PREFACE

This Criteria is being revised and approved based on the knowledge that the effective Flood Insurance Rate Maps (FIRMs) do not accurately define flood risks because they are based on rainfall information that has since been updated.

The National Oceanic and Atmospheric Administration's (NOAA) Atlas 14 precipitation frequency analysis indicates that the updated 100-year frequency rainfall approximates the current 500-year frequency rainfall. Therefore, this Criteria has been adjusted to reflect that fact.

Upon issuance of the new FIRMs using updated rainfall data as part of the MAAPnext project undertaken by the Harris County Flood Control District and FEMA, and concurrent with their adoption, this Criteria may require adjustments to more accurately regulate flood risks.

SECTION 2 – REVIEW AND ACCEPTANCE PROCEDURES

2.1 Introduction

Purpose of Review and Coordination 2.1.1

The purpose of this section is to define the procedure for coordinating projects with HCFCD, specify the responsibilities at each of the steps, and to facilitate successful completion of the project.

HCFCD reviews and coordinates developer and agency projects impacting HCFCD facilities:

- To help others plan, design, and build or modify HCFCD facilities that comply with design and acceptance criteria, and function as intended.
- That proposes placement of non-flood control features in HCFCD facilities.
- To assist local jurisdictions with flood plain management reviews.

Review Authority 2.1.2

The authority of HCFCD to control activities within HCFCD facilities and be involved in the management of stormwater in the watersheds comes from:

- Enabling legislation and subsequent amendments.
- Harris County Commissioners Court.
- Regulations of Harris County.
- Property rights.
- Interlocal agreements with municipalities within Harris County and other agencies (such as TxDOT).
- TPDES Permit.

In This Section 2.1.3

This section contains:

- Acceptance criteria and types of projects and documents reviewed.
- Overview of the review and coordination process.
- Variance submittals.
- Specific process description for:
  - New or modified HCFCD facilities.
  - Non-flood control features.
- Review process for federal projects.
- Requirements for regional flood control project watersheds.

2.2 Acceptance Criteria

Overview
2.2.1

Acceptance of work or features in existing or proposed HCFCD maintained facilities is contingent upon completion of the review, approval, and acceptance procedures and satisfaction of the criteria presented in this manual.

Two types of projects are those:

1. **Accepted by HCFCD for maintenance** –
   HCFCD does maintain this infrastructure or feature.
2. **Allowed in a HCFCD maintained facility** –
   HCFCD does not maintain this infrastructure or feature.

Purpose
2.2.2

The purpose of the acceptance criteria is to ensure the public will have flood control facilities that are designed and built to work when needed, last a long time, and require only normal maintenance and repair. At the beginning of a project, the design engineer and owner know what is required for HCFCD to accept the infrastructure or feature.

Continued on next page

2.2 Acceptance Criteria, Continued

Acceptance for HCFCD Maintenance 2.2.3

HCFCD will accept a new HCFCD facility or modification to an existing HCFCD facility for HCFCD maintenance if all of the following are satisfied:

- The proposed channel or detention basin receives stormwater from a public street or public storm sewer system, and provides area-wide drainage.
- The detention basin outfalls into HCFCD maintained channel and is adjacent to a HCFCD maintained channel.
- The project drainage or design report and construction drawings are:
  - Prepared using sound engineering practices.
  - In compliance with HCFCD policies and design criteria.
  - Signed and sealed by a licensed Texas Professional Engineer.
  - Reviewed and approved by HCFCD.
- The project is in compliance with local flood plain management requirements and Harris County regulations.
- All applicable local, state, and federal permits and approvals are obtained prior to construction.
- The project is constructed in accordance with the sealed and approved construction drawings, good construction practices, and applicable local, state, and federal permits and approvals.
- Prior to construction, the design engineer or contractor obtains approval from the HCFCD to enter the HCFCD right-of-way and submits the required 48 hour pre-construction notification to the HCFCD.
- Changes that are necessary due to different field conditions are coordinated with HCFCD prior to making the change and documented on the record drawings.
- The construction is inspected under the supervision of a licensed Texas Professional Engineer and the Professional Engineer certifies the completed work was constructed in accordance with the sealed construction drawings.
- The appropriate turf establishment criteria are satisfied.
- The appropriate right-of-way interest is conveyed to the HCFCD for both the proposed and ultimate facility and access to the facility for inspection, maintenance, and rehabilitation.
- Sealed record drawings are submitted and the project passes a final inspection by HCFCD.

Continued on next page

2.2 Acceptance Criteria, Continued

Unacceptable HCFCD Facilities 2.2.4

Some examples where HCFCD will not accept a new facility for maintenance are when the facility:

- Is not constructed in accordance with the sealed and approved construction drawings, good construction practices, and the applicable local, state, and federal permits and approvals.
- Only serves private streets or private development.
- Is a detention basin that outfalls into a road right-of-way or non-HCFCD maintained channel, or is not adjacent to a HCFCD maintained channel.
- Is a roadside ditch.
- Does not have well established turf or an executed agreement for HCFCD to perform turf establishment.
- Cannot be accessed from public property or within the project itself for maintenance or rehabilitation.
- Is not within a HCFCD right-of-way.

Typical Non-Flood Control Features 2.2.5

Typical non-flood control features not maintained by HCFCD are:

- Infrastructure, pipelines, and utilities:
  - Pipe and box outfalls (public and private).
  - Bridges and culverts.
  - Water and sanitary sewer lines.
  - Utilities and pipelines.
- Environmental and recreation features and associated appurtenances including but not limited to:
  - Hike and bike trails and bridges.
  - Recreation equipment.
  - Landscape plantings.
  - Habitat plantings such as riparian corridor plantings or native grass and wildflower plantings.
  - Wetland or stream mitigation required for Section 10 or 404 permit compliance, or other wetland or stream enhancement projects.
  - Water quality features not designed and constructed in accordance with HCFCD Design Guidelines for Wet Bottom Detention Basins with Water Quality Features.

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2.2 Acceptance Criteria, Continued

Sponsor for Recreation and Environmental Features 2.2.6

A sponsor is required for recreation and environmental features in HCFCD facilities. Depending on the feature, the sponsor can be a city, county precinct, utility district, other political subdivision, or legal entity acceptable to the HCFCD and approved by Harris County Commissioners Court.

The term feature also includes associated appurtenances such as retaining walls, signage, etc.

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2.2 Acceptance Criteria, Continued

Non-Flood Control Features Allowed in a HCFCD Facility 2.2.7

HCFCD will allow non-flood control features in a HCFCD maintained facility if all of the following are satisfied:

- The feature does not interfere with the function, integrity, operation, access, maintenance, or rehabilitation of the HCFCD facility, or any multi-purpose uses, such as environmental, recreation, or aesthetic features.
- The sponsor agrees to the following rules:
  - Obtain an independent property right or permission from the fee owner of the property; or for HCFCD fee property, obtain an easement from HCFCD with conditions and requirements included.
  - Maintain the feature in perpetuity in substantially the same condition existing at the time that sealed record drawings are submitted and the project passes a final inspection by HCFCD.
  - Repair damages to the HCFCD facility caused or made worse by the existence of the feature, by sponsor's failure to timely perform work necessary to keep the feature in the required condition, by sponsor's vehicles, equipment or contractor, or by erosion or displacement of soil around the feature from any cause.
  - Remove the feature at sponsor's cost or reimburse HCFCD for cost of removal when the feature is no longer in use or is abandoned or sponsor fails to remedy a violation of these rules, after receiving written demand by HCFCD for removal.
  - Relocate or restore sponsor's non-utility feature at sponsor's own cost to accommodate restoration of or improvements to HCFCD's facility.
  - The sponsor acknowledges that HCFCD will not repair or replace features and associated appurtenances:
    - Damaged or removed by HCFCD or its contractors in the course of maintaining, repairing, rehabilitating, modifying, or enlarging the HCFCD facility.
    - Damaged by erosion or siltation of the HCFCD facility.
  - The sponsor acknowledges that HCFCD will not repair or restore damages such as slope failures, erosion, siltation, etc. to a HCFCD facility to safeguard, repair, or replace non-flood control features and associated appurtenances.

Continued on next page

2.2 Acceptance Criteria, Continued

Non-Flood Control Features Allowed in a HCFCD Facility - Continued 2.2.7

- The design report and construction drawings are:
  - Prepared using sound engineering practices.
  - In compliance with HCFCD policies and design criteria.
  - In compliance with applicable local, state, and federal laws, rules, and regulations.
  - Signed and sealed by a licensed Texas Professional Engineer and landscape architect, if applicable.
  - Reviewed and approved by HCFCD.
- The project is in compliance with local flood plain management requirements and Harris County regulations.
- For recreation and environmental features:
  - An executed agreement is required between HCFCD and the sponsor prior to construction.
  - For HCFCD fee properties:
    - The sponsor is required to maintain a portion of the right-of-way encumbered by the feature in accordance with the agreement. This includes, but is not limited to, mowing, trimming, and litter removal on a routine basis.
    - Recreation features must be open to the public at no charge.
- The project is constructed in accordance with the sealed construction drawings, good construction practices, and the applicable local, state, federal permits and approvals.
- Prior to construction, design engineer or contractor obtains approval from the HCFCD to enter the HCFCD right-of-way and submits the required 48 hour pre-construction notification to the HCFCD.
- Changes that are necessary due to different field conditions are coordinated with HCFCD prior to making the change and documented on the record drawings.
- The construction is inspected under the supervision of a licensed Texas Professional Engineer and the Professional Engineer certifies the completed work was constructed in accordance with the sealed construction drawings.
- The appropriate turf establishment criteria are satisfied.
- Copies of all environmental permits are provided.
- Sealed record drawings are submitted and the project passes a final inspection by HCFCD.

2.3 Projects and Documents

Projects Reviewed 2.3.1

HCFCD reviews three types of proposed projects that affect the function or maintenance of existing or proposed HCFCD facilities:

1) Projects with flood control infrastructure that:
   - Create a new HCFCD facility.
   - Physically modify an existing HCFCD facility.
   - Change or impact the maintenance of an existing HCFCD facility.

   Examples:
   - Open channels
   - Detention basins
   - Outfall channels and structures
   - Open channel enclosures

2) Projects with non-flood control features that are physically located in, on, over, under, or adjacent to the HCFCD facility:

   Examples:
   - Land development projects
   - Roads and highways
   - Bridges and culverts
   - Storm sewer outfall pipes
   - Water and sanitary sewer lines
   - Pipelines and public utilities
   - Environmental features (like wetlands and tree plantings)
   - Recreation amenities (like hike and bike trails)
   - Encroachments

3) Development or public projects with no work in a HCFCD facility that are:
   - Referred to HCFCD by the flood plain permitting jurisdiction.
   - Located in a watershed with an adopted regional or master plan.

   Examples:
   - Proposed subdivision and site developments
   - Roads and highways

Continued on next page

2.3 Projects and Documents, Continued

Within City of Houston 2.3.2

For proposed projects within Harris County and the City of Houston (COH) city limits excluding ETJ, use the following table for determining if HCFCD review is required and which detention criteria to use.

If the site outfalls directly into:	And the site location is:	HCFCD review required:	Detention criteria:
COH storm sewer*	Not adjacent to an open channel	No	COH
COH storm sewer*	Within or adjacent to an open channel	Yes	COH
Open channel	Any	Yes	HCFCD

*including roadside ditches in a road right-of-way

Documents Reviewed 2.3.3

For projects impacting HCFCD facilities, HCFCD reviews:

- Drainage or design reports.
- Construction drawings.
- Environmental and recreation plans.
- Right-of-way related documents:
  - Plats.
  - Instruments.
  - Metes and bound descriptions.
- Interlocal agreements.
- Encroachment requests.

Document Submittal Requirements 2.3.4

To facilitate review, submit documents that are factual, clear, concise, complete, and accurately represent the project.

Follow the current electronic submittal guidelines posted on the Harris County ePermits website.

All applicable documents submitted to HCFCD must be properly identified, sealed, signed, and dated as required by the Texas Board of Professional Engineers and Texas Board of Professional Land Surveying.

Documents submitted for preliminary review must be clearly labeled as preliminary and comply with Texas Board of Professional Engineers and Texas Board of Professional Land Surveying, as required.

Continued on next page

2.3 Projects and Documents, Continued

Document Responses 2.3.5

HCFCD response depends on the type of document, type of project, location, HCFCD authority, and what is being proposed. Once documents are determined to accurately represent the project, and are factual, clear, concise, complete, in substantial compliance with this manual, and represent reasonable engineering principles and practices, the following responses are possible for construction drawings:

Interpose No Objection: For projects outside HCFCD right-of-way, HCFCD does not object to the project or feature being built as documented.

Approved: For projects within existing or proposed HCFCD right-of-way, HCFCD approves the project or feature being built as documented.

Not Approved: HCFCD does not approve the project or feature because it would negatively impact the HCFCD facility's function or maintenance.

No Review Required: For projects outside HCFCD right-of-way that do not impact HCFCD's function or maintenance, HCFCD does not need to review the project or feature.

For drainage, design, hydrology and hydraulic, geotechnical, environmental, etc. reports, the HCFCD's response after the conditions listed above are satisfied is **Interpose No Objection**.

Note**:** In no case shall the response of HCFCD be considered as acting or performing the duties of the licensed Texas Professional Engineer with regard to analysis, design, or inspection performed under their supervision. HCFCD's review and signature on a construction drawing does not mean analysis and design associated with the project have been reviewed in detail.

Signature Expiration 2.3.6

This section reserved.

2.4 Review and Coordination Process Overview

Introduction 2.4.1

This section outlines the review and coordination process for property owners, developers, public agencies, private utility companies, utility districts, and homeowner groups to build a new HCFCD facility; modify an existing HCFCD facility; build a new development or facility on a site; or construct environmental, aesthetic, or recreation features in a HCFCD facility.

Continued on next page

2.4 Review and Coordination Process Overview, Continued

Departments and Responsibilities 2.4.2

The following HCFCD Divisions and Departments are directly involved in project reviews and coordination and work closely together, as necessary. Other HCFCD Departments and Sections are brought in when needed.

Watershed Management Department (WMD): Reviews private development and public agency projects to verify compliance with policies and criteria. Coordinates review of construction drawings by other HCFCD departments and signs all construction drawings on behalf of HCFCD. See Appendix G, References, for list of WMD staff and contact information. Focus is:

- Drainage and engineering issues.
- Right-of-way determination/requirement (alignments and widths).
- Hydrologic and hydraulic analysis review.
- Public and private utilities and pipelines.

Infrastructure Division (INF): Responsible for maintenance of all HCFCD facilities and reviews construction drawings to ensure that:

- New or modified HCFCD facilities can be adequately maintained and that a permanent access is provided,
- Recreation features (like hike and bike trails) are compatible, and
- Proposed tree plantings and other landscape features in HCFCD facilities are acceptable.

Property Management Department (PRM): Responsible for management of all HCFCD real property.

- Prepares interlocal, maintenance, and specialized agreements for non-flood control features in HCFCD facilities.
- Reviews construction drawings to ensure compliance with existing interlocal and maintenance agreements.
- Processes conveyance of easements from HCFCD to other entities (e.g. utility easements, etc.).
- Processes abandonment of existing HCFCD right-of-way where appropriate.

Property Acquisition Services Department (PAS): Responsible for acquisition of property and rights-of-way for HCFCD facilities and projects.

- Processes the conveyance and donation of right-of-way to HCFCD by others.
- Coordinates acquisition of HCFCD rights-of-way with the Harris County Right-of-Way Department.

Continued on next page

2.4 Review and Coordination Process Overview, Continued

Departments and Responsibilities - Continued 2.4.2

Development Coordination and Inspection Department (DCID): Assures HCFCD facilities or features are constructed in compliance with the PCPM and the construction drawings by monitoring the construction and accepting the work after all criteria are satisfied. In addition, DCID:

- Reviews construction drawings for potential impediments to HCFCD maintenance access.
- Assigns HCFCD Unit Numbers to new drainage channels and detention basins.
- Processes the release of construction bonds for work in HCFCD right-of-way.

Other Engineering Departments (ED+): Three separate departments in the Engineering Division are responsible for managing capital improvements, federal projects, and infrastructure repairs and rehabilitation. Each of the three departments, as necessary:

- Reviews construction drawings to determine if developer or agency infrastructure projects will overlap with proposed or ongoing HCFCD projects.
- Coordinates scheduling, design compatibility, and implementation between HCFCD and developer/agency engineers where work is within the same project area.

Environmental Regulatory Compliance Department (RCD) and Stormwater Quality Department (SQD): Oversees environmental and cultural resource compliance including permitting and mitigation, as well as compliance with HCFCD's TPDES permit.

Relative to HCFCD facilities and flood plain management, the Harris County Permit Office is responsible for:

- FEMA compliance in unincorporated Harris County.
- TPDES compliance in unincorporated Harris County.
- Issuance of approval (notification) to work in HCFCD right-of-way.

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2.4 Review and Coordination Process Overview, Continued

Process Overview 2.4.3

The table below is an overview of the review and coordination process. Exhibit 2-1 shows the overall process. Each stage of the process is explained in detail in subsequent sections.

Stage	Who Does It	What Happens
1 Initiation	Applicant	Contacts WMD to arrange a pre-project meeting to discuss design issues and review process. Provides meeting agenda to WMD.
	HCFCD (WMD, DCID, PRM, SQD, RCD)	Attends pre-project meeting and reviews meeting notes.
2 Drainage or Design Report	Applicant	Prepares and submits drainage or design report.
	HCFCD (WMD)	Reviews and responds appropriately (see Section 2.3.5, Document Responses).
3 Construction Drawings	Applicant	Prepares construction drawings.
	HCFCD (WMD, INF, PRM, DCID, ED+, SQD, RCD)	Reviews and responds appropriately, and WMD signs plans (see Section 2.3.5, Document Responses).
4 Construction	Applicant	Obtains necessary permits. Obtains approval to enter HCFCD facility/ROW and notifies HCFCD prior to beginning work. Constructs project, inspects work, and certifies completed work.
	HCFCD (DCID)	Monitors ongoing work and confirms work completed satisfactorily in accordance with PCPM and construction drawings.
5 Acceptance	HCFCD (DCID)	After one year warranty period, accepts work for maintenance when all applicable requirements in this manual are completed; OR Allows non-flood control feature in a HCFCD facility (owner maintains) when all applicable requirements in this manual are satisfied and construction completed satisfactorily.

Note: WMD: Watershed Management Department
PRM: Property Management Department
INF: Infrastructure Division
ED+: Other Engineering Departments
DCID: Development Coordination and Inspection Department
SQD: Stormwater Quality Department
RCD: Environmental Regulatory Compliance Department

Continued on next page

2.4 Review and Coordination Process Overview, Continued

Concurrent Activities 2.4.4

Working on concurrent activities as early in the process as possible can facilitate project completion. Possible concurrent activities shown in Exhibit 2-1 are:

- Variance requests (see Section 2.5).
- Environmental and cultural resources compliance (see Section 17).
- Dedication or conveyance of HCFCD right-of-way (see Sections 2.11, 2.12, and Section 15).
- Purchase of right-of-way for a non-flood control feature (see Sections 2.11 and Section 15).
- Negotiation and execution of agreements (see Section 2.13).
- Execution of turf establishment agreement with HCFCD (see Section 2.7).

2.5 Variances

Introduction 2.5.1

Good engineering practice and practical considerations are necessary when developing stormwater management plans and preparing construction drawings for specific projects. The criteria in this manual cannot cover every possibility.

The closer the criteria are followed, the more likely the plan or drawing will be approved and the construction accepted. For those situations where varying from the criteria is warranted or a specialized analysis or design is needed, the variance process is described below.

Submittal 2.5.2

Submit variance requests in writing on the Request for Variance from HCFCD form provided in Appendix B, as early as possible. The variance request must include:

- The specific criteria that you want to vary.
- Why the criteria needs to be varied.
- How the basis for the criteria will still be satisfied, or why the criteria is not applicable.
- Indication if there are no criteria for the proposed analysis, design, or feature in this manual.
- Appropriate technical information supporting the variance request, such as calculations, excerpts from the drainage or design plan, and/or construction drawings.

Note: Submittals with insufficient technical information to support the variance request will be returned without review.

HCFCD Response 2.5.3

HCFCD will either approve or reject the variance in writing on the variance request form. If it is rejected, a written explanation will be provided.

The HCFCD Director or his appointee(s) approves or rejects variances.

2.6 Noncompliance

Introduction 2.6.1

If the Acceptance Criteria are not satisfied and the procedures are not followed in this manual, HCFCD has no obligation to accept the facility or infrastructure for maintenance.

Possible Consequences 2.6.2

HCFCD will give the owner or developer of a project a reasonable opportunity to satisfy the criteria and follow the procedures. If an impasse is reached, some of the possible situations and consequences of noncompliance are presented below.

Before Construction Begins 2.6.3

During the development of the drainage or design report or construction drawings, possible consequences of noncompliance are:

- The proposed infrastructure or project is not approved by HCFCD.
- Work cannot take place in a HCFCD right-of-way.

After Construction Begins 2.6.4

After construction begins or is completed, possible consequences of noncompliance are:

- Constructed work may require removal if:
  - work is constructed without HCFCD approved constructed drawings,
  - work is constructed differently than HCFCD approved construction drawings,
  - HCFCD approval (notification) to enter HCFCD right-of-way is not obtained,
  - 48-hour pre-construction notification is not submitted to HCFCD, or
  - work requiring HCFCD monitoring is not observed by HCFCD inspectors
- Giving bond company the opportunity to bring into compliance.
- HCFCD will not accept the facility and the owner or developer maintains the channel or detention basin.
- The owner or developer is referred to the County Attorney's Office.

2.7 Turf Establishment Responsibility

Turf Establishment Responsibility 2.7.1

The entity or developer that disturbs the existing or proposed HCFCD right-of-way is responsible for establishing the turf prior to final acceptance of the work. Minimum criteria for turf acceptance are in Section 10.3, Turf Establishment.

The entity or developer has the option to enter into an agreement with HCFCD to perform turf establishment. If the entity or developer satisfies the terms of the turf establishment agreement, including paying the designated fee, then HCFCD will provide turf establishment and vegetation management. The entity or developer will not be held responsible for satisfying the turf establishment criteria prior to final inspection or acceptance.

2.8 New or Modified HCFCD Facilities

Introduction 2.8.1

This section covers the specific review and coordination process for projects by others that create new or modify existing HCFCD maintained facilities.

Responsible Departments 2.8.2

Reports and construction drawings are submitted through the Harris County ePermits System for logging and tracking purposes.

The HCFCD Watershed Management Department (WMD) reviews projects to verify compliance with the policies and criteria in this manual, hydrology and hydraulic reports or analysis, variance requests, and signs construction drawings. WMD staff coordinates with other HCFCD departments as necessary, such as the:

- Engineering Division Departments – coordination with active and proposed HCFCD projects, and general design and geotechnical questions.
- Environmental Regulatory Compliance Department and Stormwater Quality Department – permitting and compliance in existing or future HCFCD facilities.

The HCFCD Property Management Department (PRM) coordinates right-of-way requested by others and prepares agreements.

The Development Coordination and Inspection Department (DCID) reviews construction drawings, monitors construction, and accepts completed projects.

See Section 2.4, Review and Coordination Process Overview for a complete list and descriptions of their responsibilities.

Federal Channels and Detention Basins 2.8.3

Any work in or alteration of a channel or detention basin constructed as part of an U.S. Army Corps of Engineers project must receive permission from the Corps of Engineers, Galveston District. See Section 2.14, Federal Projects for additional information and requirements.

2.8.4 Stage 1, Initiation
New or Modified HCFCD Facilities

Preliminary Assessment 2.8.4.1

Fill out the Preliminary Assessment of HCFCD Requirements Form and submit to the HCFCD Watershed Management Department. The form is available in Appendix B, Forms.

The information required for HCFCD's initial review of the proposed project is:

- The type, location, and size of the proposed project.
- Available topographic information.
- Existing and proposed preliminary drainage route.
- Existing land use or condition.
- Adjacent land use.
- Existing roads.
- Proximity to existing HCFCD maintained facilities.
- Indication if the owner intends HCFCD to maintain the proposed new facility or feature, or modification of an existing HCFCD facility.
- Any known factors that could affect the drainage or design plan, such as jurisdictional wetlands, limited outfall depth, existing drainage problems, existing channel or detention condition, flood plain limits, flood plain elevations, floodway limits, etc.

HCFCD Response 2.8.4.2

The HCFCD Watershed Management Department will work closely with the applicant at this initiation stage. Possible responses are a:

- Request for more detailed information or a meeting to better understand the proposed project.
- Letter indicating the HCFCD review process is complete.
- Letter with specific HCFCD requirements unique to the proposed project.
- Referral to and response from the HCFCD Property Management Department.
- Request for submittal of a drainage or design report or construction drawings.

2.8.5 Stage 2, Drainage or Design Report New or Modified HCFCD Facilities

Overview 2.8.5.1

Drainage or design reports are required for new or modified HCFCD maintained facilities to confirm the proposed project is designed in accordance with the policies and criteria in this manual and sound engineering practice. Drainage reports may also be required to confirm development or public projects do not increase flood risks or flood hazards, or create new flood hazard areas.

A drainage or design report also documents, identifies, and resolves issues early in the project development which facilitates completion of the construction drawings and a successful project.

