Transportation *integrated* Stormwater Management (TriSWM) Appendix

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1.0 Overview of TriSWM Appendix

1.1 Introduction

The TriSWM Appendix has been developed as an appendix to the iSWM Criteria Manual for Site Development and Construction for use by cities, counties, and transportation agencies in the planning and design of stormwater management systems for public streets, roads, and highways. The purpose of this Appendix is to provide design guidance and a framework for incorporating effective and environmentally sustainable stormwater management into the project development and construction processes and to encourage a greater regional uniformity in developing plans for stormwater management systems that meet the following goals:

- Control runoff within and from the site to minimize flood risk to people and properties;
- Assess discharges from the site to minimize downstream bank and channel erosion; and
- Reduce pollutants in stormwater runoff to protect water quality and assist communities in meeting regulatory requirements.

The table below indicates the chapters or sections of the iSWM Criteria Manual for Site Development and Construction that have been replaced by information in the TriSWM Appendix for use in the planning and design of stormwater management facilities for public transportation projects. Chapters or sections of the iSWM Criteria Manual for Site Development and Construction not referenced in the table are to be used "as is."

Affected Chapter/Section of the iSWM Criteria Manual	Replacement Chapter/Section in TriSWM Appendix	Comments
Chapter 1, Overview of iSWM Criteria Manual	Chapter 1, Overview of TriSWM Appendix	General content modifications as needed to reflect TriSWM requirements.
Chapter 2, *integrated* Development Process	Chapter 2, TriSWM Planning and Development Process	Complete section replaced; the project planning and development process for public facilities is significantly different than for private development projects.
Chapter 3, Section 3.2, Water Quality Protection	Chapter 3, Section 3.2, TriSWM Water Quality Protection	The Water Quality Protection Criteria has been modified due to the nature of linear facilities.
Chapter 3, Section 3.8, Stormwater Control Selection	Chapter 3, Section 3.8, TriSWM Stormwater Control Selection	The "*Ability to treat the Water Quality Volume"* section has been modified to reflect TriSWM water quality treatment designations. The tables have been changed as indicated below.
Table 3.6, Suitability of Stormwater Controls to Meet *integrated* Focus Areas, and Table 3.15, Stormwater Treatment Suitability[1]	Table 3.2, Stormwater Treatment Suitability[2]	Designations in the "Water Quality Protection" column have been changed to reflect TriSWM designations (Primary or Secondary changed to Levels I, II, or III). Also, *integrated* Stormwater Controls not typically associated with streets or roadways (Green Roofs, Rain Barrels, etc.) have been removed.

Affected Chapter/Section of the iSWM Criteria Manual	Replacement Chapter/Section in TriSWM Appendix	Comments
Table 3.16 Water Quality Performance	Table 3.3 Water Quality Performance	*integrated* Stormwater Controls not typically associated with streets or roadways have been removed.
Table 3.17 Site Applicability	Table 3.4 Site Applicability	
Table 3.18 Implementation Considerations	Table 3.5 Implementation Considerations	
Table 3.19 Physiographic Factors	Table 3.6 Physiographic Factors	
Table 3.20 Soils	Table 3.7 Soils	
Table 3.21 Special Watershed Considerations	Table 3.8 Special Watershed Considerations	
Table 3.22 Location and Permitting Checklist	Table 3.9 Location and Permitting Checklist	Minor updates for clarification.

1. Tables 3.6 and 3.15 in the iSWM Criteria Manual contain the same information and are both replaced by Table 3.2 in the TriSWM Appendix.
2. The Water Quality Protection designations for stormwater controls in Table 3.2 of the TriSWM Appendix shall also be used in place of the Water Quality Protection designations in Table 1.3 of the Stormwater Controls Technical Manual.

Note: Stormwater runoff from residential streets should be managed as part of the overall stormwater management system for the entire site. The iSWM Criteria Manual for Site Development and Construction should be used for the planning and design of stormwater management facilities for residential subdivisions and internal residential streets. The TriSWM Appendix does not apply to local or residential classified streets within residential subdivisions, unless required by the local jurisdiction. However, when a city or county cooperates with a developer in the construction of a collector or arterial street for access, the local government may require the use of the TriSWM Appendix for that portion of the project.

Local Provision Boxes

Throughout this manual there are “Local Provision” boxes. These boxes are used by a local government/agency to add, delete, or modify sections of the criteria and specify the options allowed and/or required by the local government/agency. Additional local information can be added at the back of this document.

Local Provisions:

Applicability

TriSWM is applicable under the following conditions for projects that will ultimately disturb one or more acres as indicated in Table 1.1.

Table 1.1 Applicability

Applicable for TriSWM Criteria :	Applicable for iSWM Construction Criteria:
Land disturbing activity of 1 acre or more **OR** land disturbing activity of less than 1 acre where the activity is part of a common plan of development that is one acre or larger.	Land disturbing activity of 1 acre or more **OR** land disturbing activity of less than 1 acre where the activity is part of a common plan of development that is one acre or larger. (Requirements located in Chapter 4, *integrated* Construction Criteria of the iSWM Criteria Manual for Site Development and Construction)

The criteria within the TriSWM Appendix is applicable to projects that disturb 1 acre or more, including projects less than one acre that are part of a larger common project plan or scope that will disturb 1 acre or more. A common plan of development consists of construction activity that is completed in separate stages, separate phases, or in combination with other construction activities.

Projects located in or near critical or sensitive areas, or as identified through a watershed study or plan, may be subject to additional performance and/or regulatory criteria. Furthermore, these sites may need to utilize certain structural controls in order to protect a special resource or address certain water quality or drainage problems identified for a drainage area or watershed.

For some projects, particularly expansion projects, practical limitations may present obstacles to fully meeting stormwater management requirements within the project right-of-way (ROW). Limitations could include lack of land availability, engineering constraints, health and safety issues associated with operations and maintenance activities, or low benefit/cost ratio. If the project planning, assessment, and design process reveals that stormwater requirements for a project cannot be met because it is not feasible to do so, an explanation must be provided in the planning documents for the project. The explanation must include the reasons why the requirements cannot be met for the site and the provisions for stormwater management that can be provided.

Projects below Applicability Threshold

Projects that are below the size threshold for applicability requirements (above) are not subject to the water quality or streambank protection requirements of the TriSWM Appendix. However, it is recommended that these criteria still be used and that temporary controls be provided during construction. Flood mitigation and conveyance criteria still apply. The planning process is also simplified for sites below the applicable criteria to an optional pre-development review before the final submittal of the engineering plans.

Local Provisions:

1.2 TriSWM Development Process

Chapter 2 presents information on the process of collecting and considering appropriate information needed to effectively and efficiently manage stormwater on roadway, street, and highway projects. Descriptions of the city/county and Texas Department of Transportation (TxDOT) project development processes are provided along with information on site analysis and inventory, conditions for accepting off-site flows, and special planning and design considerations.

Local Provisions:

1.3 TriSWM Design Criteria

Chapter 3 presents an approach for meeting stormwater runoff quality and quantity management goals by addressing the key adverse impacts of development on stormwater runoff. Its framework consists of three focus areas, each with options in terms of how the focus area is applied.

Design Focus Areas

The stormwater management focus areas and goals are:

- **Water Quality Protection:** Remove or reduce pollutants in stormwater runoff to protect water quality
- **Streambank Protection:** Regulate discharge from the site to minimize downstream bank and channel erosion
- **Flood Mitigation and Conveyance:** Control runoff within and from the site to minimize flood risk to people and properties for the conveyance storm as well as the 100-year storm.

Each of the Design Focus Areas must be used in conjunction with the others to address the overall stormwater impacts from a development site. When used as a set, the Design Focus Areas control the entire range of hydrologic events, from the smallest runoff-producing rainfalls up to the 100-year, 24-hour storm.

Local Provisions:

Design Storms

TriSWM design is based on the following four (4) storm events.

Table 1.2 Storm Events

Storm Event Name	Storm Event Description
"Water Quality"	Criteria based on a volume of 1.5 inches of rainfall, not a storm frequency
"Streambank Protection"	1-year, 24-hour storm event
"Conveyance"	25-year, 24-hour storm event
"Flood Mitigation"	100-year, 24-hour storm event

Throughout the manual the storms will be referred to by their storm event names.

Local Provisions:

Design Focus Area Application Options

There are multiple options provided to meet the required criteria for water quality protection, streambank protection, and flood mitigation. Design requirements and options are summarized in Table 1.3.

Design criteria for streambank protection and flood mitigation are based on a **downstream assessment**. The purpose of the downstream assessment is to protect downstream properties and channels from increased flooding and erosion potential due to the proposed project. A downstream assessment is required to determine the extent of improvements necessary for streambank protection and flood mitigation. Downstream assessments shall be performed for streambank protection, conveyance, and flood mitigation storm events. More information on downstream assessments is provided in Section 3.3. of the iSWM Criteria Manual for Site Development and Construction

If a project causes no adverse impacts to existing conditions, then it is possible that little or no mitigation would be required.

