS, align it with opportunities and barriers within the state of South Carolina, and create practical and equitable steps for implementation.

There are a total of seven workshops in the series. The first workshop served as a springboard for the rest of the series, offering an introduction to NNBS and gathering input from participants. The information gathered during that workshop informed the focal topics for the remaining workshops. Workshops 2 through 7 focused on one specific topic each to ensure a targeted conversation with produced outcomes.

WORKSHOP 1
Introduction to Natural and Nature-based Solutions
May 18th, 2022

WORKSHOP 2
Common Messaging on Natural and Nature-based Solutions
July 27th, 2022

WORKSHOP 3
Planning for Natural and Nature-based Solutions
September 14th, 2022

WORKSHOP 4
Funding NNBS: Navigating Grants, Risk Assessment, and Costs Benefit Analysis
November 16th, 2022

WORKSHOP 5
Equity in Natural and Nature-Based Solutions
January 18th, 2023

WORKSHOP 6 & 7
Design Standards for Natural and Nature-Based Solutions, Part 1 & 2
March 22nd, 2023
May 17th, 2023

Workshop 6: Design Standards for Natural & Nature-Based Solutions, Part 1

AGENDA ITEMS
(9:30 am - 12:30 pm)

- Welcome and Introduction
- NBS Design Process Case Study: Pensacola East Bay Oyster Habitat Restoration Project by David Bell, PWS, Jacobs
- Engineering Design Standards for Nature-Based Solutions to Water Management by Joshua Robinson, MS, PE, Robinson Design Engineers
- Nature-Based Solutions . . . Living Systems by Keith Bowers, FASLA, PLA, PWS, Biohabitats, Inc.
- Clemson Extension Water Resources Programming by Kim Morganello, Clemson Extension
- Panel Discussion (Q&A)

The sixth Nature-Based Exchange workshop was focused on design standards, specifically from the perspectives of practitioners. Organized to demonstrate that natural and nature-based solutions are the new standard, not a risky or temporary fad, this workshop was loaded with an abundance of information that designers and practitioners of all kinds can find useful. Speakers covered topics such as design details, specifications, source material, and project examples as well as existing learning opportunities and certifications.

Through these presentations and case studies, the speakers made it clear that nature-based projects are not only possible, but they are already happening across South Carolina and beyond. As more education becomes available and more projects get in the ground each year, the excuses for not pursuing nature-based solutions should fade. By sharing knowledge and resources we can advance the use of nature-based projects across our state and encourage others to implement these projects as well.

NBS Design Process Case Study: Pensacola East Bay Oyster Habitat Restoration Project

DAVID BELL, PWS, JACOBS

While nature-based solutions have become more commonplace in recent years thanks to an increased understanding of their benefits, the design of these projects still carries risk, in part because many unknowns continue to exist, especially in large projects. As such, it is important for designers and engineers to **manage risk** throughout the design process to increase the chances of success. Some best practices to help mitigate risk include:

1. defining project objectives,
2. understanding baseline conditions,
3. performing rigorous monitoring and modeling, and
4. planning for future scenarios and extreme events.

If the design team follows these strategies, the risks may become better understood as the design process progresses, resulting in a design that is more resilient. Even though nature-based projects work with nature, basic design principles and best practices should still be followed, such as soliciting feedback on the design, creating a basis of design report, regularly checking cost estimates, and communicating with contractors throughout the process to better understand constructibility.

Case Study: Jacobs worked with the Florida chapter of The Nature Conservancy to design, permit, and construct 33 oyster reefs in Pensacola East Bay, Florida. The reef area totaled approximately 6 acres and spanned nearly 6.5 miles of shoreline. Funded by the National Fish and Wildlife Foundation's Deepwater Horizon settlement grant, the project sought to increase oyster and estuary habitat without impacting the adjacent shoreline. An interdisciplinary approach was used to integrate ecology, engineering, and modeling into the preliminary design, which considered a range of materials and shapes to develop oyster reefs with a 25-year design life. By working with a contractor through a Construction Management At-Risk (CMAR) process, the team was able to solidify reef designs, layout, and materials in a cost-effective way that met project objectives. While the design team encountered multiple challenges along the road to the final design, they were able to overcome each one by being flexible and adapting as they went. The overall project took 12 years to accomplish from initial conception and funding through design construction. Eight months after construction, monitoring of the site indicated oyster recruitment and positive changes in the ecological community, demonstrating success.

