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Realizing Multiple Benefits in a Southeast Louisiana Urban Flood Control Project through Application of Engineering With Nature® Principles

By Michelle Bourne, Jack Milazzo, and Burton Suedel

PURPOSE: The application of Engineering With Nature® (EWN®) principles in urban environments and watersheds within and outside the US Army Corps of Engineers (USACE) is increasing. Extreme rainfall events have triggered the need and development of more sustainable urban infrastructure in urban areas such as New Orleans, Louisiana. This technical note documents a USACE–New Orleans District (MVN) project that successfully applied EWN principles in an urban landscape to reduce flood risk while providing other environmental, social, economic, and engineering benefits to both the community and the environment.

BACKGROUND: Advancing best practices within USACE involves identifying actions that will better align and integrate engineered and natural systems to produce more socially acceptable, economically viable, and environmentally sustainable projects. EWN is a USACE initiative that supports more sustainable practices, projects, and outcomes by working to intentionally align natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through collaborative processes (Bridges et al. 2021, 2018; King et al. 2020). The EWN initiative fosters the development of practical methods to provide a holistic approach to infrastructure development that is applicable across multiple USACE missions and business lines. Projects demonstrating EWN principles illustrate the use of science and engineering to maximize natural processes to produce practical operational efficiencies that support substantiated engineering, economic, social, and environmental benefits while meeting project objectives. Science- and evidence-based collaborative processes that organize and focus interests, stakeholders, and partners to produce more broadly acceptable projects form a critical aspect of the EWN initiative (www.engineeringwithnature.org).

Developing sustainable and resilient infrastructure requires USACE to apply new approaches to engineering and operating infrastructure—especially given the predictions from the Intergovernmental Panel on Climate Change (IPCC) that the state of Louisiana can expect multiple extreme events in the coming years, including Category 3, 4, or 5 hurricanes accompanied by extreme rainfall, higher temperatures, and trending rising seas (Arias et al. 2021). The extreme rainfall events have triggered the need for and development of more sustainable urban infrastructure in New Orleans. As a result, USACE has changed its approach to the planning, design, and construction of infrastructure projects to respond to these extreme rainfall challenges (King et al. 2021; Holmes et al. 2021). To address this challenge directly, USACE launched the EWN initiative (and in 2021, the EWN program) to develop and demonstrate the capabilities

needed to achieve sustainable project outcomes. The implementation projects that embody EWN principles promote project designs that adapt to climate change and enhance resilience of communities and vulnerable and environmentally marginalized populations in the face of increasing flood risk. While engineers and scientists that practice EWN are knowledgeable about natural and engineering processes, they also understand the value that integrating the two provides to infrastructure projects. As King et al. (2021) explain, adding landscape architect (LA) expertise brings additional capability, in that LAs think about landscapes "in terms of performance criteria (such as flood risk reduction), ecological impacts (both positive and negative), and human interaction (such as recreational use and aesthetics), and how these factors interact with one another over time" (109). The following case study illustrates a project executed by multistakeholder collaboration, including MVN, that exemplifies how EWN concepts combined with LA principles (EWN-LA) addressed flood risk in an urban environment by designing and implementing a nature-based solution.

INTRODUCTION: The Southeast Louisiana Urban Flood Control Project (SELA) was authorized by Congress in 1996* in response to extensive flood damage in southeast Louisiana that occurred in 1989 and 1995 for the purpose of reducing the risk of flood damages from rainfall flooding in Orleans, Jefferson, and St. Tammany Parishes (USACE n.d.). The SELA improvements aim to support the parishes' master drainage plans and provide flood risk reduction up to a level associated with a 10-year rainfall event (USACE n.d.). Work for SELA is located on both the east and west banks of the Mississippi River in Orleans and Jefferson Parishes. The Louisiana Coastal Protection and Restoration Authority (CPRA) Board serves as the nonfederal sponsor, with strong support from local partners at Jefferson Parish, Sewerage and Water Board of New Orleans, St. Tammany Parish, and the City of Slidell.