Common Topics 2.8.5.2

Some common topics a drainage or design report can address are the:

- Development and drainage plan layout.
- Hydrology and hydraulics analysis.
- Existing and proposed drainage facility layouts.
- Right-of-way, existing and proposed.
- Pipelines and utilities.
- Geotechnical issues.
- Structural design issues.
- Environmental and cultural resources issues, studies, and permits.
- Stormwater quality features, existing and proposed.
- Environmental, recreation, and aesthetic features, existing and proposed.
- Turf establishment plan.
- Maintenance access plan.
- Operation plan for pumped detention basins.

Report Requirements 2.8.5.3

Minimum report requirements and electronic submittal guidelines are provided in Section 19, Report Requirements.

Continued on next page

2.8.5 Stage 2, Drainage or Design Report New or Modified HCFCD Facilities, Continued

HCFCD Response 2.8.5.4

The HCFCD Watershed Management Department will work closely with the applicant during development of the drainage or design report providing comments and feedback. However, please note that submittals with insufficient technical information to support the proposed project will be returned without review.

One of the document responses listed in Section 2.3.5, Document Responses will be issued for the report.

2.8.6 Stage 3, Construction Drawings New or Modified HCFCD Facilities

Overview 2.8.6.1

Following completion of the drainage or design report, the next stage involves design and preparation of construction drawings.

Scale Drawings 2.8.6.2

Include scale drawings of hydraulic structures and associated details with typical sections, dimensions, notes, and references to construction specifications, as appropriate.

Design Details 2.8.6.3

Use standard details only where applicable. HCFCD Standard Details are in Appendix D, Standards, Details, and Guidelines.

When the design engineer determines a structural analysis is needed for non-standard hydraulic structures, submit the analysis with the construction drawings and design details.

Standard Notes 2.8.6.4

Standard notes for construction drawings are required when work is proposed in or adjacent to existing or proposed HCFCD maintained facilities. HCFCD Standard Notes for Construction Drawings are in Appendix D, Standards, Details, and Guidelines.

Checklists 2.8.6.5

To facilitate the preparation of the construction drawings by the engineer and the review of the drawings by HCFCD, checklists are provided in Appendix C, Checklists. Checklists are provided for the following types of projects:

- Projects with Storm Sewer Outfalls.
- Channels.
- Detention Basins.
- Bridges and Culverts.
- Wastewater Treatment Plants.
- Pipeline/Utility Crossings.
- Recreation, Environmental, and Aesthetic Features.

These are the most common project types submitted to HCFCD.

Continued on next page

2.8.6 Stage 3, Construction Drawings New or Modified HCFCD Facilities, Continued

U.S. Army Corps of Engineers Permit 2.8.6.6

On the Express Review Sheet, indicate the U.S. Army Corps of Engineers' Section 404 permit or Section 10 permit compliance for work in existing or proposed HCFCD rights-of-way by:

- Indicating an individual permit is needed and providing a copy prior to construction,
- Listing the nationwide permit number(s) that apply,
- Indicating no permit is needed, and explain why, or
- Explaining another means of compliance.

Note: If any special permit conditions are reflected in the construction drawings, clearly highlight such conditions on the drawings.

Continued on next page

2.8.6 Stage 3, Construction Drawings, New or Modified HCFCD Facilities, Continued

Review Procedure 2.8.6.7

The following is the review procedure for construction drawings submitted to the HCFCD Watershed Management Department. Submit all documents via the Harris County ePermits System.

Step	Who Does It	Action
1	Design Engineer	Submits in pdf format in a single file: – One digital set of sealed prints. – Completed checklist. – Geotechnical Report – Environmental and cultural resources permit compliance status on Express Review Sheet – Applicable correspondence – Drainage or design report, or reference report if already submitted and approved.
2	HCFCD (WMD, INF, PRM, DCID, SQD, RCD)	Reviews construction drawings and returns mark-ups to design engineer.
3	Design Engineer	Revises construction drawings, if necessary.
4	Design Engineer	Submits final construction drawings.
5	HCFCD (WMD)	Confirms final construction drawings are in compliance. Drawings are signed and returned to the applicant.

Note 1: For work in or alteration of a U.S. Army Corps of Engineers channel or detention basin, see Section 2.14, Federal Projects.

Note 2: For pumped detention basins, submit the operation plan and draft Operations and Maintenance Manual with the construction drawings.

Changes to Drawings 2.8.6.8

After the HCFCD Watershed Management Department signs construction drawings, changes to the project may occur during review by other agencies or during construction. Document major changes that affect the design or layout of the work in the existing or proposed HCFCD facility as a revision to the original signed drawings and resubmit for another signature as soon as practical. HCFCD cannot accept the work if the changes are not accurately depicted on the signed construction drawings.

2.8.7 Stage 4, Construction
New or Modified HCFCD Facilities

Overview
2.8.7.1

The design engineer, owner's engineer, and/or agency engineer have responsibilities during construction as outlined in this chapter.

The construction stage is broken down into three sub-stages:

- Pre-construction.
- During construction.
- Post construction.

Pre-Construction
2.8.7.2

1. Using Harris County ePermits online system, the applicant applies for approval (Right-of-Way Notification) from the HCFCD WMD to enter HCFCD right-of-way which requires submittal of:
   - The construction drawings approved by HCFCD.
   - A properly executed two-year bond payable to HCFCD, issued in the name of the contractor. (Bond forms are available in the Harris County Permit Office and online.)
   - Applicable processing fee.
2. Forty-eight hours prior to entering an existing HCFCD facility or beginning work on a proposed HCFCD facility, the design engineer or contractor must submit a completed copy of the 48 Hour Pre-Construction Notification Form provided in Appendix B, Forms, to the HCFCD Development Coordination and Inspection Department with the following attachments:
   - One copy of the construction drawings signed by HCFCD.*
   - One copy of approval (Right-of-Way Notification) to enter the HCFCD right-of-way.*
   - One copy of the Corps of Engineers' Section 404 or Section 10 individual permit or other specific permits (e.g. TPDES and local stormwater quality permits, State water quality certification), if requested by HCFCD.
   - One copy of the executed turf establishment agreement and proof of payment, if applicable.
   - One copy of right-of-way documentation for non-flood control feature, if applicable.

   * A copy of these items must be on site during construction.

Continued on next page

2.8.7 Stage 4, Construction
New or Modified HCFCD Facilities, Continued

During Construction 2.8.7.3

In order for the HCFCD Development Coordination and Inspection Department to verify the project is constructed according to the construction drawings and industry practices, the HCFCD Inspector will monitor the construction and the condition of the HCFCD facility. HCFCD encourages the contractor and owner's engineer to stay in close communication with the HCFCD Inspector.

The owner's engineer or someone under his supervision should perform inspections during construction. The HCFCD does not perform the construction inspection services. If problems develop, the engineer is encouraged to contact the HCFCD Development Coordination and Inspection Department.

HCFCD requires the owner's engineer to certify the work was constructed according to the signed construction drawings with actual elevations, grades, locations, etc. shown on record drawings. If substantive changes are made to the construction drawings, see Section 2.8.6.8, Changes to Drawings.

Post Construction 2.8.7.4

The owner's engineer or public agency must submit a written request for an inspection to the HCFCD Development Coordination and Inspection Department. Prior to the HCFCD inspection, stake and flag the HCFCD right-of-way. Include the following with the request:

- One set of sealed record construction drawings.
- Written certification that the work was constructed in substantial conformance with the sealed construction drawings (see Certification of Construction Completion in Appendix B, Forms).
- Written certification that the work was performed in conformance with the applicable permits and approvals.

The owner's engineer or public agency may be requested to provide copies of the inspection reports, laboratory reports, delivery tickets, and photographs before, during, and after construction.

If deficiencies are found, the HCFCD inspector will document them and provide a written list to the design engineer. All deficiencies must be completed or repaired prior to HCFCD's issuance of the letter acknowledging the work was constructed according to the construction drawings and the one year warranty period will begin.

2.8.8 Stage 5, Acceptance for HCFCD Maintenance New or Modified HCFCD Facilities

Acceptance for HCFCD Maintenance 2.8.8.1

The process to complete acceptance of work for HCFCD maintenance is as follows:

Step	Who Does It	Action
1	Owner's Engineer or Public Agency	Conducts inspection and submits the: – Certification of Construction Completion (see Appendix B, Forms). – Executed Interlocal and/or Turf Establishment Agreements, if applicable.
2	HCFCD (DCID)	Conducts inspection with the design engineer or public agency and issues letter acknowledging work completed according to construction drawings. (Starts one-year warranty period.)
3	Owner or Public Agency	Performs responsibilities specified in Section 2.8.8.2 during the one-year warranty period.
4	Owner's Engineer or Public Agency	At the end of the one-year warranty period, submits a completed "Application for Acceptance of Maintenance of a Drainage/Detention Facility by HCFCD" (see Appendix B, Forms). Dedicate/convey facility and access right-of-way to HCFCD.
5	HCFCD (DCID, PAS, and PRM)	Conducts inspection with the design engineer or public agency. Confirms HCFCD right-of-way conveyed and receives metes and bounds, deed, and exhibit.
6	Owner or Public Agency	Corrects any deficiencies, if necessary, and engineer certifies all conditions satisfied.
7	HCFCD (DCID)	Conducts final inspection with the owner's engineer or public agency to confirm deficiencies corrected and work acceptable.
8	HCFCD (DCID)	Sends recommendation to Commissioners Court to approve a new facility for HCFCD maintenance.

Note: WMD: Watershed Management Department
DCID: Development and Construction Inspection Department
PRM: Property Management Department
PAS: Property Acquisition Services Department

Continued on next page

2.8.8 Stage 5, Acceptance for HCFCD Maintenance New or Modified HCFCD Facilities, Continued

One Year Warranty Responsibilities 2.8.8.2

The owner's or public agency's responsibilities for the work or facility, unless otherwise noted, during the one-year warranty period are as follows:

Maintenance and repairs:

- The owner or public agency is responsible for maintenance of the work or facility and correcting or repairing deficiencies.
- The contractor is required to have a bond in effect until final acceptance.
- HCFCD will use the bond to make repairs if the owner does not make them.

Turf establishment:

- Owner or public agency establishes the turf and satisfies minimum turf requirements to receive final acceptance (see Section 10.3, Turf Establishment).

- OR -

- Owner or public agency executes agreement and pays the turf establishment fee to HCFCD (see Section 10.3, Turf Establishment).
  - HCFCD establishes the turf and vegetation during the one-year warranty period.
  - HCFCD waives any deficiencies related to turf establishment noted during final inspection.
  - An executed turf establishment agreement with HCFCD does not relieve the owner or public agency from deficiencies that occur to the site while in the turf establishment phase.

Longer warranty period:

The warranty period can be longer than one year if the owner or public agency has not corrected all deficiencies or satisfied all conditions of final acceptance.

2.9 Non-Flood Control Features

Introduction 2.9.1

This section covers the specific review and coordination process for features placed and maintained by others in, on, over, or under a HCFCD maintained facility. Examples include access roads, parking lots, waterlines, sanitary sewer lines, utilities, pipelines, and environmental, aesthetic, and recreation features.

The criteria for allowing non-flood control features are in Section 2.2, Acceptance Criteria.

Responsible Departments 2.9.2

Reports and construction drawings are submitted through the Harris County ePermits System for logging and tracking purposes.

HCFCD Watershed Management Department (WMD) reviews projects to verify compliance with policies and criteria in this manual and signs construction drawings. WMD staff coordinates with other HCFCD divisions and departments, such as the several Engineering Division Departments (ED+), Environmental Regulatory Compliance Department (RCD), Stormwater Quality Department (SQD), Property Management Department (PRM), Infrastructure Division (INF), Development Coordination and Inspection Department (DCID), and Property Acquisition Services Department (PAS).

See Section 2.4, Review and Coordination Process Overview for an overview of the roles and responsibilities of these divisions and departments.

Water Quality Features 2.9.3

For water quality features in a HCFCD maintained facility, see Section 16, Water Quality Features and coordinate the design with the HCFCD Stormwater Quality Department.

Federal Channels and Detention Basins 2.9.4

Any work in or alteration of a channel or detention basin constructed as part of an U.S. Army Corps of Engineers project must receive permission from the Corps of Engineers, Galveston District. See Section 2.14, Federal Projects for additional information and requirements.

2.9.5 Stage 1, Initiation
Non-Flood Control Features

Preliminary Evaluation 2.9.5.1

Prepare a written description of the proposed feature and submit to the HCFCD Watershed Management Department.

The information required for HCFCD's initial evaluation of the proposed feature is:

- The type, location, and layout of the proposed feature.
- Existing or proposed flood control facility layout where the feature would be located.
- Existing or proposed right-of-way for the HCFCD facility.
- Adjacent land use and roads.
- Property ownership information.
- Any known factors that could affect the feature and flood control facility such as jurisdictional wetlands, existing drainage problems, existing facility conditions, or community support or opposition.

HCFCD Response 2.9.5.2

This table lists some of the possible HCFCD responses to the written description:

- Request more detailed information or a meeting to better understand the proposed project.
- Letter indicating the HCFCD review process is complete.
- Letter with specific HCFCD requirements unique to the proposed project.
- Referral to and response from the HCFCD Property Management Department.
- Request submittal of a drainage or design report or construction drawings.

2.9.6 Stage 2, Drainage or Design Report Non-Flood Control Features

Overview 2.9.6.1

Drainage or design reports are required for proposed features that can potentially increase flood risks or flood hazards or significantly alter a HCFCD facility.

Close coordination with the appropriate HCFCD department is encouraged.

Involvement of other government entities and/or community organizations is recommended and required for some features.

Common Topics 2.9.6.2

Some common topics a drainage or design report can address are the:

- Acknowledgement of the criteria listed in Section 2.2, Acceptance Criteria.
- Feature layout within the HCFCD facility.
- Effect of feature on the HCFCD facility function and integrity.
- Drainage/mitigation plan.
- HCFCD right-of-way – existing and proposed.
- Feature right-of-way – existing and proposed.
- Maintenance plan for the feature.
- Environmental and cultural resources issues, studies, and permits.
- Turf or vegetation establishment plan.

Report Requirements 2.9.6.3

Minimum report requirements and electronic submittal guidelines are provided in Section 19, Report Requirements.

HCFCD Response 2.9.6.4

HCFCD will work closely with the applicant during development of the drainage and design report providing comments and feedback. One of the document responses listed in Section 2.3.5, Document Responses, will be issued for the final report.

2.9.7 Stage 3, Construction Drawings Non-Flood Control Features

Overview
2.9.7.1

Following completion of the drainage or design report, the next stage involves design and preparation of construction drawings.

Scale Drawings
2.9.7.2

Include scale drawings of structures and associated details with typical sections, dimensions, notes, and references to construction specifications, as appropriate.

Design Details
2.9.7.3

Use standard details only where applicable. HCFCD Standard Details are in Appendix D, Standards, Details, and Guidelines.

When the design engineer determines a structural analysis is needed for non-standard hydraulic structures, submit the analysis with the construction drawings and design details.

Standard Notes
2.9.7.4

Standard notes for construction drawings are required when work is proposed in existing or proposed HCFCD maintained facilities. HCFCD Standard Notes for Construction Drawings are in Appendix D, Standards, Details, and Guidelines.

Checklists
2.9.7.5

To facilitate the preparation of the construction drawings by the design engineer and review of the drawings by HCFCD, checklists are provided in Appendix C, Checklists. Checklists are provided for the following types of non-flood control projects:

- Projects with Storm Sewer Outfalls
- Bridges and Culverts
- Wastewater Treatment Plants
- Pipeline/Utility Crossings
- Recreation, Environmental, and Aesthetic Features

If a checklist does not exist for a type of project not listed above that will be submitted to HCFCD, please contact the HCFCD Watershed Management Department.

Continued on next page

2.9.7 Stage 3, Construction Drawings Non-Flood Control Features, Continued

U.S. Army Corps of Engineers Permit 2.9.7.6

On the Express Review Sheet, indicate the U.S. Army Corps of Engineers Section 404 permit or Section 10 permit compliance for work in existing or proposed HCFCD rights-of-way by:

- Indicating an individual permit is needed and providing a copy prior to construction,
- Listing the nationwide permit number(s) that apply,
- Indicating no permit is needed and explain why, or
- Explaining another means of compliance.

Note: If any special permit conditions are reflected in the construction drawings, clearly highlight such conditions on the drawings.

Continued on next page

2.9.7 Stage 3, Construction Drawings Non-Flood Control Features, Continued

Review Procedure 2.9.7.7

The following is the typical review procedure for non-flood control feature construction drawings. This procedure can change if an agreement specifies a different procedure or other government entities are involved. Submit all documents via the Harris County ePermits System.

Step	Who Does It	Action
1	Design Engineer	Submits in pdf format in a single file: − One digital set of prints. − Completed checklist. − Geotechnical Report, if necessary. − Environmental and cultural resources permit compliance status on Express Review Sheet − Applicable correspondence − Drainage or design report or references report if already submitted and approved.
2	HCFCD (WMD, INF, PRM, DCID, SQD, RCD)	Reviews construction drawings and returns mark-ups.
3	Design Engineer	Revises construction drawings, if necessary.
4	Design Engineer	Submits final construction drawings. Submits one copy of the fully-executed agreement with the public agency or feature sponsor, if applicable.
5	HCFCD (WMD)	Confirms final construction drawings are in compliance and agreement fully-executed. Drawings are signed and returned to the applicant.

Note: For work in or alteration of a U.S. Army Corps of Engineers' channel or detention basin, see Section 2.14, Federal Projects.

Changes to Drawings 2.9.7.8

After the Watershed Management Department signs construction drawings, substantial changes to the feature may occur during review by other agencies or during construction. These changes must be documented on the drawings and resubmitted for another signature as soon as practical. HCFCD cannot monitor or acknowledge the feature in the HCFCD facility if the changes are not accurately documented on the construction drawings.

2.9.8 Stage 4, Construction Non-Flood Control Features

Overview 2.9.8.1

The emphasis of HCFCD monitoring is the integrity and restoration of the HCFCD facility, not the non-flood control feature. The design engineer, owner's engineer, and/or agency engineer have responsibilities during construction as outlined in this chapter.

The construction stage is broken down into three sub-stages:

- Pre-construction.
- During construction.
- Post construction.

Pre-Construction 2.9.8.2

1. Using Harris County ePermits online system, the applicant applies for approval (Right-of-Way Notification) from the HCFCD WMD to enter HCFCD right-of-way, which requires submittal of:
   - The construction drawings approved by HCFCD.
   - A properly executed two-year bond payable to HCFCD issued in the name of the contractor, unless there is an executed agreement with Harris County Commissioners Court. (Bond forms are available in the Harris County Permit Office and online.)
   - Applicable processing fee.
2. Forty-eight hours prior to entering an existing HCFCD facility or beginning work on a proposed HCFCD facility, the design engineer or contractor must submit a completed copy of the 48 Hour Pre-construction Notification Form provided in Appendix B, Forms, to the HCFCD Development Coordination and Inspection Department with the following attachments:
   - One copy of the construction drawings signed by HCFCD. *
   - One copy of the approval (Right-of-way Notification) to enter the HCFCD right-of-way.*
   - One copy of the Corps of Engineers Section 404 or Section 10 individual permit or other specific other permits (e.g. TPDES and local stormwater permits, State water quality certification), if requested by HCFCD.
   - Proof of right-of-way for the feature, if applicable.*

   * A copy of these items must be on site during construction.

Continued on next page

2.9.8 Stage 4, Construction
Non-Flood Control Features, Continued

During Construction 2.9.8.3

The HCFCD Development Coordination and Inspection Department will monitor the construction and answer questions. If problems develop, the owner's engineer is encouraged to contact HCFCD.

HCFCD requires the owner's engineer to certify the feature was constructed and the HCFCD facility was restored according to the signed construction drawings. Therefore, the owner's engineer or someone under his supervision should perform inspections during construction, particularly at key points. The HCFCD does not perform the construction inspection services.

Post Construction 2.9.8.4

The owner's engineer or public agency must submit a written request for a final inspection to the HCFCD Development Coordination and Inspection Department. The following must be included with the request:

- One set of sealed record construction drawings.
- Written certification that the feature was constructed in substantial conformance with the sealed construction drawings (see Certification of Construction Completion in Appendix B, Forms).
- Written certification that the work was performed in conformance with the applicable permits and approvals.

The owner's engineer or public agency may be requested to provide copies of the inspection reports, laboratory reports, and photographs before, during, and after construction.

If deficiencies are found, the HCFCD inspector will document them and provide a written list to the owner's engineer. All deficiencies must be completed or repaired prior to acknowledgment of construction completion.

If deficiencies are satisfactorily corrected or no deficiencies are found, the HCFCD Development Coordination and Inspection Department will issue a written acknowledgment of construction completion to the owner's engineer or public agency.

2.9.9 Stage 5, Acknowledgment Non-Flood Control Features

Overview 2.9.9.1

Features not maintained by HCFCD are allowed in HCFCD maintained facilities contingent upon completion and satisfaction of the criteria and procedures presented in this manual (see Section 2.2, Acceptance Criteria).

In some cases, a project could include a new or modified HCFCD maintained facility and incorporate a non-flood control feature that HCFCD would not maintain.

Example: A detention basin constructed for a new roadway has a jogging trail on the maintenance berm. The detention basin would be accepted for HCFCD maintenance. The jogging trail would be allowed in the HCFCD facility, but maintained by the sponsor.

Acknowledging Features Allowed in a HCFCD Facility 2.9.9.2

The process for obtaining acknowledgment of a non-flood control feature in a HCFCD maintained facility is shown in the table below.

If the sponsor fails to complete the process to obtain acknowledgement after construction is initiated, the feature sponsor must remove the feature and restore the HCFCD facility to the condition prior to construction.

Step	Who Does It	Action
1	Owner's Engineer, Public Agency, or Sponsor	Submits a letter requesting inspection including a Certification of Construction Completion (see Appendix B, Forms).
2	HCFCD (DCID)	Conducts inspection with the owner's engineer, public agency, or sponsor.
3	HCFCD (DCID)	Issues final acknowledgment letter to the owner's engineer, public agency, or sponsor after all deficiencies are resolved.

2.10 Concurrent Activities

Concurrent Activities 2.10.1

Some projects will require some activities to take place while developing the drainage or design report, preparing construction drawings, and/or building the project.

Right-of-Way:

When a HCFCD right-of-way dedication or conveyance is needed, or the non-flood control feature needs right-of-way, begin the process early.

Platting:

When the development project is to be platted, begin the preparation and coordination with HCFCD.

Interlocal, Specialized, or Turf Establishment Agreements:

When an interlocal, specialized, or turf establishment agreement is needed for the project or non-flood control feature, begin the preparation and coordination with HCFCD.

Acceptance for HCFCD Maintenance:

For projects that modify or create a new HCFCD facility, initiate all applicable activities as early as necessary to complete the "Application for Acceptance of Maintenance of a Drainage/Detention Facility by HCFCD".

Non-Flood Control Features Allowed in a HCFCD facility:

For non-flood control features in a HCFCD maintained facility, initiate all applicable activities as early as necessary to obtain an acknowledgment of construction completion.

2.11 Right-of-Way

HCFCD Right-of-Way Conveyance or Dedication 2.11.1

For projects requiring new or additional right-of-way, initiate dedication to the public or conveyance to HCFCD as early in the process as possible. See Section 1.3.8, Policy VIII: Right-of-Way Dedication/Conveyance for the amount of right-of-way required.

HCFCD will not accept new facilities for maintenance until the right-of-way dedication or conveyance is completed. The dedication and conveyance process is presented in this manual in Section 15, Right-of-Way.

For work within or adjacent to an existing HCFCD facility, dedicate or convey the right-of-way prior to plan signature unless another arrangement is made with the HCFCD.

Right-of-Way for Non-Flood Control Features 2.11.2

If the proposed non-flood control feature requires new or additional right-of-way, the sponsor should begin to acquire the right-of-way as early in the process as possible.

HCFCD will not allow construction of the non-flood control feature in the HCFCD facility until the right-of-way dedication or conveyance for the feature is completed.

Property Ownership Determination 2.11.3

The sponsor is required to provide a property ownership map and deeds showing existing property ownerships and easements relative to the proposed feature location.

Abstracting right-of-way is the sponsor's responsibility.

HCFCD Fee Strip 2.11.4

If HCFCD has fee ownership at the location of the proposed non-flood control feature, sponsors must obtain an easement from HCFCD for the proposed feature.

The process for obtaining an easement from HCFCD for a non-flood control feature is presented in this manual in Section 15.4, Easements for Pipelines, Utilities, and Roadways.

HCFCD or Public Easement 2.11.5

If HCFCD or public has an easement at the location of the proposed non-flood control feature, the sponsor is responsible for obtaining an easement or written legal permission from the fee owner for the proposed feature.

2.12 Plats

Overview
2.12.1

HCFCD only reviews plats to confirm that the existing HCFCD right-of-way is shown accurately and to alert the property owner where additional HCFCD right-of-way is required for HCFCD maintained facilities.

Plats Reviewed
2.12.2

HCFCD reviews plats within unincorporated Harris County, City of Houston, and many other municipalities that are adjacent to existing or proposed HCFCD maintained facilities.

Plat Reviews
2.12.3

The HCFCD does not review preliminary plats for adequacy or information other than stated above.

A list of HCFCD related items which must be included on final plats is in the Plat Checklist provided in Appendix C, Checklists.