WORKSHOP 6 PROCEEDINGS // NBS DESIGN PROCESS CASE STUDY

A few of the built oyster reefs that Jacobs designed for Pensacola East Bay, Florida. Top photo by NWFWMD and bottom photo by Russell C. Mick.

Engineering Design Standards for Nature-Based Solutions to Water Management

JOSHUA ROBINSON, MS, PE, ROBINSON DESIGN ENGINEERS

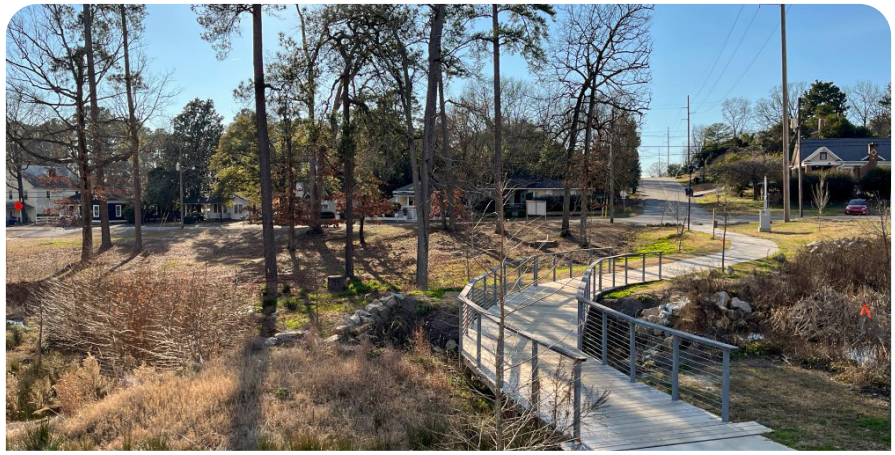
There has long been a sentiment in the United States that water is a problem to be solved and that the best solution is to simply get rid of the water using whatever means necessary. As we have learned more about the limitations of hard infrastructure, the benefits of nature-based solutions, and the power of water, this mentality has begun to change. Yet many of our laws and regulations continue to uphold the old way of thinking, preventing large-scale cultural change.

There are three main drivers that influence engineering design: **risk**, **cost**, and **regulations**. Projects should be designed to mitigate risks while prioritizing the safety, health, property, and welfare of the public. Cost limits the extent that risks can be addressed while regulations set requirements on how the project can be designed. Since risk, cost, and regulations are the foundation of design decisions, Robinson Design Engineers (RDE) has begun to offer clients multiple design concepts, ranging from nature-based solutions to conventional hard infrastructure, with detailed explanations on the risk, cost, and regulations for each concept. Not only does this method clearly show the client the tradeoffs of different approaches, but it also gives them the opportunity to fairly consider nature-based solutions.

	Conventional Design	*Nature-Based Design*
Risk	Discrete problem definition	Multi-objective
	Prescriptive design	Iterative design, context-specific
	Static structures	Dynamic processes
	Construction focus	Adaptive management
	Maintenance divorced from design	Stewardship intrinsic to design
Cost	Design fees 3 to 5%	Design fees depend on objectives
	Large first costs expected	First costs depend on objectives
	Externalized downstream costs	Externalized downstream benefits
	Retrofits are expensive	Routine management budgeted
	Large decommissioning costs	No decommissioning
Regulations	Site	System
	"Standard of care"	Interdisciplinary
	Design manuals	Reference condition
	Pre-construction permitting	Post-construction monitoring
	Limited accountability	Long-term commitment

Chart #1: Comparing Conventional Design and Nature-Based Design in Risk, Cost, and Regulations

WORKSHOP 6 PROCEEDINGS // ENGINEERING DESIGN STANDARDS



Above image: Daylighting case study project at Hyatt Park, Columbia, SC. Hyatt Park is now a bustling public space with meandering trails and boardwalks, native plantings, and infrastructure for people of all ages to enjoy.

While each design alternative will come with its own tradeoffs, there are some general comparisons between conventional design and nature-based design that prove true in most cases (refer to Chart #1).

