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POLICY, CRITERIA, AND PROCEDURE MANUAL FOR APPROVAL AND ACCEPTANCE OF INFRASTRUCTURE

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Chapters and Standard Details Only; No Appendices

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INTRODUCTION

I.1 Preface

Introduction I.1.1

The Harris County Flood Control District's (HCFCD) first design criteria manual entitled "Criteria Manual for the Design of Flood Control and Drainage Facilities" was adopted by Harris County Commissioners Court on February 21, 1984. Since the original manual was published, experience with constructed facilities and changes in community preferences necessitated updating policy and criteria. On October 5, 2004, the first major update was adopted by Harris County Commissioners Court entitled "Policy, Criteria, and Procedure Manual for Approval and Acceptance of Infrastructure". The first update of the October 5, 2004 manual consisted of 2 new policies, clarifications, additions, and improvements and was approved by Harris County Commissioners Court on December 21, 2010. This is the second update of the 2004 manual.

Goal I.1.2

Plan, design and build stormwater management facilities in a consistent manner that will:

- Work when needed.
- Require only routine maintenance.
- Be cost effective.
- Respect community and natural values.

Objectives I.1.3

Provide written policies and criteria for the engineering community and HCFCD staff to use for land development and infrastructure projects that are effective, consistent, and practical.

Provide a written review and acceptance procedure to efficiently coordinate land development and infrastructure projects with the HCFCD.

Limitations I.1.4

This manual is intended to provide a guideline for the most commonly encountered flood control designs in Harris County. The manual was written for users with knowledge and experience in the applications of standard engineering principles and practices of stormwater design and management.

There will be situations not covered by this manual that merit variations to the criteria specified in this manual. Other methods of design or exceptions to criteria are permissible provided the variance procedure in this manual is followed. Close coordination with the HCFCD is recommended during the planning, design, and construction of all flood control facilities.

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I.1 Preface, Continued

Warning
I.1.5

The minimum degree of flood protection required by these policies and associated design criteria is considered reasonable for approving work within HCFCD right-of-way and is based on scientific and engineering considerations. On occasion, greater floods may occur and flood heights higher than expected from man-made or natural causes. These policies and design criteria do not imply that any area or the work within an area will be free from flooding or flood damage.

Disclaimer of Liability
I.1.6

The policies and design criteria in this manual shall not create liability on the part of the HCFCD, Harris County, or any officer or employee thereof for any flood damages, property damage, or personal injury that results from reliance on these policies or any administrative decision lawfully made.

Changes
I.1.7

Changes to the Policy, Procedures, and Criteria in Sections 1-19 must be approved by Harris County Commissioners Court.

Changes to the Appendices which contain forms, checklists, standards, etc. must be approved by the HCFCD Executive Director.

I.2 Transition Plan

Introduction
I.2.1

The objective of the transition plan is to apply the updates as quickly as possible without causing undue hardships to ongoing projects. Since the changes in this update are not nearly as extensive as the October 5, 2004 update, the transition plan is simpler and not as lengthy.

Adoption and First Update
I.2.2

This manual was originally adopted by Harris County Commissioners Court on October 5, 2004. The first update was approved by Harris County Commissioners Court on December 21, 2010.

Second Update Approval
I.2.3

This second update to the 2004 manual was approved by Harris County Commissioners Court on xxxxxx xx, 2018

Policy and Procedures
I.2.4

Effective immediately upon approval by Harris County Commissioners Court for all projects are:

- Section 1, Policy.
- Section 2, Review and Acceptance Procedures.

Criteria
I.2.5

All criteria in this manual are important for the successful design, construction, and function of HCFCD facilities. The HCFCD encourages using the "new and improved" criteria as soon as practical.

HCFCD approval time periods in Section 2.3.6, Signature Expiration, are unchanged and will be honored.

Effective dates for Sections 3-19 are provided below based on the project status on the day of adoption of this update: *sf to change*

Stage 1, Initiation (New)	Effective immediately
Stage 2, Drainage or Design Report	Effective July 1, 2011 (six months)
Stage 3, Construction Drawings	Effective July 1, 2011 (six months)
Stage 4, Construction	Not applicable
Stage 5, Acceptance	Not applicable

Note: See Section 2.4, Review and Coordination Process Overview for explanation of stages.

I.3 Acknowledgements

Thanks
I.3.1

The HCFCD would like to thank Brown & Gay Engineers, Dannebaum Engineering Corporation, and McDonough Engineering Corporation for their assistance with preparing the Applications and Examples, and the American Council of Engineering Companies of Houston, Drainage Subcommittee for their valuable suggestions and input on the updates in this manual.

Thanks also to the following organizations for their valuable input and review comments: *sf to update*

American Council of Engineering Companies of Houston
American Society of Civil Engineers
Bayou Preservation Association, Inc.
Brays Bayou Association
Cypress Creek Flood Control Coalition
Greens Bayou Coalition
Katy Prairie Conservancy
Greater Houston Builders Association
Houston Real Estate Council

Harris County Engineering Department - Permits
Public Works Department
Texas Department of Transportation

SECTION 1 – POLICY

1.1 Overview

Authority 1.1.1

These policies, design criteria, and procedures are adopted by the Commissioners Court of Harris County, Texas, acting in its capacity as the governing body of the Harris County Flood Control District (HCFCD) and Harris County.

Associated Regulations 1.1.2

Associated regulations may be found in:

- Regulations of Harris County, Texas for Flood Plain Management.
- Regulations of Harris County, Texas for the Approval and Acceptance of Infrastructure.
- Regulations of Harris County, Texas for Stormwater Quality Management.
- 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

HCFCD Enabling Legislation 1.1.3

Harris County Flood Control District was created by the 45th Texas Legislature under Article XVI §59 of the Texas Constitution. HCFCD was charged with "*the control, storing, preservation, and distribution of the storm and flood waters, and the waters of the rivers and streams in Harris County and their tributaries, for domestic, municipal, flood control, irrigation and other useful purposes, the reclamation and drainage of the overflow land of Harris County, the conservation of forests, and to aid in the protection of navigation on the navigable waters by regulating the flood and storm waters that flow into said navigable streams.*"

As a political subdivision of state government, HCFCD can legally perform only those responsibilities specified by the State Legislature.

Area Covered by Policies, Design Criteria, and Procedures 1.1.4

These policies apply:

- To geographical areas within the jurisdiction of HCFCD which is Harris County, Texas.
- To areas where HCFCD owns and/or maintains the rights-of-way, including "bed and banks".
- As required by Harris County regulations.

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1.1 Overview, continued

Definitions 1.1.5

The following words and terms, when used in these policies, will have these meanings unless the context clearly indicates otherwise:

- Commissioners Court – Commissioners Court of Harris County, Texas.
- Harris County – Denotes the Harris County Engineering Department which is responsible for administration of the regulations of Harris County.
- HCFCD – Harris County Flood Control District.
- HCFCD Facility – Any infrastructure managed by HCFCD. These may include, but are not limited to, rivers, streams, bayous, creeks, tributaries, channels, detention basins, land, buildings, and associated infrastructure.
- HCFCD Stormwater Management System – A record of facilities accepted by Commissioners Court for management and maintenance by HCFCD.
- HCFCD Right-of-Way (ROW) – Implies HCFCD has property rights to manage the HCFCD facility. This includes:
  1. Property owned in fee by HCFCD.
  2. HCFCD drainage or flooding easement conveyed to and accepted by HCFCD through Commissioners Court.
  3. A public drainage easement accepted by HCFCD through Commissioners Court into the HCFCD Stormwater Management System.
  4. A channel's bed and banks as defined in the HCFCD's enabling legislation.
- Main Stem – The primary river, stream, bayou, creek, or channel within the watershed or sub-watershed as listed in Appendix F.
- Primary Drainage Facility – Generally an open conveyance system such as a river, stream, bayou, creek, detention basin, or channel serving area-wide drainage from infrastructure constructed upon public rights-of-way and eligible for acceptance by HCFCD through Commissioners Court into the HCFCD Stormwater Management System.
- Projects by Others – A general term to denote any construction within HCFCD ROW by someone other than HCFCD, or a primary drainage facility constructed by someone other than HCFCD eligible for acceptance into the HCFCD Stormwater Management System.

1.2 Purpose and Application

Purpose of Policies, Design Criteria, and Procedures 1.2.1

The purpose of these policies, design criteria, and procedures is to:

- Ensure the ability of the HCFCD facility to function as intended.
- Avoid increases in flood risks or flood hazards or create new flood hazard areas.
- Ensure the constructed infrastructure within HCFCD ROW performs its intended function with normal maintenance and repair.
- Ensure compliance with enabling legislation.
- Provide procedures for the review and approval of constructing infrastructure within HCFCD ROW.
- Provide procedures for acceptance by HCFCD through Commissioners Court of infrastructure into the HCFCD Stormwater Management System for management and maintenance.
- Provide procedures to address requests for variances.
- Minimize conflicts that may occur between a HCFCD flood damage reduction project, either on-going or proposed, and projects by others.
- Support continued participation in the National Flood Insurance Program by Harris County and the local communities.
- Ensure the opportunity to continue to modify and expand the primary drainage facilities as the area develops.
- Ensure HCFCD facilities are in compliance with applicable federal, state, and local regulations.

Application of Policies, Design Criteria, and Procedures 1.2.2

These policies, design criteria, and procedures apply when:

- Proposing to construct infrastructure within or adjacent to a HCFCD facility.
- Proposing an infrastructure to be accepted by HCFCD through Commissioners Court into the HCFCD Stormwater Management System.
- Required by Harris County regulations.

1.3 Policies

Policy I: Primary Function of a HCFCD Facility 1.3.1	The primary function of a HCFCD facility is to accomplish the responsibilities established by the State Legislature and authorized by Commissioners Court. Consequently, proposed projects by others must be compatible with the primary function of the HCFCD facility. HCFCD reserves the right to withhold approval of any proposed project that, in the opinion of HCFCD, is not compatible with the primary function of the HCFCD facility.
Policy II: Local Flood Plain Management 1.3.2	HCFCD acknowledges and supports participation by local communities in the National Flood Insurance Program. Consequently, projects by others shall comply with all local rules and regulations related to flood plain management.
Policy III: No Adverse Impact 1.3.3	Property owners and public agencies are responsible for not adversely impacting the community, neighbors, future property owners, or HCFCD facilities in terms of flood risks or flood hazards, erosion, and siltation. An adverse impact is an increase in flood risks or flood hazards or an action that causes significant damage to a HCFCD facility.
Policy IV: Harris County Regulations 1.3.4	Projects by others shall comply with all applicable Harris County regulations.
Policy V: Acceptance Into the HCFCD Stormwater Management System 1.3.5	Commissioners Court, on behalf of HCFCD, shall accept drainage infrastructure into the HCFCD Stormwater Management System that complies with HCFCD policies, design criteria, and procedures. Neither Commissioners Court nor the HCFCD are required to accept new facilities or modifications to existing HCFCD facilities for maintenance that do not comply with the policies, criteria, and procedures in this manual, or in HCFCD's experience, will not likely perform or function as intended.

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1.3 Policies, Continued

Policy VI: HCFCD Support of Multi-Use Functions 1.3.6	HCFCD recognizes the opportunities presented by HCFCD facilities to enhance both community and natural values. Consequently, HCFCD supports and encourages such multi-use functions as trails, green space, parks, greenways or corridors, stormwater quality facilities, practice fields, and other recreational and natural features provided they are compatible with the primary function of the HCFCD facility. (See related Policy XIII, Natural Environments and Habitats)
Policy VII: HCFCD Support of Regional Drainage 1.3.7	HCFCD believes an open conveyance system comprised of channels and detention facilities represent the best opportunity to meet the regional needs of area drainage, greenway facilities, and open space. HCFCD will work with the public, engineers, developers, and property owners to define regional drainage plans that work with appropriate regard for community and natural values. HCFCD will aid in the implementation of the regional plan; however, HCFCD cannot guarantee the required rights-of-way, implementation of the regional plan, or the needed system capacity.
Policy VIII: Right-of-Way Dedication/ Conveyance 1.3.8	Establishing adequate right-of-way for the long-term maintenance, operation, and expansion of HCFCD facilities is essential to the success of regional and watershed drainage. New land developments are required to dedicate or convey ultimate right-of-way for HCFCD channels and detention basins within or adjacent to the boundary of the new development. For offsite channel modifications or detention basins, land development projects are required to dedicate or convey only the right-of-way for the HCFCD channel or detention basin necessary for the project.
Policy IX: HCFCD Right to Work on Main Stem 1.3.9	HCFCD, and only HCFCD, is authorized to implement modifications or improvements along main stems for increasing conveyance, flood plain storage compensation, hydraulic mitigation, or other flood control purposes. HCFCD may enter into agreements or contracts with others to accomplish modifications or improvements.

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1.3 Policies, Continued

Policy X: HCFCD Border Bayous 1.3.10	Cedar Bayou, Clear Creek, and Spring Creek define part of the Harris County boundary. HCFCD jurisdiction over these bayous is limited to the watershed within Harris County. No change should occur on these bayous until a comprehensive master plan is adopted by all appropriate jurisdictions. This includes no increase in peak flows from new developments in the watershed and no modification of the main stem, except as allowed in accordance with Policy IX, HCFCD Right to Work on Main Stem. Right-of-way requirements will be based on maintenance of the existing creek or bayou, or a comprehensive master plan as adopted by all appropriate jurisdictional entities.
Policy XI: Levees 1.3.11	New levee systems are strongly discouraged in Harris County. HCFCD has no criteria for levee systems; therefore, HCFCD will not review, approve, accept for maintenance, or provide back-up operation and maintenance for new levee systems.
Policy XII: Water Quality 1.3.12	HCFCD acknowledges and supports the community goal of improving water quality in creeks, bayous, and channels in Harris County and complying with the Texas Pollutant Discharge Elimination System (TPDES) permit. Consequently, projects by others shall comply with all local rules, regulations, and permit conditions related to water quality.
Policy XIII: Natural Environments and Habitats 1.3.13	HCFCD supports and encourages preservation of natural environments; enhancing aquatic, riparian, and upland habitats; and incorporation of natural stable channel design principles and features into or in conjunction with HCFCD facilities.

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.

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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.

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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:
  - Storm sewer outfalls – private or within road right-of-way.
  - 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 wildflowers 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.

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, ~~or~~ 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 criteria 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:
  - Be responsible for the feature at no cost to HCFCD, including construction, repair, rehabilitation, maintenance, and replacement.
  - Repair damages to the HCFCD facility caused by the feature or its construction, repair, rehabilitation, maintenance, or replacement.
  - Remove the feature when it is no longer in use or is abandoned.
- The sponsor acknowledges that HCFCD ~~will~~is not ~~be~~ responsible for repairing or replacing 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 is not responsible for repairing or restoring damages such as slope failures, erosion, siltation, etc. to a HCFCD facility to safeguard, repair, or replace non-flood control features and associated appurtenances.
- 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:~~

~~o 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.~~

~~reation features must be open to the public at no charge.~~

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2.2 Acceptance Criteria, Continued

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

- 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

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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.

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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

HCFCD approvals or signatures on construction drawings or responses to drainage or design reports are valid for two years from the date of the signature. If a HCFCD approval (Right-of-Way Notification) to enter the HCFCD right-of-way for the proposed construction is not obtained within two years of HCFCD's signature, resubmit the construction drawings for review with changes and revisions clearly noted.

HCFCD approvals or responses to master drainage plan reports or multi-phase development project reports are valid for five years from the date of the signature.

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.

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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 ~~and~~, 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.

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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.

Continued on next page

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.
	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 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 ~~interlocal~~ 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.

~~Notes:~~

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

~~Variance requests to make it easier to construct a project is not a sufficient reason for not complying with HCFCD criteria.~~

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) approve or reject 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 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, DCIS 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 ~~interlocal~~ 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, DCIS, 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 ~~interlocal~~ 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.

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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 ~~must be dedicated or conveyed~~ 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 ~~Interlocal~~ Agreements

Overview
2.13.1

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

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

Guidelines 2.13.3

~~Typical~~General guidelines are:

- HCFCD can enter into interlocal agreements only with other governmental entities such as cities, TxDOT, and utility districts. HCFCD ~~cannot~~can enter into ~~interlocal~~specialized agreements with non-government organizations for features such as ~~homeowner associations~~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 ~~interlocal~~ 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 ~~alternation~~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
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

Continued on next page

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

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 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.

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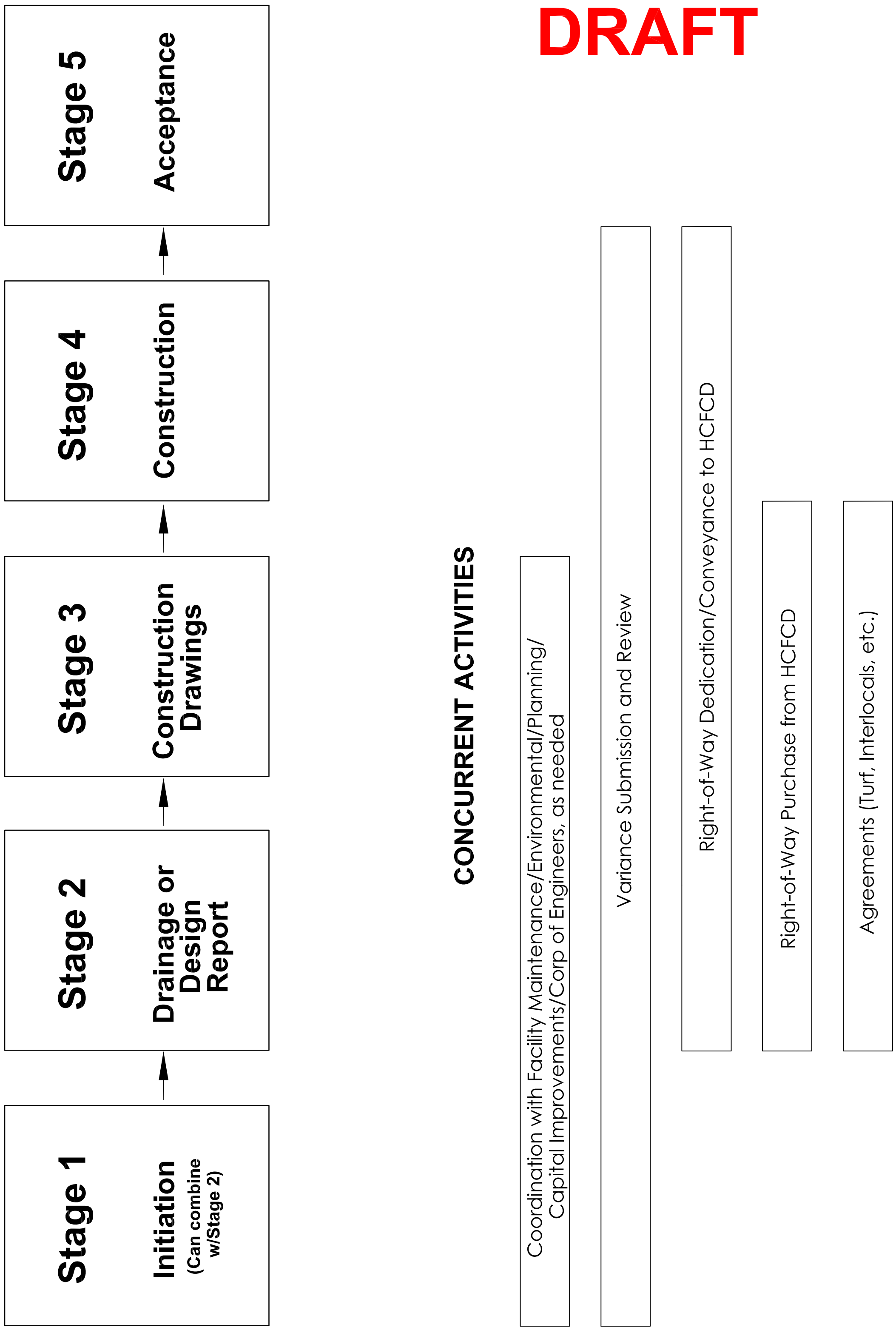


HARRIS COUNTY FLOOD CONTROL DISTRICT — POLICY, CRITERIA, & PROCEDURE MANUAL	REVIEW & COORDINATION PROCESS FOR WORK IN A NEW OR EXISTING HCFCD FACILITY	
	DATE: 8/7/2018	EXHIBIT 2-1

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
H500-01-00
HUNTING BAYOU
ADDICKS RESERVOIR
BARKER RESERVOIR
SHELDON RESERVOIR
HIGHLANDS RESERVOIR
BUFFALO BAYOU
DOWNTOWN HOUSTON
D500-01-00
D500-04-00
D500-06-00
BRAYS BAYOU
D512-01-00
SIMS BAYOU
LITTLE VINCE BAYOU
VINCE BAYOU
CLEAR CREEK

LEGEND

- HARRIS COUNTY BOUNDARY
- CHANNEL NETWORK

COMPLETED

- CHANNEL
- DETENTION BASIN

FUTURE

- CHANNEL
- DETENTION BASIN

DRAFT

HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

DATE: 8/7/2018

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 Watershed Modeling Method for Harris County so peak discharges could be determined for smaller areas using a consistent and simplified methodology.

See A.1, Site Runoff Curve Examples in Appendix A.

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
0.823 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%	0.6	1.2	1.2	2.1	2.0	3.4	2.8	4.8
10%	0.8	1.5	1.5	2.6	2.5	4.3	3.5	5.9
20%	1.0	1.8	1.8	3.1	3.1	5.3	4.3	7.3
30%	1.2	2.1	2.3	3.9	3.8	6.4	5.3	9.1
40%	1.4	2.4	2.7	4.6	4.3	7.3	6.0	10.7
85%	2.2	3.7	3.5	5.9	5.1	8.7	7.1	12.1

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 affects 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.

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.

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	20	100
Residential – Large Lot (Older)	> ¼ acre, older neighborhoods with limited capacity roadside ditches	20	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	60	100
High Density	Commercial, business, industrial, or apartments	85	100
Isolated Transportation*	Highway or major thoroughfare corridors	90	100
Water	Detention basins, lakes, and channels	100	100

Note: Based on 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.

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 not 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 ~~Hydrology and Hydraulics Guidance Manual~~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)	12.4	7.9	9.7	11.7
Region 2				
Brays Bayou (D) Buffalo Bayou (W) Greens Bayou (P) Hunting Bayou (H) Luce Bayou (S) San Jacinto River (G) White Oak Bayou (E)	13.2	11.1	12.0	12.9
Region 3				
Armand Bayou (B) Carpenters Bayou (N) Cedar Bayou (Q) Clear Creek (A) Galveston Bay (F) Goose Creek (O) Jackson Bayou (R) Sims Bayou (C) Vince Bayou (I)	13.5	10.6	11.7	13.1

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 ~~Hydrology and Hydraulics Guidance Manual.~~ 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)	7.1	3.5	4.9	6.6
Region 2				
Brays Bayou (D) Buffalo Bayou (W) Greens Bayou (P) Hunting Bayou (H) Luce Bayou (S) San Jacinto River (G) White Oak Bayou (E)	7.6	5.7	6.5	7.3
Region 3				
Armand Bayou (B) Carpenters Bayou (N) Cedar Bayou (Q) Clear Creek (A) Galveston Bay (F) Goose Creek (O) Jackson Bayou (R) Sims Bayou (C) Vince Bayou (I)	7.8	5.2	6.4	7.4

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 ~~Hydrology and Hydraulics Guidance Manual.~~ 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)	4.1	2.0	2.8	3.8
Region 2				
Brays Bayou (D) Buffalo Bayou (W) Greens Bayou (P) Hunting Bayou (H) Luce Bayou (S) San Jacinto River (G) White Oak Bayou (E)	4.4	3.3	3.8	4.2
Region 3				
Armand Bayou (B) Carpenters Bayou (N) Cedar Bayou (Q) Clear Creek (A) Galveston Bay (F) Goose Creek (O) Jackson Bayou (R) Sims Bayou (C) Vince Bayou (I)	4.5	3.0	3.5	4.3

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)	17.7	12.9	14.8	17.0
Region 2				
Brays Bayou (D) Buffalo Bayou (W) Greens Bayou (P) Hunting Bayou (H) Luce Bayou (S) San Jacinto River (G) White Oak Bayou (E)	18.9	16.8	17.6	18.6
Region 3				
Armand Bayou (B) Carpenters Bayou (N) Cedar Bayou (Q) Clear Creek (A) Galveston Bay (F) Goose Creek (O) Jackson Bayou (R) Sims Bayou (C) Vince Bayou (I)	19.3	16.6	17.6	18.9

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 (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.

~~The design engineer has the option to use this technique.~~ 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.

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 in the effective model or the value calculated using direct runoff depths in Section 3.6.6, ~~Direct Runoff, 1% Probability Event;~~ Section 3.6.7, ~~Direct Runoff, 10% Probability Event;~~ and Section 3.6.8~~, Direct Runoff, 50% Probability Event~~.

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

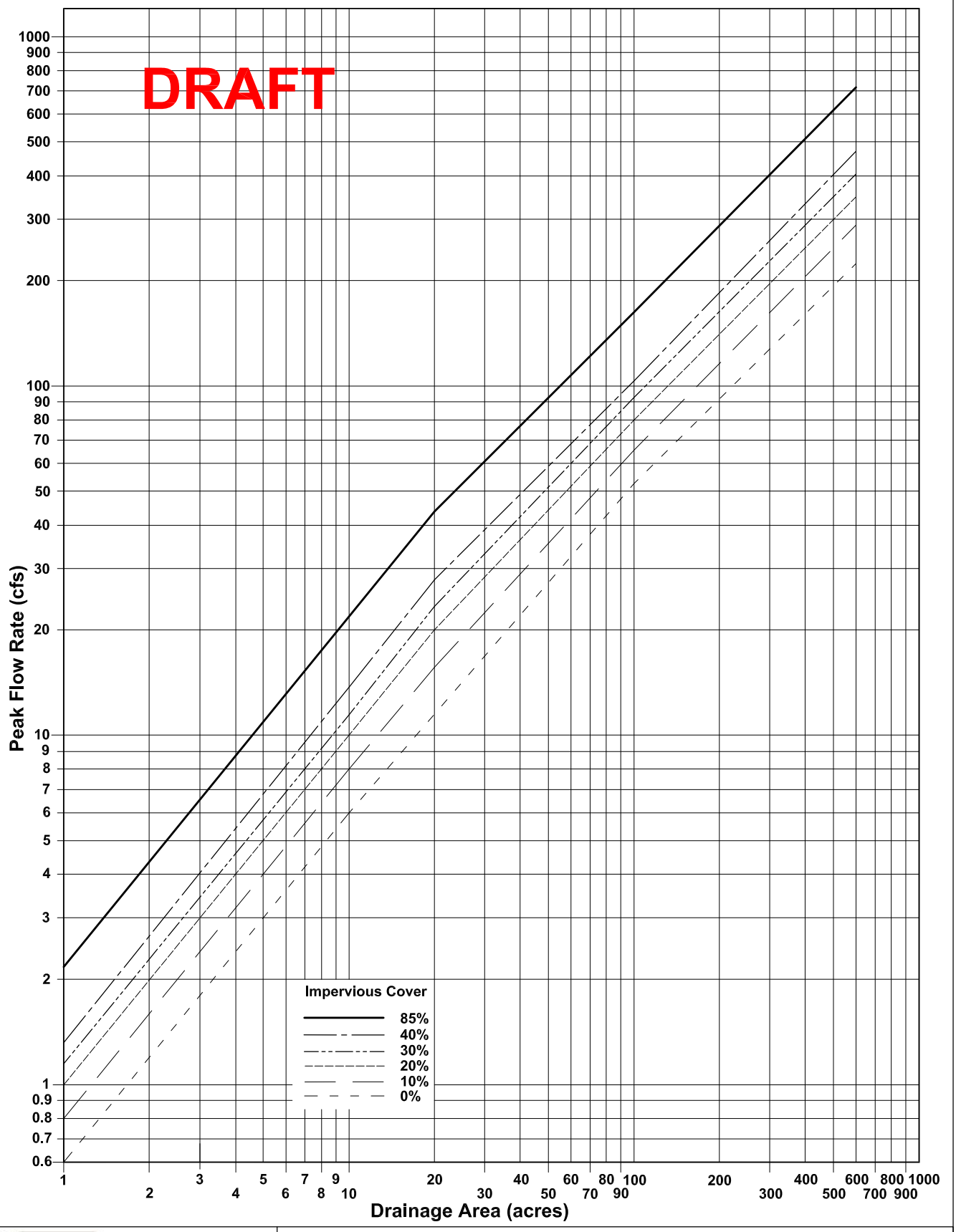
The following criteria applies in addition to the applicable criteria and considerations in the rest of this manual:

- 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.



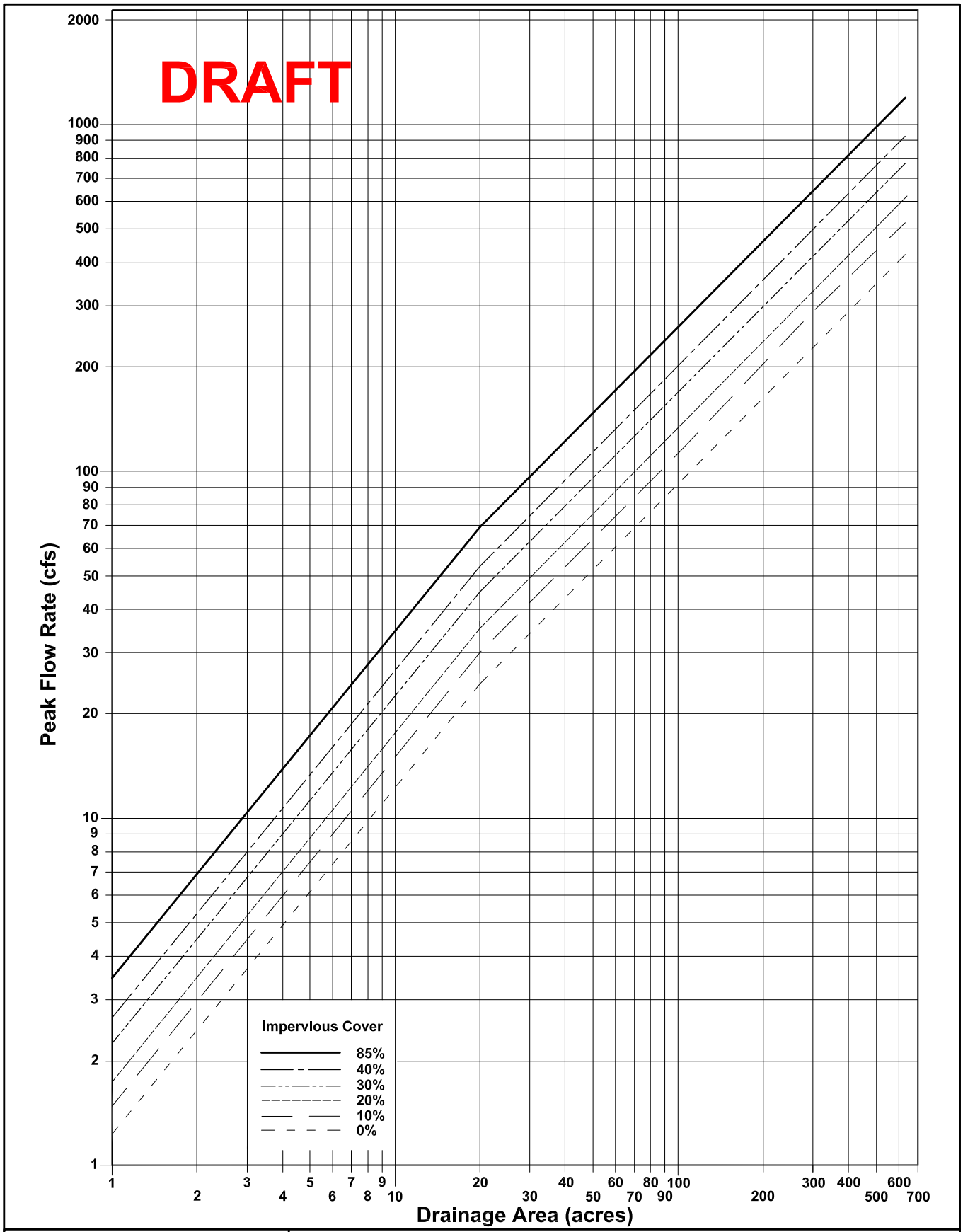
HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY CRITERIA, & PROCEDURE MANUAL

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

DATE: 8/7/2018

EXHIBIT 3-1



HARRIS COUNTY FLOOD CONTROL DISTRICT

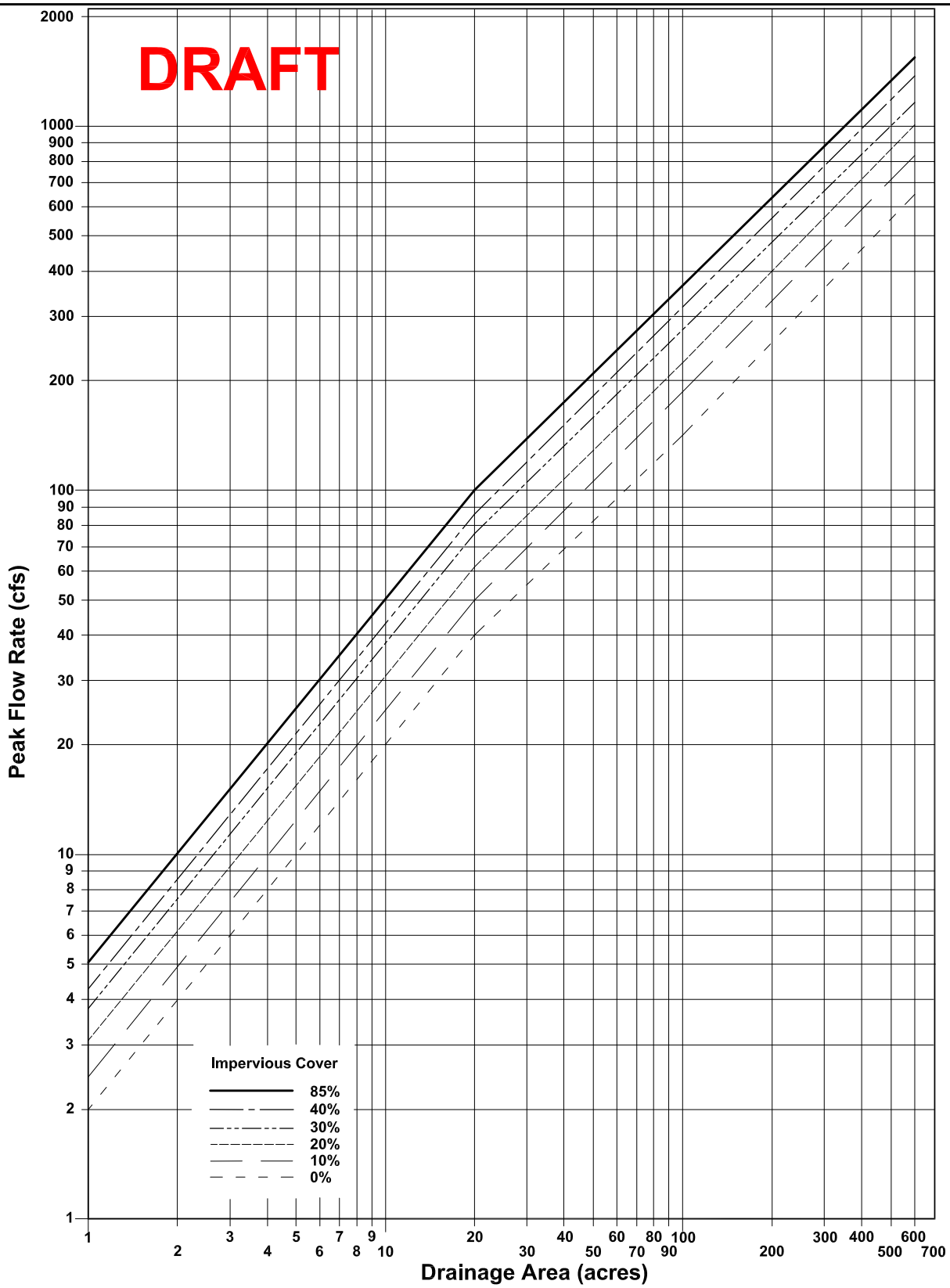
POLICY, CRITERIA, & PROCEDURE MANUAL

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

DATE: 8/7/2018

EXHIBIT 3-2

DRAFT



HARRIS COUNTY FLOOD CONTROL DISTRICT

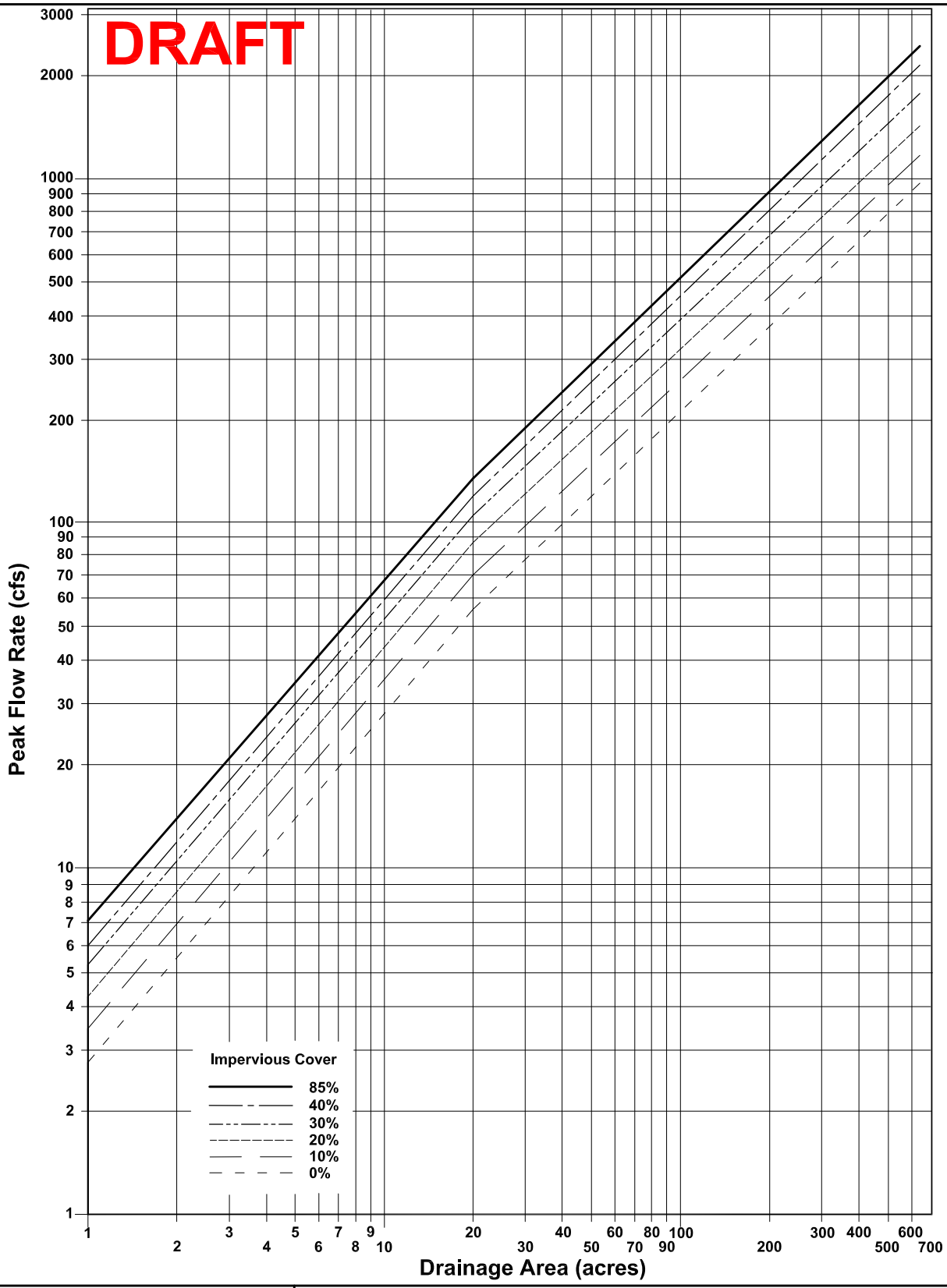
POLICY, CRITERIA, & PROCEDURE MANUAL

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

DATE: 8/7/2018

EXHIBIT 3-3

DRAFT



HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

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

DATE: 8/7/2018

EXHIBIT 3-4

SECTION 4 – HYDRAULICS

4.1 Introduction

Overview
4.1.1

The water surface profile or hydraulic gradeline is essential to the design and analysis of existing or proposed channels, detention basins, and closed conduits. The analysis involves calculating energy losses due to friction, obstructions, transitions, bends, and confluences. When calculating water surface profiles either by hand or with a computer program, include all relevant sources of headloss.

