Table of Contents
C04. Stormwater

C04. Stormwater

C04.1 Introduction

The Tyndall Air Force Base (AFB) drainage system comprises two systems, generally divided by U.S. Highway 98 (US 98) and identified as the Flightline District drainage system and the Support District drainage system. The Florida Department of Transportation (FDOT) constructed and maintains the drainage system for US 98. This system ties into the existing base drainage systems along the highway. FDOT has developed an improvements plan for US 98 that will coincide with the reconstruction of Tyndall AFB.

The Flightline system includes a piped system and a few onsite treatment ponds in the upland areas, and a combination of piped and channelized drainage systems throughout the airfield. Wet ponds are generally not used in the Flightline areas because of Bird/Wildlife Aircraft Strike Hazard (BASH) risks. The Support District's existing drainage infrastructure consists of an aging piped system that has been poorly maintained, linear surface channels, and scattered dry and wet detention ponds. Because the existing control structures were not studied in detail, the efficacy of the current ponds is unknown.

The onsite soils are highly permeable and the depth to the water table is generally shallow (approximately 2-5 feet below the ground). There are some areas that are more compacted and will require special treatments as described in this section. This creates challenges to designing and constructing dry stormwater elements (sometimes referred to as Integrated Management Practices [IMPs] or Best Management Practices [BMPs]) and will result in the base systems having large areas and shallow depths in order to provide at least 12 inches of separation to groundwater. In addition, there are known contaminant plumes in the ground that should be avoided for surface elements. Finally, there are several cultural heritage sites where grey stormwater infrastructure is not permitted.

C04.1.1 Opportunities

Tyndall AFB has an opportunity to improve the performance of the existing stormwater system. Green and natural infrastructure alternatives are integrated throughout the rebuilt installation. These strategies are aimed at improving stormwater quality, reducing capital and maintenance costs, and enhancing environmental benefits, including the management of storm surge.

C04.1.2 Authority

This stormwater plan was developed based on local and federal stormwater ordinances, and environmental regulations and protections. It expands the stormwater requirements found in the *Tyndall AFB Installation Faculties Standards* (IFS) and presents criteria for stormwater management associated with an integrated land management approach.

Stormwater system designs will comply with all design and permitting requirements of the Florida Department of Environmental Protection (FDEP) as well as those listed in the Unified Facilities Criteria (UFC):

- UFC 3-201-01, *Civil Engineering*
- UFC 3-201-02, *Landscape Architecture*
- UFC 3-210-10, *Low Impact Development*

C04.1.3 Warranty

Coordination of design and construction with Tyndall AFB staff, agencies, service providers and third-party contractors is critical to the successful implementation of planned improvements. All work is required to be warrantied regarding location and installation of materials in a manner consistent with the intent of the Landscape Master Plan and IFS, and to not create a conflict for installation of adjacent improvements by others. All potential conflicts will be identified by designers/contractors in respective sections of the Compliance Checklist and reviewed by Tyndall AFB Staff.

C04.2 Design Objectives

The stormwater management system is designed to meet the following objectives:

- Provide a consistent design standard for stormwater and for ease of maintenance
- Provide pipes and open channels to convey the 10-year, 24-hour storm
- Design the stormwater management facilities to safely pass floodwaters for up to the 100-year, 24-hour storm event
- Design stormwater facilities that align with the objectives of **Section B04, Integrated Land Management**
- Create a balanced green and grey stormwater system that provides a sustainable, lower initial cost system with lower maintenance costs
- Comply with all UFC and FDEP design and permitting requirements.
- Comply with antiterrorism (AT) requirements.
- Comply with the required Design Flood Elevation for the base. This is 19 feet in the Support District, impacted by the Gulf of Mexico, and 14 feet on the Flightline District, is impacted by the St. Andrew Bay.

Stormwater management interfaces with many design components:

- Transportation and Roadway Drainage
- Architecture
- AT Protection
- Landscape Architecture
- Land Management

C04.2.1 Goals

- Use green and grey infrastructure to manage, treat, and convey stormwater runoff
- Manage the 10-year storm event per the UFC requirements
- Create a sustainable, low-maintenance system
- Minimize flooding potential on roads and building sites
- Maintain or improve stormwater quality, including in existing areas
- Comply with environmental permitting requirements

C04.3 Design Approach

C04.3.1 Integrated Stormwater Management

The success of Tyndall AFB's integrated stormwater management approach requires a balanced relationship between integrated land management and nature-based Infrastructure. This combines conventional engineered infrastructure with natural landscape areas to manage stormwater through a vegetated treatment network. This hybrid of grey and green infrastructure design goes beyond the traditional "pipe-and-pond" infrastructure and considers the watershed and base hydrology. This concept produces a coordinated, natural system that has a lower environmental impact. It promotes individual site-level improvements to manage stormwater and provides solutions to enhance installation-wide and regional watersheds.

The base infrastructure is planned to include both grey and natural components that will work with nature to create sustainable conditions and climate-resilient solutions for increased mission resilience. This hybrid approach combines coastal and inland strategies that offer multiple lines of defense against storm surge and high-wind storms that often occur along Florida's Gulf coast. The inland strategies work in tandem with coastal solutions. Inland strategies manage stormwater and overland flooding by restoring the native Longleaf Pine forest and other naturalized and highly permeable landscapes. Once restored, the native areas that flourished before Tyndall AFB was developed will provide additional natural stormwater management.

Tyndall AFB's watershed must be analyzed on a case-by-case basis for all new construction and site rehabilitation efforts. Integrated land management designs must replicate natural hydrologic conditions and adequately mitigate onsite precipitation. This approach is in alignment with the requirements for low impact development and conservation design as outlined in the U.S. Environmental Protection Agency's *Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects* (under Section 438 of the Energy Independence and Security Act of 2007) and Northwest Florida Water Management District's *St. Andrew Bay Watershed Surface Water Improvement and Management Plan*.

