This is a working document
that has not been adopted.

Chapter 20

Drainage

Figures

Tables

20 Drainage

20.1 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.~~

20.2 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 Channels
- Culverts
- Bridge Hydraulics
- Storm Drains
- Exfiltration Systems
- Optional Pipe Materials
- Stormwater Management Facilities~~y~~
- Temporary Drainage Design

20.3 Regulatory Requirements

20.3.1 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.~~

20.3.2 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.

20.3.3 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.

20.4 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.

20.4.1 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 – ~~4~~1 Stormwater Flow Design Frequencies**.

Table 20-1 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.

20.4.2 Hydrological Analysis

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

1. A frequency analysis of observed (gauge) 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.

20.4.3 Hydraulic Analysis

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

20.4.3.1 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.

20.4.3.2 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.

20.4.3.3 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**.

20.4.3.4 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.

20.4.4 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.

20.4.5 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.

20.4.6 Documentation

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

20.5 Storm Drain Hydrology and Hydraulics

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

20.5.1 Pipe Materials

See **Section 20.7** for pipe material requirements.

20.5.2 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.

20.5.3 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.

20.5.4 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.

20.5.4.1 Time of Concentration

Minimum time of concentration shall be 10 minutes.

20.5.5 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.

20.5.5.1 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.

20.5.5.2 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.

20.5.5.3 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.

20.5.5.4 Manning's Roughness Coefficients

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

20.5.6 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.

20.5.6.1 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.

20.5.6.2 Grades

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

20.5.7 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 – ~~5~~ 2 Spread Criteria**.

Table 20-2 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

Notes:

*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.

20.5.8 Construction and Maintenance Considerations

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

20.5.8.1 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

20.5.8.2 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.

20.5.9 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 – ~~6~~ 3 Protective Treatments**.

Table 20-3 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.

20.5.10 Documentation

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

20.6 Cross Drain Hydraulics

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

20.6.1 Design Frequency

The recommended minimum design flood frequency for culverts is shown in **Table 20 – ~~7~~ 4 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 20-4 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

Notes:
*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***."

20.6.2 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.

20.6.3 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.

20.6.4 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.

20.6.5 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 – ~~8~~ 5 Bridge Hydraulic Modelling Selection** may be used to determine the appropriate modeling approach.

Table 20-5 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 17.3.3.5 for additional information on Drainage Criteria for structures.

20.7 Culvert Materials

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

20.7.1 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.

20.7.2 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.

20.7.3 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.