Design of channels and closed conduits generally focus on minimizing energy losses (results in a smaller channel/conduit) and controlling dissipation of excessive energy (reduces erosion problems).

When Analysis Is Required
4.1.2

A hydraulic 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.
- A flow obstruction or fill in the overbanks or 1% floodplain is proposed.

4.2 Methods

Overview
4.2.1

The method selected depends on the type of project, complexity of the hydraulic design, and the level of accuracy desired.

See A.4, Channel Hydraulic Design Examples in Appendix A.

Normal Depth
4.2.2

For closed conduits or channels with the flow confined in a uniform cross section, few obstructions or transitions, and little or no backwater from downstream, the water surface will approximate normal depth. Manning's Equation is commonly used for calculating normal depth (see Section 4.3, Manning's Equation).

Standard Step Method and Computer Programs
4.2.3

For channels with non-uniform sections, flow in the overbanks, and/or bridge or culvert crossings, calculate the water surface using the standard step method. The steady state HEC-RAS option uses the standard step method.

The reasons for using HEC-RAS are that:

- It is widely used and accepted.
- It offers flexibility in the design of channels.
- Bridge, culvert, and expansion and contraction losses are calculated.
- It is used in the FEMA Flood Insurance Studies in Harris County.
- Its use will simplify and expedite reviews by HCFCD.

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

Detention Basin Inflow/Outflow Design
4.2.4

For design of detention basin inflow and outflow structures, spreadsheet calculations using appropriate headloss equations are often used. The equations and discussion are in Section 6.6, Inflow Structures and Section 6.7, Outflow Structures.

Several commercial computer programs are available for designing detention basins and their associated inflow/outflow structures. Early coordination with HCFCD is recommended.

Alternative Methods
4.2.5

If an alternative method not presented in this manual is used for a specific problem, coordinate with HCFCD prior to initiation of the analysis.

4.3 Manning's Equation

Background
4.3.1

Manning's Equation is an empirical formula used to evaluate the effects of friction and resistance in open channels and closed conduits. For uniform flow conditions where the conduit or channel bottom and energy line are essentially parallel, Manning's Equation can be used to compute the normal depth.

Manning's Equation
4.3.2

The equation is:

$$Q = (1.486/n)\ A\ R^{2/3}\ S^{1/2}$$

Where Q = Total discharge in cubic feet per second

n = Manning's coefficient of roughness

A = Cross sectional area of channel or conduit in square feet

R = Hydraulic radius of the channel or conduit in feet

and S = Slope of energy line in feet per foot (same as channel bottom slope for uniform flow)

Subdividing Sections
4.3.3

Subdivide channel and overbank sections to represent differences in roughness across the section, particularly for natural, composite, or non-prismatic sections.

Gradually Varied Flow
4.3.4

For gradually varied flow conditions, the slope of the energy line at a given channel section can be computed using Manning's Equation. HEC-RAS uses Manning's Equation to compute energy losses between cross sections due to friction.

Continued on next page

4.3 Manning's Equation, Continued

Manning's "n" Values
4.3.5

Manning's "n" value represents the relative roughness of the channel, conduit, or overbank area. Values to use for design purposes are in the table below. Submit justification when a different "n" value is used.

Description	Manning's "n" Value
Channel	
Grass-Lined	0.040[1]
Riprap-Lined	0.040[1]
Articulated Concrete Block - Grassed	0.040[1]
Articulated Concrete Block - Bare	0.030
Concrete-Lined	0.015
Natural or Overgrown Channels	Usually 0.050 – 0.080
Overbanks	
Some flow	Usually 0.080 – 0.150
Ineffective flow areas	0.99[2]
Conduit[3]	
Concrete Pipe	0.013
Concrete Box	0.013
Corrugated Metal Pipe	0.024

[1] For design flows larger than 10,000 cfs, an "n" value of 0.035 may be used.

[2] Use the ineffective flow area option in HEC-RAS

[3] If the conduit is maintained by another jurisdiction, the "n" value specified by that jurisdiction can be used.

Adjustment to "n" for Trees in the Channel
4.3.6

Where trees are planted in a channel, adjust the "n" value to account for the additional head loss.

Contact the HCFCD for guidelines regarding "n" value adjustments to account for trees in the channel.

4.4 Velocities

Maximum Velocities 4.4.1

Where average velocities exceed the maximum, provide erosion protection capable of withstanding the erosional forces (see Section 10, Erosion and Sediment Control).

Maximum average cross section velocities are based on a 1% exceedance probability flow. Values are presented in the table below.

Channel Description	Maximum Velocity (fps)[1]
Channel	
Grass-Lined: Some Sand and/or Dispersive Clay	3.0
Grass-Lined: Mostly Clay	5.0
Riprap-Lined – Gradation 1[2]	7.0
Riprap-Lined – Gradation 2[2]	9.0
Articulated Concrete Block Lined	9.0
Concrete-Lined	11.0
Overbanks and Existing Natural or Overgrown Channels	Site Specific
Conduit	
Concrete Pipe or Box	8.0
Corrugated Metal Pipe	6.0

[1] For low turbulence areas only. Contact HCFCD WMD for assistance with determining velocities in specific channels, if necessary.

[2] Gradations are defined in HCFCD Standard Specification Section 02378, Riprap and Granular Fill.

Continuity Equation 4.4.2

The average velocity at a channel cross section or in a conduit is computed using the continuity equation:

$$Q = VA$$

where Q = discharge in cubic feet per second

V = average velocity in feet per second

and A = cross sectional flow area in square feet

4.5 Cross Sections

Overview
4.5.1

Using accurate and current cross sections is essential to hydraulic analysis and developing water surface profiles.

Channels
4.5.2

Criteria for channel cross sections are:

- Field survey channel sections at spacing sufficient to represent significant changes in channel dimensions. (Construction drawings should only be used for preliminary evaluations.)
- Extend the sections into both overbanks where stormwater is expected to flow or be stored for existing, proposed, or ultimate conditions.
- Obtain overbank elevations either from field survey or the best topographic information available.

Conduits
4.5.3

Criteria for conduit cross sections are:

- Use construction drawings.
- Field verify pipe sizes and flowlines.

Detention Basins
4.5.4

Depending on the type of hydraulic analysis and the location of the detention basin relative to the outfall channel, either cross sections or a site topographic grid can be used.

Criteria for detention basins are:

- Field survey the existing or proposed detention basin site.
- Extend the survey into adjacent areas where stormwater is expected to flow or be stored.
- Adjacent area elevations may be obtained from available topographic information if the accuracy is satisfactory.

4.6 Starting Water Surface Elevation

Design of Channels 4.6.1

Base the starting water surface at the channel mouth on the normal depth in the design channel except as noted below.

When a channel outfalls into a tidal zone, use the average high tide as a starting water surface.

Design of Conduits 4.6.2

Use the top of the pipe or box as the starting water surface for a conduit.

Actual Flood Levels 4.6.3

In determining actual flood profiles or flood plain delineation in non-coastal areas, project the water-surface elevation from the outfall channel horizontally upstream until it intersects the flood profile on the design channel or conduit.

For coastal areas, use the results of the combined probability analysis to determine flood profiles.

4.7 Floodplain and Overbank Modifications

Overview
4.7.1

Physical modifications to overbank areas in the 1% or 0.2% floodplains can impact flow along the channel and overbank flow, stormwater storage, and water surface elevations.

Physical Modifications
4.7.2

Physical modifications for a proposed land development or infrastructure project include:

- Removing or adding trees or other vegetation.
- Removing or adding buildings, fences, or other types of structures.
- Adding fill material within the floodplain or overbank areas.

Analysis and Mitigation
4.7.3

For proposed conveyance impacts, calculate changes in water surface elevations along the channel with proposed changes in cross section area, Manning's "n" values, discharges, etc. Mitigate any increases in water surface elevations.

For floodplain fill, see Section 6.9.4, Floodplain Fill Mitigation.

SECTION 5 – Channels

5.1 Introduction

Uses
5.1.1

Natural and man-made channels are the primary area-wide conveyance system for carrying stormwater.

Channels are usually constructed or modified to:

- Collect and convey stormwater.
- Reduce the flooding potential on a property.
- Mitigate increased flood stages caused by higher flows.
- Accommodate the depth needed for a storm sewer outfall.
- Reduce erosion and enhance water quality.

Terminology
5.1.2

Terminology and definitions associated with channels are in Appendix E, Terminology.

Review and Coordination
5.1.3

The review and coordination process for new channels or modification of existing HCFCD maintained channels is presented in Section 2.8, New or Modified HCFCD Facilities.

Analysis and Methodologies
5.1.4

General hydrologic and hydraulic analysis and methodologies are presented in Section 3, Hydrology and Section 4, Hydraulics. Hydraulic aspects specific to channels are presented in this section.

In This Section
5.1.5

This section covers HCFCD criteria for the design of channels. Specifically, this section covers:

- Location and alignment.
- General design criteria.
- Typical sections.
- Right-of-way.
- Confluences.
- Horizontal transitions.
- Bends.

Other design topics for channels are covered in subsequent sections.

5.2 Location and Alignment

Overview
5.2.1

Location and alignment of new or modified channels are important because this affects the:

- Primary function of the channel to convey stormwater.
- Ability of overland flow to get in the channel.
- Construction and maintenance costs.
- Impact on natural and man-made features.

Considerations
5.2.2

Factors to consider when locating and establishing an alignment for a channel are to:

- Follow existing/natural channels, ditches, swales, or other low areas.
- Avoid crossing drainage divides.
- Align the proposed channel pointing downstream at its confluence with the outfall channel.
- Avoid severe channel bends.
- Avoid areas of high erosion potential.
- Provide adequate access for maintenance.
- Minimize conflicts with existing buildings, homes, pipelines, and contaminated sites.
- Minimize number of property owners affected, if possible.

5.3 General Design Criteria

Design Frequency and Freeboard 5.3.1

Design new channels to contain the 1% exceedance probability, 24-hour storm event for existing, proposed, and ultimate watershed conditions.

When channel modifications are necessary to accommodate a proposed storm sewer outfall or to offset increased flows from a proposed development, design the modifications so that the 1% exceedance probability water surface profiles upstream or downstream are not increased above existing conditions.

Design new or modified channels with a minimum of one foot of freeboard below the low top of bank or low ground near the channel, whichever is lowest.

Note: If the 1% exceedance probability water surface elevation ~~at the~~ downstream ~~end~~ of the new or modified channel is above the low top of bank or low ground near the channel, then use normal depth as the starting water surface elevation to design the proposed new or modified channel with a minimum of one foot of freeboard.

Flowline Slope 5.3.2

Flowline slope criteria are as follows:

- Minimum 0.08% for grass and riprap unless a flatter slope is justified by the engineer based on physical conditions and approved by the HCFCD.
- Minimum 0.05% for full or partially concrete-lined channels.
- Maximum controlled by maximum velocity (see Section 4.4, Velocities).

  Note: Use a flowline slope greater than the minimum where possible to minimize standing water in the channel bottom, increase low flow velocities, and maximize capacity for a range of flows.

Existing Sections 5.3.3

Criteria for obtaining existing cross sections used in design of a new or modified channel are:

- Field survey channel sections at a sufficient spacing for design.
- Field survey channel bottom, side slopes, normal water surface elevation, significant grade breaks, confluences, and areas of erosion.
- Extend the survey beyond the existing or proposed channel right-of-way a minimum distance of 20 feet; where possible (see Section 11.1, Backslope Drainage Systems).
- Field survey outfall pipes, pipe flowlines, manholes, bridges, pipelines, utilities, and other physical features affecting design.

Continued on next page

5.3 General Design Criteria, Continued

Natural Channels 5.3.4

When discharging stormwater from a manmade channel, detention basin, storm sewer, or pump into a natural channel, address potential erosion and siltation problems at the discharge point and downstream. Identify existing and known problems as well as evaluate soil and vegetation conditions, existing and future flows, and velocities for a range of frequencies.

Channel Linings 5.3.5

The selection of channel lining is based on several factors including erosion potential, slope stability, conveyance, available right-of-way, cost, USACE jurisdiction, environmental situation, and aesthetics. Lining choices and design criteria are discussed in Section 10, Erosion and Sediment Control.

Hydraulic Structures 5.3.6

Hydraulic structures typically constructed within a channel are:

- Backslope drainage systems.
- Inflow and outflow structures.
- Storm sewer outfalls.
- Transition control structures.
- Culverts.
- Bridges (roads, pipelines, etc.).

Criteria for these types of hydraulic structures are presented in other sections of this manual.

Continued on next page

5.3 General Design Criteria, Continued

Geotechnical Investigations 5.3.7

A geotechnical investigation is required for new HCFCD maintained channels and proposed work that deepens or widens an existing HCFCD channel. Previous investigations can be utilized, if applicable to the proposed project and the following design topics are addressed.

As a minimum, address the following:

- Stability of the channel side slopes for short term, long term, and rapid drawdown conditions. (If channel depth ≤ 5 feet, slope stability analysis is not required.)
- Location of ground water level(s).
- Identification of dispersive soils.
- Potential erosion problems.
- Constructability issues.

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

Environmental Investigations 5.3.8

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).

Continued on next page

5.3 General Design Criteria, Continued

Maintenance Access Plan 5.3.9

A new or updated maintenance access plan is required for all new or modified channels and detention basins. Include a preliminary maintenance access plan as part of the drainage or design report, and a final plan with the construction drawings. Consider both existing and ultimate conditions. Coordinate closely with the HCFCD as early as possible.

Show or include the following on the maintenance access plan:

- The existing, proposed, and ultimate physical features (above and below ground) within the HCFCD right-of-way that may physically impede the movement or work of maintenance or repair equipment and vehicles.
- The existing and proposed HCFCD right-of way including full property rights for what's needed for access to and along the channel or detention basin.
- Arrows showing the ingress and egress into and along the HCFCD facility, as well as dimensioning the 20 foot minimum width between physical impediments and a 15 foot minimum vertical clearance.

Physical impediments to maintenance equipment and vehicles include but are not limited to uneven terrain, steep slopes, bridges, tributaries, backslope swales and drains, subdivision or trail entrance structures, fences, walls, guardrails, curbs, trees and shrubs, gardens, manholes, above and below ground utilities, utility poles and boxes, guy wires, trash receptacles, benches, and other recreational features.

Note: The most common maintenance access is from public roads at bridges or culverts. If the access pathway is not planned, provided, and kept open, HCFCD maintenance may cease until access is provided or restored.

Continued on next page

5.3 General Design Criteria, Continued

Maintenance Access Criteria 5.3.10

Maintenance access criteria are:

- Provide sufficient off-road staging area for vehicles or equipment to safely clear traffic for access onto HCFCD right-of-way. Minimum distance from road right-of-way is 20 feet, minimum width is 20 feet, and minimum height is 15 feet.
- Avoid combining maintenance access with utility and pipeline rights-of-way.
- If proposed maintenance access route crosses utility or pipeline easements, provide a HCFCD easement for the crossing and load protection to accommodate mowers and heavy equipment.
- If paved extreme event flow conveyance features are used for maintenance access, modify geometry and concrete design to accommodate mowers and heavy equipment.
- See Section 7.2.3, Access to HCFCD Facilities at Bridges and Section 8.2.3, Access to HCFCD Facilities at Culvert Crossings for additional criteria at bridges and culverts.

Excavation In Channel Right-of-Way for Floodplain Fill Compensation 5.3.11

Excavation in the HCFCD channel right-of-way to compensate for floodplain fill on adjacent or nearby property is not allowed ~~without prior HCFCD approval~~ because:

- All of the channel right-of-way is needed for flow conveyance, especially for high-flow flood events.
- HCFCD right-of-way cannot be used for the benefit of an individual landowner.

Normal Water Level 5.3.12

The normal water level is the water surface in the bottom of a channel when the flow is not influenced by prior rainfall events or drought conditions. Obvious clues include visible soil and vegetation indicators along the shoreline, flow conditions, and water turbidity. The normal water level is not the regulatory ordinary high water mark line as defined by the U.S. Army Corps of Engineers.

The normal water level is important for setting outfall pipe flowlines in the channel and designing the bottoms of both wet and dry detention basins. It can also be an indicator of the ground water level.

Show the normal water level on cross-sections and profiles in the construction drawings and preliminary engineering reports where necessary for design.

5.4 Typical Cross Sections

Overview
5.4.1

Typical channel sections have minimum dimensions and required features based on construction and maintenance experience. Actual dimensions and shapes are determined from detailed hydraulic analysis, geotechnical investigations, and environmental, aesthetic, and multi-use considerations.

Typical channel sections are presented in this section.

Alternative sections are permissible; see Section 18 – Optional Environmental, Recreation, and Aesthetic Features.

Trapezoidal Section
5.4.2

The most common channel shape is trapezoidal and the most common lining is grass. Concrete lining is used where right-of-way is limited or expensive, conveyance efficiency is critical, or erosion potential is high. Concrete lining does not provide structural support for the underlying soil.

The table below contains the criteria for both grass-lined and concrete-lined trapezoidal channel sections. See Exhibits 5-1 and 5-2 for typical sections.

Feature/Item	Grass-Lined	Concrete-Lined
Minimum bottom width	6 feet	6 feet
Bottom configuration	See Section 5.4.3	See Concrete Channel Lining Details
Side slopes no steeper than	4:1	2:1
Backslope drainage system	Yes	No*
Maintenance access and minimum berm widths	See Section 5.5.3, Minimum Berm Widths	

* Where the concrete lining extends to the top of bank.

Additional criteria for concrete-lined channels:

- Minimum concrete lining thickness is 5 inches (verify in design).
- Concrete toe walls are required on all sides to reduce the chance of flow under the lining and decrease the chance of lining failure.
- Access stairways are required for side slopes 2.5:1 and steeper. Locate stairways on the upstream side of road crossings and at intervals less than 1,500 feet.
- Weep holes are required to accommodate subsurface drainage.
- See HCFCD Concrete Channel Lining Details in Appendix D, Standards and Details.

Continued on next page

5.4 Typical Cross Sections, Continued

Bottom Configuration - Trapezoidal Grass-Lined 5.4.3

Use the table below to design the bottom of trapezoidal grass-lined channels.

Center depression = distance to depress channel centerline below toe of slope.

The purpose is to more accurately replicate the stable channel bottom shape that will naturally form, reduce erosion at the toe of slope, and reduce slope stability problems (see Exhibit 5-1).

Bottom Width	Center Depression	Pipe Outlet Invert*
6 feet ≤ BW ≤ 20 feet	0.5 foot	1 foot above flowline
20 feet < BW ≤ 60 feet	1.0 foot	At toe of slope
BW > 60 feet	3% cross slope	At toe of slope

* At elevations indicated or 1 foot above normal water level, whichever is higher. See additional criteria for pipe outfalls in Section 11, Backslope Drainage Systems and Pipe Outfalls.

Grass-Lined Bench Section 5.4.4

The bench section more closely replicates a natural channel than a trapezoidal section.

Benches can:

- Improve the overall slope stability of the channel.
- Reduce maintenance and repair costs.
- Improve the aesthetics and habitat of the channel corridor.
- Provide a location for trails and trees if included in hydraulic analysis.

The design considerations and criteria presented for grass-lined and concrete-lined channels apply to bench sections.

Criteria for benches:

- Place at least 5 feet above the toe of the side slope.
- Minimum width – 10 feet.
- Minimum cross slope toward channel – 2%.

Two typical bench sections are shown in Exhibit 5-3.

Continued on next page

5.4 Typical Cross Sections, Continued

Rectangular Concrete-Lined Section
5.4.5

Rectangular concrete-lined channel sections are used when right-of-way is limited or expensive or additional depth is needed. The side slopes above the rectangular section can be either grass-lined or concrete-lined, depending on the conditions. The criteria for trapezoidal sections apply on the side slopes.

Criteria are:

- Minimum bottom width is 8 feet.
- Minimum height of vertical walls is 4 feet.
- Equipment access ramps to the channel bottom are required for maintenance and rehabilitation work.
- Access stairways are required. Recommended locations are on the upstream side of road crossings and at intervals less than 1500 feet.
- See Concrete Channel Lining Details in Appendix D, Standards and Details.

A typical section is shown in Exhibit 5-4.

Note: For concrete vertical walls taller than 4 feet, contact the HCFCD Watershed Management Department for additional criteria and considerations.

5.5 Right-of-Way

Overview
5.5.1

This section provides criteria and guidelines for determining the right-of-way limits for a channel maintained by HCFCD.

Right-of-way definitions and dedication and conveyance process are presented in Section 15, Right-of-Way.

Right-of-Way Widths
5.5.2

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

The minimum HCFCD right-of-way limit for a typical grass-lined channel is:

- The channel top width plus.
- Twenty feet for maintenance access on each side plus.
- Ten feet for the backslope swale system where used (see Section 11.1.2, Where To Use).
- Plus ten feet minimum if trails, trees, or other multi-use features are planned or anticipated in the future.

Use field survey data and channel profile to determine channel top widths.

Minimum Berm Widths
5.5.3

Minimum berm widths on each side are shown on the typical sections in Exhibits 5-1 through 5-4, and presented in the table below. Add minimum ten more feet if trails, trees, or other multi-use features are planned.

~~*Continued on next page*~~

~~5.5 Right-of-Way,~~ ~~Continued~~

~~Minimum Berm Widths 5.5.3~~

~~Minimum berm widths on each side are shown on the typical sections in Exhibits 5-1 through 5-5, and presented in the table below. Add minimum ten more feet if trails, trees, or other multi-use features are planned.~~

Channels That Are	The Minimum Berm Width Is
Grass-lined[1] with a top width > 60 feet or a depth > 7 feet	30 feet
Grass-lined[1] with a top width ≤ 60 feet or a depth ≤ 7 feet	20 feet[2]
~~Grass-lined where side slopes are 8(horizontal):1(vertical) or flatter~~	~~15 feet[3]~~
Lined with riprap or partially concrete-lined	Same as grass-lined channel
Fully concrete-lined	20 feet one side, 15 feet other side[2]

[1] See Section 5.5.5 below for natural channels.
[2] Backslope swale system not needed.
~~[3] Maintenance access is on the side slope.~~

Continued on next page

5.5 Right-of-Way, Continued

New HCFCD Channels 5.5.4

New HCFCD channels require HCFCD right-of-way to cover the interim channel, ultimate right-of-way width, and maintenance access including access from public roads.

Development Adjacent to Existing or Natural Channels 5.5.5

~~Existing and~~ Proposed development adjacent to a natural ~~channels require~~ channel or an existing or future HCFCD ~~right-of-way to cover~~channel must be located outside of the channel ~~flow~~ right-of-way needed for the existing channel area, ~~a future~~ stable channel~~, ultimate right-of-way width, and/or~~ cross section, future channel expansion, maintenance access~~. Typically,~~, and backslope drainage systems.

The channel right-of-way boundary is typically 30' ~~is added to~~from the existing channel~~ bank, future stable channel, or ultimate~~ top of bank, future stable channel top of bank, or ultimate top of bank determined by a drainage master plan, whichever is greater. ~~Consider current channel stability, existing and known erosion/problem areas, soil and vegetation conditions, and future/ultimate channel geometry once equilibrium is achieved.~~On channels where recreational features are planned, the future channel right-of-way boundary might be more than 30 feet from the top of bank. Coordinate right-of-way limits with HCFCD.

The stable channel top of bank is generally determined by projecting a 4H:1V slope starting at the existing bank toe. Note that the toe might be located outside of an existing low flow channel. The point where the 4H:1V projected slope intercepts the top of natural ground is considered to be the stable channel top of bank. In areas where known geotechnical information indicates that a 4H:1V channel slope is not stable, use a slope flatter than 4H:1V as determined by the best available geotechnical information to determine the stable channel side slope.

Refer to Exhibit 5-5 for scenarios.

Adjacent HCFCD Channel and HCFCD Detention Basin 5.5.6

Where a HCFCD maintained channel is adjacent to a HCFCD maintained detention basin, place the backslope drainage swale in the middle of the berm. A minimum combined berm width of ~~40~~30 - 50 feet is required ~~(see~~per Exhibit 5-~~5).~~6. Do not place backslope interceptor structures in this area unless backslope swale length and/or local conditions warrant it (see Section 11.1.3, Criteria).

Continued on next page

5.5 Right-of-Way, Continued

Adjacent HCFCD Channel and Public or Private Detention Basin
5.5.7

Where a HCFCD maintained channel is adjacent to a publically or privately maintained detention basin, the public or private detention basin does not need a backslope drainage system if one already exists along the channel. Place a minimum 20-foot wide access berm outside the HCFCD right-of-way for the detention basin.

If a backslope drainage system does not already exist along the channel, a minimum 30-foot wide maintenance berm ~~is required~~ and ~~a~~ backslope drainage system outside the HCFCD right-of-way is recommended for the detention basin.

Coordinate design, layout, and requirements with HCFCD as early as possible.

Roads Adjacent to HCFCD Maintained Facility
5.5.8

Where a public road, drained by either storm sewers or roadside ditches, is adjacent to a HCFCD maintained facility, a backslope drainage system is not needed, provided the maintenance berm drains to the road. A minimum width of 20 feet is satisfactory unless more distance is needed for public safety.

Bridges and Culverts
5.5.9

At bridges and culverts, additional HCFCD right-of-way may be necessary for maintenance and repair equipment to access the channel (see Section 7, Bridges and Section 8, Culverts).

Trails, Trees, Etc.
5.5.10

Where multi-use or non-flood control features such as trails and trees are placed within a HCFCD channel right-of-way, additional right-of-way width is recommended to minimize damages and facilitate maintenance, repairs, and rehabilitation. An additional 10 feet minimum is required.

Continued on next page

5.5 Right-of-Way, Continued

Ultimate Right-of-Way Determination 5.5.11

Determine the ultimate HCFCD right-of-way width and alignment in coordination with HCFCD.

GUIDELINES:

- Procedure is same as described in Section 5.5.2, Right-of-Way Widths except the channel top width is based on full upstream development under stormwater management policies in effect.
- If a master drainage plan for a watershed is available:
  1. Determine if the assumptions and conditions (particularly topography) are still applicable, then
  2. Either confirm or reestablish the width, location, and alignment.
- If no master drainage plan is available, work with HCFCD to make the ultimate HCFCD right-of-way determination and document the results.

CRITERIA:

- A development project located on both sides of a channel is required to dedicate or convey the ultimate HCFCD right-of-way width through the project.
- A development project located on one side of a channel is required to dedicate or convey one half of the HCFCD ultimate right-of-way, or the right-of- way necessary for maintenance of the interim channel, whichever is wider. The width may be influenced by existing development, channel alignment, or utility conflicts.
- For offsite channel modifications, a development project is required to obtain the offsite HCFCD right-of-way width necessary for the proposed channel project. Acquisition of the ultimate offsite HCFCD right-of-way is not required of the development project owner.

  Note: Building and utility set backs are needed offsite to preserve the ability to obtain the necessary additional offsite right-of-way in the future for channel expansion.

5.6 Confluences

Overview
5.6.1

The alignment of channel confluences and large pipe or box outfalls is critical with regard to channel erosion (scour) and energy losses caused by turbulence and eddies.

Criteria for pipe or box outfalls are in Section 11.3, Pipe Outfalls.

Confluence Design Criteria
5.6.2

Primary factors used in design are angle of intersection; shape and dimensions of the side channel, pipe, or box; flow rates; and flow velocities.

If the main channel flowline is lower than the side channel flowline, use a drop structure in the side channel (see Section 9, Transition Control Structures).

Angle of Intersection
5.6.3

Criteria for angle of intersection (see Exhibit 5-~~6~~7 for definition) are as follows:

- Use a small angle of intersection between the side and main channel to minimize erosion potential and energy loss.
- Angles between 30° and 60° are generally satisfactory in Harris County.
- Angles between 60° and 90° are discouraged, but permissible if 1% exceedance probability velocities in both channels are less than 4 feet per second.
- Angles greater than 90° can cause severe hydraulic and erosion problems and are therefore not permissible.

Erosion Protection Criteria
5.6.4

- The minimum extent of erosion protection is shown in Exhibit 5-~~6~~7, Erosion Protection at Channel Confluences.
- Types of erosion protection measures and design criteria are in Section 10, Erosion and Sediment Control.
- Extend structural erosion protection at least one-third up the channel slope from the bottom in both channels.
- Establish turf grass from the edge of the structural protection to the top of bank.

5.7 Horizontal Transitions

Overview 5.7.1

Horizontal transitions in channels and closed conduits consist of either a change in cross section size or geometry. These changes cause head losses due to flow expansion or contraction. For channels, horizontal transitions generally occur at bridges or culverts and at confluences where channel sizes change.

Criteria 5.7.2

Design horizontal transitions in channels with minimal flow disturbance and energy loss. Criteria are:

Sub-critical flow (common in Harris County):

- Design horizontal transitions with angles of transition no greater than 12 degrees (5:1 ratio).
- When transitioning from a vertical wall or steep side slope to a mild side slope, the warped or wedge type transition is recommended.

Super-critical flow (rare in Harris County):

- Check with HCFCD.

Hydraulic Analysis 5.7.3

Compute and include horizontal transition losses in all water surface profiles submitted to HCFCD for review.

Head Loss Equation 5.7.4

Compute horizontal transition losses using the energy equation below:

$$h_L = c\left|\frac{\left(V_2^2 - V_1^2\right)}{2g}\right|$$

where

h_L = head loss in feet

c = expansion or contraction coefficient (see table in Section 5.7.5, Loss Coefficients)

V_2 = average channel velocity of downstream section in feet per second

V_1 = average channel velocity of upstream section in feet per second

g = acceleration due to gravity (32.2 ft/sec^2)

Continued on next page

5.7 Horizontal Transitions, Continued

Loss Coefficients 5.7.5

Typical transition loss coefficients are presented in the following table:

Transition Type	Contraction Coefficient	Expansion Coefficient
Gradual or warped	0.10	0.30
Bridge sections, wedge, or straight lined	0.30	0.50
Abrupt or squared end	0.60	0.80

Computation Considerations 5.7.6

If the HEC-RAS computer program is used to compute the water surface profile, expansion and contraction losses are calculated using the above loss coefficients provided by the user. See the HCFCD Hydrology & Hydraulic Guidance Manual for more information.

5.8 Bends

Overview 5.8.1

To minimize head loss and to reduce the erosion and sediment problems, design channel bends or curves as gradual as possible.

Criteria 5.8.2

Primary factors used in design are radius of curvature, channel top width, and bend angle. Other factors which can be important are flow velocity, soil type, channel geometry, and sinuosity.

Design channel bends with:

- A radius of curvature (measured from the channel centerline) three times or greater than the ultimate channel top width.
- A bend angle no larger than 90°.

Structural Erosion Protection 5.8.3

Structural erosion protection is needed where flow velocity, turbulence, and secondary circulation is anticipated to cause erosion.

Structural erosion protection is required when:

- The radius of curvature is less than three times the ultimate channel top width.
- Soil type, channel geometry, or flow velocity indicate a potential erosion problem.
- Field observation of the existing channel indicates a potential erosion problem.

Minimum limits of erosion protection are shown in Exhibit 5-~~7~~8. Additional protection may be needed for the reasons listed above.

Types of structural erosion protection measures to consider are in Section 10, Erosion and Sediment Control.

Hydraulic Analysis 5.8.4

Incorporate head losses into hydraulic profile computations for channel bends when the:

- Radius of curvature is less than three times the channel top width, and the
- Average channel velocity is greater than 4 feet per second for the 1% exceedance probability event.

Continued on next page

5.8 Bends, Continued

Head Loss Equation 5.8.5

Compute bend losses using the energy equation below:

$$h_L = c_f\left(\frac{V^2}{2g}\right)$$

where

h_L = head loss in feet
c_f = coefficient of resistance
V = average channel velocity in feet per second
g = acceleration due to gravity (32.2 feet/sec^2)

Coefficient of Resistance 5.8.6

The coefficient of resistance, c_f, is shown in the table below:

Radius of Curvature Divided By Channel Top Width	c_f
Between 1.5 and 3.0	0.2
Between 1.0 and 1.5	0.3

Computation Considerations 5.8.7

The HEC-RAS computer program does not include a bend loss computation option. However, it does allow the adjustment of "n" values both horizontally and vertically at the same time. See the HCFCD Hydrology & Hydraulic Guidance Manual for more information.

HARRIS COUNTY FLOOD CONTROL DISTRICT

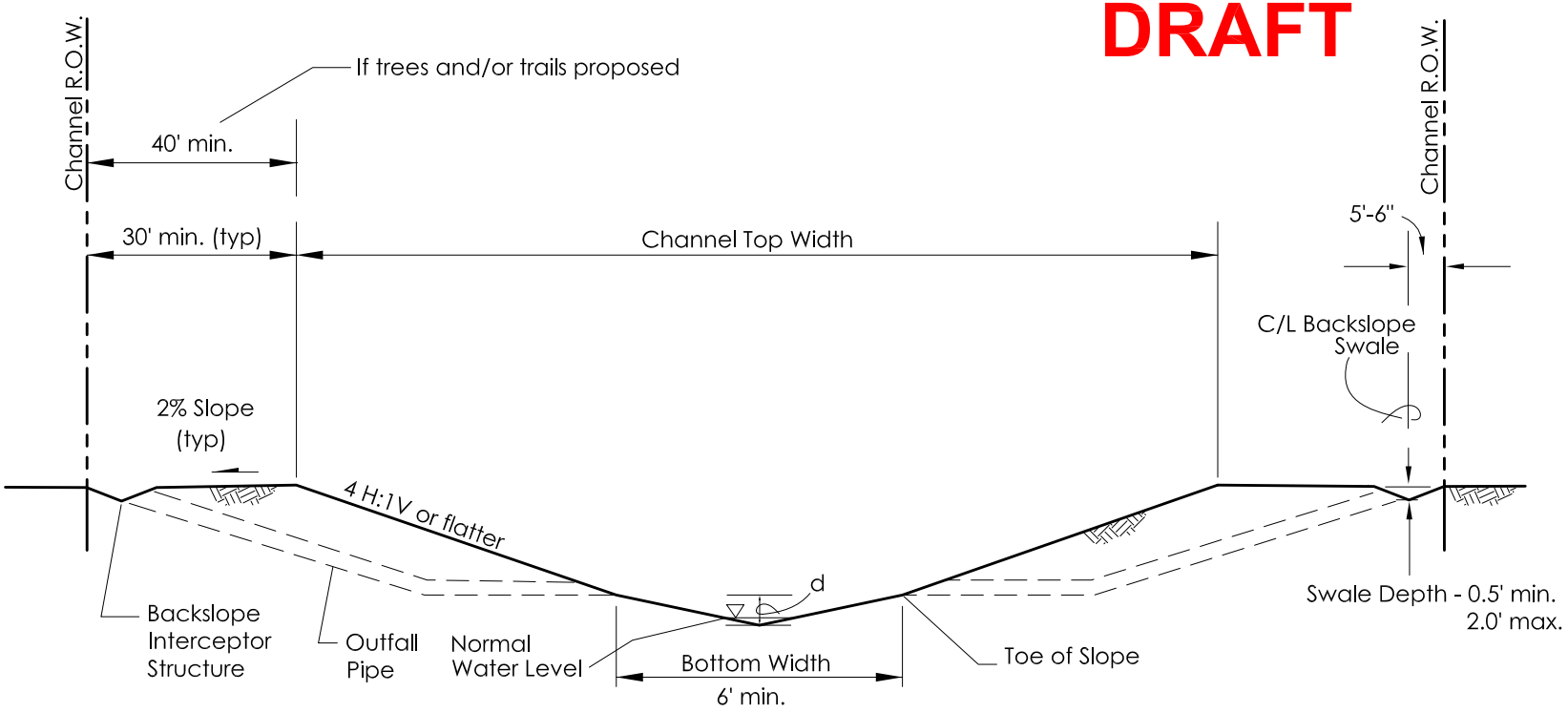
POLICY, CRITERIA, & PROCEDURE MANUAL

TYPICAL GRASS-LINED TRAPEZOIDAL CHANNEL SECTION

DATE: 8/7/2018

EXHIBIT 5-1

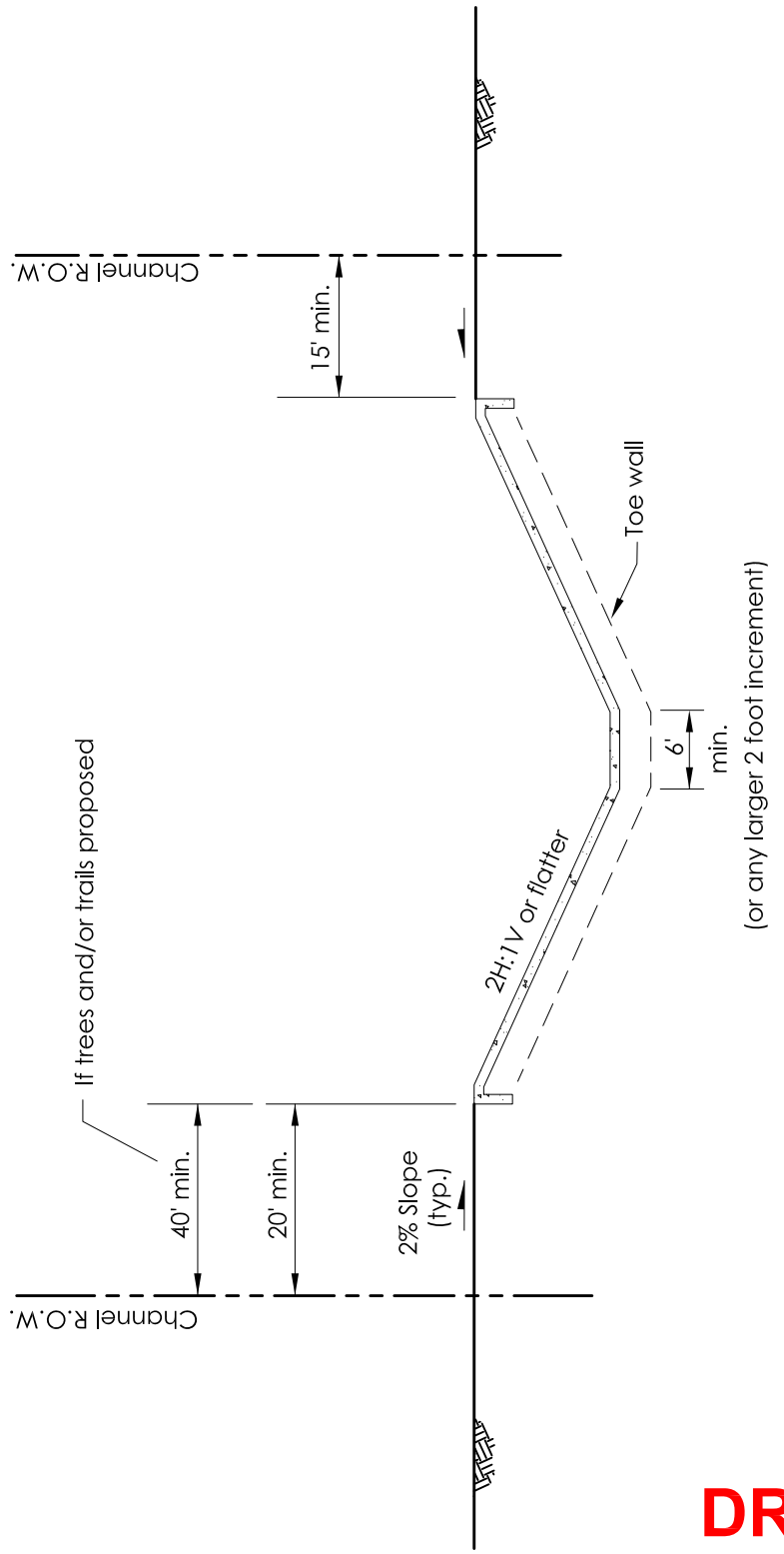
DRAFT



Bottom Width	Center Depression, d	Pipe Inverts
6'-20'	0.5'	1' above bottom
20'-60'	1.0'	at toe
>60'	3% cross slope	at toe

Maintenance berms and backslope drainage systems required on both sides of channel.