The MVN played multiple roles in the project, including facilitating all aspects of planning, public scoping, stakeholder engagement, historic surveys, National Environmental Policy Act (NEPA)† compliance, agency coordination, hydraulic modeling, construction administration, quality assurance, and quality control throughout the project life cycle. In 2011, and prior to project design, MVN prepared a historic landscape inventory study for SELA that focused on local street infrastructure features existing in the past. The accompanying report inventoried and assessed historic landscape features intrinsic to the streetscape, including vegetation, lighting fixtures, encaustic (street name) tiles, and granite curbs. This detailed inventory and coordination with the city and the public during this initial stage provided a framework for a greenspace restoration plan to be developed (URS and Perez 2011). Following the construction of SELA, MVN provided LA expertise to interpret the historic landscape inventory and prepare a plan that would holistically restore the affected greenspace.

In Orleans Parish, SELA involves improving 16 major drainage lines, adding pumping capacity to two pump stations, and constructing two new pump stations (USACE n.d.). Planned improvements

* Energy and Water Development Appropriations Act of 1996, Pub. L. No. 104-46, § 108, 109 Stat. 402, 408, https://www.govinfo.gov/content/pkg/STATUTE-109/pdf/STATUTE-109-Pg402.pdf; Water Resources Development Act of 1996, Pub. L. No. 104-303, § 533, 110 Stat. 3658, 3775, https://www.govinfo.gov/content/pkg/PLAW-104publ303/pdf/PLAW-104publ303.pdf.

† National Environmental Policy Act of 1970, 42 U.S.C. 55 § 4321 et seq. (2020). https://www.govinfo.gov/content/pkg/USCODE-2020-title42/pdf/USCODE-2020-title42-chap55-sec4321.pdf.

in Orleans Parish include several projects within New Orleans city limits. This technical note presents one of the SELA improvements constructed on South Claiborne Avenue in the city of New Orleans as an example of the implementation of EWN-LA principles in urban environments.

CASE STUDY: A portion of SELA planning included work on South Claiborne Avenue to reduce flood risk to this part of New Orleans, which had experienced several street flooding events in the past, causing damages to street infrastructure and flooded nearby homes. Historically, this stretch of South Claiborne Avenue was an open canal built before the 1840s. The canal was covered in the 1970s, and greenspace was created in the neutral ground (median greenspace between the roadway) while preserving the drainage vault underneath (URS and Perez 2011). The informal plantings during this period consisted of live oak, palm, ornamental trees, and shrubs (Figure 1). Many of the plantings have since been disturbed by infilling, utility maintenance, and infrastructure upgrades.

Figure 1. The neutral ground (consisting of the greenspace between lanes of traffic) along South Claiborne Avenue before construction included informal plantings of native and ornamental trees.

In 2016, drainage flow was doubled through extensive culvert work on South Claiborne Avenue as part of SELA improvements (Figure 2). The culvert work required removing existing trees and disturbing greenspace along South Claiborne Avenue. As a result, the South Claiborne Avenue Phase 2 Greenspace Restoration project was constructed along South Claiborne Avenue from Leonidas Street to Pine Street (Figure 3). The greenspace restoration included planting native trees and grading efforts (that is, bioretention areas) to promote stormwater infiltration as green infrastructure components of the project.

Figure 2. On South Claiborne Avenue, a new canal was constructed next to the existing underground canal (culvert) below the neutral ground.

Figure 3. The South Claiborne Avenue Phase 2 Greenspace Restoration project (*blue line*) stretches from Leonidas Street (*center*) to Pine Street (*right*) in the city of New Orleans.

The four critical elements of EWN that define the progress and success of an EWN project are summarized as producing efficiencies, using natural processes, broadening benefits, and promoting collaboration (Bridges et al. 2018, iii). These EWN elements are used below to further describe this case study's urban greenspace transformation.

