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CHAPTER 16

RESIDENTIAL STREET DESIGN

TABLES

CHAPTER 16

RESIDENTIAL STREET DESIGN

A INTRODUCTION

The street is a public way designed for the purposes of serving motor vehicles, bicycles, pedestrians, and transit vehicles. The primary function of residential streets is to provide access to homes that front those streets. The primary consideration, therefore, of residential street design should be to foster a safe and pleasant environment for the residents that live along the street, and safe traveling conditions for motorists, bicyclists and pedestrians. The convenience of motorists is a secondary consideration.

The street design should create an environment that cautions drivers that they are in a residential area where they must safely share the traveling space with pedestrians and bicyclists, both child and adult. Visual cues such as meandering streets, sidewalks, landscaping, signage, narrowed streets, changes in pavement texture (such as brick, stamped, or textured surfaces), and raised crosswalks all serve to heighten drivers' awareness for the need to maintain lower speeds. Incorporating such features into residential street design at inception will reduce or eliminate the need for traffic calming retrofits.

Section B of this chapter discusses the primary objectives of Residential Street Design in more detail, to aid the designer in the selection of proper criteria. ***Section C*** sets forth specific design criteria for residential streets.

B OBJECTIVES

The basic principles of residential street design are based on four factors:

1. Safety
2. Efficiency of Service
3. Livability and Amenities
4. Economy of Land Use, Construction, and Maintenance

The following 17 principles incorporate these factors. These principles are not intended as absolute criteria, since instances may occur where certain principles conflict. The principles should therefore be used as concepts for layout of proper street systems.

1. Adequate vehicular and pedestrian access should be provided to all parcels.
2. Local street systems should be designed to minimize through traffic movements unless it is specifically desired by the County or municipality to connect residential developments.
3. Street patterns should minimize excessive vehicular travel through connectivity between adjacent residential developments, and to larger street networks.
4. Local street systems should be logical and comprehensible, and systems of street names and house numbers should be simple, consistent, and understandable.
5. Local circulation systems and land-development patterns should not detract from the efficiency of adjacent major streets due to lack of connectivity.
6. Elements in the local circulation system should not have to rely on extensive traffic regulations and enforcement in order to function efficiently and safety.
7. Traffic generators within residential areas should be considered in the local circulation pattern.
8. The planning and construction of residential streets should clearly indicate their local function. The street's residential nature should be obvious to those driving on them.
9. The street system should be designed for a relatively uniform low volume of traffic.
10. Local streets should be designed to discourage excessive speeds.

11. Pedestrian-vehicular conflict points should be minimized.
12. The amount of space in the land development devoted to motor vehicle uses should be minimized.
13. Smaller block sizes may be used to encourage walking or bicycling. See ***Chapter 19 – Traditional Neighborhood Development*** for more information.
14. The arrangement of local streets should permit economical and practical patterns, shapes, and sizes of development parcels and provide interconnectivity without using arterials or collectors.
15. Local streets should consider and utilize topography from the standpoint of both economics and amenities.
16. Appropriate provisions for transit service within residential areas should be included.
17. Street design should consider horizontal and vertical compatibility and connectivity with sidewalks, bicycle lanes, and pedestrian walkways.

C DESIGN ELEMENTS

C.1 Design Speed

For local residential streets, design speeds of 15 to 30 mph are appropriate, depending on the adjacent development, terrain, available right of way, and other area controls. Alleys and narrow roadways intended to function as shared spaces (that is, could be used to access driveways, for garbage pickup, and travel by walking or bicycling) may have design speeds as low as 10 mph. Design speeds greater than 30 mph in residential areas require increased sight distances and radii which are contrary to the function of a local residential street.

C.2 Sight Distance

C.2.a Stopping Sight Distance

The minimum stopping sight distance is shown in Table 16 – 1 Minimum Stopping Sight Distance for Residential Streets.

Table 16 – 1 Minimum Stopping Sight Distance for Residential Streets

Design Speed (mph)	Stopping Sight Distance (feet)
10	45
15	75
20	125
25	150
30	200

C.2.b Passing Sight Distance

Passing should not be encouraged on local residential streets, and design for passing sight distance is seldom applicable on these streets. If longer straight sections and higher design and posted speeds support passing, the street shall be designed under the design criteria established in ***Chapter 3 – Geometric Design***.

C.2.c Intersection Sight Distance

Intersections shall be designed with adequate corner sight distance as set forth in Table 16 – 2 Minimum Corner Intersection Sight Distance for Residential Streets. Intersection design should take into consideration growth of landscaping and other amenities. Where a local residential street intersects a higher-order street, the design criteria of the higher-order street shall control within the right of way of the higher-order street.

Table 16 – 2 Minimum Corner Intersection Sight Distance for Residential Streets

Design Speed (mph)	Corner Intersection Sight Distance * (feet)
10	110
15	160
20	210
25	260
30	310

* Corner sight distance measured from a point on the minor road at least 14.5 feet from the edge of the major road pavement and measured from a height of eye at 3.5 feet on the minor road to a height of object at 3.5 feet on the major road.

Where stop or yield control is not used, the corner sight distance should be a minimum of 300 feet. If restrictions are unavoidable, a minimum of 200 feet is allowed with proper warning signage found in the ***Manual on Uniform Traffic Control Devices (MUTCD)*** such as an intersection warning sign (W2 series) or cross traffic does not stop here plaque (W4-4P). To maintain the minimum sight distance, restrictions on height of embankments, locations of buildings, and screening fences may be necessary. Any landscaping in the sight distance triangle should be low growing, and should not be higher than 3 feet above the level of the intersecting street pavements. Tree overhangs should be trimmed to at least 8 feet above the level of the intersections.

Intersecting streets should meet at approximately right angles. Angles of less than 60 degrees should be avoided.

C.3 Horizontal Alignment

C.3.a Minimum Centerline Radius

The minimum radii for horizontal curves are given in Table 16 – 3 Minimum Centerline Radii for Residential Streets. Typically, superelevation should not be utilized on local residential streets. Where superelevation is appropriate or required, the street shall be designed under the design criteria established in ***Chapter 3 – Geometric Design***.

Table 16 – 3 Minimum Centerline Radii for Residential Streets

Design Speed (mph)	Min. Centerline Radius (feet)
10	25
15	50
20	89
25	166
30	275

C.3.b Minimum Curb Return Radius

Where there are substantial pedestrian movements, the minimum radius of curb return where curbs are used, or the outside edge of pavement where curbs are not used shall be 15 feet. A minimum radius of 25 feet is desirable to accommodate turning movements of service vehicles.

C.4 Vertical Alignment

C.4.a Vertical Curves

Vertical curves shall be designed for a minimum stopping sight distance using the design criteria of 30 mph established in ***Chapter 3 – Geometric Design.***

C.5 Cross Section Elements

C.5.a Width of Roadway

The minimum width of a two-way residential roadway should be 20 feet from edge-of-pavement to edge-of-pavement (excluding curbs and gutters). Travel lanes should be a minimum of 10 feet wide, and wider where practicable. Under constrained conditions or in some very rural areas, lanes 9 feet or narrower may be used. Refer to ***Chapter 4*** of the ***AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT ≤ 400)***. Lanes narrower than 9 feet are prohibited in the absence of a Design Exception as provided for in ***Chapter 14 – Design Exceptions and Variations***.

When parking lanes are provided on one or both sides of the roadway, they shall be at least 7 feet wide including the gutter section where applicable.

Where curb and gutter sections are used, the roadway may be narrowed to the travel lane width (plus bike lane if present) at intersections. This will prevent parking close to the intersection, reduce crossing distances for pedestrians, provide space for curb ramps, and reduce turning speeds. By providing intersection curb extensions, the visual width of the roadway can be reduced.

C.5.b Medians

When used in residential areas, medians or traffic separators should conform to ***Chapter 3*** or ***Chapter 19***.

C.6 Cul-de-sacs and Turnarounds

C.6.a Turning Area

A residential street more than 100 feet long and open at one end only shall have a special turning area at the closed end. This turning area should be circular and have a radius appropriate to the types of vehicle expected. The minimum outside radius of a cul-de-sac shall be 30 feet. In constrained circumstances, other turning configurations such as a “hammerhead” may be considered. Cul-de-sacs can detract from connectivity if used excessively or inappropriately.

C.7 Pedestrian Considerations

C.7.a Sidewalks

In residential areas, sidewalks should be provided on both sides of the street. The sidewalks should be located as far as practicable from the travel lanes and usually close to the right of way line. In certain circumstances, such as where lots are very large or there are environmental limitations, sidewalk on only one side may be considered. Along collector roadways shared use paths may be provided in lieu of sidewalks. Connectivity to and between existing public sidewalk or shared use path facilities is desired.

Pedestrian access should be provided to schools, day care facilities, parks, churches, shopping areas, and transit stops within or adjacent to the residential development. Pedestrian access to these destinations and throughout the neighborhood shall be designed for safe and convenient pedestrian circulation. Sidewalks or shared use paths between houses or to connect cul-de-sacs may be used where necessary to provide direct access.

Sidewalks, crosswalks and mid-block crossings shall be constructed under the criteria set forth in ***Section C.7.d*** of ***Chapter 3 – Geometric Design***, and ***Chapter 8 – Pedestrian Facilities***.

C.8 Bicyclist Considerations

C.8.a Bicycle Facilities

Residential roadways are generally sufficient to accommodate bicycle traffic. When specific bicycle facilities are desired, they should connect to existing facilities and be designed in accordance with ***Chapter 3 – Geometric Design*** and ***Chapter 9 – Bicycle Facilities***. For bike lane transitions, see ***Chapter 9***.

C.9 Shared Use Paths

Shared use paths may be provided in lieu of sidewalks along collector roads in accordance with ***Section C.7.a***. When shared use paths are desired, they should connect to other pedestrian and bicycle facilities within or adjacent to the residential area, and connect to schools, day care facilities, parks, churches, shopping areas, and transit stops. Shared use paths shall be designed in accordance with ***Section C*** of ***Chapter 9 – Bicycle Facilities***. Shared use paths may be used by golf carts in certain areas, under certain circumstances in accordance with ***Sections 316.212, 316.2125 and 316.2126, F.S.***.

C.10 Clear Zone

Clear zone requirements for residential streets shall be based on ***Chapter 4 – Roadside Design***, Table 4 – 1 Minimum Width of Clear Zone and Table 4 – 2 Lateral Offset.

D REFERENCES FOR INFORMATIONAL PURPOSES

The following is a list of publications that may be referenced for further guidance:

- AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT ≤ 400):
  https://aashtojournal.org/2019/05/31/aashto-issues-second-edition-of-low-volume-roads-guidelines/

- Manual on Uniform Traffic Control Devices (MUTCD)
  Manual on Uniform Traffic Control Devices (MUTCD) - FHWA (dot.gov)

CHAPTER 17

BRIDGES AND OTHER STRUCTURES

FIGURES

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BRIDGES AND OTHER STRUCTURES

A INTRODUCTION

Bridges provide safe passage for multimodal traffic over various obstacles along a road or path. This chapter presents guidelines and standards for designing, constructing, inspecting, and maintaining bridges as well as other structures such as walls and supports for signs, lights, and traffic signals. These standards and criteria are necessary due to the critical function these structures serve to communities throughout their lifespan. This chapter establishes uniform minimum standards and criteria for all bridges used by the public for vehicular and/or pedestrian traffic as well as other structures such as walls and supports for signs, lights, and traffic signals. The geometry of structures shall follow the standards and criteria set forth in ***Chapters 3, 8, 9***, and ***13***. Exceptions to these standards and criteria must be processed in accordance with the procedures described in ***Chapter 14***.

In addition to the design criteria provided in this chapter, the ***United States Department of Transportation ADA Standards for Transportation Facilities (2006), United States Department of Justice ADA Standards (2010)***, as required by ***49 C.F.R 37.41 or 37.43*** and the ***2020 Florida Building Code – Accessibility, 7th Edition*** as required by ***61G20-4.002*** impose additional requirements for the design and construction of pedestrian facilities on bridges or other structures. Examples of facilities include sidewalks and shared use paths, and drainage grates and inlets in or near the accessible route. Significant ADA design considerations exist for all facilities with grades that exceed 5%. The ***Public Rights-of-Way Accessibility Guidelines (PROWAG)*** provide additional information for the design of pedestrian facilities.

Note: This chapter applies to all bridges under local control, except for bridges constructed on or over the FDOT's system. For bridges constructed on and over the FDOT's system, as well as all bridges that will be maintained by the FDOT, FDOT policies, procedures, standards, and specifications will apply.

B OBJECTIVES

The objectives of this chapter are as follows:

- To prescribe uniform criteria with respect to bridge and miscellaneous structures design and geometric layout.
- To alert owners to the various federal and state requirements to be included in the design, construction, maintenance, and inspection of their bridges and other structures.
- To provide practical suggestions specific to Florida on prudent structural engineering based on experience with statutes, standards, and criteria.

C DESIGN

The design of bridges and other structures shall be led by a licensed professional engineer who shall assume responsible charge of the work. The standards and criteria included here are directed only toward specific considerations that shall be followed. Other considerations are necessary to create a comprehensive bridge design allowing owners and their engineer's flexibility in design. All bridges and other structures shall be designed in accordance with specifications (including guide specifications) published by the American Association of State Highway and Transportation Officials (AASHTO).

C.1 Bridges - General

All bridges and other structures shall be designed in accordance with specifications (including guide specifications) published by the American Association of State Highway and Transportation Officials (AASHTO). At a minimum, the ***AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications, 9th Edition (2020)*** shall be used. Any bridge reconstruction (i.e., lengthening, widening, and/or major component replacement) shall be designed as specified in this section. Record of such reconstruction shall be maintained as specified in Section D of this chapter. The remaining design life should be considered in the design.

C.2 Bridge Live Loads

In addition to the notional (HL - 93) design load specified in ***LRFD***, bridges shall also require a FL 120 permit load rating greater than 1 as defined in the FDOT's ***Structures Manual, Volume 1 – Structures Design Guidelines, 2022 (SDG).*** This vehicle allows for a more consistent load rating comparison considering the current bridge inventory.

C.3 Bridge Superstructure

The superstructure of a bridge is that portion of the structure that spans between its supports or piers. Considerations that shall be incorporated into the design of all superstructures will include the following:

C.3.a Girder Transportation

The Engineer of Record (EOR) is responsible for investigating the feasibility of transportation for heavy, long and/or deep girder field sections. In general, the EOR should consider the following during the design phase:

- Whether or not multiple routes exist between the bridge site and a major transportation facility.
- The transportation of field sections longer than 130 ft or weighing more than 160,000 pounds requires coordination through the FDOT's Permit Office during the design phase of the project. Shorter and/or lighter field sections may be required if access to the bridge site is limited by roadway(s) with sharp horizontal curvature or weight restrictions.
- On steel superstructures, where field splice locations required by design result in lengths greater than 130 feet, design, and detail "Optional Field Splices" in the plans.
- For curved steel box girders, prefabricated trusses, and integral pier cap elements, size field pieces such that the total hauling width does not exceed 16 feet.

C.3.b Vertical Clearance

All new bridges over roadways and shared use paths shall be designed to meet the vertical clearance standards specified in ***Chapter 3, Section C.7.j.4.(b)***, and ***Chapter 9, Section C.6***.

All new bridges over water shall be designed to meet the following vertical clearance standards:

- To allow debris to pass without causing damage, the clearance between the design flood stage and the low member of bridges shall be a minimum of two feet. This standard does not apply to culverts and bridge-culverts.
- For crossings subject to boat traffic, the minimum vertical navigation clearance should be:

Tidewater bays and streams	6 feet above Mean High Water *
Freshwater rivers, streams, non-regulated/controlled canals, and lakes	6 feet above Normal High Water
Regulated/controlled lakes and canals	6 feet above control elevation

* For locations subject to tidal salt / brackish water splashing, a 12-foot vertical clearance above Mean High Water should be considered for bridge durability reasons.

Higher clearances apply for crossings over legislated channels under the control of the U.S. Coast Guard (USCG). Designers should also consider future navigation demands and future shared use path demands in setting the vertical clearance of a bridge.

C.3.c Railings

All traffic, pedestrian, and bicycle railings shall comply with the requirements in ***Section 13*** of ***LRFD***. Traffic railings shall meet the crash requirements of at least Test Level 3 (TL-3) for bridges with design speeds greater than 45 mph and at least TL-2 for design speeds less than or equal to 45 mph.

For pedestrian/bicycle railings, two-pipe guiderails, and details similar to those in the FDOT's ***Standard Plans*** may be mounted on walls or other structures where drop-off hazards are 5 feet or less. Concrete, aluminum or steel railing and details similar in strength and geometry to those in the FDOT's ***Standard Plans*** shall be used (or modified to suit environmental runoff concerns) where drop-off hazards are greater than 5 feet. See ***Standard Plans Instructions*** for more information.

C.3.d Expansion Joints

The number of joints should be minimized to reduce the inspection and maintenance needs of the bridge.

C.3.e Drainage

All bridge designs shall include a drainage design that is specific to its site. Conveyance of drainage off the bridge roadway should be designed to meet spread standards contained in the FDOT's ***Drainage Manual, (2022)*** and may include open systems (i.e., scuppers) or closed systems (i.e., inlets and pipes) based on environmental permitting restrictions. Drainage from the bridge should not drop onto traffic below. Longitudinal conveyance piping attached to bridges is expensive and maintenance-intensive, and should be avoided whenever possible.