Confirm side slope with geotechnical analysis.



Confirm side slope with geotechnical analysis.

Narrow maintenance berm - one side only.

No backslope drainage system.

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HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

TYPICAL CONCRETE-LINED TRAPEZOIDAL CHANNEL SECTION

DATE: 8/7/2018

EXHIBIT 5-2

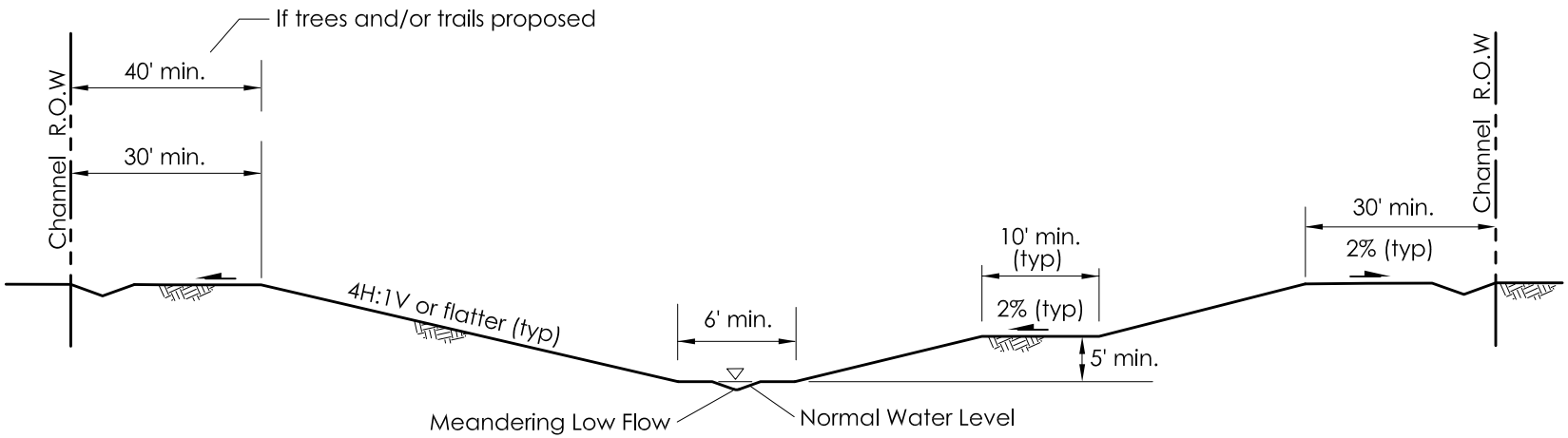
HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

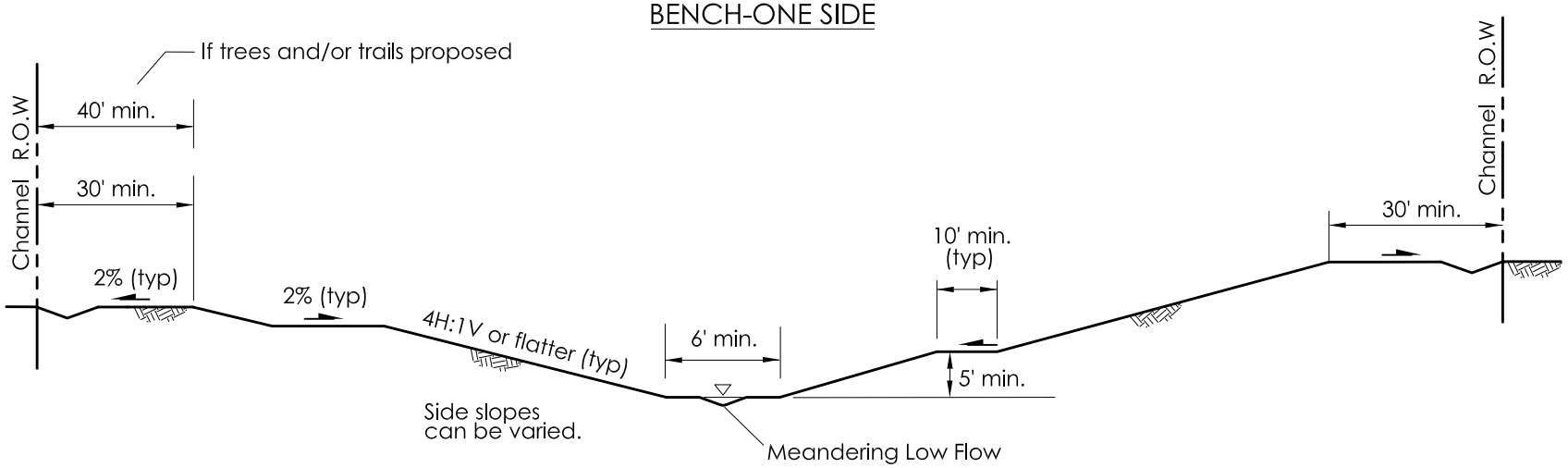
DATE: 8/7/2018

EXHIBIT 5-3

TYPICAL GRASS-LINED BENCHED CHANNEL SECTIONS



BENCH-ONE SIDE



BENCH-BOTH SIDES

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Note: Optional trail location - channel bench

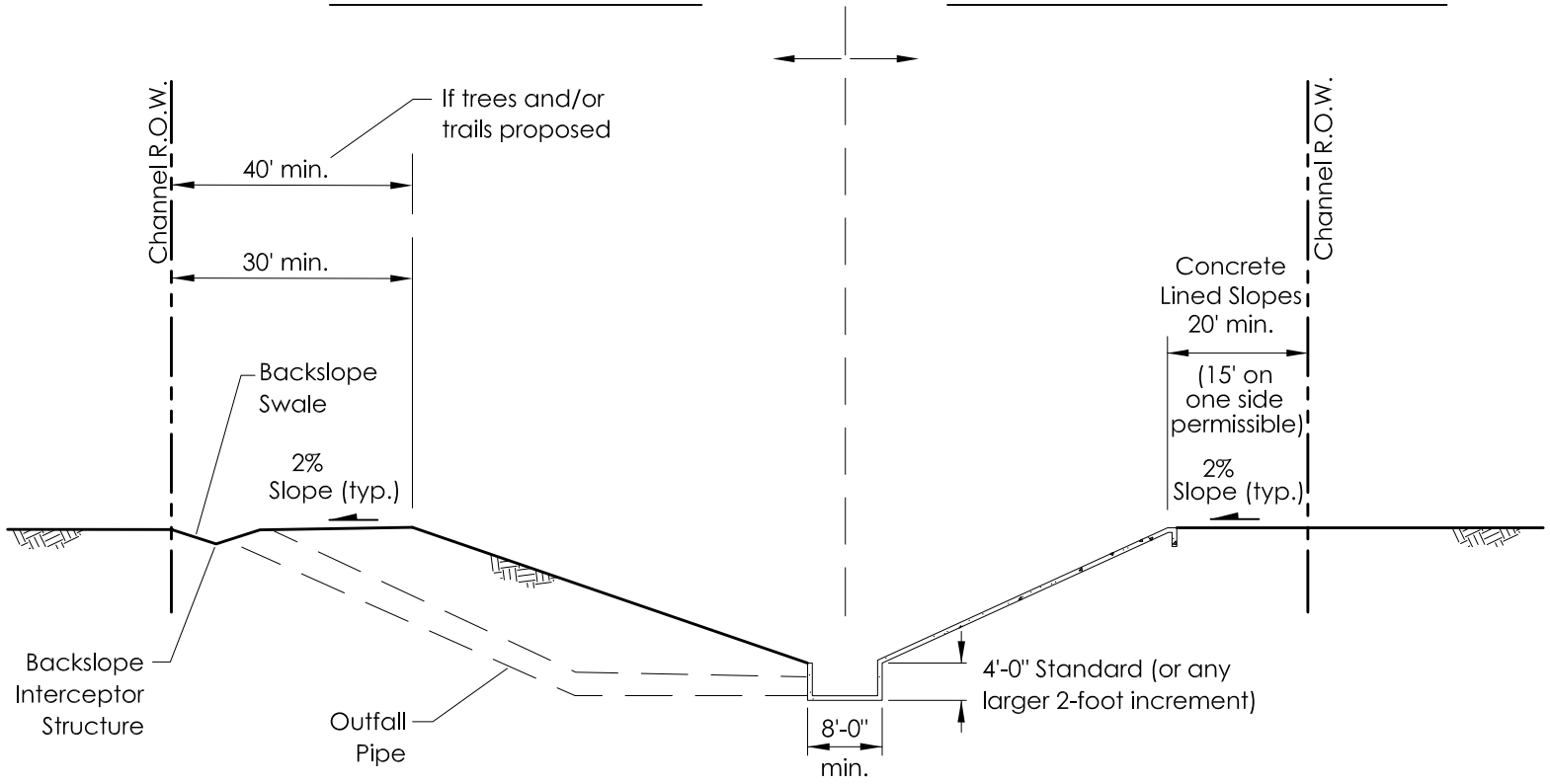
HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

DATE: 8/7/2018

EXHIBIT 5-4

TYPICAL RECTANGULAR CONCRETE-LINED CHANNEL SECTION



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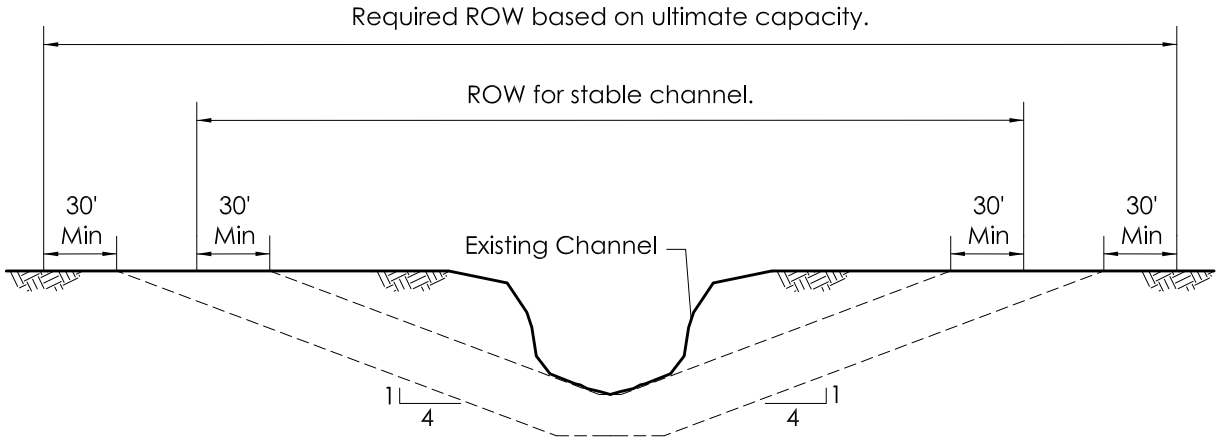
Confirm side slope with geotechnical analysis.

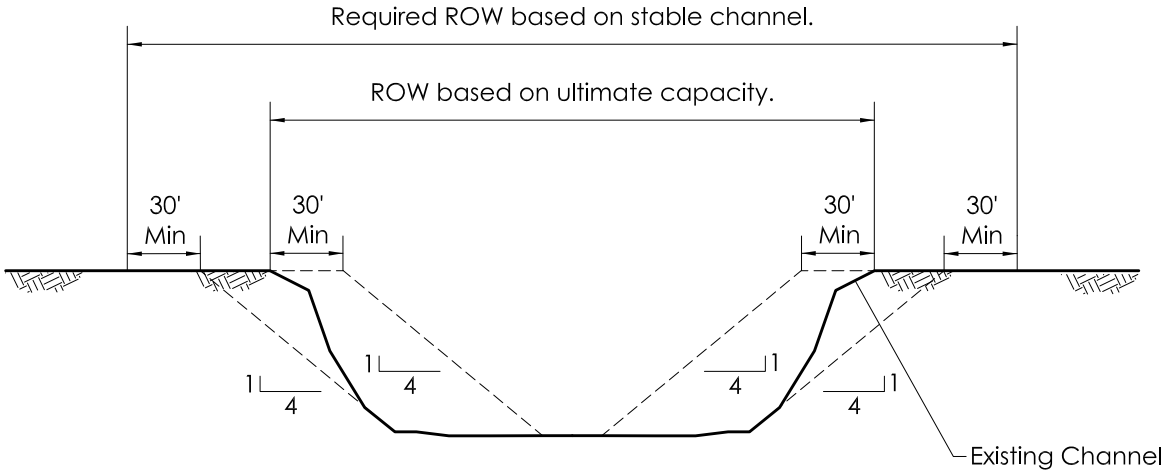
4H:1V or flatter for unlined side slope.

2H:1V or flatter for concrete-lined side slope.

SCENARIO 1



SCENARIO 2



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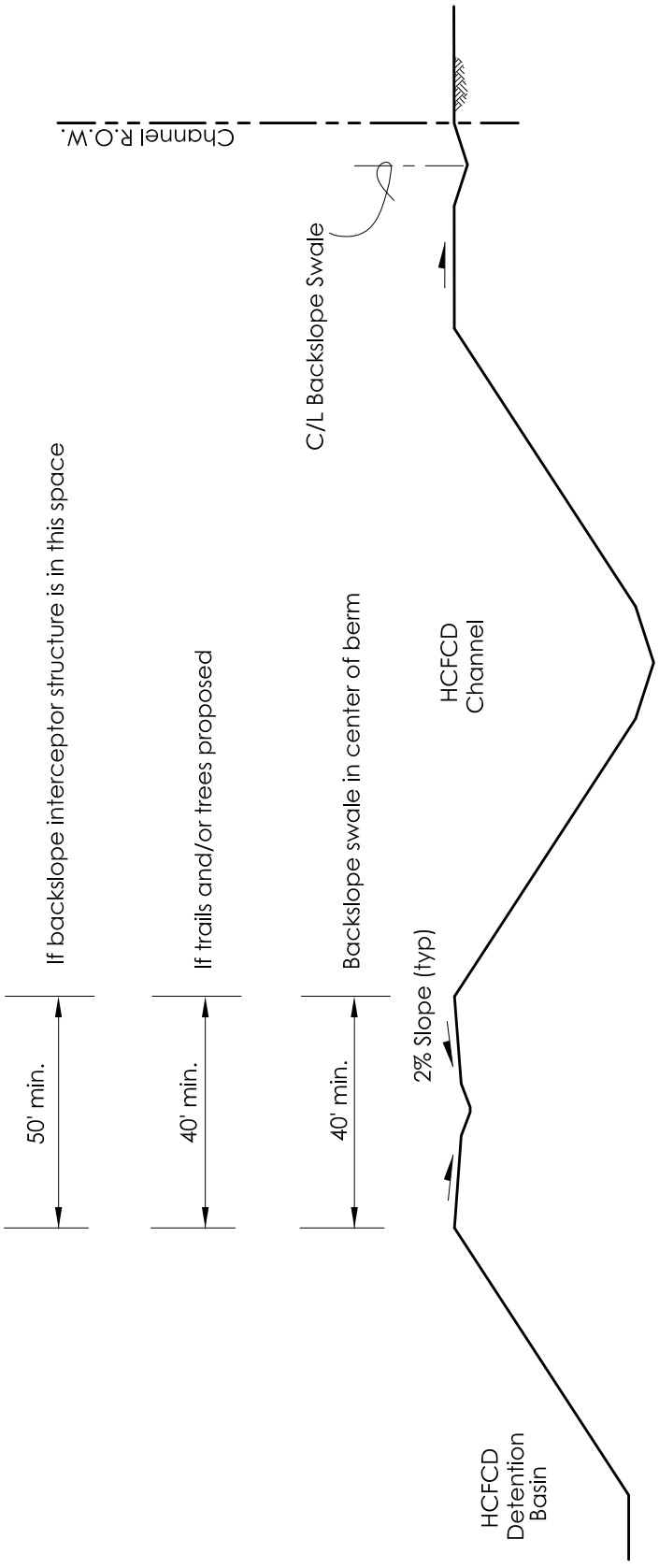
HARRIS COUNTY FLOOD CONTROL DISTRICT	**POLICY, CRITERIA, & PROCEDURE MANUAL**	**REQUIRED HCFCD RIGHT-OF-WAY SCENARIOS**
		DATE: 8/7/2018 / **EXHIBIT 5-5**



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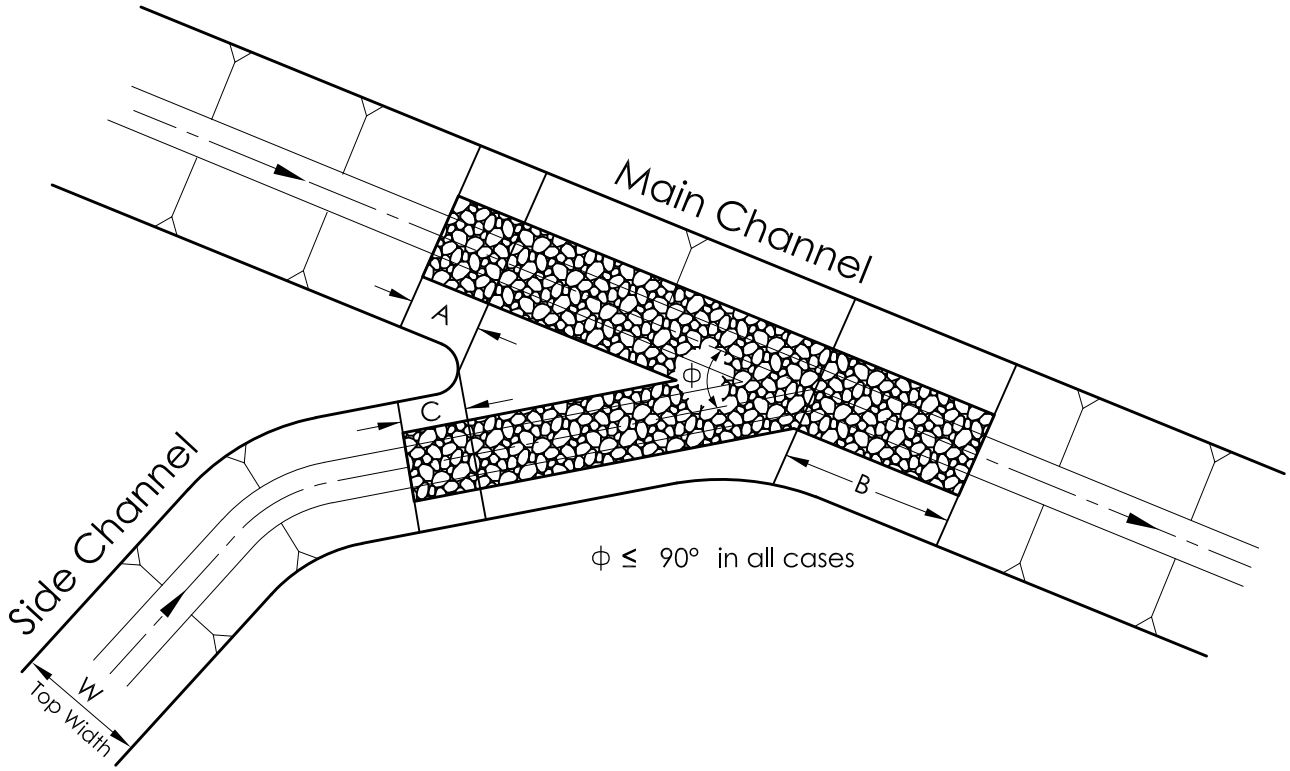
HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

MAINTENANCE BERM BETWEEN HCFCD CHANNEL AND HCFCD DETENTION BASIN

DATE: 8/7/2018

EXHIBIT 5-6



MINIMUM EXTENT OF EROSION PROTECTION

Location	Distance (ft.)
A	20'
B	Larger of 50' or 0.75 X W ÷ TAN ϕ
C	20'

Extend erosion protection across bottom and at least one-third up the side slopes.

1% Exceedance Velocity * In Side Channel (ft. per sec.)	Angle of Intersection, ϕ	
	30°- 45°	45°- 90°
5 or more	Protection	Protection
3 - 5	No Protection	Protection
3 or less	No Protection	No Protection

* Assume no backwater from main channel

DRAFT

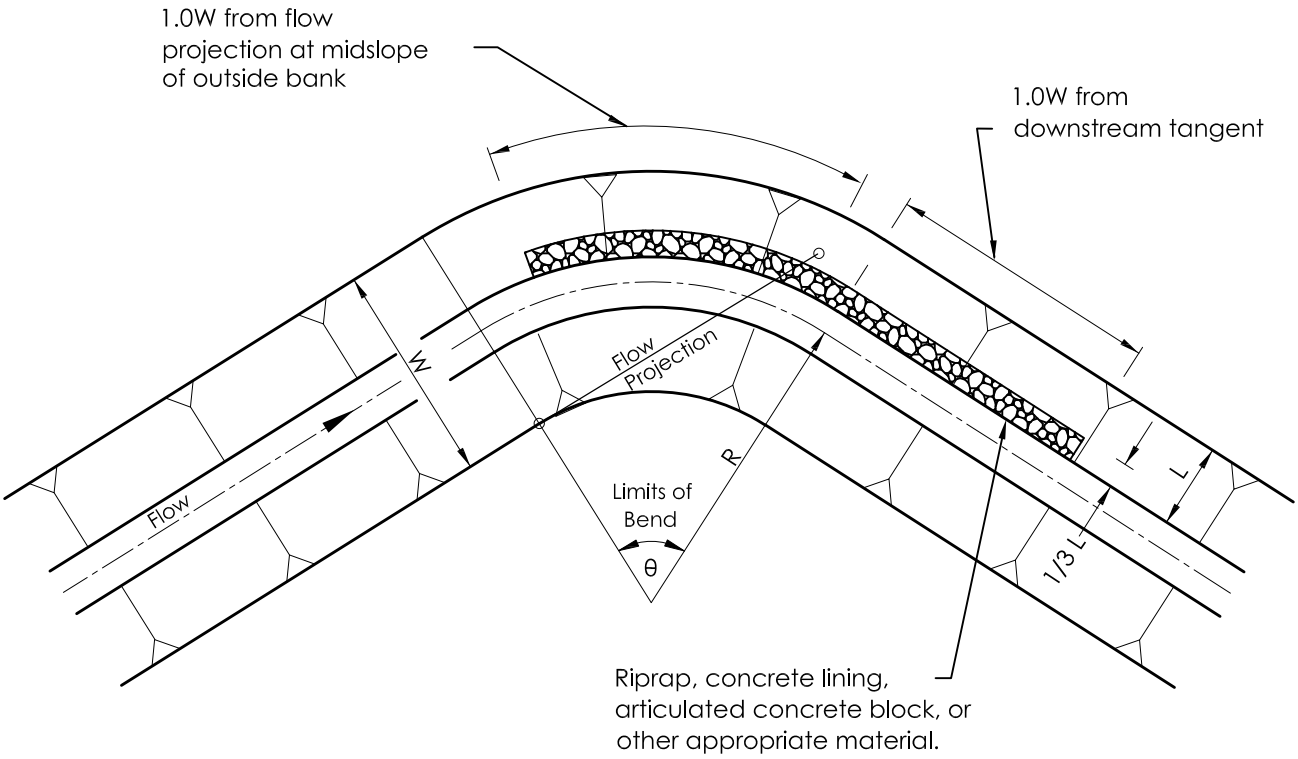
HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

EROSION PROTECTION AT CHANNEL CONFLUENCES

DATE: 8/7/2018

EXHIBIT 5-7



θ = Bend Angle

R = Radius of curvature

W = Ultimate channel top width

L = Length of side slope

DRAFT

Recommended bend design: $R \geq 3\ W$, $\theta \leq 90°$

Erosion protection required when:

- R < 3 W and 1% exceedance velocity > 3 feet per second
- Soil type, channel geometry, sinuosity or velocity indicate a potential problem
- Recommended minimum R = W.

Erosion protection in the channel bottom is not shown, but it may be needed.

HARRIS COUNTY FLOOD CONTROL DISTRICT	**POLICY, CRITERIA, & PROCEDURE MANUAL**	**EROSION PROTECTION AT CHANNEL BEND**
		DATE: 8/7/2018 / **EXHIBIT 5-8**

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

Design new detention facilities to detain the 50%, 10%, and 1% exceedance probability, 24-hour storm events for existing, proposed, and ultimate project drainage areas and watershed conditions.

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.

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 for the roadside ditch or storm sewer.

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. ~~Use~~Do not exceed this elevation for the emergency overflow design~~. The difference between this elevation and the design water elevation is referred to as freeboard~~.

Design Water Elevation
~~The~~The water elevation not to exceed during the 1% exceedance probability, 24-hour storm event (100 year~~) water elevation with a minimum of one foot of freeboard below the maximum allowable water~~).

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

~~Storm Sewer~~ 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 ~~deep~~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 in 24 hours, when possible. Maximum drain time is 48 hours (2 days). If drain time is longer than 48 hours, use 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 peak design detention volume to the 80% drained volume or 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.

Duration	Total Rainfall	Increase in Detention Volume
1 Day	13.2”	0%
3 Day*	15.3”	5%
4 Day	16.1”	10%

* 3 day value interpolated.

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 ~~deep and shallow~~permanent pools and vegetated shelfs, see Section 6.4.11, Wet Bottom Design.

For pumped detention systems, see Section 6.15, ~~Pump~~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 ~~it is not a~~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 ~~deep~~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 ~~deep~~ 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 ~~a point source~~ 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 ~~the~~ 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 ~~riprap~~erosion protection. Riprap is the default choice, the same as outfalls into channels. See Section 11.3.4, Design Criteria, for detailed criteria. ~~Due~~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~~. Use structural erosion control measures, as needed, such as~~ 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 ~~deep or shallow~~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 ~~deep or shallow~~permanent pools 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:

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

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

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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, and in some cases, a more frequent event associated with the bankfull capacity of the outfall channel (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).

~~Typical multiple~~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 50 acres
2	Moderate	Between 50 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.

Floodplain Fill Mitigation
6.9.4

Where fill in the 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 1% floodplain elevation by removing an equal volume from the 1% floodplain~~.~~,
- Add the fill mitigation volume to the detention volume needed~~.~~, and
- Coordinate the analysis~~-~~, excavation and fill locations, and LOMR with the HCFCD WMD and local floodplain administrator.

~~Contact the HCFCD WMD for excavation location limitations and LOMR guidelines.~~ Note: 1% floodplain limit is based on the site topography, not the effective FEMA Flood Insurance Rate Maps.

Continued on next page

6.9 Detention Volume, Continued

Minimum Detention Volume 6.9.5

Minimum detention volumes are:

- The volume calculated using Method 1 or 2 (Section 6.10 and 6.11), 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 using the Optional Project Routing Technique (Section 3.7), but not less than 0.45 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 0.45 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.

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 ~~deep~~ pool or wetland.

Do not include storage volume used to mitigate flood plain fill.

Do not include storage volume in an existing flood plain.

6.10 Method 1 – Small Project Drainage Areas

When to Use 6.10.1

For projects with drainage areas less than 50 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 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 0.55 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 0.55 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 50 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 50 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.

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% 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 ~~maximum allowable water surface~~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 ~~without flooding slabs upstream.~~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.

Use the criteria presented in Section 13, Extreme Event Overflow in designing emergency overflow weirs.

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.

Continued on next page

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, ~~follow Harris County~~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. ~~If the project meets the criteria for a Method 3 hydrologic and hydraulic analysis (see Section 6.12.1, When to Use), the minimum volume is as described in Section 6.9.5, Minimum Detention Volume.~~
- 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 ~~and in the receiving stream~~ is below the midpoint elevation of the gravity outlet ~~elevation~~ 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 ~~pump~~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:

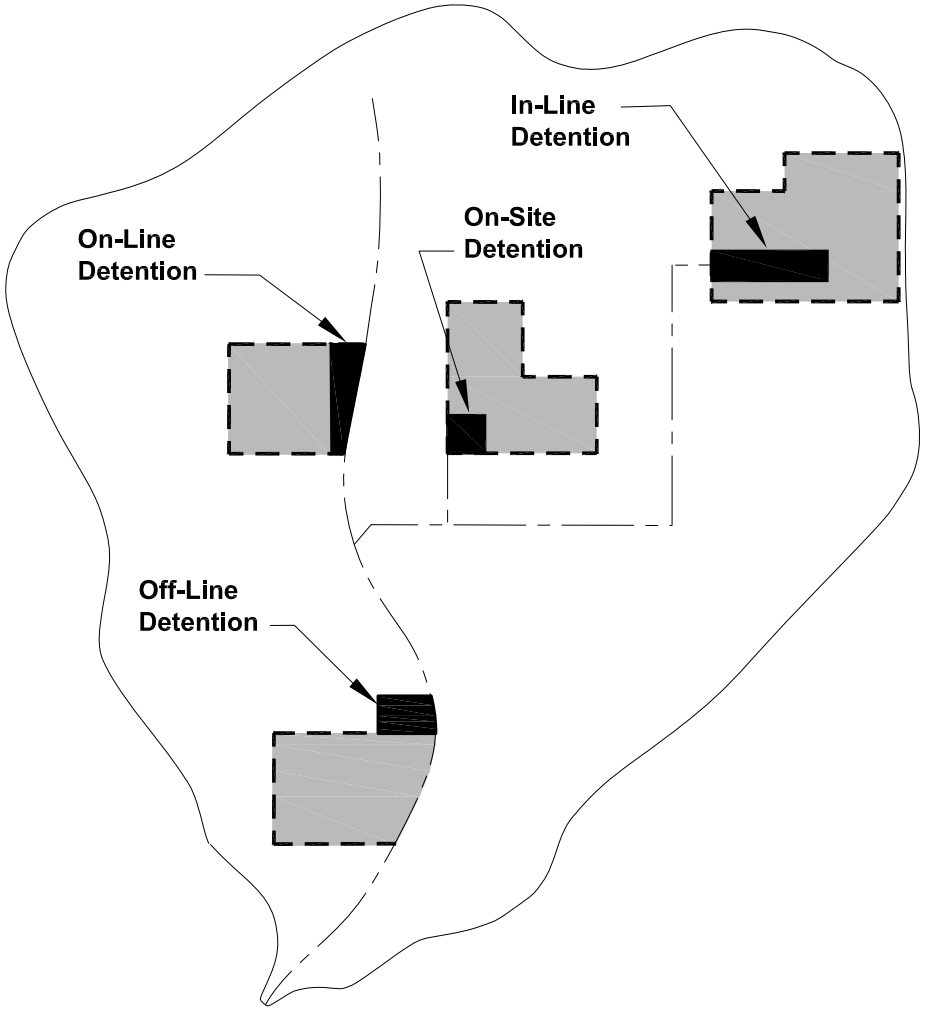
- Accept off-site sheetflow into the ~~developments~~development's storm sewer and detention system. Upsize the internal storm sewer, sheetflow system, and development's detention system, as necessary, to accommodate the additional off-site undeveloped or existing development flow. When the off-site 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.
- ~~For cases where~~Analyze the ~~detention basin outlet pipe is oversized to convey~~conditions with and without the ~~peak runoff from~~ offsite ~~areas, consider retrofitting~~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

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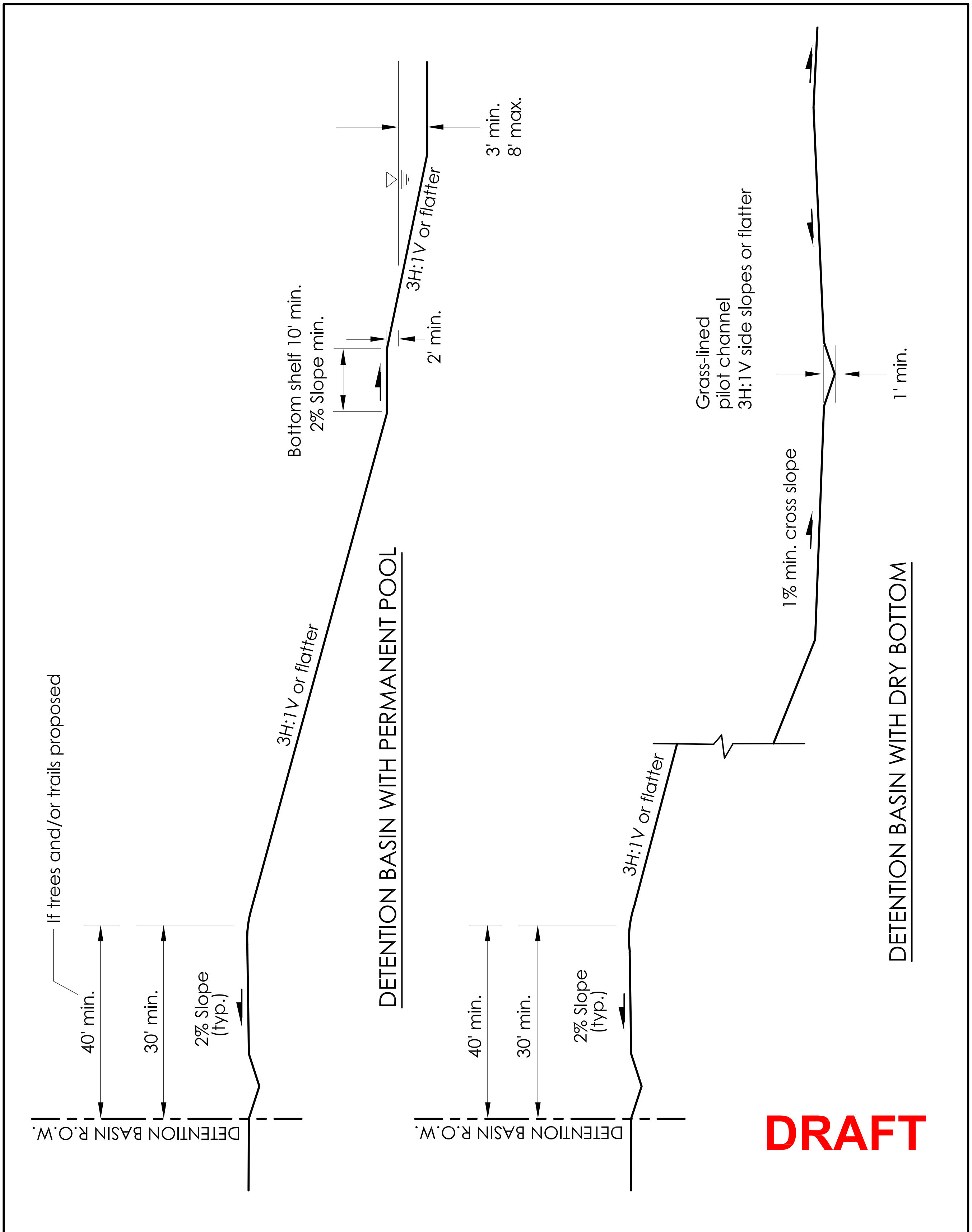
HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