Due to the range of stormwater requirements and the need for long-term guidance that will lead to consistency in implementation, a series of framework typologies, discussed in **Section C04.4**, were defined on four spatial delineations, salt marshes, bioswales, wet (retention) ponds, and dry (detention) ponds, as indicated in the adjacent photographs.

Salt Marsh

Parking Lot Bioswale

Wet (Retention) Pond

Dry (Detention) Pond

C04.3.2 Stormwater at Individual Building Sites

The "stormwater treatment train," as shown in Exhibit C04-1, uses a systems-based design approach that considers vegetation, soils, water, and surface treatments as an integrated and connected system to manage and treat stormwater. This design approach reduces traditional stormwater capital and system maintenance costs, reduces damage to buildings due to storm surge, improves water quality, and establishes a more self-sustaining landscape for lower maintenance costs.

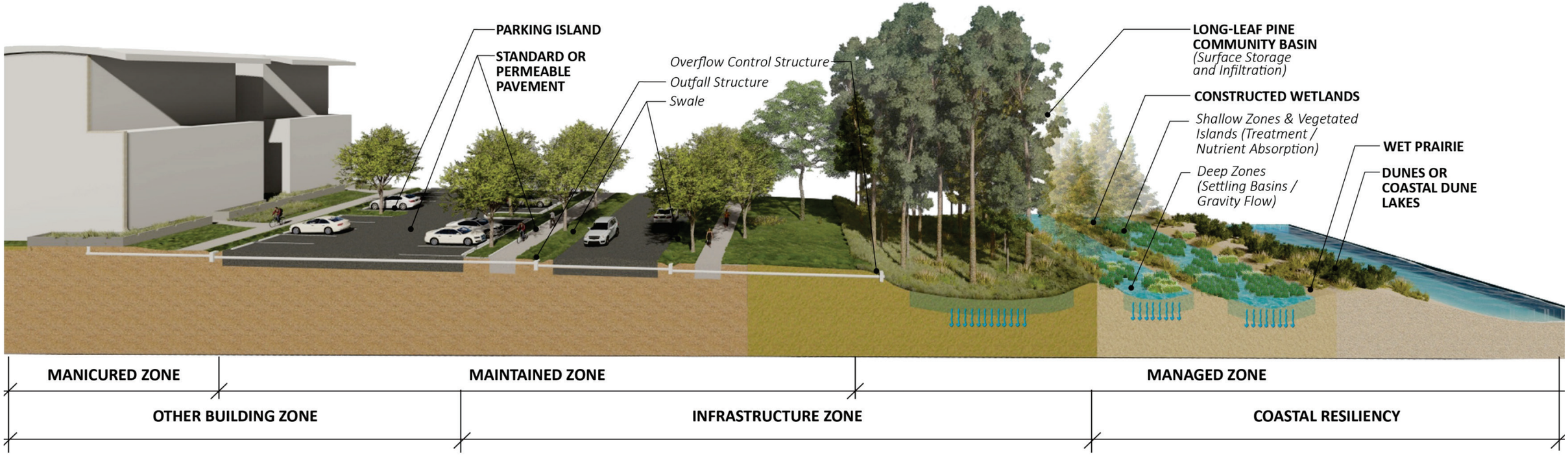
The stormwater treatment train begins at the buildings and their immediate surrounding sites. Building sites should incorporate natural and nature-based features (NNBF) or green infrastructure to manage stormwater flows and elevated surface temperatures from impervious areas when possible.

Incorporating more vegetation in the building sites will further improve air quality and improve quality of life, wellbeing, and walkability on the base. As a result, carbon emissions and energy use will be reduced, thus reducing the effects of climate change, witnessed today with rising sea levels and more frequent, severe storm events.

The next car of the stormwater treatment train is at the parking lot and roadway locations. Along these vehicular corridors, shallow swales should be used to treat runoff in the immediate area. These treatment areas will then flow into more regional basins, which are larger and contain native plant habitats. These regional basins increase permeation as well as sustain the plant communities.

The coastal zones are the final car in the stormwater treatment train. They are the last treatment area before discharge into the ocean. It is important to ensure that the stormwater that drains into the coastal areas is of high quality so as not to damage the coastal habitats.

Exhibit C04-1. Stormwater Treatment Train



C04.3.3 Groundwater

The depth to the groundwater table from the surface is generally 2 to 5 feet throughout the base, as shown on Exhibit C04-2. Stormwater elements should be appropriately located, designed, and/or raised to provide at least 12 inches of separation between their bottoms and the groundwater.

Groundwater Depths Less Than 4 Feet

Groundwater depths less that 4 feet are ideal for constructed wetlands and wet ponds. Other elements may be considered if they can be elevated, configured as broad and shallow, use impermeable liners or underdrains, and/or incorporate sand filters at the bottom. Bioswales should be designed as wet swales for conveyance, water quality, and/or pretreatment for other elements.