Plat Release Letters
2.12.4

Release of the final plat for signatures and recording requires the following:

- Information on plat must be complete and correct.
- All construction drawings associated with the plat must be signed and prints provided for HCFCD files, where applicable.

The final plat review process for City of Houston plats is as follows:

Step	Who Does It	Action
1	Design Engineer	Submits two prints of the final plat, City of Houston CP101 form, mark-up from previous submission, and one print of the signed construction drawings, if applicable.
2	HCFCD (WMD)	Reviews the final plat.
3	HCFCD (WMD)	If plat requires corrections, the design engineer is informed of the deficiencies.
4	Design Engineer	Changes made, if necessary, and plat is resubmitted to HCFCD.
5	HCFCD (WMD)	If the plat is satisfactory, a release letter is sent directly to the City of Houston Planning Department. Delivery of the release letter by the design engineer is not permissible. If requested, a copy of the release letter can be provided.

2.13 Agreements

Overview
2.13.1

An agreement between HCFCD and another public agency or qualified non-flood control feature sponsor is necessary for any activity in a HCFCD right-of-way to allow them to:

- Build, operate, and maintain non-flood control features such as recreation, environmental, aesthetic, or stormwater quality features.
- Jointly fund a HCFCD flood control project addressing design, construction and maintenance responsibilities.
- Participate in the HCFCD Turf Establishment Program.
- Utilize stormwater mitigation capacity in a HCFCD maintained facility.

Coordination
2.13.2

Coordinate preparation of agreements with the HCFCD Property Management Department and the appropriate HCFCD department. The Harris County Attorney assigned to HCFCD must review and approve all agreements.

Since agreements can take time to complete, start them as early as possible, such as during the Drainage or Design Report, Stage 2.

The agreement must be fully-executed prior to beginning construction.

Guidelines
2.13.3

General guidelines are:

- HCFCD can enter into interlocal agreements only with other governmental entities such as cities, TxDOT, and utility districts. HCFCD can enter into specialized agreements with non-governmental organizations for features such as environmental preservation or trails. HCFCD can enter into landscape maintenance agreements with homeowner associations or individuals.
- One public entity cannot give something of value to another public entity. There must be some form of equitable compensation such as money, services, or overall benefit to the taxpayers.
- Clearly state the reason(s) for the agreement in the recital (Whereas) statements.
- Clearly state responsibilities for each party.
- For non-flood control features, include all applicable conditions listed in Section 2.2, Acceptance Criteria.
- If the agreement creates an obligation on the part of HCFCD, the agreement must provide for funding.
- HCFCD cannot indemnify another party and include provisions for termination.

2.14 Federal Projects

Overview
2.14.1

Alterations to channels, detention basins, or structures constructed as part of a U.S. Army Corps of Engineers' project or within the federal project right-of-way require permission from the Corps of Engineers, Galveston District. The Corps of Engineers makes sure the effectiveness and integrity of federal flood control projects are not diminished by physical or structural changes.

Alterations
2.14.2

Alterations are defined in 33 USC 408 (Section 408) and associated U.S. Army Corps of Engineers' policies and guidance. Basically, an alteration is any action that may affect the usefulness, or the structural or the ecological integrity of a USACE project within the HCFCD right-of-way. Access for routine maintenance and repairs as well as emergency access during floods is a factor, as well. Examples include physical changes to a channel, detention basin, or structure including access and maintenance berms. Some common alterations are new or modified outfall pipes, bridges, and utility crossings; trails; tree plantings; and channel or detention basin modifications.

Continued on next page

2.14 Federal Projects, Continued

Corps of Engineers' Projects 2.14.3

The Corps of Engineers' project locations currently requiring Corps of Engineers review and permission to alter are listed in the table below and shown on Exhibit 2-2, Federal Project Locations Requiring U.S. Army Corps of Engineers Permission to Alter. Also listed and shown are the active federal project construction locations that will be subject to future Corps of Engineers review and permission to alter.

Channel	Reach
Brays Bayou	Calhoun to Old Westheimer Road *Future: Mouth to S.H. 6 channel*
White Oak Bayou	Mouth to Cole Creek *Future: Cole Creek to S.H. 6 channel*
Vince Bayou	Mouth to Hernandez Street
Little Vince Bayou	Mouth to Wichita Street
Buffalo Bayou	Sam Houston Tollway to S.H. 6
Clear Creek	Second Outlet Channel at S.H. 146 *Future: Clear Creek-Dixie Farm Road to S.H. 288, Mud Gully-0.8 miles, Turkey Creek-Mouth to Dixie Farm Road*
Sims Bayou	Mouth to 1,500' Upstream of Croquet Ln
Greens Bayou	*Future: Stuebner-Airline to Cutten Road*
Hunting Bayou	*Future: 1,400' downstream of N. Wayside Drive to US 59*

Detention Basin	Location
Brays Bayou	*Future: Eldridge (D500-04-00), Old Westheimer (D500-01-00), Arthur Storey Park (D500-06-00), Willow Waterhole (D512-01-00)*
Greens Bayou	*Future: Antoine Road (P500-05-00)*
Hunting Bayou	*Future: Homestead Road (H500-01-00)*
White Oak Bayou	*Future: Fairbanks North (E500-01-00), Fairbanks South (E500-02-00), Hollister (E500-03-00), West Belt (E500-10-00), Ranchstone (E500-11-00), Fall Brook (E500-12-00)*
Addicks Reservoir	West Harris County; North of I-10
Barker Reservoir	West Harris County; South of I-10

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2.14 Federal Projects, Continued

Buyout Properties 2.14.4

Land use requirements exist for land purchased by HCFCD as part of a Corps of Engineers or Federal Emergency Management Agency (FEMA) buyout program.

FEMA buyout properties are located throughout Harris County. Corps of Engineers buyout properties are located in few locations along Cypress Creek. Coordinate proposed modifications to these properties with HCFCD as early as possible.

Projects Reviewed 2.14.5

Typical projects the HCFCD and Corps of Engineers review are:

- Channel enlargements or modifications
- Detention basin modifications
- Storm sewer outfall pipes, both new and modifications
- Bridge and utility crossings, both new and modifications
- Addition of non-flood control features such as trees and trails

Basically, any project that modifies or is within a channel or detention basin constructed as part of a Corps of Engineers project needs to be reviewed, as well as, any modification of land acquired as part of a Corps of Engineers or FEMA buyout project.

Review Procedure in Corps of Engineers' Projects 2.14.6

The following table shows the review procedure with the HCFCD Watershed Management Department and Corps of Engineers. The Corps of Engineers authority and process is referred to as "Section 408".

Table continued on next page

2.14 Federal Projects, Continued

Review Procedure in Corps of Engineers' Projects - Continued 2.14.6

Step	Who Does It	Action
1	Design Engineer	Proceeds with Stage 1, Initiation and Stage 2, Drainage or Design Report with the WMD.
2	HCFCD (WMD)	Provides specific design criteria for the subject reach or location, as well as expectations of Corps requirements and review time. Early coordination with Corps may be advised.
3	Design Engineer	Submits construction drawings and completed checklist.
4	HCFCD (WMD)	Reviews construction drawings and returns mark-ups to design engineer.
5	Design Engineer	Revises construction drawings, if necessary. Contacts HCFCD if there are any questions or issues. Submits final construction drawings.
6	HCFCD (WMD)	Confirms final construction drawings are in compliance. Notifies design engineer.
7	Design Engineer	Submits a single digital pdf file of construction drawings and any supporting information to HCFCD.
8	HCFCD (WMD)	Forwards submittal to the Corps of Engineers, Galveston District for their review, comments, and concurrence.
9	Corps of Engineers	Develops scope of work and fee estimate to complete the review and provides information to HCFCD.
10	HCFCD	Notifies design engineer of the estimated review fee.
11	Design Engineer	Pays the estimated review fee to the HCFCD.
12	HCFCD	Notifies the Corps of Engineers to begin the review.
13	Corps of Engineers	Sends a reply to HCFCD with comments or permission to alter the federal project.
14	HCFCD (WMD)	Notifies design engineer of Corps of Engineers comments or concurrence with the alteration. Direct coordination with the Corps may be advised.
15	Design Engineer	Submits digital pdf file of final construction drawings with changes summarized or shown on separate markup to HCFCD.
16	HCFCD (WMD)	Signs drawings and returns originals to applicant.

2.15 Regional Flood Control Projects

Introduction 2.15.1

The HCFCD supports regional drainage as stated in Section 1.3.7, Policy VII: HCFCD Support of Regional Drainage. Regional projects are generally more efficient and reliable than individual projects.

Adopted Regional Projects 2.15.2

The regional project watersheds, Harris County Commissioners Court approval dates, and adopted impact fees are:

Watershed	Approval Date	Fee
White Oak Bayou	November 6, 1984	$3,000/acre
Brays Bayou	October 15, 1985	$7,000/acre
Sims Bayou	October 15, 1985	$3,000/acre
Langham Creek	March 25, 1986	$3,100/acre
Greens Bayou	June 24, 1986	$3,300/acre
Cypress Creek (includes Little Cypress Creek)	November 18, 1986	$4,000/acre

Previous Commissioners Court Actions 2.15.3

This manual replaces the regional plan implementation clarifications adopted by Commissioners Court on April 3, 1990; November 13, 1990; February 5, 1991; and August 8, 2000.

Application 2.15.4

All new developments in the service area of a regional project are subject to the drainage and impact fee requirements specified by the regional project regardless of whether the project proposes work within HCFCD ROW. However, the requirements specified in the regional project do not necessarily supersede drainage and detention requirements from other agencies involved in reviewing the project, such as Harris County Engineering Department, the City of Houston, TXDOT, etc. Confirm HCFCD regional project requirements during initial coordination with the HCFCD WMD. See Section 2.8.4 Stage 1, Initiation.

Continued on next page

2.15 Regional Flood Control Projects, Continued

New Development 2.15.5

New development is defined as any increase in impervious cover or change in land condition or drainage system that affects the amount or rate of runoff from a property and is used to calculate detention volume or impact fees. See Appendix E, Terminology, for a complete definition and Section 3.5.1, Relationship to Development for a generalized relationship between land use, percent impervious, and percent development.

Example: Single family subdivisions with lots less than ¼ acre and schools with open areas built on undeveloped property are considered new development.

Detention Volume and Impact Fee Calculation 2.15.6

The acreage used to calculate detention volume or impact fees is the new development acreage minus:

- Existing development area.
- Existing or proposed HCFCD right-of-way.
- Proposed right-of-way along existing major thoroughfares intended for road widening.
- Major pipeline or energy corridors not useful for development.

Impact Fee Collection Criteria 2.15.7

Impact fees can only be collected in watersheds or sub-watersheds:

- With a regional or master plan adopted by Harris County Commissioners Court,
- Where system capacity exists for the new development as determined by the HCFCD and accepted by Harris County Commissioners Court, and
- Where the new development can convey its stormwater runoff up to and including the 1% exceedance probability event to the regional project without increasing flood risks for others.

Continued on next page

2.15 Regional Flood Control Projects, Continued

Impact Fee Payment 2.15.8

Rules regarding impact fee payments are as follows:

- Pay impact fees in full by cashier's check made payable to the HCFCD prior to plan approval.
- Apply previous partial payments, if any, to the amount due.
- Permanent improvements to the regional project constructed or contributed by a developer in accordance with a formal agreement with the HCFCD can be recognized as payment toward the amount due.
- No land shall pay the full fee more than once.
- If another government agency requires site-specific detention and the detention facility constructed equals or exceeds HCFCD criteria in this manual, then no impact fee is required. (See Section 2.3.2, Within City of Houston.)
- See exceptions in Section 2.15.9, Upper Langham Creek; Section 2.15.10, Little Cypress Creek – Interim Guidelines; and Section 2.15.11, Addicks, Barker, Upper Cypress Creek – Supplemental Guidelines.

Continued on next page

2.15 Regional Flood Control Projects, Continued

Upper Langham Creek 2.15.9

For the Langham Creek watershed upstream of Barker-Cypress Road, the "Upper Langham Creek Capital Improvement and Impact Fee Utilization Plan" was adopted by Harris County Commissioners Court on January 27, 2009. This plan has the impact fee of $3,100/acre that was adopted in March 1986. In addition to complying with the criteria in Regional Flood Control Projects, Section 2.15.1 to 2.15.8, new developments within the Upper Langham Creek service area are required to:

- Pay the impact fee to cover the costs of right-of-way acquisition, pipeline adjustments, control structures, and environmental mitigation, and
- Construct their share of the detention volume within the Upper Langham Creek Plan stream corridor and/or detention basins to mitigate the hydrologic effects of land development and flood plain reduction.

To establish clear roles and responsibilities, Harris County Commissioners Court adopted the December 2011 "Guidelines for New Development in the Upper Langham Creek Service Area" on January 10, 2012. The guidelines facilitate the orderly development of flood damage reduction features, environmental mitigation, multi-use opportunities, and facilities with cost effective maintenance requirements. Contact the HCFCD Watershed Management Department for a copy of the guidelines or download from the HCFCD website.

This section supersedes the two Commissioners Court actions referenced above.

Little Cypress Creek – Interim Guidelines 2.15.10

For the Little Cypress Creek watershed, the "Interim Guidelines for New Development in the Little Cypress Creek Service Area" was adopted by Harris County Commissioners Court on February 11, 2014 to establish clear roles and responsibilities. This plan has the impact fee of $4,000/acre that was adopted in November 18, 1986. In addition to complying with the criteria in Regional Flood Control Projects, Section 2.15.1 to 2.15.8, new developments within the Little Cypress Creek service area are required to:

- Pay the impact fee to cover the costs of right-of-way acquisition, and
- Construct their share of the Total Required Excavation (TRE) of 0.89 acre-ft/acre within the Little Cypress Creek Watershed and the stream corridors and/or detention basins to mitigate the hydrologic effects of land development and flood plain reduction.

The interim guidelines facilitate the development of flood damage reduction features until the final regional drainage plan and guidelines are completed. Contact the HCFCD Watershed Management Department for a copy of the interim guidelines or download from the HCFCD website.

This section supersedes the Commissioners Court action referenced above.

Continued on next page

2.15 Regional Flood Control Projects, Continued

Addicks, Barker, Upper Cypress Creek – Supplemental Guidelines 2.15.11

For the Addicks Reservoir and Barker Reservoir watersheds and the upper Cypress Creek watershed upstream of US 290, the "Supplemental Guidelines and Criteria for Developing in the Addicks Reservoir Watershed, Barker Reservoir Watershed and the Cypress Creek Watershed Upstream of US 290" was adopted by Harris County Commissioners Court on March 29, 2016 to establish clear roles and responsibilities. The supplemental guidelines and criteria are necessary due to unique hydrologic and hydraulic conditions that exist in the western region of Harris County, but does not replace or alter applicable regional drainage and impact fee program requirements in this Section 2.15, Regional Flood Control Projects. In general, new developments and infrastructure projects within the specified watersheds are required to:

- Perform impact analyses demonstrating no adverse impacts associated with development of properties or infrastructure projects that are affected by, or contribute to, the Cypress Creek overflow.
- Dedicate and construct public overflow conveyance facilities.
- Install stormwater runoff volume control (retention volume) for development of properties located within the Addicks Reservoir and Barker Reservoir watersheds, as well as a portion of the upper Cypress Creek watershed upstream of and adjacent to locations where the overflow occurs.
- Use revised Site Runoff Curve equations for detention calculations in the upper Cypress Creek watershed.
- Use revised minimum detention requirements in the upper Cypress Creek watershed.

The supplemental guidelines and criteria include requirements, analysis, exceptions, watershed specific criteria, variations to current criteria, and other complexities. Contact the HCFCD Watershed Management Department early to coordinate and request a copy of the supplemental guidelines or download from the HCFCD website.

This section supersedes the Commissioners Court action referenced above.

Continued on next page

2.15 Regional Flood Control Projects, Continued

One Acre Limit 2.15.12

Due to practical considerations and questionable effectiveness, new developments less than or equal to one acre can pay the impact fee in accordance with Section 2.15.8, Impact Fee Payment instead of providing site specific detention.

Compliance Summary 2.15.13

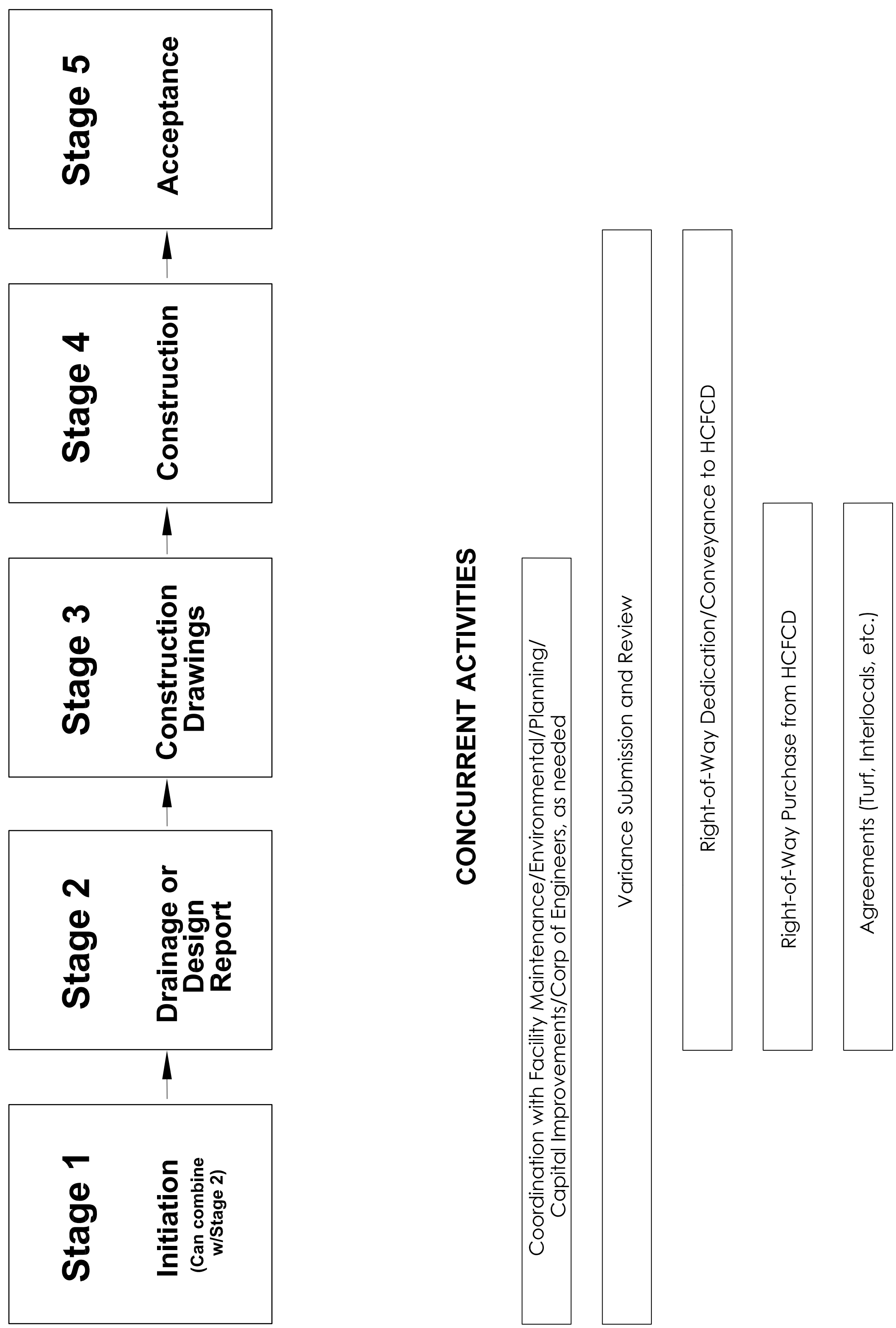
Based on the policies and criteria in this manual, the table below is provided to assist in determining HCFCD requirements for a new development project.

Conditions	Provide Site Specific Detention	Pay Impact Fee	Comments
Regional Watershed Program			
• System Capacity Available and • Can Convey Runoff to Regional Project Without Impact and • New Development – Any Size		X	See Section 2.15.8, Impact Fee Payment
• System Capacity Not Available and • New Development >1 acre	X		
• System Capacity Not Available and • New Development ≤ 1 acre		X	See Section 2.15.8, Impact Fee Payment
No Regional Watershed Program – See Section 6.1.1, When to Use, and Section 6.1.2, Where Not Required.			

Impact Fee Not Required 2.15.14

The impact fee is not required for

- Only one single family residence where no major changes in existing conditions are proposed and it is not part of a larger development project.
- Redevelopment projects that do not increase the amount of impervious cover or the runoff from the site.



HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

REVIEW & COORDINATION PROCESS FOR WORK IN A NEW OR EXISTING HCFCD FACILITY

DATE: 10/23/2018	EXHIBIT 2-1

FEDERAL PROJECT LOCATIONS REQUIRING U.S. ARMY CORPS OF ENGINEERS PERMISSION TO ALTER

GREENS BAYOU
P500-05-00
E500-12-00
E500-11-00
E500-01-00
E500-10-00
E500-02-00
E500-03-00
WHITE OAK BAYOU
529
ADDICKS RESERVOIR
10
BUFFALO BAYOU
BARKER RESERVOIR
D500-01-00
D500-04-00
D500-06-00
BRAYS BAYOU
610
SIMS BAYOU
D512-01-00
H500-01-00
HUNTING BAYOU
DOWNTOWN HOUSTON
8
2100
SHELDON RESERVOIR
HIGHLANDS RESERVOIR
1942
LITTLE VINCE BAYOU
VINCE BAYOU
CLEAR CREEK
MUD GULLY
TURKEY CREEK

LEGEND

- HARRIS COUNTY BOUNDARY
- CHANNEL NETWORK

COMPLETED CORPS PROJECT

- CHANNEL
- DETENTION BASIN

FUTURE CORPS PROJECT

- CHANNEL
- DETENTION BASIN

HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

DATE: 10/23/2018

EXHIBIT 2-2

CriteriaDesign 2010 / 2010 modified to 2016/Location of Federal Corps of Engineers Projects_11x17.mxd

SECTION 3 – HYDROLOGY

3.1 Introduction

Overview 3.1.1

Estimating peak discharges and routing flow hydrographs for existing and future conditions is necessary for the planning, analysis, and design of both new development and redevelopment and associated flood damage reduction facilities. This section presents hydrologic methodologies for use in Harris County.

When Analysis Is Required 3.1.2

A hydrologic analysis is required when:

- A new HCFCD maintained facility is proposed.
- An existing HCFCD maintained facility is modified.
- A private development or public agency project outfalls into a HCFCD maintained facility that was not designed and constructed for the proposed development's flows.
- A non-flood control feature is placed in or across a HCFCD maintained facility that would impact flows, maintenance access, or facility integrity.
- Harris County requests HCFCD review of new developments in unincorporated Harris County.

Computer Models and Programs 3.1.3

Current effective models use the HEC-HMS and HEC-RAS computer programs. Guidance for applying these programs is in the HCFCD Hydrology and Hydraulics Guidance Manual. Use the HCFCD Hydrologic and Hydraulic Modeling and Management Standards when modifying HEC-HMS and HEC-RAS models and associated data sets. Obtain current versions of the standards from the HCFCD website.

If a channel has not been modeled, an approximate or simplified application of the methodologies presented in this section may be sufficient. Coordination with HCFCD as early as possible is recommended.

In some cases, HEC-HMS and HEC-RAS cannot accurately model some projects or hydrologic conditions. Inform HCFCD, in writing, early in the review process of the computer program that will be used, justification for using the program(s), and provide program documentation, if required, to facilitate the review.

3.2 Methodology

Overview
3.2.1

The methodology selected depends primarily on the drainage area of the project. In some cases, the complexity of the design or level of accuracy may influence the method selected.

Discharge Methodologies
3.2.2

Two methods for determining discharges are listed below. Assumptions, limitations, and application guidance are covered in detail in subsequent sections.

Method	For …	Project Drainage Areas
Site Runoff Curves	Small or Moderate	Less than 640 acres
Watershed Modeling	Large	Greater than 640 acres

Simplified Hydrograph Methodology
3.2.3

A simplified method for developing a hydrograph in conjunction with the Site Runoff Curves is presented in Section 3.6, Small Watershed Hydrograph Method.

Roadway Only Analysis
3.2.4

For analyzing mitigation for roadway projects, use the hydrology presented in Section 6.16, Roadway Impacts and Mitigation.

3.3 Site Runoff Curves

Introduction 3.3.1

Site Runoff Curves are a simplified method to determine peak discharges for relatively small areas which involve the design and analysis of stormwater detention facilities or overland sheet flow conditions for new developments.

Site Runoff Curves are based on the updated hydrologic methodology that is consistent with new hydrologic methods being used in the Mapping Assessment and Awareness Program (MAAP*next*) which is updating Harris County floodplains. This will allow for peak discharges to be determined for smaller areas using a consistent and simplified methodology.

See A.1, Site Runoff Curve Examples in Appendix A (See note in Appendix A Cover regarding applicability of Examples).

Applications 3.3.2

Site Runoff Curves are used to determine peak flows for:

- Onsite detention facilities.
- Overland flow situations (extreme event).
- Storm sewer systems or overland swales to handle the overland flow.
- Closed conduits.

Limitations 3.3.3

Use Site Runoff Curves when:

- Only peak flows are needed.
- The drainage area is less than 640 acres.

Do not use flows from the Site Runoff Curves to define or modify effective FEMA regulatory flood plains or floodway.