TYPES OF DETENTION

DATE: 8/7/2018

EXHIBIT 6-1



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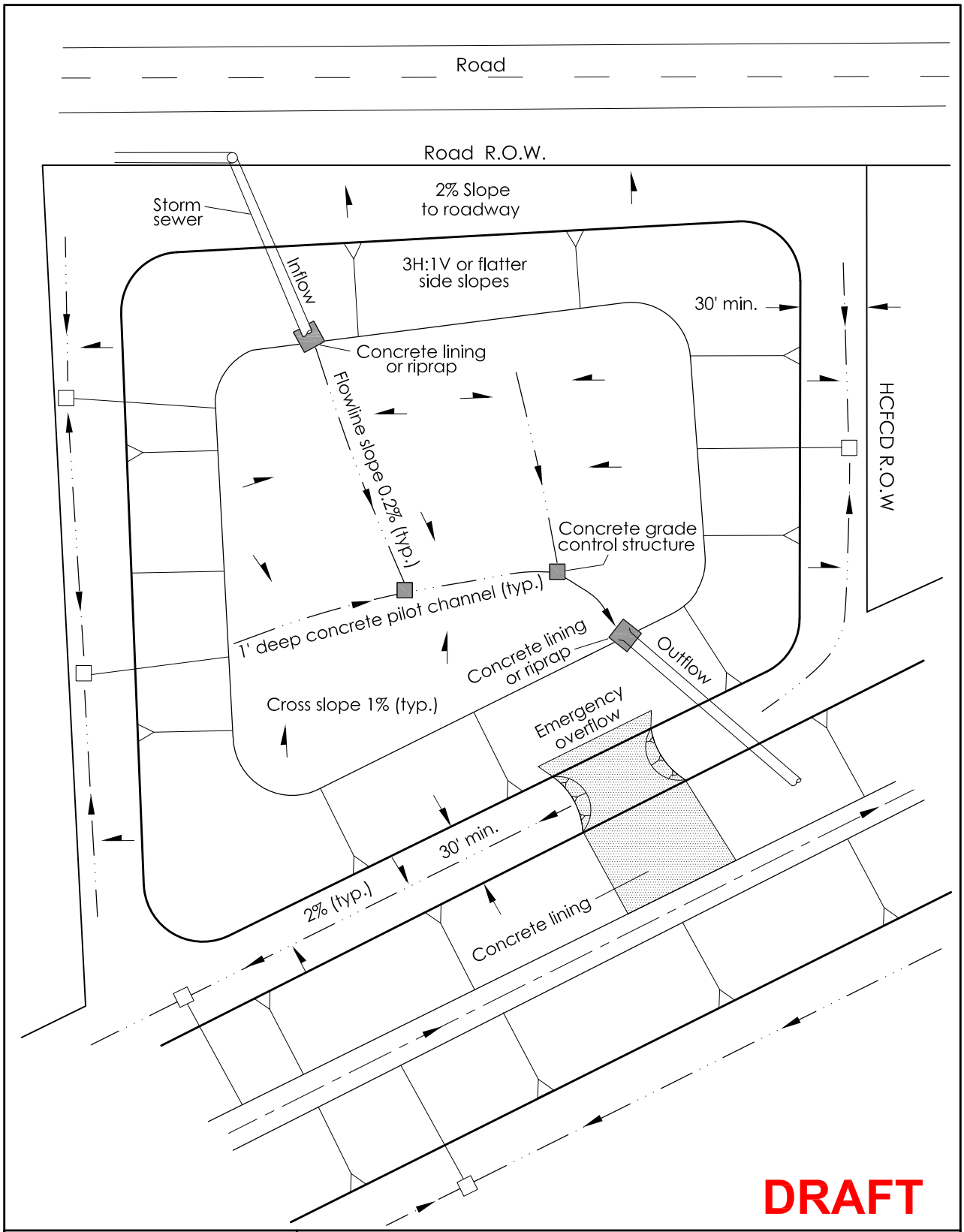
HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

TYPICAL DETENTION BASIN SECTIONS

DATE: 8/7/2018

EXHIBIT 6-2



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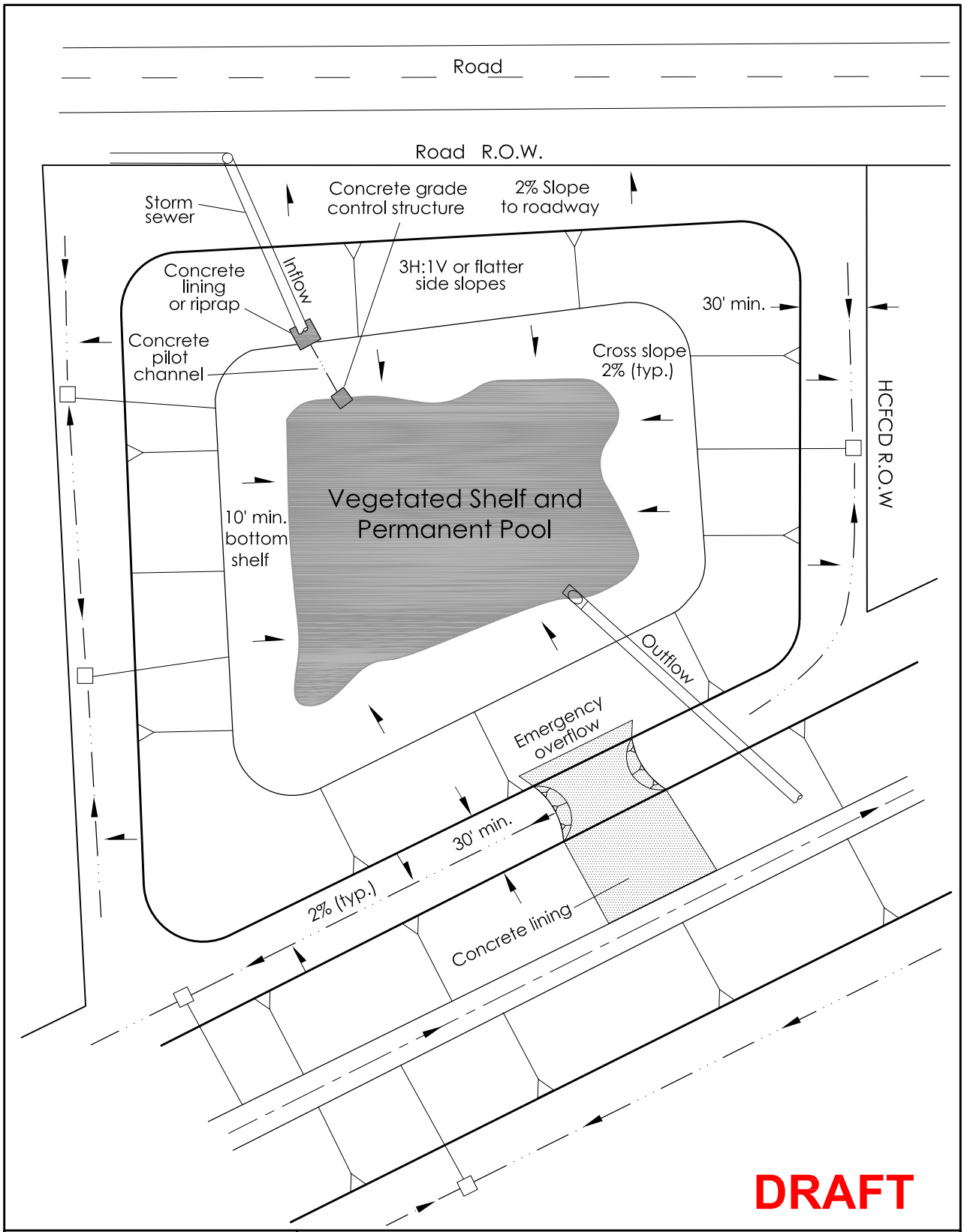
HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

WELL-GRADED, "DRY" DETENTION BASIN

DATE: 8/7/2018

EXHIBIT 6-3



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HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

"WET" BOTTOM DETENTION BASIN

DATE: 8/7/2018

EXHIBIT 6-4

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

- Design the bridge to pass the 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. ~~Design~~Confirm no adverse impacts for the ~~50~~bankfull event also, if the 10% exceedance event ~~also, if necessary~~flow 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, 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, whichever is higher, if possible without causing an impact on the existing or ultimate 1% 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.
- 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.
- 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.

Continued on next page

7.2 Design Criteria, Continued

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.

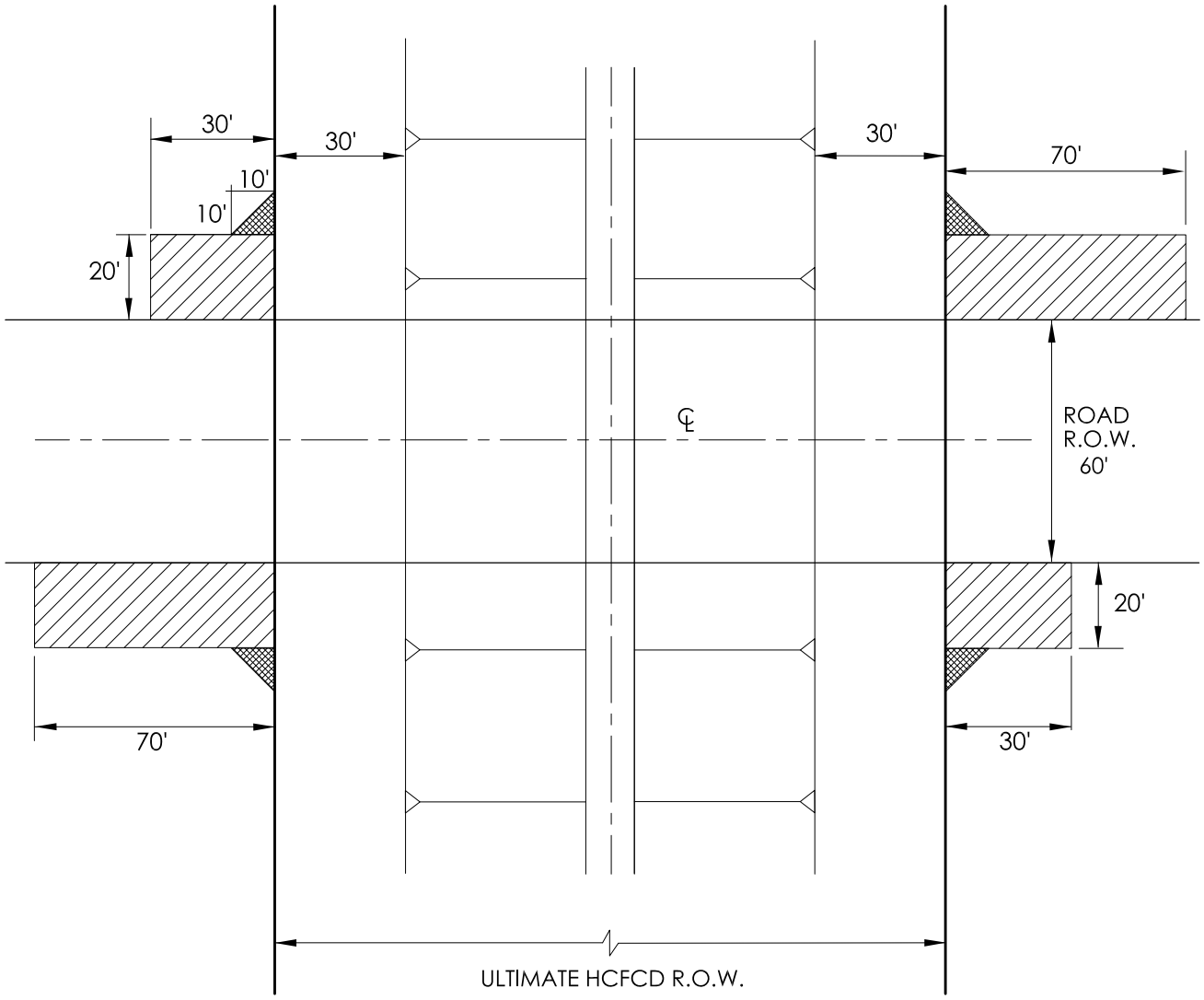
7.3 Hydraulic Analysis

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 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 ~~of~~for the ~~50% exceedance probability~~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

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HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

ACCESS TO HCFCD FACILITIES FROM ROADWAYS, BRIDGES AND CULVERTS

DATE: 8/7/2018	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

- Design the culvert to pass the 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. ~~Design~~Confirm no adverse impacts for the ~~50~~bankfull event also, if the 10% exceedance event ~~also, if necessary~~flow 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.

~~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.~~

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 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 ~~of~~for the ~~50% exceedance probability~~bankfull event, if necessary.
- For culverts on FEMA studied streams, also follow the FEMA and Flood Plain Administrator's submission and review requirements.

SECTION 9 – TRANSITION CONTROL STRUCTURES

9.1 Introduction

Overview 9.1.1

Transition control structures are used where there are abrupt changes in flowline elevation, channel shape, velocity, or change in channeling lining type (e.g. concrete to grass lined channels). Their purpose is to dissipate energy without eroding the channel or detention basin or causing a structural failure. In addition, they can also reduce the extent and cost of structural erosion protection in grass-lined channels.

The focus of this section is transition control structures in grass-lined channels.

See A.14, Transition Control Structure Examples in Appendix A.

Drop Structures 9.1.2

The most common transition control structure in Harris County is the drop structure – a structure used in channels at abrupt changes in flowline and on lateral channels where they enter a deeper receiving channel.

Three common drop structure types presented in this section are the:

- Straight drop spillway
- Sloped drop
- Baffle chute

Submittal Requirements 9.1.3

Submit the following to HCFCD for each transition control structure:

- Structural design calculations and sketches
- Geotechnical report
- Hydraulic design calculations and sketches

9.2 General Design Criteria

General Design Criteria 9.2.1

General design criteria for transition control structures are:

- Design for a range of flows and tailwater conditions up to and including the bank full and 1% exceedance events.
- Conduct a geotechnical investigation to assist with design of the structure.
- Locate transition control structures where flow is straight. Avoid channel bends and high turbulence areas, if possible.
- Provide structural erosion protection where maximum velocities are exceeded upstream and downstream of the transition control structure and where the hydraulic jump occurs (see Section 5.7, Horizontal Transitions and Section 10, Erosion and Sediment Control).
- For drop structures in lateral channels at the confluence with the receiving channel:
  - Locate the drop just inside the ultimate right-of-way of the receiving channel.
  - Design the hydraulic jump to occur before it enters the receiving channel.

9.3 Straight Drop Spillways

Overview
9.3.1

The three parts of a straight drop spillway (see Exhibit 9-1) are:

- Upstream draw down reach
- Drop opening
- Downstream hydraulic jump reach

The drop is usually constructed of steel sheet piling. Reinforced concrete lining and riprap are placed upstream and downstream of the drop structure for erosion and scour protection.

Design Criteria
9.3.2

Design criteria for straight drop spillways are:

- Comply with general design criteria for all transition control structures in Section 9.2.1, General Design Criteria.
- Design steel sheet piling to prevent bending or rotating.
- Coat steel sheet piling in accordance with industry standards to reduce rusting and scaling.
- Use concrete lining on the entire cross-section upstream and downstream of the drop (see Appendix D, HCFCD Concrete Channel Lining Details).
- Tie the concrete lining to the steel sheet piling drop structure.
- Use a minimum 8-inch thick slab on the downstream concrete lining due to the impact load and potential severe turbulence.
- Determine length of concrete lining upstream and downstream of the drop.
- Include 20 feet of riprap at the ends of the concrete slope paving to decrease flow velocities and protect the concrete toe from scour (see Section 10.5, Riprap).

9.4 Sloped Drops

Overview
9.4.1

Sloped drops are typically used for small drops (usually less than 4 feet) and in small channels (usually bottom widths less than 10 feet). Compared to a straight drop spillway, a sloped drop does not reduce the length of draw down through a constriction at the drop and dissipate energy in a free fall. A typical sloped drop is shown in Exhibit 9-2.

Design Criteria
9.4.2

Design criteria for sloped drops are:

- Comply with minimum design criteria for all transition control structures in Section 9.2.1, General Design Criteria.
- Use concrete lining on the entire cross section for the structure (see Appendix D, HCFCD Concrete Channel Lining Details).
- Determine length of concrete slope paving upstream and downstream of the drop.
- Include 20 feet of Grade 2 riprap upstream and a minimum of 20 feet of Grade 2 riprap downstream of the concrete slope paving to decrease flow velocities and protect the channel from scour (see Section 10.5, Riprap).
- Do not construct sloped drop structures with riprap or articulated concrete blocks.
- The drop slope no steeper than 2(H):1(V).
- Recommended side slopes of 4(H):1(V) or flatter.
- No side slope steeper than 2(H):1(V).

9.5 Baffled Chutes

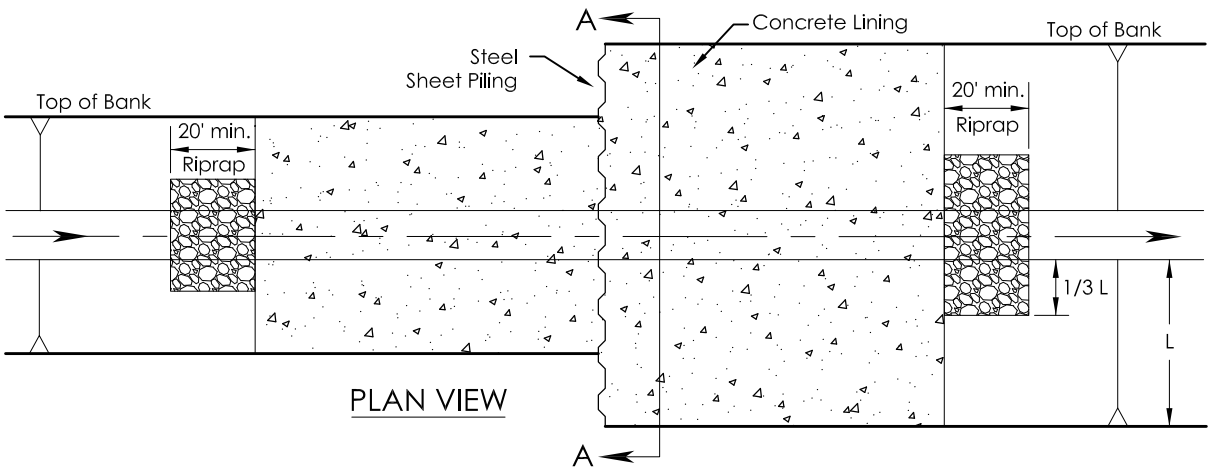
Overview
9.5.1

Baffled chutes are used to dissipate energy at abrupt changes in channel flowline and require no tailwater to be effective. They are generally selected over straight drop spillways for larger drop heights and where lateral channels drop into main channels. Baffle blocks prevent undue acceleration of the flow as it passes down the chute. Since the flow velocities entering the downstream channel are low, no stilling basin is needed. A generic baffled chute is shown in Exhibit 9.3.

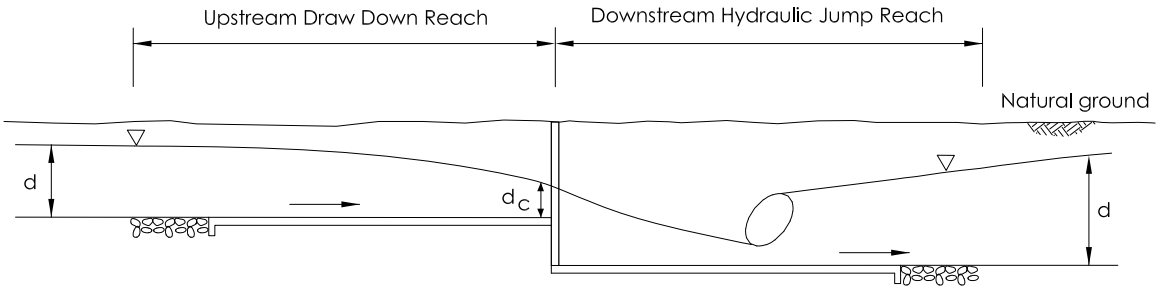
Design Criteria
9.5.2

Design criteria for baffled chutes:

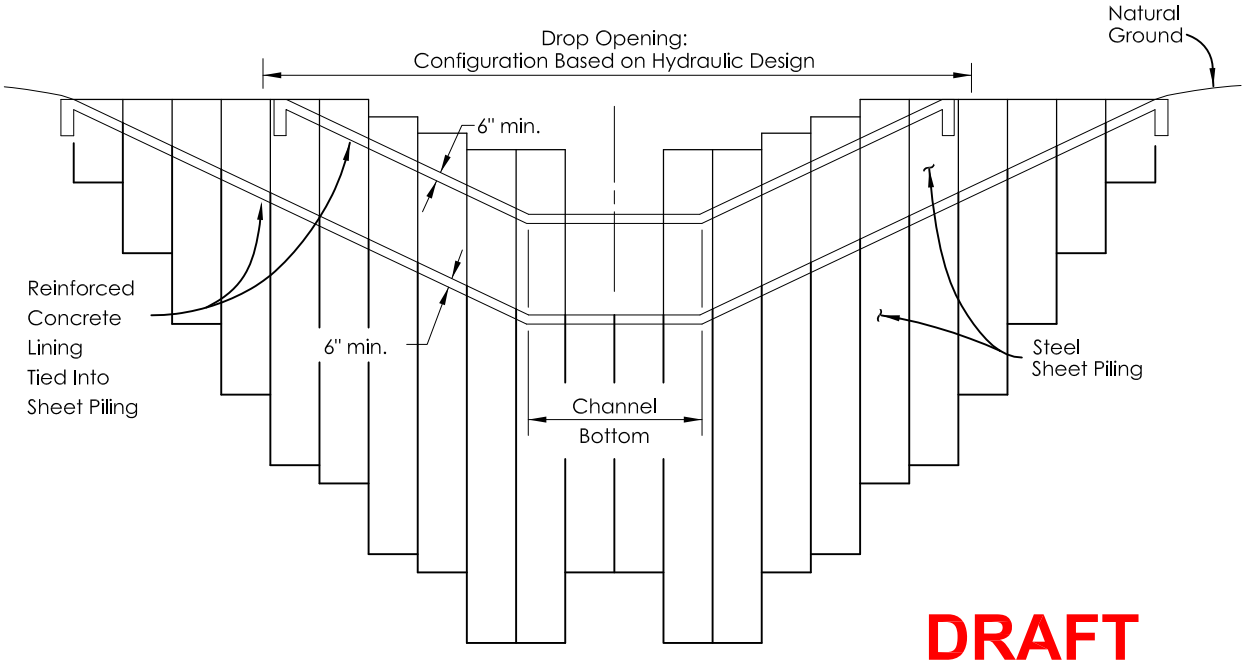
- Comply with minimum design criteria for all transition control structures in Section 9.2.1, General Design Criteria.
- Use concrete lining on the entire cross section for the structure (see Appendix D, HCFCD Concrete Channel Lining Details).
- Include 20 feet of riprap at the upstream end of the concrete lining to decrease flow velocities and protect the concrete toe from scour (see Section 10.5, Riprap).
- Use an applicable structural and hydraulic design methodology for baffled chutes.
- Use ultimate watershed conditions for establishing the design flow rate to avoid rebuilding the baffled chute as the watershed develops.



PLAN VIEW



PROFILE VIEW



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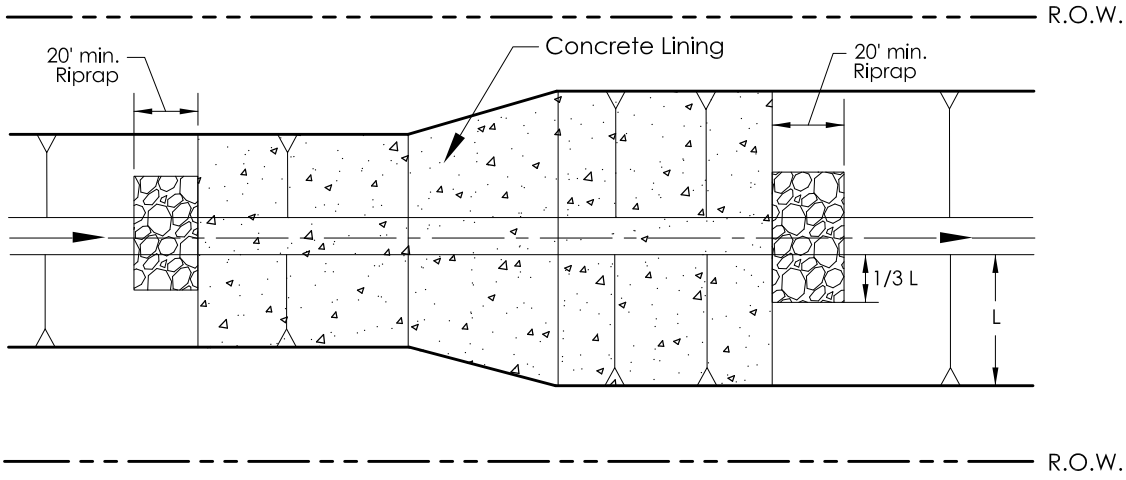
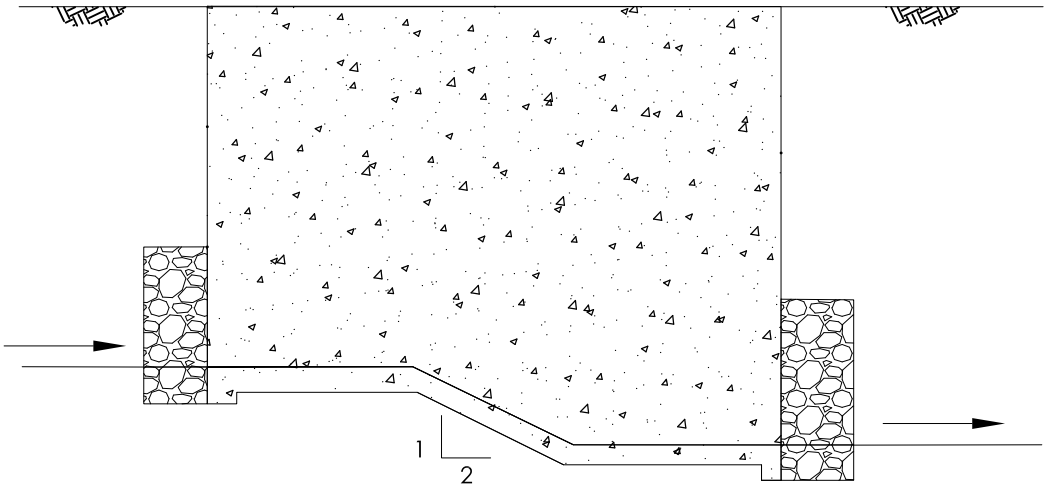
SECTION A-A

HARRIS COUNTY FLOOD CONTROL DISTRICT	POLICY, CRITERIA, & PROCEDURE MANUAL	**TYPICAL STRAIGHT DROP**
		DATE: 8/7/2018 / **EXHIBIT 9-1**



PLAN VIEW



PROFILE VIEW

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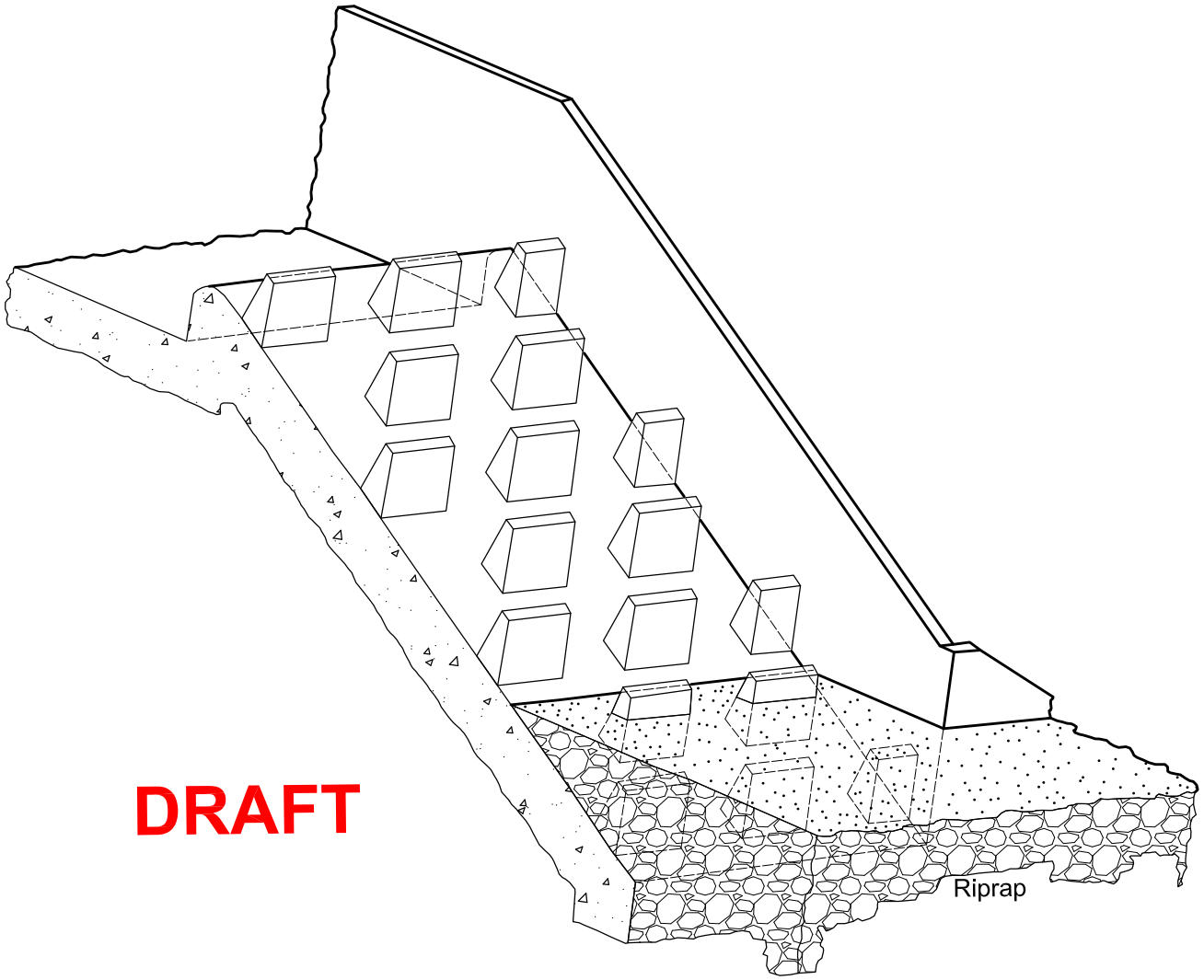
HARRIS COUNTY FLOOD CONTROL DISTRICT	**POLICY, CRITERIA, & PROCEDURE MANUAL**	**TYPICAL SLOPE DROP**
		DATE: 8/7/2018 / **EXHIBIT 9-2**



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See "Hydraulic Design of Stilling Basins and Energy Dissipators," Engineering Monograph No. 25, U.S. Department of the Interior, Bureau of Reclamation, 1984.

HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

BAFFLE BLOCK DROP

DATE: 8/7/2018

EXHIBIT 9-3

SECTION 10 – EROSION AND SEDIMENT CONTROL

10.1 Introduction

Overview 10.1.1

Address erosion potential in all designs of open channels, detention basins, and hydraulic structures. Knowledge of the geotechnical conditions, channel hydraulics, and actual field conditions are essential in developing a good erosion control plan. However, due to the dynamic and complex nature of water flow and the soil interface, erosion control plans are usually based on empirical relationships, water flow fundamentals, and field experience.

Causes of Erosion 10.1.2

Erosion in a channel or detention basin is caused by:

1. Excessive water velocity or turbulence within the banks, especially at confluences, storm sewer outfalls, bends, drop structures, and transitions.
2. Sheet flow over the bank.
3. Water flow out of the banks. (Examples: Natural ground water or leaks from swimming pools, irrigation systems, waterlines, etc.)

Results of Erosion 10.1.3

Erosion results in one or more of the following:

- Reduction of channel conveyance due to increased turbulence or flow irregularities.
- Reduction of channel conveyance or stormwater storage due to sedimentation.
- Interference with maintenance.
- Bank failures that lead to safety problems or threat to adjacent property.

Geotechnical Investigation 10.1.4

Knowing the soil type is critically important in understanding the erosion potential and designing appropriate erosion protection.

Submit a geotechnical report that specifically addresses soil types (including dispersive soils), erosion potential, and suggested erosion control measures.

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

Continued on next page

10.1 Introduction, Continued

Specific Problem Areas 10.1.5

Criteria at specific potential problem areas are in the sections listed below.

Problem Area	Section
Bends	5.8
Bridges	7
Culverts	8
Pipe Outfalls	11.3
Horizontal Transitions	5.7
Confluences	5.6
Transition Control Structures	9

Erosion Control Options 10.1.6

Various options exist depending on the anticipated conditions. A.15, Erosion Control Options in Appendix A, Applications and Examples provides practical design information and advantages/disadvantages of the common types of erosion control.

10.2 Hydraulic Considerations

Maximum Velocities 10.2.1

Maximum average cross-section velocities are based on a 1% exceedance probability flow. Values are presented in Section 4.4.1, Maximum Velocities.

Turbulence 10.2.2

Erosion often occurs in areas of high turbulence, such as at bridge bents, outfall pipes, drop structures, and abrupt transitions. Avoid creating high turbulence, if possible. Where it cannot be avoided, provide adequate erosion and scour protection.

10.3 Turf Establishment

Introduction 10.3.1

An established permanent turf grass stand is an effective and economical method to stabilize banks and minimize erosion caused by overbank flow and high velocities in channels and detention basins. Establishing a good turf grass cover requires testing and preparing the seedbed, fertilizing, selecting the proper seed, seeding properly, keeping the seed in place, and watering.

Native grasses may provide additional value to wildlife, water quality, and reduced maintenance. Coordinate with the HCFCD as early as possible.

Turf Grass Establishment Criteria 10.3.2

Turf grass establishment is required on all areas within HCFCD maintained facilities disturbed by construction, except channel bottoms and where structural erosion control measures are used.

Criteria for turf grass established by the developer or public entity is as follows:

- Establish turf grass as quickly as possible to minimize erosion and sedimentation.
- The means for establishing turf grass are in HCFCD Standard Specification Section 02921 - Turf Establishment.
- Turf grass establishment is required for final acceptance at the end of the one year warranty period. Minimum acceptance criteria is:
  - 75% coverage of live Bermuda, native grass species, or vegetation acceptable to HCFCD on disturbed areas.
  - No erosion or rills deeper than 4".

Conditions for HCFCD to Perform Turf Grass Establishment 10.3.3

HCFCD will perform turf grass establishment for a public entity or developer who disturbs existing or proposed HCFCD right-of-way if all conditions below are satisfied:

1. Follow applicable procedures in this manual for the proposed work.
2. The Turf Establishment Agreement is executed and the fee paid prior to commencing construction.
3. The owner or contractor notifies HCFCD 14 calendar days prior to completion of the work or a portion of the work to allow time for HCFCD to schedule the turf grass contractor.

10.4 Concrete Lining

Overview 10.4.1

Concrete lining is poured in place and reinforced concrete is used for erosion protection in channels or detention basins.

Basis of Design 10.4.2

The stability of concrete lining is based on its ability to withstand temperature changes, shear forces created by flow in the channel, and the hydrostatic forces from the soil. Important factors include:

- Concrete thickness and reinforcing
- Transitions
- Soil type
- Flow velocity
- Channel geometry
- Channel grade

Note: If the concrete lining is intended to enhance slope stability, design the lining as a structural element considering reinforcement, deeper toe walls, and other design features.

Concrete Lining Criteria 10.4.3

Criteria are presented in the table below. See Appendix D, HCFCD Concrete Channel Lining Details, for a typical section and plan view.

Feature	Criteria
Side slopes no steeper than	2(H):1(V)
Upper limit of lining	1/3 up side slope minimum
Concrete thickness on slope and bottom	5 inches minimum
Minimum reinforcing steel	#4 bars on 12 inch centers each way or equivalent welded wire fabric
Minimum toe wall depth	Channel bottom – 3 feet Side slope – 2 feet Top of lining – 2 feet
Toe wall thickness	8 inches
Top of lining	See HCFCD Concrete Channel Lining Details in Appendix D.

Continued on next page

10.4 Concrete Lining, Continued

Concrete Lining Criteria - Continued 10.4.3

- Geotechnical investigations are required to confirm side slopes. Channel linings do not provide structural support for the soil.
- Partially concrete-lined channels require backslope drainage systems.
- Concrete toe walls are required on all sides to reduce the chance of flow under the lining and decrease the chance of lining failure.
- Riprap is required in channels a minimum of 20 feet upstream and downstream of the paving across the bottom and one-third up the side slopes to decrease flow velocities.
- Access stairways are required for side slopes 2.5:1 and steeper, including concrete low-flow sections. Locate stairways on the upstream side of road crossings and at intervals less than 1500 feet.
- Detailed construction drawings are required where removing, modifying, or replacing existing concrete lining is proposed for a project. Example: Installing a new storm sewer outfall through concrete lining.

10.5 Riprap

Overview
10.5.1

Riprap is broken concrete rubble or stone used for erosion or scour protection in channels or detention basins.

Proper design, gradation, and placement are essential to the success of riprap. See HCFCD Standard Specification 02378.

Basis of Design
10.5.2

The stability of riprap is based on the ability of the riprap to withstand the shear forces created by flow in the channel. Important factors include:

- Stone size and shape.
- Stone weight and gradation.
- Riprap mat thickness.
- Geotextile fabric or bedding.
- Flow velocity.
- Channel geometry.
- Channel grade.

Continued on next page

10.5 Riprap, Continued

Design Process 10.5.3

The overall process for riprap design is:

- Identify areas of the channel where erosion or scour might occur or is occurring
  - Historic problem areas
  - Direct observation
  - Average depths of various storm frequency flows
  - Velocities in the channel and/or outfalls
  - Other hydraulic conditions such as turbulence
- Apply details and standards for acceptable minimums
  - Select the appropriate size, gradation, mat thickness
  - Lay out riprap to the appropriate slope, limits, extents
- Confirm that these minimums meet the hydraulic conditions for
  - Depth, velocity, energy loss, shear stress
  - If not, perform a custom riprap design
- Verify erosion or scour will not be translated upstream or downstream
- Perform geotextile fabric design, where necessary

Note: Direct observation and assessment of existing field conditions is important for identifying soil types, vegetation type and extent, side slope failures, erosion features, groundwater, etc.

See A.16, Riprap Gradation Examples in Appendix A for sizing riprap and physical layout needed for a pipe outfall, channel transition, channel confluence, and channel bend.

Velocity – Typical Conditions 10.5.4

In Harris County, two levels of riprap gradation (HCFCD Specification 02378, Riprap and Granular Fill) are usually sufficient based on ranges of maximum average cross section velocity in low to moderate turbulence areas (see Section 4.4, Velocities):

For $5 \text{ fps} \leq V < 7 \text{ fps}$, use riprap gradation No. 1

For $7 \text{ fps} \leq V < 9 \text{ fps}$, use riprap gradation No. 2

For $V \geq 9$ fps, specify a custom riprap design or use another type of erosion control.

In areas of potential high turbulence such as at bridges, transition control structures, or high velocities such as a pipe outfall from a detention, use the shear stress equations in Example A.16 to confirm or revise the riprap size and layout.

Continued on next page

10.5 Riprap, Continued

Riprap Criteria 10.5.5

Criteria are presented in the table below. See HCFCD Storm Sewer and Riprap Details in Appendix D for a typical section and plan view.

Feature	Criteria
Side slopes no steeper than	2(H):1(V)
Upper limit of riprap	1/3 up side slope minimum
Minimum riprap mat thickness	18 inches
Side slope finish	Finish leveling with topsoil and no riprap visible on surface
Minimum limit into channel or detention bottom	1.5 times the mat thickness from toe of slope
Minimum toe wall depth at toe of slope and in bottom	1.5 times the mat thickness

In addition,

- Use HCFCD standard riprap sizes, gradations, and mat thickness in HCFCD Standard Specification Section 02378 – Riprap and Granular Fill, where applicable.
- See Appendix D, HCFCD Storm Sewer and Riprap Details.
- Geotechnical investigations are required to confirm side slopes.
- On side slopes, riprap voids are filled and covered with a minimum of 6 inches of topsoil for turf establishment.
- Riprap-lined channels require backslope drainage systems.
- For minimum riprap extent at pipe outfalls, drop structures, bends, etc., see the sections in this manual for those specific features.
- Detailed construction drawings are required where removing, modifying, or replacing existing riprap is proposed for a project. Example: Installing a new storm sewer outfall through riprap.