Table 1.3 Summary of Options for Design Focus Areas

Design Focus Area	Reference Section	Required Downstream Assessment	Design Requirements/Options
Water Quality Protection	**3.2** TriSWM Appendix	no	Water Quality Protection requirements are determined based on the quality of receiving waters, proximity of project discharge to any wetlands and/or drinking water supply intakes, and projected traffic volume. Refer to Section 3.2 to determine the Water Quality Treatment Level required (Treatment Level I, II, or III).
Streambank Protection	**3.4** iSWM Criteria Manual	yes	**Option 1:** Reinforce/stabilize downstream conditions
			Option 2: Install stormwater controls to maintain or improve existing downstream conditions
			Option 3: Provide on-site controlled release of the 1-year, 24-hour storm event over a period of 24 hours (Streambank Protection Volume, SP_V)
Flood Mitigation and Conveyance	**3.5 and 3.6** iSWM Criteria Manual	yes	**Flood Mitigation** **Option 1:** Provide adequate downstream conveyance systems
			Option 2: Install stormwater controls on-site to maintain or improve existing downstream conditions
			Option 3: In lieu of a downstream assessment, maintain existing on-site runoff conditions
			Conveyance Minimize localized site flooding of streets, sidewalks, and properties by a combination of on-site stormwater controls and conveyance systems

Local Provisions:

2.0 TriSWM Development Process

2.1 Project Development Goals

In order to most effectively and efficiently manage stormwater on new public roadway, street, and highway projects, as well as significant expansion projects, consideration of stormwater runoff needs to be fully integrated into the project planning and design process. This involves a comprehensive planning approach and a thorough understanding of the physical characteristics and natural resources in proximity to the proposed route. In addition, the management of the quantity and the quality of stormwater should be addressed in an integrated approach. The purpose of the TriSWM Appendix is to provide design guidance and a framework for incorporating effective and environmentally sensitive stormwater management into the street and highway project development process and to encourage a greater uniformity in developing plans for stormwater management systems that meet the following goals:

- Provide safe driving conditions
- Minimize the downstream flood risk to people and properties
- Minimize downstream bank and channel erosion
- Reduce pollutants in stormwater runoff to protect water quality.

2.2 Stormwater Management Planning

2.2.1 Introduction

The planning phase offers the greatest opportunity to avoid adverse water quality impacts as alignments and right-of-way requirements are developed and refined. Conducting natural and cultural resource studies concurrently with early project planning provides timely information to assist in identifying and avoiding potential impacts. Sections 2.2.6, Site Analysis and Inventory, and 2.3, Special Planning and Design Considerations, describe the features that should be considered and avoided if possible. Avoiding impacts may reduce or eliminate the need for higher level water quality treatment controls.

Once the alignment has been determined, planning and design of stormwater management controls should be performed early in the preliminary design phase of the project so that adequate right-of-way may be acquired. This would generally be at the site assessment and preliminary design phases of a city/county street project or the preliminary design phase of a TxDOT project. The proposed alignment should include sufficient reserved land to construct and maintain all required BMPs at appropriate locations.

Local Provisions:

2.2.2 City / County Project Development Process

Local governments plan for the preservation and creation of transportation corridors through master thoroughfare plans and/or comprehensive plans. The function of these planning tools is to establish the future roadway network and design guidelines to provide an adequate level of service. Thoroughfare planning is used by local government to proactively prepare for future traffic conditions, accommodate growth and development and identify projects for the capital improvements program (CIP), determine roadway right-of-way requirements, and improve community aesthetics and safety. Conventional

thoroughfare planning should be expanded to include avoidance of sensitive natural features where possible and to accommodate stormwater management best management practices (BMPs).

Planning for individual projects typically starts with identification in the capital improvement program, which is a long-range financial planning tool to address community needs in the long-term future for improving streets, drainage, parks, public facilities, utilities and other city functions. Projects selected for funding in the CIP would proceed through various stages of development including Site Assessment, Preliminary Design, Right-of-Way Acquisition, Final Design, and Drawings & Specifications.

The Site Assessment phase consists of identifying physical and environmental constraints on the potential alignment of the project. The Preliminary Design phase incorporates information from the site assessment and identifies the vertical alignment for the street or roadway. Typically, preliminary design drawings are reviewed by the local government at a point where the engineering design is approximately 30 to 50 percent complete. Once the preliminary plans and vertical alignment are approved, activities to acquire the right-of-way are initiated. While right-of-way acquisition efforts are in progress, the final design drawings and specifications for the project are completed and reviewed by the local government.

Since many stormwater management best management practices require additional space beyond the typical right-of-way (50' two-lane streets, 120 – 130' for 6-lane divided with median), stormwater management practices must be identified during the Preliminary Design phase. Once stormwater management controls are identified, the right-of-way acquisition process and development of the final design may proceed accordingly.

Local Provisions:

2.2.3 TxDOT Project Development Process

The TxDOT project development process is laid out in detail in the Project Development Process Manual, which may be accessed at http://onlinemanuals.txdot.gov/txdotmanuals/pdp/index.htm. A general characterization of the process is outlined below:

- Planning and Programming
  Consists of needs identification, site visit, project authorization, compliance with planning requirements, determination of study requirements, and construction funding identification.
- Preliminary Design
  Consists of data collection and preliminary design preparation, public meetings, preliminary schematic preparation, geometric schematic preparation (including determination of right-of-way needs), and value engineering. Development of the preliminary and geometric schematics is a particularly important phase since alternative alignments are evaluated, ROW and access control requirements are defined, and initial siting and sizing of permanent stormwater BMPs must be determined.
- Environmental
  Consists of environmental issues determination and data collection, interagency coordination and permitting, environmental documentation, public hearing, and environmental clearance. This process is further described below.
- Right-of-Way and Utilities
  Consists of right-of-way and utility data collection, mapping, appraisals and acquisition, and utility adjustments.

- Plans, Specifications, and Engineering Development
  Consists of the design conference, design of bridges, final vertical and horizontal alignment design, roadway design, drainage design, and final review.
- Letting
  Consists of final funding approval and bidding and award of construction contract.

The project development process is overseen by the District's Area Engineer and Project Manager. The District Environmental Quality Coordinator (DEQC) reviews project plans prior to letting to ensure that the Stormwater Pollution Prevention Plan and Environmental Permits, Issues, and Commitments (EPIC) plan sheets are complete. The EPIC sheet is used to summarize the special requirements and restrictions related to the construction activity that has been permitted and the conditions of any permits. For example, it may depict areas to be avoided during construction due to the presence of endangered species, wetlands, etc. The DEQC and divisional and central management are aided by the Environmental Compliance Oversight System (ECOS). It's a database system that tracks the environmental process for projects generated by TxDOT's 25 Districts. The ECOS tracks and facilitates coordination throughout the TxDOT system concerning:

- Project environmental clearance
- Environmental Permits, Issues and Commitments (EPIC)
- Public involvement
- Cultural resources protection
- Hazardous material avoidance or removal
- Corps of Engineers permits
- Biological resource protection
- Water quality protection
- Coordination with other regulatory agencies as necessary

Local Provisions:

2.2.4 Determine/Confirm Local Requirements

The consultant or project designer must determine the stormwater management requirements of the jurisdiction(s) that the project will be located in. For local governments that have adopted the iSWM™ Criteria Manual for Site Development and Construction, much of this information is available in the jurisdiction's adopted version of the iSWM Criteria Manual. These requirements may include:

- Design storm frequencies
- Conveyance design criteria
- Floodplain criteria
- Buffer/setback criteria
- Watershed-based criteria
- Need for physical site evaluations such as infiltration tests, geotechnical evaluations, etc.

Local Provisions:

2.2.5 Conditions for Accepting Off-Site Flows

Local governments and the Texas Department of Transportation (TxDOT) must provide for the passage of off-site flows through street and highway right-of-way to maintain natural drainage paths. If a private developer's project discharges off-site flow to public right-of-way, local governments designated as Municipal Separate Storm Sewer Systems (MS4s) must require the private development project to comply with the requirements of the *integrated* Stormwater Management (iSWM™) Criteria Manual for Site Development and Construction (if adopted) or other local government post construction stormwater quality management requirements. Once the local government MS4 accepts discharge of water onto its right-of-way, the jurisdiction becomes liable for the quality of that discharge under Texas Pollutant Discharge Elimination System (TPDES) regulations.