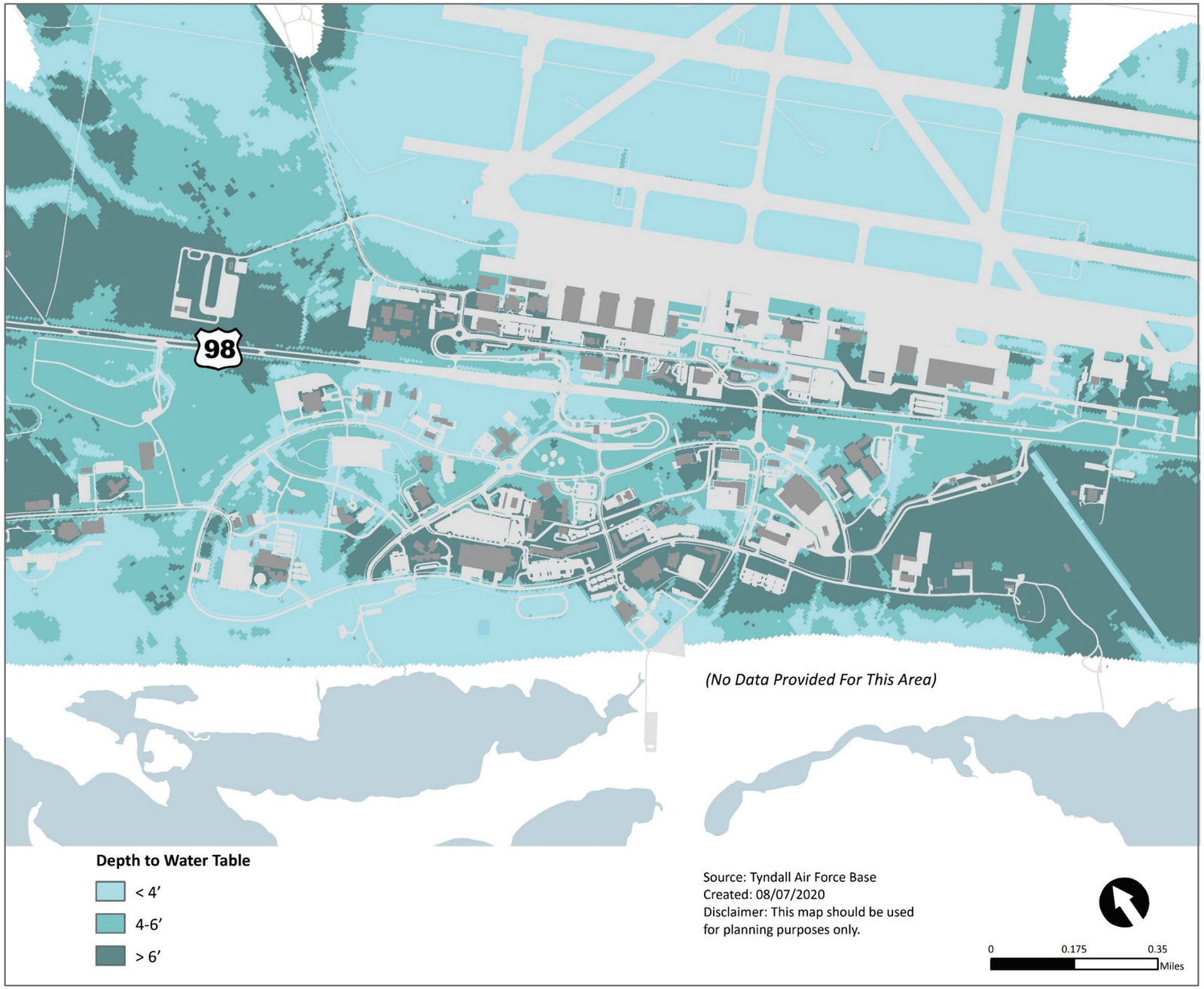
Groundwater Depths from 4 to 6 Feet

At groundwater depths between 4 and 6 feet, most stormwater elements are applicable, but some (bioretention, enhanced tree trench, stormwater planters, subsurface storage, and infiltration) may require broad and shallow configurations and/or impermeable liners or underdrains.

Groundwater Depth Greater Than 6 Feet

At groundwater depths of greater than 6 feet, most stormwater elements have high applicability (possible exceptions are constructed wetlands and wet ponds).

Exhibit C04-2. Depth to Water Table



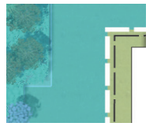
The figure above is based on available data from Tyndall AFB and is for placing purposes only. Depth to groundwater should be verified for each project on Tyndall AFB.

C04.4 Design Typologies

The following are typical solutions to treat stormwater at various locations of the site area. For the purposes on the diagram below, the major site components are presented as site design typologies.

Refer to **Section B04, Integrated Land Management**, for information regarding green infrastructure treatments, applications, components, and materials.

Legend

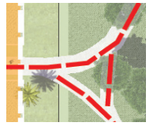


Building Perimeter
- Bioretention or bioswale (edge)
- Subsurface storage/infiltration

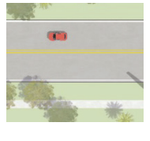
Open Space
- Forested basin (Longleaf Pine) / surface storage and infiltration
- Bioretention and bioswale (edges)
- Constructed wetland
- Meadow restoration
- Wet pond

Overflow Parking Areas
- Stabilized turf or pervious pavement
- Subsurface storage/infiltration