RDE has used this approach with multiple clients, resulting in the inclusion of nature-based elements where they otherwise may not have been incorporated. Examples include **Hyatt Park in Columbia, SC** and **Turkey Creek Canal in Sumter, SC**. At Hyatt Park, RDE was tasked with daylighting (or restoring) the historic creek to its natural state, resulting in the removal of approximately 1,000 feet of pipe. This restoration transformed a place that once was a source of flooding downstream into a functional landscape that attenuates floodwaters, retains stormwater, creates aquatic habitat, and improves water quality downstream. The Turkey Creek Canal project addressed erosion, sedimentation, and downcutting by using a conventional engineering approach along the bottom of the creek and a bioengineered, more natural approach along the top. This flexible, combination approach saved trees along the canal while supporting the flow of water and sediment.

By thinking through different design alternatives (including ways the design could fail and the associated consequences of that failure) and comparing the full life cycle costs of all alternatives, designers (and their clients) can have a clearer understanding of which design is suitable for their needs and budget, hopefully leading to the design of more nature-based projects.

Nature-Based Solutions . . . Living Systems

KEITH BOWERS, FASLA, PLA, PWS, BIOHABITATS, INC.

Nature-based solutions are living systems; if we truly want to design in a way that incorporates, benefits, and mimics nature, we must consider all aspects of living systems – from soil, water, flora, and fauna to processes that are mostly invisible to the naked eye, such as the food web, climate, community dynamics, and water and nutrient cycles. While there are many aspects of living systems to analyze and implement into a project's design, four key categories include **reference communities**, **soils**, **planting**, and **habitat enhancement features**. The more we think about these aspects and plan for associated risks, the better we can design a project to stand up to unforeseen conditions and thrive for years to come.

Reference Communities

The best way to imitate nature in a project's design is to visit and analyze reference communities in the surrounding area and apply those findings to the project site. Analyses should consider:

- Fauna – What focal species will occupy the site? What plants do they rely on? What geomorphological and hydrological elements need to be present to make the area a suitable habitat? Will the food web support them?
- Flora – What plant communities exist? Will the community be viable in the future due to climate change? Will the species shift in their range? Where are species growing in the landscape? What geomorphological and hydrological elements make the site suitable for their growth?

While it is important to consider how climate change will impact the area, the composition and processes that evolved on the site serve as our best analog for restoring the future.

Above image: Stream restoration case study project at Unity Park, Greenville, SC.

Soils

Soils are the foundation of everything we do, and yet for many nature-based projects, they are an afterthought. Soil quality – including its physical, chemical, and biological components – will influence plant community structure and composition, food webs, and nutrient cycles, as well as overall project success, so it is vital to have a deep understanding of existing soils prior to site disturbance and development activities. Soil assessments should consider:

- What is the soil quality and composition of the site (down to the level of final grades)?
- Have soil horizons been impacted? If so, how can those horizons be reestablished?
- Does the soil contain beneficial mycorrhizal? If so, what is the plan to retain and restore mycorrhizal to the designed plant communities?
- What steps can be followed to keep, replace, and restore existing topsoil?
- What steps can be taken to prevent the use of peat moss at the site?

Top image: During rain event and high flood levels, Unity Park is designed to store flood waters.
Bottom image: Flood levels receding after 24 hours, allowing visitors to enjoy the park.

Planting (Revegetation)

There are multiple factors that should be considered before revegetating a site, including the site's context in the landscape, existing site conditions, reference conditions, and the timing of planting. Native plants that match the local genotype will likely outperform non-native plants or cultivars, although the availability of these species can be limited. When planning for revegetation, consider:

- How does the context of the site interact with the surrounding landscape?
- How do physical conditions – such as elevation, sun intensity, wind direction, and rainfall – affect the success of plant communities?
- What plant life cycles and seasonality differences must be considered when determining the timing of planting?
- Are the plants specified in the design native to the area? Do the specified plants match native genotypes?
- Can plant material be salvaged from nearby sites?
- How can the distribution, composition, size, and abundance of targeted plant species in reference communities be used to assist in planting design?