TxDOT lacks statutory authority to prohibit or control post-construction discharges of stormwater from development projects outside the right-of-way. TxDOT should coordinate with local governments to the extent possible to ensure that private development projects meet the jurisdiction's post construction stormwater management requirements.

Local Provisions:

2.2.6 Site Analysis and Inventory

Using approved field and mapping techniques, the project designer shall collect and review information on the existing site conditions and map the following site features:

- Topography
- Drainage patterns and basins
- Intermittent and perennial streams / receiving waters
- Stream flow data
- Soils
- Ground cover and vegetation
- Wetlands
- Critical habitat areas
- Boundaries of wooded areas
- Floodplain boundaries
- Steep slopes
- Required buffers

- Other required protection areas (e.g., well setbacks)
- Clean Water Act Section 303(d) listed impaired stream segments
- Proposed stream crossing locations
- Existing stormwater facilities (open channels & enclosed)
- Existing development
- Utilities
- Adjacent areas
- Property lines and easements

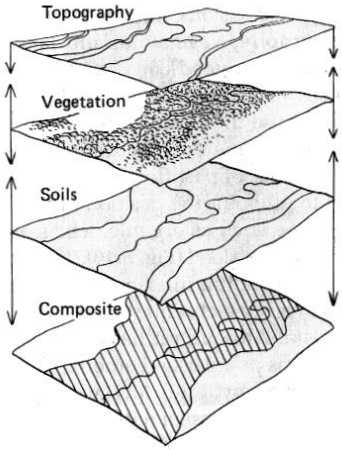

Figure 1.1
Composite Analysis
(Source: Marsh, 1983)

Some of this information may be available from previously performed studies or from a feasibility study. For example, some of the resource protection features may have been mapped as part of erosion and sediment control activities. Other recommended site information to map or obtain includes utilities information, seasonal groundwater levels, and geologic data.

Individual map or geographic information system (GIS) layers can be designed to facilitate an analysis of the site through what is known as map overlay or composite analysis. Each layer (or group of related information layers) is placed on the map in such a way as to facilitate comparison and contrast with other layers. A composite layer is often developed to show all the layers at once (see Figure 1.1).

Local Provisions:

2.3 Special Planning and Design Considerations

This section discusses several environmental features that need to be identified and assessed during the earliest stages of planning for a project, as well as design considerations for bridges and right-of-way. Proposed alignments for a project should avoid sensitive natural resources to the greatest extent practicable. In cases where avoidance is not possible, providing an undisturbed buffer and additional practices or structural controls to minimize impact must be considered.

Preserving natural conservation areas such as undisturbed forested and vegetated areas, floodplains, stream corridors and wetlands helps to preserve the original hydrology and avoids the impact of stormwater runoff and pollutants. Undisturbed vegetated areas also stabilize soils, provide for filtering and infiltration, decreases evaporation, and increases transpiration.

Buffer areas and sensitive features in proximity to project alignments should be clearly marked on all construction and grading plans to ensure equipment is kept out of these areas and native vegetation is kept in an undisturbed state. The boundaries of each conservation area should be mapped by carefully determining the limit that should not be crossed by construction activity.

Projects located in or near critical or sensitive areas, or as identified through a watershed study or plan, may be subject to additional performance and/or regulatory criteria. Furthermore, these sites may need to utilize certain structural controls in order to protect a special resource or address certain water quality or drainage problems identified for a drainage area or watershed.

For some projects, particularly expansion projects, practical limitations may present obstacles to fully meeting stormwater management requirements within the project right-of-way (ROW). Limitations could include lack of land availability, engineering constraints, health and safety issues associated with operations and maintenance activities, or low benefit/cost ratio. If the project planning, assessment, and design process reveals that stormwater requirements for a project cannot be met because it is not feasible to do so, an explanation must be provided in the planning documents for the project. The explanation must include the reasons why the requirements cannot be met for the site and the provisions for stormwater management that can be provided.

Local Provisions:

2.3.1 Sensitive Areas

Stream segments classified by the Texas Commission on Environmental Quality (TCEQ) as Exceptionally-High quality should be avoided if possible when considering potential alignments. These are waters that have been designated “Exceptional Quality Aquatic Habitat” by the TCEQ or “Endangered/Protected Species Habitat” by the Texas Parks and Wildlife Department.

- Exceptional Quality Aquatic Habitat – segments that are significant due to unique or critical habitats and exceptional aquatic life uses dependent on or associated with high water quality
- Endangered/Protected Species Habitat – sites along segments where water development projects would have significant detrimental effects on state or federally listed threatened and endangered species, and sites along segments that are significant due to the presence of unique, exemplary, or unusually extensive natural communities

Local Provisions:

2.3.2 Wetlands

Because the alteration of ground cover and drainage patterns will almost always affect the hydrology of wetlands, and because hydrologic changes strongly impact vegetation and amphibian communities, it is always preferable to avoid wetland areas when determining road or street alignments if possible.

An important measure to maintain the health of a natural wetland is the protection and control of the wetland’s hydroperiod. The hydroperiod is the pattern of fluctuation of water depth and the frequency and duration of drying in the summer. A hydrological assessment is performed to determine pre-project hydroperiod characteristics and to model the post-project conditions. Coordination with the TCEQ is necessary to properly assess the impact of hydroperiod changes.

The design of facilities adjacent to wetlands should maximize natural water storage and infiltration opportunities within the project area. Natural wetlands may not be used in lieu of runoff treatment BMPs. Any construction of stormwater treatment or flow control facilities is discouraged within natural wetland areas, with the exception of the following situations, which involve additional permitting:

- Necessary conveyance systems with applicable permits
- Lower quality wetland approved for hydrologic modification

Local Provisions:

2.3.3 Floodplains

Development in floodplain areas can reduce the ability of the floodplain to convey stormwater, potentially causing safety problems or significant damage to the site in question, as well as to both upstream and downstream properties. Ideally, the entire 100-year full-buildout floodplain should be avoided for clearing or building activities, and should be preserved in a natural undisturbed state where possible. Floodplain protection is complementary to riparian buffer preservation.

Roadway construction can displace hydrologic storage, resulting in increased stream flows, erosion, and decreased infiltration. Loss of hydrologic storage may require creation of additional hydrologic storage elsewhere in the watershed. Design for management of stormwater runoff from transportation facilities in floodplains differs from parcel based BMPs primarily in the increased influence of off-site stormwater entering the facility, space limitations of a linear facility, and the likelihood that roadways will cross jurisdictional boundaries.

Local Provisions:

2.3.4 Aquifers and Wellhead Protection Areas

Pollutants can enter aquifers through stormwater runoff treatment and storage systems. Local ordinances may specify minimum setbacks or buffers between wellheads and roadway construction. In Texas, the TCEQ's Source Water Assessment Program (SWAP), Source Water Protection Program (SWP) and Wellhead Protection Program (WHP) may also impact BMP selection and implementation for transportation projects. Aquifer recharge zones may also have state or local restrictions.

Local Provisions:

2.3.5 Streams and Riparian Areas

Roadway alignments should cross streams and riparian areas as few times as possible and should be located a sufficient distance from the stream when the alignment is parallel. Maintaining riparian buffers is important for the protection of stream banks and stream ecosystems.

Forested riparian buffers should be maintained and reforestation should be encouraged where no wooded buffer exists. Proper restoration should include all layers of the forest plant community, including understory, shrubs and groundcover, not just trees. A riparian buffer can be of fixed or variable width, but should be continuous and not interrupted by impervious areas that would allow stormwater to concentrate and flow into the stream without first flowing through the buffer.

Ideally, riparian buffers should be sized to include the 100-year floodplain as well as steep banks and wetlands. The buffer depth needed to perform properly will depend on the size of the stream and the surrounding conditions, but a minimum 25-foot undisturbed vegetative buffer is needed for even the smallest perennial streams and a 50-foot or larger undisturbed buffer is ideal. Any structural controls for management of stormwater should be located outside the riparian buffer if possible.

Generally, the riparian buffer should remain in its natural state. However, some maintenance is periodically necessary, such as planting to minimize concentrated flow, the removal of exotic plant species when these species are detrimental to the vegetated buffer and the removal of diseased or damaged trees.

Local Provisions:

2.3.6 Impaired Water Bodies

Impaired water bodies are those surface waters identified in the *Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d)* as not meeting water quality standards. In compliance with the federal Clean Water Act, the Texas Commission on Environmental Quality (TCEQ) researches, updates, and then publishes the list every two years. Impaired water bodies are eventually assigned a Total Maximum Daily Load (TMDL), which is the maximum amount of the impairing pollutant that the water body can receive and still comply with water quality standards. There are several impaired water bodies in the Dallas-Fort Worth metropolitan area, including those with and without TMDLs. Impairments may be for a variety of pollutants including bacteria and legacy pollutants such as PCBs and dioxin. Discharges of stormwater runoff containing pollutants of concern (any pollutant identified as a cause of impairment) to impaired water bodies will be governed by an entity's Texas Pollutant Discharge Elimination System (TPDES) Municipal Separate Storm Sewer System (MS4) permit, if applicable.