Conveyance of drainage off pedestrian facilities shall be designed to provide an accessible route for pedestrians. Further guidance on the design of bridge deck drainage may be found in the current version of ***FHWA Publication HEC-21, "Design of Bridge Deck Drainage."***

C.3.f End Treatments

Requirements for end treatments of structures are given in ***Chapter 4 – Roadside Design***. Bridge barriers shall be designed to accommodate connection of a guardrail transition or energy absorbing system.

C.4 Bridge Substructure

The substructure of a bridge consists of all elements below the superstructure including its bearings, piers, and foundations. For guidance on bridges vulnerable to coastal storms, see ***SDG, Section 2.5***. Considerations that shall be incorporated into the design of all substructures include the following:

C.4.a Scour

A hydrologic/hydraulic analysis shall be performed to quantify expected stages and flows at the bridge site. Anticipated substructure scour shall be developed for the following conditions:

Hydraulic Design Flood Frequency	Scour Design Flood Frequency	Scour Design Check Flood Frequency
Q_{10}	Q_{25}	Q_{50}
Q_{25}	Q_{50}	Q_{100}
Q_{50}	Q_{100}	Q_{500}
Notes: "Q" is the common term used for flow rate, an expression of volume of fluid which passes per unit of time. "x" is the return period in years (10, 25, 50, 100, 500).		

Any exceptions to the standards above hydrologic/hydraulic and scour analysis requirements shall be approved in writing by the FDOT District Drainage Engineer. Methodology for computing bridge hydrology/hydraulics and bridge scour should follow the guidelines set forth in the FDOT's ***Drainage Manual (2022).*** Further guidance and training may be obtained through ***FHWA Hydraulic Engineering Circulars (HEC) "HEC-18"*** and ***"HEC-20"*** and the FDOT's training courses on these topics. Additionally, for larger bridges (>120,000 sq. ft.), hydraulic designers may wish to consult with the FDOT District Drainage Engineer for case-specific guidance. The ***SDG, Section 2.11*** and ***2.12*** and the FDOT's ***Drainage Manual, (2022)*** provide guidance on scour load combinations with other loads.

C.4.b Navigation Aids and Vessel Collision

All bridges over USCG designated navigable waterways shall include bridge fender systems and consideration for potential vessel collision.

For guidance on navigation aids and bridge fender system design, see ***SDG Section 314***. For guidance on vessel collision design see ***SDG, Section 2.11*** and ***LRFD, Section 3.14.***

C.4.c Pier Locations

All bridges over roadways shall have substructures supports set back from vehicular traffic lanes in accordance with ***Chapter 3, Section C.7.j.4.(a)***.

All bridges over water shall have substructure supports located with horizontal clearance requirements as listed below. In this case, horizontal clearance is defined as the clear distance between piers, fender systems, culvert walls, etc., projected by the bridge normal to the flow.

- For crossings subject to boat traffic a minimum horizontal clearance of 10 feet shall be provided.
- Where no boat traffic is anticipated, horizontal clearance shall be provided consistent with debris conveyance needs and structure economy.

C.4.d Wildlife Crossing Features

Consider the use of wildlife connectivity features (e.g. shelves and wildlife fencing) in accordance with the FDOT ***Wildlife Crossing Guidelines*** to enhance wildlife mobility and reduce motor vehicle collisions with wildlife. Wildlife crossing features help maintain habitat connectivity, promote wildlife diversity, and enhance motorist safety. Adding shelves into the bridge abutment design is a low cost technique which allows for better wildlife connectivity and makes bridge inspections safer.

Wildlife crossing feature(s) may include new or modified structures, such as bridges, bridges with shelves, specially designed culverts, enlarged culverts or drainage culverts and/or exclusionary devices such as fencing, walls or other barriers, or some combination of these features. Wildlife refers to listed, protected, or otherwise regulated species that the US Fish and Wildlife Service (USFWS) and/or Florida Fish and Wildlife Conservation Commission (FWC) have jurisdiction over.

The National Transportation Library provides additional information on ***Wildlife Crossing Structures.***

Figure 17 – 1 Bridge with Shelves for Wildlife

C.5 Retaining and Noise Walls

The design of conventional, anchored, mechanically stabilized, and prefabricated modular retaining wall structures shall meet the requirements of ***LRFD Section 11.*** Local agencies should consider using only wall types approved by the FDOT. These are described in ***Section 3.12*** of the ***SDG***. Local agencies should also follow the design criteria for retaining walls found in ***Section 3.13*** of the ***SDG***.

The design of noise walls should meet the requirements of the ***SDG, Section 3.16***. For noise walls within the clear zone, their design and/or protection should comply with the following:

- For noise walls attached to the top of traffic railings only use crash tested systems consistent with the design speed of the facility. The FDOT has standards for TL-4 systems that meet the requirements of ***NCHRP Report 350 or the Manual for Assessing Safety Hardware (MASH)***.
- Non-crash tested noise walls may be attached to structures if located behind an approved traffic railing and mounted at least five feet from the face of the traffic railing at deck level.

Potential existing off-site stormwater inflows through the proposed wall location should be verified in the field and considered in the wall design. For railings on top of walls, see ***Section C.3.c. Railings.***

C.6 Sign, Lighting, and Traffic Signal Supports

The design of sign, lighting, and traffic signal support structures shall meet the requirements of ***AASHTO's LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 1st Edition, with 2017, 2018, 2019 and 2020 Interim Revisions*** and the FDOT ***Structures Manual Volume 3 - FDOT Modifications to LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals (LRFDLTS-1).***

C.7 Pedestrian Bridges

For guidance on pedestrian bridges, see ***SDG Chapter 10***.

D CONSTRUCTION

During the construction of a bridge or any structure at, over, or near a public facility, safety awareness is necessary and precautions shall be taken to protect the public. Provisions for protecting the public during construction shall be in accordance with the ***MUTCD (2009 Edition with Revision Number 1 and 2, May 2012)*** work zone traffic control procedures and the standards and criteria described in ***Chapter 11 – Work Zone Safety and Mobility***. Worker safety is the responsibility of the contractor. Temporary barriers shall be installed on all bridges being widened or whose new construction is phased. Spread of stormwater on the bridge deck should be considered in planning temporary traffic routing.

During the construction of a bridge or any structure, records to be kept and maintained throughout its life shall include foundation construction records (pile driving records, shaft tip elevations, borings) and as-built plans. These records provide critical information necessary for future inspection, maintenance, emergency management, enhancement, reconstruction, and/or demolition of these structures. These records shall be delivered to the FDOT's local District Structures Maintenance Engineers.

Any proposed changes to the construction details or specifications shall be signed, sealed, and dated by a professional engineer licensed in the State of Florida.

E ROUTINE INSPECTION AND MAINTENANCE

Title 23, Code of Federal Regulations, Part 650, Subpart C, sets forth the ***National Bridge Inspection Standards (NBIS)*** for bridges on all public roads. ***Section 650.3*** defines bridges, specifies inspection procedures and frequencies, and indicates minimum qualifications for personnel. Each state is permitted to modify its bridge inspection standards to deviate from the NBIS standards but only following approval from the FHWA.

Section 335.074, F.S., mandates safety inspection of bridges. Bridge inspectors shall be certified in accordance with ***Chapter 14-48, F.A.C.*** Safety inspection of bridges shall be conducted in accordance with ***Chapter 14-48, F.A.C.***

The FDOT inspects all bridges in Florida, both on-system and off-system and provides each local government with copies of its inspection reports. Each local government should maintain these reports to be responsive to Metropolitan Planning Organization requests for bridge rehabilitation, replacement, or enhancement designations. Please see the following for further information: ***Bridge and Other Structures Reporting Manual 850-010-030.***

All on-system and off-system bridges are assigned a Bridge Number by the FDOT. For new bridges, local agencies shall contact the FDOT's local District Structures Maintenance Engineers to have a number assigned.

F BRIDGE LOAD RATING AND POSTING

Section 335.074, F.S. Safety Inspection of Bridges requires that bridges on a public transportation facility be inspected for structural soundness and safety at regular intervals. The inspection shall consider age, traffic characteristics, state of maintenance, and known deficiencies of the bridge. The governmental entity having maintenance responsibility for any such bridge shall be responsible for having inspections performed and reports prepared.

As required by ***Section 335.074, F.S.,*** each inspection shall be reported to the FDOT, using the Bridge Load Rating Summary Table form shown in the FDOT ***Bridge Load Rating Manual***. Further information for preparing a bridge load rating summary and fillable form may be found on the FDOT's ***Office of Maintenance, Bridge Load Rating*** web site.

Upon receipt of an inspection report that recommends reducing the weight limit on a bridge, the governmental entity having maintenance responsibility for the bridge shall load post the bridge within 30 days in accordance FS 335.074(5). Further requirements for reporting and posting of weight, size or speed limits on bridges are found in this statute, ***Section 316.555 F.S. Weight, load, speed limits may be lowered.*** The appropriate signage shall be promptly installed in accordance with the ***MUTCD***.

For new construction or reconstruction projects, the bridge owner is responsible for providing the FDOT with a load rating and completed Bridge Load Rating Summary Table within 90 days of opening for on-system bridges or 180 days for off-system bridges. The bridge owner should consider requiring the engineer of record to perform the load rating.

G RECOMMENDATIONS

- Involve the public in determining "*the appropriate aesthetics based upon scale, color, and architectural style, materials used to construct the facility, and the landscape design and landscape materials around the facility…" (Section 336.045, F.S.).*
- Consider the potential for future expansion of a bridge's capacity (vehicular transit and pedestrian) in its layout and bridge-type selection.
- Use the FDOT's objective construction unit prices (contained in the Structures Design Guidelines, Sections 9.2 and 9.3) to select bridge type(s) to consider for final design.

H REFERENCES FOR INFORMATIONAL PURPOSES

The publications referenced in this chapter can be obtained from the following websites.

- FDOT Publications may be found at:
  http://www.fdot.gov/publications/
- AASHTO, all publications may be ordered from:
  bookstore.transportation.org
- FHWA "HEC-18" and "HEC-20" may be found at:
  http://www.fhwa.dot.gov/engineering/hydraulics/library_listing.cfm
- 2006 Americans with Disabilities Act Standards for Transportation Facilities
  https://www.access-board.gov/files/ada/ADAdotstandards.pdf
- 2017 Florida Accessibility Code for Building Construction
  https://codes.iccsafe.org/public/document/FAC2017

CHAPTER 18

SIGNING AND MARKING

TABLES

FIGURES

CHAPTER 18

SIGNING AND MARKING

A INTRODUCTION

Signing and pavement markings help improve highway safety by providing guidance information to road users. Both signs and pavement markings should provide sufficient visibility to meet the user's needs. The design of signs and pavement markings should complement the basic highway design. Designers and engineers should also be aware of the capabilities and needs of seniors, and consider appropriate measures to better meet their needs and capabilities.

Sections C and D of this chapter specifically discuss traffic control devices for both signing and pavement marking that accommodate not only the needs of all types of road users, but also the special needs of seniors.

B BACKGROUND

Section 316.0745, F.S., requires the FDOT to compile and publish a manual of uniform traffic control devices for use on the streets and highways of the state. To comply with this statute, the Federal Highway Administration's (FHWA) ***Manual on Uniform Traffic Control Devices (MUTCD)*** has been adopted for use in ***Rule 14-15.010, F.A.C.:*** All references in this chapter are in conformance with the ***MUTCD***:

The ***Manual on Speed Zoning for Highways, Roads, and Streets in Florida (2019),*** is adopted for use by the State of Florida under ***Rule 14-15.012, F.A.C.*** This manual is prepared by the FDOT in compliance with ***Chapter 316, F.S***., to promote uniformity in the establishment of state, municipal, and county speed and school zones throughout the State.

C SIGNS

C.1 Advance Street Name Signs

The use of advance street name signs provides advance notification to road users to assist them in making safe roadway decisions. Signs should be used for signalized or non-signalized intersections that are classified as a minor arterial or higher, or a cross street that provides access to a traffic generator or possesses other comparable physical or traffic characteristics deemed to be critical or significant.

C.1.a Standards

The words Street, Boulevard, Avenue, etc., may be abbreviated, deleted, or reduced in size to conserve sign panel length. However, if confusion would result due to similar street names in the area, the deletion should not be made.

Use of the local name is preferred on advance street name signs. When a cross street has a different name on each side of the intersection, both names shall be shown with an arrow beside each name to designate direction. Additional legend such as NEXT SIGNAL or XX FEET may be added.

C.1.b Installation

Advance street name signs should be installed in advance of the intersection in accordance with the distances shown in "Condition A" of ***Table 2C-4. Guidelines for Advance Placement of Warning Signs of the MUTCD***. These distances are to be considered the minimum for a single lane change maneuver, and should be measured from the begin taper point for the longest auxiliary lane designed for the intersection. The degree of traffic congestion and the potential number of lane change maneuvers that may be required should also be considered when determining the advance placement distance.

C.1.c Sign Design

Advance street name signs shall be designed in accordance with ***Part 2 Signs*** of the ***MUTCD***. The lettering for the signs shall be composed of a combination of lower case letters with initial upper case letters.

Letter height should conform to Table 18 – 1 Design Guidelines for Advance Street Name Signs. Various layouts for advance street name signs are shown in Figure 18 – 1 Examples of Advance Street Name Signs.

Table 18 – 1 Design Guidelines for Advance Street Name Signs

Posted Speed Limit	**Street Name Legend**	**Next Signal or Intersection**
	Letter Size (inches) Series E Modified (EM) Upper/Lower Case Letters	**Letter Size (inches) Series D (D) Upper Case Letters**
35 mph or less	8 EM	6 D
40 mph or greater	10.67 EM	8 D

Figure 18 – 1 Examples of Advance Street Name Signs

C.2 Advance Traffic Control Signs

Advance Traffic Control signs, i.e., Stop Ahead (W3-1), Yield Ahead (W3-2), and Signal Ahead (W3-3) signs, shall be installed on an approach to a primary traffic control device that is not visible for a sufficient distance to permit the driver to respond to the device. The visibility criteria for traffic signals shall be based on having a continuous view of at least two signal faces for the distance specified in ***Table 4D-2. Minimum Sight Distance for Signal Visibility*** of the ***MUTCD***.

An Advance Traffic Control sign may be used for additional emphasis of the primary traffic control device, even when the visibility distance to the device is satisfactory.

C.3 Overhead Street Name Signs

Overhead street name signs with mixed-case lettering should be used at major intersections (with multi-lane approaches) as a supplement to post mounted street name signs.

C.3.a Standards

Overhead street name signs shall only be used to identify cross streets, not destinations such as cities or facilities. To avoid the need for lighting of overhead signs, they should have a minimum maintained retroreflectivity value as shown in ***Table 2A-3. Minimum Maintained Retroreflectivity Levels, MUTCD***. Roadway geometry and forward sight distance will also influence the need for overhead sign lighting.

The words Street, Boulevard, Avenue, etc., may be abbreviated, deleted, or reduced in size to conserve sign panel length. The border should be eliminated on overhead street name signs to minimize sign panel size. When a cross street is known by both a route number and a local name, use of the local name is preferred.

When a cross street has a different name on each side of the intersection, two options are permitted:

- When two sign panels are used, install one sign panel on the left and the other sign panel on the right side of the signal heads; or
- When one sign panel is used, the left name should be displayed over the right name. Arrows should be provided to indicate which side of the intersection the street name applies.

C.3.b Installation

Due to the possibility of hurricane strength winds, overhead street name signs should not be installed on span wire but should be mounted to the strain pole or mast arm.

The location of the overhead street name sign on a signal strain pole and/or mast arm may vary. However, it shall not interfere with the motorist's view of the signal heads. The preferred location is shown in the FDOT's ***Standard Plans***. In the case of separate street names on each side of the street, where separate signs are used, one sign should be placed to the right of the signal heads and the other sign to the left of the signal heads.

C.3.c Sign Design

On roadways with speeds of 40 mph or above, the sign panel should be at least 24 inches in height with the length determined by text. At a minimum, use 8-inch upper case and 6-inch lower case lettering for the street name. If block numbering text is included, use 6-inch all upper case lettering on the second line. The preferred font is Series E-Modified; however, Series E may be used to accommodate the amount of legend so as not to exceed the 96-inch maximum length.

Where structurally possible, overhead street name signs should be designed in compliance with the FHWA recommendations for older drivers using a minimum lettering size of 10-inch upper case with 9-inch lower case.

C.3.d Internally Illuminated Overhead Street Name Signs

An internally illuminated overhead street name sign may be used to improve night-time visibility. Internally illuminated overhead street name signs should have a standardized height of 24-inches and a length not to exceed 108-inches (nine feet).

A Series E Modified or Series E font, which may vary to accommodate the amount of text on the panel should be used.

The sign design shall be in accordance with the ***MUTCD.*** When possible, the text should utilize the following text attributes in descending order to limit the maximum width:

- 10-inch upper case with 8-inch lower case, Type EM font
- 10-inch upper case with 8-inch lower case, Type E font
- 8-inch upper case with 6-inch lower case, Type EM font
- 8-inch upper case with 6-inch lower case, Type E font

Internally illuminated overhead street name signs shall be on the FDOT's ***Approved Products List (APL)***.

C.4 Community Wayfinding Guidance

Community wayfinding guide signs should be developed and approved through local resolution with criteria for the destinations shown on the community wayfinding guide sign system plan. Any wayfinding guide sign should be used in accordance with ***Rule 14-51.030, F.A.C.*** The intent is to provide guidance and navigation information to local cultural, historical, recreational, and tourist activities. No destination should be displayed for the purpose of advertising.