Site Parking Area Landscaping
- Bioretention or bioswale
- Stormwater planter

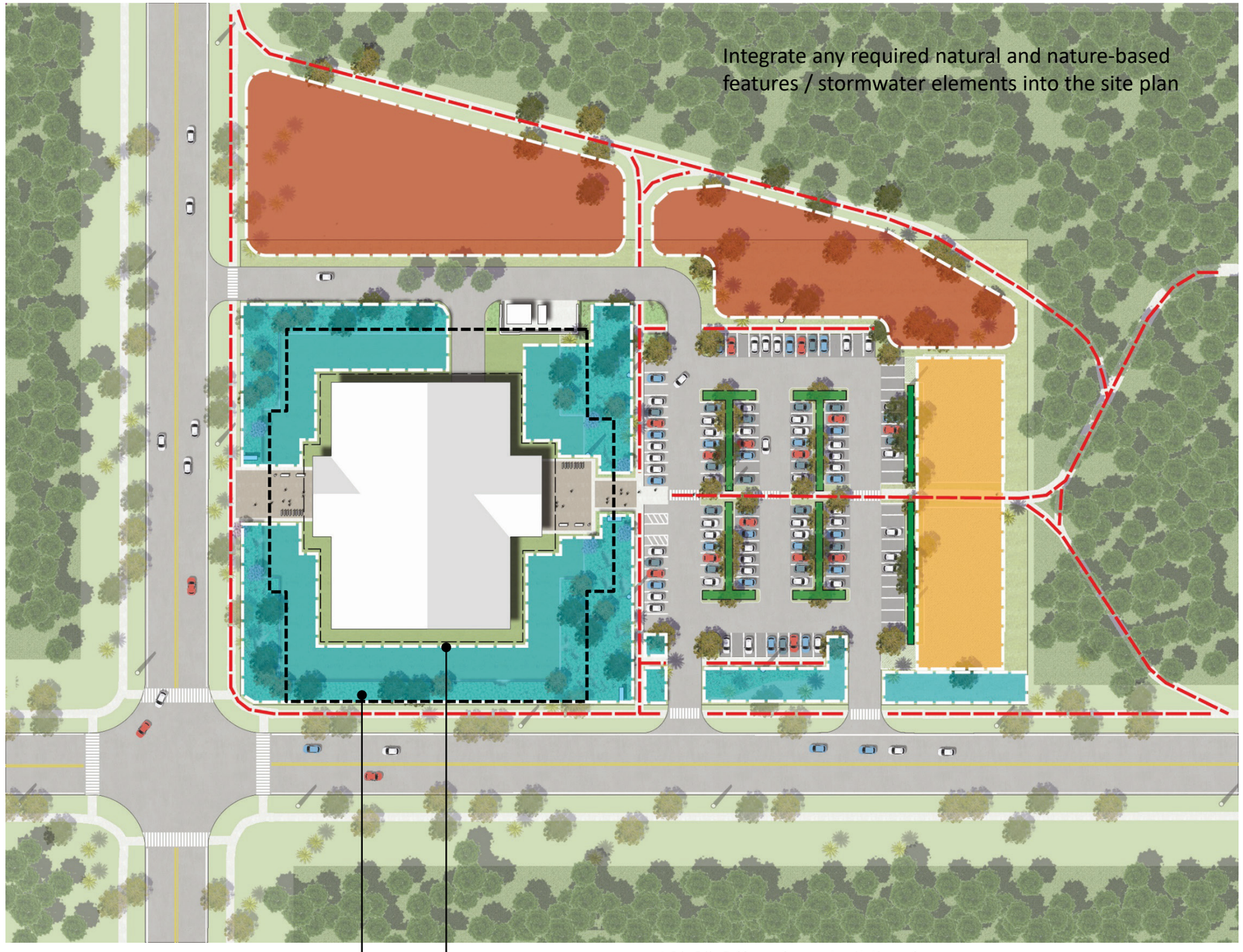


Site Sidewalks
- Standard concrete pavement design
- Specialty paving can be pervious pavement
- Pedestrian walkways should not conflict with stormwater requirements



Corridors
- Bioretention
- Bioswale
- Pervious Pavement sidewalks

Exhibit C04-3. Stormwater System Design Typologies



C04.5 Stormwater Typology Criteria

C04.5.1 Stormwater Criteria (SC)

The criteria in this section relate to specific design requirements, including IFS requirements, and guidelines for designers/contractors to follow and Tyndall AFB personnel to review. Additional criteria are provided in the other sections of this **Landscape Master Plan** and are not repeated in this section; however, the requirements for stormwater must be coordinated with other site elements. The sections that follow serve as worksheets, with supporting guidance and illustrations, for designers/contractors to use among their teams and in coordination with Tyndall AFB. These worksheets should be used to complete the **Compliance Checklist** submittal for each project. Each requirement includes a selection of check boxes to indicate the applicability of that requirement to a specific context, and to demonstrate compliance with the requirements.

Yes No N/A

☑ ☐ ☐ The designer/contractor either selects "Yes" if compliance has been met, "No" if it has not, or "N/A" if the requirement is not applicable to the project.

C04.5.2 General Stormwater Criteria

Yes No N/A

☐ ☐ ☐ SC 1. Site stormwater management plan fully integrates, to the maximum extent technically feasible (METF), traditional "hard" infrastructure elements with NNBF to reduce flooding potential, enhance water quality, comply with the antiterrorism (AT) requirements, and generally provide a more livable and sustainable environment on the base.

☐ ☐ ☐ SC 2. Satisfy applicable requirements of UFC 3-201-01, *Civil Engineering.*

☐ ☐ ☐ SC 3. Satisfy requirements of UFC 3-210-10, *Low Impact Development.*

☐ ☐ ☐ SC 4. Satisfy requirements of *Environmental Resource Permitting Applicant's Handbook – Volume I.*

☐ ☐ ☐ SC 5. Satisfy requirements of *Environmental Resource Permitting Applicant's Handbook – Volume II*, which provides specific sizing and design guidance for various stormwater elements.

☐ ☐ ☐ SC 6. Employ NNBF to the METF for stormwater that use or mimic natural processes to: (1) infiltrate and recharge, (2) filter and treat, (3) evapotranspire through biological uptake, and/or (4) harvest and use precipitation near to where it falls to earth.

☐ ☐ ☐ SC 7. Locate stormwater elements in such a way as to maximize stormwater runoff capture, align with site drainage patterns, integrate with proposed land uses, enhance safety, and ensure accessibility.

☐ ☐ ☐ SC 8. Maximize the use of vegetated open channels and minimize the use of pipes for conveyance of stormwater runoff.

☐ ☐ ☐ SC 9. Minimize impervious surfaces and minimize turf areas.

Yes No N/A

☐ ☐ ☐ SC 10. Incorporate pervious pavement at overflow parking areas, walkways, plazas, and other large expanses of pavement with low traffic loads.

☐ ☐ ☐ SC 11. Locate, design, and/or raise (that is, configure as broad and shallow) stormwater elements in accordance with FDEP requirements to comply with minimum separation of seasonal high groundwater and bottom of facility.

☐ ☐ ☐ SC 12. Avoid stormwater treatment and storage sites in contaminant areas.