20.8 Stormwater Management Strategies

20.8.1 Watershed Approach to Evaluate Regional Stormwater Solutions (WATERSS)

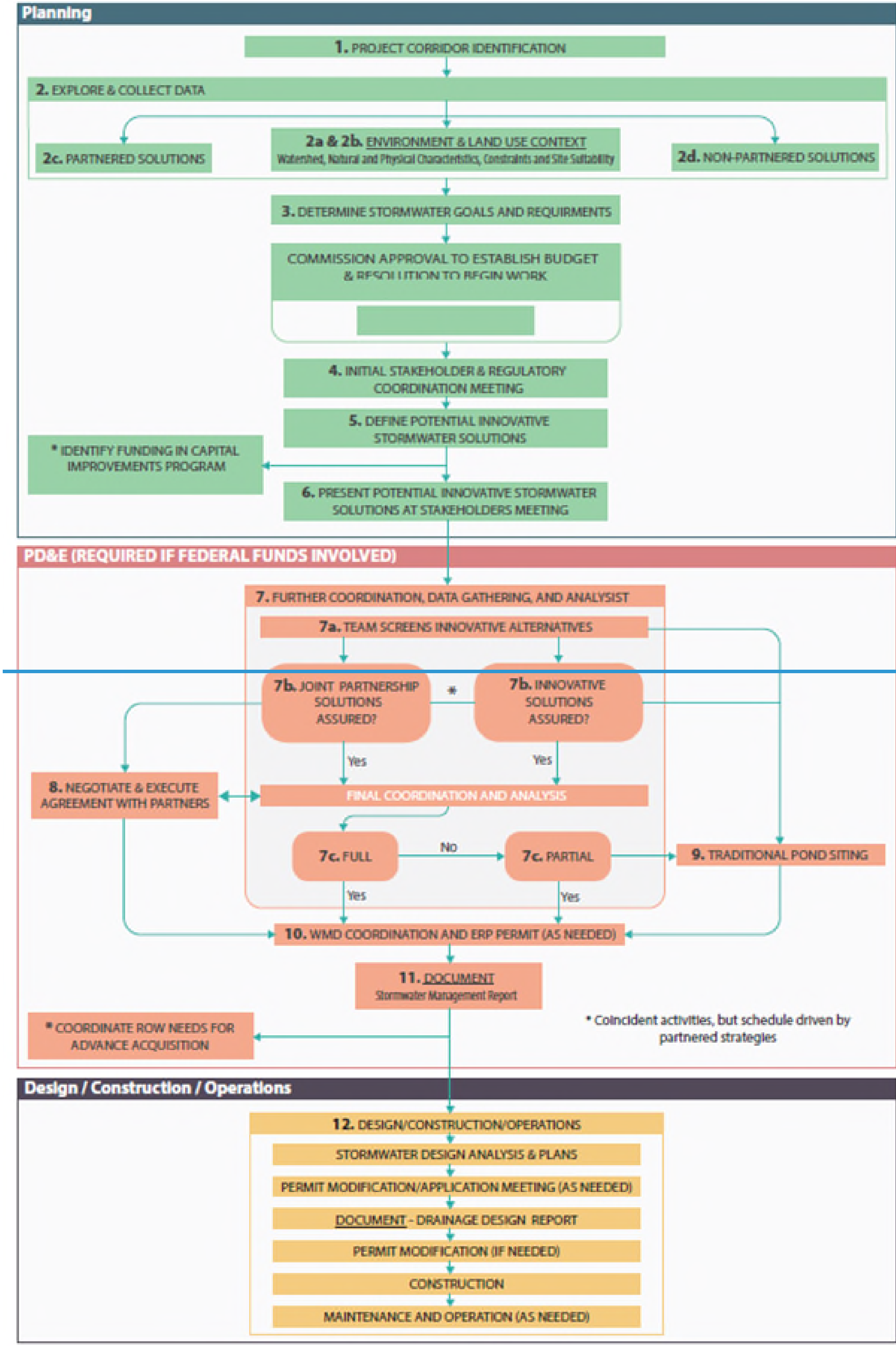
WATERSS is a regional stormwater management process that promotes collaboration with state and local agencies, water resource managers and stakeholders to implement innovative stormwater management practices. The process is scalable depending on the type, size, complexity, context, and geographic location 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.

For additional guidance see the ***WATERSS Process Guidebook (2021)***.

~~Figure 20-1 WATERSS Process Flowchart~~



This is a working document that has not been adopted.

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 FDOT runoff as a condition of county approvals.	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 coordinate agreements	(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.
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.
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.

Table 20-1 Matrix of Typical Innovative Stormwater Management Practices (Continued)

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									
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/ Resource 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 environmental 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									
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**~~

4. ~~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.~~

5. ~~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.~~

6. ~~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.~~

7. ~~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).~~

8. ~~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 **Table 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.~~
~~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.~~

This is a working document that has not been adopted.

~~**Table 20-2 Evaluation Factors for Screening of Solutions (Continued)**~~

~~Factor~~	~~Description/Issues to Consider~~
~~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.~~