C.5 DMS Overview

The main purpose of dynamic message signs (DMS) is to convey timely and important en-route and roadside information to motorists and travelers. Further information on how DMS signs may be used can be found in the FDOT's policy on ***Displaying Messages on Dynamic Message Signs Permanently Mounted on the State Highway System.***

C.6 Design Details for Signs

The ***MUTCD*** shall govern all sign details. At a minimum, the "Conventional Road" size shall be used on signs intended for motor vehicle operators.

Shared use path sign sizing for traffic control shall follow the "Shared-Use Path" sizing and height shown in the MUTCD. See ***Chapter 9 – Bicycle Facilities*** for additional requirements on the signing of shared use paths.

D PAVEMENT MARKINGS

D.1 Pavement Markings

6-inch pavement markings should be used for all pavement center line, lane separation line and edge line markings. The ***FDOT Design Manual, Chapter 230*** provides additional information, including material options.

D.2 Reflective Pavement Markers

To provide greater emphasis and increase visibility to the pavement markings, especially during wet/night conditions, Raised Pavement Markers (RPMs) should be used. More information on RPM configurations is shown in the FDOT's ***Standard Plans, Index 76-001.***

D.3 Pavement or Surface Art

Do not apply pavement or surface art on travel lanes, paved shoulders, bridges, intersections, crosswalks, or sidewalks. Pavement or surface art is defined as surface markings that are not in direct support of traffic control or public safety.

E AUDIBLE AND VIBRATORY TREATMENTS

E.1 Longitudinal Audible Vibratory Treatments

Longitudinal Audible and Vibratory Treatments (AVTs) are an effective low-cost countermeasure to reduce the severity and frequency of lane departure crashes.

Audible Vibratory Treatments (AVTs) shall be provided for edge lines and center lines on flush-shoulder roadways with a posted speed of 50 mph or greater and lane widths of 11 feet or greater. Sections where advisory speeds are used due to restricted horizontal or vertical geometry shall not be excluded. AVTs shall not be placed within the limits of crosswalks.

More information on these types of treatments are shown in the FDOT's ***Standard Plans, Index 546-010*** and ***FDOT Design Manual, Chapter 210 Arterials and Collectors.*** AVT options include sinusoidal ground-in rumble strips and profiled thermoplastic. The sinusoidal ground-in rumble strip option provides the most economical and durable solution with less noise pollution.

E.2 Transverse Rumble Strips

Transverse rumble strips alert the driver in rural areas to upcoming stop conditions or abrupt changes in alignment. Factors influencing their use include crash history, roadway geometry and surrounding land use (noise pollution). They should not be placed in crosswalks or bicycle facilities. On roadways open to bicycle travel, a minimum clear path of 4 feet on the outside edge should be provided. ***Sections 3J.02 Transverse Rumble Strip Markings*** and ***6F.87 Rumble Strips, MUTCD*** provide further information on the use of transverse rumble strips.

See ***Chapter 11 – Work Zone Safety and Mobility*** for requirements for installation of short term transverse rumble strips during construction activities.

F RAILROAD DYNAMIC ENVELOPE PAVEMENT MARKING AND SIGNAGE

Railroad Dynamic Envelope pavement markings are used to delineate the area around at-grade railroad crossings where vehicles should not stop. See ***Chapter 7 – Rail-Highway Crossings*** for guidance on the design and installation of railroad dynamic envelope pavement markings and signage.

CHAPTER 19

TRADITIONAL NEIGHBORHOOD DEVELOPMENT

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TRADITIONAL NEIGHBORHOOD DEVELOPMENT

A INTRODUCTION

Florida is a national leader in planning, design and construction of Traditional Neighborhood Development (TND) communities, and in the renovation of downtown neighborhoods and business districts. TND refers to the development or redevelopment of a neighborhood or town using traditional town planning principles. Projects should include a range of housing types and commercial establishments, a network of well-connected streets and blocks, civic buildings and public spaces, and include other uses such as stores, schools, and worship within walking distances of residences.

They represent patterns of development aligned with the state's growth management, smart growth and sprawl containment goals. This approach, with its greater focus on pedestrian, bicycle and transit mobility; is distinct from Conventional Suburban Development (CSD). CSDs are comprised largely of subdivision and commercial strip development.

TND communities rely on a strong integration of land use and transportation. A TND has clearly defined characteristics and design features that are necessary to achieve the goals for compact and livable development patterns reinforced by a context-sensitive transportation network. The treatment of land use, development patterns and transportation networks necessary for successful TND communities is a major departure from those same elements currently utilized in other Greenbook chapters.

To provide a design that accomplishes the goals set out in this chapter, designers will be guided by the context of the built environment, established or desired, for a portion of the communities because TND communities rely on a stronger integration of land use and transportation than CSD communities. This chapter provides criteria that may be used for the design of streets within a TND when such features are desired, appropriate and feasible. This involves providing a balance between mobility and livability. This chapter may be used in planning and designing new construction, urban infill, and redevelopment projects.

Section B of this chapter discusses the primary objectives of TND in more detail to aid the designer in the selection of proper criteria. Section C sets forth specific design criteria for the transportation system within TND.

The Department's Traditional Neighborhood Development Handbook (2011) provides designers guidance in the successful application of this Chapter.

B APPLICATION

A project or community plan may be considered a TND when at least the first seven of the following principles are included:

Has a compact, pedestrian-oriented scale that can be traversed in a five to ten-minute walk from center to edge.

Is designed with low speed, low volume, interconnected streets with short block lengths, 150 to 500 feet, and cul-de-sacs only where no alternatives exist. Cul-de-sacs, if necessary, should have walkway and bicycle connections to other sidewalks and streets to provide connectivity within and to adjacent neighborhoods.

Orients buildings at the back of sidewalk, or close to the street with off-street parking located to the side or back of buildings, as not to interfere with pedestrian activity.

Has building designs that emphasize higher intensities, narrow street frontages, connectivity of sidewalks and paths, and transit stops to promote pedestrian activity and accessibility.

Incorporates a continuous bike and pedestrian network with wider sidewalks in commercial, civic, and core areas, but at a minimum has sidewalks at least five feet wide on both sides of the street. Accommodates pedestrians with short street crossings, which may include mid-block crossings, bulb-outs, raised crosswalks, specialty pavers, or pavement markings.

Uses on-street parking adjacent to the sidewalk to calm traffic, and offers diverse parking options, but planned so that it does not obstruct access to transit stops.

Varies residential densities, lot sizes, and housing types, while maintaining an average net density of at least eight dwelling units per acre, and higher density in the center.

Integrates at least ten percent of the developed area for nonresidential and civic uses, as well as open spaces.

Has only the minimum right of way necessary for the street, median, planting strips, sidewalks, utilities, and maintenance that are appropriate to the adjacent land uses and building types.

Locates arterial highways, major collector roads, and other high-volume corridors at the edge of the TND and not through the TND.

The design criteria in this chapter shall only be applicable within the area defined as TND.

C PLANNING CRITERIA

Planning for TND communities occurs at several levels, including the region, the city/town, the community, the block, and, finally, the street and building. Planning should be holistic, looking carefully at the relationship between land use, buildings, and transportation in an integrated fashion. This approach, and the use of form based codes, can create development patterns that balance pedestrian, bicycling, and transit with motor vehicle transportation.

C.1 LAND USE

In addition to its importance in calculating trip generation, the Institute of Transportation Engineers (ITE) recognizes land use as fundamental to establishing context, design criteria, cross-section elements, and right of way allocation. The pedestrian travel that is generated by the land uses is also important to the design process for various facilities.

A well-integrated, or “fine grained”, land use mix within buildings and blocks is essential. These buildings and blocks aggregate into neighborhoods, which should be designed with a mix of uses to form a comprehensive planning unit that aggregates into larger villages, towns, and regions. Except at the regional scale, each of these requires land uses to be designed at a pedestrian scale and to be served by “complete streets” that safely and attractively accommodate many modes of travel.

The proposed land uses, residential densities, building size and placement, proposed parking (on-street and off-street) and circulation, the location and use of open space, and the development phasing are all considerations in facility design for TNDs. ITE recommends a high level of connectivity, short blocks that provide many choices of routes to destinations, and a fine-grained urban land use and lot pattern. Higher residential density and nonresidential intensity, as measured by floor area ratios of building area to site area, are required for well-designed TNDs.

C.2 NETWORKS

Urban networks are frequently characterized as either traditional or conventional. Traditional networks are typically characterized by a relatively non-hierarchical pattern of short blocks and straight streets with a high density of intersections that support all modes of travel in a balanced fashion.

Figure 19 – 1 Traditional Network

New York, NY

Savannah, GA

(Source: VHB)

The typical conventional street network, in contrast, often includes a framework of widely-spaced arterial roads with limited connectivity provided by a system of large blocks, curving streets and a branching hierarchical pattern, often terminating in cul-de-sacs.

Figure 19 – 2 Conventional Network

Walnut Creek, CA
(Source: VHB)

Traditional and conventional networks differ in three easily measurable respects: (1) block size, (2) degree of connectivity and (3) degree of curvature. While the last does not significantly impact network performance, block size and connectivity create very different performance characteristics.

Advantages of traditional networks include:

Distribution of traffic over a network of streets, reducing the need to widen roads;

A highly interconnected network providing a choice of multiple routes of travel for all modes, including emergency services;

More direct routes between origin and destination points, which generate fewer vehicle miles of travel (VMT) than conventional suburban networks;

Smaller block sizes in a network that is highly supportive to pedestrian, bicycle, and transit modes of travel;

A block structure that provides greater flexibility for land use to evolve over time.

It is important in TND networks to have a highly interconnected network of streets with smaller block sizes than in conventional networks. There are several ways to ensure that these goals are achieved.

One method is based upon the physical dimensions used to layout streets and blocks. The following list identifies those parameters:

1. Limit block size to an average perimeter of approximately 1,320 feet.
2. Encourage an average intersection spacing for local streets of 300-400 feet.
3. Limit maximum intersection spacing for local streets to approximately 600 feet.
4. Limit maximum spacing between pedestrian/bicycle connections to approximately 300 feet (that is, it creates mid-block paths and pedestrian shortcuts).

D OBJECTIVES

The basic objectives of a Traditional Neighborhood Development are:

1. Safety
2. Mobility of all users (vehicles, pedestrians, bicyclists and transit)
3. Compact and livable development patterns
4. Context-sensitive transportation network

TND features are based upon the consideration of the following concepts. These concepts are not intended as absolute criteria since certain concepts may conflict. The concepts should therefore be used for the layout of proper street systems.

1. Strong integration of land use and transportation.
2. Very supportive of pedestrian, bicycle, and transit modes.
3. Smaller block sizes to improve walkability, and to create a fine network of streets accommodating bicyclists and pedestrians, and providing a variety of routes for all users.
4. On-street parking is favored over surface parking lots.
5. Limited use of one way streets.
6. Speeds for motor vehicles are ideally kept in the range of 20-35 mph through the design of the street, curb extensions, use of on-street parking, the creation of enclosure through building and tree placement.

7. Street geometry (narrow streets and compact intersections), adjacent land use, and other elements within a TND must support a high level of transit, pedestrian and bicycle activity.
8. Provide access to emergency services, transit, waste management, and delivery trucks.
9. Provide access to property.

This approach to street design requires close attention to the operational needs of transit, fire and rescue, waste collection, and delivery trucks. For this reason, early coordination with transit, fire and rescue, waste collection, and other stakeholder groups is essential. For fire and rescue, determination of the importance of that corridor for community access should be determined, e.g. primary or secondary access.

More regular encroachment of turning vehicles into opposing lanes will occur at intersections. Therefore, frequency of transit service, traffic volumes, and the speeds at those intersections must be considered when designing intersections.

When designing features and streets for TND communities, creativity and careful attention to safety for pedestrians and bicyclists must be balanced with the operational needs of motor vehicles.

Finally, it is very important when designing in TND communities to ensure that a continuous network is created for pedestrians, bicyclists, and transit throughout the community to create higher levels of mobility that are less dependent on automobile travel.

E DESIGN ELEMENTS

The criteria provided in this chapter shall require the approval of the maintaining authority's designated Professional Engineer representative with project oversight or general compliance responsibilities. Approval may be given based upon a roadway segment or specific area.

The criteria provided in this chapter are generally in agreement with AASHTO guidelines with a special emphasis on urban, low-speed environments. Design elements within

TND projects not meeting the requirements of this chapter are subject to the requirements for Design Exceptions found in ***Chapter 14*** of this manual.

E.1 Design Controls

E.1.a Design Speed

The application of design speed for TND communities is philosophically different than for conventional transportation and CSD communities. Traditionally, the approach for setting design speed was to use as high a design speed as practical.

In contrast to this approach, the goal for TND communities is to establish a design speed that creates a safer and more comfortable environment for pedestrians and bicyclists, and is appropriate for the surrounding context.

Design speeds of 20 to 35 mph are desirable for TND streets. Alleys and narrow roadways intended to function as shared spaces may have design speeds as low as 10 mph.

E.1.b Movement Types

Movement types are used to describe the expected driver experience on a given thoroughfare, and the design speed for pedestrian safety and mobility established for each of these movement types. They are also used to establish the components and criteria for design of streets in TND communities.

Yield: Has a design speed of less than 20 mph. Drivers must proceed slowly with extreme care, and must yield to pass a parked car or approaching vehicle. This is the functional equivalent of traffic calming. This type should accommodate bicycle routes through the use of shared lanes.

Slow: Has a design speed of 20-25 mph. Drivers can proceed carefully, with an occasional stop to allow a pedestrian to cross or another car to park. Drivers should feel uncomfortable exceeding design speed due to the presence of parked cars, enclosure, tight turn radii, and other design elements. This type should accommodate bicycle routes through the use of shared lanes.

Low: Has a design speed of 30-35 mph. Drivers can expect to travel generally without delay at the design speed, and street design supports safe pedestrian movement at the higher design speed. This type is appropriate for thoroughfares designed to traverse longer distances, or that connect to higher intensity locations. This type should accommodate bicycle routes through the use of bike lanes.

Design speeds higher than 35 mph should not normally be used in TND communities due to the concerns for pedestrian and bicyclist safety and comfort. There may be locations where planned TND communities border, or are divided by, existing corridors with posted/design speeds higher than 35 mph. In those locations, coordination with the regulating agency should occur with a goal to re-design the corridor and reduce the speed to 35 mph or less. The increase in motorist travel time due to the speed reduction is usually insignificant because TND communities are generally compact.

When the speed reduction cannot be achieved, measures to improve pedestrian safety for those crossing the corridor should be evaluated and installed when appropriate.

E.1.c Design Vehicles

There is a need to understand that street design with narrow streets and compact intersections requires designers to pay close attention to the operational needs of transit, fire and rescue, waste collection, and delivery trucks. For this reason, early coordination with transit, fire and rescue, waste collection, and other stakeholder groups is essential.

Regular encroachment of turning vehicles into opposing lanes will occur at intersections. Therefore, frequency of transit service, traffic volumes, and the speeds at those intersections must be considered when designing intersections. For fire and rescue, determination of the importance of the street for community access should be determined, e.g. primary or secondary access.

The designer should evaluate intersections using turning templates or turning movement analysis software to ensure that adequate operation of vehicles can occur. Treatment of on-street parking around intersections should be evaluated during this analysis to identify potential conflicts between turning vehicles and on-street parking.

E.2 Sight Distance

See ***Chapter 3 – Geometric Design, C.3 Sight Distance.***

E.2.a Stopping Sight Distance

See ***Chapter 3 – Geometric Design, C.3.a Stopping Sight Distance***.

E.2.b Passing Sight Distance

Due to the importance of low speeds and concerns for pedestrian comfort and safety, passing should be discouraged or prohibited.

E.2.c Intersection Sight Distance

Sight distance should be calculated in accordance with ***Chapter 3, Section C.9.b***, using the appropriate design speeds for the street being evaluated. When executing a crossing or turning maneuver after stopping at a stop sign, stop bar, or crosswalk, as required in ***Section 316.123, F.S*****.**, it is assumed that the vehicle will move slowly forward to obtain sight distance (without intruding into the crossing travel lane) stopping a second time as necessary.

Therefore, when curb extensions are used, or on-street parking is in place, the vehicle can be assumed to move forward on the second step movement, stopping just shy of the travel lane, increasing the driver's potential to see further than when stopped at the stop bar. The resulting increased sight distance provided by the two step movement allows parking to be located closer to the intersection.

The ***MUTCD*** requires that on-street parking be located at least 20 feet from crosswalks. The minimum stopping sight distance is 60 feet for low volume (< 400 ADT) streets. Even on slow speed, low volume urban streets, the combination of curb return, crosswalk width and 20-foot setback to the first parking space may not meet the minimum stopping distance. Justification for locating parking spaces 20 feet from crosswalks may be achieved based on community history with existing installations.

E.3 Horizontal Alignment

E.3.a Minimum Centerline Radius

See ***Chapter 3 – Geometric Design, C.4 Horizontal Alignment*** and Table 3 – 12 Minimum Radii (feet) for Design Superelevation Rates Low Speed Local Roads ((e_{max} = 0.05) .

E.3.b Minimum Curb Return Radius

Curb return radii should be kept small to keep intersections compact. The use of on-street parking and/or bike lanes increases the effective size of the curb radii, further improving the ability of design vehicles to negotiate turns without running over the curb return.