☐ ☐ ☐ SC 13. Perform a groundwater mounding analysis to document that the design will perform as required (not required for wet detention facilities) per the requirements listed in *Environmental Resource Permitting Applicant's Handbook – Volume II.*

C04.5.3 Stormwater Criteria for Building Perimeters

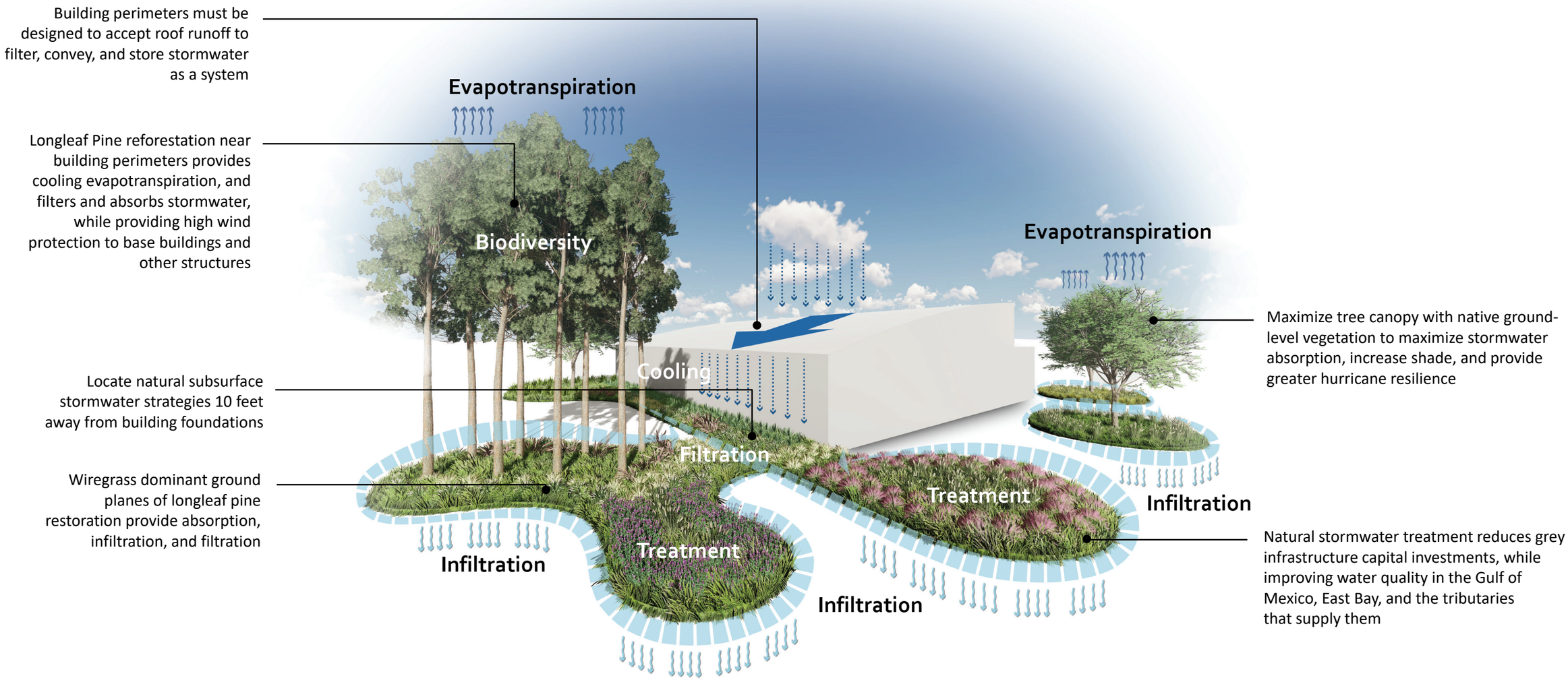
Through the collective use of plantings, naturally occurring element, and proper planning, the site will function as a cohesive system that achieves its maximum stormwater management potential.

Exhibit C04-4 represents a stormwater management system that operates efficiently; it is intended that Tyndall AFB's environment achieve this success as described in this section.

Designers/contractors must think beyond the limits of their site and understand its context within the overall base and how individual actions may adversely impact sites downstream.

Yes	No	N/A		
☐	☐	☐	SC 14.	Use Bioretention, Bioswale, and/or Subsurface Storage and Infiltration elements to the METF to reduce the need for pipes for conveyance.

Exhibit C04-4. Efficient Stormwater Management System



C04.5.4 Stormwater Criteria for Parking Areas

Within parking areas, NNBF can often be seamlessly integrated into landscaped areas along edges or within islands, as well as within no parking zones. With careful design that considers pedestrian and vehicular circulation patterns, such features will not only effectively capture and treat site runoff, but also provide increased shade, hurricane resiliency, and greater wellbeing.

In areas of Tyndall AFB with high groundwater elevations, soil depths can limit required tree soil volumes and stormwater storage areas immediately under the surface. In such conditions, stormwater elements are often most effective when configured to be broad and shallow at the surface and/or within subsurface areas under paved surfaces.

Yes	No	N/A		
☐	☐	☐	SC 15.	Direct roof runoff into nearby stormwater element(s) where it can be treated and infiltrated.
☐	☐	☐	SC 16.	To the METF, use Pervious Pavement, Subsurface Storage and Infiltration, and/or Tree Pits/Trenches.
☐	☐	☐	SC 17.	Break up expansive impervious pavements with vegetated stormwater elements to increase shade and filter/infiltrate stormwater.