Local Provisions:

2.3.7 Facilities Designated as Hazardous Materials Routes

Shipments of hazardous materials along roadways that are listed on the National Hazardous Material Route Registry have the potential for accidental release of hazardous materials. Hazardous material traps should be considered for placement depending on the level of sensitivity of receiving waters, the probability of spills, and the nature of the stormwater collection system (particularly if the road surface drains directly to inlet and pipe system that discharge to surface waters). Gravity or other proprietary oil-water separators provide some level of protection, but the capacity may be exceeded and these devices are also generally not effective at containing corrosives. For maximum protection of sensitive areas, detention basins lined with clay, concrete, or other impermeable liner with a capture volume of at least 10,000 gallons should be considered.

Local Provisions:

2.3.8 Bridges

The portion of bridge stormwater runoff associated with the part of the bridge over water is the same volume as would have fallen in the water body without the presence of the bridge. The water quality, however, is impacted by material deposited on the road surface. Furthermore, the bridge itself doesn't offer an opportunity for treatment or infiltration. Although bridges have traditionally been built with gutters routing stormwater directly into the receiving waters, this is no longer the preferred alternative. It is recommended that runoff be collected and conveyed to the ends of the bridge and directed to the selected treatment facility as necessary. Collection and conveyance systems must be designed to prevent backup of stormwater onto the bridge surface in the event of clogging by trash and debris.

Local Provisions:

2.3.9 Right-of-Way

After the stormwater treatment requirements of the project are determined, and the hydrology of the site is known, the area required for stormwater treatment facilities can be estimated. Availability and cost of right-of-way may influence treatment selection. Placement of the roadway and stormwater treatment facilities within the right-of-way can be adjusted and additional right-of-way requirements may be identified.

Local Provisions:

2.3.10 Protection of Permanent Stormwater Controls during Construction

Permanent stormwater controls must be protected from damage due to excess sedimentation during construction of the project. All disturbed areas upstream of permanent stormwater controls should ideally achieve final stabilization prior to stormwater runoff being permitted to flow into the permanent control. At a minimum, permanent stormwater controls receiving runoff from disturbed areas must be protected by sediment controls such as silt fence or filter tubes. Permanent stormwater controls must be fully operational (no sediment buildup, no clogged filter media, plant material in place, proper infiltration rates achieved, etc.) as a condition of project acceptance from the contractor.

Local Provisions:

3.0 TriSWM Design Criteria

3.1 Hydrologic Methods

Refer to the iSWM Criteria Manual for Site Development and Construction, Section 3.1, Hydrologic Methods.

3.2 TriSWM Water Quality Protection

3.2.1 Water Quality Treatment Level Criteria

In assessing the need to incorporate post-construction water quality control measures into street and highway construction projects, the quality of receiving waters is to be considered along with projected traffic volume for the facility. Of many variables that affect the quality of runoff from a roadway (rainfall characteristics, traffic type, surrounding land use, etc.), average daily traffic volume (ADT) is a determining factor for which data is readily available.

Various studies and reports published by the Federal Highway Administration have concluded that greater pollutant levels in stormwater runoff could be anticipated where traffic volume exceeds 30,000 ADT. Therefore, 30,000 vehicles per day (VPD) is used as the threshold between low volume and high volume roadways and the corresponding level of post-construction stormwater quality treatment required.

The water quality of streams or reservoirs and existence of downstream critical areas are used to classify receiving waters and riparian environments. The classification is based on the susceptibility of the receiving waters and riparian areas to negative impact from pollutants in stormwater runoff from the proposed project. The classification of receiving waters is as follows:

1. **High**: These are receiving waters that meet one or more of the following criteria:
   - Designated as “Exceptional Quality Aquatic Habitat” by the TCEQ
   - Identified as Endangered/Protected Species Habitat by the Texas Parks and Wildlife Department
   - Proximity and potential impact to drinking water supply reservoir (as determined by water treatment provider)

2. **Moderate**: These are receiving waters that meet one or more of the following criteria:
   - Three or more designated uses on the Texas Surface Water Quality Standards, or any perennial stream* not classified on the Texas Surface Water Quality Standards
   - Wetlands located on the project site or downstream of the project where flow from the project would constitute more than 10% of total flow to the wetland

3. **Minimal**: All receiving waters not categorized above, including receiving waters listed with two or less designated uses on the Texas Surface Water Quality Standards and intermittent streams*

* Intermittent stream: A stream that has a period of zero flow for at least one week during most years. Perennial stream: A stream that has flow nearly continually (does not reach zero flow for one week or more) during most years.

Table 3.1 shows the level of post-construction stormwater management measures required for street and highway projects based on the previously discussed factors of traffic volume and quality of receiving waters. The levels should be considered during project planning and design for construction of new streets and highways and major reconstruction projects. The ADT will be based on a 20-year design projection.

Table 3.1 Post-Construction Water Quality Treatment Levels			
Traffic Volume	**Receiving Water / Riparian Area Susceptibility**		
	Minimal	**Moderate**	**High**
Low (<30,000 VPD)	Level I	Level I	Level II
High (>30,000 VPD)	Level I	Level II	Level III

Once the treatment level requirements have been established for the project, select practices or structural stormwater controls in accordance with the appropriate category. Section 3.8 and the *Site Development Controls Technical Manual* contain selection, pollutant removal effectiveness, and design information for the structural controls listed.

Treatment Level I

Select one or more of the following practices and/or structural controls:

- Program of Scheduled Pollution Prevention Practices
  Municipal pollution prevention/good housekeeping practices such as street sweeping, storm drain inlet cleaning, and proper application of landscape chemicals
- Off-site Pollution Prevention Activities/Programs
  Route stormwater runoff to new or existing watershed-level BMPs (i.e. regional detention, Dallas CBD sumps, etc.) identified in the entity's MS4 Permit / Stormwater Management Program
- Grass Channels
- Filter Strips
- Gravity (Oil-Grit) Separator
- Proprietary Structural Controls
- Porous Concrete / Modular Porous Paver Systems

Treatment Level II

Select one or more of the following practices and/or structural controls:

- Enhanced Swales
- Bioretention Areas
- Dry Detention / Extended Detention Dry Basins
- Supplement with any BMPs identified in Level I

Treatment Level III

Select one or more of the following practices and/or structural controls:

- Organic Filter
- Sand Filter
- Underground Sand Filter
- Infiltration Trenches
- Stormwater (Wet) Ponds
- Stormwater Wetlands
- Alum Treatment Systems (used as pretreatment in conjunction with wet pond)
- Supplement with any BMPs identified in Levels I and II

Once the treatment level is established and potential practices and structural controls are identified, the volume of runoff to be treated must be calculated in accordance with the following section for some controls. Refer to the *Site Development Controls Technical Manual* for each of the proposed controls to determine whether the water quality protection volume is applicable. Structural controls or practices from a higher Treatment Level category may be used to meet lower Treatment Level requirements if desired. Combinations of practices and controls may also be implemented. A detailed discussion of each of the controls, as well as design criteria and procedures, can be found in the *Site Development Controls Technical Manual*.

Local Provisions:

3.2.2 Water Quality Protection Volume

Treat the Water Quality Protection Volume by reducing total suspended solids from the development site for runoff resulting from rainfall of 1.5 inches (85th percentile storm). Stormwater runoff equal to the Water Quality Protection Volume generated from sites must be treated using a variety of on-site structural and nonstructural techniques with the goal of removing a target percentage of the average annual total suspended solids.

The Water Quality Protection Volume (WQ_v) is the runoff from the first 1.5 inches of rainfall. Thus, a stormwater management system designed for the WQ_v will treat the runoff from all storm events of 1.5 inches or less, as well as a portion of the runoff for all larger storm events. For methods to determine the WQ_v, see *Section 1.2 of the Water Quality Technical Manual*.

Local Provisions:

3.2.3 Stormwater Controls Overview

This section provides an overview of stormwater controls used to address stormwater quality, as well as streambank protection and flood mitigation, which are covered in Sections 3.4 and 3.5 of the iSWM Criteria Manual for Site Development and Construction. Table 3.2, Stormwater Treatment Suitability (located in Section 3.8.1 of the TriSWM Appendix) summarizes the stormwater management suitability of the various stormwater controls in addressing the stormwater Focus Areas. The *Site Development Controls Technical Manual* provides guidance on the use of stormwater controls as well as how to calculate the pollutant removal efficiency for stormwater controls in series. The *Site Development Controls Technical Manual* also provides guidance for choosing the appropriate stormwater control(s) for a site as well as the basic considerations and limitations on the use of a particular stormwater control.