Continued on next page

10.5 Riprap, Continued

Geotextile Fabric/ Bedding 10.5.6

Where the soil is primarily silt, sand or granular, design a geotextile fabric to reduce soil migration. Design a geotextile fabric compatible with site specific soils based on particle size distribution, plasticity, porosity and hydraulic conductivity. Select a fabric that minimizes the long term clogging potential and meets the required strength criteria. Design procedures in Hydraulic Engineering Circular No. 23, September 2009, Design Guideline 16 (Publication No. FHWA-NHI-09-112, Volume 2) are recommended for design of the fabric and developing a selection criteria for the use of the geotextile fabric.

Granular bedding under riprap is not common in Harris County, but if there is potential application then coordinate with the HCFCD as early as possible.

10.6 Other Linings

Overview
10.6.1

If other erosion protection linings are being considered, consult with HCFCD prior to design for acceptability and/or minimum criteria, if available.

Detailed construction drawings are required where removing, modifying, or replacing existing linings is proposed for a project. (Example: Installing a new storm sewer outfall through an existing erosion control product.)

10.7 Sediment Control During Construction

Criteria 10.7.1

Comply with the Texas Pollutant Discharge Elimination System (TPDES) requirements.

TPDES Construction General Permit Compliance includes, but is not limited to:

- Developing a Storm Water Pollution Prevention Plan (SWPPP);
- Submitting a Notice of Intent (NOI) and/or Construction Site Notice (CSN);
- Coordinating SWPPP and NOI review with HCFCD Stormwater Quality Department.

SECTION 11 – BACKSLOPE DRAINAGE SYSTEMS AND PIPE OUTFALLS

11.1 Backslope Drainage Systems

Introduction 11.1.1

Backslope drainage systems collect stormwater within the maintenance berm and convey it to the channel or detention basin through a pipe to minimize overbank flow and erosion. Backslope drainage systems are necessary for the long-term integrity of grass-lined channels or detention basins.

Where to Use 11.1.2

Backslope drainage systems are required for HCFCD maintained channels and detention basins except where:

- The side slope is concrete-lined to the top of bank.
- The depth at the toe of the side slope is less than 7 feet.
- The ground slopes 2% or steeper away from the top of bank to an adjacent curb and gutter street or roadside ditch.
- The ground slopes 2% or steeper from the top of bank to an adjacent jurisdictional wetland that will remain.

Continued on next page

11.1 Backslope Drainage Systems, Continued

Criteria 11.1.3

Criteria for backslope swale design are in the table below. See Exhibit 11-1, Backslope Swale Design Criteria.

Feature	Criteria
Depth from natural ground at edge of right-of-way	0.5 foot minimum
Depth from top of channel or detention basin bank	1 foot minimum
Depth of swale	2 feet maximum
Depth of swale at summit	0.5 foot
Depth at interceptor structure centerline	2.5 feet maximum
Swale side slope	No steeper than 1.5(H):1(V)
Swale gradient, typical	0.2%
Swale gradient, dispersive clays	0.4%
Swale centerline	5.5 feet inside right-of-way line
Interceptor structure spacing, typical	800 feet maximum (400 feet from swale summit)
Interceptor structure spacing, dispersive clays	400 feet maximum (200 feet from swale summit)
Berm width for the backslope drainage system	10 feet minimum

Note: Establish final interceptor structure elevations and locations based on actual or proposed ground topography and local drainage patterns.

Continued on next page

11.1 Backslope Drainage Systems, Continued

Criteria - Continued 11.1.3

- Design and construct interceptor structures in accordance with HCFCD Interceptor Structure and Concrete Pilot Channel Details in Appendix D.
- Include design details of interceptor structures for pipe sizes larger than the ones shown on the HCFCD Interceptor Structure and Concrete Pilot Channel Details in Appendix D.
- Developed property is not allowed to drain to backslope swales, except as noted below:
  - To avoid retaining walls and steep earthen slopes at the back of residential or commercial lots that adjoin a HCFCD maintained facility,
    - one-half or less of adjacent residential lots may be sloped to drain to a backslope drainage system.
    - earthen slopes over 6 inches high adjacent to a backslope drainage system must be 3(H):1(V) or flatter .
- Where undeveloped acreage drains into the backslope swale system, no more than 10 acres (15 cfs) can drain into one standard backslope interceptor structure. If necessary, include additional interceptor structures and/or larger pipes than the 24 inch minimum to carry the total offsite flow (submit a drainage area map). Other interceptor structures are available to collect offsite flow as shown on the HCFCD Interceptor Structure and Concrete Pilot Channel Details in Appendix D.
- Urban interceptor structures can be used in developed areas with limited right-of-way if HCFCD approval is obtained prior to submitting construction drawings.
- Do not place interceptor structures in the corners of a detention basin or in channel curves tighter than 45 degrees.
- Locate high points of backslope swales in the corners of a detention basin and in channel curves, so storm water drains away from the corners and curves. See Exhibit 11-2, Backslope Swale & Interceptor Structure Layout - Acceptable and Unacceptable.

11.2 Offsite Ditch Interceptor Structure

Introduction
11.2.1

The offsite ditch interceptor structure is used to convey flow from small ditches into HCFCD maintained facilities through a pipe to minimize overbank flow and erosion problems. The ditch can be along a roadway or a natural or manmade ditch draining to the HCFCD facility from adjacent property.

Criteria
11.2.2

- Design and construct offsite interceptor structures in accordance with HCFCD Interceptor Structure and Concrete Pilot Channel Details in Appendix D.
- Confirm pipe sizes by submitting a drainage area map and calculations using the Harris County method for determining flow rates for storm sewers or the bankfull capacity of the ditch.
- Locate offsite ditch interceptor structures just outside HCFCD right-of-way, wherever possible. If not, locate it as close to the edge of the right-of-way as possible to maximize the room for maintenance and construction vehicles. Minimum space from top of bank to edge of offsite ditch interceptor structure is 20 feet.

11.3 Pipe Outfalls

Introduction 11.3.1

Pipe and box outfalls are a common method for conveying flow into channels and detention basins. References to pipe outfalls include box outfalls, as well. See Section 6.7, Outflow Structures.

Considerations 11.3.2

Factors to consider when designing and laying out a pipe outfall into a HCFCD maintained facility are:

- Exit velocity from the pipe.
- Alignment relative to the flow in the HCFCD facility.
- Location of the pipe relative to the HCFCD facility geometry.
- Location of the pipe relative to other structures in the HCFCD facility.

Backflow Preventers 11.3.3

Two common types are flap gates and duckbill check valves.

Backflow preventers are acceptable provided they :

- Are above the normal water surface.
- Do not project into the channel flow.
- Are recessed into the channel side slope with a headwall and wingwalls.
- Can be easily accessed and designed appropriately to remove debris. See Section 16.3, Floatables Collection Structure. (For example, including lifting rings and equipment pad to raise gates or remove valves.)
- Include an all-weather access road to the backflow preventer to remove debris and make repairs. See Section 16.3.5, All-Weather Access Road Criteria.

Backflow preventers on storm sewer outfalls are not accepted by HCFCD for maintenance since they are part of the storm sewer system. They are permissible if another entity agrees to maintain them, provided the above criteria are satisfied and a note is added on the construction drawings indicating the entity responsible for maintenance and repair.

HCFCD will maintain backflow preventers on pipe or box structures draining from a HCFCD regional detention facility into a HCFCD channel. Coordinate the type HCFCD will accept with the HCFCD Watershed Management Department and Mechanical/Electrical Section.

Continued on next page

11.3 Pipe Outfalls, Continued

Design Criteria 11.3.4

Standard Details:

- Design and construct outfall pipes in grass-lined channels and detention basins in accordance with HCFCD Storm Sewer and Riprap Details in Appendix D.
- Design and construct outfall pipes in concrete-lined channels and detention basins in accordance with HCFCD Concrete Channel Lining Details in Appendix D.
- Use the pipe adjustment details shown on the HCFCD Storm Sewer and Riprap Details in Appendix D, where applicable, and include custom pipe adjustment details where necessary.
- Use corrugated metal pipe (galvanized steel or aluminum) or HDPE pipe with a minimum 24-inch diameter for outfall pipes within a HCFCD facility right-of-way.
- Install riprap erosion protection in grass-lined channels and detention basins for any size storm sewer pipe, wastewater treatment plant outfall pipes, or where the design velocity out of the pipe exceeds the maximum for the soil type in Section 4.4.1, Maximum Velocities table. Minimum riprap layout is shown on the HCFCD Storm Sewer and Riprap Details in Appendix D. Near bridges or other locations where velocities and turbulence are high, expand riprap layout and use the shear stress equations in Example A.16 to confirm or revise the riprap size.
- Include a swale across a bottom or lower vegetated shelf from the pipe outfall to the low flow channel or pool using the swale criteria in Section 6.6.5, Pipe Outfalls on a Bottom Shelf, except in channels do not use concrete lining in the swale.

Plan Layout:

- Place a standard manhole or junction box just outside the ultimate channel or detention basin right-of-way.
- Place all storm sewer inlets outside HCFCD facility right-of-way.
- Angle pipes and boxes downstream a minimum of 30 degrees starting at the last manhole and measured from line perpendicular to the channel.
- Locate storm sewer outfalls on the downstream side of bridges and culverts.
- Avoid placing outfalls 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.

For storm sewer outfall pipes in HCFCD channels and detention basins, clearly indicate in the construction drawings the entity responsible for their maintenance and repair.

Continued on next page

11.3 Pipe Outfalls, Continued

Design Criteria - Continued 11.3.4

Exceptions:

- Pave the corrugated metal pipe invert of wastewater effluent outfalls with concrete or use plastic pipe designed for wastewater effluent.
- For submerged inflow pipes or boxes, see Section 11.3.5, Submerged Inflow and Outflow Pipes below.
- HDPE pipes are not allowed to outfall through concrete slope paving or concrete headwalls.
- Corrugated metal pipe outfalls through concrete slope paving or concrete headwalls are discouraged because they tend to separate. If it is unavoidable, include a detailed drawing satisfactory to the HCFCD.
- Inflow pipes from backslope drains into detention basins can match the dry bottom elevation at the toe of slope.
- Storm sewer inflow pipe invert into detention basins and channels can match the pilot channel flowline, bottom or lower shelf swale flowline, or one foot above normal water level, whichever is higher.
- Storm sewer inflow pipes into detention basins can be reinforced concrete pipe (see Section 6.6.2, Inflow Structures).
- Where concrete pipe larger than 42 inches or box culverts are used to convey inflow into a detention basin or channel, provide a structurally designed headwall and wingwalls recessed into the detention basin or channel slope at the end of the pipe. Concrete slope paving alone is not sufficient. Design and construct the box culvert and headwall/wingwalls in accordance with TxDOT or Harris County criteria. If the HCFCD channel is natural or naturalized, a headwall may be problematic.
- For outfalls from a HCFCD detention basin with a floatables collection structure into a HCFCD channel, a manhole is allowed in the HCFCD right-of-way if needed to angle the outfall downstream (see Section 16.3, Floatables Collection Structure).

Detention Basin Outfalls:

See Section 6.7, Outflow Structures for additional criteria.

Continued on next page

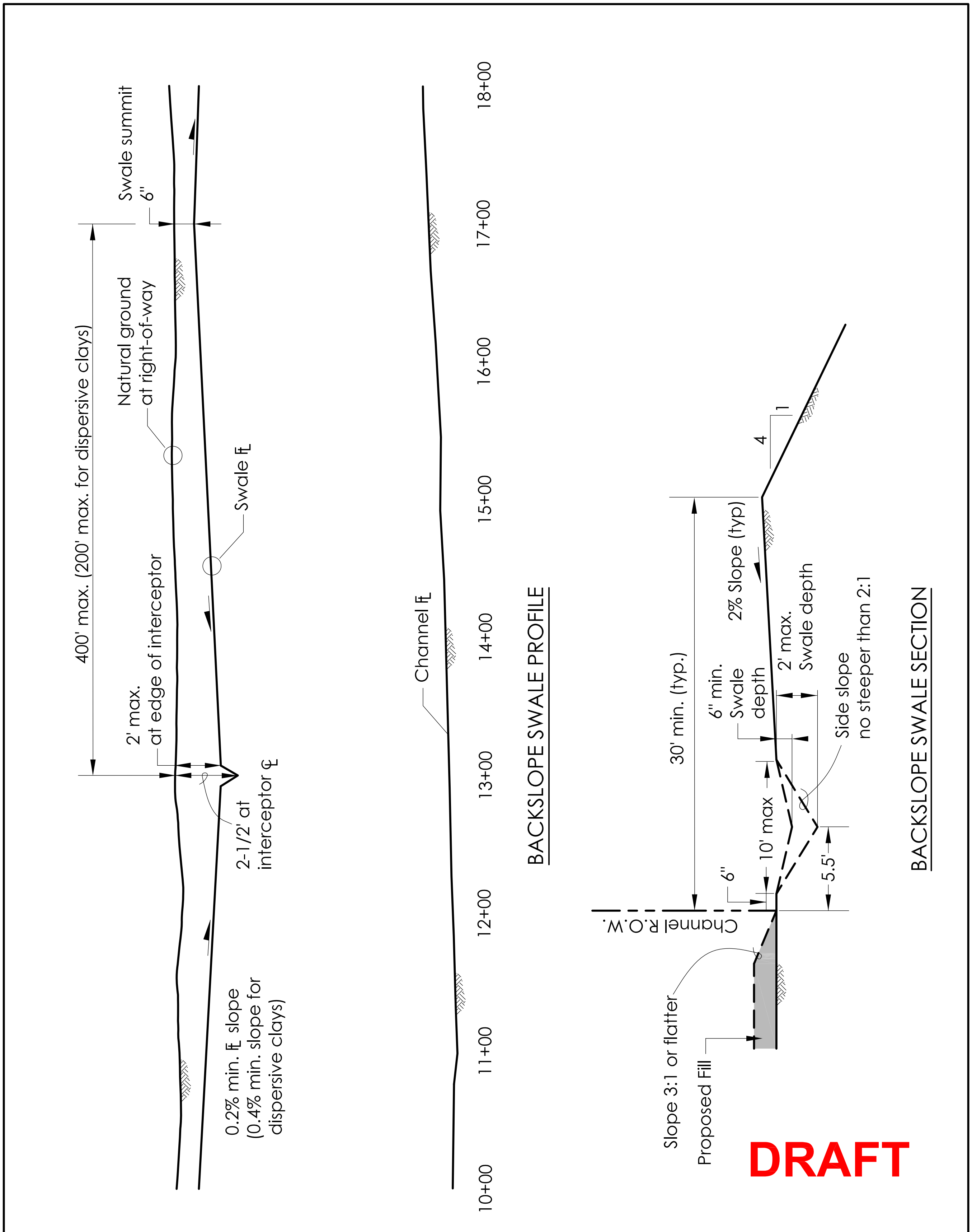
11.3 Pipe Outfalls, Continued

Submerged Inflow and Outflow Pipes 11.3.5

Storm sewer pipes or boxes carrying inflow into a HCFCD maintained stormwater detention basin may be partially or fully submerged in a ~~deep or shallow~~permanent pool or vegetated shelf provided:

- Current "Regulations of Harris County, Texas for the Approval and Acceptance of Infrastructure" or the criteria of the entity who will maintain the inflow or outflow pipes or boxes are followed.
- The construction drawings designate the entity responsible for maintenance and repair of any submerged pipe within a HCFCD or other government entity detention basin or channel.
- A complete detail is included in the construction drawings.
- Partially or fully submerged pipes are RCP. Submerged CMP or HDPE are not allowed in HCFCD right-of-way.
- A structurally designed concrete headwall or anchoring system is used at the end of the pipe.
- Backflow preventers (e.g. flap gates) are not allowed on submerged pipes

Note: Do not submerge backslope drain pipes or outflow pipes.

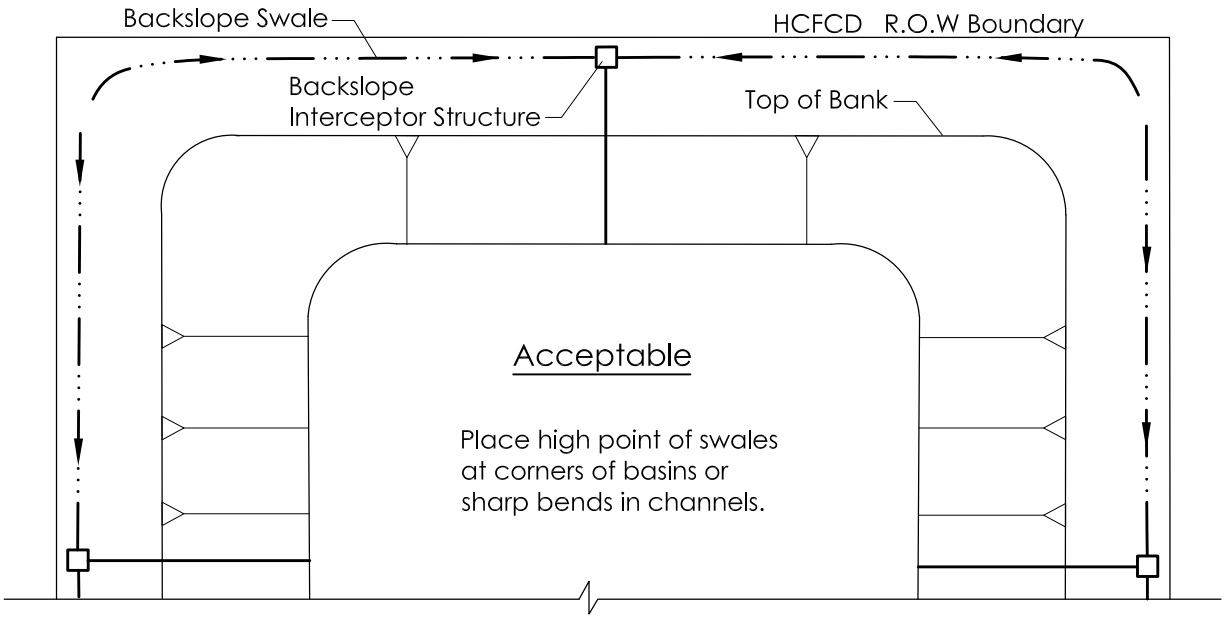


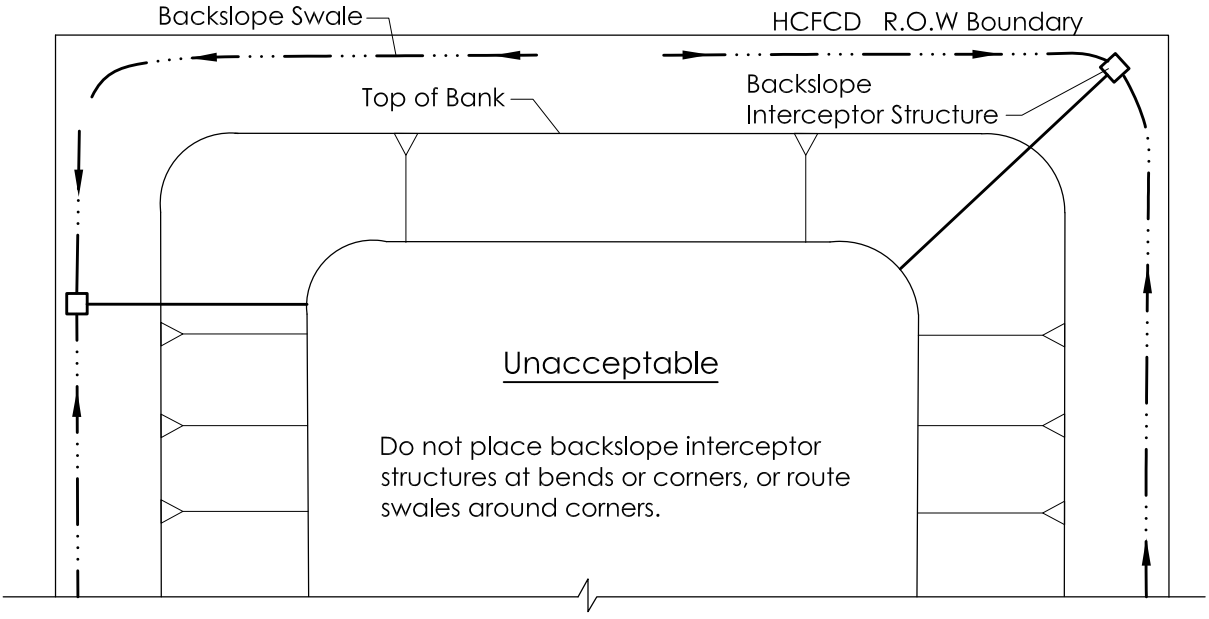
HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

BACKSLOPE SWALE DESIGN CRITERIA FOR TYPICAL BACKSLOPE INTERCEPTOR STRUCTURE

DATE: 8/7/2018 | **EXHIBIT 11-1**





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HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

BACKSLOPE SWALE & INTERCEPTOR STRUCTURE LAYOUT - ACCEPTABLE AND UNACCEPTABLE

DATE: 8/7/2018	EXHIBIT 11-2

SECTION 12 – CHANNEL ENCLOSURES

12.1 Introduction

Overview 12.1.1

Channels normally maintained by HCFCD can be enclosed provided the criteria and procedures in this manual are followed.

Analysis and Methodologies 12.1.2

Hydraulic analysis and submittal requirements that apply to channels also apply to channel enclosures. Hydraulic aspects specific to channel enclosures are presented in this section.

Maintenance Responsibility 12.1.3

Since the HCFCD's primary responsibility is for open drainage facilities, convey the right-of-way and maintenance responsibility of an enclosed channel to a taxing entity that maintains underground drainage systems.

Long Detention Basin Outfalls 12.1.4

While not a channel enclosure as defined in Section 12.1.1, Overview, a long outfall pipe or box from a HCFCD detention basin to a HCFCD channel may qualify for HCFCD maintenance (see Section 2.2.4, Unacceptable HCFCD Facilities) provided all Acceptance Criteria are satisfied (see Section 2.2.3, Acceptance for HCFCD Maintenance) .

Use concrete boxes or pipes for long outfalls and comply with design criteria in this chapter; Section 6.7, Outflow Structures; and Section 11.3, Pipe Outfalls.

12.2 Design Criteria

Application 12.2.1

The criteria in this section apply where the drainage area for the enclosure is greater than 200 acres, where the HCFCD maintained facility would normally begin, or long detention basin outfalls that HCFCD will maintain (Section 12.1.4).

Hydraulic Criteria 12.2.2

Hydraulic criteria are:

- For new developments or new drainage facilities, design the pipe or box to contain the 1% exceedance probability, 24-hour storm event water surface within the enclosure with one foot of freeboard for ultimate watershed conditions. Accommodate the energy grade line within the facility right-of-way, as well.
- Verify internal, entrance, and exit velocities are not excessive (see Section 4.4.1, Maximum Velocities).
- Show how the 1% exceedance probability flow will get into the pipe or box.
- Accommodate extreme event flows (in excess of the 1% exceedance probability) where possible.
- Submit hydraulic calculations, profiles, and design for review.
- For long detention basin outfalls, use the hydraulic criteria in Section 6.7, Outflow Structures.

Design Criteria 12.2.3

Use the criteria from the jurisdiction that is going to maintain the enclosed drainage facility.

For an enclosure HCFCD will maintain, the criteria are:

- Use only concrete structures.
- Evaluate safety factors against uplift and buoyancy.
- Investigate and account for locations and potential conflicts with aerial and subsurface utilities.
- Address and account for off-site sheet flow.
- Avoid crossing under roadways.
- May need safety racks on inlet end depending on box or pipe size.

Continued on next page

12.2 Design Criteria, Continued

Manholes and Inlets 12.2.4

Criteria for manholes are:

- Use the criteria from the jurisdiction that is going to maintain the enclosed drainage facility.
- Manholes can be combined with City of Houston Type "E" or Type "B" inlets to drain surface swales.
- Select inlets to minimize reduction in flow capacity due to clogging.

Right-of-Way 12.2.5

- Minimum right-of-way width is the outside width of the pipe(s) or box(es) plus a distance on each side equal to the flowline depth measured from natural ground or proposed fill elevation, whichever is higher and rounded up to the nearest 5 feet. The minimum width on each side shall be 10 feet.
- Encompass all manholes within the right-of-way for the facility. Extend the right-of-way limit 5 feet from the edge of the manholes and inlets.
- Provide continuous linear surface access for repair and routine maintenance and a HCFCD right-of-way.
- Provide sufficient off-road staging area for vehicles or equipment to safely clear traffic for access onto HCFCD right-of-way. See Section 5.3.9, Maintenance Access Plan.

SECTION 13 –EXTREME EVENT OVERFLOW

13.1 Introduction

Overview
13.1.1

This section covers the criteria for conveying extreme event overland flow into HCFCD ~~maintained~~ channels or detention basins and emergency overflow spillways from detention basins into HCFCD channels to minimize chance of damage to ~~the~~homes and business and HCFCD ~~facility~~facilities. For swales or ditches carrying normal flows to a HCFCD maintained facility, see Section 11, Backslope Drainage Systems and Pipe Outfalls.

~~For emergency overflow spillways from a HCFCD detention basin to a HCFCD channel, see Section 6.13, Emergency Overflow for general design criteria and considerations, and Section 13.2 below for criteria and considerations for an emergency weir, a common emergency overflow structure.~~

Overland Flow Design
13.1.2

Stormwater runoff that travels on the surface trying to reach an open channel or detention basin is referred to, in this manual, as overland flow. Roadway, house, and business flooding from overland flow is a significant problem in Harris County, therefore, proper design is critically important. A.17, Overland Flow Example in Appendix A, is included to assist with proper design.

Local jurisdictions, such as Harris County, TxDOT, and the City of Houston, have regulations and/or requirements for accommodating extreme event overland flow and water levels within the storm sewers, roadways and developments.

Emergency Overflow Spillway
13.1.3

For emergency overflow spillways from a HCFCD detention basin to a HCFCD channel, see Section 6.13, Emergency Overflow for general design criteria and considerations, and Section 13.2 below for criteria and considerations for an emergency weir, a common emergency overflow structure. Use the overflow swale shown in Exhibit 13-1 as a guide for erosion protection in the detention basins, as well.

13.2 Extreme Event Overland Flow ~~Swales~~Swale and Emergency Overflow ~~Weirs~~Spillway

Criteria 13.2.1

A typical extreme event overland flow concrete swale or weir within a HCFCD right-of-way is shown in Exhibit 13-1.

Criteria are:

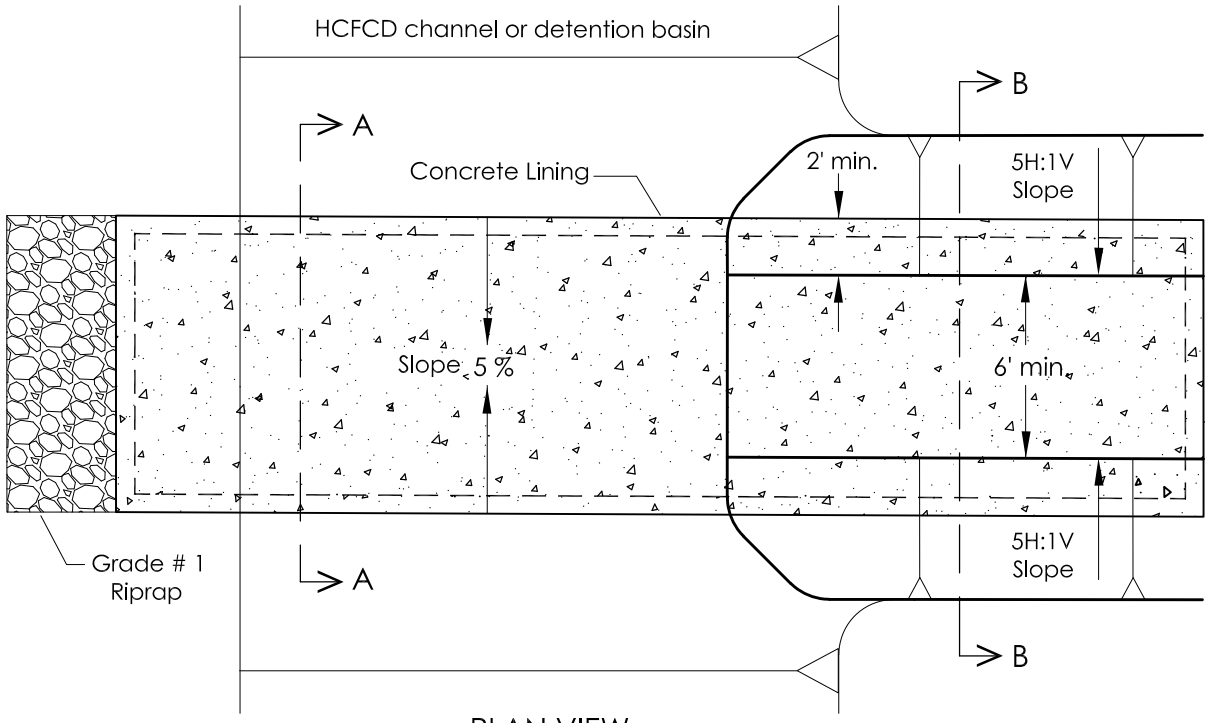
- Size the swale or weir to carry the overflow appropriate for the situation or as required by the jurisdictional entity. Generally, design flows range from the proposed or ultimate 1% exceedance probability (100-year) discharge up to the 0.2% probability (500-year) (Use the Section 6.13.2 outflow criteria from a detention basin for the weir design into a channel or detention basin).
- Set the high bank elevation in the swale or weir below the ~~nearest and~~ lowest slab elevation to reduce the chance of flooding during an extreme overland flow event. Design the berm beyond the weir to carry additional flow.
- Design the swale or weir geometry such that inspection and maintenance vehicles in the maintenance berm can drive across the swale during dry periods.

  Criteria are:

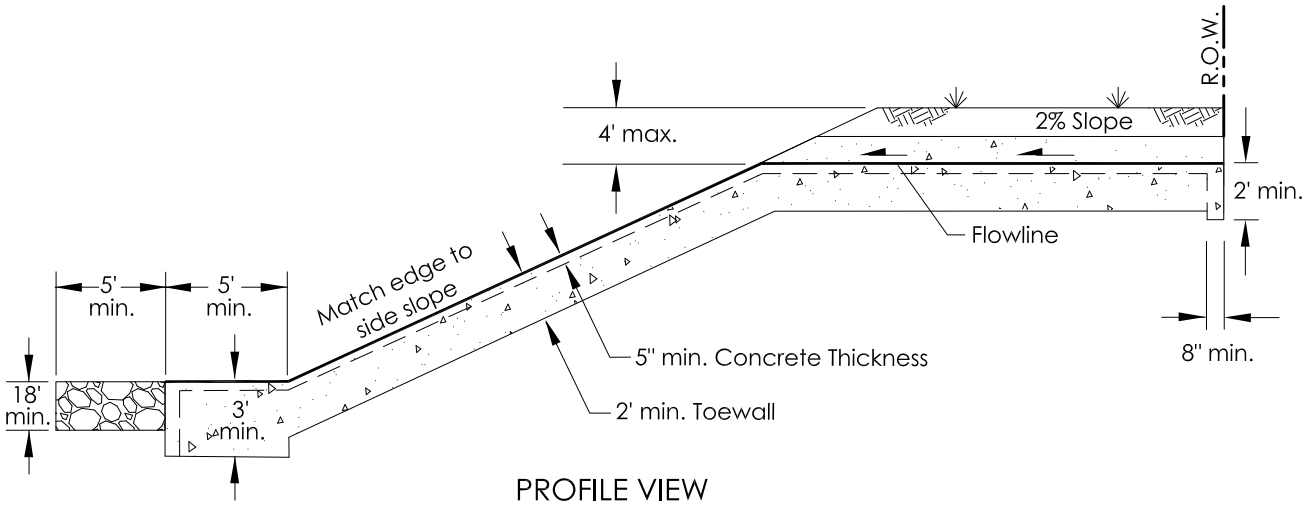
  - 6 foot minimum bottom width.
  - 4 foot maximum depth.
  - Side slopes 5(H):1(V) or flatter.
- Line swale or weir with concrete lining on the channel or detention basin maintenance berm, side slope, and into the bottom at least 5 feet as shown in Exhibit 13-1.
- Design and construct the concrete lining in accordance with HCFCD Concrete Channel Lining Details in Appendix D.
- Do not drain backslope swales into the extreme event overflow swale or weir.
- Place extreme event overflow ~~structures~~weirs at the high point of the backslope swale system and avoid placing them over outfall pipes or boxes, if possible. See Section 6.7.7, Outflow Structures.

Considerations 13.2.2

- Modify design to accommodate onsite soil conditions such as dispersive clays or erosive silts or sands.
- Where a channel or detention basin has a lower or bottom shelf, transition the spillway across the shelf to the low flow or pilot channel, or design the transition to spread the flow out across the shelf.



PLAN VIEW



PROFILE VIEW

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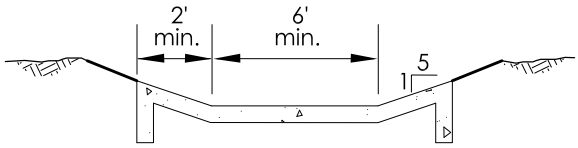
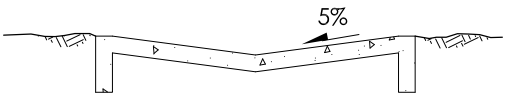


SECTION A-A



SECTION B-B

HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

TYPICAL EXTREME EVENT OVERFLOW - CONCRETE-LINED SWALE

DATE: 8/7/2018

EXHIBIT 13-1

SECTION 14 – PIPELINES, UTILITIES, AND ROADWAYS

14.1 Introduction

Overview
14.1.1

Pipelines, utilities, and roadways are allowed to cross HCFCD facilities, and roadway drainage systems are allowed to outfall into HCFCD facilities provided the criteria and procedures in this manual are followed, and the utility, pipeline, or roadway owner agrees to the conditions.

HCFCD does not maintain or operate pipelines, utilities, or roadways.

Review and Coordination
14.1.2

Follow the review and coordination process in Section 2.9, Non-Flood Control Features, for pipelines, utilities, and roadways proposed to be placed in, on, over, or under a HCFCD maintained facility.

Early coordination with HCFCD is recommended; particularly obtaining concurrence on the location within the HCFCD facility.

Criteria
14.1.3

HCFCD acceptance criteria for placing a pipeline, utility, or roadway within a HCFCD maintained facility are presented in Section 2.2.7, Non-Flood Control Features Allowed in a HCFCD Facility. Specific criteria and conditions are in this section.

Easements
14.1.4

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

Maintenance Access
14.1.5

Some of the most common physical impediments to maintenance equipment and vehicles to HCFCD channels and detention basins from public roads at bridges or culverts are above ground utility and pipe lines, utility poles, and utility boxes (See photos in A.12, Bridge Examples). Maintenance access requirements and additional HCFCD right-of-way for maintenance access at bridge and culvert crossings are provided in Section 5.3.9, Maintenance Access Plan; Section 7.2.3, Access to HCFCD Facilities at Bridges; and Section 8.2.3, Access to HCFCD Facilities at Culvert Crossings.

If the access pathway is not kept open by utility company managers, civil engineers, and roadway agencies, HCFCD maintenance may cease which could lead to increased flood levels and erosion outside the HCFCD right-of-way.

14.2 Crossings

Criteria and Conditions 14.2.1

Specific criteria and conditions for crossings within HCFCD maintained facilities are:

General:

- Submit location of proposed crossing for HCFCD approval prior to preparing construction drawings.
- Submit hydraulic analysis to show no adverse impact to the HCFCD facility or flood levels, if the crossing is overhead or exposed in the channel or detention basin.
- An easement for the pipeline, utility, or roadway across HCFCD right-of-way is required from the underlying fee owner.
- Easement widths must encompass the pipeline, utility, or roadway plus the area disturbed by construction, repair, or rehabilitation.

Design:

- Locate pipes or conduits spanning the channel 1.5 feet or more above the existing or ultimate 1% exceedance water surface, whichever is higher and if possible, without causing an impact on the existing or ultimate 1% exceedance water surface profile (see Exhibit 14-1).
- Minimum cover over pipelines or buried utilities is 5 feet below the ultimate channel bottom across the entire ultimate right-of-way (see Exhibit 14-1).
- Minimum clearance above natural ground for overhead utility lines is 18 feet and support poles or structures must be outside the ultimate channel right-of-way (see Exhibit 14-1).
- Design to minimize impact on the HCFCD facility maintenance and access.
- Manholes are not allowed in HCFCD right-of-way.