Producing efficiencies. Existing underground infrastructure was used to design and construct a second separate culvert (Figure 2), doubling stormwater capacity at a substantial cost savings over designing and constructing a single, new, underground culvert. Following the construction of the new culvert, the project completed extensive soil remediation. These efforts were essential to capture stormwater within the greenspace and allow the water to be absorbed into the ground for tree uptake within the urban context. Existing infrastructure constrained the measures that could be designed and implemented, including poor drainage in the roadway beds and shallow underground drainage vaults, both of which impeded stormwater infiltration. Existing streets have a cross slope that drains to the outer roadway, not towards the neutral grounds. And finally, maintenance requirements and constrained budgets prevented the city from including native grasses along the neutral ground to enhance the habitat value.

Existing infill consisted of heavy clays with nutrient deficiencies, which restricted root growth and water transfer. Soil permeability tests illustrated the need for extensive soil remediation to allow for stormwater to infiltrate the depressed areas. Using existing infill on nearby SELA projects, organic content and coarse sand were added to excavated material then mixed and placed 0.6 m (24 in)* in depth within critical root zones. Critical root zones were determined by the individual tree species' mature canopy extent. Depressions were excavated along the center of each median island, and a drainage soil layer lined the bottom of the depression (Figure 4). This coarse, sandy soil allowed stormwater to be stored for vegetation uptake and infiltration. Bermuda grass was planted in the bioretention areas for rapid soil-surface coverage and to reduce erosion and for its roots to serve as anchors to the underlying amended soil, improving permeability. Finished grades provided 0.3 m (12 in) of storage depth within the drainage soil layer and another 0.22 m (9 in) within each depression. The bioretention areas were designed and constructed for stormwater to infiltrate within 48 hours to address stakeholders' concern for standing water and the area becoming an attractive nuisance.

* For a full list of the spelled-out forms of the units of measure and the unit conversions used in this document, please refer to *US Government Publishing Office Style Manual*, 31st ed. (Washington, DC: US Government Publishing Office, 2016), 248–52 and 345–47, https://www.govinfo.gov/content/pkg/GPO-STYLEMANUAL-2016/pdf/GPO-STYLEMANUAL-2016.pdf.

Figure 4. Ground-level view of the bioretention component of the neutral ground. Bermuda grass was planted, consistent with New Orleans Department of Parks and Parkways maintenance standards, to foster biofiltration.

Using natural resources. As part of the greenspace restoration on South Claiborne Avenue, approximately 98 trees of a variety of native species were planted to restore trees removed prior to construction and to enhance habitat value. Tree selection was based on native species adapted to the region, wildlife habitat and food production provided, stormwater uptake, and historic and cultural vegetation inventory prior to construction. Additional selection criteria included size (large canopy and understory trees), aesthetic appearance (seasonal color, evergreen, foliage and flowers), and environmental considerations (contribute to enhanced biodiversity; provide shade, reduce runoff). Tree varieties included Nuttall oak (*Quercus texana*), bald cypress (*Taxodium distichum*), southern magnolia (*Magnolia grandiflora*), spruce pine (*Pinus glabra*), sweet bay magnolia (*Magnolia virginiana*), and crape myrtle "Muskogee" (*Lagerstromia indica*). While non-native, "the crape myrtle is unrivaled among Southern small-flowering trees in ease of culture, length of bloom, interesting trunks, and many other features" (Odenwald and Turner 2006, 343).

Numerous benefits are expected as the newly planted trees mature. Oak leaves provide food for a diversity of native terrestrial invertebrate species or insects, and these insects attract a variety of insectivorous birds. The oak trees are also expected to attract frugivorous birds and mammals and provide nesting sites and cover. The sweet bay magnolias are expected to serve as a seed food source for the rufous-sided towhee (*Pipilo erythrophthalmus*), red-eyed vireo (*Vireo olivaceus*), and gray squirrel (*Sciurus carolinensis*) and serve as a larval host and nectar source for the sweet bay silk moth (*Callosamia securifera*) and nectar beetles. Berries of the spruce pine are consumed by songbirds, bluebirds (*Sialia sialis*), and cedar waxwings (*Bombycilla cedrorum*); the trees also

provide hummingbird cover. Bald cypress trees provide wildlife value for the purple finch (*Haemorhous purpureus*), goldfinch (*Spinus tristis*), chickadees (*Poecile atricapillus*), and junco (*Junco hyemalis*).