The stormwater control practices recommended in this manual vary in their applicability and ability to meet stormwater management goals:

Water Quality Protection
Stormwater Controls are classified as Level I, Level II, or Level III depending on the ability of the control to achieve the desired reduction in pollutants. When designed to treat the required Water Quality Volume

(WQ_v) and constructed and maintained in accordance with recommended specifications, the desired level of protection is presumed to be provided to the receiving waters.

Streambank Protection and Flood Control
Stormwater Controls designated as "Primary" controls have the ability to fully address one or more of the Steps in the TriSWM Planning and Design Approach if designed appropriately. Several of these structural controls can be designed to provide primary control for downstream streambank protection (SPv) and flood control (Qf). These structural controls are recommended stormwater management facilities for a site wherever feasible and practical.

Stormwater Controls designated as "Secondary" controls are recommended only for limited use or for special site or design conditions. Generally, these practices either: (1) do not have the ability on their own to fully address a specifc stormwater Focus Area, (2) are intended to address hotspot or specific land use constraints or conditions, and/or (3) may have high or special maintenance requirements that may preclude their use.

Using Other or New Structural Stormwater Controls
Local governments and agencies can utilize controls not included in this guide at their discretion. Such controls may be utilized if independent performance data shows that the structural control conforms to requirements for treatment, conveyance, maintenance, and environmental impact.

Local Provisions:

3.3 Acceptable Downstream Conditions

Refer to the iSWM Criteria Manual for Site Development and Construction, Section 3.3, Acceptable Downstream Conditions.

3.4 Streambank Protection

Refer to the iSWM Criteria Manual for Site Development and Construction, Section 3.4, Streambank Protection.

3.5 Flood Mitigation

Refer to the iSWM Criteria Manual for Site Development and Construction, Section 3.5, Flood Mitigation.

3.6 Stormwater Conveyance Systems

Refer to the iSWM Criteria Manual for Site Development and Construction, Section 3.6, Stormwater Conveyance Systems.

3.7 Easements, Plats, and Maintenance Agreements

Refer to the iSWM Criteria Manual for Site Development and Construction, Section 3.7, Easements, Plats, and Maintenance Agreements.

3.8 TriSWM Stormwater Control Selection

3.8.1 Control Screening Process

Outlined below is a screening process for structural stormwater controls that can effectively treat the water quality volume, as well as provide water quantity control. This process is intended to assist the site designer and design engineer in the selection of the most appropriate structural controls for a development site and to provide guidance on factors to consider in their location. This information is also contained in the *Site Development Controls Technical Manual*.

The following four criteria shall be evaluated in order to select the appropriate structural control(s) or group of controls for a development:

- Stormwater treatment suitability
- Water quality performance
- Site applicability
- Implementation considerations

In addition, the following factors shall be considered for a given site and any specific design criteria or restrictions need to be evaluated:

- Physiographic factors
- Soils
- Special watershed or stream considerations

Finally, environmental regulations shall be considered as they may influence the location of a structural control on site or may require a permit.

The following steps provide a selection process for comparing and evaluating various structural stormwater controls using a screening matrix and a list of location and permitting factors. These tools are provided to assist the design engineer in selecting the subset of structural controls that will meet the stormwater management and design objectives for a development site or project.

Step 1 Overall Applicability

The following are the details of the various screening categories and individual characteristics used to evaluate the structural controls.

Table 3.2 – Stormwater Treatment Suitability

The first category in the matrix examines the capability of each structural control option to provide water quality treatment, downstream streambank protection, and flood control. A blank entry means that the structural control cannot or is not typically used to meet an *integrated* Focus Area. This does not necessarily mean that it should be eliminated from consideration, but rather it is a reminder that more than one structural control may be needed at a site (e.g., a bioretention area used in conjunction with dry detention storage).

Ability to provide water quality protection: Stormwater Controls are classified as Level I, Level II, or Level III depending on the ability of the control to achieve the desired reduction in pollutants. When

designed to treat the required Water Quality Volume (WQ_v) and constructed and maintained in accordance with recommended specifications, the desired level of protection is presumed to be provided to the receiving waters.

Ability to provide Streambank Protection (SP_v): This indicates whether the structural control can be used to provide the extended detention of the streambank protection volume (SP_v). The presence of a "P" indicates that the structural control can be used to meet SP_v requirements. An "S" indicates that the structural control may be sized to provide streambank protection in certain situations, for instance on small sites.

Ability to provide Flood Control (Q_f): This indicates whether a structural control can be used to meet the flood control criteria. The presence of a "P" indicates that the structural control can be used to provide peak reduction of the flood mitigation storm event.

Table 3.3 - Relative Water Quality Performance

The second category of the matrix provides an overview of the pollutant removal performance for each structural control option when designed, constructed, and maintained according to the criteria and specifications in this manual.

Ability to provide TSS and Sediment Removal: This column indicates the capability of a structural control to remove sediment in runoff. All of the Primary structural controls are presumed to remove 70% to 80% of the average annual TSS load in typical urban post-development runoff (and a proportional removal of other pollutants).

Ability to provide Nutrient Treatment: This column indicates the capability of a structural control to remove the nutrients nitrogen and phosphorus in runoff, which may be of particular concern with certain downstream receiving waters.

Ability to provide Bacteria Removal: This column indicates the capability of a structural control to remove bacteria in runoff. This capability may be of particular concern when meeting regulatory water quality criteria under the Total Maximum Daily Load (TMDL) program.

Ability to accept Hotspot Runoff: This last column indicates the capability of a structural control to treat runoff from designated hotspots. Hotspots are land uses or activities that produce higher concentrations of trace metals, hydrocarbons, or other priority pollutants. Examples of hotspots might include: gas stations, convenience stores, marinas, public works storage areas, garbage transfer facilities, material storage sites, vehicle service and maintenance areas, commercial nurseries, vehicle washing/steam cleaning, landfills, construction sites, industrial sites, industrial rooftops, and auto salvage or recycling facilities. A check mark indicates that the structural control may be used on hotspot site. However, it may have specific design restrictions. Please see the specific design criteria of the structural control for more details in the *Site Development Controls Technical Manual*. Local jurisdictions may have other site uses that they designate as hotspots. Therefore, their criteria should be checked as well.

Table 3.4 - Site Applicability

The third category of the matrix provides an overview of the specific site conditions or criteria that must be met for a particular structural control to be suitable. In some cases, these values are recommended values or limits and can be exceeded or reduced with proper design or depending on specific circumstances. Please see the specific criteria section of the structural control for more details.

Drainage Area: This column indicates the approximate minimum or maximum drainage area considered suitable for the structural control practice. If the drainage area present at a site is slightly greater than the maximum allowable drainage area for a practice, some leeway can be permitted if more than one practice can be installed. The minimum drainage areas indicated for ponds and wetlands should not be considered inflexible limits and may be increased or decreased depending on water availability (baseflow or groundwater), the mechanisms employed to prevent outlet clogging, or

design variations used to maintain a permanent pool (e.g., liners).

Space Required (Space Consumed): This comparative index expresses how much space a structural control typically consumes at a site in terms of the approximate area required as a percentage of the impervious area draining to the control.

Slope: This column evaluates the effect of slope on the structural control practice. Specifically, the slope restrictions refer to how flat the area where the facility is installed must be and/or how steep the contributing drainage area or flow length can be.

Minimum Head: This column provides an estimate of the minimum elevation difference needed at a site (from the inflow to the outflow) to allow for gravity operation within the structural control.

Water Table: This column indicates the minimum depth to the seasonally high water table from the bottom or floor of a structural control.

Table 3.5 - Implementation Considerations

The fourth category in the matrix provides additional considerations for the applicability of each structural control option.

Residential Subdivision Use: This column identifies whether or not a structural control is suitable for typical residential subdivision development (not including high-density or ultra-urban areas).

Ultra-Urban: This column identifies those structural controls appropriate for use in very high-density (ultra-urban) areas, or areas where space is a premium.

Construction Cost: The structural controls are ranked according to their relative construction cost per impervious acre treated, as determined from cost surveys.

Maintenance: This column assesses the relative maintenance effort needed for a structural stormwater control, in terms of three criteria: frequency of scheduled maintenance, chronic maintenance problems (such as clogging), and reported failure rates. It should be noted that **all structural controls** require routine inspection and maintenance.