Site Runoff Curves 3.3.4

The 50%, 10%, 1%, and 0.2% exceedance probability peak discharges are on the Site Runoff Curves in Exhibits 3-1, 3-2, 3-3, and 3-4, respectively. Two variables needed are:

- Size of the drainage area in acres.
- Amount of impervious cover defined as a percentage of the drainage area.

Continued on next page

3.3 Site Runoff Curves, Continued

Equations for Site Runoff Curves 3.3.5

The equation for the Site Runoff Curves is:

$$Q = bA^m$$

where: Q = peak discharge (cfs)

A = drainage area (acres)

m = 1.0 for 1 to 20 acres and
0.786 for more than 20 acres up to 640 acres

b = variable dependent on impervious cover. See table below.

Impervious Cover	50% Prob.		10% Prob.		1% Prob.		0.2% Prob.	
	≤ 20 acres	> 20 acres	≤ 20 acres	> 20 acres	≤ 20 acres	> 20 acres	≤ 20 acres	> 20 acres
0%	0.7	1.4	1.3	2.4	2.4	4.6	3.6	6.8
10%	0.9	1.8	1.6	3.0	2.9	5.5	4.3	8.1
20%	1.2	2.2	1.9	3.6	3.4	6.5	5.0	9.5
30%	1.4	2.7	2.3	4.4	4.1	7.7	5.8	11.0
40%	1.7	3.3	2.8	5.2	4.7	8.9	6.6	12.6
85%	2.3	4.3	3.5	6.6	5.7	10.9	8.0	15.1

Notes:

Interpolate "b" linearly to determine peak discharges for percentages of impervious cover between those listed in the table.

For areas with more than 85% impervious cover, use the 85% impervious curve.

Plots of these curves are shown in Exhibits 3-1, 3-2, 3-3, and 3-4.

3.4 Watershed Modeling Method

Introduction 3.4.1

The Watershed Modeling Method involves use of the HCFCD hydrologic methodology developed to identify regulatory flood plains in Harris County, estimate effects of proposed developments or projects, and identify flood damage reduction and mitigation projects.

Current guidance for watershed modeling in Harris County is in the HCFCD Hydrology and Hydraulics Guidance Manual.

Note: Effective models used for Watershed Modeling have not yet been updated with Atlas 14 rainfall and will continue to be used until updated models are available. Where watershed modeling is performed, the effective 0.2% annual chance event (500-year) must be included in the analysis in addition to the effective 50%, 10%, and 1% events. Because the rainfall included in the 0.2% event is similar to the updated Atlas 14 1% rainfall, using the effective 0.2% event will serve as a substitute for the Atlas 14 1% (100-year) event until the effective models have been updated.

Applications 3.4.2

The Watershed Modeling Method is used when hydrograph analysis is needed to:

- Analyze and design channels and detention basins for new land development or public agency projects:
  - For drainage areas greater than 640 acres.
  - Where correlation with existing HEC-HMS or HEC-RAS is necessary.
  - Where development of runoff hydrographs with consistent timing is necessary.
- Define or modify effective FEMA regulatory flood plains or floodway due to the new development or changes to HCFCD maintained facilities.

Note: Analysis is run along the entire length of the main stem.

Limitations 3.4.3

- Use the Watershed Modeling Method only for areas with an open channel or major enclosed channel.
- Results may not be valid for drainage areas less than 640 acres.
- The Watershed Modeling Method may be used where complexity of a project justifies a detailed analysis for a project drainage area greater than 300 acres and less than 640 acres.

Continued on next page

3.4 Watershed Modeling Method, Continued

Optional Technique 3.4.4

For moderate project drainage areas (50 to 640 acres), the Optional Project Routing Technique in Section 3.7 can be used for calculating detention volumes and sizing outflow structures. This technique is not the same as the Watershed Modeling Method because:

- Consistent hydrograph timing with current models is not considered,
- The HCFCD hydrologic methodology developed for Harris County to calculate TC and R is not used, and
- It is for moderate project drainage areas only.

3.5 Impervious Cover

Relationship to Development 3.5.1

The generalized relationship between percent land development and percent impervious cover is shown below for various land uses:

Land Use Categories	Land Use Descriptions	% Impervious	% Development
Undeveloped	Unimproved, natural, or agricultural	0	0
Residential – Rural Lot	≥ 5 acre ranch or farm	5	0
Residential – Large Lot (Newer)	> ½ acre new residential neighborhoods , storm sewers or roadside ditches with adequate capacity	25	100
Residential – Large Lot (Older)	> ¼ acre, older neighborhoods with limited capacity roadside ditches	25	50
Residential – Small Lot	≤ ¼ acre	40	100
Schools	Schools with non-paved areas	40	50
Developed Green Areas	Parks or golf courses	15	50
Light Industrial/ Commercial	Office parks, nurseries, airports, warehouses, or manufacturing with non-paved areas	65	100
High Density	Commercial, business, industrial, or apartments	85	100
Isolated Transportation*	Highway or major thoroughfare corridors	80	100
Water	Detention basins, lakes, and channels	100	100

Note: Based on updated guidance included in the MAAP*next* floodplain remapping project that will be documented in a future edition of the HCFCD Hydrology and Hydraulics Guidance Manual.

* Not to be used for linear roadway project impact analysis (see Section 6.16, Roadway Impacts and Mitigation)

Continued on next page

3.5 Impervious Cover, Continued

Detention Basins, Lakes, Channels, Roadside Ditches 3.5.2

Consider detention basins, lakes, channels, and roadside ditches to be 100% impervious when conducting hydrologic analysis for estimating runoff or sizing HCFCD facilities. Use the area within the top of bank.

3.6 Small Watershed Hydrograph Method

Introduction 3.6.1

The Small Watershed Hydrograph Method is a method for developing a curvilinear design hydrograph for small to moderate size drainage areas (less than 640 acres) which peaks at a designated flow rate and contains a runoff volume consistent with the design rainfall as updated by Atlas 14.

Applications 3.6.2

A common application of the Small Watershed Hydrograph Method is the design of detention basins for new development or public agency projects. It facilitates the design of the outlet structure and determination of storage volume.

Caution 3.6.3

Do <u>not</u> attempt to compare, combine, or route the hydrograph generated by the Small Watershed Hydrograph Method with hydrographs from the Watershed Modeling Method or effective FEMA models. There is no correlation.

Hydrograph Computation Equations 3.6.4

The Small Watershed Hydrograph Method consists of the following equations:

$$T_P = \frac{V}{1.39 Q_P}$$

$$q_i = \left(\frac{Q_P}{2}\right)\left[1 - \cos\left(\frac{\pi t_i}{T_p}\right)\right] \qquad t_i \le 1.25 T_P$$

$$q_i = 4.34 Q_P e^{\left(-1.3 t_i / T_p\right)} \qquad t_i > 1.25 T_P$$

in which:

Q_P = peak discharge in cubic feet per second from Site Runoff Curves

T_P = time to Q_p in seconds

V = total volume of runoff for the design storm in cubic feet

t_i and q_i = the respective time and discharges which determine the shape of the hydrograph

Note: The argument of cosine ($B*t_i/T_p$) is in radians.

Source: Malcom, H.R., "A Study of Detention in Urban Stormwater Management," Report No. 156, Water Resources Research Institute, University of North Carolina, July 1980.

Continued on next page

3.6 Small Watershed Hydrograph Method, Continued

Total Volume of Runoff, V
3.6.5

Multiply the drainage area by the depth of direct runoff to calculate the total volume of runoff, V.

Direct Runoff, 1% Probability Event
3.6.6

The depths of direct runoff for the 24-hour, 1% probability rainfall events are provided below for each rainfall region and for three impervious conditions. Use linear interpolation for other impervious conditions.

The values are based on loss rates resulting from application of the HCFCD hydrologic methodology to watersheds in Harris County, with rainfall depths updated by Atlas 14.

Watershed: Name and HCFCD Letter Designation	Total Rainfall (inches)	Direct Runoff (inches)		
		0% Impervious	40% Impervious	85% Impervious
Region 1				
Addicks Tributaries (U) Barker Tributaries (T) Cypress Creek (K) Little Cypress Creek (L) Spring Creek (J) Willow Creek (M)	16.3	12.2	13.6	15.1
Region 2				
Brays Bayou (D) Buffalo Bayou (W) Greens Bayou (P) Hunting Bayou (H) Luce Bayou (S) San Jacinto River (G) Sims Bayou (C) White Oak Bayou (E)	16.9	14.9	15.6	16.4
Region 3				
Armand Bayou (B) Carpenters Bayou (N) Cedar Bayou (Q) Clear Creek (A) Galveston Bay (F) Goose Creek (O) Jackson Bayou (R) Vince Bayou (I)	18.0	16.0	16.7	17.5

Continued on next page

3.6 Small Watershed Hydrograph Method, Continued

Direct Runoff, 10% Probability Event 3.6.7

The depths of direct runoff for the 24-hour, 10% probability rainfall events are provided below for each rainfall region and for three impervious conditions. Use linear interpolation for other impervious conditions.

The values are based on loss rates resulting from application of the HCFCD hydrologic methodology to watersheds in Harris County, with rainfall depths updated by Atlas 14.

Watershed: Name and HCFCD Letter Designation	Total Rainfall (inches)	Direct Runoff (inches)		
		0% Impervious	40% Impervious	85% Impervious
Region 1				
Addicks Tributaries (U) Barker Tributaries (T) Cypress Creek (K) Little Cypress Creek (L) Spring Creek (J) Willow Creek (M)	8.2	4.9	6.0	7.2
Region 2				
Brays Bayou (D) Buffalo Bayou (W) Greens Bayou (P) Hunting Bayou (H) Luce Bayou (S) San Jacinto River (G) Sims Bayou (C) White Oak Bayou (E)	8.7	7.0	7.6	8.3
Region 3				
Armand Bayou (B) Carpenters Bayou (N) Cedar Bayou (Q) Clear Creek (A) Galveston Bay (F) Goose Creek (O) Jackson Bayou (R) Vince Bayou (I)	9.3	6.8	7.7	8.8

Continued on next page

3.6 Small Watershed Hydrograph Method, Continued

Direct Runoff, 50% Probability Event 3.6.8

The depths of direct runoff for the 24-hour, 50% probability rainfall events are provided below for each rainfall region and for three impervious conditions. Use linear interpolation for other impervious conditions.

The values are based on loss rates resulting from application of the HCFCD hydrologic methodology to watersheds in Harris County, with rainfall depths updated by Atlas 14..

Watershed: Name and HCFCD Letter Designation	Total Rainfall (inches)	Direct Runoff (inches)		
		0% Impervious	40% Impervious	85% Impervious
Region 1				
Addicks Tributaries (U) Barker Tributaries (T) Cypress Creek (K) Little Cypress Creek (L) Spring Creek (J) Willow Creek (M)	4.8	2.3	3.1	4.0
Region 2				
Brays Bayou (D) Buffalo Bayou (W) Greens Bayou (P) Hunting Bayou (H) Luce Bayou (S) San Jacinto River (G) Sims Bayou (C) White Oak Bayou (E)	5.1	3.6	4.1	4.8
Region 3				
Armand Bayou (B) Carpenters Bayou (N) Cedar Bayou (Q) Clear Creek (A) Galveston Bay (F) Goose Creek (O) Jackson Bayou (R) Vince Bayou (I)	5.3	3.2	4.0	4.9

Continued on next page

3.6 Small Watershed Hydrograph Method, Continued

Direct Runoff, 0.2% Probability Event 3.6.9

The depths of direct runoff for the 24-hour, 0.2% probability rainfall events are provided below for each rainfall region and for three impervious conditions. Use linear interpolation for other impervious conditions.

The values are based on loss rates resulting from application of the HCFCD hydrologic methodology to watersheds in Harris County.

Watershed: Name and HCFCD Letter Designation	Total Rainfall (inches)	Direct Runoff (inches)		
		0% Impervious	40% Impervious	85% Impervious
Region 1				
Addicks Tributaries (U) Barker Tributaries (T) Cypress Creek (K) Little Cypress Creek (L) Spring Creek (J) Willow Creek (M)	24.2	19.8	21.3	22.9
Region 2				
Brays Bayou (D) Buffalo Bayou (W) Greens Bayou (P) Hunting Bayou (H) Luce Bayou (S) San Jacinto River (G) Sims Bayou (C) White Oak Bayou (E)	25.0	22.9	23.6	24.4
Region 3				
Armand Bayou (B) Carpenters Bayou (N) Cedar Bayou (Q) Clear Creek (A) Galveston Bay (F) Goose Creek (O) Jackson Bayou (R) Vince Bayou (I)	27.2	24.1	25.2	26.4

3.7 Optional Project Routing Technique

Introduction 3.7.1

The Optional Project Routing Technique can be used for calculating detention volume and sizing the outflow structure for moderate project drainage areas (from 50 to 640 acres, see Section 6.9.2, Methods) as well as verifying the effects of the proposed development and detention basin downstream on the receiving channel. It also provides a limited degree of correlation with current watershed models.

If a model other than HEC-HMS is used, another model is used in conjunction with HEC-HMS, or a unit hydrograph method other than Clark's Unit Hydrograph is used, contact the HCFCD for verification of the model and technical approach to be used. Ensure model is updated with NOAA Atlas 14 rainfall, or include the effective 0.2% event rainfall in the analysis.

See A.2, Optional Project Routing Technique Example in Appendix A.

Applications 3.7.2

The Optional Project Routing Technique is used for analysis and design of detention basins for new land development or public agency projects:

- For drainage areas between 50 and 640 acres.
- To facilitate analysis and design using common computer programs and techniques.

Limitations 3.7.3

- Do not use this technique
  - To compare hydrograph timing with existing HCFCD HEC-HMS or HEC-RAS watershed models.
  - To define or modify effective FEMA regulatory flood plains or floodways.
- When comparing pre- and post- project peak flows, compare at the detention basin outfall in the outfall channel and at least three nodes downstream on the main stem.

Clark's Unit Hydrograph 3.7.4

If Clark's Unit Hydrograph approach is used in the HEC-HMS model, do not use the HCFCD hydrologic methodology to calculate TC and R. Instead,

- Estimate TC using a velocity based method, and
- Adjust R such that the peak discharge matches the Site Runoff Curve peak value and the runoff volume approximates the value calculated using direct runoff depths in Section 3.6.6, Section 3.6.7, Section 3.6.8, and Section 3.6.9.

3.8 Watershed Diversions

Introduction
3.8.1

In some cases, development and infrastructure projects divert stormwater from one watershed to another because it is not practical or feasible to convey stormwater to two different watersheds. A watershed diversion occurs when open channels and detention basins divert storm water from one main channel watershed to another, such as from the Willow Creek (M100-00-00) watershed to the Spring Creek (J100-00-00) watershed. The HCFCD unit letters designate different main channel watersheds.

Development and infrastructure projects that redirect stormwater from one tributary to another tributary within the same main channel watershed are also considered watershed diversions for the purpose of ensuring no adverse impacts. Examples are redirecting flow from the U101-03-00 watershed to the U101-06-00 watershed or from the Halls Bayou (P118-00-00) watershed to the P138-00-00 watershed.

Note: With flat terrain in most parts of Harris County, drainage boundaries between watersheds are not always clear and are dependent on rainfall severity and drainage improvements. Where drainage area boundaries are not easily identified, coordinate with the HCFCD.

See A.3, Watershed Diversion Example in Appendix A.

Criteria
3.8.2

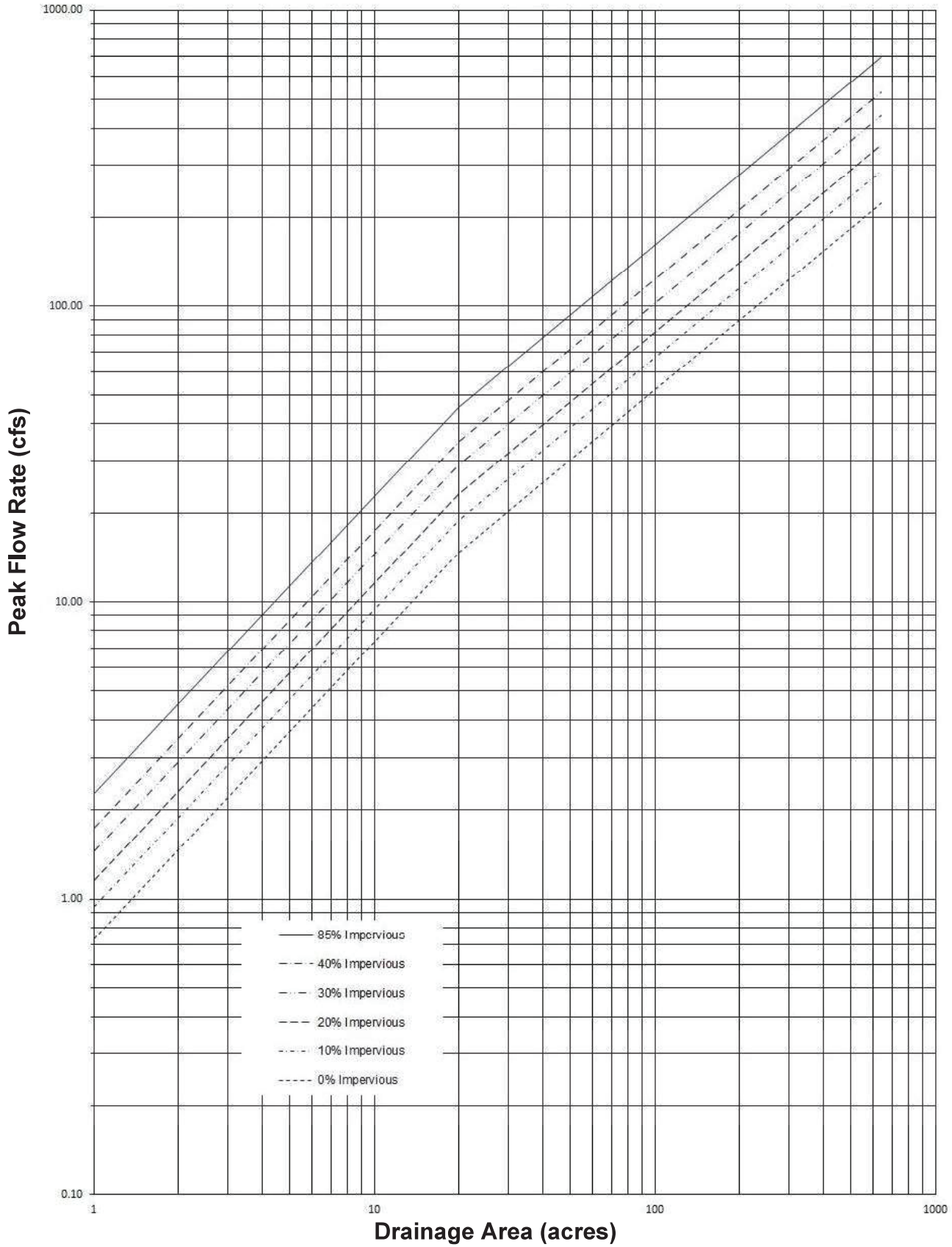
The following criteria applies in addition to the applicable criteria and considerations in the rest of this manual:

- Document the existing and proposed watershed boundaries relative to the proposed project drainage area boundary.
- Retain 100% of the runoff volume from the diverted area in addition to the detention volume calculated for the non-diverted area.
- In addition to the events designated in Section 6.3.4, Outflow Rates, also restrict the outflow to the allowable 50% exceedance probability, 24 hour event into the receiving channel.
- For diverted areas larger than 50 acres, contact HCFCD prior to performing analysis to identify other criteria or conditions that may apply, and to coordinate analytical approach.

Considerations
3.8.3

Consider contacting the Texas Commission on Environmental Quality to find out if there is a surface water rights issue that needs to be addressed as a result of the proposed diversion.

To determine if FEMA related reviews and submittals are necessary, contact the local flood plain administrator.



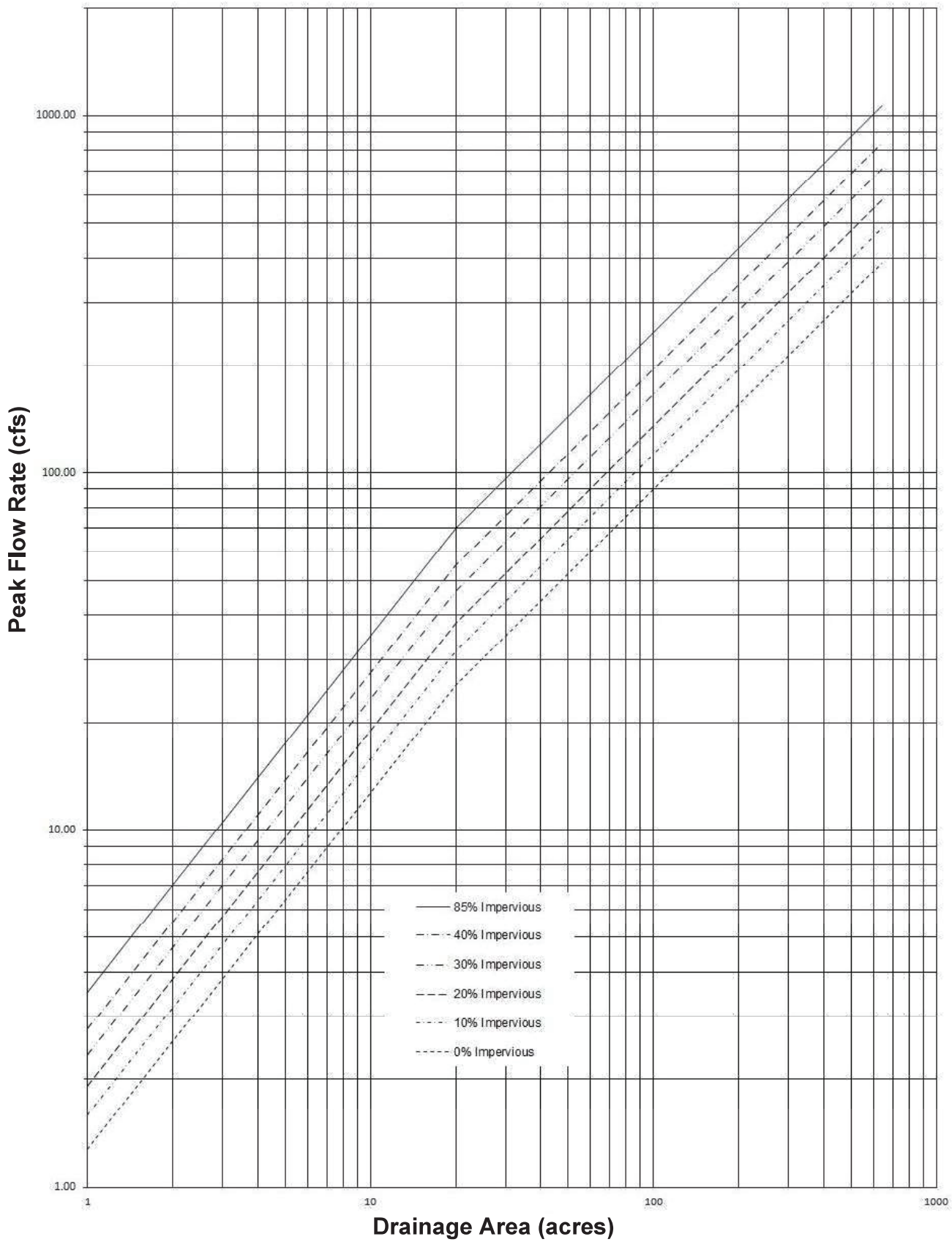
HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY CRITERIA, & PROCEDURE MANUAL