Broadening benefits. Improving the sustainability of South Claiborne Avenue infrastructure was a prime consideration in the design of the neutral grounds. This focus on sustainability achieved several additional benefits after project construction—in addition to the greenspace and environmental benefits discussed above. First, the project increased the stormwater storage and efficiency of both the surface and subsurface drainage system, reducing flood risks. The completed project can manage water from heavier storms, now approximately 0.22 m (9 in) of rainfall in a 24-hour period. Reducing surface flooding along the roadway also safeguards the South Claiborne Avenue portion of the US 90 Hurricane Evacuation Route and as a result protects the Port of Orleans, nearby railroads, local commerce, businesses, and residents.

A key flood risk reduction feature was the bioretention areas. Bioretention areas were incorporated along the center of the neutral grounds as green infrastructure and stormwater infiltration components of the city's overarching plan. Bioretention areas were constructed in the middle of the median to capture stormwater, provide biofiltration, and recharge groundwater (Figure 5). The seven bioretention areas constructed were designed to capture approximately 613,236 L (162,000 gal) of initial rainfall when at capacity and then prevent this water from reaching and overburdening the city's storm drain system. Through the natural processes of infiltration, evaporation, and transpiration, no standing water would remain on-site longer than 48 hours.

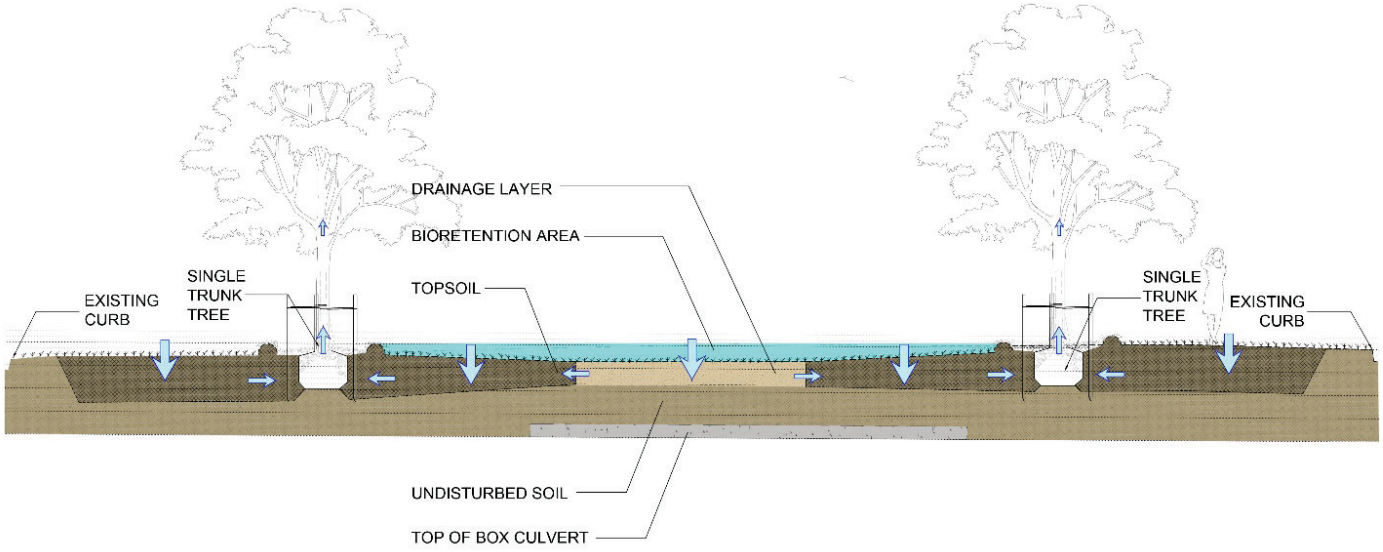

Figure 5. Cross-sectional rendering of the primary components of the bioretention areas of the project. *Arrows* mark surface and near-surface water flow designed to reduce flood risk.