Local Provisions:

Table 3.2 Stormwater Treatment Suitability

Category	Stormwater Controls	TSS/ Sediment Removal Rate	Water Quality Protection#	Streambank Protection	On-Site Flood Control	Downstream Flood Control
Bioretention Areas	Bioretention Areas	80%	Level II	S	S	-
Channels	Enhanced Swales	80%	Level II	S	S	S
	Channels, Grass	50%	Level I	S	P	S
	Channels, Open	-	-	-	P	S
Chemical Treatment	Alum Treatment System	90%	Level III	-	-	-
Conveyance System Components	Culverts	-	-	-	P	P
	Energy Dissipation	-	-	P	S	S
	Inlets/Street Gutters	-	-	-	P	-
	Pipe Systems	-	-	P	P	P
Detention	Detention, Dry	65%	Level II	P	P	P
	Detention, Extended Dry	65%	Level II	P	P	P
	Detention, Multi-purpose Areas	-	-	P	P	P
	Detention, Underground	-	-	P	P	P
Filtration	Filter Strips	50%	Level I	-	-	-
	Organic Filters	80%	Level III	-	-	-
	Sand Filters, Surface/Perimeter	80%	Level III	S	-	-
	Sand Filters, Underground	80%	Level III	-	-	-
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	40%	Level I	-	-	-
Infiltration	Infiltration Trenches	80%	Level III	S	-	-
Ponds	Wet Pond	80%	Level III	P	P	P
	Wet ED Pond	80%	Level III	P	P	P
	Micropool ED Pond	80%	Level III	P	P	P
Porous Surfaces	Modular Porous Paver Systems	[2]	Level I	S	-	-
	Porous Concrete	[2]	Level I	S	-	-
Proprietary Systems	Proprietary Systems [1]	[1]	Level I	S	S	S
Wetlands	Wetlands, Stormwater	80%	Level III	P	P	P
	Wetlands, Submerged Gravel	80%	Level III	P	S	-

P = Primary Control: Able to meet design criterion if properly designed, constructed and maintained.

S = Secondary Control: May partially meet design criteria. Designated as a Secondary control due to considerations such as maintenance concerns. For Water Quality Protection, recommended for limited use in approved community-designated areas.

= Applicability of controls to meet Water Quality Treatment Level Criteria.

- = Not typically used or able to meet design criterion.

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data, if used as a primary control. Third-party sources could include Technology Acceptance Reciprocity Partnership, Technology Assessment Protocol – Ecology, or others.

[2] = Porous surfaces provide water quality benefits by reducing the effective impervious area.

Table 3.3 Water Quality Performance

Category	Stormwater Controls	Water Quality Performance			
		TSS/ Sediment Removal Rate	Nutrient Removal Rate (TP/TN)	Bacteria Removal Rate	Hotspot Application
Bioretention Areas	Bioretention Areas	80%	60%/50%	-	✓
Channels	Enhanced Swales	80%	25%/40%	-	✓
	Channels, Grass	50%	25%/20%	-	
	Channels, Open	-	-	-	
Chemical Treatment	Alum Treatment System	90%	80%/60%	90%	✓
Conveyance System Components	Culverts	-	-	-	
	Energy Dissipation	-	-	-	
	Inlets/Street Gutters	-	-	-	
	Pipe Systems	-	-	-	
Detention	Detention, Dry	65%	50%/30%	70%	✓
	Detention, Extended Dry	65%	50%/30%	70%	✓
	Detention, Multi-purpose Areas	-	-	-	
	Detention, Underground	-	-	-	
Filtration	Filter Strips	50%	20%/20%	-	
	Organic Filters	80%	60%/40%	50%	✓
	Sand Filters, Surface/Perimeter	80%	50%/25%	40%	✓
	Sand Filters, Underground	80%	50%/25%	40%	✓
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	40%	5%/5%	-	
Infiltration	Infiltration Trenches	80%	60%/60%	90%	
Ponds	Wet Pond	80%	50%/30%	70%	✓
	Wet ED Pond	80%	50%/30%	70%	✓
	Micropool ED Pond	80%	50%/30%	70%	✓
Porous Surfaces	Modular Porous Paver Systems	[2]	80%/80%	-	
	Porous Concrete	[2]	50%/65%	-	
Proprietary Systems	Proprietary Systems [1]	[1]	[1]	[1]	
Wetlands	Wetlands, Stormwater	80%	40%/30%	70%	✓
	Wetlands, Submerged Gravel	80%	40%/30%	70%	✓

✓ = Meets suitability criteria

\- = Not typically used or able to meet design criterion.

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

[2] = Porous surfaces provide water quality benefits by reducing the effective impervious area.

Table 3.4 Site Applicability

Category	Stormwater Controls	Site Applicability				
		Drainage Area (acres)	Space Req'd (% of Tributary imp. Area)	Site Slope	Minimum Head Required	Depth to Water Table
Bioretention Areas	Bioretention Areas	5 max[3]	5-7%	6% max	5 ft	2 ft
Channels	Enhanced Swales	5 max	10-20%	4% max	1 ft	Below WT
	Channels, Grass					
	Channels, Open					
Chemical Treatment	Alum Treatment System	25 min	None			
Conveyance System Components	Culverts					
	Energy Dissipation					
	Inlets/Street Gutters					
	Pipe Systems					
Detention	Detention, Dry		2-3%	15% across pond	6 to 8 ft	2 ft
	Detention, Extended Dry		2-3%	15% across pond	6 to 8 ft	2 ft
	Detention, Multi-purpose Areas	200 max		1% for Parking Lot; 0.25 in/ft for Rooftop		
	Detention, Underground	200 max				
Filtration	Filter Strips	2 max[3]	20-25%	2-6%		
	Organic Filters	10 max[3]	2-3%		5 to 8 ft	
	Sand Filters, Surface/Perimeter	10 max[3] / 2 max[3]	2-3%	6% max	5 ft per 2-3 ft	2 ft
	Sand Filters, Underground	5 max	None			
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	1 max[3]	None			
Infiltration	Infiltration Trenches	5 max	2-3%	6% max	1 ft	4 ft
Ponds	Wet Pond		2-3%	15% max	6 t 8 ft	2 ft, if hotspot or aquifer
	Wet ED Pond	25 min[3]				
	Micropool ED Pond	10 min[3]				
Porous Surfaces	Modular Porous Paver Systems	5 max	Varies			
	Porous Concrete	5 max	Varies			
Proprietary Systems	Proprietary Systems [1]	[1]	[1]			
Wetlands	Wetlands, Stormwater	25 min	3-5%	8% max	3 to 5 ft (shallow) 6 to 8 ft (pond)	2 ft, if hotspot or aquifer
	Wetlands, Submerged Gravel	5 min			2 to 3 ft	Below WT

- = Not typically used or able to meet design criterion.
1 = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.
2 = Porous surfaces provide water quality benefits by reducing the effective impervious area.
3 = Drainage area can be larger in some instances

Table 3.5 Implementation Considerations

Category	Stormwater Controls	Implementation Considerations			
		Residential Subdivision Use	High Density/Ultra Urban	Capital Cost	Maintenance Burden
Bioretention Areas	Bioretention Areas	✓	✓	Moderate	Low
Channels	Enhanced Swales	✓		High	Low
	Channels, Grass	✓		Low	Moderate
	Channels, Open	✓		Low	Low
Chemical Treatment	Alum Treatment System	✓	✓	High	High
Conveyance System Components	Culverts	✓	✓	Low	Low
	Energy Dissipation	✓	✓	Low	Low
	Inlets/Street Gutters	✓	✓	Low	Low
	Pipe Systems	✓	✓	Low	Low
Detention	Detention, Dry	✓		Low	Moderate to High
	Detention, Extended Dry	✓		Low	Moderate to High
	Detention, Multi-purpose Areas	✓	✓	Low	Low
	Detention, Underground		✓	High	Moderate
Filtration	Filter Strips	✓		Low	Moderate
	Organic Filters		✓	High	High
	Sand Filters, Surface/Perimeter		✓	High	High
	Sand Filters, Underground		✓	High	High
Hydrodynamic Devices	Gravity (Oil-Grit) Separator		✓	High	High
Infiltration	Downspout Drywell	✓	✓	Low	Moderate
	Infiltration Trenches	✓	✓	High	High
	Soakage Trenches	✓	✓	High	High
Ponds	Wet Pond	✓		Low	Low
	Wet ED Pond	✓		Low	Low
	Micropool ED Pond	✓		Low	Moderate
	Multiple Ponds	✓		Low	Low
Porous Surfaces	Green Roof		✓	High	High
	Modular Porous Paver Systems		✓	Moderate	High
	Porous Concrete		✓	High	High
Proprietary Systems	Proprietary Systems [1]	[1]	✓	High	High
Re-Use	Rain Barrels	✓	✓	Low	High
Wetlands	Wetlands, Stormwater	✓		Moderate	Moderate
	Wetlands, Submerged Gravel	✓	✓	Moderate	High

✓ = Meets suitability criteria
- = Not typically used or able to meet design criterion.
[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

Step 2 Specific Criteria

The last three categories in the Stormwater Control Screening matrix provide an overview of various specific design criteria and specifications, or exclusions for a structural control that may be present due to a site's general physiographic character, soils, or location in a watershed with special water resources considerations.