SITE RUNOFF CURVES FOR 50% EXCEEDANCE PROBABILITY (2-YEAR FREQUENCY) STORM

DATE: **JUNE 2019**

EXHIBIT 3-1



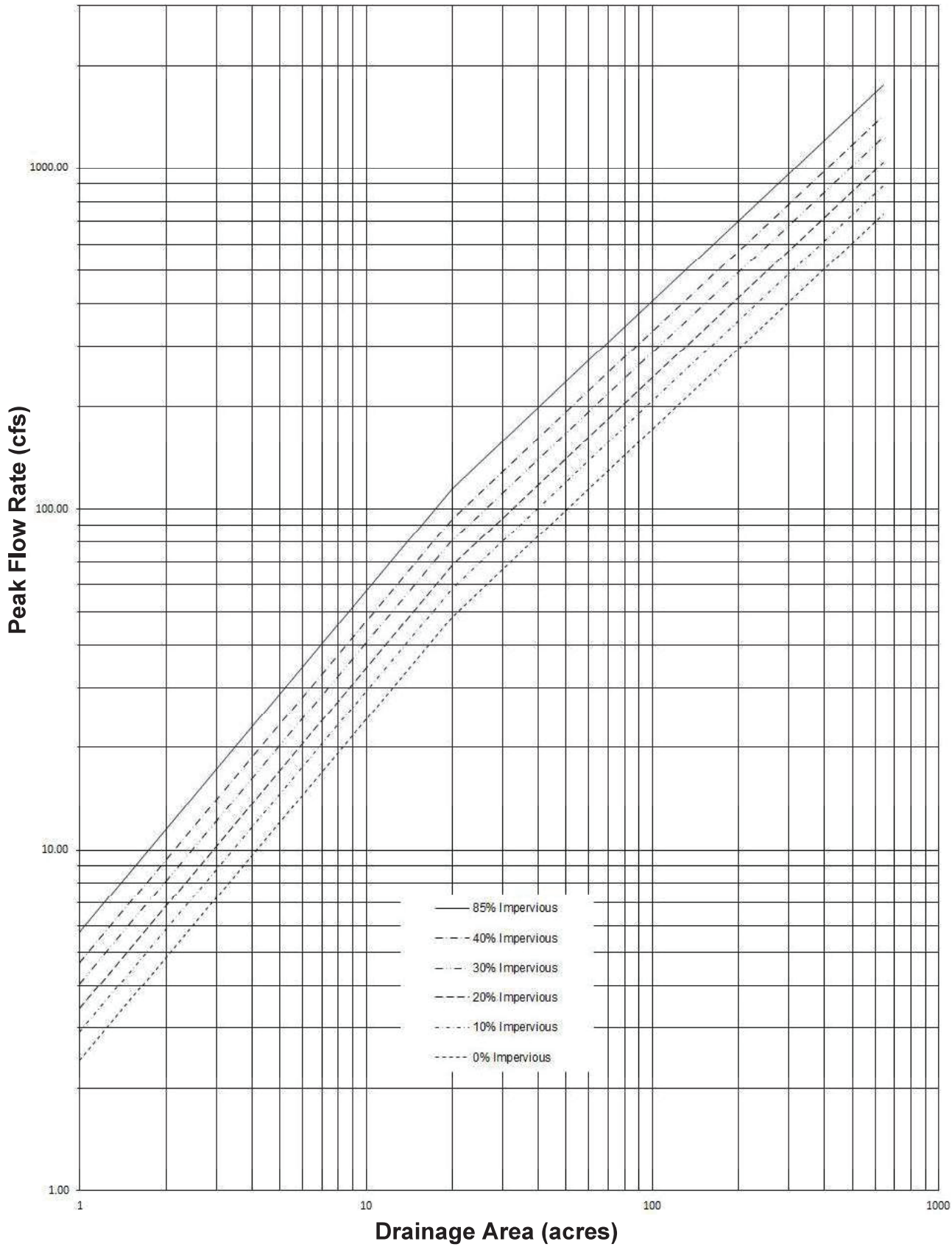
HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY CRITERIA, & PROCEDURE MANUAL

SITE RUNOFF CURVES FOR 10% EXCEEDANCE PROBABILITY (10-YEAR FREQUENCY) STORM

DATE: **JUNE 2019**

EXHIBIT 3-2



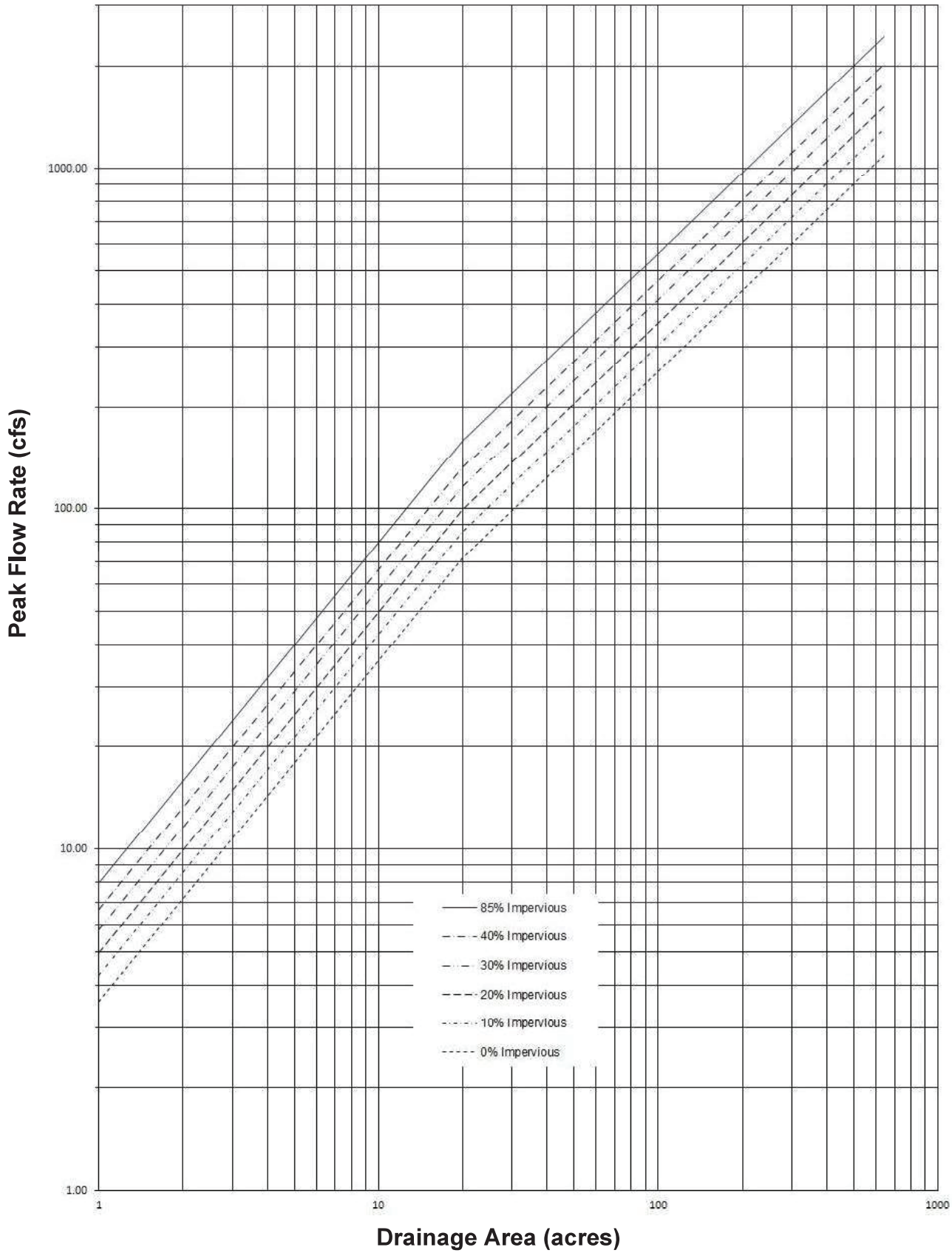
HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY CRITERIA, & PROCEDURE MANUAL

SITE RUNOFF CURVES FOR 1% EXCEEDANCE PROBABILITY (100-YEAR FREQUENCY) STORM

DATE: **JUNE 2019**

EXHIBIT 3-3



HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY CRITERIA, & PROCEDURE MANUAL

SITE RUNOFF CURVES FOR 0.2% EXCEEDANCE PROBABILITY (500-YEAR FREQUENCY) STORM

DATE: **JUNE 2019**

EXHIBIT 3-4

SECTION 6 - STORMWATER DETENTION BASINS

6.1 Introduction

When to Use 6.1.1

Use stormwater detention basins:

- To reduce flood risks.
- To limit peak flow rates to pre-development or pre-project rates.
- In conjunction with channel conveyance improvements so flood levels downstream of the project do not increase.

Where Not Required 6.1.2

Stormwater detention basins are not required:

- Where system capacity exists for the new development as determined by the HCFCD and accepted by Harris County Commissioners Court.
- For only one single family residence where no major changes in existing conditions are proposed and it is not part of a larger development project.
- For developments less than or equal to one acre.
- For redevelopment projects that do not increase the amount of impervious cover or the runoff from the site.

Terminology 6.1.3

Detention basin definitions used in this manual are presented in Appendix E, Terminology. Exhibit 6-1 illustrates an on-line detention basin, off-line detention basin, on-site detention basin, and in-line detention storage.

In-line Detention Storage 6.1.4

In-line detention is permissible within a HCFCD channel only when:

- The proposed development is located at the headwaters of a watershed or sub-area and no other landowners drain into the in-line facility.
- Multiple landowners of proposed developments located at the headwaters of a watershed or sub-area execute an agreement to mutually utilize an in-line facility and no other landowners drain into it.
- It is part of a HCFCD approved regional or subregional plan.
- An existing HCFCD maintained channel is already an in-line detention facility.

Note: Use channel design criteria for in-line detention basins.

6.2 Design Procedure

Design Procedure 6.2.1

A suggested procedure for designing a new gravity detention basin is given in the table below. Location and general layout considerations and criteria are in Section 6.3, General Design Criteria and Section 6.4, Layout. For developments less than 50 acres, some steps are simplified (see Section 6.10, Method 1 – Small Project Drainage Areas).

Step	Action
1	Select a location and prepare a general layout for the detention basin.
2	Determine the inflow hydrographs and maximum allowable outflow rates based on the existing, proposed, and ultimate project, drainage areas, and watershed conditions.
3	Establish the maximum allowable water elevation and design water elevation in the basin and determine tailwater condition in the outfall channel.
4	Estimate the detention volume needed and size the outflow structure. Determine the relationship between storage, discharge, and elevation.
5	Route the design 1% exceedance inflow hydrograph through the basin and outflow structure with appropriate tailwater condition.
6	Adjust the detention volume and outflow structure, if necessary, until the allowable 1% exceedance outflow rate is not exceeded and the detention basin fills to or near the maximum allowable water surface elevation and design water elevation.
7	Route the 10% exceedance hydrograph through the facility and make appropriate adjustments to the outflow structure. Route the 50% and other frequencies, as appropriate, and make adjustments, as necessary. Re-check the 1% exceedance event if changes are made to the outflow structure.
8	Verify storm sewers, street drainage, and channels entering the basin will function as intended, relative to the design water levels in the detention basin.
9	Provide an emergency spillway or overflow structure for an extreme rainfall event or in the event of a blocked outfall pipe.
10	Investigate potential geotechnical and structural problems and establish an erosion control plan.
11	Establish the right-of-way limits, including access for maintenance and space for multi-use.

6.3 General Design Criteria

Overview 6.3.1

A gravity detention basin's location, size, and layout are influenced by the physical features of the site, the type of development proposed, the receiving stream's characteristics, the storage volume needed, and the detention basin's other uses. This section covers general criteria and subsequent sections cover criteria for specific features.

See A.5, Stormwater Detention Basins in Appendix A for assistance with design and submittal requirements particular to detention basins.

Basin Location Considerations 6.3.2

Factors to consider when locating a detention basin:

- Overland and storm sewer flow to the detention basin. (Preferred location of the basin is the lowest area of the property. See Section 6.17, Off-Site Sheetflow.)
- Effect of the detention basin function with respect to the floodplain. For detention basins in a flood plain, consider and evaluate factors such as backwater elevation, inundation timing versus site runoff timing, and inundation duration. For example, flow from the receiving stream (outflow channel) may fill the basin prior to flow from the proposed project.
- Location of the emergency overflow from the detention basin and the path of the emergency overflow beyond the detention basin.
- Other factors listed in Section 6.4.1, Overview.

Design Frequencies 6.3.3

For Method 1 & 2 analyses, design new detention facilities to detain the updated Atlas 14 50%, 10%, and 1% exceedance probability, 24-hour storm events for existing, proposed, and ultimate project drainage areas and watershed conditions. For Method 3 analysis (watershed modeling), use the effective HEC-HMS/HEC-RAS models and design detention facilities to detain the effective 50%, 10%, 1% and 0.2% exceedance probability, 24-hour events.

When detention basin modifications are necessary to accommodate a proposed storm sewer outfall or a proposed development, design the modifications such that the 50%, 10% and 1% exceedance probability water surface profiles in the detention basin and downstream channels are not increased above the existing, proposed, or ultimate conditions.

Note: If a downstream channel has less than a 50% exceedance probability capacity, also design for the frequency when the channel is flowing full or at its flooding threshold.

Continued on next page

6.3 General Design Criteria, Continued

Outflow Rates 6.3.4

To comply with local regulations and HCFCD policy to avoid adverse impacts, maximum allowable outflow rates from detention basins are restricted to each of the pre-development (existing) 50%, 10%, and 1% exceedance probability, 24-hour events. Include the effective 0.2% event if conducting a watershed analysis (Method 3).

If a downstream channel has less than a 50% exceedance probability capacity, also restrict the outflow to the amount the pre-development project site contributes to the channel when it is flowing bankfull or at its flooding threshold so the detention basin does not initiate out-of-bank flooding more frequently.

If the outflow is into a roadside ditch or storm sewer, restrict the maximum allowable outflow to the rate allowed from the proposed site development using criteria adopted by the jurisdiction responsible. .

Critical Water Surface Elevations and Freeboard 6.3.5

Establish critical water surface elevations within the detention basin for existing, proposed, and ultimate conditions. Critical water surface elevations are:

Maximum Allowable Water Elevation
When setting the maximum allowable water surface elevation consider natural ground elevations, finish floors of buildings, variable flow depths in the receiving channel, sanitary sewer manhole elevations, ponding depth in roadways, emergency spillway design, and local subdivision and roadway criteria and regulations. Do not exceed this elevation for the emergency overflow design.

Design Water Elevation
The water elevation not to exceed during the updated Atlas 14 1% exceedance probability (100-year), 24-hour storm event (Methods 1 & 2) or effective 0.2% (500-year) if performing watershed modeling.Method 3.

Freeboard
The difference between the low natural or finished ground elevation and design water elevation with the minimum being one foot.

Design Tailwater Elevation for Storm Sewers
Use the criteria adopted by the jurisdiction responsible for the storm sewer. However, for pumped detention basins, detention basins with severely restricted outflow rates, or submerged storm sewer outfalls, the 10% exceedance probability water surface elevation is recommended in the detention basin to minimize the time and depth streets are flooded.

Prepare and submit a hydraulic profile in a drainage report from the outfall channel through the basin for the various design frequencies and existing, proposed, and ultimate conditions. Show the project features and critical elevations in the area served by the basin to support the maximum and design water surface elevations. (See Section 19, Report Requirements, for an example.)

Continued on next page

6.3 General Design Criteria, Continued

Hydraulic Features 6.3.6

Hydraulic features typically constructed within a detention basin are listed in the table below. Criteria for the hydraulic features are presented in the sections indicated in the table below.

Hydraulic Feature	Section
Backslope Drainage System	11.1
Inflow Structures	6.6
Outflow Structures	6.7
Emergency Overflow	6.13
Pipe Outfalls	11.3
Layout	6.4

Geotechnical Investigations 6.3.7

A geotechnical investigation is required for all work in existing and proposed new HCFCD maintained detention basins and proposed work that deepens or enlarges an existing HCFCD detention basin. For geotechnical reports prepared prior to the date of this manual, the Geotechnical Engineer should review and update, as needed.

As a minimum, address the following:

- Stability of the basin side slopes for short term and long term conditions. (If basin depth ≤ 5 feet, a slope stability analysis is not required, however, a geotechnical report is still required to address the other issues.)
- Stability of the permanent pool side slopes.
- Evaluation of bottom instability due to excess hydrostatic pressure.
- Control of groundwater.
- Identification of dispersive soils.
- Potential erosion problems.
- Constructability issues.
- Evaluation of inflow and outflow structures.

Follow the geotechnical investigation requirements as provided in HCFCD's Geotechnical Investigation Guidelines in Appendix D.

Continued on next page

6.3 General Design Criteria, Continued

Water Quality Features
6.3.8

Water quality features placed in a HCFCD maintained detention basin are covered in Section 16, Water Quality Features.

Assess the impact of water quality features that affect the hydraulic design of the detention basin.

Tree and Shrub Plantings
6.3.9

Planting trees and shrubs in a HCFCD maintained detention basin is acceptable to the HCFCD without accounting for their volume provided criteria and procedures are followed in Section 18, Optional Environmental, Recreation, and Aesthetic Features and Section 2.2.7, Non-Flood Control Features Allowed in a HCFCD facility.

Environmental Investigations
6.3.10

Compliance with appropriate federal, state, and local environmental rules, laws, regulations, and permits is required when modifying or constructing HCFCD facilities (see Section 17, Environmental and Cultural Resources Compliance).

Maintenance Access Plan
6.3.11

A new or updated maintenance access plan is required for all new or modified detention basins to be maintained by HCFCD. Include a final maintenance access plan with the construction drawings. Consider both existing and ultimate conditions. Coordinate closely with the HCFCD as early as possible. See Section 5.3.9, Maintenance Access Plan for details.

Continued on next page

6.3 General Design Criteria, Continued

Drain Time 6.3.12

Empty detention basins within 24 hours, when possible. Maximum drain time is 48 hours (2 days). If drain time is longer than 48 hours, use the rainfall amount and increase in detention volume that approximates the drain time as shown in the table below. The detention volume is increased to account for the volume of another rainfall event because the longer the drain time the greater the chance of another rain event. Drain time over 96 hours (4 days) is not allowed.

Measure drain time from the time at which the peak design detention volume is reached to the point when 80% of the peak volume has drained from the basin or when the remaining basin volume consists of only the stormwater quality volume.

It is not necessary to consider backwater from the outfall channel when calculating drain time using Section 6.10, Method 1 or Section 6.11, Method 2. For Section 6.12, Method 3, backwater from the outfall channel may be considered. The consultant is responsible for determining the appropriate conditions to analyze and flow rate(s) to use in computing the drain time.

Drain Time	Total Rainfall	Increase in Detention Volume
1-2 Days	16.9”	0%
3 Day	22.1”	10%
4 Day	23.0”	15%

Note: Recalculation of drain time with the higher detention volume is the design engineer’s or owner’s choice.

6.4 Layout

Overview
6.4.1

Layout of a detention basin is influenced by many factors, such as:

- Topography.
- Volume needed.
- Grading and depth requirements.
- Geometric design criteria.
- Existing and future roads, pipelines, and utilities.
- Location of inflow, outflow control, and emergency overflow structures.
- Maintenance access requirements.
- Environmental features.
- Soil and groundwater conditions.
- Owner designated features.

Whether the plan shape is rectangular or curvilinear, the minimum radius of curvature for corners is 25 feet to facilitate mowing.

This section focuses on the geometric design factors influencing the detention basin size, depth, side slopes, and bottom design.

Depth
6.4.2

The depth of a gravity detention basin is usually determined by the depth of the outfall channel, roadside ditch, or storm sewer. In some cases, the depth may be determined by the depth of the inflow channel or storm sewer, groundwater level, or soil conditions.

For dry bottom basins, see Section 6.4.6, Dry Bottom Design.

For permanent pools and vegetated shelves, see Section 6.4.11, Wet Bottom Design.

For pumped detention systems, see Section 6.15, Pumped Detention Systems.

Side Slopes
6.4.3

For detention basin side slopes:

- For grass-lined slopes, the steepest side slope allowed is 3(horizontal):1(vertical) for long term stability and maintenance. (See Section 6.3.7, Geotechnical Investigations.)
- For concrete-lined slopes, follow the recommendations in this manual regarding concrete-lined channels.
- For benches on grass-lined slopes, follow the criteria in Section 5.4.4, Grass-Lined Bench Section.

Continued on next page

6.4 Layout, Continued

Typical Sections 6.4.4

Typical detention basin sections are shown in Exhibit 6-2.

See Section 6.5.3, Minimum Berm Widths for maintenance access and minimum berm widths.

Bottom Design – Introduction 6.4.5

The detention basin bottom impacts a basin's long-term maintenance, aesthetics, and multi-use. The bottom design affects the detention basin depth, volume, and surface area.

The bottom can be designed to either be dry, wet, or a combination of wet and dry between periods of inundation, depending on the desired use and maintenance requirements.

Dry Bottom Design 6.4.6

A well-graded bottom incorporating pilot channels and good cross slopes is required to facilitate routine mowing and complete drainage of a basin following a runoff event. This is referred to as a dry bottom.

Criteria for a well-graded (or dry) bottom are presented in the table below and shown in Exhibits 6-2 and 6-3.

Feature		Criteria
Outfall Pipe	Outlet Invert	For flat bottom channels, one foot above channel flowline or one foot above the normal water surface, whichever is higher. For channels with center depression, use table in Section 5.4.3, Bottom Configuration-Trapezoidal Grass-Lined.
	Inlet Invert	A minimum of 0.5 foot above outlet invert and minimum 3 feet per second velocity when hydraulic gradient = flowline gradient.
Concrete Pilot Channel (see Appendix D, HCFCD Interceptor Structure and Concrete Pilot Channel Details)	Starting Flowline	At outfall pipe inlet invert. If no outfall pipe, a minimum of 1.5 feet above the receiving channel flowline or normal water surface.
	Flowline Gradient	Minimum 0.002 feet per foot (0.2%)
	Depth	One-foot
	Side Slope	No steeper than 3:1
	Design	See HCFCD Interceptor Structure and Concrete Pilot Channel Details in Appendix D.
	Location	A minimum of 20 feet away from the toe of the basin side slope.
Inflow Pipe	Invert	At or up to 1 foot above pilot channel flowline
Transverse or cross slopes		Minimum 0.01 feet per foot (1%).

Continued on next page

6.4 Layout, Continued

Wet Bottom Design – Introduction 6.4.7

The use of a wet bottom such as a permanent water pool and/or vegetated shelf is permissible. The wet bottom can be used in combination with a dry bottom.

The HCFCD will maintain the wet bottom portion provided compliance with the conditions in Section 2.2.3, Acceptance for HCFCD Maintenance and this section. For HCFCD to maintain water quality features in a HCFCD maintained detention basin, see Section 16.1.3, Water Quality Feature Maintenance

A wet bottom in a HCFCD maintained detention basin must comply with this section, however, the HCFCD "Design Guidelines for Wet Bottom Detention Basins with Water Quality Features" may be used in close coordination with the HCFCD WMD and SQD to enhance water quality benefits.

Vegetated Shelf 6.4.8

The purpose of a vegetated shelf (formerly shallow pool) is to support aquatic plants and habitat, improve water quality, and make it easier for people and animals to get back onshore. Water depth in a vegetated shelf usually fluctuates.

A vegetated shelf can be incorporated around the edge of a permanent pool. See Section 18.2, Environmental Features, for additional information on vegetated shelves. HCFCD will maintain a vegetated shelf and permanent pool combination provided all criteria are satisfied. See Section 16.1.3, Water Quality Feature Maintenance for water quality feature maintenance requirements.

HCFCD will not maintain dry basins with wet pilot channels. HCFCD discourages wet bottoms consisting only of shallow pools.

Permanent Pool 6.4.9

The purpose of a permanent pool (formerly deep pool) is to:

- Provide open water for aesthetics.
- Reduce vegetation management costs in larger detention basins.
- Support benthic and fish habitats that help sustain a healthy pond.
- Improve water quality.
- Provide fishing opportunities.

A permanent pool cannot be used alone. The bottom shelf must be used in conjunction with the permanent pool.

Continued on next page

6.4 Layout, Continued

Bottom Shelf 6.4.10

The purpose of the bottom shelf is to:

- Reduce the risk of people (children) running or rolling down a slope into the water.
- Improve the aesthetics around a permanent pool.

A bottom shelf is required around both vegetated shelves and permanent pools.

Wet Bottom Design 6.4.11

Criteria for a wet bottom are presented in the table below and shown in Exhibits 6-2 and 6-4.

The minimum water surface area for a permanent pool and vegetated shelf in a HCFCD maintained facility is one acre.

Feature	Criteria	
Outfall Pipe	Outlet Invert	Same as Section 6.4.6, Dry Bottom Design
	Inlet Invert	• Same as Section 6.4.6, Dry Bottom Design • Visible for inspection and maintenance from at least one end of the pipe
Risers	Inlet	Visible for inspection and maintenance
Inflow Pipe	Outlet End Into Basin	Use criteria of the entity responsible for the inflow pipe. If HCFCD, visible for inspection and maintenance and use criteria in Section 6.6.5, Pipe Outfalls on a Bottom Shelf.
Bottom Shelf	Height	2 feet above static water surface, except 5 feet when used for vehicular access
	Cross slope	Minimum 0.02 feet per foot (2.0%)
	Width	Minimum 10 feet
Permanent Pool	Depth	Minimum 3 feet; Maximum 8 feet, depends on soils, geometry, and habitat goals
	Side Slope	No steeper than 3:1 (see Section 6.4.3, Side Slopes)
	Bottom Slope	Flat
Vegetated Shelf	Depth	0 – 18 inches
	Bottom Slope	Flat or mild slope

Continued on next page

6.4 Layout, Continued

Water Edge Walls 6.4.12

Walls at the water's edge (bulkheads) are permissible under the following conditions:

- An entity other than HCFCD agrees to maintain the walls at the water's edge. They are a non-flood control feature.
- A bottom shelf is included with the water edge wall.

Water Quality Feature Access 6.4.13

For maintenance access requirements to water quality features, see Section 16.3, Floatables Collection Structure.

Maintenance Access Alternative – Gentle Slope 6.4.14

For grass-lined side slopes no steeper than 8:1, maintenance access can be along the slope itself (see Section 6.5.3, Minimum Berm Widths). However, all weather access roads cannot be located on the 8:1 side slope.

6.5 Right-of-Way

Overview
6.5.1

This section provides criteria and guidelines for determining the right-of-way or public drainage easement limits for a detention basin maintained by HCFCD.

The dedication and conveyance process is presented in Section 15, Right-of-Way.

Right-of-Way Limits
6.5.2

HCFCD detention basins require right-of-way to contain the basin, maintenance access around the basin, backslope drainage systems if included, and unobstructed maintenance access from public roads or HCFCD channel. See Section 5.3.9, Maintenance Access Plan for more details.