Incorporation of EWN-LA concepts produced plant palettes that achieved aesthetic benefits. Trees are grouped in plant palettes for each section of the corridor, as shown in the Figure 6 renderings. These palettes include primary, secondary, and tertiary tree species. Trees defined as primary species provide a sense of unity and structure to the entire corridor. Trees defined as secondary species provide a sense of environmental context to the corridor, and tertiary trees provide accents.

In this way, the plant palette improves the aesthetics of the area for adjacent homeowners and persons in passing autos.

During Hurricane Ida, which made landfall in southeast Louisiana on 29 August 2021, the bioretention areas were observed to be functioning at capacity. This project, in addition to other New Orleans green infrastructure projects city-wide, culminate in community-scaled benefits.

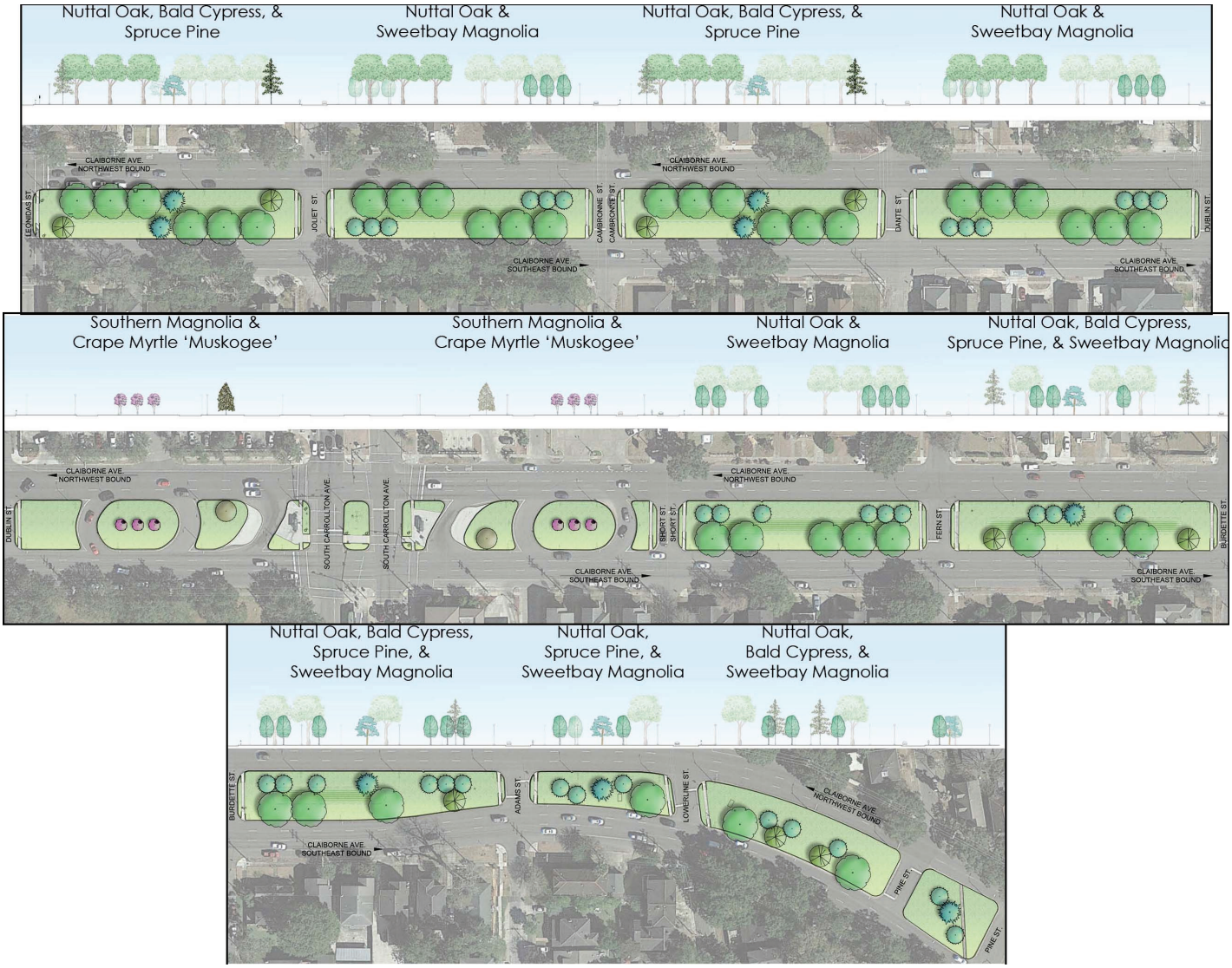

Figure 6. The scaled plan and elevation renderings for the greenspace restoration of South Claiborne Avenue demonstrate the planting design and rhythm of the native street trees that a driver may experience passing at 56 kmh (35 mph).

Promoting collaboration. Development of the design plans were coordinated with USACE project partners at the Louisiana State Historic Preservation Office (SHPO), the Coastal Restoration Authority Board (CPRAB), the New Orleans Sewerage and Water Board (SWBNO), City Planning Department, Parks and Parkways, Department of Public Works, and the Louisiana

State Department of Transportation and Development (LADOTD), and with consideration of the city's "Plan for the 21st Century" (https://masterplan.nola.gov/) and input collected from the public. Claiborne Avenue is a designated Louisiana state highway, and any landscape improvements must adhere to the requirements of the LADOTD Policy for Roadside Vegetation Management (LADOTD 2000).

MVN, CPRAB, and SWBNO consulted with SHPO, neighborhood groups, and the Parks and Parkways Department of the City of New Orleans as part of the planning process, prior to construction. Stakeholder meetings were held featuring alternative concepts, in which input received informed the conceptual design process. Public outreach and engagement efforts identified secondary stakeholders that were contacted via email, postcard mail-out, and public notice requesting attendance. Two public open houses were held with neighborhood groups and associations, state senators and representatives, the mayor's office, city planning commission, associated city council members, and local business associations.