Table 19 – 1 Curb Return Radii

Movement Type	Design Speed	Curb Radius w/Parallel Parking*
Yield	Less than 20 mph	5-10 feet
Slow	20-25 mph	10-15 feet
Low	30-35 mph	15-20 feet

***** Dimensions with parking on each leg of the intersection. Both tangent sections adjacent to the curb return must provide for on-street parking or else curb radii must be evaluated using “design vehicle” and either software or turning templates.

E.4 Vertical Alignment

See ***Chapter 3 – Geometric Design, C.5 Vertical Alignment***.

E.5 Cross Section Elements

E.5.a Introduction

As discussed earlier in this chapter, TND street design places importance on how the streets are treated since they are part of the public realm. The street portion of the public realm is shaped by the features and cross section elements used in creating the street. For this reason, it is necessary the designer pay more attention to what features are included, where they are placed, and how the cross section elements are assembled.

E.5.b Lane Width

Travel lane widths should be based on the context and desired speed for the area where the street is located. Table 19-2 shows travel lane widths and associated appropriate speeds. It is important to note that in low speed urban environments, lane widths are typically measured to the curb face instead of the edge of the gutter pan. Consequently, when curb sections with gutter pans are used, the motor vehicle and parking lanes include the width of the gutter pan.

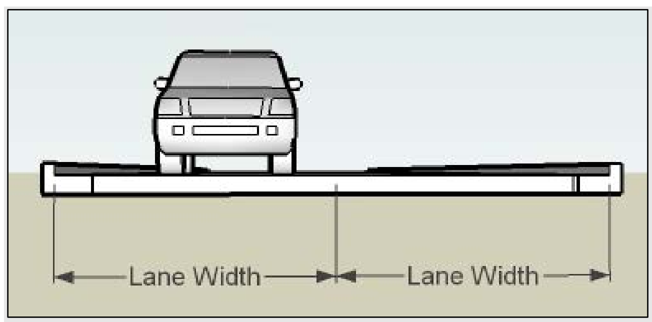
Table 19 – 2 Minimum Lane Width

Movement Type	Design Speed	Travel Lane Width
Yield*	Less than 20 mph	N/A
Slow	20-25 mph	9-10 feet
Low	30-35 mph	10-11 feet

* Yield streets are typically residential two-way streets with parking on one or both sides. When the street is parked both sides, the remaining space between parked vehicles (10 feet minimum) is adequate for one vehicle to pass through. Minimum width for a yield street with parking on both sides should be 24 feet curb face to curb face. Minimum width for a yield street with parking on one side should be 20 feet curb face to curb face, allowing for two 10-foot lanes when the street is not parked.

Figure 19 – 3 Lane Widths shows a typical measurement.

Figure 19 – 3 Lane Width



(Source: VHB)

In order for drivers to understand the appropriate driving speeds, lane widths should create some level of discomfort when driving too fast. The presence of on-street parking is important in achieving the speeds shown in Table 19 – 2 Minimum Lane Widths. When bicycle lanes or multi-lane configurations are used, there is more room for vehicles, such as buses, to operate. However car drivers may feel more comfortable driving faster than desired.

Alleys and narrow roadways that act as shared spaces can have design speeds as low as 10 mph, as noted in ***Chapter 16 – Residential Street Design***.

Alleys can be designed as either one way or two way. Right of way width should be a minimum of 20 feet with no permanent structures within the right of way that would interfere with vehicle access to garages or parking spaces, access for trash collection, and other operational needs. Pavement width should be a minimum of 12 feet. Coordination with local municipalities on operational requirements is essential to ensure that trash collection and fire protection services can be completed.

E.5.c Medians

Medians used in low-speed urban thoroughfares provide for access management, turning traffic, safety, pedestrian refuge, landscaping, lighting, and utilities. These medians are usually raised with raised curb.

Landscaped medians can enhance the street or help create a gateway entrance into a community. Medians can be used to create tree canopies over travel lanes for multi-lane roadways contributing to a sense of enclosure.

Medians vary in width depending on available right of way and function. Because medians require a wider right of way, the designer must weigh the benefits of a median with the issues of pedestrian crossing distance, speed, context, and available roadside width.

Table 19 – 3 Recommended Median Width

Median Type	Minimum Width	Recommended Width
Median for access control	4 feet	6 feet
Median for pedestrian refuge	6 feet	8 feet
Median for trees and lighting	6 feet [1]	10 feet [2]
Median for single left turn lane	10 feet [3]	14 feet [4]

Table Notes:

[1] Six feet measured curb face to curb face is generally considered the minimum width for the proper growth of small caliper trees (less than 4 inches),

[2] Wider medians provide room for larger caliper trees and more extensive landscaping,

[3] A ten foot lane provides for a turn lane without a concrete traffic separator,

[4] Fourteen feet provides for a turn lane with a concrete traffic separator.

E.5.d Turn Lanes

The need for turn lanes for vehicle mobility should be balanced with the need to manage vehicle speeds and the potential impact on the border width, such as sidewalk width. Turn lanes tend to allow through vehicles to maintain higher speeds through intersections, since turning vehicles can move over and slow in the turn lane.

Left turn lanes are considered to be acceptable in an urban environment since there are negative impacts to roadway capacity when left turns block the through movement of vehicles. The installation of a left turn lane can be beneficial when used to perform a road diet such as reducing a four lane section to three lanes with the center lane providing for turning movements. In urban areas, no more than one left turn lane should be provided.

Right turns from through lanes do not block through movements, but do create a reduction in speed due to the slowing of turning vehicles. Right turn lanes are used to maintain speed through intersections, and to reduce the potential for rear end crashes. However, the installation of right turn lanes increases the crossing distance for pedestrians and the speed of vehicles, therefore the use of exclusive right turn lanes are rarely used except at “T” intersections.

E.5.e Parking

On-street parking is important in the urban environment for the success of those retail businesses that line the street, to provide a buffer for the pedestrian, and to help calm traffic speeds. When angle parking is proposed for on-street parking, designers should consider the use of back in angle parking in lieu of front in angle parking.

Table 19 – 4 Parking Lane Width

Movement Type	Design Speed	Parking Lane Width
Slow	20-25 mph	(Angle) 17-18 feet
Slow	20-25 mph	(Parallel) 7 feet
Low	30-35 mph	(Parallel) 7-8 feet

E.6 Cul-de-sacs and Turnarounds

Cul-de-sacs should only be used where no other alternatives exist. Cul-de-sacs should have walkway or bicycle connections to other sidewalks and streets to provide connectivity within and to adjacent neighborhoods.

E.6.a Turning Area

A residential street open at one end only should have a special turning area at the closed end. A residential street more than 100 feet long and open at one end only shall have a special turning area at the closed end. This turning area should be circular and have a radius appropriate to the types of vehicle expected. The minimum outside radius of a cul-de-sac shall be 30 feet. In constrained circumstances, other turning configurations such as a “hammerhead” may be considered.

E.7 Pedestrian Considerations

In urban environments, the “border,” or area between the face of a building or right of way line and the curb face, serves as the pedestrian realm because it is the place for which pedestrian activity is provided, including space to walk, socialize, places for street furniture, landscaping, and outdoor cafes. In an urban environment, the border consists of the furniture, walking and shy zones.

Figure 19 – 4 Border

(Source: VHB)

E.7.a Furniture Zone

The furniture zone can be located adjacent to the building face, but more commonly is adjacent to the curb face. The furniture zone contains parking meters, lighting, tree planters, benches, trash receptacles, magazine and newspaper racks, and other street furniture. The furniture zone is separate from the walking/pedestrian and shy zones to keep the walking area clear for pedestrians, including proper access to transit stops.

E.7.b Walking/Pedestrian Zone

Chapter 8 addresses considerations for pedestrians. In a properly designed urban environment, where buildings are at the back of the sidewalk and vehicle speeds are low, the separation from traffic is normally provided by on-street parking, which also helps to calm traffic. The width of the walking/pedestrian zone should be at least four feet and should be increased based on expected pedestrian activity.

E.7.c Shy Zone

The shy zone is the area adjacent to buildings and fences that pedestrians generally “shy” away from. A minimum of one foot is provided as part of the sidewalk width. This space should not be included in the normal walking zone of the sidewalk.

E.7.d Mid-Block Crossings

Properly designed TND communities will not normally require mid-block crossings due to the use of shorter block size. When mid-block crossings are necessary, the use of curb extensions or bulbouts should be considered to reduce the crossing distance for pedestrians.

E.7.e Curb Extensions

Curb extensions are helpful tools for reducing the crossing distance for pedestrians, providing a location for transit stops, managing the location of parking, providing unobstructed access to fire and rescue, and increasing space for landscaping and street furniture.

Designers should coordinate with public works staff to ensure that street cleaning can be achieved with their equipment, and adequate drainage can be provided to avoid ponding at curb extensions.

E.8 Bicyclist Considerations

E.8.a Bicycle Facilities

Chapter 9 contains information on bicycle facilities. This section is directed to designing bike facilities in TND communities. Designing for bicycles on thoroughfares in TND communities should be as follows: bicycles and motor vehicles should share lanes on thoroughfares with design speeds of twenty five mph or less. It is important to recognize that the addition of bike lanes does increase roadway widths and can increase the tendency for drivers to speed.

When bicycle lanes are used in TND communities, they should be a minimum of 5 feet wide and designated as bike lanes. On curb and gutter roadways, a minimum 4-foot width measured from the lip of the gutter is required. The gutter width should not be considered part of the rideable surface area, but this width provides useable clearance to the curb face. Drainage inlets, grates, and utility covers are potential problems for bicyclists. When a roadway is designed, all such grates and covers should be kept out of the bicyclists' expected path. If drainage inlets are located in the expected path of bicyclists, they should be flush with the pavement, well seated, and have bicycle compatible grates.

Where parking is present, the bicycle lane should be placed between the parking lane and the travel lane, and have a minimum width of 5 feet. Designers should consider increasing the bicycle lane to 6 feet in lieu of increasing parallel parking width from 7 to 8 feet. This helps encourage vehicles to park closer to the curb, and provides more room for door swing, potentially reducing conflict with bicyclists.

Shared lane markings, or "sharrows," can be used instead of bicycle lanes adjacent to on-street parking. The sharrow allows the bicyclist to occupy the lane and therefore avoids placing bicyclists in the "door zone", and does not require an increase in lane width or ROW width for the thoroughfare. Guidance for use of the shared lane marking is included in ***Chapter 9 – Bicycle Facilities*** and the ***MUTCD***. See Figure 9 –24 –

Shared Lane Marking in ***Chapter 9*** for a detailed drawing of a shared lane marking.

E.8.b Shared Use Paths

Greenways, waterfront walks, and other civic spaces should include shared use paths, and provide for bicycle storage or parking. Bicycle storage or parking should also be included in areas near transit facilities to maximize connectivity between the modes.

E.9 Transit

See ***Accessing Transit, Design Handbook for Florida Bus Passenger Facilities, Version III, 2013*** for information.

E.10 Clear Zone

In urban areas, horizontal clearances, based on clear zone requirements for rural highways, are not practical because urban areas are characterized by lower speed, more dense abutting development, closer spaced intersections and accesses to property, higher traffic volumes, more bicyclists and pedestrians, and restricted right of way. The minimum horizontal clearance shall be 1.5 feet measured from the face of curb.

Streets with curb, or curb and gutter, in urban areas where right of way is restricted do not have roadsides of sufficient widths to provide clear zones; therefore, while there are specific horizontal clearance requirements for these streets, they are based on clearances for normal operation and not based on maintaining a clear roadside for errant vehicles. It should be noted that curb has essentially no redirectional capability; therefore, curb should not be considered effective in shielding a hazard.

F REFERENCES FOR INFORMATIONAL PURPOSES

The following publications were either used in the preparation of this chapter, or may be helpful in designing TND Communities and understanding the flexibility in AASHTO design criteria:

- Designing Walkable Urban Thoroughfares: A Context Sensitive Approach: An ITE Recommended Practice, 2010

  https://www.ite.org/technical-resources/topics/complete-streets/
- SmartCode 9.2
  http://www.smartcodecentral.org/
- A Guide for Achieving Flexibility in Highway Design, AASHTO, May 2004
  https://store.transportation.org/Common/DownloadContentFiles?id=305
- Accessing Transit, Design Handbook, 2017, FDOT Public Transit Office:
  https://www.fdot.gov/fdottransit/transitofficehome/transitplanning.shtm/newtransitfacilitiesdesign.shtm
- Safe Routes to Schools Program, FDOT Safety Office:
  http://www.dot.state.fl.us/safety/2A-Programs/Programs.shtm

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CHAPTER 20

DRAINAGE

TABLES

FIGURES

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CHAPTER 20

DRAINAGE

A INTRODUCTION

This chapter recognizes that Florida is regularly affected by adverse weather conditions. As such, the proper design of a roadway's drainage system is critical to its function and to the safety of the motoring public as well as pedestrians, bicyclists, and other users of these facilities. Standing water on a roadway can not only create a hazard but could also impede the flow of traffic.

This chapter represents the minimum standards that should be used when designing roadway drainage. As is the case for all elements in a facility's design, the designer must consider site specific conditions and determine the proper level of service the facility's drainage system should provide. The design of drainage facilities should not only consider the system's ability to handle the design storm, but also consider the system's recovery time during an event which exceed the design storm.

B OBJECTIVES

The objective of this chapter is to establish the minimum standards to which a roadway's drainage system is to be designed. In order for the drainage system to function properly, the below guidelines should be used in the design, construction and maintenance of these systems.

- Design and maintain drainage systems to quickly move water out of the travel lanes in order provide a safer environment for users of a facility during adverse weather conditions.
- Design drainage systems by taking into consideration the future maintenance of said system to avoid creating hazardous conditions to drivers and maintenance staff during routine servicing.

The FDOT's ***Drainage Design Guide (DDG)*** is a reference for designers, providing guidelines and examples of how these objectives can be accomplished. The DDG provides information on the following areas of drainage design:

- Hydrology
- Open Channel
- Culvert
- Bridge Hydraulics
- Storm Drains
- Exfiltration Systems
- Optional Pipe Material
- Stormwater Management Facility
- Temporary Drainage Design

C REGULATORY REQUIREMENTS

C.1 Chapter 62-330, Florida Administrative Code

Chapter 62-330, F.A.C., rules of the Florida Department of Environmental Protection, implements the comprehensive, statewide environmental resource permit (ERP) program under ***Section 373.4131, F.S.*** The ERP program governs the following: construction, alteration, operation, maintenance, repair, abandonment, and removal of stormwater management systems, dams, impoundments, reservoirs, appurtenant works, and works (including docks, piers, structures, dredging, and filling located in, on or over wetlands or other surface waters, as defined and delineated in ***Chapter 62-340, F.A.C.***. ***Chapter 62-25 F.A.C.*** has been repealed.

C.2 Chapter 62-40, Florida Administrative Code

Chapter 62-40, F.A.C., rules of the Florida Department of Environmental Protection outlines basic goals and requirements for surface water protection and management to be implemented and enforced by the Florida Department of Environmental Protection and Water Management Districts.

C.3 National Pollutant Discharge Elimination System

The ***National Pollutant Discharge Elimination System (NPDES)*** permit program is administered by the U. S. Environmental Protection Agency and delegated to the Florida Department of Environmental Protection in Florida. This program requires permits for stormwater discharges into waters of the United States from industrial activities; and from large and medium municipal separate storm sewer systems (MS4s). Construction projects are within the definition of an industrial activity.

D STORMWATER MANAGEMENT STRATEGIES

D.1 Watershed Approach to Evaluate Regional Stormwater Solutions (WATERSS)

WATERSS is a regional stormwater management process that promotes collaboration with state and local agencies, water resource managers and stakeholders to implement innovative stormwater management practices. The process is scalable depending on the type, size, complexity, context, and geographic location of the project. It enables the comparison of innovative solutions and partnerships with traditional solutions. The 12 steps detailing the WATERRS process is shown in Figure 20 – 1 WATERSS Process Flow Chart.

The WATERSS process identifies potential cost savings or additional environmental benefits for implementing feasible, non-traditional stormwater management solutions. Innovative practices include regional ponds, joint-use ponds, stormwater harvesting, land use modifications, upstream compensatory treatment, basin, or resource improvements, well injection, and bio-sorption activated media (BAM). These practices along with examples of opportunities that can be leveraged by this process are found in Table 20 – 1 Matrix of Typical Innovative Stormwater Management Practices.

Collaboration with external partners is essential for the discovery of stormwater management partnership opportunities. This may involve more time and effort than traditional stormwater pond design, which focuses on isolated activities and design of individual ponds. However, collaborative stormwater management solutions have proven to result in substantial environmental and investment benefits across a watershed or region.