Exhibit C04-5. Typical Parking Area Stormwater Management Section

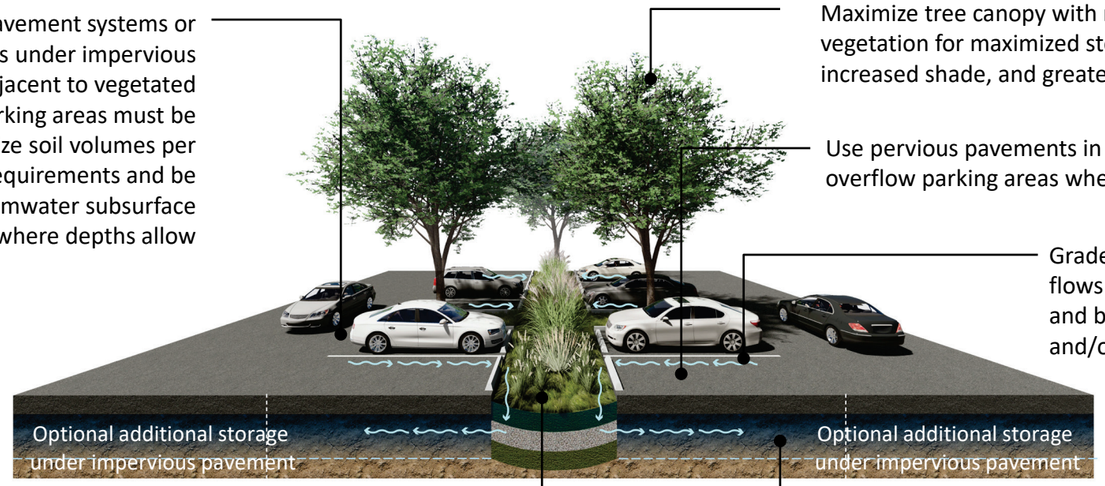
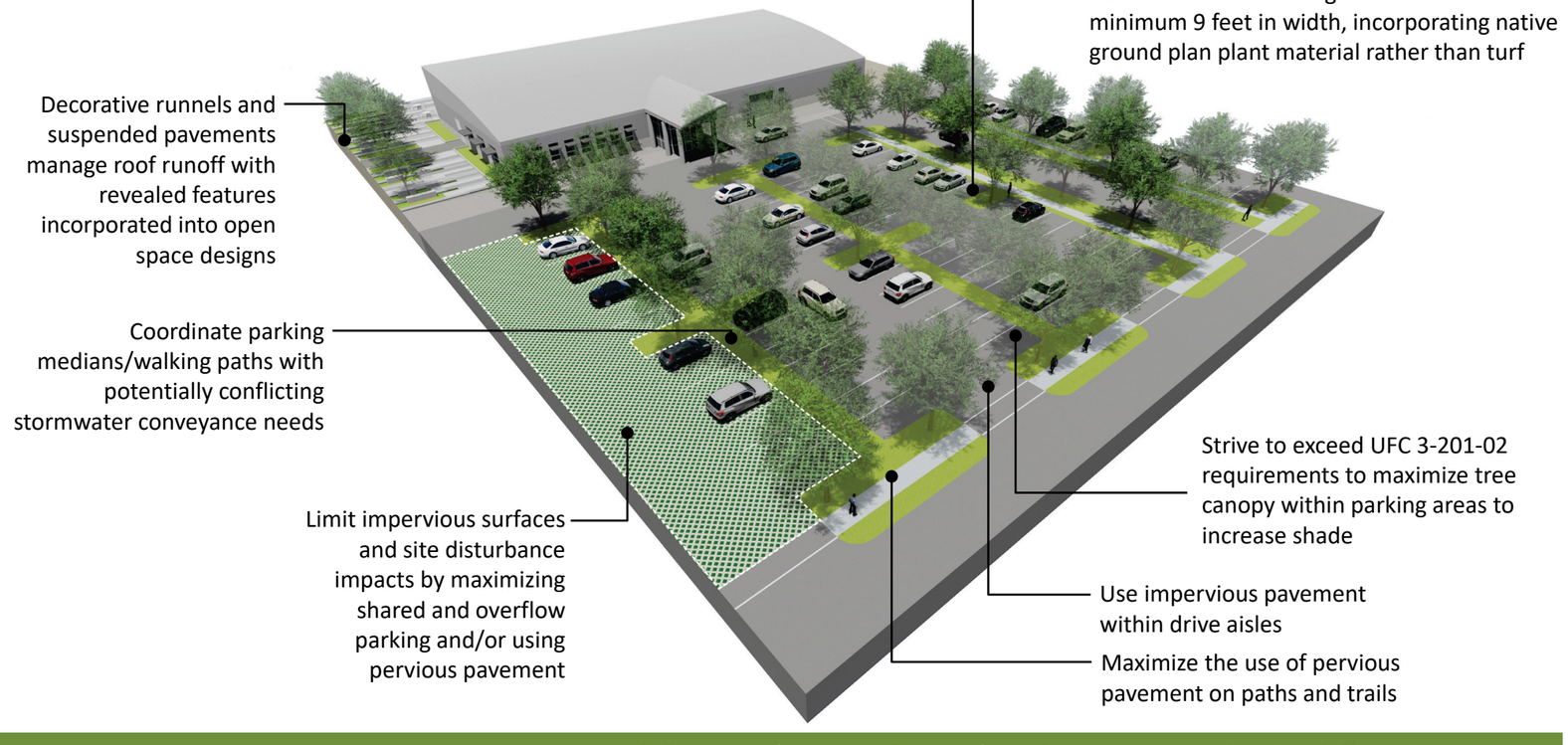