Continued on next page

14.2 Crossings, Continued

Criteria and Conditions - Continued 14.2.1

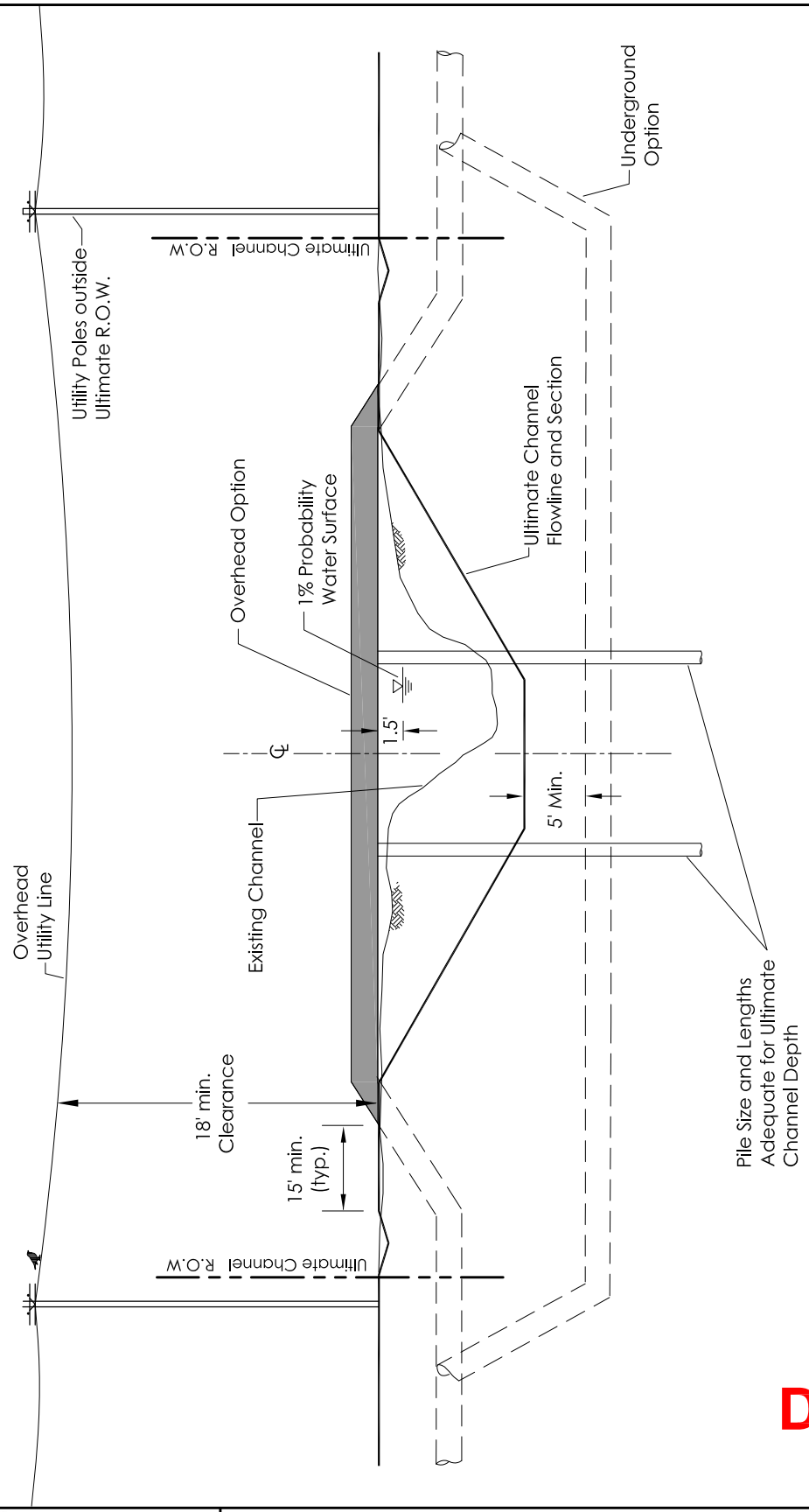
Construction related items:

- Maintain or reestablish existing backslope drainage systems.
- Haul off all trench excavation not used for backfill from HCFCD right-of-way and outside 1% exceedance (100-year) floodplain.
- Backfill within the channel or detention right-of-way shall be in accordance with the backfill requirements specified by the respective city, county, utility company, or the applicable HCFCD standard specification, whichever is more restrictive.
- Remove abandoned lines within HCFCD right-of-way.
- Repair all damage to the HCFCD facility.
- Reestablish vegetation disturbed in the HCFCD or drainage right-of-way. This may include a maintenance period to restore to the condition prior to disturbance. Vegetation includes turf, trees, and shrubs.

14.3 Parallel Pipelines and Utilities in HCFCD Facilities

Overview
14.3.1

Pipelines and utilities within HCFCD facilities and parallel to the channel or detention basin are not allowed.



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HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

PIPELINE AND UTILITY CROSSINGS

DATE: 8/7/2018

EXHIBIT 14-1

SECTION 15 - RIGHT-OF-WAY

15.1 Introduction

Overview 15.1.1

Establishing adequate right-of-way for HCFCD maintained facilities is essential for construction, expansion, and long-term operation, maintenance, and rehabilitation. In addition, easements for pipelines, utilities, and roadways across a HCFCD maintained facility are also necessary for those facilities.

Locate new development and infrastructure projects adjacent to existing or proposed HCFCD channels and other HCFCD maintained facilities outside of the existing and ultimate HCFCD right-of-way needed for the future expansion of the facility. (See Section 1.3.8, Policy VIII: Right-of-Way Dedication/Conveyance.)

Definitions 15.1.2

RIGHT-OF-WAY – An interest in real property, either in fee or easement.

HCFCD RIGHT-OF-WAY – Implies HCFCD has property rights to manage the HCFCD facility (see Section 1.1.5, Definitions).

ULTIMATE RIGHT-OF-WAY – The maximum right-of-way necessary to construct and maintain a stable channel or detention facility, assuming full upstream development, under stormwater management policies in effect for that watershed.

FEE, FEE SIMPLE, FEE TITLE – Full ownership of real property by an individual or entity.

EASEMENT – A limited interest conveyed to the HCFCD in real property for a specific purpose, usually designated in the granting instrument or plat. Another entity or individual has fee title to the property.

DEDICATION – The act of a property owner who sets aside a portion of his property for the use of the public for a specific purpose. A dedication may be accomplished by plat or separate instrument and creates a Public drainage easement.

CONVEYANCE – Transfer of a real property interest, either in fee or easement, from one party to another.

Continued on next page

15.1 Introduction, Continued

Real Estate Interest Preferences 15.1.3

HCFCD real estate interest preferences in order are:

1. HCFCD Fee – Convey fee title to HCFCD who will make all the decisions with respect to flood control, drainage, and other purposes to prevent degrading flood risk reduction and environmental benefits as well as increasing costs to maintain and repair HCFCD facilities. This is the default for all real estate conveyances.
2. HCFCD Easement – Convey easement to HCFCD who will make all the decisions with respect to flood control, drainage, and other purposes specified in the instrument. HCFCD makes future decisions affecting the specific purposes cited. This is an exception, so coordinate with the HCFCD Watershed Management Department early to determine if it is acceptable.
3. Public Drainage Easement – Dedicate drainage easement for operation, maintenance, and expansion of the drainage facility to the public agency or agencies that have jurisdiction for stormwater regulation at that location such as an incorporated city or utility district. HCFCD facilities covered by a public drainage easement are at risk of benefits decreasing and costs to maintain and repair increasing if other public entities are making the decisions.

Conveyance Timing 15.1.4

HCFCD will not accept new facilities for maintenance until the HCFCD right-of-way dedication or conveyance is completed.

For work within or adjacent to an existing HCFCD facility, dedication or conveyance of the HCFCD right-of-way is required prior to plan signature.

Conveyance of the HCFCD right-of-way is a condition for the local jurisdiction's acceptance of new storm sewer outfalls and HCFCD acceptance of the flood control facility or work within an existing HCFCD facility after the one-year warranty period.

Recreation and Environmental Features in Easements 15.1.5

In September 2003, the State of Texas passed an amendment that gave reclamation districts, such as HCFCD and utility districts, the right to use their drainage easements for recreational, environmental mitigation, and other related purposes. This amendment became effective in 2004. (see Texas Water Code §§ 49.461, 49.462, 49.463, 49.464, 49.465, as amended, and Texas Natural Resources Code Ann. §§ 221.001-221.040, as amended).

The HCFCD requires recreational and environmental uses to be included in all new easements conveyed to HCFCD.

The 2003 amended law is not retroactive. Therefore, easements conveyed to HCFCD prior to 2004 include the right to recreational use only if the easement document specifically states that the easement can be used for recreation.

15.2 Right-of-Way Determination

Existing Rights-of-Way 15.2.1

Determine existing rights-of-way and associated property rights for the HCFCD facility when a modification is proposed to an existing HCFCD maintained facility, or a development is proposed adjacent to an existing HCFCD maintained facility.

Channels 15.2.2

Guidelines for determining proposed channel rights-of-way are in Section 5.5, Right-of-Way.

Detention Basins 15.2.3

Guidelines for determining proposed detention basin rights-of-way are in Section 6.5, Right-of-Way.

Channel Enclosures 15.2.4

Guidelines for determining proposed rights-of-way for channel enclosures are in Section 12.2.5, Right-of-Way.

Maintenance Access 15.2.5

Guidelines for determining the proposed rights-of-way for maintenance access to channels and detention basins are in the following sections:

Section 5.3.9, Maintenance Access Plan (channels)
Section 6.3.11, Maintenance Access Plan (detention basins)
Section 7.2.3, Access to HCFCD Facilities at Bridges
Section 8.2.3, Access to HCFCD Facilities at Culvert Crossings

15.3 Right-of-Way Conveyance and Dedication

Introduction 15.3.1

HCFCD fee strips and easements are conveyed by an instrument. Public drainage easements are dedicated by a plat or separate instrument. Procedures for conveyance and dedication are presented below.

Separate Instrument Conveyance or Dedication 15.3.2

The process for conveying a fee strip or easement to HCFCD or dedicating a public easement by separate instrument is presented in the table below.

Step	Description
1	Applicant verifies proposed right-of-way width or area with the HCFCD Watershed Management Department or Property Acquisition Services Department.
2	Applicant provides: – Deed for parent tract establishing current ownership. – Three (3) copies of the metes and bounds description on 8-1/2" x 11" white paper. – Three (3) copies of the tract plat on 8-1/2" x 11" white paper. – Environmental site assessment report for fee conveyances. Submittal requirements: – Must conform to HCFCD survey guidelines. – All copies must be sealed and signed by a Texas Registered Professional Land Surveyor. – Tract(s) must be monumented.
3	HCFCD Property Acquisition Services Department reviews metes and bounds description and tract plat for compliance. (Returns to applicant for corrections, if necessary.)
4	HCFCD Property Acquisition Services Department provides standard language instrument to applicant.
5	Applicant drafts conveyance or dedication instrument and submits to the HCFCD Property Acquisition Services Department for review.
6	HCFCD Property Acquisition Services Department forwards the instrument to the applicant for execution.
7	Applicant makes any corrections necessary and returns executed instrument to HCFCD Property Acquisition Services Department.
8	HCFCD Property Acquisition Services Department confirms instrument is properly executed, submits to the Harris County Attorney for review, forwards to Commissioners Court for acceptance, and then records instrument.

Continued on next page

15.3 Right-of-Way Conveyance and Dedication, Continued

Dedication Process – Subdivision Plat 15.3.3

The process for dedicating a public drainage easement for a HCFCD maintained facility by plat is:

- Applicant verifies proposed right-of-way width or area with HCFCD Watershed Management Department.
- Applicant prepares plat for the dedication in accordance with the Plat Checklist in Appendix C.
- Applicant and HCFCD follow the current municipal or Harris County platting procedures.

15.4 Easements for Pipelines, Utilities, and Roadways

Requirement 15.4.1	Encompass new pipelines, utilities, and roadways located within a HCFCD maintained facility in an easement to facilitate inspection, maintenance, and rehabilitation of the feature.
Procedures 15.4.2	Procedures for coordinating pipelines, utilities, and roadways with HCFCD and establishing easement widths are presented in Section 14, Pipelines, Utilities, and Roadways.
Easements in New Subdivisions 15.4.3	For new subdivisions or developments established by platting, the HCFCD prefers the easements for utilities and roadways located within a HCFCD maintained facility be dedicated by the plat.
Right to Cross Paragraph 15.4.4	When a right-of-way is conveyed to HCFCD in fee, a right to cross paragraph can be included in the instrument to allow future crossings without having to obtain individual easements, but subject to HCFCD review and approval.
Obtaining an Easement from Underlying Fee Owner 15.4.5	If the right-of-way for an existing HCFCD maintained facility is a HCFCD easement or public drainage easement, then the owner of the pipeline, utility, or roadway must obtain an easement from the underlying fee owner. If HCFCD is the fee owner, then the execution and recordation of the utility or road easements are required prior to HCFCD signing the construction plans. Show the easement boundaries and recording information on the construction drawings.

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15.4 Easements for Pipelines, Utilities, and Roadways, Continued

Obtaining an Easement from HCFCD 15.4.6

If the right-of-way for an existing HCFCD maintained facility is a HCFCD fee strip, then the owner of a pipeline, utility, or roadway must obtain an easement from HCFCD. A separate instrument recorded at the Harris County Clerk's Office is required and the process is described in the table below.

Step	Description
1	Applicant secures approval of the proposed route or location from the HCFCD Property Management Department and Watershed Management Department.
2	Applicant provides three copies of a metes and bounds description and three copies of a tract plat on 8-1/2" x 11" white paper to the HCFCD Property Management Department. Requirements: – Must conform to current HCFCD Survey Guidelines. – All copies must be sealed and signed by a Texas Registered Professional Land Surveyor. – Tract(s) must be monumented.
3	HCFCD Property Management Department forwards the metes and bounds description and tract plat to the Property Acquisition Services Department for processing. The Property Acquisition Services Department then forwards the metes and bounds and the tract plat to the Harris County Right-of-Way Department and requests the easement be appraised and sold at the appraised value.
4	Harris County Right-of-Way Department obtains appraisal fee from applicant in advance.
5	Harris County Right-of-Way Department prepares the easement instrument and court order authorizing the sale of the easement to the applicant.
6	HCFCD Property Acquisition Services Department reviews the proposed deed and court order and authorizes the Harris County Right-of-Way Department to proceed with the sale.

Table continued on next page

15.4 Easements for Pipelines, Utilities, and Roadways, Continued

Obtaining an Easement from HCFCD - Continued 15.4.6

Step	Description
7	Commissioners Court approves the sale of the easement.
8	Harris County Right-of-Way Department concludes the transaction: 1. Collects the payment for the easement. 2. Records the easement instrument. 3. Returns the original instrument to the applicant. 4. Sends copy of instrument to the HCFCD Property Acquisition Services Department.

SECTION 16 – WATER QUALITY FEATURES

16.1 Introduction

Overview 16.1.1

Improving water quality in creeks, bayous, and channels in Harris County is a goal of the community and a requirement of the Texas Pollutant Discharge Elimination System (TPDES) permit issued by the Texas Commission on Environmental Quality (TCEQ) to Harris County, the City of Houston, and HCFCD (collectively called the Joint Task Force (JTF)). The permit and corresponding City of Houston ordinance and Harris County regulation requires industrial activities, construction sites, new development, and significant redevelopment to implement and maintain structural and nonstructural controls to reduce pollutants in stormwater run-off.

Review and Coordination Process 16.1.2

For water quality features placed in a HCFCD maintained facility to comply with the TPDES permit, use the review and coordination process presented in Section 2.9, Non-Flood Control Features.

Water Quality Feature Maintenance 16.1.3

HCFCD will maintain the floatable collection structure water quality feature in a HCFCD maintained detention basin provided all criteria are satisfied in Section 16.3, Floatables Collection Structure and an adequate all-weather access to the structure is constructed.

HCFCD will maintain water quality features in a HCFCD maintained detention basin provided all design and construction criteria and requirements are satisfied using current HCFCD Design Guidelines for Wet Bottom Detention Basins with Water Quality Features.

If a sponsor wants to maintain the water quality feature, then comply with the conditions in Section 2.2.7, Non-Flood Control Features Allowed in a HCFCD Facility**.**

Riparian Vegetation 16.1.4

Riparian vegetation such as native and non-native trees and grasses contribute to improved water quality, aquatic habitat, and habitat for wildlife. Riparian vegetation is allowed in HCFCD maintained channels and detention basins provided all applicable conditions and criteria in this section and Section 18, Optional Environmental, Recreation, and Aesthetic Features are satisfied.

16.2 Acceptance Criteria

Acceptance Criteria in a HCFCD Maintained Detention Basin 16.2.1

HCFCD will allow a water quality feature in a detention basin provided:

- The water quality feature within a proposed or existing HCFCD maintained detention basin is designed and constructed using current HCFCD Design Guidelines for Wet Bottom Detention Basins with Water Quality Features.
- The water quality feature and operation does not unduly interfere with the function, operation, maintenance, or rehabilitation of the HCFCD detention basin, or other multi-purpose uses, such as environmental, recreation, or aesthetic features.
- The water quality feature is approved by the jurisdiction responsible for the water quality function of the feature.
- The appropriate vegetation establishment criteria are satisfied (see Section 10.3, Turf Establishment).
- For new or modified detention basins, the acceptance criteria in Section 2.2.3, Acceptance for HCFCD Maintenance is satisfied.
- The water quality feature satisfies the criteria in Section 2.2.7, Non-Flood Control Features Allowed in a HCFCD Facility.

16.3 Floatables Collection Structure

Objective 16.3.1

Design and construct floatables collection structures to collect debris within a stormwater detention basin in a manner that the structure does not fail or collapse, and facilitates efficient and unobstructed maintenance within existing or future HCFCD right-of-way. The floatables collection structure is not meant for collection of large debris within a channel.

General Criteria 16.3.2

- Locate floatables collection structures, associated concrete paving, and access roads in a compatible location in the basin.
- Provide an all-weather access road from a public road, along the maintenance berm, and to the top of the screen to facilitate debris removal (see Section 16.3.4, Access Criteria)
- The owner or public agency that builds the floatables collection structure and maintenance access road is responsible for correcting or repairing any deficiencies during the one year warranty period (see Section 2.8.8.2, One Year Warranty Responsibilities).
- Keep the entire structure, adjacent erosion control features, and the entire maintenance access within HCFCD rights-of-way.
- All other HCFCD design criteria are in effect.

Structural Criteria 16.3.3

Use the HCFCD Floatables Collection Structure Details in Appendix D. Modify accordingly to accommodate flow, soil, and geometric conditions and fill in the design information required. A typical plan view and cross section of a floatables collection structure is shown in Exhibits 16-1 and 16-2.

Provide:

- Collection screens and supports with sufficient structural reinforcement to withstand loads from mowers and large maintenance equipment. A 3,000 lb tractor wheel load is recommended.
- Components and dimensions as shown on the detail and a concrete paving around entire structure (4 feet minimum on the top and 5 feet minimum on the sides and basin bottom) to allow for debris removal and maintenance.
- For multiple side-by-side screens, include a minimum 3 foot concrete paving between screens along the entire length for maintenance access.
- Recessed hinges to prevent damage from maintenance equipment traversing the structure.
- Lifting handles capable of lifting the screen for removal of debris and which can be lifted by mechanized equipment without failing.

Continued on next page

16.3 Floatables Collection Structure, Continued

Access Criteria 16.3.4

Coordinate the access route and design early with the Watershed Management Department. The following are necessary for mechanized equipment (cranes), bulldozers, backhoes, dump trucks, trash trucks, etc. to open and clean the screens, remove debris in front of and inside the structure, and haul the debris out of the detention basin (see Exhibits 16-1 and 16-2):

- Provide a minimum 15-foot wide all-weather access road (Section 16.3.5, All-Weather Access Road Criteria) from the public road access point and within the maintenance berm to the floatables collection structure to allow access of heavy equipment just above the structure, a vertical distance of no more than one foot. A minimum 15-foot wide ramp on the basin side slope may be necessary to reach the top of the structure.
- Provide continuous access around the top of the basin for a trash truck to exit from the entrance, or a turning "T" sufficient to turn the trash truck around.
- Provide a concrete pad for equipment staging directly above structures to facilitate lifting of screens and removal of debris.
- Consider height restrictions on overhead utilities and locate floatables collection structures and equipment staging areas clear of obstructions.
- Provide a minimum 15-foot wide all-weather access road to reach the mid-shelf of large regional basins.

All-Weather Access Road Criteria 16.3.5

For all-weather access roads in HCFCD facilities:

- Connect to a public road with a curb cut and access gate at least 20 feet from the road right-of-way (see Section 5.3.9, Maintenance Access Plan for additional criteria).
- Construct out of reinforced concrete road paving or crushed limestone with subgrade.
- For a crushed limestone access road:
  - Include a minimum 8" subgrade of 3" x 5" granular fill or cement stabilized sand.
  - Use a minimum 6" crushed limestone riding surface.
- For a reinforced concrete paved road, use Harris County criteria for residential roads.
- Use a minimum 2% cross slope for drainage.
- Width at least 15 feet.
- Use a grade no steeper than 7% (14:1).

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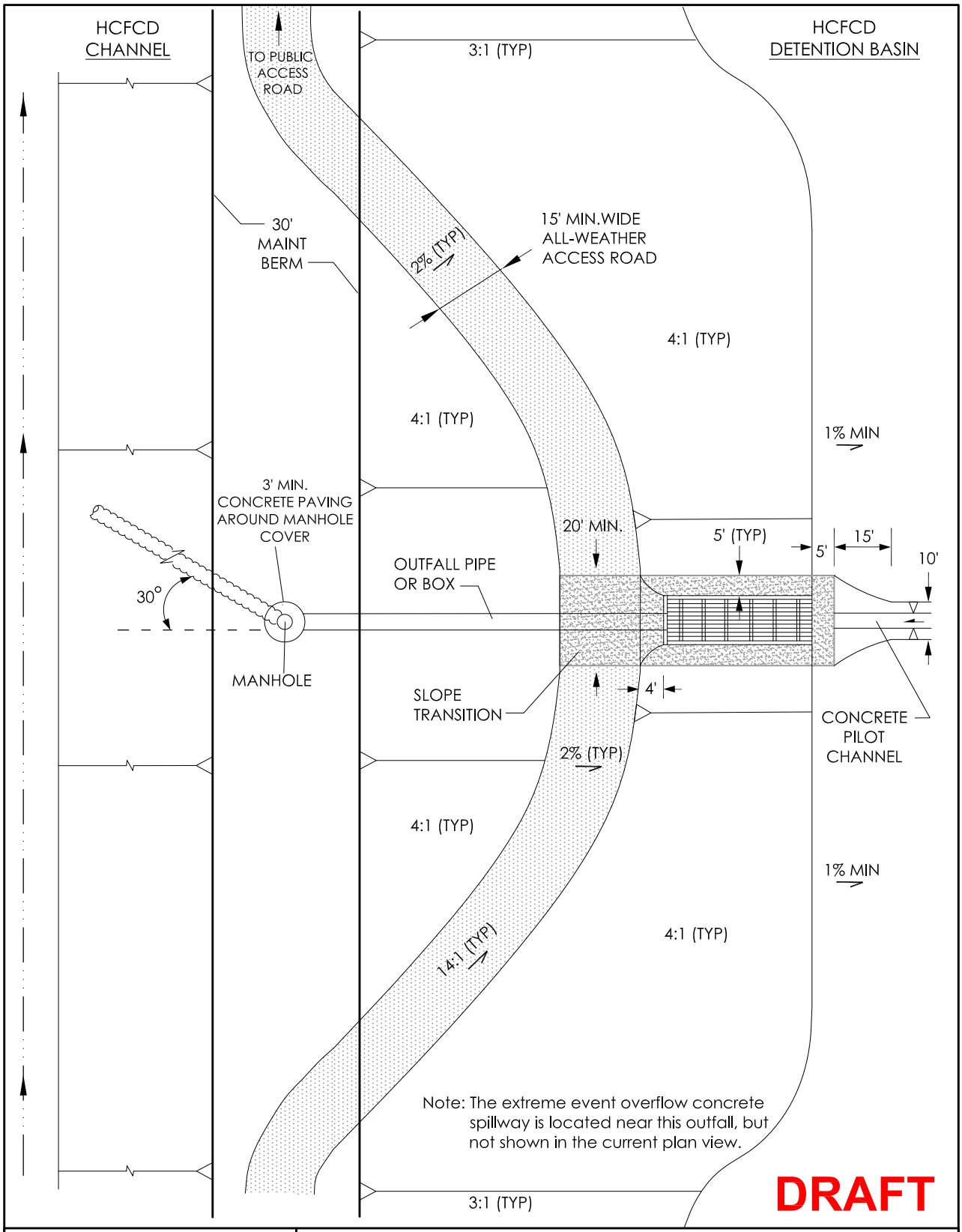
16.4 Wet Bottom Storm Water Quality Features

Criteria 16.4.1

For wet bottom features in HCFCD detention basins that are required for storm water quality and/or require periodic silt and debris removal:

- Coordinate the design with the HCFCD Water Quality Department.
- Include an all-weather access road (Section 16.3.5, All-Weather Access Road Criteria) and pad where silt and debris removal is to occur (can be combined with the turnaround). Coordinate design with the HCFCD.

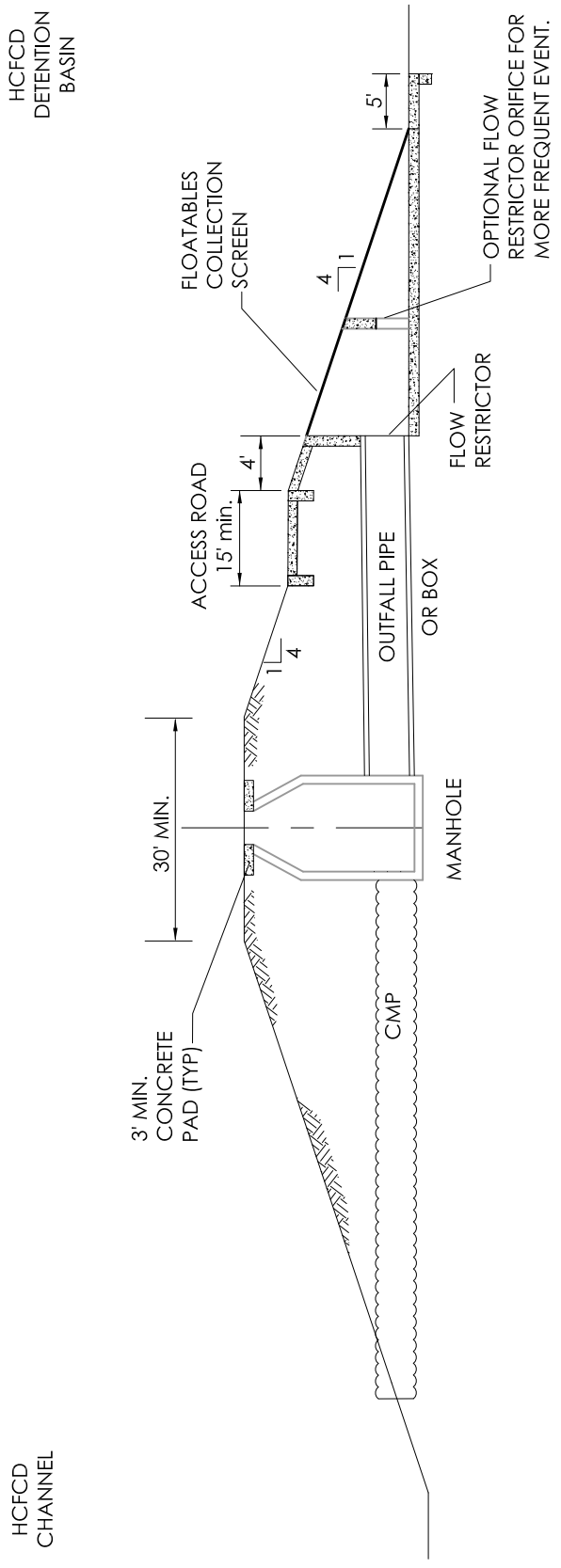


HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

FLOATABLES COLLECTION STRUCTURE - PLAN VIEW

DATE: 8/7/2018	EXHIBIT 16-1



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HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

FLOATABLES COLLECTION STRUCTURE - CROSS SECTION

DATE: 8/7/2018	EXHIBIT 16-2

SECTION 17 – ENVIRONMENTAL AND CULTURAL RESOURCES COMPLIANCE

17.1 Environmental Compliance

Overview
17.1.1

Compliance with appropriate federal, state, and local environmental rules, laws, regulations, and permits is the responsibility of the proposed project's owner, agency, consultants, and/or contractors when working in or modifying HCFCD maintained facilities. Coordinate the environmental and cultural resources aspects of the design through HCFCD Watershed Management Department and they will involve the Regulatory Compliance Department (RCD), when necessary.

Common environmental regulations include:

- Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbor Act enforced by U.S. Army Corps of Engineers (USACE);
- State of Texas Section 401 Water Quality Certification enforced by the Texas Commission on Environmental Quality (TCEQ); and
- Texas Pollutant Discharge Elimination System (TPDES) for construction and new development enforced by the TCEQ.

Other possible environmental regulations are the:

- Environmental Protection Agency (EPA) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA);
- EPA Resource Conservation and Recovery Act (RCRA);
- U.S. Fish and Wildlife Service (USFWS) Threatened and Endangered Species Act; and
- Section 106 of the National Historic Preservation Act enforced by the Texas Historical Commission.

Continued on next page

17.1 Environmental Compliance, Continued

Existing and New HCFCD Maintained Facilities 17.1.2

When modifying existing or constructing new HCFCD maintained facilities:

- All parties are legally obligated to comply with all applicable environmental laws and regulations, and conditions specified in subsequent permits and/or agency approvals, where required. Coordinate with the HCFCD Watershed Management Department, particularly for major modifications or new HCFCD facilities and Section 404 Individual Permits. HCFCD must concur with permit conditions, which includes identifying the party responsible for compliance.
- Comply with the TPDES Construction General permit for all work in existing or proposed HCFCD right-of-way. Use the HCFCD Stormwater Pollution Prevention Details in Appendix D, where appropriate.
- When modifying an existing HCFCD maintained facility, determine if existing features in the HCFCD facility were constructed under a previous environmental permit that would impose conditions or restrict the ability to modify the HCFCD facility or its features.
- Identify areas to preserve or minimize disturbance to existing native trees and shrubs, aquatic features, habitats, etc. in HCFCD right-of-way, where possible.
- Restore disturbed areas using native species, where appropriate and coordinate planting plan, maintenance, species, specifications, etc. early with HCFCD.
- Prepare and obtain new or revised environmental permits through coordination with HCFCD, where applicable.

Continued on next page

17.1 Environmental Compliance, Continued

Review and Coordination Process 17.1.3

Use the review and coordination process in Section 2.8, New or Modified HCFCD Facilities, which includes the following for environmental compliance within existing or proposed HCFCD right-of-way:

- Identify environmental issues, permits, and/or agency approvals during initial coordination with the HCFCD WMD. See Section 2.8.4 Stage 1, Initiation New or Modified HCFCD Facilities.
- If there are impacts to jurisdictional wetlands and/or streams, coordinate the permit details with HCFCD prior to submittal to USACE. Consider potential USACE permit conditions and any potential wetland and stream mitigation requirements. For individual permits, include HCFCD during coordination with the USACE and resource agencies.
- Indicate in Section 9 on the Express Review Sheet the USACE permit(s) that applies to the proposed project. If no USACE permit is required for the project, add a brief explanation to the Express Review Sheet.
- Prior to construction, submit copies of all applicable environmental reports, permits, and agency approvals obtained for the project if requested by the HCFCD.
- Following construction, provide written certification that the work was performed in conformance with the permits, if applicable. (see Section 2.8.7.4, Post Construction)
- Provide documentation from the USACE that mitigation is complete, if applicable.

Water Quality Features 17.1.4

If a water quality feature is required to comply with a TPDES permit, HCFCD will accept only floatable collection structures for maintenance in a HCFCD maintained detention basin (not channel) provided the criteria in Section 16, Water Quality Features, are satisfied.

Wetland and Stream Mitigation 17.1.5

Wetland and stream mitigation by others cannot be located in HCFCD right-of-way.

Continued on next page

17.2 Cultural Resources Compliance

Overview
17.2.1

Compliance with Section 106 of the National Historic Preservation Act of 1966 and subsequent regulations is the responsibility of the proposed project's owner, agency, consultants, and/or contractors when working in or modifying HCFCD maintained facilities. Currently, the Texas Historical Commission (THC) oversees the protection and preservation of the state's historical and prehistoric resources. Identifying historic and prehistoric cultural resource sites is important so they can be avoided or mitigated.

The four investigational phases are listed below. Whether or not you proceed to the next phase depends on the findings.

1. Reconnaissance: Records research and visual field visit; Product – Letter Report.
2. Pedestrian Survey: Records research, shovel tests, and backhoe trenches; Product – Comprehensive Report.
3. National Register Testing: Delineation and determination if site is eligible for National Register of Historic Places (NRHP); Product – Comprehensive Report.
4. Mitigation: Recover artifacts, archive, and record site data; Product – Comprehensive Report.

Existing and New HCFCD Facilities
17.2.2

For existing and new HCFCD facilities, comply with Section 106 of the National Historic Preservation Act of 1966 and subsequent regulations, as applicable and provide written proof of compliance if requested by the HCFCD.

Cultural resources are most likely to exist in or along natural or naturalized channels.

Coordinate with the HCFCD Watershed Management Department, particularly for major modifications or new HCFCD facilities.

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17.2 Cultural Resources Compliance, Continued

Review and Coordination Process 17.2.3

- Coordinate cultural resource reviews and investigations with the THC and HCFCD Watershed Management Department.
- When modifying existing HCFCD maintained facilities, coordinate with the HCFCD Watershed Management Department and THC to obtain past reports and/or THC concurrence letters for the facility.
- Prior to invasive investigations, obtain an Antiquities Permit from the THC.
- Use the review and coordination process in Section 2.8, New or Modified HCFCD Facilities, which includes the following for cultural resources compliance:
  - Identify if a cultural resources review is needed or not in the preliminary engineering or design report.
  - Continue coordination of the report and THC recommendations and/or requirements with HCFCD for review and concurrence during preparation of construction drawings.
  - Prior to construction, submit a copy of the cultural resources report and THC concurrence letter obtained for the project if requested by the HCFCD.

SECTION 18 – OPTIONAL ENVIRONMENTAL, RECREATION, AND AESTHETIC FEATURES

18.1 Introduction

Overview 18.1.1

HCFCD allows inclusion of environmental, recreation, and aesthetic features in HCFCD maintained facilities in recognition of community and natural values, provided the features do not compromise the flood control function or integrity of the HCFCD facility or inhibit the ability to maintain, repair, modify, or inspect the HCFCD facility.

A sponsor is required for environmental and recreation features (see Section 2.2.6, Sponsor for Recreation and Environmental Features) and an agreement is required between the HCFCD and the sponsor.

Acceptance Criteria 18.1.2

Criteria and conditions for acceptance of non-flood control features in HCFCD maintained facilities are presented in Section 2.2.7, Non-Flood Control Features Allowed in a HCFCD Facility. Specific criteria are presented in subsequent sections.

Review and Coordination Process 18.1.3

The review and coordination process for environmental, recreation, and aesthetic features is presented in Section 2.9, Non-Flood Control Features.

Coordinate proposed projects with the HCFCD Watershed Management Department (WMD) and HCFCD ~~Property Management Department (PRM).~~Infrastructure Division (INF). As a minimum, submit requests showing a plan view and cross sections taken at key right-of-way points to determine if the berm width and side slopes meet the criteria for the proposed features. Show the maximum and minimum area of the berm, toe of slope, water's edge, top of bank and the HCFCD right-of-way as well as all right-of-way and channel cross section irregularities.

Continued on next page

18.1 Introduction, Continued

Right-of-Way 18.1.4

Where environmental, recreation, and aesthetic features are included or anticipated within a new or expanded channel or detention basin right-of-way, additional right-of-way is recommended to minimize damages to the HCFCD facilities and multi-use features, and facilitate maintenance, repairs, and rehabilitation. Coordinate with HCFCD as early as possible.

The sponsor is required to obtain written permission from the HCFCD and underlying fee owner(s) for HCFCD and public drainage easements that do not specifically allow for environmental and recreation facilities (see Section 15.1.5, Recreation and Environmental Features in Easements) prior to constructing or installing environmental and/or recreation features in a HCFCD maintained facility.

Environmental and Cultural Resources Compliance 18.1.5

Comply with applicable environmental and cultural resources laws and regulations for all work in HCFCD right-of-way per Section 17, Environmental and Cultural Resources Compliance. Coordinate the environmental and cultural resources aspects of the design through HCFCD WMD and they will involve the Environmental Regulatory Compliance Department, when necessary.

Existing HCFCD Maintained Facilities 18.1.6

When modifying existing HCFCD maintained facilities with existing environmental, recreation, or aesthetic features:

- Coordinate proposed changes to the facility and features with the HCFCD ~~PRM~~INF and WMD.
- Show the existing features on the construction drawings.
- Show how the integrity of the existing features will be maintained during and after construction.

18.2 Environmental Features

Examples
18.2.1

Examples of environmental features are:

- Native grass and wildflower plantings.
- Prairie creation in a detention basin.
- Wetland creation in a detention basin.
- Preservation of existing trees and shrubs.
- Habitat-type tree and shrub plantings in areas of excess channel right-of-way.
- Habitat-type tree and shrub plantings in a detention basin.
- Naturally designed low flow channels in detention basins and channels.

Criteria
18.2.2

Each project is different and is evaluated on a case-by-case basis. Close coordination with the HCFCD ~~PRM~~INF, WMD, and/or Environmental Regulatory Compliance and Stormwater Quality Departments is necessary early in the planning phase when considering incorporation of environmental features. Allow sufficient time to coordinate and develop criteria specific to the proposed project.

Preservation
18.2.3

Preservation of existing natural habitat areas such as native prairie, trees, and shrubs is encouraged where possible. Planting new trees and shrubs is costly and can take many years to achieve size, habitat value, aesthetic value, and diversity. Leaving existing trees along roads and adjacent to subdivisions also has aesthetic and environmental benefits.

See Harris County Regulations for Approval and Acceptance of Infrastructure for tree and shrub requirements that offer incentives for preserving existing trees.

Vegetated Shelf
18.2.4

A shallow, vegetated shelf located on the edge of a detention basin with a flat or mild slope (10:1) is permissible. The purpose of the vegetated shelf is to:

- Provide substrate for habitat and wetland creation.
- ~~Make it easier~~Facilitate onshore movements for animals and people ~~to get back onshore~~.
- Improve water quality.

See Section 6.4.8, Vegetated Shelf for additional information.

Continued on next page

18.2 Environmental Features, Continued

Specific Criteria for Tree and Shrub Plantings 18.2.5

Specific criteria for proposed tree and shrub plantings are:

- Plant trees in a channel only if their effect on water surface levels are accounted for in the design and there is no negative impact on water surface levels or erosion.
- Maintain a continuous minimum maintenance access of 20-feet wide along both sides of a grass-lined or partially grass-lined channel and around an entire detention basin. The access can be curvilinear provided curves allow for equipment maneuverability. It does not have to be continuous along the top of bank.
- Minimum spacing is 7 feet for habitat planting, 15 feet for non-habitat planting, and 20 feet for the maintenance access corridor.
- Do not plant trees and shrubs in backslope drainage systems.
- Do not plant trees or shrubs within 20 feet of outfall pipes, manholes or interceptor structures to allow for maintenance access.
- Trees and shrubs may be planted individually or in clusters along the top of bank only if spaced 20 feet apart to allow equipment access to the entire side slope.
- Consider the trees typical mature height and canopy spread to avoid future conflicts with utility lines and maintenance access, and impacts to adjacent private property and fences.
- Include plant species (common and botanical), size, number, and spacing in planting plans sealed by a landscape architect.
- Provide additional HCFCD right-of-way (10 feet minimum) to satisfy maintenances access criteria, if necessary.
- Watering plants by water truck is acceptable. Temporary irrigation systems are not allowed. The sponsor is responsible for repairs to the slope or HCFCD facility features caused by installation, watering, or maintenance of the plants.
- For planting standards and specifications, contact HCFCD.
- For typical tree locations - benched channel sections, see Exhibit 18-1.

Continued on next page

18.2 Environmental Features, Continued

Trees
18.2.6

Adaptable, native trees are recommended to reduce maintenance costs and increase survivability. Some trees to consider are:

Shumard Oak	Willow Oak
Water Oak	Nuttal Oak
Sweetgum	Bald Cypress
River Birch	Cedar Elm
Green Ash	Southern Magnolia
Texas Palm	Drummond Red Maple
Black Gum	Red Cedar
Sycamore	American Holly

Shrubs
18.2.7

Some native shrubs small understory trees to consider are:

Wax Myrtle	Yaupon (female)
Redbud	Parsley (Green Hawthorne)
Red Buckeye	Button Bush
Beauty Berry	Dwarf Palmetto
Roughleaf Dogwood	

18.3 Recreation Features

Examples
18.3.1

Examples of recreation features are:

- Hike and bike trails.
- Nature trails and other passive recreation features.
- Sports fields in detention basins.
- Picnic and open field play areas in detention basins.
- Fishing ponds.