The minimum right-of-way limits for a typical detention basin to be maintained by HCFCD are:

- The area within the top of bank plus,
- Twenty feet for maintenance access plus,
- Ten feet for the backslope swale system, where used,
- Plus ten feet minimum if trails, trees, or other multi-use features are planned or anticipated in the future within the maintenance berm area at the top of bank.

Exceptions:

- See Section 5.5.6, Adjacent HCFCD Channel and HCFCD Detention Basin.
- See Section 11.1.2, Where To Use, for conditions where backslope swale systems are not needed.

Use field survey data and detention basin profile to determine the limits of the detention basin top of bank.

Continued on next page

6.5 Right-of-Way, Continued

Minimum Berm Widths 6.5.3

Minimum berm widths around a detention basin are shown on typical sections in Exhibits 6-2, and presented in the table below. Add minimum ten more feet if trails, trees, or other multi-use features are planned.

Detention Basins That Are	The Minimum Berm Width Is
Grass-lined with a depth > 7 feet	30 feet
Grass-lined with a depth ≤ 7 feet	20 feet[1]
Grass-lined where side slopes are 8 (horizontal):1(vertical) or flatter	15 feet[2]
Lined with riprap or partially concrete-lined	Same as grass-lined channel
Fully concrete-lined	20 feet[1]

[1] Backslope swale system not needed.
[2] Maintenance access is on the side slope.

HCFCD Detention Basins Adjacent to Channels or Roads 6.5.4

See Sections 5.5.6 and 5.5.8 for berm widths and right-of-way criteria where HCFCD detention basins are located adjacent to a HCFCD channel or road.

Ultimate Right-of-Way Determination 6.5.5

Determine the ultimate HCFCD right-of-way limits in coordination with HCFCD. Procedure is same as described in Section 6.5.2, Right-of-Way Limits except when the proposed detention basin will serve areas outside of the proposed development.

6.6 Inflow Structures

Inflow 6.6.1

Stormwater run-off enters off-stream detention basins through storm sewer pipes, backslope swale pipes, ditches, and/or overland. Normal hydrologic analysis is performed for calculating the inflow rate.

Design the storm sewer and overland flow system to convey the 1% storm event into the detention basin.

Inflow Structures 6.6.2

- For overland inflow at a concentrated location, see Section 13.2, Extreme Event Overland Flow Swales and Emergency Overflow Weirs.
- For sheet flow inflow, see Section 11.1, Backslope Drainage Systems.
- For storm sewer pipe inflow, see Section 11.3, Pipe Outfalls.
- For storm sewer and backslope drainage inflow pipes, see Section 6.6.5, Pipe Outfalls on a Bottom Shelf.
- For submerged inflow pipes or boxes, see Section 11.3.5, Submerged Inflow and Outflow Pipes.
- For HCFCD detention basins, do not locate inflow structures in the corner of the basin.

Side-Weir 6.6.3

When a delay in filling the detention basin is desired until the water in the channel reaches a certain level, an inflow structure referred to as a side-weir can be used. This approach:

- Keeps the detention basin from being inundated from smaller, more frequent storms that do not result in flooding. (By means of a backflow preventer on the pipe outfall.)
- Reserves the detention volume for later in a severe storm event when the volume is more effective at reducing peak flows.
- Can require less stormwater volume and land than a conventional flow-through facility.

For analysis, modeling, and design of side weirs, contact HCFCD staff for consultation and latest analytical tools and guidance.

Note: Whether a side-weir or flow-through is used depends on where the detention basin is located in the watershed and where the area of flood level reduction is located. If the area of flood level reduction is hydraulically close to the detention basin, a side-weir is usually more efficient.

Continued on next page

6.6 Inflow Structures, Continued

Erosion Control 6.6.4

High velocities and turbulence can occur at inflow pipes. All storm sewer pipe outfalls require erosion protection. Riprap is the default choice, the same as outfalls into channels. See Section 11.3.4, Design Criteria, for detailed criteria. In some cases, due to outfall pipe or box size, basin geometry, and/or soil type, a custom outfall erosion protection design may be needed using concrete lining and/or riprap.

Use concrete lining for protection at weir structures. Design adequate coverage, thickness, reinforcement, and toe walls for each structure. Use riprap to transition to a grass-lined channel or detention basin.

A typical extreme event overflow structure to carry flow into a detention basin is in Section 13, Extreme Event Overflow.

Pipe Outfalls on a Bottom Shelf 6.6.5

For storm sewer or offsite ditch interceptor pipes that outfall on a grass-lined bottom shelf in a wet bottom basin (see Section 6.4.10, Bottom Shelf), include a swale from the pipe to the permanent pool or vegetated shelf. For the outfall pipe, use Section 11.3.4, Design Criteria.

The swale criteria is:

- Minimum 6 inches deep.
- Flowline gradient = same as bottom shelf cross slope (typically 2%).
- Minimum top width = 2x pipe diameter or box width.
- Center on pipe.
- Line with 3”-5” granular material, concrete lining, or other acceptable material for the flow condition anticipated.
- Cover granular material lining with minimum 6” top soil and vegetate.
- Extend lining a minimum of 5 feet beyond edge of bottom shelf into permanent pool or the vegetated shelf.

Note: Backslope drain pipes do not require a swale across the bottom shelf.

Pipe Outfalls – Dry Bottom 6.6.6

For storm sewer or offsite ditch interceptor pipes and inflow weirs that outfall into a dry bottom basin, include a concrete pilot channel (see Section 6.4.6, Dry Bottom Design). For the outfall pipe, use Section 11.3.4, Design Criteria.

6.7 Outflow Structures

Common Structures 6.7.1

Common structures used to restrict outflow from a gravity flow detention basin are pipes, box culverts, risers, and weirs. The numbers, sizes, and elevations can be varied to control outflows for different storm frequencies. References to pipe outflows include box culvert outflows, as well.

Several equations and computer programs are available to compute flows and head losses through pipes, boxes, and weirs. Pipe, box culvert, and weir equations for outlet control conditions are presented below.

Pipe Equation 6.7.2

For a round pipe flowing full with both the entrance and exit submerged, the head loss equation is:

$$H = \left[\frac{2.52(1 + k_e)}{D^4} + \frac{466 n^2 L}{D^{16/3}} \right] \frac{Q^2}{100}$$ *Pipe Culvert Head Loss Equation*

where:

- H = head difference between entrance and exit in feet
- k_e = entrance loss coefficient (see Section 6.7.4, Entrance Loss Coefficients)
- D = diameter of pipe in feet
- n = Manning's roughness coefficient (0.024 for a corrugated metal pipe and 0.013 for a concrete pipe)
- L = length of pipe in feet
- Q = design discharge rate in cubic feet per second

Box Culvert Equation 6.7.3

For a box culvert flowing full with both the entrance and exit submerged, the head loss equation is:

$$H = (1.0 + k_e) \frac{V^2}{2g} + \frac{V^2 n^2 L}{2.21 R^{4/3}}$$ *Box Culvert Head Loss Equation*

where:

- H = head difference between entrance and exit in feet
- k_e = entrance loss coefficient (see Section 6.7.4, Entrance Loss Coefficients)
- V = velocity in the culvert in feet per second = discharge/culvert area
- g = acceleration due to gravity (32.2 feet per second^2)
- n = Manning's roughness coefficient (0.013 for a concrete box)
- L = length of box in feet
- R = hydraulic radius of culvert in feet = culvert area/wetted perimeter

Continued on next page

6.7 Outflow Structures, Continued

Entrance Loss Coefficients 6.7.4

Entrance loss coefficients, k_e, for common entrances are:

Sharp, projecting corrugated metal pipe...…….....0.9
Square edge pipe or culvert with headwall…...…….…….....0.5
Well rounded edge, tapered wingwalls……..0.2

See the FHWA, Hydraulic Design Series No. 5, *Hydraulic Design of Highway Culverts* (1985), for a complete list of entrance loss coefficients.

Minimum Pipe Size or Opening 6.7.5

To reduce the chance of clogging and improve the chance a detention basin will work when needed and as designed, minimum pipe size restrictors are as designated by local jurisdiction where detention basin is located (typically Harris County or City of Houston).

For detention facilities discharging into a HCFCD maintained facility, the minimum outfall pipe size within the HCFCD maintained facility is 24 inches. If a restrictor smaller than 24 inches is needed, place a short section of smaller pipe or a plate at the upstream end of the outfall pipe within the detention basin to facilitate inspection and debris removal. The minimum restrictor size is a 6" diameter pipe or a 5" wide x 6" high rectangular opening. Rectangular openings are recommended because they are less likely to clog.

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6.7 Outflow Structures, Continued

Orifice Equation 6.7.6

To restrict the outflow with a short segment of pipe or reduced opening size, use the orifice equation below. For other configurations, see Brater and King's Handbook of Hydraulics or other applicable references.

$$Q = CA\sqrt{2gH}$$

where:

Q = discharge in cubic feet per second
C = coefficient of discharge
- 0.8 for short segments of pipe
- 0.6 for openings in plates, standpipes, or concrete walls

A = area of opening in square feet
g = acceleration due to gravity (32.2 feet/second^2)
H = head difference between entrance and exit in feet when orifice is fully submerged, or the difference between the water surface elevation at the entrance and the centroid of the orifice in feet when orifice is partially submerged.

Outflow Structures 6.7.7

For pipe outflow structures in HCFCD maintained channels:

- Use only one outfall pipe or box into the HCFCD channel where hydraulically and physically feasible (see Section 6.7.13, Multiple Frequency Outflow Structures).
- For corrugated metal pipes (see Section 11.3, Pipe Outfalls) include riprap erosion protection in grass lined channels and detention basins for any size outfall pipe (see Appendix D, HCFCD Storm Sewer and Riprap Details for typical channel conditions. Include custom erosion protection design where necessary.)
- For reinforced concrete pipes or box culverts, use a headwall/wingwalls with an apron in the basin and a headwall/wingwalls with an apron recessed into the HCFCD channel that does not disrupt the flow in the channel (See Section 11.3.4, Design Criteria.)
- Avoid placing outfall pipes and boxes under concrete slope paving, spillways, retaining walls, and other structures so as not to hinder maintenance and repairs. If there is no alternative, use concrete pipes or box culverts with headwall/wingwalls and aprons.

Backflow Preventers 6.7.8

See Section 11.3.3, Backflow Preventers

Continued on next page

6.7 Outflow Structures, Continued

Floatables Collection Structure 6.7.9

See Section 16.3, Floatables Collection Structure for criteria.

Seepage 6.7.10

Seepage around pipe or box outflow structures can be a significant problem due to the potential high head differential between the channel and detention basin. Carefully construct with cement stabilized sand around the entire pipes or boxes and use backfill compaction in accordance with HCFCD standard specifications around the pipes or boxes or as recommended by the geotechnical engineer.

Weirs 6.7.11

Weirs can be used to control the design outflow or the emergency overflow from a detention basin. Weirs are sometimes used as an inflow structure, also.

The rectangular weir equation is:

$$Q = CLH^{3/2}$$

where:

- Q = weir discharge in cubic feet per second
- C = weir coefficient
- L = horizontal length of weir in feet
- H = head on weir in feet

The value of the weir coefficient, C, depends on the weir shape (for example, broad crested or sharp crested) and if the weir is submerged or not. See Brater and King's Handbook of Hydraulics or other applicable references.

Erosion Control 6.7.12

High head differentials and erosive velocities for prolonged periods of time can occur at pipe inlets. Use concrete lining or riprap around pipe inlets where erosive velocities and turbulence are expected.

Flow from the outflow structure can cause erosion in the outfall channel due to high velocities and turbulence. See Section 10, Erosion and Sediment Control for specific erosion control guidelines and criteria.

Use concrete lining for weirs. Design coverage, thickness, reinforcement, and toe walls for each structure. Use riprap to transition to a grass-lined channel or detention basin.

Continued on next page

6.7 Outflow Structures, Continued

Multiple Frequency Outflow Structures 6.7.13

Maximum allowable outflow rates are restricted to pre-development 50%, 10%, and 1% exceedance probability discharges, in some cases, a more frequent event associated with the bankfull capacity of the outfall channel, and/or the effective 0.2% (500-year) event when performing a Method 3 analysis (see Section 6.3.4, Outflow Rates). If a water quality improvement feature is also included, then there is also outflow control for frequent rainfall events (see Section 16, Water Quality Features).

Multiple frequency outflow control structures generally consist of pipes or boxes of various sizes at different elevations or a riser and an emergency overflow weir (see Section 6.13, Emergency Overflow). Use only one outfall pipe or box into the HCFCD channel, where possible, and coordinate design with the HCFCD WMD.

6.8 Tailwater

Overview
6.8.1

The water surface elevation in the outfall channel at the outflow structure is the tailwater. The tailwater affects both the outflow structure design and the stage-outflow relationship of the detention basin.

To facilitate analysis and design of detention basins, two tailwater assumptions are possible:

- Fixed.
- Variable.

Note: Specific criteria are provided for each of the three methods for determining detention volume.

Backwater
6.8.2

Near channel confluences and in coastal zones, backwater can occur that is higher than the tailwater from the flow in the channel itself. Consider the backwater in designing the emergency overflow and establishing design water levels in the detention basin and proposed development.

6.9 Detention Volume

Overview
6.9.1

Determining the stormwater detention volume for a small development project or a complex large development project requires use of the same hydrologic and hydraulic principles. However, different methodologies are presented in this section which recognizes sizes of projects and levels of complexity to facilitate the analytical and design process.

Methods
6.9.2

Where detention is required in watersheds or portions of watersheds, the three methods to determine the detention volume are listed below and covered in detail in subsequent sections. Each method addresses the inflow, allowable outflow, and tailwater conditions.

Method	For	Project Drainage Areas
1	Small	Less than 20 acres
2	Moderate	Between 20 acres and 640 acres
3	Large	Greater than 640 acres

Note: The Optional Project Routing Technique (Section 3.7) may only be used for project drainage areas between 50 and 640 acres in conjunction with Method 2 (Section 6.11).

Roadway Only Method
6.9.3

Due to the potential impact of new and improved road projects on overland flow patterns and stormwater runoff, an alternative method for analyzing and sizing mitigation for roadways only is presented in Section 6.16, Roadway Impacts and Mitigation.

Continued on next page

6.9 Detention Volume, Continued

Floodplain Fill Mitigation 6.9.4

Where fill in the effective 1% floodplain is proposed for a proposed land development or infrastructure project:

- Avoid or mitigate any conveyance impacts of flow along the channel and overland flow.
- Mitigate the volume of fill below the effective 0.2% floodplain elevation by removing an equal volume from the floodplain.

Where fill in the effective 0.2% floodplain is proposed for a proposed land development or infrastructure project:

- Avoid or mitigate any conveyance impacts of flow along the channel and overland flow.
- Mitigate the volume of fill below the 0.2% floodplain elevation by removing an equal volume from the 0.2% floodplain.

Add the floodplain fill mitigation volume to the detention volume needed, and coordinate the analysis, excavation and fill locations, and LOMR requirements as necessary with the HCFCD WMD and local floodplain administrator.

Notes: Because updated 1% floodplains based on Atlas 14 are not yet available, the 0.2% floodplain serves as an estimate of the future Atlas 14 1% floodplain.

Floodplain limits are based on the site topography compared to the effective model elevations, not the effective FEMA FIRM Panels.

Continued on next page

6.9 Detention Volume, Continued

Minimum Detention Volume 6.9.5

Minimum detention volumes for the 1% (100-year) storm are:

- The volume calculated using Method 1 or 2 (Section 6.10 and 6.11), but not less than 0.65 acre-feet per acre of new development or as defined in a watershed or sub-watershed with an adopted regional or master plan.
- The volume calculated using the Optional Project Routing Technique (Section 3.7), but not less than 0.55 acre-feet per acre of new development or as defined in a watershed or sub-watershed with an adopted regional or master plan.
- The volume calculated by conducting a hydrologic and hydraulic analysis along the entire length of the main channel using Method 3, Large Project Drainage Areas (Section 6.12), but not less than 0.55 acre-feet per acre of new development or as defined in a watershed or sub-watershed with an adopted regional or master plan.
- For new developments with limited on-site drainage improvements and relatively small amounts of impervious cover (less than or equal to 15%), the volume calculated using Method 1, 2, or 3, but not less than 0.35 acre-feet per acre of new development.
- For pumped detention facilities, see Section 6.15, Pumped Detention Systems.
- If a 0.2% (500-year) analysis is required, the 0.2% (500-year) detention rate may be higher than the minimum shown for the 1% (100-year) event.

Note: The area of new development is based on the area of the property, not just the impervious cover area. See Appendix E, Terminology, for a complete definition and Section 3.5.1, Relationship to Development, for a generalized relationship between impervious cover and land development.

What to Include 6.9.6

Include only the storage volume below the detention basin design water surface elevation in the detention basin itself and storm sewers and open channels discharging into the detention basin.

Storage volume in streets above the detention basin design water surface calculated in dynamic hydrologic and hydraulic models cannot be included in the detention storage volume.

Include only the storage volume above the normal pool elevation for detention basins with a permanent pool or wetland.

Do not include storage volume used to mitigate floodplain fill.

Do not include storage volume in an existing floodplain.

6.10 Method 1 – Small Project Drainage Areas

When to Use
6.10.1

For projects with drainage areas less than 20 acres, Method 1 is recommended. Some of the steps presented in Section 6.2, Design Procedure, are simplified to facilitate the design process for these smaller sites.

See A.6, Method 1 Detention Example in Appendix A.

Inflow
6.10.2

No inflow hydrograph or discharge is calculated.

Maximum Allowable Outflow
6.10.3

Maximum allowable outflow criteria are in Section 6.3.4, Outflow Rates.

For HCFCD maintained channels, use:

- The updated Atlas 14 Site Runoff Curves (Exhibits 3-1, 3-2, and 3-3) to determine the maximum outflow rate for the 50%, 10% and 1% exceedance probabilities.
- The amount of flow the project site contributes to the bankfull capacity if the outfall channel bankfull capacity is less than 50%.
- For roadside ditches or storm sewers, use the methodology adopted by the agency responsible for the roadside ditch or storm sewer to determine the maximum outflow rate.

Tailwater
6.10.4

Tailwater is not used to determine the detention volume in Method 1, but it is used to size the outflow structure.

Use the top of pipe in the outfall channel as a fixed tailwater condition. For the 50% exceedance probability analysis, the midpoint of the outlet pipe can be used if the pipe is not fully submerged.

Since hydrographs are not used in Method 1, variable tailwater is not used.

Detention Volume
6.10.5

Use the minimum detention storage volume designated in Section 6.9.5, Minimum Detention Volume.

For most small projects, it will be 0.65 acre-feet per acre of new development.

If the maximum allowable outflow rate is less than the existing runoff rate from the Site Runoff curves, then a Method 2 routing analysis is necessary to determine if additional detention volume is needed.

Continued on next page

6.10 Method 1 – Small Project Drainage Areas, Continued

Outflow Structure 6.10.6

Using the maximum allowable outflow rate and applicable tailwater condition, size the outflow structure using the appropriate equations and information in Section 6.7, Outflow Structures.

For the 1% exceedance probability outflow control, use the design water surface in the detention basin based on 0.65 acre-feet per acre volume.

For the 10% exceedance probability outflow control, use the design water surface in the detention basin based on 0.33 acre-feet per acre volume.

For the 50% exceedance probability outflow control, use the design water surface in the detention basin based on 0.17 acre-feet per acre volume.

Documentation 6.10.7

Include assumptions, justifications, calculations, and sketches on the construction drawings or in the drainage report submittal to HCFCD (see Section 19, Report Requirements).

6.11 Method 2 – Moderate Project Drainage Areas

When to Use 6.11.1

For projects with drainage areas between 20 and 640 acres, Method 2 is recommended. Some of the steps presented in Section 6.2, Design Procedure, are simplified to facilitate the design process for moderate size sites.

Use Method 2 only if correlation with existing HEC-HMS or HEC-RAS modeling on the outfall channel is not necessary. If correlation is necessary, use Method 3.

See A.7, Method 2 Detention Example in Appendix A.

Inflow 6.11.2

Use the Small Watershed Method presented in Section 3.6, Small Watershed Hydrograph Method, to develop hypothetical inflow hydrographs for each of the design exceedance probabilities.

Determine peak inflow rates using the Site Runoff Curves for areas between 20 and 640 acres for the 50%, 10% and 1% exceedance probabilities (Exhibits 3-1, 3-2, and 3-3).

Maximum Allowable Outflow 6.11.3

Maximum allowable outflow criteria are in Section 6.3.4, Outflow Rates.

For HCFCD maintained channels, use:

- The Site Runoff Curves (Exhibits 3-1, 3-2, and 3-3) to determine the maximum outflow rate for the 50%, 10% and 1% exceedance probabilities.
- The amount of flow the project site contributes to the bankfull capacity if the outfall channel bankfull capacity is less than 50%.
- For roadside ditches or storm sewers, use the methodology adopted by the agency responsible for the roadside ditch or storm sewer to determine the maximum outflow rate.

Tailwater 6.11.4

Since a hypothetical inflow hydrograph is used that does not have any correlation with the outfall channel hydrograph, a variable tailwater based on an existing watershed model is not used.

Use the top of outlet pipe in the outfall channel as a fixed tailwater condition for the 10% and 1% exceedance probabilities analysis.

For the 50% exceedance probability analysis, the midpoint of the outlet pipe can be used if the pipe is not fully submerged.

Continued on next page

6.11 Method 2 – Moderate Project Drainage Areas, Continued

Outflow Structure – Preliminary Size Estimate 6.11.5

Using the maximum allowable outflow rate and applicable tailwater condition, determine a preliminary size of the outflow structure using the appropriate equations and information in Section 6.7, Outflow Structures.

Detention Volume and Outflow Structure 6.11.6

Follow steps 5-7 in Section 6.2.1, Design Procedure to determine the detention volume and final outflow structure size and configuration.

The minimum detention volumes designated in Section 6.9.5, Minimum Detention Volume, apply.

To route the inflow hydrographs through the detention basin, a standard reservoir routing procedure is recommended.

Note: The reservoir routing procedure requires the development of stage versus storage and stage versus outflow relationships.

Optional Project Routing Technique 6.11.7

The Optional Project Routing Technique (Section 3.7) may be used for calculating detention volume and sizing the outflow structure. The Optional Project Routing Technique cannot be used for sites smaller than 50 acres without prior approval by HCFCD WMD.

Alternative Models 6.11.8

In some cases, a standard reservoir routing procedure may be difficult to use or not be applicable. For example, multiple detention basins in series that are hydraulically dependent or an unconventional control structure. Applicable alternative models can be used. Inform HCFCD early in the review process of the computer model that will be used and provide model documentation, if required, to facilitate the review.

Documentation 6.11.9

Include assumptions, justifications, calculations, summary tables, profiles, hydrographs, and sketches in the drainage report submitted to HCFCD. See Section 19, Report Requirements for a list of requirements.

6.12 Method 3 – Large Project Drainage Areas

When to Use 6.12.1

Use Method 3 for projects:

- With drainage areas greater than 640 acres, or
- Where correlation with existing HEC-HMS or HEC- RAS is necessary, or
- Where definition or modification of effective FEMA regulatory flood plains or floodways is necessary, or
- Where complexity of the project justifies a detailed analysis for a drainage area greater than 300 acres and less than 640 acres.

See A.8, Method 3 Detention Example in Appendix A.

Analysis 6.12.2

A detailed hydrologic and hydraulic analysis is required utilizing HEC-HMS and HEC-RAS using the current Watershed Modeling Method (see Section 3.4, Watershed Modeling Method).

Use the above referenced models to determine the following:

- Inflow hydrographs.
- Maximum allowable outflow rates.
- Variable tailwater conditions.
- Detention volume requirements.
- Outflow structure configuration and sizes.

The minimum detention volumes designated in Section 6.9.5, Minimum Detention Volume, apply.

Coordinate the 50% and the effective 0.2% event analysis with the HCFCD WMD.

Alternative Models 6.12.3

In some cases, HEC-HMS and HEC-RAS cannot accurately simulate some projects or detention basin conditions. For example, multiple detention basins in series that are hydraulically dependent or an unconventional control structure. It is acceptable to use inflows from HEC-HMS as input into special programs, such as detention basin routing programs. The outflows from the special programs can then be inserted back into HEC-HMS to analyze the effects on the channel.

Documentation 6.12.4

Include assumptions, justifications, summary tables, profiles, hydrographs, computer runs, and sketches in the drainage report submitted to HCFCD. See Section 19, Report Requirements for a list of requirements.

6.13 Emergency Overflow

Purpose 6.13.1

The purpose of emergency overflows from detention basins are to keep water levels from exceeding an elevation that would:

- Flood houses, businesses, roadways, etc. the detention basin is meant to protect.
- Put the structural integrity of the detention basin itself in jeopardy of failing.
- Overtop the detention basin and erode the HCFCD channel bank.

Water elevations above design elevations are possible when:

- Rainfall amounts, duration, pattern, etc. result in inflows that exceed outflows and the available detention storage volume.
- The outflow structure is physically blocked resulting in reduced outflow.
- High backwater conditions in the outfall channel.

Criteria 6.13.2

An emergency overflow structure or route is required for all detention basins.

Design the emergency overflow as a path for the water to follow when water levels exceed the 1% exceedance probability design water level in the detention basin.

Design the emergency overflow weir or structure to pass the 1% exceedance probability ultimate development flow assuming the primary outflow pipes or boxes are obstructed without exceeding the low natural or finished ground elevation (see Section 6.3.5, Critical Water Surface Elevations and Freeboard).