Habitat Enhancement Features

Habitat enhancement features, such as bird boxes, bird-friendly glass, large wood debris, and constructed aquatic habitat, can assist in recruitment and serve as refuge for local fauna. The use of wood and other natural elements can reestablish or recruit desired species to the site, even in urban settings. Including the community in the creation of these features can build community buy-in and serve as an education tool. When identifying habitat enhancement features, consider:

- What are the site's focal species? What other species are in the food web? What features would benefit these species?
- How can wood be returned to the landscape?
- Is there a way for the community to get involved in the construction or installation of these features?

Top image: Beaver Creek Floodplain Reconnection and Water Quality Enhancement, Munson Township, OH.

Bottom image: Sandy River Engineered Log Jam for Juvenal Salmonid Fish Habitat.

Clemson Extension Water Resources Programming

KIM MORGANELLO, CLEMSON EXTENSION

Clemson University is a Land-Grant University, comprised of a three-pronged system: education, research, and extension. Extension provides science-based information to the communities of South Carolina for the betterment of the state's economy and natural environment. Clemson Extension's Water Resources Team offers effective, in-depth water resource management training and engagement opportunities for community members and professionals in South Carolina and beyond. The courses offered by Clemson Extension provide educational support for the incorporation of nature-based solutions in South Carolina. In-person, online, and hybrid training opportunities cover diverse topics that inform participants on aspects of design, installation, maintenance, and inspection of nature-based projects as well as the stewardship of South Carolina's natural resources.

Clemson Extension seeks to identify water-related areas of concern and address those contributing factors through education whenever possible. Clemson Extension has enjoyed close partnerships and working relationships with State Agencies, Universities, Non-Profit Organizations, and the private sector to assure outreach products are as up-to-date and pertinent to the community needs as possible. Participants in Extension programs receive unbiased, science-based information enabling participants to feel confident and prepared for application of information gained in the field.

How the courses are designed...

HYBRID TRAINING APPROACH

Online Classroom + Hands-on Field Experience

The online classroom is asynchronous, allowing instructors to go into more detail while participants have the chance to learn at the time, place, and pace that works for them.

Online Classroom: includes audio recorded presentations, discussion forums, weekly quizzes, and a final exam.

Field Experience: offers participants the chance to apply information gained through hands-on learning activities.

AUDIENCE

Courses are designed for a diverse audience, including professionals seeking technical instruction and residential application. Certification courses offer participants the opportunity to take the full certificate class or take a portion of the class to receive a letter of completion based on their level of interest.

WORKSHOP 6 PROCEEDINGS // CLEMSON EXTENSION PROGRAMMING

Above image: Best Management Practices (BMP) Field Day in 2021

CLEMSON EXTENSION WATER RESOURCES PROGRAMMING COURSES

Certification Courses	Compliance-Based Stormwater Certification Courses (multiple)	Includes courses on erosion prevention, stormwater control, and stormwater plan review
	Master Pond Manager	Teaches stormwater and recreational ponds management
	Post Construction BMP Inspector	Explores inspection and maintenance methods for a variety of stormwater practices
	Master Rain Gardener	Covers the design, construction, and maintenance of rain gardens and rainwater harvesting systems
Short Courses	Dam Ownership in SC	Explains dam maintenance to ensure that both regulated and unregulated dams function as intended
	The Salt Marsh	Examines the South Carolina salt marsh and its role as a critical ecosystem
Courses in Development	Living Shorelines Training Program	Dives into the regulations, methods, design, construction, and maintenance of living shorelines
	Stormwater Plan Education for Engineering Design	Delves into regulations, permitting, hydrology, sedimentology, design, construction, and low impact development for stormwater projects

WORKSHOP 6 PROCEEDINGS // CLEMSON EXTENSION PROGRAMMING

Participants in Clemson Extension's Master Rain Gardener program installed two rain gardens and a cistern at the Green Hearts Community Garden at Enston Home in downtown Charleston. As part of the field day, participants gained hands-on experience complimenting lessons learned in the online portion on the class; field day activities include soil assessment, site analysis, system sizing, construction, landscape design, and more. To learn more about the program visit clemson.edu/raingarden

NBS Design Summary

While there can be many people involved in a nature-based project from concept development through permitting, construction, and monitoring, the success of the project often hinges on the work of the design team. Since nature-based solutions aim to protect, manage, and restore natural systems and, in many cases, also strive to offer social and economic benefits, there is a lot riding on a well-planned design that can be effective over many years. By spending time studying the site's ecology, considering the plant and animal communities who call the site home, and analyzing the natural processes that occur there, the design team can plan and prepare for risk, improving the chance of the project's success.