Criteria
18.3.2

Each project is different and is evaluated on a case-by-case basis. Close coordination with the HCFCD ~~PRM~~INF, WMD, and/or Environmental Regulatory Compliance and Stormwater Quality Departments is necessary early in the planning phases when considering incorporation of recreational features. Allow sufficient time to coordinate and develop criteria specific to the proposed project. The HCFCD ~~PRM~~INF and WMD confirm the project feasibility, and WMD reviews and approves the project construction drawings.

Since trails are a common recreation feature, Section 18.4, Trails provides considerations, criteria, and guidance to assist trail sponsors, engineers, and landscape architects.

Recreation Features Not Allowed
18.3.3

Recreation features, including trails, are not allowed in a HCFCD facility if any of the criteria or conditions listed in this manual cannot be satisfied or are not met. If a sponsor builds a trail that is not in compliance, they are required to bring it into compliance or remove it and repair the HCFCD channel or detention basin at their cost.

There are many existing HCFCD channels and detention basins where recreation features, including trails, would adversely impact the flood control function, performance, or maintenance.

18.4 Trails

Caution 18.4.1

Section 18.1, Introduction establishes the general conditions that must be satisfied for HCFCD to allow a trail in a HCFCD facility. Follow and comply with the criteria and conditions in Section 2.2.7, Non-Flood Control Features Allowed in a HCFCD Facility and in the agreement with the HCFCD that is required to place a trail in a HCFCD facility.

Trails can be in a HCFCD facility provided the sponsor demonstrates they do not hinder maintenance and construction equipment access to and along the HCFCD facility, cause an adverse hydraulic impact, cause bank erosion or failures, or degrade channel stability.

In deciding to invest in a trail, potential trail sponsors should assess the:

- Effort and cost of obtaining easements or permissions to build and maintain the trail from the fee property owners.
- Risk of losing, repairing, or replacing the trail and associated appurtenances.
- Cost of repairing the HCFCD facility if damaged by the trail's construction, repair, rehabilitation, maintenance, or replacement.
- Cost of maintaining, repairing, or rehabilitating a portion of the HCFCD channel or detention basin following HCFCD requirements, generally
  - From top of bank to the HCFD right-of-way limit for trails along the top of bank.
  - From the edge of water to the HCFCD right-of-way for trails on the side slope or under a bridge.

Continued on next page

18.4 Trails, Continued

General Considerations 18.4.2

Below are considerations and references.

- For existing HCFCD maintained facilities, confirm the HCFCD's property rights. If it is an easement, see Section 18.1.4, Right-of-Way.
- If existing encroachments impact trail layout, design, or construction, coordinate with HCFCD during planning and preliminary design. It is the sponsor's responsibility to remove encroachments in conflict with the proposed trail.
- Preserve stormwater conveyance, capacity and storage in HCFCD facilities and verify no adverse impacts.
- Coordinate with HCFCD and others to ensure no conflicts with current, proposed, or future developer, agency, or HCFCD projects on the channel or detention basin.
- Coordinate design with jurisdictions and trail organizations located within the proposed trail limits, such as trail advocate groups, municipalities or county precincts, to ensure the trail features complement with master plan or community objectives.
- Some trail systems in HCFCD maintained facilities require review and approval from other entities such as the:
  - USACE Section 408 Policy and Procedural Guidance for the Approval of Modification or Alteration of Corps of Engineer Projects (HCFCD submits to USACE).
  - Texas Department of Licensing and Regulation (TDLR).
  - City of Houston Permitting and Code Enforcement (if underlying ownership's other than HCFCD).
  - Local Floodplain Administrators for the applicable jurisdictions.
- References:
  - AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities.
  - AASHTO Guide for the Development of Bicycle Facilities.
  - TXDOT Guidelines for Bicycle and Pedestrian Facilities in Texas.
  - TMUTCD for Bicycle Facilities.
  - COH Standard Specifications.
  - Harris County Parks Master Plan.

Continued on next page

18.4 Trails, Continued

Specific Criteria 18.4.3

Specific criteria for proposed trails are:

- Provide an additional 10 foot minimum HCFCD right-of-width for new HCFCD facilities and for existing HCFCD facilities where existing berm widths do not meet current criteria (Section 18.4.4, Maintenance Access Criteria) or where maintenance access is limited, to avoid further reduction of maintenance access.
- Position the edge of trail at least 5 feet from the channel top of bank of a stable, grass-lined trapezoidal channel (3:1 side slopes or flatter) and at least 15 feet from the channel top of bank of a natural or naturalized channel, or a channel with highly erosive soils or unstable channel banks.
- Width of the available berm, excluding backslope swales and interceptor structures, dictates the maximum trail width.
- Keep trails out of backslope drainage swales and interceptor structures. If interceptor structures are relocated or replaced, use the HCFCD Interceptor Structure and Concrete Pilot Channel Details in Appendix D.
- Do not place handrails around interceptor structures on the berm.
- Maintain conveyance in the backslope swale if the trail crosses the backslope swale.
- Design trail such that water does not pond adjacent to the trail from local runoff.
- Pipes installed to facilitate drainage of the berm, blocked by the trail construction, may not outfall into the HCFCD channel at the top of bank (see Section 11.1, Backslope Drainage Systems for alternatives).
- Address and account for sheet flow coming from trails.
- For trails set below grade, carefully design drainage so water does not pond, flow overbank, or create point erosion caused by concentrated overbank flow.
- Plan how silt and other debris accumulations will be removed from the trail and HCFCD facility. Do not dispose silt or debris into the channel or detention basin.
- Railing is not permitted along the top of bank.
- Minimize use of retaining walls, handrails, and guardrails.
- If handrails/guardrails are used, design to withstand water and debris forces, to minimize debris collection, and facilitate debris removal.
- No utilities, utility lines, or irrigation lines are permitted in the HCFCD right-of-way. Temporary irrigation systems are not allowed.

Continued on next page

18.4 Trails, Continued

Specific Criteria - Continued 18.4.3

- Replace existing corrugated metal pipe outfalls with reinforced concrete pipes under or near proposed retaining walls.
- Use reinforced concrete pipe rather than corrugated metal pipe for new outfalls under trail retaining walls
- If applicable, design and construct in accordance with Americans with Disabilities Act (ADA) and other applicable state and federal laws.

Maintenance Access Criteria 18.4.4

- Maintain a continuous minimum 20 foot horizontal and a 15 foot vertical maintenance access along both sides of the grass-lined or partially grass-lined channel and entirely around detention basins. The access can be curvilinear provided curves allow for equipment maneuverability, which is a minimum radius of 25 feet.
- Design the trail to accommodate maintenance and construction equipment loads where a trail is within or crosses maintenance access.
- If blocking public vehicular access is a trail objective, install removable or collapsible bollards or special access gates a sufficient distance from the road to ensure an unobstructed 20 foot wide by 15 foot high access for HCFCD vehicles and equipment. Include a HCFCD lock on the gate or bollards. Provide sufficient off-road access for HCFCD vehicles or equipment to safely clear traffic for entry onto HCFCD right-of-way.
- Ensure retaining walls constructed for trails do not block access.
- Provide HCFCD maintenance access at both ends of a trail.
- Do not block heavy equipment access under bridges if there is existing access.

Trail Appurtenances 18.4.5

- Ensure all trail appurtenances such as bollards, signage, bicycle racks, benches, trash receptacles, and landscaping in the HCFCD right-of-way do not block the 20 foot horizontal maintenance access and are not located on side slopes.
- Keep all appurtenances clear of the backslope swale.
- Locate all appurtenances on the side of the trail opposite from the channel or detention basin top of slope.
- Ensure appurtenances are securely fixed so they stay in place during flood events.
- Trees and shrubs may be planted individually or in clusters along the top of bank only if spaced 20 feet apart to allow maintenance and construction equipment access to the entire side slope (See Section 18.2, Environmental Features).

18.5 Aesthetic Features

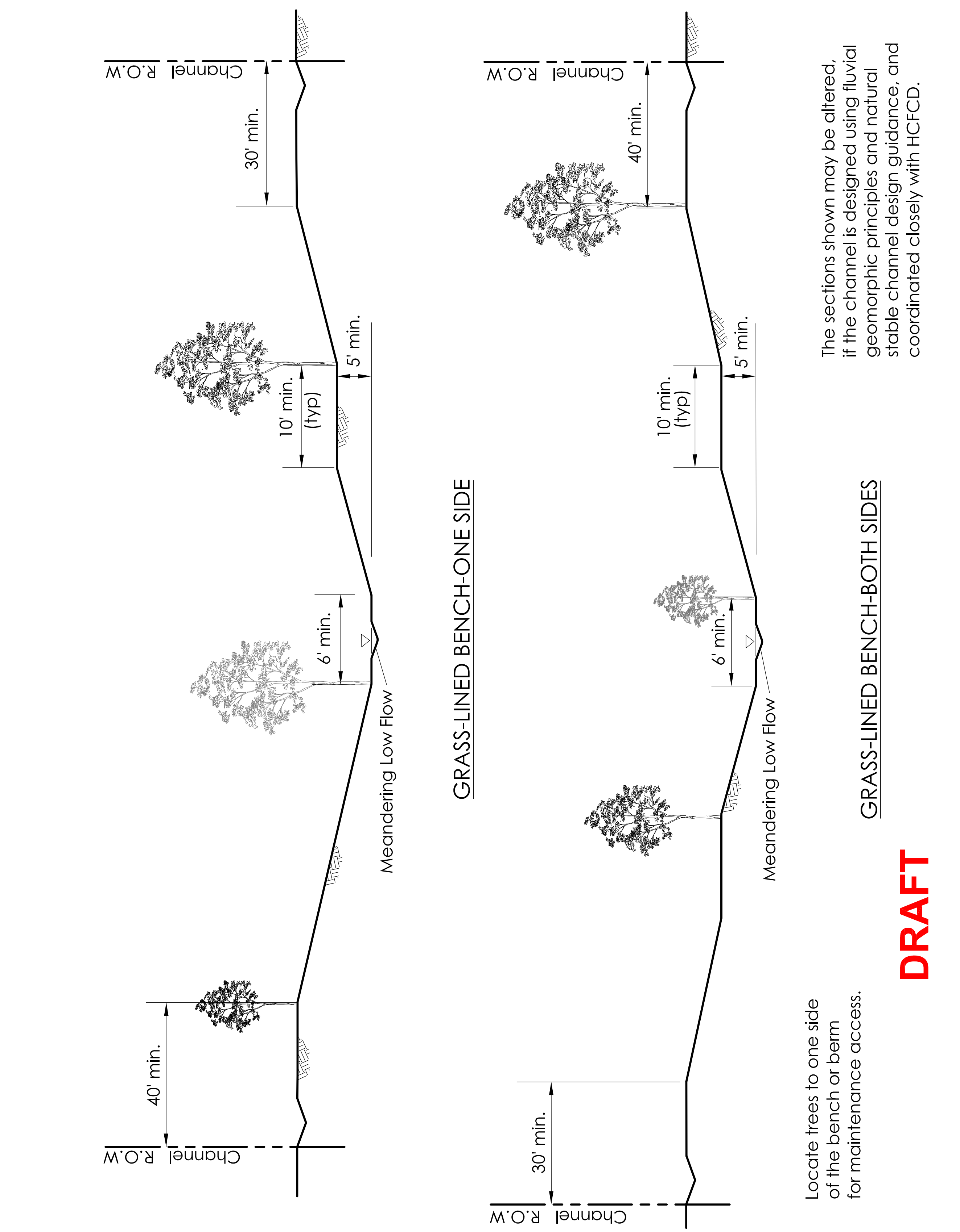
Examples 18.5.1

Examples of aesthetic features are:

- Preservation of existing trees.
- Landscape-type tree and shrub plantings.
- Horizontal and vertical curvilinear contouring of detention basins.
- Variations of the side slopes of detention basins.
- Variations of the side slopes and horizontal alignment of channels.
- Composite channel sections.
- Aesthetic design of hydraulic structures and erosion control.

Specific Criteria 18.5.2

Each project is different and is evaluated on a case-by-case basis. Close coordination with the HCFCD ~~PRM~~INF, WMD, and/or Environmental Regulatory Compliance and Stormwater Quality Department is necessary early in the planning phase when considering incorporation of aesthetic features. Allow sufficient time to coordinate and develop criteria specific to the proposed project. The HCFCD ~~PRM~~INF confirms the project feasibility and the HCFCD WMD approves the project construction drawings.



HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

TREE LOCATIONS BENCHED CHANNEL SECTIONS

DATE: 8/7/2018

EXHIBIT 18-1

SECTION 19 – REPORT REQUIREMENTS

19.1 Introduction

Overview 19.1.1

A drainage or design report is important to confirm a proposed project is designed in accordance with the policies, guidelines, and criteria in this manual and sound engineering practice. The report communicates the justification of the drainage plan or design for review and approval purposes, and is a reference document for others in the future who want to perform additional work in, on, over, under, or adjacent to the same HCFCD facility.

Purpose of Reports 19.1.2

The purpose of a drainage or design report is to document, identify, and resolve as many design issues as possible early in the project development phase in order to facilitate completion of the construction drawings and a successful project.

Report Content 19.1.3

Prepare clear, concise, and complete reports for the proposed project that:

- Cover applicable topics.
- Explain the decisions made.
- Indicate where and why criteria were not followed.
- Summarize pertinent information and data.
- Include tables, maps, exhibits, photographs, calculations, etc.
  Exhibits 19-1 through 19-4 are examples of a plan view and profile for a proposed detention basin project and a proposed channel project.

Length of the report is not important provided the applicable design topics are covered clearly and completely commensurate with the scale of the project and the project phase. Indicating report sections do not apply or will be covered in a later version is acceptable.

No Adverse Impact Analysis 19.1.4

To clarify a misunderstanding with some agencies and the engineering community, a hydrologic and hydraulic (H&H) no adverse impact analysis and/or report is necessary to verify compliance with Section 1.3.3, Policy III, No Adverse Impact. However, it does not preclude the preparation and submittal of a drainage or project report described in this this section. Depending on the scale of the proposed project or work, the H&H No Adverse Impact analysis can be included in the drainage or project report verbatim, as an appendix, or referenced as a separate report.

Continued on next page

19.1 Introduction, Continued

Texas State Board of Registration for Professional Engineers Requirement 19.1.5

All reports submitted to HCFCD must be properly identified, sealed, signed, and dated as required by the Texas State Board of Registration for Professional Engineers.

Reports submitted for preliminary review must be clearly labeled as preliminary and comply with Texas State Board requirements.

Submittal Requirements 19.1.6

For all drainage and design reports submitted to the HCFCD, follow the current electronic submittal guidelines posted on the Harris County ePermits website.

A drainage or design report is required for any proposed project or work in a new or existing HCFCD facility.

A drainage or design report is not required for a detention basin that HCFCD will not maintain and Section 6.10, Method 1 – Small Project Drainage Areas is used because the design information is documented on the Express Review sheet in the construction drawings.

For modified or new detention facilities, include the Detention Summary Table in Section 6.17 in the drainage or design report.

19.2 Report Outline

Report Outline 19.2.1

To facilitate preparation and review of drainage and design reports, an outline for a typical new development project is provided below. Include all applicable sections. For specialty reports in the appendix, summarize results, conclusions, and recommendations in the main report. For projects that include detention, include the detention summary table in Section 19.3.1, Detention Summary Table in the Executive Summary.

EXECUTIVE SUMMARY

SECTION 1 - INTRODUCTION

1.1 Project Name and Purpose
1.2 Project Limits
1.3 Project Objectives, Assumptions and Constraints
1.4 Prior Studies

SECTION 2 - EXISTING CONDITIONS

2.1 Location and Topography
2.2 Land Use
2.3 HCFCD Facilities and Unit Numbers
2.4 Right-of-Way
2.5 Pipelines and Utilities

SECTION 3 - HYDROLOGY AND HYDRAULICS

3.1 Analysis Objective
3.2 Hydrologic and Hydraulic Methodologies
3.3 Existing Conditions
3.4 Proposed Conditions

SECTION 4 - PROPOSED DRAINAGE PLAN

4.1 Description
4.2 Channel and/or Detention Layout
4.3 Hydrologic and Hydraulic Analysis
4.4 Results and No Adverse Impact Evaluation
4.5 Maintenance Access Plan Requirements
4.6 Right-of-Way Requirements
4.7 Special Erosion Control Features
4.8 Stormwater Quality Features
4.9 Multi-Use Features
4.10 Potential Pipeline and Utility Conflicts
4.11 Geotechnical Requirements
4.12 Environmental Issues
~~4.13 Operation and Maintenance Plan for Pumped Detention Basins~~
~~4.14~~4.13 Other Considerations

Outline ~~continued~~Continued on next page

~~19.2 Report Outline,~~

19.2 Report Outline, Continued

Report Outline - Continued 19.2.1

TABLES

- Detention Summary Table

MAPS AND EXHIBITS

- Vicinity Map
- Drainage Area Map, Showing Existing and Proposed
- Project Area Map, Showing Existing and Proposed:
  - Land Use
  - Topography/Grading
  - Drainage Facilities (Public and/or Private)
  - Right-of-Way
  - Floodplain Limits
  - Stationing Used in Hydraulic Calculations
- Channel Hydraulic Profile Showing:
  - Existing, Proposed, and Ultimate Flowlines, Bottom Widths, and Side Slopes
  - Typical Natural Ground Elevations at the Right-of-Way Lines
  - Bridge, Culvert, Utility, and Pipeline Crossings for Existing, Proposed, and Ultimate Conditions
  - Locations of Major Confluences
  - Drop Structures, Transitions, Inflow and Outflow Structures, Stormwater Quality Features, and other Items Influencing the Design
  - Existing, Proposed, and Ultimate 1%, 10% and 50% Exceedance Probability Water Surface Profiles and Other Frequencies As Appropriate
  - Datum and Year of Adjustment

Outline ~~continued~~Continued on next page

~~19.2 Report Outline,~~

19.2 Report Outline, Continued

Report Outline - Continued 19.2.1

- Detention Hydraulic Profile Showing:
  - Existing, Proposed, and Ultimate Flowlines, Bottom Widths, and Side Slopes
  - Typical Natural Ground Elevations at the Right-of-Way Lines
  - Bridge, Culvert, Utility, and Pipeline Crossings for Existing, Proposed, and Ultimate Conditions
  - Inflow and Outflow Structures, Stormwater Quality Features, and other Items Influencing the Design
  - Existing, Proposed, and Ultimate 1%, 10% and 50% Exceedance Probability Water Surface Profiles and Other Frequencies As Appropriate
  - Datum and Year of Adjustment
- Existing, Proposed, and Ultimate Cross-Sections, Including Datum and Year of Adjustment
- Existing and Proposed Hydrographs at Critical Locations

APPENDIX

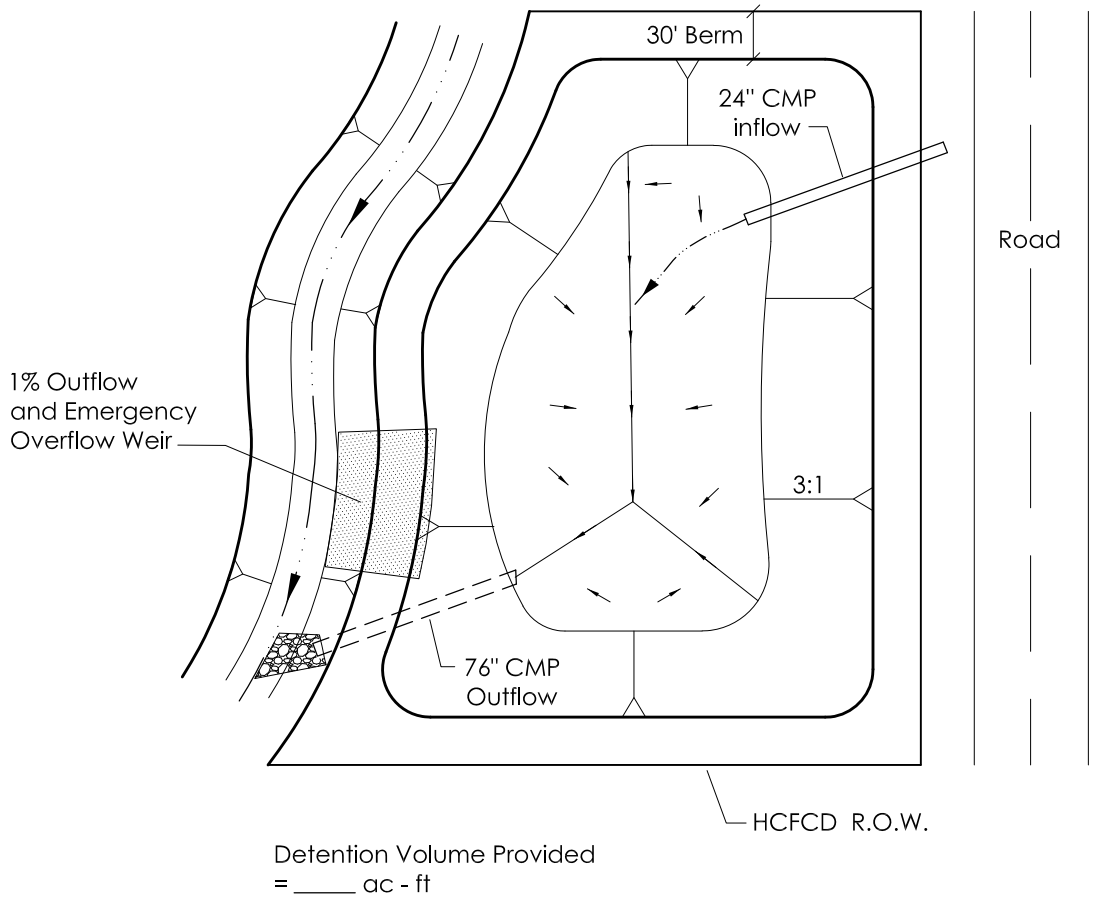
- Detailed Hydrologic and Hydraulic Analysis
- Geotechnical Report
- Environmental Site Investigation/Assessment Report
- Maintenance Access Plan
- Operation and Maintenance Plan for Pumped Detention Basins

19.3 Detention Summary

Detention Summary Table 19.3.1

For modified or new detention facilities include the following detention summary table.

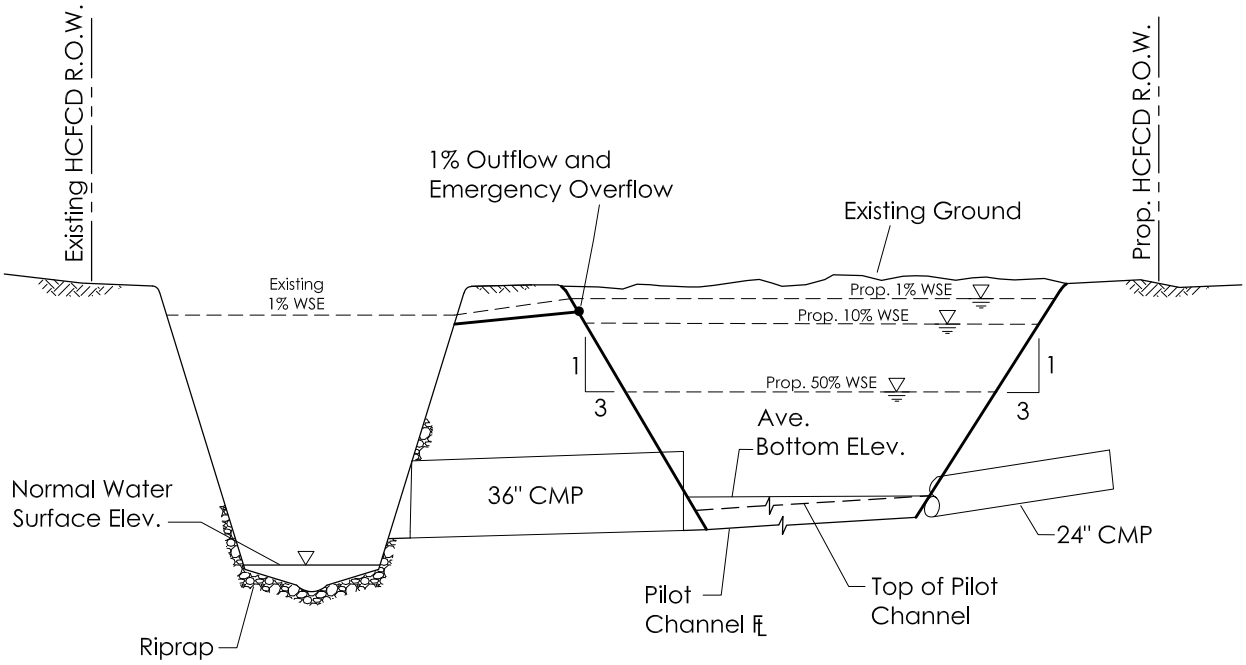
	Project Name:		Date: xx-xx-xxxx	
	Detention Basin Drainage Area		acres	
	Proposed Development Area		acres	
	Storm Event	50% (2-yr)	10% (10-yr)	1% (100-yr)
Flows (cfs)	Post-development Inflow			
	Maximum Allowable Outflow (pre-development peak flow)			
	Maximum Outflow Provided (peak flow from basin)			
Elevations (1988 NGVD, 2001 Adj.)	Lowest Top of Curb or Natural Ground Elev. Estimate			
	Lowest Slab Elevation Estimate			
	Maximum Allowable Water Surface Elevation			
	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	Outflow Pipe Size (ft)			
	Restrictor Size, if applicable (ft)			
	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.)			



PLAN VIEW

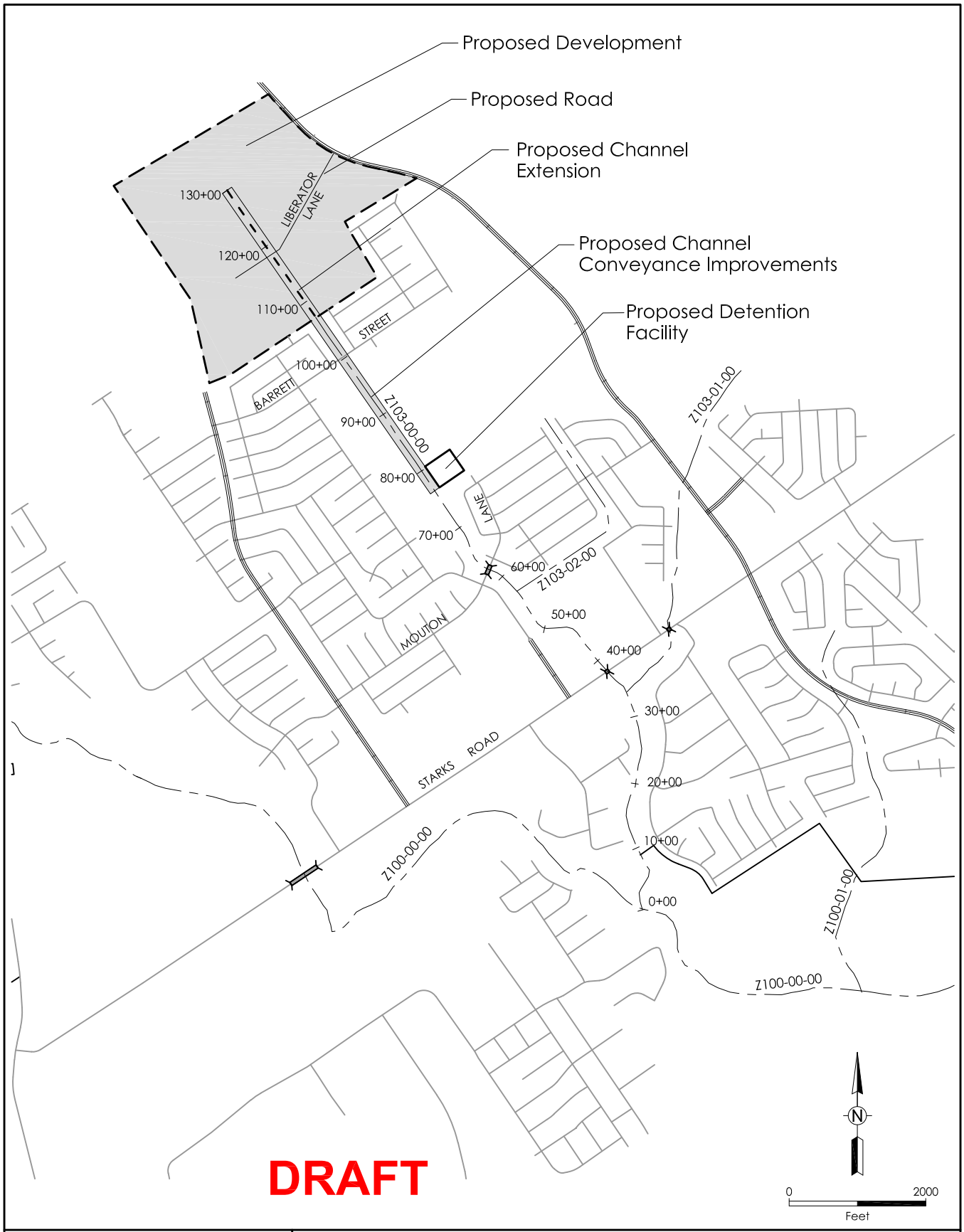
DRAFT

HARRIS COUNTY FLOOD CONTROL DISTRICT **POLICY CRITERIA, & PROCEDURE MANUAL**	**PROPOSED DETENTION BASIN PLAN VIEW**	
	DATE: 8/7/2018	**EXHIBIT 19-1**



PROFILE VIEW

DRAFT



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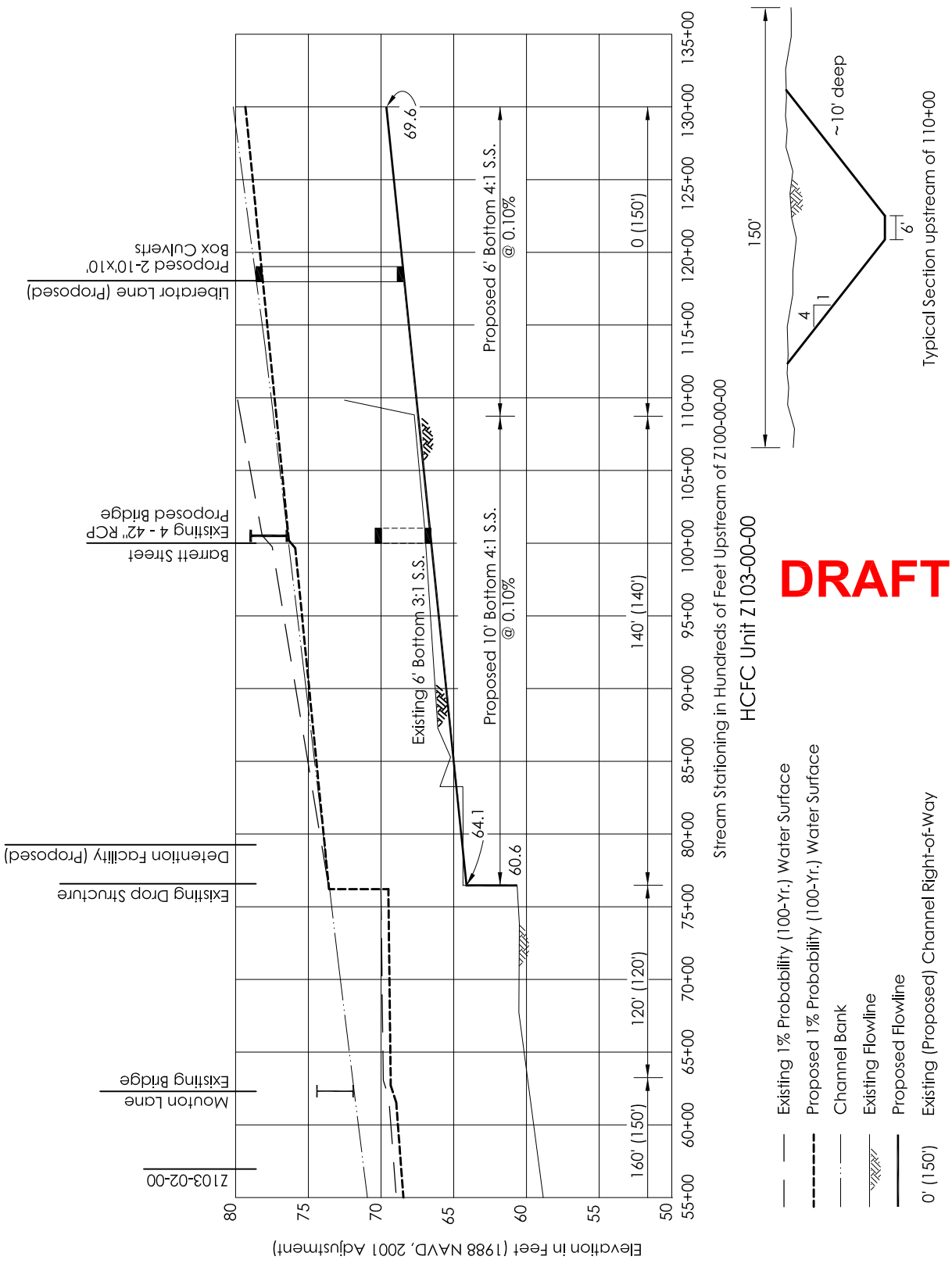
HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

CHANNEL CONVEYANCE IMPROVEMENT PLAN VIEW

DATE: 8/7/2018

EXHIBIT 19-3

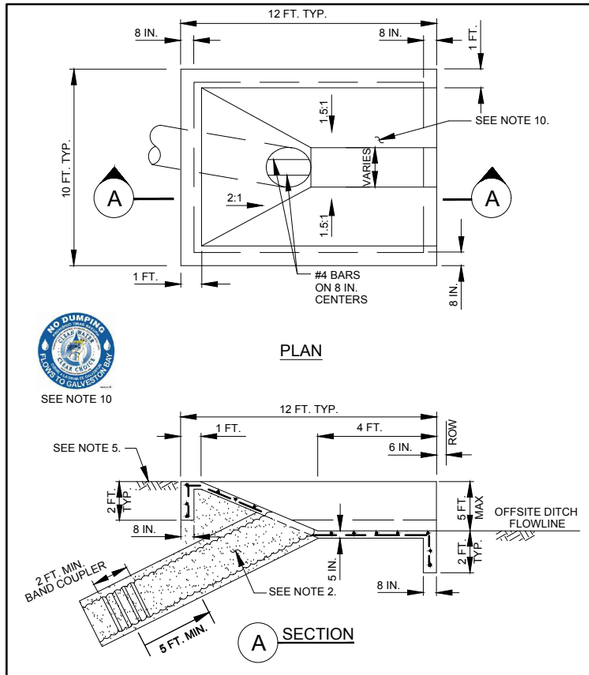


HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY, CRITERIA, & PROCEDURE MANUAL

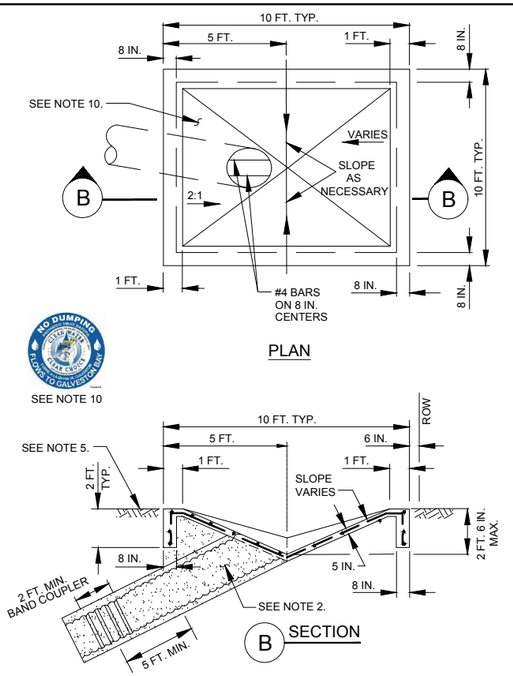
CHANNEL CONVEYANCE IMPROVEMENT PROFILE VIEW

DATE: 8/7/2018	EXHIBIT 19-4



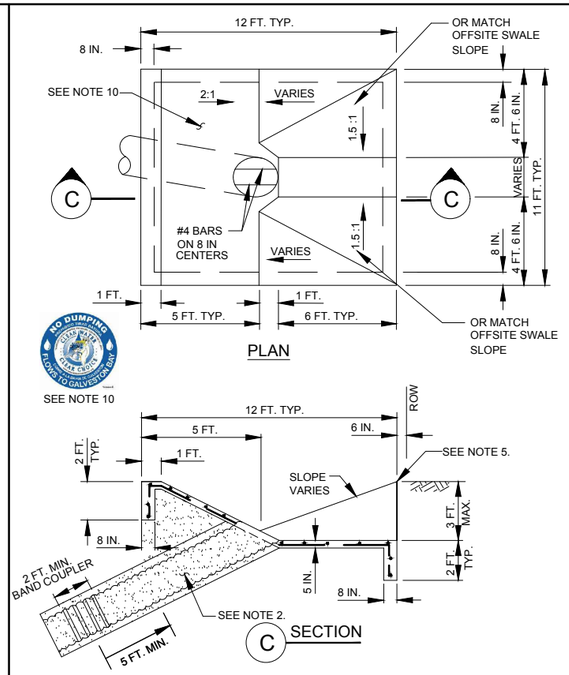
TYPICAL OFFSITE DITCH INTERCEPTOR STRUCTURE

(42 INCH MAX.)