Verify the proposed and/or existing development or infrastructure project drainage systems can pass the 0.2% exceedance probability flow assuming the primary outflow pipes or boxes are obstructed without exceeding the maximum allowable water elevation. At the detention basin emergency overflow structure, the grassed berm beyond the concrete weir may be designed to accommodate the additional flow from a 0.2% event.

Note: If a Method 3 watershed analysis is being performed ensure that the structure operates in the 0.2% event while still maintaining required freeboard and outflows from the project at the allowable pre-development levels.

Use the criteria presented in Section 13, Extreme Event Overflow in designing emergency overflow weirs. Coordinate design and layout with the HCFCD WMD, if necessary.

Continued on next page

6.13 Emergency Overflow, Continued

Considerations 6.13.3

Consider water levels relative to residential and commercial structures, and roadways upstream and downstream of the detention basin when locating and designing the emergency overflow.

Consider the consequences of flooding upstream residential and commercial structures in establishing the maximum allowable water elevation (see Section 6.3.5, Critical Water Surface Elevations and Freeboard) and design flow.

Consider the natural flow pattern when locating the emergency overflow path.

Avoid placing the emergency overflow on fill and banks or bottoms which are easily eroded. If erodible banks or bottoms cannot be avoided, modify or extend erosion control structure design to minimize erosion.

Do not place the emergency overflow weir over the outflow pipe structure to minimize disturbance of the overflow weir when the outflow pipe is replaced or repaired. The outflow pipes can be adjacent to the emergency overflow weir.

Note: The examples in Appendix A that include a detention basin have an emergency overflow spillway design. The emergency overflow maximum allowable water level and flow was established for each example based on the considerations above and the unique conditions at each location.

6.14 Erosion Control

Criteria 6.14.1

Establish permanent turf grass on all exposed or disturbed soil in a detention basin except where structural erosion protection, wetlands, or permanent pools are located (see Section 10.3, Turf Establishment).

Use concrete lining and/or riprap, for drops, emergency overflows, or other types of structural measures where excessive velocities or turbulence are expected (see Section 4.4, Velocities; Section 10, Erosion and Sediment Control; Section 6.6, Inflow Structures; and Section 6.7, Outflow Structures).

Know the soil types and conditions. Erosion is more likely to occur in sandy or silty soils.

Backslope Swales 6.14.2

Backslope drainage systems are required where the natural ground slopes toward the detention basin (see Section 11.1, Backslope Drainage Systems).

6.15 Pumped Detention Systems

Overview 6.15.1

Detention basins are drained by pumping instead of gravity outflow when the channel outfall depth is limited and channel deepening is not practical or possible. In other words, dewatering pumps are used to drain the detention basin that is below the outfall channel bottom.

This section covers criteria for both public and private pumped detention facilities that outfall into a HCFCD maintained channel or other open channel.

For public and private pumped detention facilities that outfall into a roadside ditch or storm sewer, use the criteria for the applicable jurisdiction.

See A.9, Pumped Detention Example in Appendix A.

Public Pumped Detention Facility Conditions 6.15.2

Only use a public pumped detention facility as a last resort when there are no reasonable alternatives for a gravity detention facility.

Public pumped detention facilities can be operated and maintained by a utility district, other political subdivision of the State, or taxing authority. HCFCD will not operate and maintain a pumped detention facility.

Design Procedure 6.15.3

Follow the same design procedure as presented in Section 6.2, Design Procedure.

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6.15 Pumped Detention Systems, Continued

Pumped Detention Criteria 6.15.4

Most of the criteria for gravity detention basins apply to pumped detention basins. Criteria that are different are presented in this section. A schematic of a pumped detention facility is shown in Exhibit 6-5.

For public and private pumped detention facilities that outfall into an open channel (not roadside ditch, use applicable jurisdiction criteria), the criteria are:

Volume

- Minimum detention volume is what you calculate but not less than 0.75 acre-feet per acre of new development.
- Limit the volume of pumped storage to no more than 50% of the total basin volume. The remaining volume must discharge by gravity.

Outflow

- Limit the outflow rate to the amount of flow the pre-project site or drainage area contributes to the outfall channel when it is flowing bankfull or at the 1% probability water level, whichever is lower.
- Provide gravity outflow for the volume above the pumped storage.
- Pump only when the water level in the basin is below the midpoint elevation of the gravity outlet in the basin.
- Provide gravity outflow for low flows (by designing the system to by-pass pumps), if hydraulically possible.
- Provide a gravity emergency overflow structure or path in the event the basin capacity is exceeded.

Continued on next page

6.15 Pumped Detention Systems, Continued

Pumped Detention Criteria - Continued 6.15.4

Pumps

- Provide a stilling basin or manhole to dissipate the energy from the pump outlet prior to gravity flow into the HCFCD maintained channel. The outflow velocity into the HCFCD maintained channel shall not exceed three feet per second (3 fps).
- Provide at least one backup pump in the event of a pump failure.
- Fence off and padlock the pump station and control panel to discourage unauthorized operation and vandalism.

Drain Time

- Empty the pumped storage volume in 24 hours after pumping begins during recession, when possible. Maximum drain time is 48 hours (2 days). If the maximum outflow rate results in a longer drain time, see Section 6.3.12, Drain Time for criteria for drain times longer than 48 hours.

Documentation

- Perform hydrologic and hydraulic analyses to determine the detention volume needed and to size the pumps and gravity outflow structure. Clearly show how the pump system and gravity outflows work to satisfy the outflow criteria.
- Document analysis, design decisions, how pumped detention system will work, and draft operations and maintenance plan in the drainage or design report.
- Provide emergency contact information for the owners(s), engineer, and operator responsible for operations and maintenance to the HCFCD WMD. HCFCD will refer calls received during floods concerning pumped detention basins and their service area to these individuals.

Continued on next page

6.15 Pumped Detention Systems, Continued

Pumped Detention Considerations 6.15.5

Consider the following regarding functionality and maintenance of the proposed pumped detention basin to ensure the facility will function during a flood event.

- Provide an emergency power source appropriate for the detention facility and service area. As a minimum, provide power from dual sources or install a quick connect for a mobile generator.
- Record pump operation and water levels.
- Provide an all-weather access road and working areas necessary to operate and maintain the pump station and detention basin.
- Ensure horizontal and vertical unobstructed access to the pump station so pumps can be pulled for maintenance.
- Prepare and use an operation and maintenance manual in accordance with the requirements of the responsible entity or operator. The HCFCD's former operations and maintenance guideline is available on the HCFCD website as a guide.

Additional Criteria for Privately Maintained Facilities 6.15.6

For privately maintained pumped detention basins that outfall into a HCFCD maintained channel, comply with:

- The criteria listed in Section 6.15.4, Pumped Detention Criteria.
- The requirements specified in Section 6.04,1. Private Facilities in the "Regulations of Harris County, Texas for the Approval and Acceptance of Infrastructure" and administered by the Harris County Permit Office.
- The requirements in "Rules of Harris County and the Harris County Flood Control District for Construction of Facilities within Harris County and Harris County Flood Control District Rights of Way" administered by the Harris County Permit Office and HCFCD WMD.

6.16 Roadway Impacts and Mitigation

Introduction 6.16.1

Due to the different characteristics of roadway and land development projects, the impacts associated with roadway projects cannot be fully analyzed using typical land development techniques. New roadways and improved roadways can significantly affect drainage patterns by:

- Increasing stormwater runoff rates into HCFCD facilities by improving conveyance in the roadway corridor.
- Changing existing overland flow patterns by modifying the roadway profile or adding a new roadway.
- Eliminating or changing existing natural storage areas in the vicinity of the roadway.
- Adding impervious cover in the road corridor.

For these reasons, criteria and considerations for analyzing and sizing mitigation for roadways are presented below.

Note: Roadways include municipal, county, state, and federal highways, frontage roads, major thoroughfares, streets, and roads with either storm sewer or roadside drainage.

See A.10, Roadway Impacts and Mitigation Example in Appendix A.

When to Use 6.16.2

Use this method for:

- New roadways.
- Widening existing roadways.
- Converting from roadside ditch to storm sewer drainage.

Criteria and Methods 6.16.3

Use the criteria and methods in this Section 6, Stormwater Detention Basins for analyzing impacts and sizing mitigation, except as noted below.

Continued on next page

6.16 Roadway Impacts and Mitigation, Continued

Analytical Criteria 6.16.4

For design of the roadside ditches or storm sewers, use the method for calculating storm sewer and roadway design flows as required by the jurisdiction responsible for the roadway drainage.

Analytical criteria for analysis and design of the roadway impact and mitigation are provided below.

- Do not use Section 3.3, Site Runoff Curves to calculate peak discharges. Use a true velocity-based rational formula. (Formulas that only use the drainage area to compute t_c are not acceptable.) Estimate t_c and changes in t_c using the true velocity-based rational formula method.
- Use the roadway right-of-way as the drainage area for analyzing roadway impacts and sizing initial mitigation (see note below).
- Account for offsite areas draining to the roadway in its current development condition and adjust design and mitigation, as necessary.
- Check capacity of existing outfall pipe or channel (See Section 6.3.4, Outflow Rates).
- The minimum detention volumes rates in Section 6.9.5, Minimum Detention Volume do not apply to roadway impact and mitigation analysis.

Note: For local or state roadway projects, mitigation of future development that drains to the road is the responsibility of the future developer.

Considerations 6.16.5

- In determining changes in imperviousness, consider whether the proposed road improvements are to be constructed in the existing road right-of-way or if additional right-of-way will be required.
- Evaluate the effect of the roadway profile on offsite overland flow.
- If the roadway outfall is into an existing roadside ditch, storm sewer, enclosed conduit, or small ditch, restrict the maximum allowable outflow to the rate allowed using criteria adopted by the jurisdiction responsible for the outfall.
- Check and show the outfall water surface elevations or outfall hydraulic grade lines used in the analysis on the roadway outfall sheet(s) to identify potential backwater flooding problems.
- Convey the 1% exceedance probability (100-year) flow into the detention basin overland, down the roadway, and/or through the last segments of the roadway storm sewer and inlets.
- Include extreme event flow conveyance to an outfall point in the design. Use the applicable criteria from the entity responsible for the roadway, or the Harris County criteria if they do not have any.

6.17 Off-Site Sheetflow

Overview 6.17.1

Sheetflow from an adjacent undeveloped area into an existing or a proposed development can create a localized flood hazard by overloading street inlets and/or flooding individual lots, houses, or businesses. Drainage plans for a proposed subdivision must take into account the drainage of adjacent lands, both under interim and ultimate developed conditions. A drainage plan that may work satisfactorily under ultimate watershed development conditions may be problematic during interim conditions due to sheetflow from adjacent undeveloped land. Accommodate such sheetflow in a controlled manner around, or through, the proposed development and into a detention basin and/or outfall channel without creating an adverse impact.

See A.11, Off-Site Sheetflow Examples in Appendix A for more detail.

Considerations 6.17.2

Some alternative approaches for accommodating off-site sheetflow are:

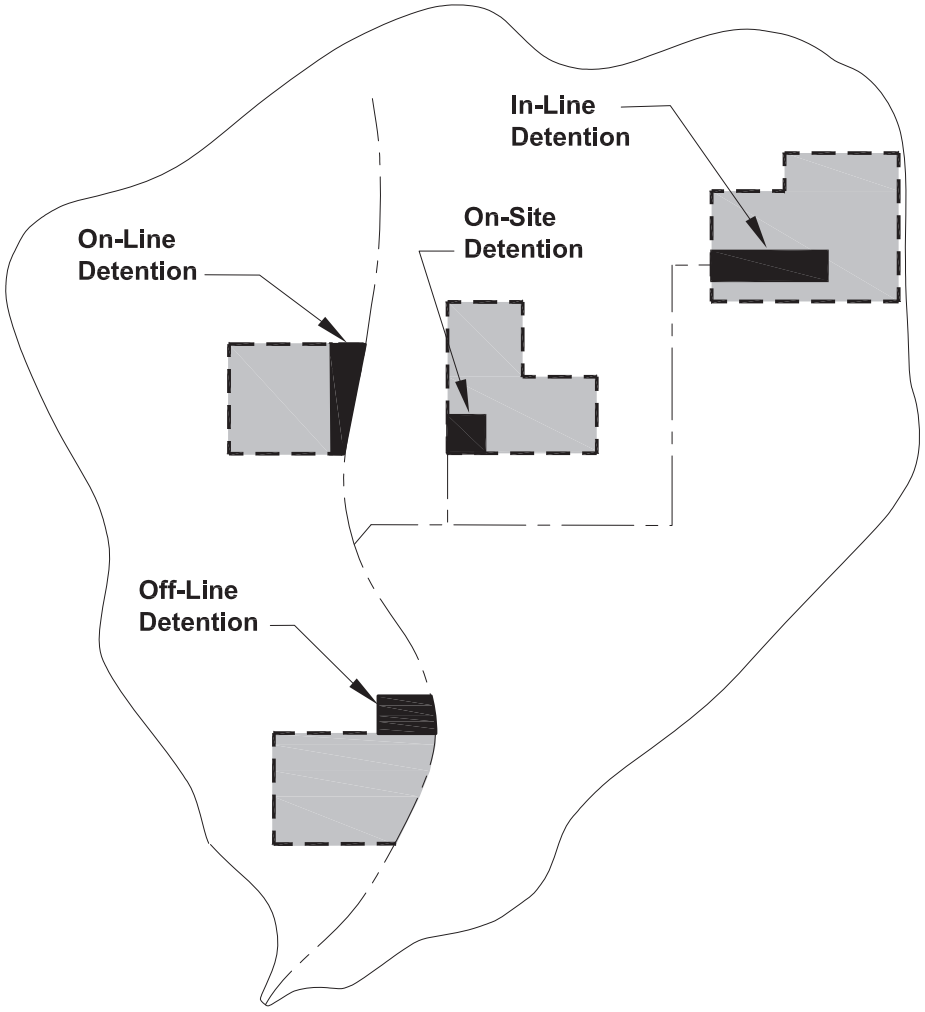
- Accept off-site sheetflow into the development's storm sewer and detention system. Upsize the internal storm sewer, sheetflow system, and development's detention system, as necessary, to accommodate the additional off-site undeveloped or existing development flow. When the off-site undeveloped property develops, they are responsible for conveying and mitigating their developed condition flows.
- Provide a drainage swale in a dedicated easement to convey the off-site runoff around the development and through the development's detention system.
- Provide a drainage swale in a dedicated easement to convey the off-site runoff around the development, by-passing the development's detention system and directly into the HCFCD channel.
- Analyze the conditions with and without the offsite flow and design the outlet for both conditions such that it can be retrofitted or that no retrofit is needed if the offsite area is redirected away from the detention basin in the future.

6.18 Detention Summary

Detention Summary Table 6.18.1

For modified or new detention facilities, include the following detention summary table in the drainage or design report (see Chapter 19, Report Requirements.)

	Project Name:			Date: **xx-xx-xxxx**
	Detention Basin Service Area			acres
	Offsite Drainage Area			acres
	Storm Event	50% (2-yr)	10% (10-yr)	1% (100-yr)
Flows (cfs)	Post-development Inflow			
	Maximum Allowable Outflow (pre-development peak flow)			
	Maximum Outflow Provided (peak flow from basin)			
Elevations (1988 NGVD, 2001 Adj.)	Lowest Natural or Finished Ground Elevation Estimate			
	Maximum Allowable Water Surface			
	Based on			
	Design Water Surface Elevation			
	Water Surface Elevation Calculated			
Storage	Minimum Storage Required (ac-ft)			
	Detention Storage Provided (ac-ft)			
	Storage Rate Provided (ac-ft/acre)			
Outflow Structure	Restrictor Size, if applicable (ft or ft^2)			
	Outflow Pipe Size (ft or ft^2)			
	Outflow Velocity into Channel (ft/second)			
	Weir Description, if applicable (type, size, elevation, etc.)			
	Drain Time – 1% only (hours)			
	Emergency Overflow (type, size, elevation, etc.)			



LEGEND

Watershed Boundary

Outfall Channel

Development

Detention

See Appendix E for definitions

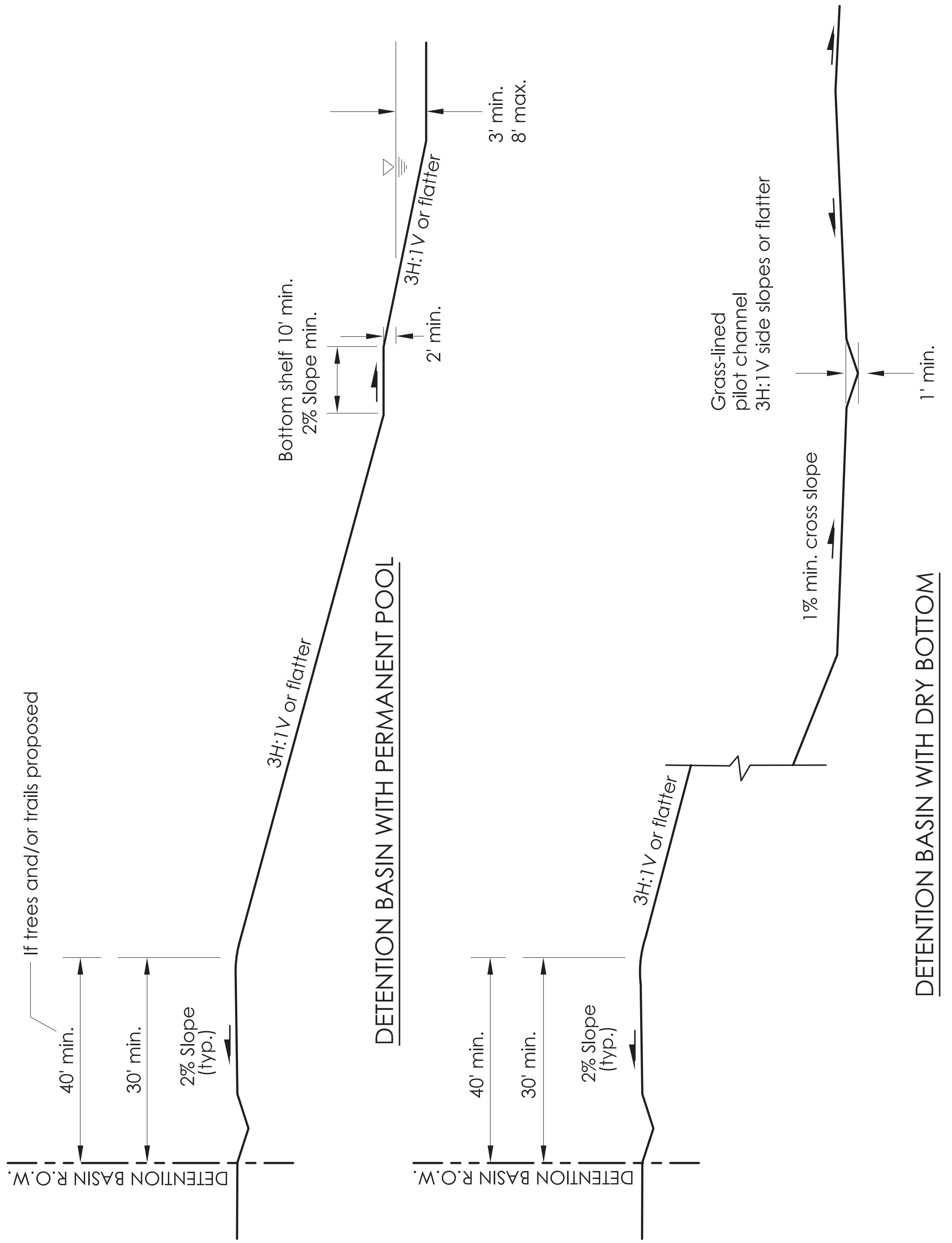
HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

TYPES OF DETENTION

DATE: 10/23/2018

EXHIBIT 6-1



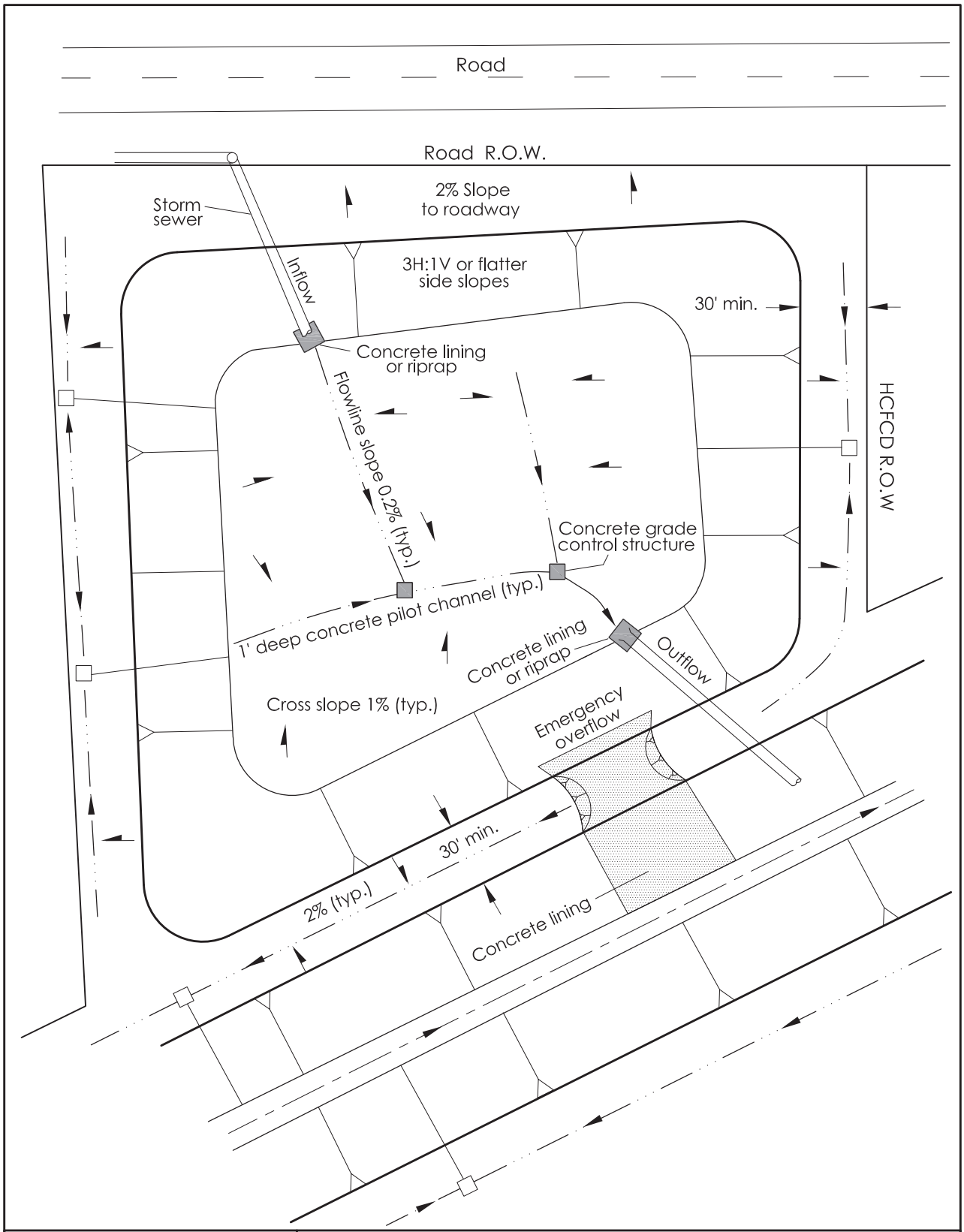
HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