Nature-based projects should...

Be designed to mitigate risk

- Define project objectives
- Understand baseline conditions and site drivers
- Perform rigorous monitoring / modeling
- Plan for future scenarios and extreme events
- Align design criteria with risk profile
- Prepare for changes during construction

Follow design process (and engineering) best practices

- Implement industry best practices for design
- Identify a separate design manager and project manager
- Include proper discipline leads – engineering, modeling, ecology
- Identify independent QA/QC review
- Hold workshops/design charettes to solicit feedback
- Develop a basis of design document
- Track and manage risk throughout project life cycle
- Develop updated cost estimates – 30, 60, 80, and 100%
- Use a professional cost estimator
- Use most recent pricing information
- Talk with contractors

WORKSHOP 6 PROCEEDINGS // DESIGN SUMMARY

Consider risk, cost, and regulations

- Risk - Engineering designs should document and explain the uncertainty of the designs and describe the specific consequences of failure.
- Cost – Engineering designs should consider life cycle costs – including the cost of constructing, operating, maintaining, and decommissioning the infrastructure for its entire life span.
- Regulations – Engineering designs should include alternatives analyses for a range of solutions ranging from conventional to natural.

Analyze the living system surrounding the project site

Reference Communities

- Restore for the future, use historical fidelity as your guide
- Choose reference communities carefully – choose more than one if needed
- Select focal species to guide design decisions and verify ecological intent

Soils

- Assess soil conditions
- Protect existing soil
- Plan for soil movement
- Amend the soil as needed
- Adopt new design ideas

Planting (Revegetation)

- Design for an entire plant community
- Select the right plant for the right place
- Look back, plant forward
- Check for plant availability when making design decisions

Habitat Enhancement

- Wood is good, more is better
- Reinforce native fauna, consider food webs
- Manage, adaptively

Workshop Takeaways

- In the design industry, the three main factors that impact decision making are **risk**, **cost**, and **regulations**.
- Risk is inherently part of the design process, but there are ways to manage risk that support the long-term co-benefits provided by nature-based solutions.
- When planning for risk, designers should document and explain any uncertainty in the design and should describe specific consequences of failure.
- When determining the cost of a nature-based project, consider the **life cycle costs of the entire project,** including the costs for constructing, operating, maintaining, and decommissioning the infrastructure.
- Offering clients multiple design concepts that range from green to gray allows the designer to demonstrate the benefits of nature-based solutions while **allowing the client to select the option that best suits their needs and desires**.
- When designing nature-based projects, designers should define project objectives at the beginning of the project, consider a range of future scenarios and extreme events, understand base drivers throughout their entire life cycle, and implement rigorous monitoring and modeling.
- There are **many aspects of living systems that should be considered** when designing any nature-based project, including soil, water, flora, and fauna. Large-scale processes such as energy flow, water and nutrient cycles, community dynamics, and climate should also be incorporated into the design.
- It is recommended to **analyze the ecosystem surrounding the site as well as the site itself**. During analysis, pay attention to the focal species you want to attract; soil health, movement, and restoration; native plant presence, genetics, distribution, and abundance; and enhancement features that can be added to support and enhance the habitat.
- **The past is the best reference when designing for the future**. Therefore, designers should consider past and present communities and conditions in their design considerations.
- Assigning a designated design manager as well as discipline leads will make the design process smoother and will improve communication and understanding among the project team, especially on large projects.
- **Flexibility and adaptability** are needed throughout the design process and into construction.

Thank you to our attendees...

Thank you to everyone who attended the workshop. These individuals contributed their thoughts, energy, and enthusiasm to the exchange and are responsible for the ideas and content produced in this compendium.

Jana Baxley	**S.C. DHEC - Bureau of Water**
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Julianna Corbin	**Beaufort County Stormwater**
Tom Daniel	**S.C. DNR**
Katie Dennis	**City of Conway**
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Wanda Lilly	**City of Conway**
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Abby Stephens	**Coastal Conservation League**
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