MVN consulted with the New Orleans Department of Parks and Parkways on specific plant material and was provided with a list of small, medium, and large plants recommended for planting. MVN also performed a landscape inventory, which specifically identified historic lighting fixtures, granite curbs, street nameplates, and demonstrably historic plantings and developed and implemented a postconstruction landscape plan to restore preconstruction landscape features and assets to the extent reasonably possible. SHPO reviewed this landscape plan prior to implementation and provided comments on the plan. MVN was required to follow all agency engineering standards in the design and installation of improvements to ensure compliance with all applicable city codes and standards. Tree-planting specifications according to the Department of Parks and Parkways were strictly adhered to, and Americans with Disabilities Act (ADA)* requirements for any paved surfaces were abided by as well.

SUMMARY: In coordination with other SELA improvements across the city of New Orleans and the city's green infrastructure initiatives, the greenspace restoration on South Claiborne Avenue has created environmental, economic, social, and aesthetic long-term benefits. These benefits include strengthening the city's neutral grounds as greenway connectors, reinforcing a sustainable and resilient image through visual design, expanding New Orleans's urban forest, enhancing the environmental value of urban green spaces, reducing the burden on the storm-drainage system, slowing land subsidence through groundwater recharge and infiltration, and improving water quality. The role of USACE in this project emphasizes its commitment to designing and implementing EWN-LA principles in urban landscapes.

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* Americans With Disabilities Act of 1990, 42 U.S.C. § 12101 et seq. (2020). https://www.govinfo.gov/content/pkg/USCODE-2020-title42/pdf/USCODE-2020-title42-chap126.pdf.

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POINTS OF CONTACT: For additional information, contact Michelle Bourne (601-634-3836, Michelle.Bourne@usace.army.mil) or Dr. Burton Suedel (601-634-4578, *Burton.Suedel@usace.army.mil*). This technical note should be cited as follows:

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