~~Figure 20-2 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~~	

~~Notes:~~

~~*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**~~

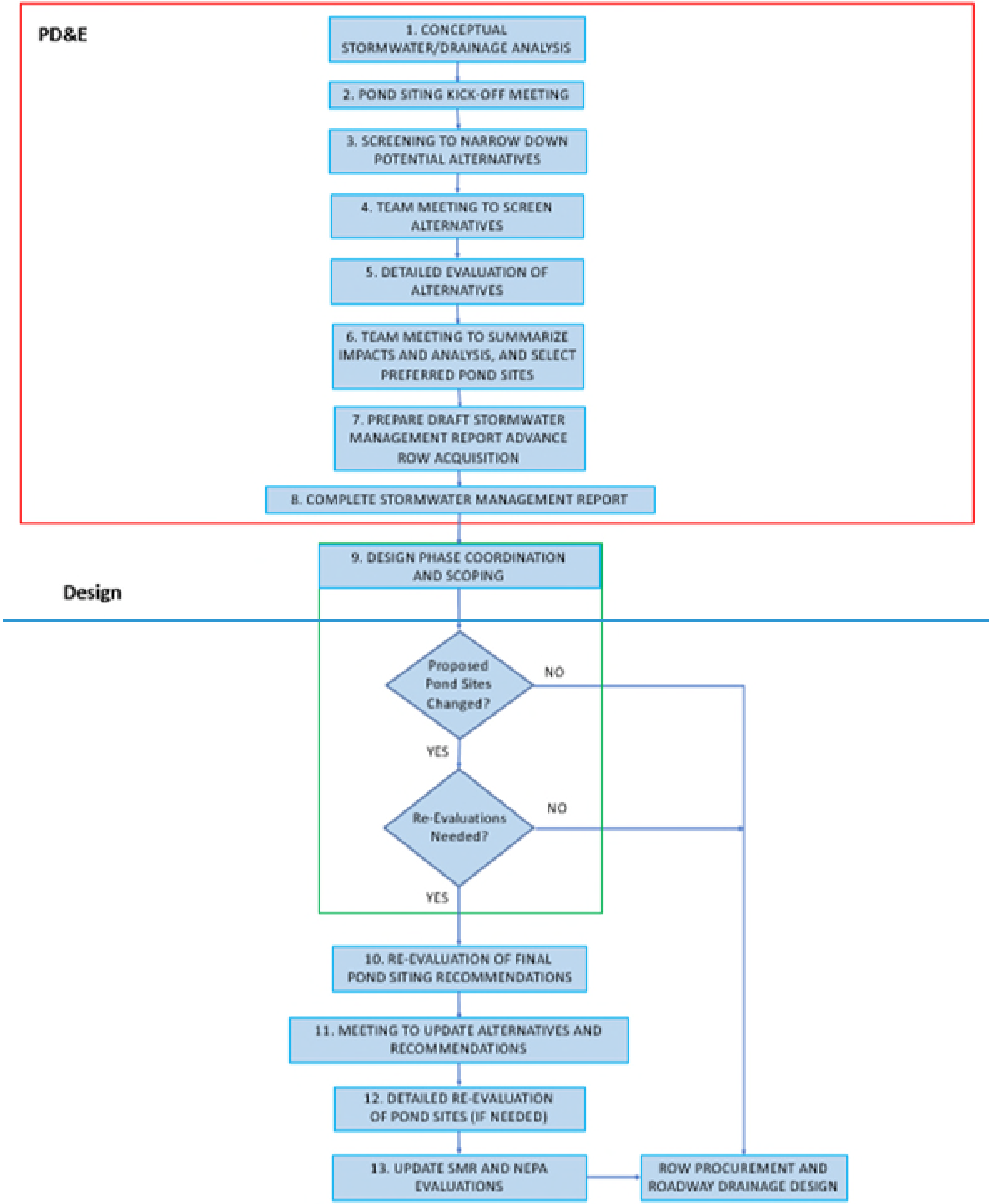
~~Design and stormwater plans production are finalized. Construction permits are obtained for the project as required. Stakeholder coordination and communication should be continued by the Champion during this time, including the transfer of maintenance responsibility to partners, if agreed upon as part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

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

~~20.8.2 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 – 3 Pond Siting Process Flowchart**.~~

~~Figure 20-3 Pond Sitting 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.~~

9. ~~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).~~

10. ~~Conduct a review of drainage permit files for the corridor and adjacent developments.~~
11. ~~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.~~

12. ~~Determine major off-site contributing areas.~~
13. ~~Establish floodplain elevations and potential for encroachment.~~
14. ~~Identify outfall locations and verify if closed basin criteria apply.~~
15. ~~Develop generic soils information (obtain from County Soil Conservation Survey or from earlier geotechnical studies conducted in the area).~~
16. ~~Establish seasonal high ground water table (SHGWT) elevations.~~
17. ~~Develop design estimates for water quality and water quantity requirements.~~
18. ~~Develop an initial system model using a routing program.~~
19. ~~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.~~
20. ~~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.~~

21. ~~Coordinate with the ROW Office on some initial sites to discuss at the kick-off meeting.~~
22. ~~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:~~