Figure 20 – 1 WATERSS Process Flowchart

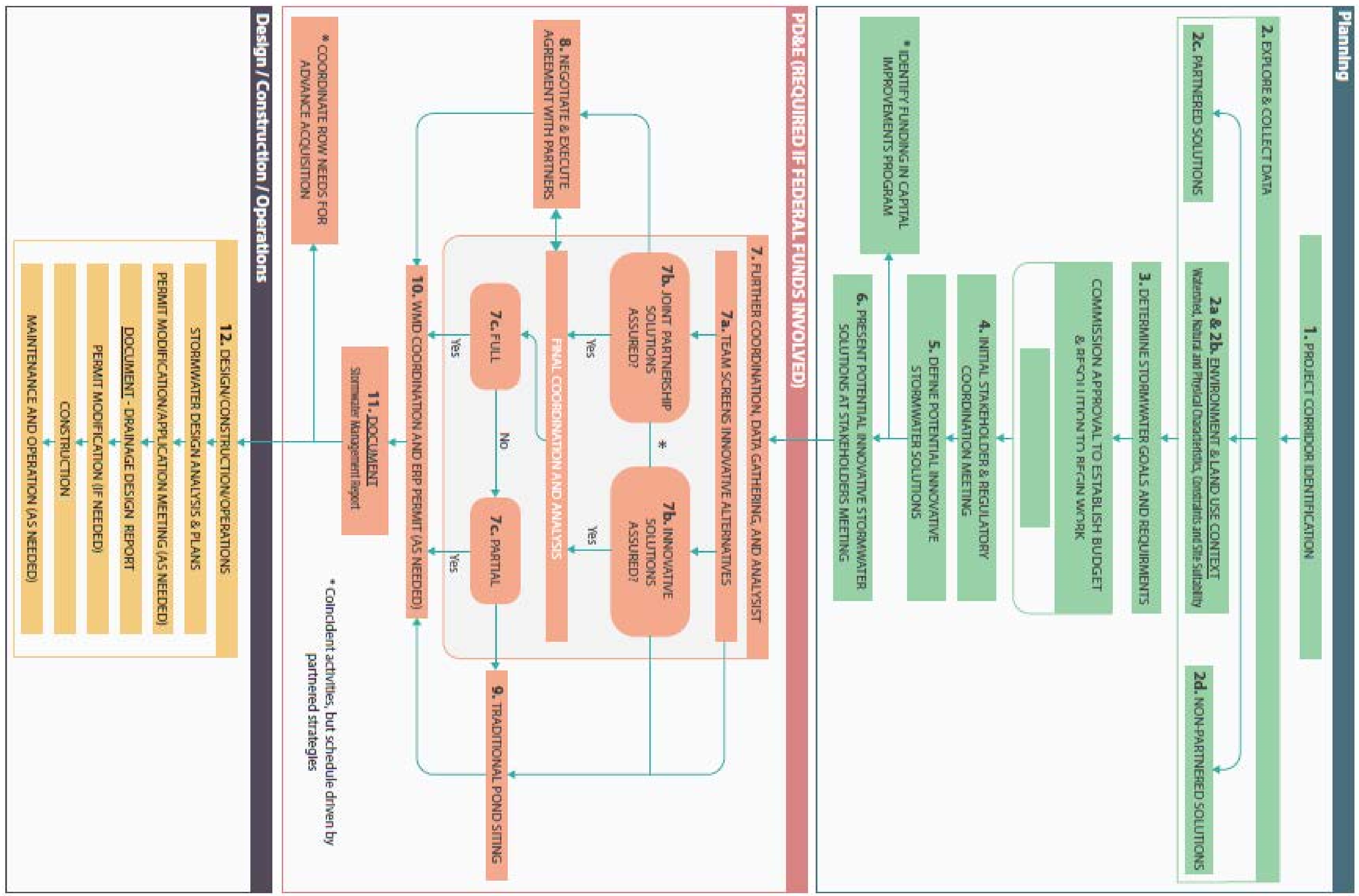


Table 20 – 1 Matrix of Typical Innovative Stormwater Management Practices

Best Management Practice (BMP)	Specific Characteristics	Applicability	Goals	Effectiveness in Meeting Stormwater Quality and Quantity Goals	Pros and Cons	Permitting Hurdles	Costs	Schedule	Design Constraints
Surface Water BMPs									
Regional Pond	Downstream pond sized to accommodate runoff from the upstream basin rather than only onsite runoff from the development.	Desirable when pond Right of Way (ROW) costs are high or land for ponds is unavailable.	Reduce long term pond costs and improve downstream water quality.	Highly effective in that land beyond the onsite project is treated and attenuated.	Pros: improved water quality and attenuation, reduced long term costs. Cons: (1) difficult to coordinate agreements and permit; and (2) possible long piped outfalls.	Minor increase in pollutants to waters of the state immediately downstream between the roadway and the regional pond.	Potential increased ROW costs are recouped by giving away maintenance to local municipalities.	Longer production schedule may be needed to accommodate negotiations with local municipalities and overcoming permitting hurdles.	Sometimes pre-treatment is required onsite, perhaps trapping sediments
Joint-Use Pond	Pond designed to accommodate runoff from two or more landowners. A formal agreement is crafted to outline terms of cooperation.	(1) Often occurs at the request of adjacent property owners to better integrate proposed pond locations into their properties; (2) sometimes initiated by the FDOT to store runoff in downstream golf courses; and (3) sometimes adjacent developments are required to take the	Reduce pond ROW acquisition and long-term maintenance costs.	Standard Environmental Resource Permit (ERP) water quality rules are satisfied.	Pros: combining ponds into a single pond reduces costs due to economy of scale; typically, maintenance is assumed by the party other than the FDOT. Cons: (1) co-mingling runoff can expose agency to NPDES responsibilities for offsite runoff; and (2) can be difficult to	(1) Permits must be obtained/modified for all parties involved; (2) phased construction must be coordinated for future roadway or development expansion; and (3) legal agreement must address the FDOT’s right to maintain pond (or hold another public agency as surety) if the developer defaults on his responsibilities.	Combining ponds into a single pond reduces ROW costs due to economy of scale; maintenance is often assumed by the offsite party.	Longer production schedule may be needed to accommodate negotiations with the cooperating party.	The overflow from the combined pond must be able to adequately drain both upstream properties.

Best Management Practice (BMP)	Specific Characteristics	Applicability	Goals	Effectiveness in Meeting Stormwater Quality and Quantity Goals	Pros and Cons	Permitting Hurdles	Costs	Schedule	Design Constraints
		FDOT runoff as a condition of county approvals.			coordinate agreements				
Stormwater Harvesting	Stormwater is collected and harvested for irrigation, raw water supply, wetland re-hydration, MFLs, or some other beneficial usage.	Useful when a high demand exists for non-potable water.	Reduce downstream pollutant loadings and provide an alternate water supply.	Highly effective in that land downstream discharge volume is reduced, lowering pollutant loading; usually has only minimal reduction in attenuating peak flow.	Pros: improved water quality and water supply. Cons: difficult to match with water consumers; partners can pull out late in the production schedule.	None, unless water consumer tries to negotiate CUP credits as part of the harvesting.	May need to design storage facility, but could assume the pond and pumping/ infrastructure costs are borne by the water consumer.	Longer production schedule may be needed to discover and negotiate with the water consumer.	(1) No privately-owned pumping/piping infrastructure within L/A ROW; (2) re-use with potential human contact must provide filtration; and (3) avoid the need for a Consumptive Use Permit (CUP) by avoiding the pumping of groundwater.

Best Management Practice (BMP)	Specific Characteristics	Applicability	Goals	Effectiveness in Meeting Stormwater Quality and Quantity Goals	Pros and Cons	Permitting Hurdles	Costs	Schedule	Design Constraints
Land Use Modification	Changing existing land usage to a usage generating less of the pollutant of concern, usually nutrients.	Desirable when pond ROW costs are high or land for ponds is unavailable.	Cost savings.	Standard ERP water quality rules are satisfied due to a reduced pollutant loading.	Pros: cost savings. Cons: involves negotiating with external property owners.	(1) Potential adverse impacts to adjacent properties; and (2) will require additional coordination for the specific permit language and conditions.	Costs are reduced by avoiding expensive ROW adjacent to the highway.	Additional production time may be needed to negotiate with land owners – no ROW condemnation authority.	None.
Upstream Compensatory Treatment	Treating upstream offsite runoff in lieu of onsite runoff.	Desirable when pond ROW costs are high or land for ponds is unavailable.	Cost savings.	Standard ERP water quality rules are satisfied.	Pros: cost savings. Cons: permitting hurdles.	(1) Potential adverse impacts to adjacent properties; and (2) will require additional coordination for the specific permit language and conditions.	Costs are reduced by the selection of an alternate treatment site.	Additional production time may be needed to find and design a suitable upstream treatment alternative.	Requires design of offsite treatment BMP.
Basin/Resourc e Improvements	In lieu of onsite stormwater treatment, modifications to the basin or downstream resource (e.g., septic tank conversions, circulation enhancements, etc.) are constructed to improve the waterbody's health.	Desirable (1) when pond ROW costs are high or land for ponds is unavailable; and/or (2) when greater environmental benefit is sought.	Potential cost savings and improved downstream environment al benefit.	Highly effective due to significantly increased environmental benefit.	Pros: improved environmental benefit and reduced costs. Cons: significant amount of permitting coordination.	With no specific rules to address this approach, regulatory leadership must provide strong evidence of the improvement's effectiveness.	Significant cost savings can be realized in comparison with pond ROW acquisition.	Longer production schedule may be needed to accommodate discussions with the permitting agencies and/or municipality.	Specialty design services may be required depending on the mitigation strategy.
Groundwater BMPs									

Best Management Practice (BMP)	Specific Characteristics	Applicability	Goals	Effectiveness in Meeting Stormwater Quality and Quantity Goals	Pros and Cons	Permitting Hurdles	Costs	Schedule	Design Constraints
Well Injection (not District 6 coastal zone)	Injecting runoff into the ground via a pipe rather than discharging it downstream.	Useful in springsheds and other areas where groundwater recharge is desirable; typically targets pond bleed down flows.	Increase groundwater recharge; decrease pollutant loadings to surface waters.	Effective in increasing groundwater recharge and reducing downstream surface water pollutant loadings by reducing discharge volume.	Pros: improved groundwater recharge; decreased surface water pollutant loadings. Cons: may need to include a special BAM design within the discharge well.	UIC permitting rules to allow this option are very restrictive. May require additional monitoring efforts and coordination for the specific permit language and conditions.	Additional costs are incurred to construct the injection system; currently, the WMDs offer no incentives such as reduced treatment requirements.	Separate permitting process with independent timelines.	Requires treatment and well injection design downstream of overflow weir.
Bio-sorption Activated Media (BAM)	Media provides a carbon source to promote the cultivation of denitrifying bacteria; also removes phosphorus, though infrequently used for that nutrient.	Useful in springsheds and coastal areas to denitrify during infiltration; useful to treat phosphorus within impaired basins.	Remove nutrients from runoff; eliminate ROW for ponds by using BAM within roadside ditches.	Highly effective in removing nutrients.	Pros: improved groundwater quality; can eliminate the need for stormwater ponds in rural typical sections. Cons: design and specifications for BAM are not yet codified into Manuals and Specs.	Design practice is new to most WMDs, though included in the BMPTRAINS program; performance measures/expectations are not well established.	Additional costs for BAM material which is sometimes offset by reduced pond ROW; when used to remove phosphorus, the design life of the media is predicted to be about 20 years and may then need replacement.	Longer production schedule may be needed to coordinate design with UCF.	Required residence time within BAM layer may require additional storage in ditches or retention ponds.

Step 1 – Project Corridor Identification

Identify the overall project characteristics including project location, environment, and land use context (urban vs. rural project), facility type, alternatives being considered, and potential stormwater needs.

Outcome: Watershed issues and concerns, conditions of the corridor(s), and potential stormwater needs.

Step 2 – Explore and Collect Data

A. Identify existing stormwater-related conditions on the project corridor and conduct an initial, desktop-level discovery of potential partnerships and innovative stormwater solutions available. Potential partnerships and initiatives are explored by using Geographic Information System (GIS) support tools, and by querying the National Pollutant Discharge Elimination System (NPDES) Coordinator regarding ongoing Total Maximum Daily Load (TMDL) and Basin Management Action Plan (BMAP) activities. The following information should be included:

- Previous planning studies.
- Existing roadway plans - as built.
- Corridor's context classification.
- Soil types, depth, slope and infiltration rates from natural resources conservation service soil surveys and existing geotechnical data from previous projects.
- Proposed alternative alignments and conceptual typical sections.
- Available topographic data and aerial photography (include local data sources).
- Existing and future land use maps.

- Tax maps & land owner information (can be provided as part of public involvement research).
- Existing right of way maps.
- Copies of any previous stormwater studies or watershed masterplans.
- Available copies of permits for projects within the vicinity.
- Existing agreements (Joint Participation Agreements (JPAs), easements, maintenance agreements, etc.).
- Water supply planning regions.
- Identified springsheds (as appropriate).
- Springs Priority Focus Areas (PFA).
- Water Management District (WMD) mean flow limitations.
- Aquifer storage and recharge wells.
- Parks, golf courses, irrigation, or water storage/recharge opportunities.
- BMAPs's.
- TMDLs with allocations.
- Identified public lands.
- Floodplain.
- Government-owned lands (schools, prisons, WMD lands, etc.).
- Developments of regional impacts (DRIs) and Sector Plans.

B. Investigate and document watershed information, environmental characteristics and constraints that may affect suitability of potential stormwater management solutions. The following list is provided as guidance:

- What are the characteristics of the watershed? Is the watershed fully developed? Mostly rural? A combination?

- Is the project area within a springshed/impaired basin? If so, is there a TMDL or BMAP for the area?
- What types of soils are in the project area?
- Is there an Outstanding Florida Water (OFW) located within the watershed?
- Is the project located in a floodplain?
- Are there wetlands in the area?
- Are there threated or endangered species or designated habitat which may cause certain types or locations of treatment to be not suitable for stormwater management?
- Are there contamination concerns which will cause a site to be not suitable for treatment?
- Is there land that is a Section 4(f) protected resource?
- Is there land that is protected by conservation easements?
- Is the project located near a designated Wild and Scenic River?
- Are there historic resources in the area?
- Is the project located within an area with a coastal management program?
- Is the project located near Essential Fish Habitat?
- Is the project located within the boundaries of a designated Sole Source Aquifer? There are two defined in Florida: Volusia-Floridan and Biscayne Aquifers.

C. Identify potential innovative stormwater solutions and partners. If the project is in an impaired basin, contact the NPDES Coordinator to obtain the BMAP stakeholder information (***https://floridadep.gov/dear/water-quality-restoration/content/basin-management-action-plans-bmaps***) and discuss a list of potential partners and available projects for funding. Pursue city, county, National Estuary Program, Water Management District, and developer partners. Examples are listed below:

- Regional Pond: If sub-basins are draining to the same outfall or future development is expected in the watershed.
- Additional offsite inflows: If new or additional offsite inflows of stormwater or wastewater are being proposed.
- Stormwater re-use: In urban or suburban areas, contact local governments or golf courses regarding their interest in stormwater as a raw water supply or for irrigation.
- Joint-use Ponds: Determine if there are large existing or proposed developments (residential or commercial) along the highway that might exchange storage on their property for an outfall.
- Springsheds: If the project is in a springshed Priority Focus Area (PFA) then additional scrutiny will be given from regulators on groundwater discharges (dry retention ponds) as opposed to surface water discharges where denitrification can occur. Is the groundwater beneath the project contaminated with nitrates or are there sources of nitrogen adjacent to the project? If so, the nitrogen-laden water may be pumped directly into the underground Bioabsorption Activated Media (BAM) layer to achieve large removals.
- Tidal or Lake Circulation Improvements: If a BMAP identifies tidal or lake flushing issues, consider improving a roadway crossing with a new or larger bridge or culvert to provide additional flushing.

D. Identify potential innovative stormwater solutions for which a partner is not typically needed. Examples are listed below:

- Regional Pond: If a substantial portion of the project drains to a single water body a regional pond would allow reduction of typical on-site ponds. Would a location downstream have equal or fewer community impacts or other benefits over on-site ponds? Consider if increased project runoff would create or worsen flooding or erosion issues between the project and the pond location? Could the runoff be piped, or the conveyance improved, given the number of parcels and the length of piping required?

- Springsheds: For projects in springsheds, critical water needs area, water supply hardship areas, or areas of nutrient impairment consider the use of a nutrient removal product such as BAM for additional treatment.
- Onsite Irrigation: Consider re-use of the pond treatment volume for irrigation near the project rather than bleeding downstream.
- Wetland Re-hydration: Are nearby wetlands underhydrated?
- Compensatory Treatment: Are there upstream areas that retrofit treatment and attenuation could be done as compensation? Look especially for land already available and runoff with high nutrient loading such as agricultural lands.
- Minimum Flows and Levels: Does the project flow to waterbodies with Minimum Flows and Levels (MFL).

E. Conclude the Explore and Collect Data step with a narrative describing the existing project stormwater conditions, potential partnerships, and innovative stormwater solutions that may be applied on the project.

Outcome: Narrative describing existing project stormwater conditions, potential stormwater management projects, partnerships, and innovative stormwater solutions.

Step 3 – Determine Stormwater Goals and Requirements

Identify and document the stormwater management goals and requirements for the project based on the information discovered in Step 2. Having a general knowledge about the scope of the proposed improvements and potential right of -way needs at the start of this step are essential to estimating the stormwater goals and requirements.

Outcome: A narrative describing identified stormwater management goals and requirements for the project.

Step 4 – Initial Stakeholders and Regulatory Coordination Meeting

Introduce the project to stakeholders and discuss cooperative or regional stormwater management opportunities and understand their priorities. During the initial stakeholders' coordination meeting, present the stormwater goals and opportunities being considered. The presentation should include the following project information:

- Project overview.
- Project baseline schedule including critical milestones.
- Stormwater goals and requirements.
- Potential innovative stormwater solutions that may be considered on the project.
- Preliminary Stormwater Costs (often based on the preliminary expected cost of traditional ponds) and Project Funding.

Outcome: List of potential partnership stormwater management solutions and innovative solutions to be further analysed.