Exhibit C04-6. Parking Area Stormwater Management Overview



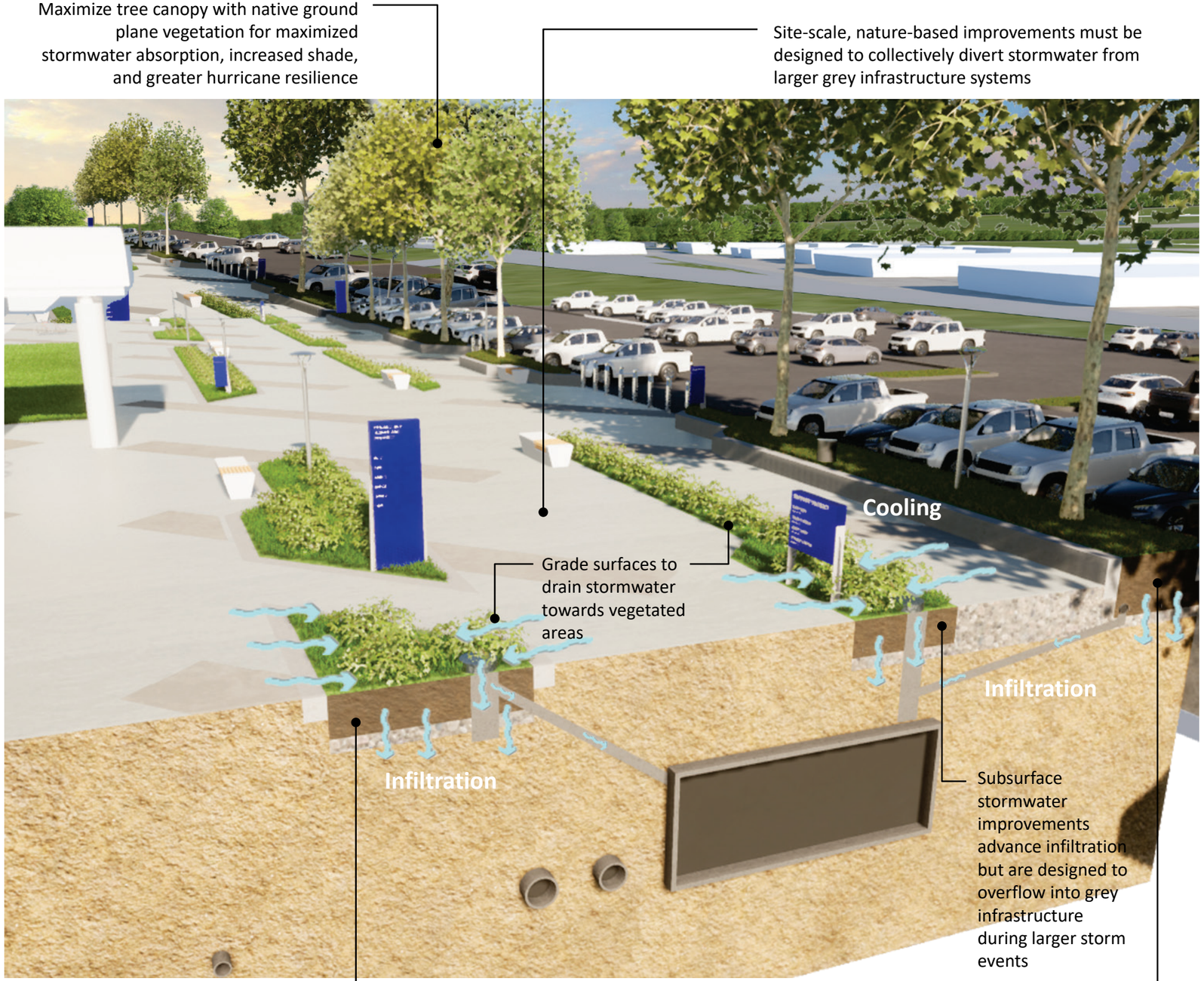
C04.5.5 Stormwater Criteria for the Multi-Modal Spine

When integrated into the landscaped pedestrian areas such as the Multi-Modal Spine, NNBF can capture and filter runoff from sidewalks and roads, thus reducing the demand on traditional stormwater conveyance elements. Such features can also greatly enhance the health and longevity of site vegetation, provide much needed shade and lower temperatures, and create more walkable pathways.

Designing effective green infrastructure elements within corridors entails careful consideration of pedestrian and vehicular accessibility and safety. Such features incorporate the following: species that will not conflict with pedestrian or vehicular circulation; more robust/reinforced curb structure when adjacent to roads; fencing or other barriers to protect trees and plants; and safe crossings over and around depressed stormwater elements.

Yes	No	N/A		
☐	☐	☐	SC 18.	Drain impervious surfaces onto landscape areas to the METF and in a manner that minimizes erosion.
☐	☐	☐	SC 19.	Use Bioswale, Enhanced Tree Pits/Trenches, Pervious Pavement walkways, and/or Stormwater Planter to the METF.
☐	☐	☐	SC 20.	Incorporate bump-out stormwater planters at intersections and mid-block crossings if on-street parking is present/available.
☐	☐	☐	SC 21.	Provide roadside drainage instead of the traditional curb and gutter with inlets and/or pipes where METF.

Exhibit C04-7. Typical Multi-Modal Spine Stormwater Management Section



C04.5.6 Stormwater Criteria for Open Space

To improve water quality, manage flows, and decrease temperatures, open spaces shall incorporate NNBF that are integrated within urban design concepts. Designing stormwater elements within open spaces must acknowledge site context and existing conditions, realize the human scale, and balance aesthetics against green infrastructure performance. The goal is a site that incorporates and enhances surface and subsurface conditions, while creating a sense of place for users as an entire performance landscape system.

Yes	No	N/A		
☐	☐	☐	SC 22.	Comply with Florida Department of Environmental Protection's technical requirements and revegetate the stormwater elements in these areas in accordance with the landscape requirement of this **Landscape Master Plan**.
☐	☐	☐	SC 23.	Maximize surface flows/expressions and minimizes the use of piped drainage conveyance.
☐	☐	☐	SC 24.	Design for desire paths and include components such as vegetative or physical barriers that discourage foot / bike traffic through element.

Exhibit C04-8. Typical Open Space Stormwater Management (Dry Weather/Wet Weather)

C04.6 Stormwater Design Elements

The stormwater management typologies discussed in Section C04.5 incorporate various elements that work together to manage stormwater.

C04.6.1 General Stormwater Elements

Yes No N/A

- ☐ ☐ ☐ SC 25. Use a maximum 3:1 side slope for vegetated stormwater elements.
- ☐ ☐ ☐ SC 26. Design infiltration stormwater elements to infiltrate have level bottoms or else check dams to promote more uniform infiltration.
- ☐ ☐ ☐ SC 27. Design infiltration stormwater elements to have not been placed on fill, but on uncompacted (or scarified) subgrade.
- ☐ ☐ ☐ SC 28. Design stormwater elements, including conveyance elements, to discharge in a controlled and non-erosive fashion, using level spreaders as possible to encourage sheet flow.
- ☐ ☐ ☐ SC 29. Provide accessible means of observing performance of stormwater elements such as cleanouts, observation wells, and/or maintenance ports for maintenance purposes.
- ☐ ☐ ☐ SC 30. Provide robust and easily maintainable pretreatment mechanisms, including approved proprietary BMPs, to protect natural conveyances or stormwater elements from clogging or degradation especially in areas potentially containing excessive levels of silt and sediment or contaminated with oils, fuels, or grease.
- ☐ ☐ ☐ SC 31. Protect stormwater elements against erosion and facilitate vegetation establishment by utilizing energy dissipators at inflows and/or biodegradable erosion control matting.
- ☐ ☐ ☐ SC 32. Provide stabilized and controlled overflow mechanisms for larger storm events and/or provide bypass/diversion structures (design stormwater elements to be “offline”).