Table 3.6 - Physiographic Factors

Three key factors to consider are low-relief, high-relief, and karst terrain. In the North Central Texas, low relief (very flat) areas are primarily located east of the Dallas metropolitan area. High relief (steep and hilly) areas are primarily located west of the Fort Worth metropolitan area. Karst and major carbonaceous rock areas are limited to portions of Palo Pinto, Erath, Hood, Johnson, and Somervell counties. Special geotechnical testing requirements may be needed in karst areas. The local reviewing authority should be consulted to determine if a project is subject to terrain constraints.

- Low relief areas need special consideration because many structural controls require a hydraulic head to move stormwater runoff through the facility.
- High relief may limit the use of some structural controls that need flat or gently sloping areas to settle out sediment or to reduce velocities. In other cases, high relief may impact dam heights to the point that a structural control becomes infeasible.
- Karst terrain can limit the use of some structural controls as the infiltration of polluted waters directly into underground streams found in karst areas may be prohibited. In addition, ponding areas may not reliably hold water in karst areas.

Table 3.7 - Soils

The key evaluation factors are based on an initial investigation of the NRCS hydrologic soils groups at the site. Note that more detailed geotechnical tests are usually required for infiltration feasibility and during design to confirm permeability and other factors.

Table 3.8 - Special Watershed or Stream Considerations

The design of stormwater controls is fundamentally influenced by the nature of the downstream water body that will be receiving the stormwater discharge. In addition, the designer should consult with the appropriate review authority to determine if their development project is subject to additional structural control criteria as a result of an adopted local watershed plan or special provision.

In some cases, higher pollutant removal or environmental performance is needed to fully protect aquatic resources and/or human health and safety within a particular watershed or receiving water. Therefore, special design criteria for a particular structural control or the exclusion of one or more controls may need to be considered within these watersheds or areas. Examples of important watershed factors to consider include:

High Quality Streams (Streams with a watershed impervious cover less than approximately 15%). These streams may also possess high quality cool water or warm water aquatic resources or endangered species. The design objectives are to maintain habitat quality through the same techniques used for cold-water streams, with the exception that stream warming is not as severe of a design constraint. These streams may also be specially designated by local authorities.

Wellhead Protection: Areas that recharge existing public water supply wells present a unique management challenge. The key design constraint is to prevent possible groundwater contamination by preventing infiltration of hotspot runoff. At the same time, recharge of unpolluted stormwater is encouraged to maintain flow in streams and wells during dry weather.

Reservoir or Drinking Water Protection: Watersheds that deliver surface runoff to a public water supply reservoir or impoundment are a special concern. Depending on the available treatment, a greater level of pollutant removal may be necessary for the pollutants of concern, such as bacteria pathogens,

nutrients, sediment, or metals. One particular management concern for reservoirs is ensuring stormwater hotspots are adequately treated so they do not contaminate drinking water.

Local Provisions:

Table 3.6 Physiographic Factors

Category	Stormwater Controls	Physiographic Factors		
		Low Relief	High Relief	Karst
Bioretention Areas	Bioretention Areas	Several design variations will likely be limited by low head		Use poly-linear or impermeable membrane to seal bottom
Channels	Enhanced Swales	Generally feasible. However, slope <1% may lead to standing water in dry swales	Often infeasible if slopes are 4% or greater	
	Channels, Grass			
	Channels, Open			
Chemical Treatment	Alum Treatment System			
Conveyance System Components	Culverts			
	Energy Dissipation			
	Inlets/Street Gutters			
	Pipe Systems			
Detention	Detention, Dry		Embankment heights restricted	Require poly or clay liner, Max ponding depth, Geotechnical tests
	Detention, Extended Dry			
	Detention, Multi-purpose Areas			
	Detention, Underground			GENERALLY NOT ALLOWED
Filtration	Filter Strips			
	Organic Filters			
	Sand Filters, Surface/Perimeter	Several design variations will likely be limited by low head		Use poly-linear or impermeable membrane to seal bottom
	Sand Filters, Underground			
Hydrodynamic Devices	Gravity (Oil-Grit) Separator			
Infiltration	Infiltration Trenches	Minimum distance to water table of 2 ft	Maximum slope of 6%; trenches must have flat bottom	GENERALLY NOT ALLOWED
Ponds	Wet Pond	Limit maximum normal pool depth to about 4 ft (dugout) Providing pond drain can be problematic	Embankment heights restricted	Require poly or clay liner Max ponding depth Geotechnical tests
	Wet ED Pond			
	Micropool ED Pond			
Porous Surfaces	Modular Porous Paver Systems			
	Porous Concrete			
Proprietary Systems	Proprietary Systems [1]			
Wetlands	Wetlands, Stormwater		Embankment heights restricted	Require poly-liner Geotechnical tests
	Wetlands, Submerged Gravel			

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

Table 3.7 Soils

Category	Stormwater Controls	Soils
Bioretention Areas	Bioretention Areas	Clay or silty soils may require pretreatment
Channels	Enhanced Swales	
	Channels, Grass	
	Channels, Open	
Chemical Treatment	Alum Treatment System	
Conveyance System Components	Culverts	
	Energy Dissipation	
	Inlets/Street Gutters	
	Pipe Systems	
Detention	Detention, Dry	Underlying soils of hydrologic group "C" or "D" should be adequate to maintain a permanent pool. Most group "A" soils and some group "B" soils will require a pond liner.
	Detention, Extended Dry	
	Detention, Multi-purpose Areas	
	Detention, Underground	
Filtration	Filter Strips	
	Organic Filters	
	Sand Filters, Surface/Perimeter	Clay or silty soils may require pretreatment
	Sand Filters, Underground	
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	
Infiltration	Infiltration Trenches	Infiltration rate > 0.5 inch/hr
Ponds	Wet Pond	"A" soils may require pond liner "B" soils may require infiltration testing
	Wet ED Pond	
	Micropool ED Pond	
Porous Surfaces	Modular Porous Paver Systems	Infiltration rate > 0.5 inch/hr
	Porous Concrete	
Proprietary Systems	Proprietary Systems [1]	
Wetlands	Wetlands, Stormwater	"A" soils may require pond liner
	Wetlands, Submerged Gravel	

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

Table 3.8 Special Watershed Considerations

Category	Stormwater Controls	Special Watershed Considerations		
		High Quality Stream	Aquifer Protection	Reservoir Protection
Bioretention Areas	Bioretention Areas	Evaluate for stream warming	Needs to be designed with no exfiltration (ie. outflow to groundwater)	
Channels	Enhanced Swales		Hotspot runoff must be adequately treated	Hotspot runoff must be adequately treated
	Channels, Grass			
	Channels, Open			
Chemical Treatment	Alum Treatment System			
Conveyance System Components	Culverts			
	Energy Dissipation			
	Inlets/Street Gutters			
	Pipe Systems			
Detention	Detention, Dry			
	Detention, Extended Dry			
	Detention, Multi-purpose Areas			
	Detention, Underground			
Filtration	Filter Strips			
	Organic Filters			
	Sand Filters, Surface/Perimeter	Evaluate for stream warming	Needs to be designed with no exfiltration (ie. outflow to groundwater)	
	Sand Filters, Underground			
Hydrodynamic Devices	Gravity (Oil-Grit) Separator			
Infiltration	Infiltration Trenches		Maintain safe distance from wells and water table. No hotspot runoff	Maintain safe distance from bedrock and water table. Pretreat runoff
Ponds	Wet Pond	Evaluate for stream warming	May require liner if "A" soils are present Pretreat hotspots 2 to 4 ft separation distance from water table	
	Wet ED Pond			
	Micropool ED Pond			
Porous Surfaces	Modular Porous Paver Systems			
	Porous Concrete			
Proprietary Systems	Proprietary Systems [1]			
Re-Use	Rain Barrels			
Wetlands	Wetlands, Stormwater	Evaluate for stream warming	May require liner if "A" soils are present Pretreat hotspots 2 to 4 ft separation distance from water table	
	Wetlands, Submerged Gravel			

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

Step 3 Location and Permitting Considerations

In the last step, a site designer assesses the physical and environmental features at the site to determine the optimal location for the selected structural control or group of controls. Table 3.9 provides a condensed summary of current restrictions as they relate to common site features that may be regulated under local, state, or federal law. These restrictions fall into one of three general categories:

- Locating a structural control within an area when expressly prohibited by law
- Locating a structural control within an area that is strongly discouraged, and is only allowed on a case by case basis. Local, state, and/or federal permits shall be obtained, and the applicant will need to supply additional documentation to justify locating the stormwater control within the regulated area.
- Structural stormwater controls must be setback a fixed distance from a site feature.