Step 5 – Define Potential Stormwater Management Strategies

Discuss opportunities identified in Step 4 and screen out non-viable stormwater management solutions. Agree on the criteria for selection (includes constraints or limiting factors that may prevent implementation of solutions). These factors may include stormwater goals and requirements, cost, challenges in permitting, maintainability, constructability, schedule, and environmental considerations. Table 20 – 2 Evaluation Factors for Screening of Solutions provides more information on the types of factors to consider in identifying feasible stormwater management strategies.

Additional evaluation factors could include reliability of partners, compatibility with production schedule, and benefit/cost. This step does not overtly compare solutions, but only eliminates solutions that are flawed or otherwise do not meet the stormwater management goals and requirements. The screening by the stormwater team includes both partnership and non-partnership innovative solutions.

Compile a matrix for the comparison of solutions using the information obtained from Steps 1 through 4. Factors used and the scoring method should be included with the matrix to demonstrate the factors and justify the scoring. An example matrix is provided in Exhibit 20 – 1 Evaluation Matrix Example.

Prepare a work plan for each partnership strategy that is recommended for detail evaluation. Use this plan to facilitate dialogue with the respective stakeholders and secure commitments for all participant's share of the stormwater management solution.

Outcome: A list of viable solutions are identified for further detailed evaluation and to be presented at follow up stakeholder meetings, documented in a memorandum.

Table 20 – 2 Evaluation Factors for Screening of Solutions

Factor	Description/Issues to Consider
Project Needs for Water Quality	Will the solution provide all the water quality credits needed for the project?
Schedule Compatibility	Identify if negotiation and implementation of the solution to obtain water quality credits can be completed within the current project production schedule.
Cost / Benefit	The cost of solution vs. the benefit, i.e., reduction in maintenance costs, right of way costs, construction costs, mitigation costs, etc.
Partner Reliability	Identify if the partner of a solution can be relied upon to work with the agency for the duration of the solution.
Ease of Permitting	Identify if there have been preliminary discussions with the regulatory agencies, and document the feedback received. Is this solution permittable or will extensive negotiations be needed?
Water Quantity/Floodplain Benefit	Identify if the solution will provide water quantity or floodplain benefits and if so, quantify the benefits to be realized from the project.
Public Perception/Acceptance	Identify if the solution will be generally accepted by the public. Will extensive public involvement be required?
Threatened and Endangered Species and Associated Costs	Identify if there are threatened or endangered species which may be impacted by the solution. Identify any costs associated with avoiding or mitigating these impacts.
Wetland Credits	Identify if any wetland credits may be realized by the implementation of the solution and the associated benefit(s) that would be provided to the agency. Identify if the anticipated wetland credits would potentially satisfy mitigation requirements

	for the project and if there would be additional credits for future projects.
Seagrass Credits	Identify if any seagrass credits may be realized by the implementation of the solution and the associated benefit(s) that would be provided to the agency. Identify if the seagrass credits would satisfy mitigation requirements for the project and if there would be additional credits for future projects.

Table 20 – 2 Evaluation Factors for Screening of Solutions (continued)

Factor	Description/Issues to Consider
Section 4(f) Involvement	Identify the presence of potential Section 4(f) properties which may have a use under the definition of Section 4(f) or if there would be a benefit as a result of the solution.
Conservation Lands	Identify the presence of any conservation lands which may affect the suitability of a solution.
Cultural Resources Involvement	Identify the potential presence of cultural resources including archaeological and historical resources which could affect the suitability of a solution.
Public Wellfield Issues	Identify the proximity to any public wellfield locations and if the solution could potentially have a direct impact.
Contamination – Hazardous Materials	Identify if the area to be utilized for the solution is contaminated. Consider the costs associated with the clean-up of the area, and if the contamination will limit the area available for stormwater facilities.
Construction	Identify any construction related impacts of the solution and associated costs, such as additional drainage piping to transport stormwater and access for construction.
Maintenance	Identify the costs and frequencies of maintenance needed to maintain the solution.
Aesthetics	Identify if there are any associated costs or benefits for aesthetics of the solution, such as the cost to install and maintain plantings.
Priority of Regulatory Agencies	Identify if this solution is a priority of the regulatory agencies.

Multiple Benefits/Future Credits/Future Capacity for Other Projects	Identify if the solution will potentially provide for multiple types of credits such as water quality and seagrass. Identify if the project will potentially have credits available for future projects.

Exhibit 20 – 1 Evaluation Matrix Example

Weight of Factor	Factor	Score	W Score	Score	W Score	Score	W Score	Score	W Score
1-10		1-10		1-10		1-10		1-10	
	Alternative Number	A		B		C		D	
	Brief Description of Alternative	Vacant land near school		Home		Developed		Vacant land	
	Parcel Number	101		105		160		170	
	Parcel Size (Acres)	5		4		3.2		6.5	
2	Project Needs for Water Quality	5	10	6	12	5	10	6	12
7	Schedule Compatibility	3	21	8	56	3	21	1	7
10	Cost / Benefit	2	20	8	80	2	20	7	70
10	Partner Reliability	6	60	8	80	6	60	4	40
2	Ease of Permitting	1	2	3	6	1	2	5	10
10	Water Quantity/Floodplain Benefit	7	70	2	20	7	70	3	30
6	Public Perception/Acceptance	4	24	1	6	4	24	2	12
6	Threatened and Endangered Species	10	60	1	6	5	30	6	36
5	Wetland/Seagrass Credits	10	50	10	50	3	15	1	5
6	Section 4(f) Involvement	2	12	6	36	2	12	7	42
6	Conservation Lands	6	36	5	30	6	36	6	36
6	Cultural Resources Involvement	10	60	1	6	1	6	10	60
6	Public Wellfield Issues	10	60	1	6	7	42	10	60
8	Contamination – Hazardous Materials	6	48	3	24	4	32	6	48
9	Construction/Maintenance	5	45	2	18	10	90	5	45

2	Aesthetics	3	6	1	2	10	20	3	6
8	Priority of Regulatory Agencies	10	80	6	48	2	16	10	80
0	Multiple Benefits/Future Credits/Future Capacity for Other Projects	0	0	0	0	0	0	0	0
	Score	664		486		506		599	
	Ranking	4		1		2		3	

Note: “W Score” = Weighted Score

Step 6 – Present Potential Stormwater Strategies at Stakeholders Meeting

Present to the stakeholders viable partnership solutions and provide the stakeholders and regulators with an opportunity to provide input. Inform the group about any potential innovative stormwater solutions which are being pursued. This is also an opportunity to learn about any other projects that may be worth considering.

Outcome: Meeting notes and a memorandum that document the findings of the Planning phase.

Step 7 – Further Coordination, Data Gathering, and Analysis

Coordination with prospective partners continues during this step. In addition to technical investigations, i.e., preliminary soil borings or survey, specific to the solutions being proposed with potential partners, the topics listed under Partnership Solutions in Step 5 should be discussed with potential partners. Share the results of the investigations with water management districts (and other partners) to ascertain the ability to permit the alternative solutions and determine what additional information is needed to resolve the level of alternatives’ certainty.

Where corridors cross several basins, a combination of solutions may be needed to address project stormwater requirements. When a single innovative approach does not fully satisfy stormwater regulatory requirements on the project, different solutions may be applied, including traditional stormwater retention or detention ponds.

Outcome: Documentation of satisfaction of stormwater regulatory requirements.

Step 8 – Negotiate and Execute Agreement with Partners

Formal agreements involving partnership solutions are developed by agency legal staff and executed between the agency and its partners. The type of legal agreement will depend on the partnering entity. For example, with state or federal regulatory agencies, a Memorandum of Agreement (MOA) or a Memorandum of Understanding (MOU) may be used, but local governments typically execute a Joint Project Agreement (JPA) or easements.

Outcome: MOU/MOA/JPA

Step 9 – Traditional Pond Siting

Once it has been determined by the Stormwater Team that ponds may be needed to meet regulatory requirements, and that the acquisition of right of way will be required to accommodate these proposed ponds, a Pond Siting Process may commence. An explanation of the Pond Siting Process is in ***Section D.2 Pond Siting Process*** of this Chapter.

Outcome: Stormwater Management Report.

Step 10 – WMD Coordination and ERP Permit (as needed)

With innovative solutions selected and agreements in place, the stormwater component of the ERP may now be ready for at least a conceptual WMD permit. Different permitting scenarios can be employed, depending on the types of stormwater management solutions selected, as shown in Table 20 – 3 Project Permitting Scenarios Involving Full and Partial Solutions.

If the Design Phase is concurrent with the Preliminary Engineering Phase a Construction ERP permit can be obtained.

Table 20 – 3 Project Permitting Scenarios Involving Full and Partial Solutions

Innovative Solutions -Full	Innovative Solutions -Partial	Pond Siting Process Complete	Resource Requirements Satisfied and Roadway Plans Sufficiently Developed	Conceptual Permit	Construction Permit
ü	-	-	ü		ü
ü	-	-	X*	ü	
-	ü	ü	ü		ü
-	ü	ü	X*	ü	

* Conceptual plans will be needed for the Conceptual Permit application.

Outcome: Appropriate WMD permit.

Step 11 – Document: Stormwater Management Report

The Stormwater Management Report summarizes the memoranda prepared in planning; discusses the stormwater solutions analyzed, and solutions considered but eliminated; and documents the stormwater management solutions which will satisfy the water quality and attenuation needs of the project. This report will include all agreements with stakeholders and a summary of all meetings. If traditional pond siting was pursued the report will contain the preliminary drainage design of the project and, as needed, all traditional pond sites analyzed for design. The memoranda prepared in planning, any agreements with stakeholders, and meeting minutes should be included as attachments to this report.

Outcome: Stormwater Management Report.

Step 12 – Final Design, Final Permits, Construction, and Maintenance

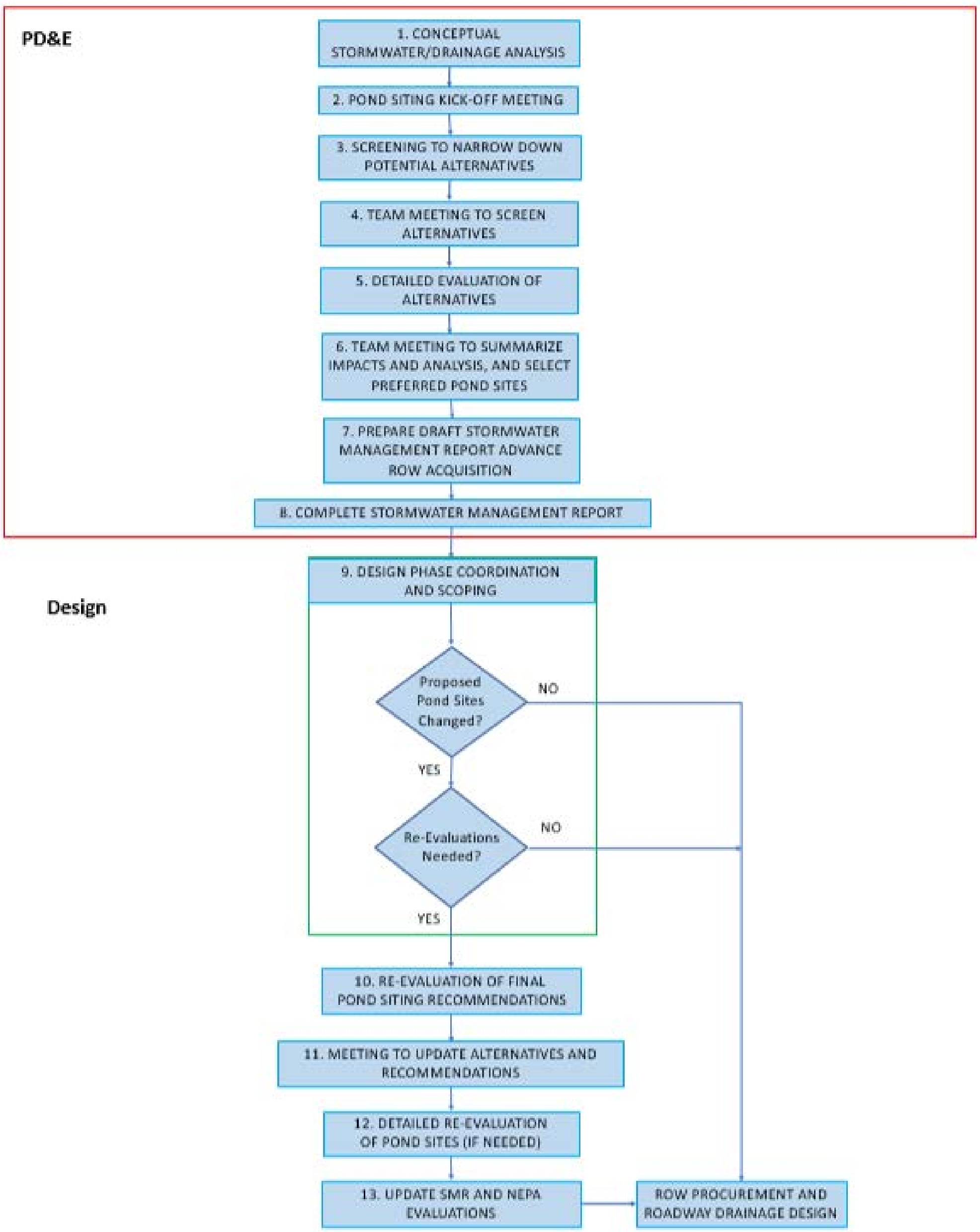
Design and stormwater plans production are finalized. Construction permits are obtained for the project as required. Stakeholder coordination and communication should be continued by the Champion during this time, including the transfer of maintenance responsibility to partners, if agreed upon as part of the partnership.

Outcome: Completed project including transfer of maintenance to partners, if applicable.

D.2 Pond Siting Process

The following pond siting process provides guidance for identifying, evaluating, and selecting locations for stormwater management ponds when those ponds require right of way (ROW) acquisition. The need for ponds may be driven by regulatory water quality, attenuation, and/or floodplain mitigation requirements. An overview is provided in Figure 20 – 2 Pond Siting Process Flowchart.

Figure 20 – 2 Pond Siting Process Flowchart



Step 1: Conceptual Stormwater/Drainage Analysis

Once it has been determined that traditional pond sites are needed to meet water quality or quantity requirements or dual evaluation will be needed, the following process can be used for conceptual analysis.

1. Establish drainage design criteria (may include a pre-permit application meeting with agencies). Criteria should include the following:
    - Permitting criteria (water quality and quantity as well as discharge limitations).
    - Rainfall intensity for critical duration events (identify design storm events).
    - Curve numbers or runoff coefficients.
    - Times of concentration.
    - Tailwater criteria (discharge condition and stages).
2. Conduct a review of drainage permit files for the corridor and adjacent developments.
3. Determine drainage basin boundaries using aerial contour maps, old construction plans, and available surveys to identify the primary basins and general outfall locations.
    - Identify high points on the profile to separate the primary basins.
    - Conduct field visits for this determination.
4. Determine major off-site contributing areas.
5. Establish floodplain elevations and potential for encroachment.
6. Identify outfall locations and verify if closed basin criteria apply.
7. Develop generic soils information (obtain from County Soil Conservation Survey or from earlier geotechnical studies conducted in the area).

8. Establish seasonal high ground water table (SHGWT) elevations.

9. Develop design estimates for water quality and water quantity requirements.

10. Develop an initial system model using a routing program.

11. Identify alternative pond design options based on project site conditions and available funding. A general rule of thumb for placement of ponds in relatively flat terrain is to target one pond per mile of corridor. In hilly areas, pond locations are typically much more frequent, as driven by the roadway profile.

12. Identify alternative stormwater management options (consider available funding):

    - Existing stormwater management facilities – are these adequate to handle the proposed improvements (with or without modifications)?
    - Potential exfiltration trench options.
    - Dry detention / retention systems.
    - Wet detention / retention systems.

13. Coordinate with the ROW Office on some initial sites to discuss at the kick-off meeting.

14. Discuss the area's stormwater management with the other agencies involved and estimate the impacts of the potential pond sites and feasibility of being incorporated into the area plan.

Outcome: Conceptual drainage design, including identified types of ponds and their approximate capacity.

Approximate Timeline: 2 months

Step 2: Pond Siting Kick-off Meeting

Before the meeting, coordinate with the right of way and legal staff to identify some initial pond sites to discuss at the kick-off meeting. During the meeting, the following issues should be addressed:

1. Verification of pond design guidelines and criteria (includes District preferences).
2. Identify potential detention / retention pond sites.
3. Assign property ID number to each property to be considered. The ROW Office will provide these numbers.
4. Identify potential joint-use pond sites (public / private).
5. Task team members with an assignment to conduct an impact analysis. Assign impact analysis to team members.

Outcome: A developed framework for future pond site evaluations.

Approximate Timeline: 2 weeks

Step 3: Screening to Narrow Down Potential Alternatives

This evaluation consists of a general review to narrow down potential alternatives. This effort may include site specific geotechnical testing, survey, constructability reviews, etc. Issues to consider when evaluating right of way include:

1. Use existing ROW whenever possible.
2. Minimize the number of parcels required for pond construction along the corridor.

3. Review aerials for potentially available vacant land. Use vacant land whenever possible and economical.

   - Establish why a property is vacant, and if the property owner has plans for development. Land may be vacant because the owner is having difficulty in permitting proposed improvements.
   - Consider the development potential of a property.

4. Look at how each pond location is situated on the site. Consider the impacts to the remainder of the parcel and its viability for development. How will it function for its current or future use?