- ~~Verification of pond design guidelines and criteria (includes District preferences).~~

23. ~~Identify potential detention / retention pond sites.~~
24. ~~Assign property ID number to each property to be considered. The ROW Office will provide these numbers.~~
25. ~~Identify potential joint-use pond sites (public / private).~~
26. ~~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 **Table 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.~~

~~Figure 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.~~

~~**Figure 20-5 Evaluation Factors for Pond Siting Alternatives (Continued)**~~

~~Factor~~	~~Description/ Issues to Consider~~	~~Cost $~~	~~Weighted Value~~
~~FEMA Flood Zone~~	~~Identify the Flood Zone and associated impacts / benefits of a pond within the flood zone. The perimeter berm will affect flood zone storage, while the pond will enhance storage. When right of way is acquired within a low-lying area, the construction of the roadway template may affect adjacent properties' ability to use that area for storage.~~	~~N/A~~	~~Meets the FDOT's needs – points TBD by Team.~~ ~~Meets most needs – points TBD by Team.~~ ~~Other issues will depend on the benefit to the floodplain at each particular site.~~
~~Contamination – Hazardous Materials~~	~~Identify if the parcel is contaminated; this will limit the ability to use the site. Consideration of this parcel must include the costs associated with the clean-up of the site.~~	~~N/A~~	~~Additional costs will need to be added to the overall site costs and a weighted value applied accordingly.~~
~~Utilities~~	~~Identify existing and proposed utilities within or adjacent to the parcel. The cost of relocating utilities must be included in the consideration of a parcel.~~	~~$~~	~~Additional costs will need to be added to the overall site costs, and weighted value applied accordingly.~~
~~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.~~

This is a working document that has not been adopted.

~~Figure 20-6 Evaluation Factors for Pond Siting Alternatives (Continued)~~

~~Factor~~	~~Description/ Issues to Consider~~	~~Cost $~~	~~Weighted Value~~
~~Public Wellfield~~	~~The proximity to a wellfield site will have a direct impact on the type of drainage facility which can be placed on the corresponding parcel.~~	~~N/A~~	~~N/A~~
~~Construction~~	~~Identify access for construction and associated impacts which may affect construction costs, such as amount of drainage piping required to reach pond.~~	~~N/A~~	~~No set weighted value is applicable for this item; however, requirements for items identified may have a direct impact on the construction cost. Consider this and add to the overall costs associated with utilizing this site.~~
~~Maintenance~~	~~Identify the costs of maintaining a facility at this location and the potential for maintenance agreements with others. Consider access costs to the pond site.~~	~~$~~	~~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~~ • ~~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.~~

~~Figure 20-7 Evaluation Factors for Pond Siting Alternatives (Continued)~~

~~Factor~~	~~Description/ Issues to Consider~~	~~Cost $~~	~~Weighted Value~~
~~Total Applicable Costs~~	~~Identify the total cost of the parcel including cost identified from all issues above.~~	~~$~~	~~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. **Figure 20 – 8**, below, is a **Sample Table of Contents for Stormwater Management** reports.~~

- ~~Discuss and address comments from the Public Meeting.~~

~~11. Re-rank recommended and alternative pond sites, if necessary.~~

~~**Outcome:** Final Stormwater Management Report is completed.~~

~~**Approximate Timeline:** 1 week~~

~~Figure 20-8 Sample Table of Contents for Stormwater Management~~

~~TABLE OF CONTENTS FOR POND SITING REPORTS~~

~~4.1 Post Development Conditions~~

~~4.2 Pond Siting Selection Criteria~~

~~4.3 Pond Siting Alternative Analysis~~

~~V. RIGHT OF WAY ACQUISTION COSTS~~

~~VI. RECOMMENDATIONS~~

~~EXHIBITS~~

~~Exhibit A- Location Map~~

~~Exhibit B- Existing Roadway Section~~

~~Exhibit C- Proposed Roadway Typical Section~~

~~Exhibit D- Rainfall Data~~

~~Exhibit E- Typical Sections for Stormwater Treatment Ponds~~

~~Exhibit F- Pond H Site Plan~~

~~Exhibit G- Pond Siting Matrix~~

~~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.~~

20.8.2 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 20-1 Green Street Elements