C04.6.2 Specific Criteria for Pervious Pavement

Yes No N/A

- ☐ ☐ ☐ SC 33. Ensure anticipated vehicular loading has been factored into design (perform structural analysis) for Pervious Pavement and Subsurface Storage & Infiltration solutions.
- ☐ ☐ ☐ SC 34. Avoid placement in areas where there is the potential to contaminate existing soils (fuel areas, industrial storage, vehicle maintenance or service areas) or where there is high sediment loading potential.

Managing Water at the Site Scale

Bioretention & Bioswale

Bioretention and bioswale facilities are sunken landscape beds containing plants in a special soil mix that sits above a gravel drainage layer. They replicate the natural water cycle by allowing water to enter the soil, evaporate to the air, or be ponded for up to 2 to 3 days. These facilities use native or naturalized vegetation that can withstand both occasional dry periods and flooding. The vegetation provides natural filtration and treatment of stormwater runoff, removing many pollutants often found in urbanized environments.

Stormwater Planters

Stormwater Planters are sunken landscape beds containing native or naturalized plants in a special soil mix that sits above a gravel drainage layer, similar to bioretention facilities. But unlike bioretention, stormwater planters are enclosed by concrete, brick, wood, or other materials, and can be placed either above or below the adjacent ground elevation.

Pervious Pavement

Pervious pavement often looks like ordinary pavement but allows stormwater to drain through it and into an underlying storage system where it is detained until it can infiltrate into the soil, reducing runoff volume, attenuating flows, and filtering out pollutants in the process. A variety of pervious pavement types can be used depending on site conditions, including pavers and paver blocks, open grid pavers, and resin-bonded flexible pavements, among others. Pervious pavement has high applicability in locations such as overflow parking areas, sidewalks and walkways, plazas, playgrounds and basketball courts, and even emergency access drives.

C04.6.3 Specific Criteria for Constructed Wetlands

Yes No N/A

- ☐ ☐ ☐ SC 35. Include a safety shelf (aquatic bench) with shrubs and tall grasses around the perimeter.
- ☐ ☐ ☐ SC 36. Specify plant species and/or other features in accordance with BASH requirements.

C04.6.4 Specific Criteria for Wet Ponds

- ☐ ☐ ☐ SC 37. Include a safety shelf (aquatic bench) with shrubs and tall grasses around the perimeter.
- ☐ ☐ ☐ SC 38. Specify plant species and/or other features in accordance with BASH requirements.

C04.6.5 Specific Criteria for Forested Basins/Surface Storage & Infiltration

- ☐ ☐ ☐ SC 39. Use longleaf pine trees and wiregrass and other native groundcover mix in the Forested Basin (Dry Pond) with Longleaf Pine Community.
- ☐ ☐ ☐ SC 40. Vegetate Surface Storage & Infiltration Dry Ponds with native grasses. Do not use trees or plants more than 8 inches high.

Managing Water at the Site Scale

Constructed Wetlands
Constructed Wetlands are shallow marshes planted with native vegetation that improve water quality through plants absorbing pollutants in their roots (uptake) and water evaporating to the atmosphere (evapotranspiration). Constructed wetlands maintain a permanent water surface using flow control structures that regulate stormwater runoff discharges from the wetland. They are vegetated with native or naturalized plants that provide natural filtration and treatment of stormwater runoff, removing many common pollutants like phosphorous and nitrogen that can degrade water bodies like Saint Andrews and East Bay.

Wet (Retention) Ponds
Wet ponds are among the most recognizable nature-based infrastructure practices in the state of Florida. They accept and hold stormwater runoff long enough to allow pollutants to settle out, resulting in cleaner water. Wet ponds are designed to maintain a permanent water surface (or permanent pool) through flow control structures that regulate discharge from the pond.

Forested Basin / Surface Storage & Infiltration
Surface storage and/or infiltration of stormwater runoff can be provided over broad and shallow areas that are either forested (e.g. longleaf pine) or finished with lawn or more naturalized landscapes. These systems are designed to receive runoff from contributing areas and then slowly release it downstream over 2 to 3 days.

Meadow Restoration
Meadow or landscape restoration is the process of re-vegetating a site using native, prairie, or wildflower species. This practice re-introduces into the landscape native plant species that do not require significant maintenance by pesticides, herbicides, and fertilizers. Restoring the landscape with native vegetation has multiple other environmental benefits, including improved water quality, reduced volume of site runoff, increased volume of water uptake, improved soil conditions through organic material and macropore formation, enhanced infiltration, and natural sequestration of carbon.

Subsurface Storage/Infiltration
Subsurface storage/infiltration systems temporarily hold stormwater runoff underground in material like gravel, high-strength plastic boxes/arches, large-diameter pipes, or concrete chambers. This allows the stormwater to be detained until it either infiltrates into the soil or drains into the base's existing drainage system over 2 to 3 days. These systems can be placed under almost any type of finished surface, whether pavement, grass, landscaping, or other material and are often "fed" by surface drains and pipes.

Dry (Detention) Ponds
Dry Ponds are often confused with detention basins with mowed grass. A dry pond is a vegetated low area with native plant species which is not mowed. The dry pond slows stormwater run off down and allows it to percolate into the ground slowly. It is wet for only a short period of time and is dry most of the time. The depth can be minimal 1-2 feet deep as ground water at Tyndall is high and if the area is too deep it will fill with ground water.