TYPICAL DETENTION BASIN SECTIONS

DATE: 10/23/2018

EXHIBIT 6-2



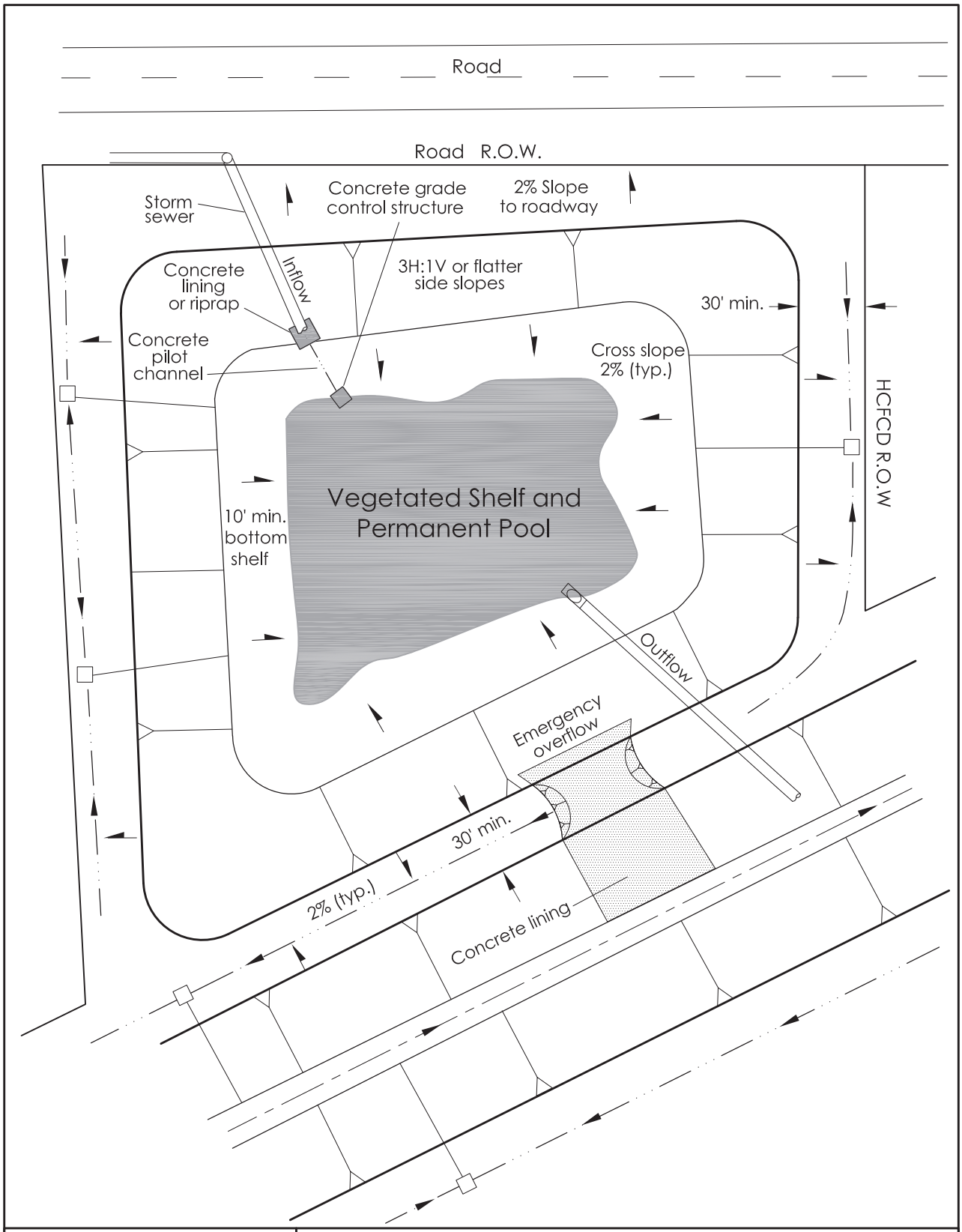
HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

WELL-GRADED, "DRY" DETENTION BASIN

DATE: 10/23/2018

EXHIBIT 6-3

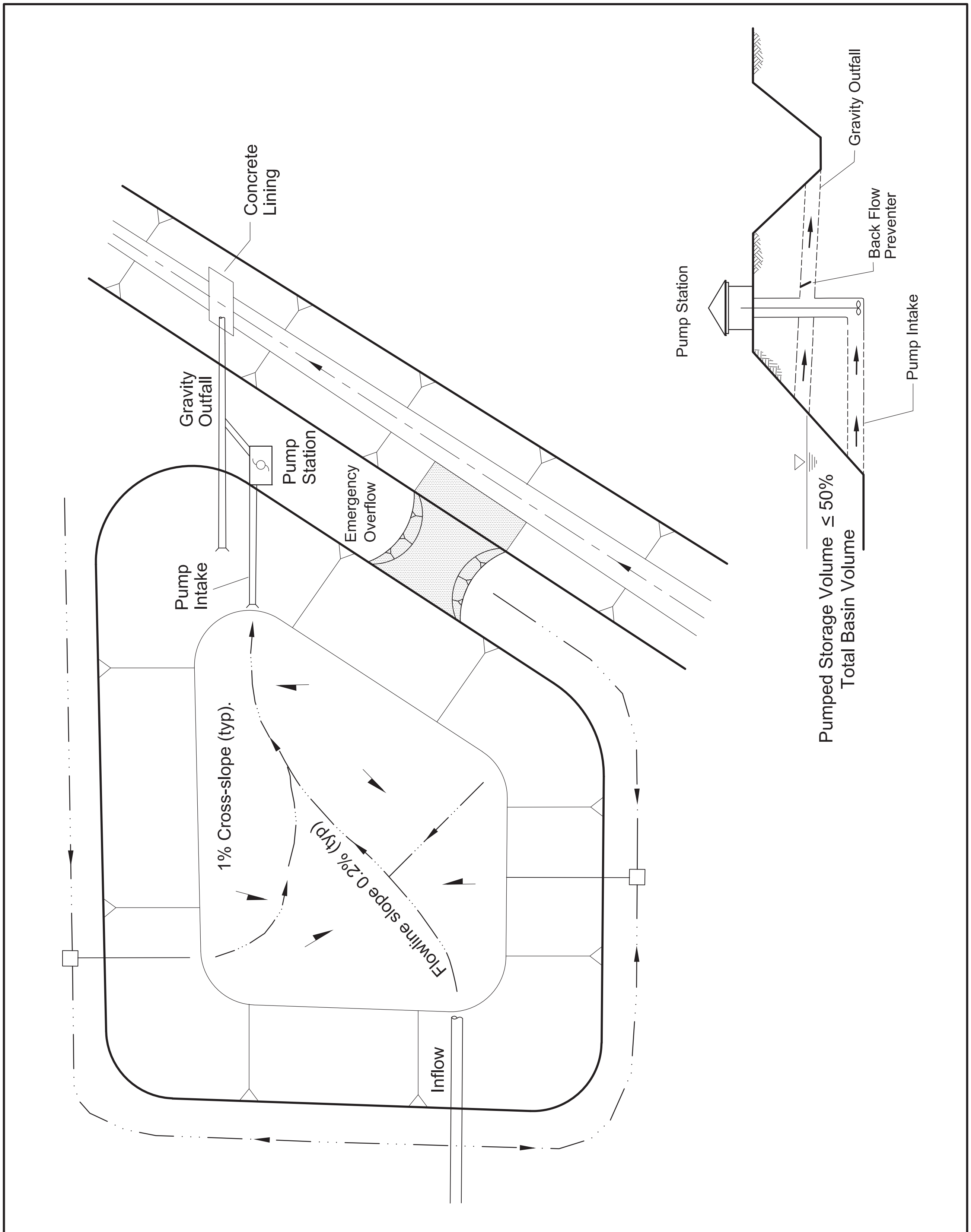


HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

"WET" BOTTOM DETENTION BASIN

DATE: 10/23/2018	EXHIBIT 6-4



HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

PUMPED DETENTION FACILITY SCHEMATIC

DATE: 10/23/2018

EXHIBIT 6-5

SECTION 7 – BRIDGES

7.1 Introduction

Overview 7.1.1

Bridges can cross HCFCD facilities provided the criteria and procedures in this manual are followed and the bridge owner agrees to the conditions specified in this manual.

The criteria presented in this manual apply to road, utility and pipeline bridges, and both public and private bridges.

See A.12, Bridge Examples in Appendix A.

Review and Coordination 7.1.2

The review and coordination process for bridges proposed to be placed in a HCFCD maintained facility is presented in Section 2.9, Non-Flood Control Features.

Early coordination with HCFCD is recommended, particularly in obtaining concurrence on the location within the HCFCD maintained facility.

Criteria 7.1.3

HCFCD acceptance criteria for placing or modifying a bridge within a HCFCD maintained facility are presented in Section 2.2.7, Non-Flood Control Features Allowed in a HCFCD Facility.

Use the criteria of the jurisdiction responsible for the bridge design and construction. Specific criteria related to the bridge being in a HCFCD facility are in this section. If the HCFCD criteria provided in Section 7.2.1, Hydraulic Criteria conflicts with the jurisdiction's criteria, use the more stringent criteria.

In addition, contact the HCFCD Watershed Management Department for specific criteria, standard notes, and guidelines that the HCFCD and Texas Department of Transportation (TXDOT) mutually developed for TXDOT bridges.

Easements 7.1.4

The procedure for acquiring an easement within a HCFCD fee strip or easement for a bridge crossing is in Section 15.4, Easements for Pipelines, Utilities, and Roadways.

7.2 Design Criteria

Hydraulic Criteria 7.2.1

The criteria in this Chapter assumes that the effective hydrologic and hydraulic models and methodology will be used for analysis. When the effective models are used, the 0.2% event must also be considered. If the bridge is on an unstudied stream with no effective models, coordinate with HCFCD WMD to define the correct project approach and design storms to be included.

- Design the bridge to pass the 0.2%, 1% and 10% exceedance event flows without causing adverse impacts (Section 1.3.3, Policy III: No Adverse Impact) or erosion problems in the channel or detention basin for existing and ultimate conditions. Confirm no adverse impacts for the bankfull event also if the 10% exceedance event water surface elevation is above the bank.
- For new bridges on all channels, set the low chord at the center of the bridge 1.5 feet or more above the existing or ultimate 1% exceedance water surface, or the effective 0.2% water surface, whichever is higher.

  Note: If vertical and horizontal roadway transitions and traffic safety issues are problematic due to the bridge elevation, coordinate a resolution with the HCFCD and entity responsible for the bridge and roadway.
- For replacement bridges:
  - Set the low chord at the center of the bridge 1.5 feet or more above the existing or ultimate 1% exceedance water surface, or 0.2% water surface, whichever is higher, if possible without causing an impact on the existing 0.2% exceedance water surface profile, or
  - Match the existing bridge roadway and approach profile, unless a channelization or detention basin project is proposed in conjunction with the bridge to offset impacts caused by the proposed bridge and ensure no adverse impact for the 0.2%, 1%, and 10% events.
- Bridge span length criteria:
  - As a minimum, span the existing full channel top width (do not narrow the channel at the bridge).
  - Span the ultimate channel top width, where possible (see Section 7.2.2, Structural Criteria).
  - Extend the bridge beyond the channel top width where the floodway and/or floodplain are wide and it is necessary to satisfy the no adverse impact criteria.
- Align bents and abutments within the channel parallel to the general direction of flow in the channel to minimize obstruction of flow.
- Minimize number of bridge bents in the channel and locate them outside of the channel bottom, if possible, to reduce debris buildup and head loss.
- Accommodate the low flow channel through the center span.

Continued on next page

7.2 Design Criteria, Continued

Hydraulic Criteria 7.2.1 (continued)

- When the average channel velocity for the 1% exceedance flood is larger than 4 feet per second and bents with individual piles are employed, use round piles to reduce debris buildup, turbulence, and head loss.
- See Section 11.3, Pipe Outfalls for criteria regarding storm sewer outfalls.

Structural Criteria 7.2.2

- Arrange bent locations and span lengths to accommodate the existing, interim, and ultimate channel sections.
- Design piles or piers for the existing, interim, and ultimate channel sections, velocities, and potential scour.
- If the bridge is not constructed to span the ultimate channel, design the bridge so it can be expanded to accommodate the ultimate channel later. For example, design the piles and caps in the interim bridge abutment to also perform as an interior bent when the bridge is lengthened for the ultimate channel and the channel is deepened.
- Erosion protection such as concrete lining, riprap, or shade and drought tolerant vegetation is recommended under the bridge on the channel side slopes, and if necessary, in the channel bottom.
- Submit a geotechnical investigation report with the construction drawings.

Access to HCFCD Facilities at Bridges 7.2.3

The primary access to HCFCD channels, and some detention basins, for inspection, maintenance, repairs, rehabilitations, and modifications is at bridge crossings. In many cases, a guardrail physically blocks access.

Provide a minimum 20-foot wide unobstructed vehicular access around existing and future guardrails, walls, above and below ground utilities, utility poles and boxes, plantings, etc. to HCFCD maintained facilities at bridge crossings within a road right-of-way, HCFCD easement, and/or public drainage easement where required by the Maintenance Access Plan (see Section 5.3.9, Maintenance Access Plan).

For curb and gutter major thoroughfares, include a curb cut driveway access to the HCFCD right-of-way.

A minimum 20 foot wide and 10’x10’x15’ corner clip HCFCD right-of-way is required adjacent to the road right-of-way for access to HCFCD channels and detention basins for maintenance access. See Exhibit 7-1 for a typical layout. Coordinate width and location with the HCFCD Watershed Management Department.

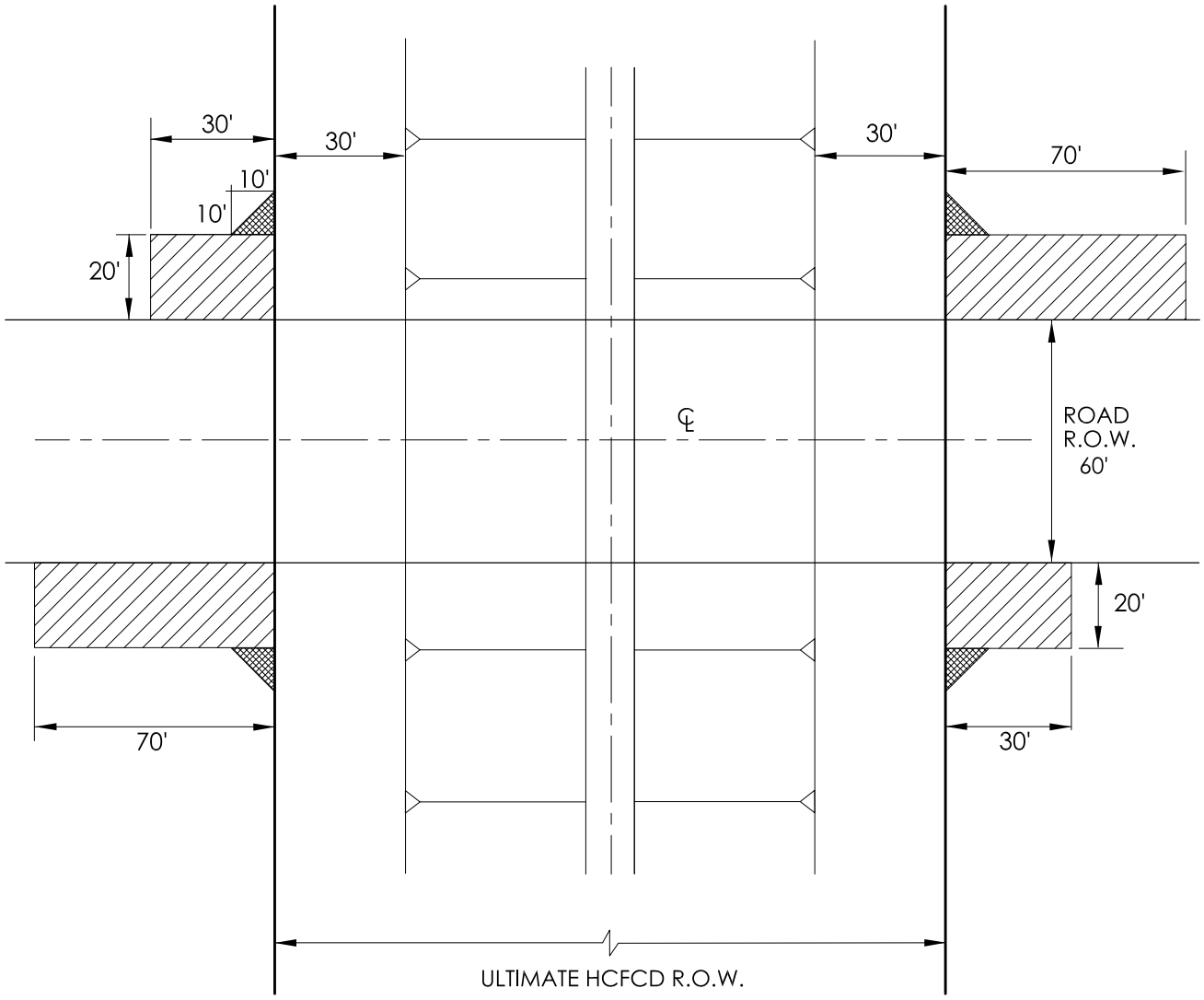
7.3 Hydraulic Analysis

Methodology 7.3.1

Several methods and equations are available for computing head losses through a bridge. The bridge routines in the HEC-RAS computer program are recommended for hydraulic analyses of bridges.

Submittal Requirements 7.3.2

- Hydraulic analysis showing no adverse impacts in the 0.2%, 1% and 10% exceedance water surface profiles upstream and downstream of the bridge for both interim and ultimate development of the watershed (see Section 19, Report Requirements).
- Hydraulic analysis showing no adverse impacts for the bankfull event, if necessary.
- For bridges on FEMA studied streams, also follow the FEMA and Flood Plain Administrator's submission and review requirements.



Additional HCFCD R.O.W. for maintenance access

Corner clip additional HCFCD R.O.W. for maintenance access

HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

ACCESS TO HCFCD FACILITIES FROM ROADWAYS, BRIDGES AND CULVERTS

DATE: 10/23/2018

EXHIBIT 7-1

SECTION 8 – CULVERTS

8.1 Introduction

Overview
8.1.1

Culverts can be used to cross HCFCD maintained facilities provided the criteria and procedures in this manual are followed and the culvert owner agrees to the conditions specified in this manual.

The criteria presented in this manual apply to road, utility, and pipeline culverts and both public and private culverts.

Criteria and analysis for culverts used in detention basin outflow control structures are presented in Section 6.7, Outflow Structures.

See A.13, Culvert Examples in Appendix A.

Review and Coordination
8.1.2

The review and coordination process for culverts proposed to be placed in a HCFCD facility is presented in Section 2.9, Non-Flood Control Features.

Early coordination with HCFCD is recommended, particularly in obtaining concurrence on the location within the HCFCD maintained facility.

Criteria
8.1.3

HCFCD acceptance criteria for placing a culvert within a HCFCD maintained facility are presented in Section 2.2.7, Non-Flood Control Features Allowed in a HCFCD Facility.

Use the criteria of the jurisdiction responsible for the culvert design and construction. Specific criteria related to the culvert being in a HCFCD facility are in this section. If HCFCD criteria conflicts with the jurisdiction's criteria, use the more stringent criteria.

Easements
8.1.4

The procedure for acquiring an easement within a HCFCD fee strip or easement for a culvert crossing is in Section 15.4, Easements for Pipelines, Utilities, and Roadways.

8.2 Design Criteria

Hydraulic Criteria 8.2.1

The criteria in this Chapter assumes that the effective hydrologic and hydraulic models and methodology will be used for analysis. When the effective models are used, the 0.2% event must also be considered. If the bridge is on an unstudied stream with no effective models, coordinate with HCFCD WMD to define the correct project approach and design storms to be included.

- Design the culvert to pass the 0.2%, 1% and 10% exceedance event flows without causing adverse impacts (Section 1.3.3, Policy III: No Adverse Impact) or erosion problems in the channel or detention basin for existing and ultimate watershed development conditions. Confirm no adverse impacts for the bankfull event also, if the 10% exceedance event water surface elevation is above the bank.
- Design the culvert in coordination with the channel or detention basin to satisfy the required minimum one foot of freeboard (see Section 5.3.1, Design Frequency and Freeboard and Section 6.3.5, Critical Water Surface Elevations and Freeboard).
- Align the culvert parallel to the general direction of flow in the channel to minimize obstruction of flow.
- Avoid placing culverts in channel bends and areas of high turbulence.
- Minimize number of culvert barrels in the channel to reduce debris build-up and head loss.
- Use 0.013 for the Manning's "n" roughness coefficient for concrete pipe and box culverts.
- For multi-barrel culverts, accommodate the earthen or structural low flow channel through the culvert by setting the center barrel flowline at least one foot lower than the other barrels. Set the center barrel flowline at the existing channel flowline or the flowline of the proposed or modified channel. For even number barreled culverts or where the low flow is not in the center of the culvert array, select the one closest to the low flow channel to match the flowline.
- See Section 8.2.2, Structural Criteria for criteria regarding accommodation of the ultimate channel.
- See Section 11.3, Pipe Outfalls for criteria regarding storm sewer outfalls in the vicinity of a culvert.

Continued on next page

8.2 Design Criteria, Continued

Structural Criteria 8.2.2

- Arrange number and size of barrels to accommodate the existing and ultimate channel sections.
- If the culvert is not constructed for the ultimate channel, design the culvert so it can be modified or expanded to accommodate the ultimate channel later.
  - Example 1: Design the interim culvert to accommodate another barrel added later to carry the higher flow.
  - Example 2: If the ultimate channel is deeper, design and construct the culvert at the ultimate flowline and backfill with granular fill up to the existing channel flowline.
- Use concrete culverts, such as precast concrete pipes or boxes or monolithic concrete boxes.
- Use a non-reinforced concrete seal slab under monolithic concrete boxes and cement stabilized sand bedding for precast pipes or boxes.
- Include headwalls and/or wingwalls and smooth flow transitions with appropriate concrete lining and riprap to protect the channel from erosion, and reduce turbulence and head loss (see Section 5.7, Horizontal Transitions and Section 10, Erosion and Sediment Control).
- Include handrails and/or guardrails where necessary for public safety.
- Use structural erosion protection such as concrete lining or riprap upstream and downstream of the culvert where the velocity exceeds the maximum for the soil type (see Section 4.4, Velocities).
- Submit a geotechnical investigation report with the construction drawings, as necessary.

Continued on next page

8.2 Design Criteria, Continued

Access to HCFCD Facilities at Culvert Crossings 8.2.3

The primary access to HCFCD channels and some detention basins from roadways for inspection, maintenance, repairs, rehabilitations, and modifications is at culvert crossings. In some cases, a roadway guardrail or wing wall physically blocks access.

Provide a minimum 20-foot wide unobstructed vehicular access around existing and future roadway guardrails, walls, above and below ground utilities, utility poles and boxes, plantings, etc. to HCFCD maintained facilities at culvert crossings within a road right-of-way, HCFCD easement, and/or public drainage easement where required by the Maintenance Access Plan (see Section 5.3.9, Maintenance Access Plan).

For curb and gutter major thoroughfares, include a curb cut driveway and gate access to the HCFCD right-of-way.

A minimum 20 foot wide and 10'x10'x15' corner clip HCFCD right-of-way is required adjacent to the road right-of-way for access to HCFCD channels and detention basins for maintenance access. See Exhibit 7-1 for a typical layout. Coordinate width and location with the HCFCD Watershed Management Department.

An alternative at culvert crossings is to provide a continuous 20-foot access from one side of the channel to the other side between the end of the culvert and the roadway guardrail by extending the culvert.

8.3 Hydraulic Analysis

Methodology 8.3.1

Several methods and equations are available for computing head losses through a culvert. Many are based on the Federal Highway Administration's publication *Hydraulic Design of Culverts*.

Use HEC-RAS or an applicable culvert design program to compute head losses through a culvert.

Flow Classification 8.3.2

Use outlet control for analysis of culverts in channels unless the channel slope is steeper than 1% or the culvert is part of a drop structure. In those cases, determine if the flow classification is inlet control or outlet control.

Submittal Requirements 8.3.3

- Hydraulic analysis showing no adverse impacts in the 0.2%, 1% and 10% exceedance water surface profiles upstream and downstream of the culvert for both interim and ultimate development of the watershed (see Section 19, Report Requirements).
- Hydraulic analysis showing no adverse impacts for the bankfull event, if necessary.
- For culverts on FEMA studied streams, also follow the FEMA and Flood Plain Administrator’s submission and review requirements.

APPENDIX A – APPLICATIONS AND EXAMPLES

Note: (Section 3.3) refers to applicable section in the main body of the HCFCD Policy, Criteria, and Procedure Manual.

The applications and examples included in this appendix were created prior to the availability of updated rainfall depth, duration and frequency data published in NOAA Atlas 14 Volume 11 Version 2.0 Texas, 2018. Users of this manual should be aware that use of the updated rainfall and associated data may produce different results. However, the approach and methodology in the applications and examples remain useful in illustrating the policies, criteria, and procedures of this manual.

Where use of the Rational Method is noted in these applications and examples, the user should be aware that existing IDF curves used for calculating rainfall intensities are also affected by Atlas 14. Where local jurisdictions have not yet updated IDF curves, coordinate with HCFCD WMD to obtain updated IDF information.

Applications and Examples Introduction

Purpose

The Applications and Examples in Appendix A are intended to help the engineering community plan, design, and build successful stormwater management facilities associated with land development and infrastructure projects. Besides realistic examples, practical guidance, considerations, and suggested approaches are included.

Limitations

These applications and examples are intended to represent the more common flood control design situations in Harris County. There will be situations or an engineer's preference that merit a different analytical or design approach than illustrated by these examples. Close coordination with the HCFCD is recommended during the planning and design of all flood control facilities.

The applications and examples included in this appendix were created prior to the availability of updated rainfall depth, duration and frequency data published in NOAA Atlas 14 Volume 11 (Texas), 2018. Users of this manual should be aware that use of the updated rainfall and associated data may produce different results. However, the approach and methodology in the applications and examples remains useful in illustrating the policies, criteria, and procedures of this manual. In addition, existing IDF curves used for calculating rainfall intensities in the Rational Method are also affected by Atlas 14. Where local jurisdictions have not yet updated IDF curves, coordinate with HCFCD WMD to obtain updated IDF information.

Audience

This appendix was prepared primarily for users with knowledge and experience in the applications of standard engineering principles and practices of stormwater design and management.

References

References to other documents are abbreviated in this appendix as follows:

PCPM	HCFCD Policy, Criteria and Procedure Manual
H&H Guidance Manual	Harris County Flood Control District Hydrology & Hydraulics Guidance Manual

Thanks

Thanks to McDonough Engineering, Brown & Gay Engineers, and Dannebaum Engineering for their assistance and hard work in developing these examples in coordination with the HCFCD. Also, thanks to ACEC and ASCE Houston Chapters for their valuable and practical input and review comments.