This checklist is only intended as a general guide to location and permitting requirements as they relate to siting of stormwater structural controls. Consultation with the appropriate regulatory agency is the best strategy.

Local Provisions:

Table 3.9 Location and Permitting Checklist

Site Feature	Location and Permitting Guidance
Jurisdictional Wetland (Waters of the U.S) U.S. Army Corps of Engineers Regulatory Permit	• Jurisdictional wetlands must be delineated prior to siting structural control. • Use of natural wetlands for stormwater quality treatment is contrary to the goals of the Clean Water Act and should be avoided. • Stormwater should be treated prior to discharge into a natural wetland. • Structural controls may also be *restricted* in local buffer zones. Buffer zones may be utilized as a non-structural filter strip (i.e., accept sheet flow). • Should justify that no practical upland treatment alternatives exist. • Where practical, excess stormwater flows should be conveyed away from jurisdictional wetlands.
Stream Channel (Waters of the U.S) U.S. Army Corps of Engineers Section 404 Permit	• All Waters of the U.S. (streams, ponds, lakes, etc.) should be delineated prior to design. • Use of any Waters of the U.S. for stormwater quality treatment is contrary to the goals of the Clean Water Act and should be avoided. • Stormwater should be treated prior to discharge into Waters of the U.S. • In-stream ponds for stormwater quality treatment are highly discouraged. • Must justify that no practical upland treatment alternatives exist. • Temporary runoff storage preferred over permanent pools. • Implement measures that reduce downstream warming. • Section 401 certification reviews by the Texas Commission on Environmental Quality are required for projects needing a Section 404 Permit.
Water Quality Certification Texas Commission on Environmental Quality (TCEQ)	• TCEQ conducts Section 401 water quality certification reviews of projects requiring a Section 404 permit from the U.S. Army Corps of Engineers for the discharge of dredged or fill material into waters of the U.S., including wetlands. • Specific stream and reservoir buffer requirements. • May be imperviousness limitations • May be specific structural control requirements that may overlap with requirements in this manual. • Mitigation will be required for impacts to existing aquatic and terrestrial habitat.
Impaired Water Bodies Texas Commission on Environmental Quality	• Determine if the project will discharge pollutants of concern into any downstream receiving waters that have been designated as impaired water bodies on TCEQ's *Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d)*. • Stormwater runoff discharges containing pollutants of concern to impaired water bodies will be governed by an entity's Municipal Separate Storm Sewer System (MS4) permit, if applicable.

Table 3.9 Location and Permitting Checklist

Site Feature	Location and Permitting Guidance
Groundwater Management Areas Texas Commission on Environmental Quality	• Conserve, preserve, protect, recharge, and prevent waste of groundwater resources through Groundwater Conservation Districts • Groundwater Conservation District pending for Middle Trinity. • Detailed mapping available from Texas Alliance of Groundwater Districts.
Floodplain Areas National Flood Insurance Program / Local Floodplain Administrator	• Grading and fill for structural control construction is generally discouraged within the 100-year floodplain, as delineated by FEMA flood insurance rate maps, FEMA flood boundary and floodway maps, or more stringent local floodplain maps. • Floodplain fill cannot raise the floodplain water surface elevation by more than limits set by the appropriate jurisdiction.
Stream Buffer Check with appropriate review authority whether stream buffers are required	• Consult local authority for stormwater policy. • Structural controls are discouraged in the streamside zone (within 25 feet or more of streambank, depending on the specific regulations).
Utilities Local Review Authority	• Call appropriate agency to locate existing utilities prior to design. • Note the location of proposed utilities to serve development. • Structural controls are discouraged within utility easements or rights of way for public or private utilities.
Roads TxDOT or DPW	• Consult TxDOT for any setback requirement from local roads. • Consult DOT for setbacks from State maintained roads. • Approval must also be obtained for any stormwater discharges to a local or state-owned conveyance channel.
Structures Local Review Authority	• Consult local review authority for structural control setbacks from structures. • Recommended setbacks for each structural control group are provided in the performance criteria in this manual.
Septic Drain fields Local Health Authority	• Consult local health authority. • Recommended setback is a minimum of 50 feet from drain field edge or spray area.
Water Wells Local Health Authority	• 100-foot setback for stormwater infiltration. • 50-foot setback for all other structural controls.

3.8.2 Example Application

A 2-mile existing 2 lane roadway is being expanded to a 4 lane divided roadway with a 15 foot median in an urban area within the Dallas/Fort Worth metropolitan area. The roadway will exceed a traffic count of 30,000 vehicles per day. The impervious coverage of the approximate 20 acre site will be 80%. The site drains to two receiving waters, 75% to an urban river with two designated uses on the Texas Surface Water Quality Standards and 25% to an unclassified urban stream. There is a small city park adjacent to the roadway. Low permeability soils limit the use of infiltration practices.

Table 3.10 lists the results of the selection analysis using the screening process described previously. The shaded rows indicate the controls that used alone or in combination may be considered for managing stormwater quality and/or quantity for portions of the site. The **X**'s indicate inadequacies in the control and ✓'s indicate adequate control capabilities for the particular category when considered for this site.

The receiving waters must be evaluated to determine the level of treatment required. The 15 acre area that drains to the urban river will require Level I treatment, while the 5 acre area that drains to the urban stream will require Level II treatment. The level designations are based on the definitions of "Minimal" and "Moderate" receiving water classifications located in Section 3.2.1, Water Quality Treatment Level Criteria, and on Table 3.1, Post-Construction Water Quality Treatment Levels.

There are no special watershed factors or physiographic factors to preclude the use of any of the practices from the structural control list. Other limiting factors of the site might include limited space within the right of way to include non-pipe storm water conveyance necessary for many Level I treatment options; limited space for detention facilities; downstream condition of the urban river and stream; offsite drainage; and large stormwater volumes.

A traditional roadway cross section for the 15 acre roadway section will only require good housekeeping practices such as street sweeping, storm drain inlet cleaning, and proper application of landscape chemicals for Level I treatment as long as the downstream assessment does not show need for additional flood and streambank protection. In order to provide secondary flood control and/or streambank protection for the 15 acres draining to the urban river, a series of grass channels can be placed in the median with the roadway draining towards the median rather than the edges of the right of way. This series of grass channels can be connected to the overall storm drainage system flowing to the urban river. The downstream conveyance system may need to be improved if downstream assessment shows need for additional flood control and/or streambank protection.

Level II treatment for the 5 acre roadway section will require the use of bioretention facilities, an enhanced swale or a detention facility which would all connect to the storm drainage system draining to the urban stream. The additional width of the right of way beyond the roadway limits determines the placement of the bioretention facilities or enhanced swale. These can either be placed in the median or on the edges of the roadway in lieu of curb and gutter with the runoff draining to the location of the stormwater control(s). The dry/extended dry detention pond could be placed in the public park adjacent to the roadway and would be better suited to provide flood control and streambank protection if a downstream assessment shows that they are necessary.

Table 3.10 Sample Structural Control Selection Matrix

Structural Control Alternative	Water Quality Treatment Level	Streambank Protection and Flood Control	Site Applicability	Implementation Considerations	Other Issues
Bioretention	Level II	✓[1]	✓[2]	✓	
Enhanced Swale	Level II	✓[1]	✓[2]	✓[3]	
Channels, Grass	Level I	✓[1]	✓[2]	✓[3]	
Dry Detention Pond	Level II	✓	✓	✓[3]	
Extended Dry Detention Pond	Level II	✓	✓	✓[3]	
Filter Strips	Level I	**X**	✓[2]	✓[3]	
Gravity (Oil-Grit) Separator	Level I	**X**	✓[2]	✓	Typically only for drainage areas less than 1 acre
Modular Porous Paver Systems	Level I	**X**	**X**	✓	Not used for travelled lane applications
Porous Concrete	Level I	**X**	**X**	✓	Typically used for low traffic applications
Proprietary Systems[4]	Level I	✓[1]	**UNK**	✓	High cost and maintenance requirements
Scheduled Pollution Prevention Practices	Level I	**X**	**NA**	✓	
Off-Site Pollution Prevention Activities	Level I	**UNK[5]**	**UNK[5]**	**UNK[5]**	

Notes:
1. Only when used with another structural control that provides onsite and downstream flood control
2. Can treat a portion of the site
3. Typically not used in high density / ultra urban settings; however conditions on this site are favorable for this control
4. The application and performance of specific commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data
5. Must be determined by the jurisdiction or agency on a case-by-case basis depending on the type of proposed off-site activity

Additional Local Requirements