   - Weigh the impacts of a partial ROW acquisition versus a whole acquisition of the property.

5. Avoid the following types of properties if possible:

   - Residential and commercial relocations.
   - Public and historic facilities.
   - Pond sites directly located on major streets and highways.
   - Pond sites on or adjacent to contaminated sites.

6. Look at access management issues and how the remainder of the site will operate.

   - Avoid landlocking the remaining property.
   - Consider how maintenance will access the pond site.

7. Avoid or minimize impacts to existing wetland systems and wildlife habitat. When placing ponds near wetlands, check the potential drawdown effects on the wetlands.

8. Avoid floodplain impacts.

9. Minimize utility relocations and review requirements for utility access for maintenance purposes.

10. Identify if proposed pond sites are candidates for advanced acquisition. If so, the ROW staff must have an increased role and the advanced ROW process identified in the project schedule.

Outcome: Initial evaluation of potential pond sites.

Approximate Timeline: 4 weeks.

Step 4: Team Meeting to Screen Alternatives

For the evaluation of stormwater management ponds several standardized factors should be considered, as shown in Table 20 – 4 Evaluation Factors for Pond Siting Alternatives. The project's stormwater team has the option of customizing the factors within the matrix to satisfy the particularities of their project. An example of a matrix format is shown in Exhibit 20 – 1 Evaluation Matrix Example.

For consistency, the team should use a ranking for each factor that is agreed upon by the entire group.

Outcome: Pond site alternatives are reduced to 3 sites per basin, with (1) team member assignments allocated for further, more detailed evaluation; and (2) needed survey requested for the alternative sites still under consideration.

Approximate Timeline: 2 - 3 weeks.

Table 20 – 4 Evaluation Factors for Pond Siting Alternatives

Factor	Description/Issues to Consider	Cost $	Weighted Value
Brief Description of Alternative	Provide a detailed description of the pond site.	N/A	N/A
Parcel Number	Identify the Parcel Number with the Right of Way office.	N/A	N/A
Estimated Parcel Size (Acres)	Provide the total area for the required ROW acquisition. The total area is to include the area to meet the water quality / quantity storage requirements as well as maintenance berm width, slopes, perimeter drainage/conveyance ditch area and access to pond sites for maintenance.	N/A	N/A
Right of Way (Zoning)	Describe the status of the parcel in question. For example, the parcel could be currently under a proposed plan for improvement (Rezoning Request) or the site may currently be located on a commercial site with an active business. Consideration should also be given to existing and proposed zoning.	N/A	If there are no zoning issues with the site add 5 points per acre. If there are potential zoning issues, add zero points.
Land Use	Identify the current and/or proposed land use, which could affect the acquisition costs of the parcel. For example, a partial ROW acquisition of a property could have a significant impact on the use of the remaining parcel.	N/A	Costs will need to be added to the overall site costs and a weighted value applied accordingly.

Right of Way Costs	Identify Right of Way Costs associated with the acquisition of the parcel.	$	Costs will need to be added to the overall site costs and a weighted value applied accordingly.
Drainage Considerations	Include a description of the system and corresponding outfall location and parameters. Consider pond location such as in the center of the basin, in the low area within the basin, adjacent to the outfall location, and piping needs / costs, etc. Also consider site elevations and the corresponding need to elevate (build-up) the perimeter berm.	$	Meets the FDOT's needs – points TBD by Team. Meets most needs – points TBD by Team. Other issues between sites will depend on construction costs of a facility at each particular site.
FEMA Flood Zone	Identify the Flood Zone and associated impacts / benefits of a pond within the flood zone. The perimeter berm will affect flood zone storage, while the pond will enhance storage. When right of way is acquired within a low-lying area, the construction of the roadway template may affect adjacent properties' ability to use that area for storage.	N/A	Meets the FDOT's needs – points TBD by Team. Meets most needs – points TBD by Team. Other issues will depend on the benefit to the floodplain at each particular site.
Contamination – Hazardous Materials	Identify if the parcel is contaminated; this will limit the ability to use the site. Consideration of this parcel must include the costs associated with the clean-up of the site.	N/A	Additional costs will need to be added to the overall site costs and a weighted value applied accordingly.
Utilities	Identify existing and proposed utilities within or adjacent to the parcel. The cost of relocating utilities	$	Additional costs will need to be added to the overall site costs, and weighted value applied accordingly.

	must be included in the consideration of a parcel.		
Threatened & Endangered Species (TES) and associated Mitigation Costs	Identify species as Threatened, Endangered, or Significant. Identify the anticipated mitigation costs.	N/A	Additional costs will need to be added to the overall site costs, and a weighted value applied accordingly.
Noise	Identify noise impacts and corresponding noise abatement, which may impact the location and placement of pond sites.	N/A	Additional costs will need to be added to the overall site costs, and a weighted value applied accordingly.
Wetlands / Protected Uplands and associated Mitigation Costs	High values indicate known habitat or historic presence such as Rookery Area. Medium values may be indicative of relatively undisturbed, natural, or stable habitat types. Low values may indicate disturbed habitats. Identify the cost of mitigating for these impacts.	$	Additional costs will need to be added to the overall site costs, and a weighted value applied accordingly.
Cultural Resources Involvement and associated Costs	Identify the presence of cultural resources including archaeological and historical resources which could affect the suitability of the site in question and associated costs.	N/A	Additional costs will need to be added to the overall site costs, and a weighted value applied accordingly.
Section 4(f)	Identify the presence of Section 4(F) properties which could affect the suitability of the site in question and associated costs.	N/A	Additional costs will need to be added to the overall site costs, and a weighted value applied accordingly.

Public Wellfield	The proximity to a wellfield site will have a direct impact on the type of drainage facility which can be placed on the corresponding parcel.	N/A	N/A
Construction	Identify access for construction and associated impacts which may affect construction costs, such as amount of drainage piping required to reach pond.	N/A	No set weighted value is applicable for this item; however, requirements for items identified may have a direct impact on the construction cost. Consider this and add to the overall costs associated with utilizing this site.
Maintenance	Identify the costs of maintaining a facility at this location and the potential for maintenance agreements with others. Consider access costs to the pond site.	$	Working with District Maintenance, staff needs to establish yearly maintenance costs per acre of pond area. This could be a yearly cost, say over a twenty-year period, and brought to present value for inclusion in the overall cost item below. Establish a cost for: • Wet Detention Maint. Cost per Acre $____ • Dry Pond Maint. Cost per Acre • Dry Linear Swale Cost per Acre

Maintenance (continued)			• Offsite Pond Maintenance by others At the beginning of the Preliminary Engineering Study, the Project Manager should consult with the Maintenance Office for current maintenance costs.
Aesthetics	Identify the need for landscape buffers, fencing, variable pond shapes, etc.	N/A	No set weighted value is applicable for this item; however, requirements for fencing, landscaping, littoral shelves, etc. which have a direct impact on the area required to physically set the pond needs to be considered. Costs associated with plants, fencing etc. will need to be added to the overall costs of using the site.
Public Opinion / Adjacent Residency Concerns	Identify possible impacts to current or proposed land use (i.e., schools may dictate a dry pond versus a wet pond).	N/A	N/A; however, this factor may affect the type of system selected for a site.
Other	Joint Use potential	N/A	If the ability to use joint use ponds is available, assume a weighted value of 10 per acre-ft of available storage.

			Otherwise use zero for this value.
Total Applicable Costs	Identify the total cost of the parcel including cost identified from all issues above.	$	Costs vary significantly between rural and urban locations. This value should be used when comparing final costs between alternative pond locations. Engineering judgment will need to be considered and an acceptable cost modifier applied as agreed to by the team members. Use 1 point per 5% differential in cost between alternative sites.
Comments, Advantages, Disadvantages, etc.	Include a detailed description of the Advantages and Disadvantages associated with the parcel in question.	N/A	N/A

Step 5: Detailed Evaluation of Alternatives

Conduct a field review(s) and obtain survey as deemed necessary. The extent of the field review should include the verification of impacts to assess the viability of a potential pond site.

Outcome: Alternatives are fully evaluated in preparation for selecting a preferred pond site in each basin.

Approximate Timeline: 4 weeks.

Step 6: Team Meeting to Summarize Impacts and Analysis, and Select Preferred Pond Sites

During the public involvement process, reasonable efforts must be made to inform the public/affected property owners of the potential impacts to the community/properties of the proposed improvements. As such, properties identified for potential acquisition for retention/detention ponds should be presented to the public in the same manner as acquisition for geometric requirements. Although the proposed right of way acquisition is displayed, the public should be clearly informed that all proposals are preliminary, and subject to change, as the project develops.

Outcome: Selection of preferred pond sites.

Approximate Timeline: 1 week.

Step 7: Prepare Draft Stormwater Management Report/Advanced ROW Acquisition

The Stormwater Management Report should have been incrementally prepared as the pond siting process was unfolding and reviewed by the team. The draft Stormwater Management Report will be presented at the Public Meeting.

Outcome: The Draft Stormwater Management Report should be made available for the Public Meeting.

Approximate Timeline: 1 month.

Step 8: Hold Public Meeting/Workshop

Advertise and host public meeting/workshop to inform the public about the project and pond locations being considered. Gather public input and document comments for further consideration in design. Conceptual project plans, aerial photos, geotechnical information can be provided to improve the public's understanding of project impacts. Ensure notice of meeting is provided in a timely manner.

Outcome: Obtain public input.

Approximate Timeline: 6 weeks.

Step 9: Complete Stormwater Management Report

Finalize Stormwater Management Report and recommendations based on team's evaluation. Exhibit 20 – 2, below, is a sample Table of Contents for Stormwater Management Reports.

1. Discuss and address comments from the Public Meeting.

2. Re-rank recommended and alternative pond sites, if necessary.

Outcome: Final Stormwater Management Report is completed.

Approximate Timeline: 1 week

Exhibit 20 – 2 Sample Table of Contents for Stormwater Management Reports

TABLE OF CONTENTS FOR POND SITING REPORTS

APPENDICES

Appendix A- Pond Siting Plan

Appendix B- Geotechnical Data

a. Excerpts from Draft Preliminary Report of Geotechnical Exploration; S.R. 50 from Hancock Road to Orange County Line, Lake County, Florida by Law Engineering and Environmental Services, Inc. October 2003.

b. Excerpts from Draft Preliminary Report of Geotechnical Exploration; S.R. 50 from Lake County Line to East Turnpike Ramps, Orange County, Florida by Law Engineering and Environmental Services, Inc. October 2003.

c. Excerpts from the PD&E Geotechnical Investigation

d. Excerpts from Soil Survey of Lake County, Florida

e. Excerpts from Soil Survey of Orange County, Florida

Appendix C- Rainfall

Appendix D- Floodplain Data

Appendix E- Pond Siting Calculations

a. Water Quality and Attenuation

b. Pond Area Requirements (Proposed Locations)

c. Pond Area Requirements (Alternative Locations)

d. Recovery Time (Preliminary Evaluation)

e. ICPR Pre-Development Model Input & Results

f. ICPR Post-Development Model Input & Results

Step 10: Reevaluation of Final Pond Siting Recommendations

If pond sites selected in the Stormwater Management Report have materially changed from their conditions at the time of the completion, the team should reevaluate the pond siting recommendations.

Outcome: Team members have reviewed changed pond sites and additional engineering data is identified for pursuit. Pond site layouts are refined.

Approximate Timeline: 1 week.

Step 11: Detailed Re-Evaluation of Pond Sites (If Needed)

Re-evaluate remaining viable recommended sites and identified alternate sites and conduct field reviews as necessary. Finalize pond site layout with site geometrics for the viable recommended sites and identified alternatives.

Outcome: Changes to previous pond sites are evaluated in preparation for team discussion and updating of documents.

Approximate Timeline: 3 weeks.

Step 12: Update Stormwater Management Report

Review the findings from the previous step, update the matrix as necessary, recommend final pond sites for project, update the Stormwater Management Report based on team evaluations, and finalize the information. Send to right of way mapping the preferred pond sites as specified in the revised Stormwater Management Report. Send right of way requirements to the right of way staff for procurement.

Outcome: Stormwater Management Report is updated, ROW acquisition begins.

Approximate Timeline: 4 weeks.

E OPEN CHANNEL

This section presents minimum standards for the design of natural or manmade open channels, including roadside ditches, swales, median ditches, interceptor ditches, outfalls, and canals.

E.1 Design Frequency

Open channels shall be designed to convey and to confine storm water within the channel. Standard design frequencies for stormwater flow are shown in Table 20 – 5 Stormwater Flow Design Frequencies.

Table 20 – 5 Stormwater Flow Design Frequencies

Facility Types	Frequency
Major roadway	10-year
All other road types	5-year

Site-specific factors may warrant the use of an atypical design frequency. Any increase over pre-development stages shall not significantly change land use values unless flood rights are acquired.

E.2 Hydrologic Analysis

For the design of open channels, use one of the following methods as appropriate for the site:

1. A frequency analysis of observed (gage) data shall be used when available. If insufficient or no observed data is available, one of the procedures below shall be used as appropriate. However, the procedures below shall be calibrated to the extent practical with available observed data for the drainage basin, or nearby similar drainage basins.

a) Regional or local regression equation developed by the United States Geological Survey (USGS).

b) Rational Equation for drainage areas up to 600 acres.

c) For outfalls from stormwater management facilities, the method used for the design of the stormwater management facility may be used.

2. For regulated or controlled canals, hydrologic data shall be requested from the controlling entity. Prior to use for design, this data shall be verified to the extent practical.

3. Stormwater modeling software, approved by the maintaining agency or local government jurisdiction.

E.3 Hydraulic Analysis

The Manning's Equation shall be used for the design of open channels.

E.3.a Manning's "n" Values

Recommended Manning's n values for channels with bare soil, vegetative linings, and rigid linings are presented in the FDOT's ***Drainage Manual (2022)***, Table 2.2 Manning's "n" Values for Artificial Channels with Bare Soil and Vegetative Linings and Table 2.3 Manning's 'n" Values for Artificial Channels with Rigid Linings. The manual is incorporated by reference in ***Rule 14-86.003, F.A.C., Permit, Assurance Requirements, and Exceptions***.

The probable condition of the channel when the design event is anticipated shall be considered when a Manning's n value is selected.

E.3.b Slope

Roadside channels should be designed to have self-cleaning velocities, where possible. Channels should also be designed to avoid standing water in the roadway right of way.

E.3.c Channel Linings and Velocity

The design of open channels shall consider the need for channel linings. When design flow velocities do not exceed the maximum permissible for bare earth, the standard treatment of ditches may consist of grassing and mulching. For higher design velocities, sodding, ditch paving, or other form of lining shall be provided. Tables for maximum velocities for bare earth and the various forms of channel lining can be found in the FDOT's ***Drainage Manual (2022),*** Tables 2.4 Maximum Shear Stress Values and Allowable Velocities for Different Soils and Table 2.5 Maximum Velocities for Various Lining Types.

E.3.d Limitations on Use of Linings

Grassing or sodding should not be used under the following conditions:

1. Continuous standing or flowing water
2. Areas that do not receive the regular maintenance necessary to prevent overgrowth by taller vegetation
3. Lack of nutrients
4. Excessive soil drainage
5. Areas excessively shaded

To prevent cracking or failure, concrete lining must be placed on a firm, well-drained foundation. Concrete linings are not recommended where expansive clays are present.

When concrete linings are to be used where soils may become saturated, the potential for buoyancy shall be considered. Acceptable countermeasures may include:

1. Increasing the thickness of the lining to add additional weight.

2. For sub-critical flow conditions, specifying weep holes at appropriate intervals in the channel bottom to relieve the upward pressure on the channel.

3. For super-critical flow conditions, using subdrains in lieu of weep holes.

E.4 Construction and Maintenance Considerations

The type and frequency of maintenance that may be required during the life of drainage channels should be considered during their design, and allowances should be made for the access of maintenance equipment.

E.5 Safety

The design and location of open channels shall comply with roadside safety and clear zone requirements. See ***Chapter 3 – Geometric Design*** for clear zone requirements, including special clearance criteria for canals.

E.6 Documentation

For new construction, design documentation for open channels shall include the hydrologic and the hydraulic analyses, including analysis of channel lining requirements

F STORM DRAIN HYDROLOGY AND HYDRAULICS

This section presents minimum standards for the design of storm drain systems.

F.1 Pipe Materials

See Section H for pipe material requirements.

F.2 Design Frequency

The minimum design storm frequency for the design of storm drain systems shall be 3 years.

Site-specific factors may warrant the use of an atypical design frequency. Any increase over pre-development stages shall not significantly change land use values unless flood rights are acquired.

F.3 Design Tailwater

For most design applications where the flow is subcritical, the tailwater will either be above the crown of the outlet or can be considered to be between the crown and critical depth. To determine the energy grade line (EGL), begin with either the tailwater elevation or (dc + D)/2, whichever is higher, add the velocity head for full flow and proceed upstream, adding appropriate losses (e.g., exit, friction, junction, bend, entrance).

An exception to the above procedure is an outfall with low tailwater. In this case, a water surface profile calculation would be appropriate to determine the location where the water surface will either intersect the top or end of the barrel and full-flow calculations can begin. In this case, the downstream water surface elevation would be based on critical depth or the tailwater, whichever is higher.

F.4 Hydrologic Analysis

The Rational Method is the preferred method in use for the design of storm drains when the momentary peak-flow rate is desired. Other methods may be used, with permission by the maintaining agency or local government jurisdiction.

F.4.a Time of Concentration

Minimum time of concentration shall be 10 minutes.

F.5 Hydraulic Analysis

Hydraulic calculations for determining storm drain conduit sizes shall be based on open channel and pressure flow as appropriate. The Manning's equation shall be used.

F.5.a Pipe Slopes

The minimum physical slope should be that which will produce a velocity of 2.5 feet per second (fps) when the storm drain is flowing full. Where not practical or possible in flat terrain, include design features to limit soils from entering the pipes.

F.5.b Hydraulic Gradient

If the hydraulic grade line (HGL) does not rise above the top of any manhole or above an inlet entrance, the storm drainage system is satisfactory. Standard practice is to ensure that the HGL is below the top of the inlet for the design discharge (some local agencies may add an additional safety factor which can be up to 12 inches). Manholes with bolted lids may be used in locations where the top is below the HGL.

F.5.c Outlet Velocity

When discharge exceeds 4 fps, consider special channel lining or energy dissipation. For computation of outlet velocity, the lowest anticipated tailwater condition for the given storm event shall be assumed.

F.5.d Manning's Roughness Coefficients

Standards Manning's Roughness Coefficients can be found in the FDOT's ***Drainage Manual (2022) Section 3.6.4.***

F.6 Hydraulic Openings

If the hydraulic grade line does not rise above the top of any manhole or above an inlet entrance, the storm drainage system is satisfactory. Standard practice is to ensure that the HGL is below the top of the inlet for the design discharge.

The design stage for a ditch bottom inlet may be allowed to exceed the inlet top when the ditch or swale can accommodate the capacity. Examine where the overtopping elevation could occur to ensure there are no adverse flooding impacts to the roadway or offsite property.

F.6.a Entrance Location and Spacing

Drainage inlets and other hydraulic openings are sized and located to satisfy hydraulic capacity, structural capacity, safety (pedestrians, cyclists, and motor vehicles), and durability requirements.

Grate inlets and the depression of curb opening inlets should be located outside the through traffic lanes to minimize the shifting of vehicles attempting to avoid them. All grate inlets shall be bicycle safe where used on roadways that allow bicycle travel.

The FDOT's ***Drainage Manual (2022), Section 3.7*** provides guidance on hydraulic openings and protective treatments. Table 3.3 Curb and Inlet

Application Guidelines, Table 3.4 Ditch Bottom Inlet Application Guidelines and Table 3-5 Drainage End Treatment – Lateral Offset Criteria in the ***Drainage Manual*** provide guidance for inlet selection.

Inlet spacing shall consider the following:

- Regardless of the results of the hydraulic analysis, inlets on grade should be spaced at a maximum of 300 feet for 48 inches or smaller pipes.
- Inlets on grade should be spaced at a maximum of 600 feet for pipes larger than 48 inches.
- Inlets should be placed on the upstream side of bridge approaches.
- Inlets should be placed at all low points in the gutter grade.
- Inlets should be placed upstream of intersecting streets.
- Inlets should be placed on the upstream side of a driveway entrance, curb-cut ramp, or pedestrian crosswalk even if the hydraulic analysis places the inlet further down grade or within the feature.
- Inlets should be placed upstream of median breaks.
- Inlets should be placed to capture flow from intersecting streets before it reaches the major highway.
- Flanking inlets in sag vertical curves are standard practice.
- Inlets should be placed to prevent water from sheeting across the highway (i.e., place the inlet before the superelevation transition begins).
- Inlets should not be located in the path where pedestrians walk.

F.6.b Grades

F.6.b.1 Longitudinal Gutter Grade

The minimum longitudinal gutter grade shall be 0.3%. Minimum grades can be maintained in very flat terrain by use of a rolling profile.

F.7 Spread Standards

The spread, in both temporary and permanent conditions, resulting from a rainfall intensity of 4.0 inches per hour shall be limited as shown in Table 20 – 6 Spread Criteria.

Table 20 – 6 Spread Criteria

Design Speed (mph)	**Spread Criteria***
Design Speed ≤ 30	Crown of Road
30 < Design speed ≤ 45	Keep ½ of lane clear
45 < Design Speed ≤ 55	Keep 8’ of lane clear
Design Speed > 55	No encroachment

* The criteria in this column apply to travel, turn, or auxiliary lanes adjacent to barrier wall or curb, in normal or super elevated sections.

In addition to the above standards, for sections with a shoulder gutter, the spread resulting from a 10-year frequency storm shall not exceed 1’ 3” outside the gutter in the direction toward the front slope. This distance limits the spread to the face of guardrail posts.

F.8 Construction and Maintenance Considerations

Proper design shall also consider maintenance concerns of adequate physical access for cleaning and repair.

F.8.a Pipe Size and Length

Consider using a minimum pipe size of 18” for trunk lines and laterals. 15” hubcaps commonly block smaller pipes resulting in roadway flooding. The minimum pipe diameter for all proposed exfiltration trench pipes (French drain systems) within a drainage system is 18”.

The maximum pipe lengths without maintenance access structures are as follows:

Pipes without French Drains:

18” - 42” pipe	300 feet
48” and larger and all box culverts	600 feet

French Drains that have access through only one end:

18” to 30” pipe	150 feet
36” and larger pipe	200 feet

French Drains that have access through both ends:

24” to 30” pipe	300 feet
36” and larger pipe	400 feet

F.8.b Minimum Clearances

A minimum cover of 1 ft should be provided between the top of pipe and the top of subgrade. A minimum clearance of 1 ft should be provided between storm drainage pipes and other underground facilities (e.g., sanitary sewers). Check with local utility companies, as their clearance requirements may vary from the 1’ minimum.

F.9 Green Stormwater Elements for Context Based Design

Drainage systems are often determined by opportunity, feasibility, and topography, rather than context. However, understanding both the existing and future land use and transportation goals can help determine drainage specific options for the proposed design. Future land use and transportation needs can alter the context and change the drainage opportunities available.

The introduction of green streets is one component of a larger drainage design approach to improving the region's stormwater management, and requires a broader based alliance for its planning, funding, maintenance, and monitoring. Green stormwater elements also serve as a visible component of "green Infrastructure" that is incorporated into the aesthetics of the community

The following is a list of drainage considerations that support context based design and minimize the amount of water that leaves the corridor:

- Bioretention/Biofiltration Planter – are stormwater infiltration cells constructed with walled vertical sides, a flat bottom area, and a large surface capacity to capture, treat and manage stormwater runoff from the street. They provide water quality treatment and reduce runoff volumes, and may be applied in more limited rights of way.
- Bioretention Swale – are shallow, vegetated, landscaped depressions with sloped sides.
- Hybrid Bioretention Cell – combines elements of both swales and planters, featuring a walled side opposite a graded side slope to increase vegetated space and infiltrating area, while providing a softer streetscape treatment for people walking.
- Pervious Strips – are long, linear landscaped areas or linear areas of pervious pavement that can capture and slow runoff.
- Street Trees – can contribute significantly to green stormwater management, with large capacity to transpire water, intercept rainfall, and treat water quality, as well as temperature mitigation and air quality improvement.
- Pervious Pavers/Permeable Pavement – allows water to infiltrate through streets, parking bays and sidewalks, reducing runoff. Maintenance of the pavement will affect long term durability.

Green stormwater infrastructure performance can improve over time if facilities are properly maintained. As vegetation establishes, roots can capture and retain more stormwater. Healthy vegetation and soil increases transpiration, reduces urban heat island effects, supports groundwater recharge, and restores natural ecological cycles and resources.

Robust and iterative operations and maintenance plans are critical to fully capitalizing on the potential of green infrastructure. Include maintenance staff in the project planning process to reduce oversights in the design and ensure that green stormwater infrastructure can achieve its full potential. Although all drainage systems require maintenance, green streets will require special attention to long term maintenance requirements and techniques. Maintenance practices and frequency of maintenance need to be established and personnel trained.

Traffic calming features such as curb extensions can be designed as bioretention areas to intercept stormwater and work with existing roadways and pedestrian features by including ADA compliant grate covered channels or inlets. These and other traffic calming features such as speed tables and raised crosswalks should be evaluated for impacts to pavement hydraulics to ensure runoff is managed without violating spread criteria.

The National Association of City Transportation Officials' (NACTO) ***Urban Street Stormwater Guide*** provides additional information on the stormwater elements of green streets. The FDOT's ***Standard Plans*** and the FDOT's ***Drainage Manual*** provide further information on the design and placement of trench drains, French drains, and underdrains.

The Transportation Research Board's (TRB) data base (TRID) includes several research projects on how pervious pavements perform in Florida titled ***Pervious Pavements – Installation, Operations, and Strength, Parts 1, 2, 3 and 4.***

Figure 20 – 3 Green Street Elements

F.10 Protective Treatment

Drainage designs shall be reviewed to determine if some form of protective treatment will be required to prevent unauthorized entry to long or submerged storm drain systems, steep ditches, or water control facilities. If other modifications, such as landscaping or providing flat slopes, can eliminate the potential hazard and thus the need for protective treatment, they should be considered first. Areas provided for retention and detention, for example, can often be effectively integrated into parks or other green spaces.

Vehicular and pedestrian safety are attained by differing protective treatments, often requiring the designer to make a compromise in which one type of protection is more completely realized than the other. In such cases, an evaluation should be made of the relative risks and dangers involved to provide the design that gives the best balance. It must be remembered that the function of the drainage feature will be essentially in conflict with total safety, and that only a reduction rather than elimination of all risk is possible.

The three basic types of protective treatment are shown in Table 20 – 7 Protective Treatments.

Table 20 – 7 Protective Treatments

Feature	Typical Use
Grates	To prevent persons from being swept into long or submerged drainage systems.
Guards	To prevent entry into long sewer systems under no-storm conditions, to prevent persons from being trapped.
Fences	To prevent entry into areas of unexpected deep standing water or high velocity water flow, or in areas where grates or guards are warranted but are unsuitable for other reasons.

When determining the type and extent of protective treatment, the following considerations should be reviewed:

- The nature and frequency of the presence of children in the area, e.g., proximity to schools, school routes, and parks, should be established.
- Highway access status should be determined. Protective treatment is usually not warranted within a limited access highway; however, drainage facilities located outside the limited access area or adjacent to a limited access highway should be considered unlimited access facilities.
- Adequate debris and access control would be required on all inlet points if guards or grates are used at outlet ends.
- Hydraulic determinations such as depth and velocity should be based on a 25-year rainfall event.
- The hydraulic function of the drainage facility should be checked and adjusted so the protective treatment will not cause a reduction in its effectiveness.
- Use of a grate may cause debris or persons to be trapped against the hydraulic opening. Grates for major structures should be designed in a manner that allows items to be carried up by increasing flood stages.
- Use of a guard may result in a person being pinned against it. A guard is usually used on outlet ends.
- A fence may capture excessive amounts of debris, which could possibly result in its destruction and subsequent obstruction of the culvert. The location and construction of a fence shall reflect the effect of debris-induced force.

F.11 Documentation

For new construction, supporting calculations for storm sewer system design shall be documented and provided to facility owner.

G CROSS DRAIN HYDRAULICS

This section presents standards and procedures for the hydraulic design of cross drains including culverts, bridge-culverts[1], and bridges.

G.1 Design Frequency

The recommended minimum design flood frequency for culverts is shown in Table 20 – 8 Recommended Minimum Design Flood Frequency. The minimum flood frequency used to design the culvert can be adjusted based on:

An analysis to justify the flood frequencies greater or lesser than the minimum flood frequencies listed below; and

The culvert being located in a National Flood Insurance Program mapped floodplain.

Table 20 – 8 Recommended Minimum Design Flood Frequency

Roadway Classification	Exceedance Probability (%)	Return Period (Year)
Local Roads and Streets ADT >3,000 VPD	4%	25
Local Roads and Streets ADT ≤ 3,000 VPD*	20 - 10%	5 - 10

*At the discretion of the local agency

[1] A culvert qualifies as a bridge if it meets the requirements of Item 112 in the FDOT's "***Bridge Management System (BMS) Coding Guide.***"

G.2 Backwater

Allowable headwater is the depth of water that can be ponded at the upstream end of the culvert during the design flood. The allowable headwater for the design frequency should:

- Have a level of inundation that is tolerable to upstream property and roadway for the design discharge,
- Consider a duration or inundation that is tolerable to the upstream vegetation to avoid crop damage; and
- Be lower than the upstream shoulder edge elevation at the lowest point of the roadway within the drainage basin.

If the allowable headwater depth to culvert height ratio (HW/D) is established to be greater than 1.5, the inlet of the culvert will be submerged. Under this condition, the hydraulics designer should provide an end treatment to mitigate buoyancy.

G.3 Tailwater

For the sizing of cross drains and the determination of headwater and backwater elevations, the highest tailwater elevation which can be reasonably expected to occur coincident with the design storm event shall be used.

G.4 Clearances

To permit the passage of debris, a minimum clearance of 2 ft should be provided between the design approach water surface elevation and the low chord of the bridge where practical. Where this is not practicable, the clearance should be established by the hydraulics engineer based on the type of stream and level of protection desired. Additional vertical clearance information can be found in ***Chapter 3 – Geometric Design***.

G.5 Bridges and Other Structures

It is important for the hydraulic engineer to accurately represent the hydraulic condition. The modeling approach should be selected based primarily on its advantages and limitations, though also considering the importance of the structure, potential project impacts, cost, and schedule.

One-dimensional models are best suited for in-channel flows and when floodplain flows are minor. They are also frequently applicable to small streams. For extreme flood conditions, one-dimensional models generally provide accurate results for narrow to moderate floodplain widths. In general, where lateral velocities are small, one-dimensional models provide reasonable results.

Two-dimensional models should be used when flow patterns are complex and one-dimensional model assumptions are significantly violated. If the hydraulic engineer has great difficulty in visualizing the flow patterns and setting up a one-dimensional model that realistically represents the flow field, then two-dimensional modeling should be used.

The National Cooperative Highway Research Program published a report entitled ***"Criteria for Selecting Hydraulic Models" (NCHRP 2006)*** that provides a procedure for selecting the most appropriate model for a particular application incorporating site conditions, design elements, available resources, and project constraints.

The following Table 20 – 9 Bridge Hydraulic Modelling Selection may be used to determine the appropriate modeling approach.

Table 20 – 9 Bridge Hydraulic Modeling Selection

Bridge Hydraulic Condition	Hydraulic Analysis Method	
	One-Dimensional	**Two-Dimensional**
Small Streams	●	⊙
In-Channel Flows	●	⊙
Narrow to Moderate-width Floodplains	●	⊙
Wide Floodplains	⊙	●
Minor Floodplain Constriction	●	⊙
Highly Variable Floodplain Roughness	⊙	●
Highly Sinuous Channels	⊙	●
Multiple Embankment Openings	⊙/×	●
Unmatched Multiple Openings in Series	⊙/×	●
Low Skew Roadway Alignment (<20’)	●	⊙
Moderately Skewed Roadway Alignment (>20’ and <30’)	⊙	●
Highly Skewed Roadway Alignment (>30’)	×	●
Detailed Analysis of Bends, Confluences and Angle of Attack	×	●
Multiple Channels	⊙	●
Small Tidal Streams and Rivers	●	⊙
Large Tidal Waterways and Wind-influenced Conditions	×	●
Detailed Flow Distribution at Bridges	⊙	●

Significant Roadway Overtopping	⊙	●
Upstream Controls	×	●
Countermeasure Design	⊙	●
● well suited or primary use ⊙ possible application or secondary use × unsuitable or rarely used ⊙/× possibly unsuitable depending on application		

See also Chapter 17 – Structures, Section C.3.e for additional information on Drainage Criteria for structures.

H CULVERT MATERIALS

The evaluation of culvert materials shall consider functionally equivalent performance in three areas: durability, structural capacity, and hydraulic capacity.

H.1 Durability

Culverts shall be designed for a design service life (DSL) appropriate for the culvert function and highway type. The design service life should be based on factors such as:

- Projected service life of the facility
- Importance of the facility
- Economics
- Potential inconvenience and difficulties associated with repair or replacement, and projected future demands on the facility.

In estimating the projected service life of a material, consideration shall be given to actual performance of the material in nearby similar environmental conditions, its theoretical corrosion rate, potential for abrasion, and other appropriate site factors. Theoretical corrosion rates shall be based on the environmental conditions of both the soil and water. In tannic water, the designer will also need to consider the effect of microbially induced corrosion of concrete pipes, especially in industrial or sewer systems.

At a minimum, the following corrosion indicators shall be considered:

- pH
- Resistivity
- Sulfates
- Chlorides

The FDOT provides a program called ***Culvert Service Life Estimator*** for estimating the service life of culverts based on the above criteria. The Culvert Service Life Estimator is based on standard measurement of soil and water parameters. Tannic water can provide an environment for organisms to grow on the material surface that is not taken into consideration by this tool, which will over-predict the facility life.

To avoid unnecessary site-specific testing, generalized soil maps may be used to delete unsuitable materials from consideration. The potential for future land use changes which may change soil and water corrosion indicators shall also be considered to the extent practical.

H.2 Structural Design

The structural design of all culverts, storm drainpipes and drainage structures shall be in accordance with specifications (including guide specifications) published by the American Association of State Highway and Transportation Officials (AASHTO). At a minimum, the ***AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications, 9th Edition (2020)*** shall be used.

H.3 Hydraulic Capacity

The hydraulic evaluation shall establish the hydraulic size for the particular culvert application. For storm drains and cross drains, the design shall use the Manning's roughness coefficient associated with the pipe material selected.

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