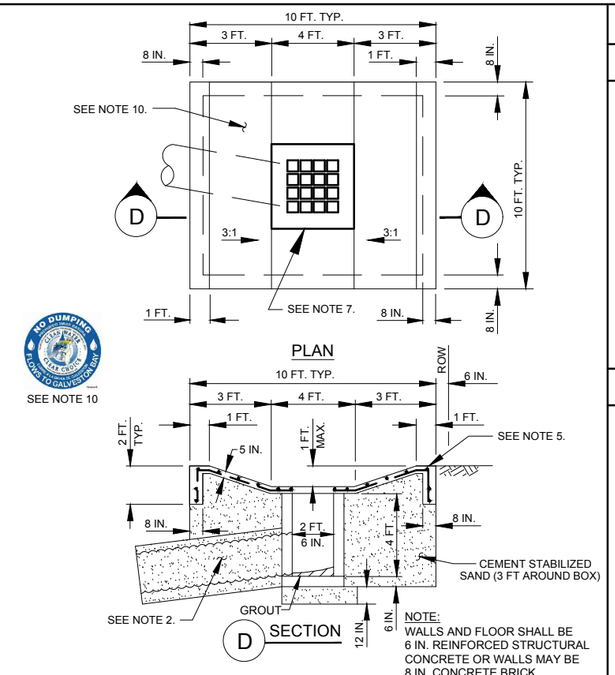
TYPICAL BACKSLOPE INTERCEPTOR STRUCTURE

(24 INCH & 30 INCH ONLY)



COMBINATION BACKSLOPE & OFFSITE DITCH INTERCEPTOR STRUCTURE

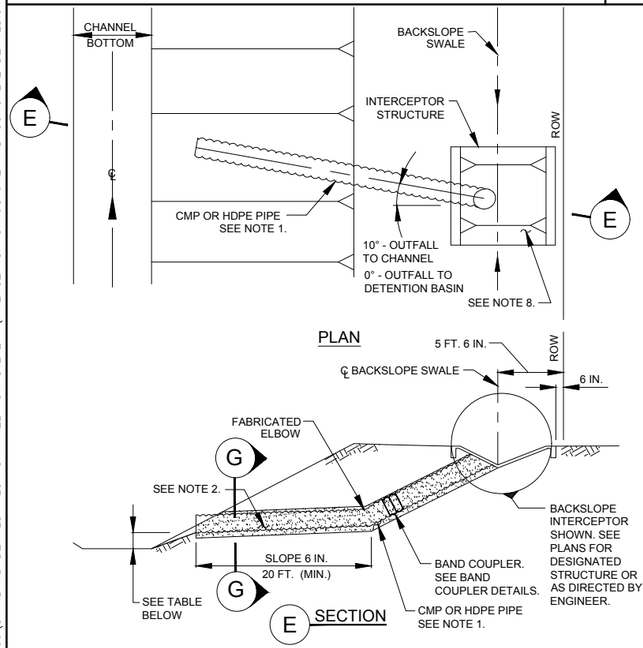
(42 INCH MAX.)



NOTE:
WALLS AND FLOOR SHALL BE 6 IN. REINFORCED STRUCTURAL CONCRETE OR WALLS MAY BE 8 IN. CONCRETE BRICK CONSTRUCTION

URBAN BACKSLOPE INTERCEPTOR STRUCTURE

(24 INCH ONLY)



TYPICAL INTERCEPTOR OUTFALL STRUCTURE LAYOUT

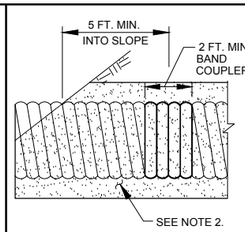
PIPE OUTFALL IN CHANNELS

BOTTOM WIDTH	PIPE OUTLET INVERT
6 FEET ≤ BW ≤ 20 FT	1 FOOT ABOVE FLOWLINE *
20 FEET < BW ≤ 60 FT	AT TOE OF SLOPE *
BW > 60 FT	AT TOE OF SLOPE *

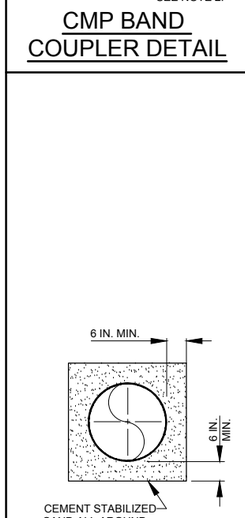
* OR 1 FOOT ABOVE NORMAL WATER LEVEL, WHICHEVER IS HIGHER

PIPE OUTFALL IN DETENTION BASINS

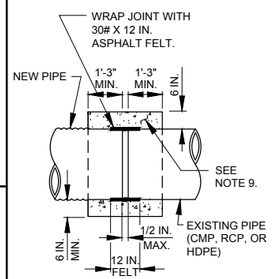
AT TOE OF SLOPE

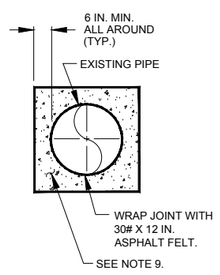


CMP BAND COUPLER DETAIL

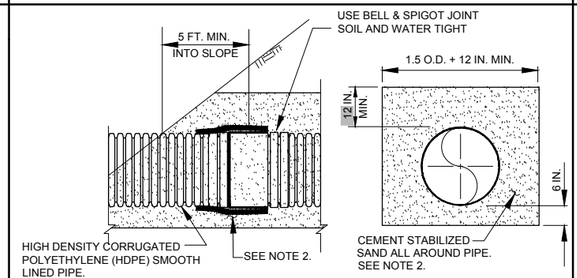


BEDDING CMP DETAIL



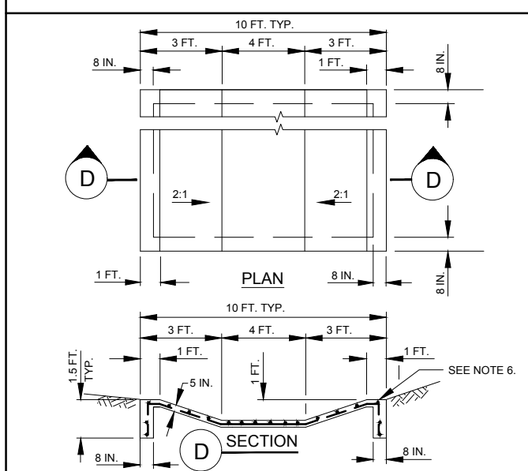


CONCRETE COLLAR DETAIL



HDPE PIPE COUPLER DETAIL

BEDDING HDPE PIPE DETAIL



CONCRETE PILOT CHANNEL - DETENTION BASIN

NOTES:

1. INTERCEPTOR OUTFALL PIPES WITHIN THE HCFCD RIGHT-OF-WAY SHALL BE CMP OR HDPE PIPE IN ACCORDANCE WITH SPECIFICATION SECTION 02642- CORRUGATED METAL PIPE, HIGH DENSITY POLYETHYLENE (HDPE) PIPE IN ACCORDANCE WITH SPECIFICATION SECTION 2505-HIGH DENSITY POLYETHYLENE, OR APPROVED EQUAL. USE TABLE ON STORM SEWER AND RIPRAP DETAILS SHEET FOR CORRUGATED GALVANIZED STEEL PIPE THICKNESS.
2. PROVIDE AND PLACE CEMENT STABILIZED SAND IN ACCORDANCE WITH SPECIFICATION SECTION 02321-CEMENT STABILIZED SAND AND SECTION 02316 - STRUCTURAL EXCAVATING.
3. EXCAVATION, FILL AND BACKFILL FOR STORM SEWER OUTFALLS SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION 02316-STRUCTURAL EXCAVATING AND BACKFILLING.
4. CONCRETE SHALL BE STRUCTURAL CONCRETE IN ACCORDANCE WITH SPECIFICATION SECTION 03310-CONCRETE.
5. INTERCEPTOR STRUCTURES:
   a. ADJUST LENGTH AND WIDTH IN FIELD AS NECESSARY.
   b. 2-FEET DEEP X 8-INCH WIDE TOE ALL AROUND THE STRUCTURE.
   c. STEEL REINFORCING-#4 BARS (GRADE 60) AT 12 INCHES ON CENTER EACH WAY.
   d. ANY INTERCEPTOR OUTFALL PIPE LARGER THAN MAXIMUM SIZE INDICATED REQUIRES A SEPARATE DETAIL.
   e. MATCH TOP OF CONCRETE WITH NATURAL GROUND.
6. CONCRETE PILOT CHANNEL
   a. 1.5 FEET DEEP X 8-INCH WIDE TOE ALL AROUND THE STRUCTURE.
   b. STEEL REINFORCING - #4 BARS (GRADE 60) AT 12 INCHES ON CENTER EACH WAY.
   c. MATCH TOP OF CONCRETE WITH BOTTOM OF DETENTION BASIN.
7. CONCRETE PAD AROUND URBAN BACKSLOPE INTERCEPTOR: PAID FOR AS CONCRETE INTERCEPTOR STRUCTURE PER UNIT PRICE SCHEDULE. TYPE "A" INLET BOX, COH DWG. NO. 2084-08 WITH GRATE TOP, VULCAN FOUNDRY COMPANY, V-4880-1 OR APPROVED EQUAL, APPROX. 473 SQ.IN. OPENING. PAID 2632-05
8. BACKSLOPE SWALE AND INTERCEPTOR STRUCTURE ELEVATIONS AND LOCATIONS SHOWN ON THE PLANS ARE APPROXIMATE. FINAL ELEVATIONS AND LOCATIONS SHALL BE FIELD VERIFIED BY THE ENGINEER PRIOR TO INSTALLATION.
9. STRUCTURAL CONCRETE WITH #4 BARS (GRADE 60) 12 INCH O.C. EACH WAY, 3 ROWS MIN. EACH WAY. - FOR COLLARS ONLY.
10. EPOXY "CLEAN WATER CLEAR CHOICE" LOGO BUTTON ON INTERCEPTORS. LOCATION TO BE DETERMINED BY THE ENGINEER.

THIS DETAIL SHEET HAS BEEN PREPARED FOR USE ON HCFCD PROJECTS OR PROJECTS TO BE MAINTAINED BY THE HCFCD WHEN COMPLETED BY OTHERS. AN ENGINEER WHO INCORPORATES THE DETAILS ON THIS SHEET BECOMES RESPONSIBLE FOR ITS USE IN THE END PRODUCT IN ACCORDANCE WITH RULE 137.33 (b) AND (c) OF THE TEXAS BOARD OF PROFESSIONAL ENGINEERS.

DRAFT

ENGINEER - CONFIRM, CHANGE, OR FILL IN.

P.E. SEAL AND SIGNATURE

REV	DESCRIPTION	DATE	APPR

PROJECT ID#

PROJECT TITLE

INTERCEPTOR STRUCTURE AND CONCRETE PILOT CHANNEL DETAILS

PREPARED:

CHECKED:

APPROVED:

COMPANY INFORMATION AND LOGO GOES HERE

HARRIS COUNTY FLOOD CONTROL DISTRICT
9900 Northwest Freeway
Houston, Texas 77092

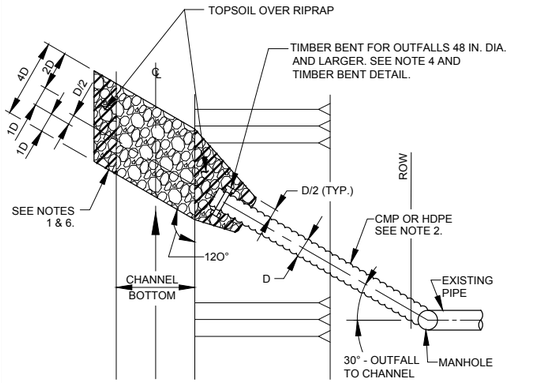
DATE: 6-13-18

SCALE: AS NOTED

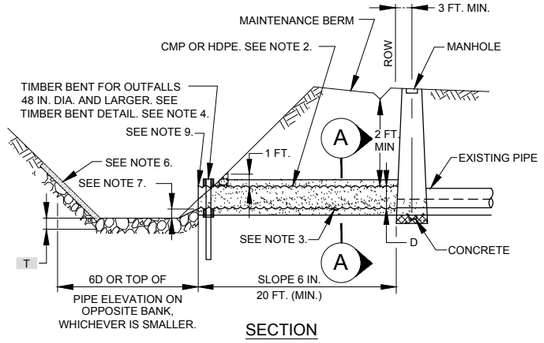
SHEET NUMBER

OF

S:\Operations\EngDiv\MED\ME Autocad\STANDARD DETAILS PILOT CHANNEL FOR STEVE F\INTERCEPTOR STRUCTURE AND CONCRETE DETAILS.dwg

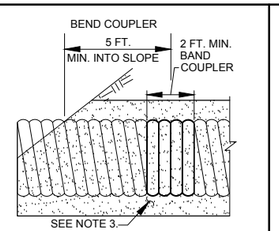


PLAN

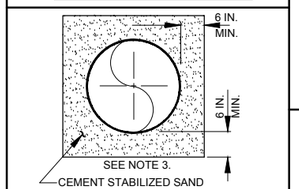


SECTION

TYPICAL STORM SEWER OUTFALL STRUCTURE LAYOUT

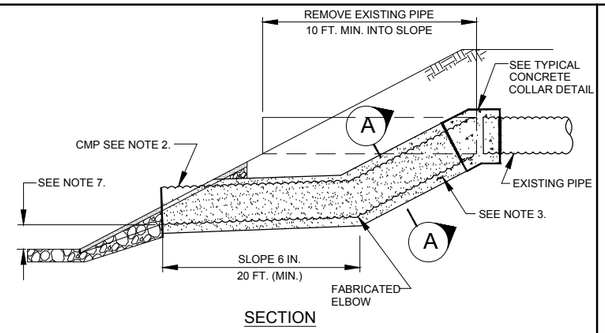


CMP BAND COUPLER DETAIL



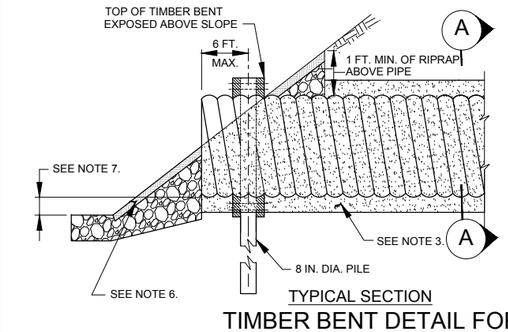
A SECTION

BEDDING RCP & CMP DETAIL



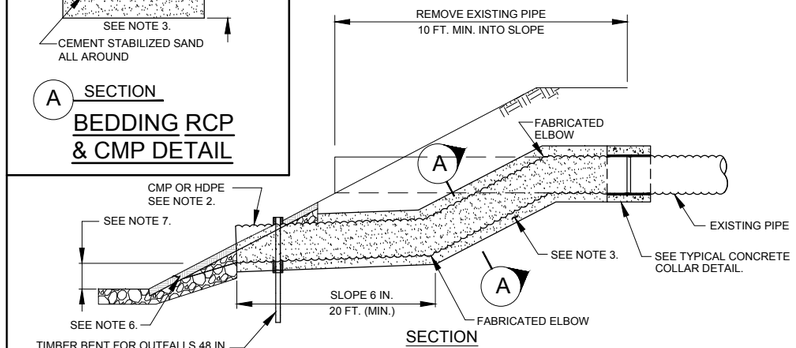
SECTION

PIPE ADJUSTMENT DETAIL 24-INCH TO 42-INCH DIAMETER



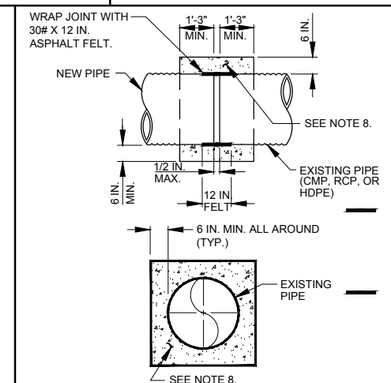
TYPICAL SECTION ELEVATION

TIMBER BENT DETAIL FOR 48-INCH CMP; 36-INCH HDPE AND LARGER OUTFALLS

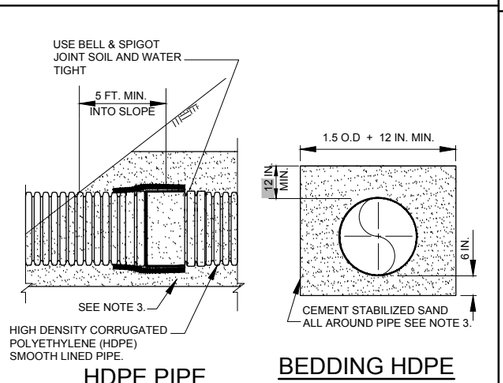


SECTION

PIPE ADJUSTMENT DETAIL 48-INCH AND LARGER DIAMETER

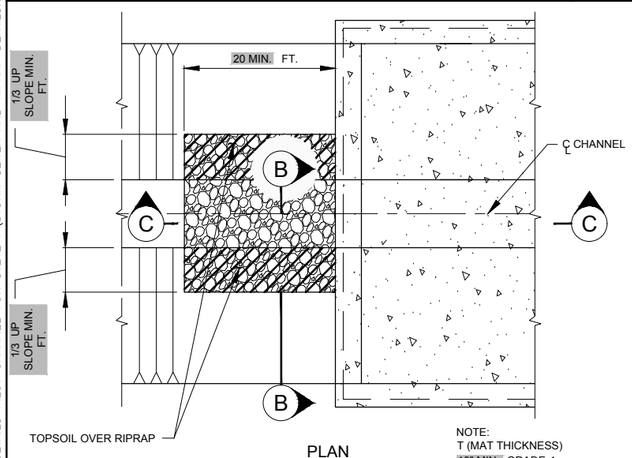


CONCRETE COLLAR DETAIL



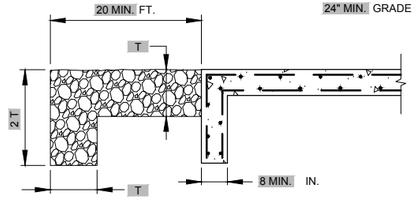
HDPE PIPE COUPLER DETAIL

BEDDING HDPE PIPE DETAIL



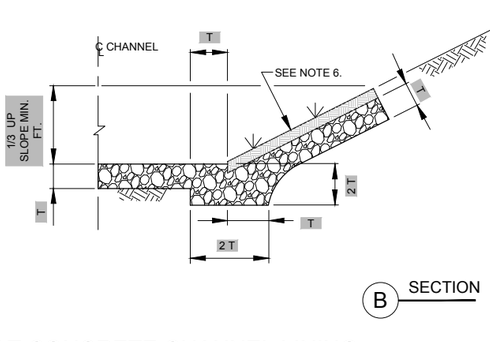
PLAN

NOTE:
T (MAT THICKNESS)
18" MIN. GRADE 1
24" MIN. GRADE 2



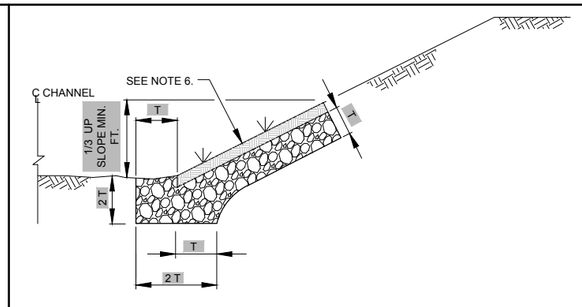
NOTE:
TOE-IN RIPRAP ACROSS CHANNEL BOTTOM & UP SLOPE. DO NOT PLACE TOE AGAINST CONCRETE.

C SECTION



B SECTION

TYPICAL RIPRAP AT CONCRETE CHANNEL LINING



TYPICAL RIPRAP LINING DETAIL-SIDE SLOPE ONLY

PIPE OUTFALL IN CHANNELS

BOTTOM WIDTH	PIPE OUTLET INVERT
6 FEET ≤ BW ≤ 20 FT	1 FOOT ABOVE FLOWLINE *
20 FEET < BW ≤ 60 FT	AT TOE OF SLOPE *
BW > 60 FT	AT TOE OF SLOPE *

* OR 1 FOOT ABOVE NORMAL WATER LEVEL, WHICHEVER IS HIGHER

NOTES:

1. INSTALL RIPRAP EROSION PROTECTION IN GRASS LINED CHANNELS AND DETENTION BASINS FOR ANY SIZE STORM SEWER PIPE AND TREATMENT PLANT OUTFALL, DIMENSIONED AS SHOWN IN "TYPICAL STORM SEWER OUTFALL STRUCTURE LAYOUT."
2. STORM SEWER OUTFALL PIPES WITHIN THE HCFCD RIGHT-OF-WAY SHALL BE CMP OR HDPE IN ACCORDANCE WITH SPECIFICATION SECTION 02642-CORRUGATED METAL PIPE, HIGH DENSITY POLYETHYLENE PIPE (HDPE) IN ACCORDANCE WITH SPECIFICATION SECTION 02505-HIGH DENSITY POLYETHYLENE PIPE, OR APPROVED EQUAL. USE TABLE BELOW FOR CORRUGATED GALVANIZED STEEL PIPE.
3. PROVIDE AND PLACE CEMENT STABILIZED SAND IN ACCORDANCE WITH SPECIFICATION SECTION NO. 02321-CEMENT STABILIZED SAND.
4. TIMBER BENTS SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION 02464-TIMBER BENTS.
5. STORM SEWER OUTFALLS SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION 02316-STRUCTURAL EXCAVATING AND BACKFILLING.
6. RIPRAP SHALL BE PLACED IN ACCORDANCE WITH SPECIFICATION SECTION 02378-RIPRAP AND GRANULAR FILL. FILL RIPRAP VOIDS AND BURY RIPRAP A MINIMUM OF 6 INCHES WITH TOPSOIL ON SIDE SLOPE AS DIRECTED BY THE ENGINEER.
7. IN DETENTION BASINS, SET FLOWLINE OF OUTFALL AT TOE OF THE SLOPE OR FLOWLINE OF PILOT CHANNEL. IN CHANNEL, USE ELEVATION INDICATED IN THE PIPE OUTFALL IN CHANNELS TABLE.
8. STRUCTURAL CONCRETE #4 BARS (GRADE 40) 12 INCH O.C. EACH WAY - FOR COLLARS ONLY.
9. FOR RCP OUTFALL IN GRASS LINED CHANNELS AND DETENTION BASINS, USE HEADWALL/ WINGWALL/APRON DETAIL ON SHEET _____. FOR RCP OUTFALL IN CONCRETE LINED CHANNEL AND DETENTION BASINS , SEE HCFCD CONCRETE CHANNEL LINING DETAILS.

CORRUGATED GALVANIZED STEEL PIPE (TYPE I)

PIPE DIA. (in.)	2-2/3" X 1/2" CORRUGATION MIN. FILL* (in.)	SHEET THICKNESS (in.) gage	(in.)	(mm)	3" X 1" & 5" X 1" CORRUGATION MIN. FILL* (in.)	SHEET THICKNESS (in.) gage	(in.)	(mm)
24	12	16	.064	1.63	-	-	-	-
30	12	16	.064	1.63	-	-	-	-
36	12	16	.064	1.63	-	-	-	-
42	12	16	.064	1.63	12	16	.064	1.63
48	12	16	.064	1.63	12	16	.064	1.63
54	12	14	.079	2.01	12	16	.064	1.63
60	15	12	.109	2.77	12	16	.064	1.63
66	15	12	.109	2.77	15	16	.064	1.63
72	18	10	.138	3.51	15	16	.064	1.63
78	18	8	.168	4.27	18	16	.064	1.63
84	18	8	.168	4.27	18	14	.079	2.01
90	-	-	-	-	18	14	.079	2.01
96	-	-	-	-	18	14	.079	2.01

* MINIMUM DEPTH OF COVER ABOVE TOP OF PIPE, MAXIMUM DEPTH OF COVER ABOVE TOP OF PIPE IS 20 FEET.

THIS DETAIL SHEET HAS BEEN PREPARED FOR USE ON HCFCD PROJECTS OR PROJECTS TO BE MAINTAINED BY THE HCFCD WHEN COMPLETED BY OTHERS. AN ENGINEER WHO INCORPORATES THE DETAILS ON THIS SHEET BECOMES RESPONSIBLE FOR ITS USE IN THE END PRODUCT IN ACCORDANCE WITH RULE 137.33 (b) AND (c) OF THE TEXAS BOARD OF PROFESSIONAL ENGINEERS.

DRAFT

ENGINEER - CONFIRM, CHANGE, OR FILL IN.

P.E. SEAL AND SIGNATURE

APPR | DATE | DESCRIPTION | REV

PROJECT ID#

PROJECT TITLE

STORM SEWER AND RIPRAP DETAILS

PREPARED: | CHECKED: | APPROVED:

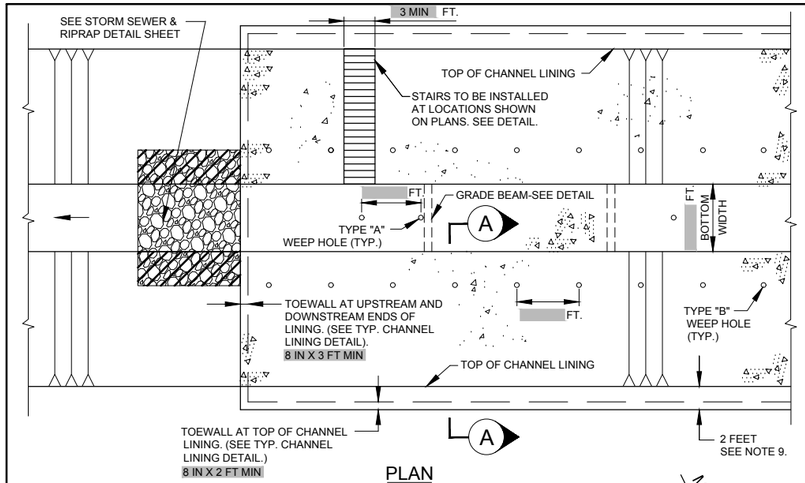
COMPANY INFORMATION AND LOGO GOES HERE

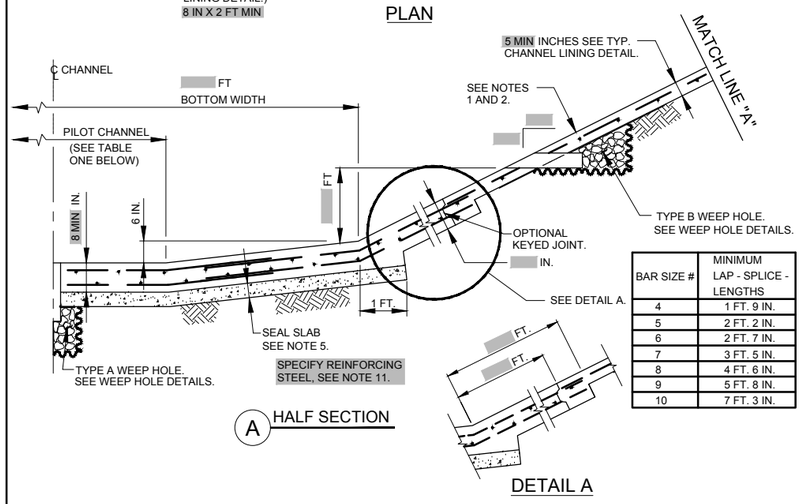
HARRIS COUNTY FLOOD CONTROL DISTRICT
9900 Northwest Freeway
Houston, Texas 77092

DATE: 6-13-18
SCALE: NTS

SHEET NUMBER
_____ OF _____

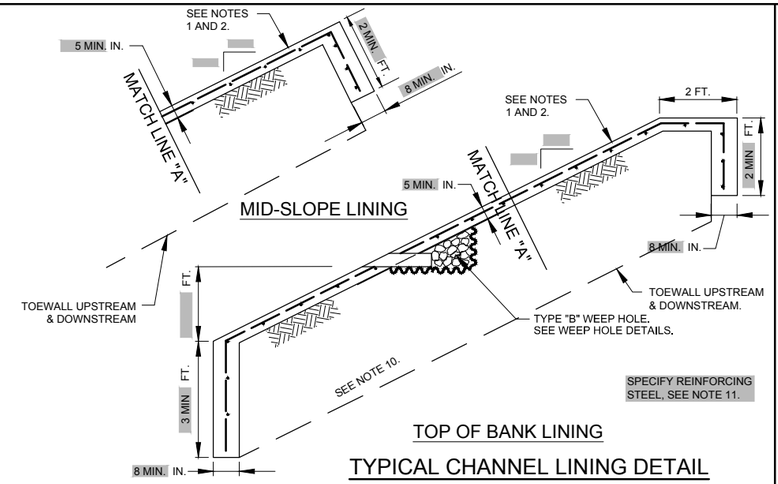
S:\Operations\EngDiv\MED\ME Autocad\STANDARD DETAILS PILOT CHANNEL FOR STEVE F\STORM SEWER AND RIPRAP DETAILS.dwg



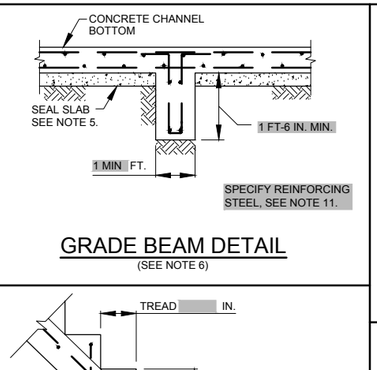


BAR SIZE #	MINIMUM LAP - SPLICE - LENGTHS
4	1 FT. 9 IN.
5	2 FT. 2 IN.
6	2 FT. 7 IN.
7	3 FT. 5 IN.
8	4 FT. 6 IN.
9	5 FT. 8 IN.
10	7 FT. 3 IN.

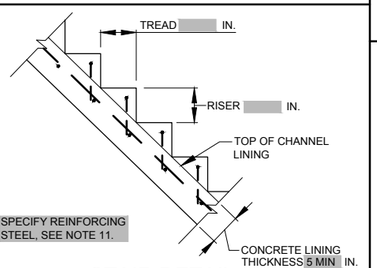
TYPICAL TRAPEZOIDAL CHANNEL LINING



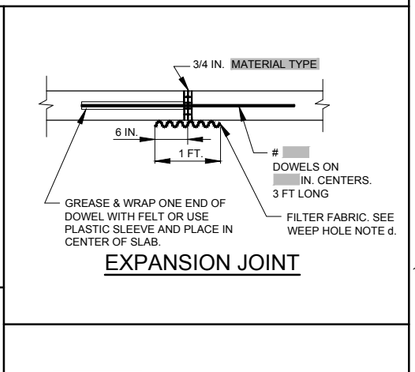
TYPICAL CHANNEL LINING DETAIL



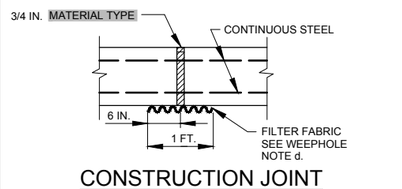
GRADE BEAM DETAIL
(SEE NOTE 6)



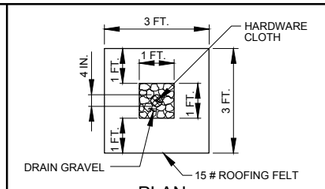
STAIR DETAIL



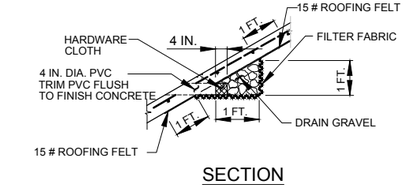
EXPANSION JOINT



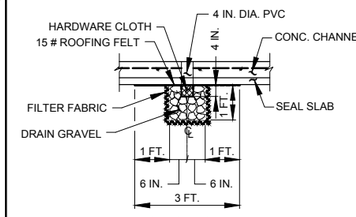
CONSTRUCTION JOINT



PLAN

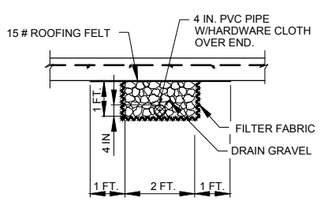


SECTION



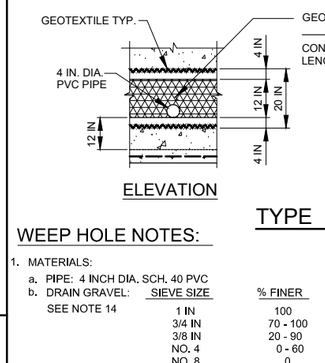
SECTION

TYPE "A" WEEP HOLE

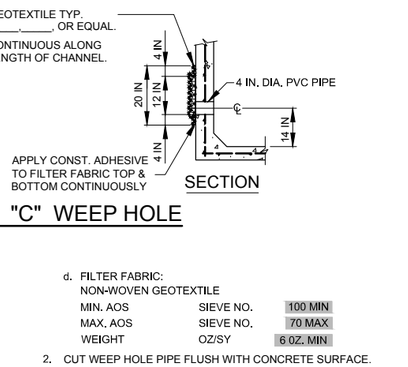


SECTION

TYPE "B" WEEP HOLE



ELEVATION



SECTION

TYPE "C" WEEP HOLE

WEEP HOLE NOTES:

1. MATERIALS:
   a. PIPE: 4 INCH DIA. SCH. 40 PVC
   b. DRAIN GRAVEL:

SIEVE SIZE	% FINER
1 IN	100
3/4 IN	70 - 100
3/8 IN	20 - 90
NO. 4	0 - 60
NO. 8	0

   SEE NOTE 14
   c. HARDWARE CLOTH: MIN. OPEN 1/8 IN, MAX. OPEN 1/4 IN
   d. FILTER FABRIC: NON-WOVEN GEOTEXTILE
   MIN. AOS — SIEVE NO. 100 MIN
   MAX. AOS — SIEVE NO. 70 MAX
   WEIGHT — OZ/SY 6 OZ. MIN
2. CUT WEEP HOLE PIPE FLUSH WITH CONCRETE SURFACE.
3. TYPE "A" AND "C" WEEP HOLES FOR TYPICAL RECTANGULAR CONCRETE CHANNEL LINING. TO BE STAGGERED.

WEEP HOLE DETAILS

NOTES:

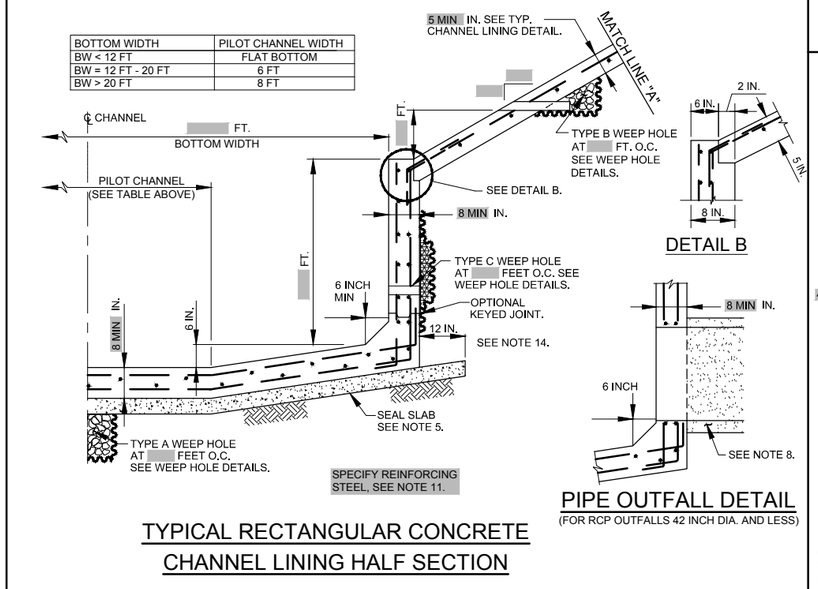
1. STRUCTURAL CONCRETE FOR CONCRETE CHANNEL LINING AND NONSTRUCTURAL CONCRETE FOR SEAL SLAB SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION NO. 03310-CONCRETE.
2. REINFORCING STEEL SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION NO. 03310-CONCRETE.
3. EXCAVATION AND BACKFILL FOR CONCRETE CHANNEL LINING SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION NO. 02316-STRUCTURAL EXCAVATING AND BACKFILLING.
4. RIPRAP SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION NO. 02378-RIPRAP AND GRANULAR FILL.
5. A NON-REINFORCED 4 INCH MINIMUM NONSTRUCTURAL CONCRETE SEAL SLAB IS REQUIRED BENEATH THE BOTTOM OF CONCRETE CHANNELS.
6. STRUCTURAL CONCRETE GRADE BEAMS SHALL BE INSTALLED TRANSVERSELY AT 20 FOOT MAX. CENTERS ON CONCRETE LINED CHANNELS WITH BOTTOM WIDTHS EQUAL TO OR GREATER THAN 20 FEET.
7. JOINTS:
   A. PLACE CONSTRUCTION JOINT IN CONCRETE LOW-FLOW, TRAPEZOIDAL BOTTOM SECTIONS AND SLOPES AT 20 FOOT MIN. SPACING CONTINUOUSLY THROUGH CHANNEL LINING.
   B. PLACE EXPANSION JOINT IN CONCRETE LOW-FLOW, TRAPEZOIDAL BOTTOM SECTIONS, AND SLOPES AT 60 FOOT MAX. SPACING CONTINUOUSLY THROUGH CHANNEL LINING.
8. CEMENT STABILIZED SAND SHALL BE PROVIDED AND PLACED IN ACCORDANCE WITH SPECIFICATION SECTION NO. 02321 -CEMENT STABILIZED SAND.
9. DELETE 2 FT FLAT EDGE WHEN LINING IS BELOW TOP OF BANK. SEE MID-SLOPE LINING DETAIL.
10. UPSTREAM AND DOWNSTREAM TOE WALL 3 FOOT MIN. DEPTH AT BOTTOM OF SLOPE AND 8 INCHES THICK.
11. MINIMUM #4 BARS (GRADE 60) AT 12 INCHES ON CENTER EACH WAY.
12. VARIES BASED ON SIDE SLOPE. MINIMUM 1 FOOT VERTICAL AT TOE OF SLOPE.
13. FOR RCP OUTFALLS 48 INCHES DIA. AND LARGER, USE HEADWALL/WINGWALL DETAIL ON SHEET
14. FOR STRUCTURAL BACKFILL MATERIAL PER SPECIFICATION SECTION 2316, USE CONCRETE COARSE AGGREGATE ASTM C33 SIZE NO. 467. LIMESTONE AND RECYCLED CONCRETE NOT ALLOWED.

THIS DETAIL SHEET HAS BEEN PREPARED FOR USE ON HCFC PROJECTS OR PROJECTS TO BE MAINTAINED BY THE HCFCD. WHEN COMPLETED BY OTHERS. AN ENGINEER WHO INCORPORATES THE DETAILS ON THIS SHEET BECOMES RESPONSIBLE FOR ITS USE IN THE END PRODUCT IN ACCORDANCE WITH RULE 137.33 (b) AND (c) OF THE TEXAS BOARD OF PROFESSIONAL ENGINEERS.

DRAFT

P.E. SEAL AND SIGNATURE

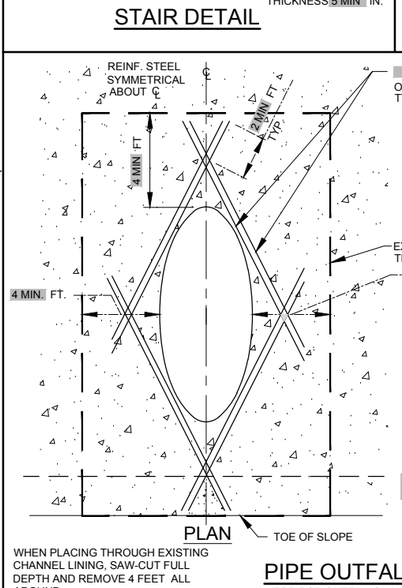
ENGINEER - CONFIRM, CHANGE, OR FILL IN.



TYPICAL RECTANGULAR CONCRETE CHANNEL LINING HALF SECTION

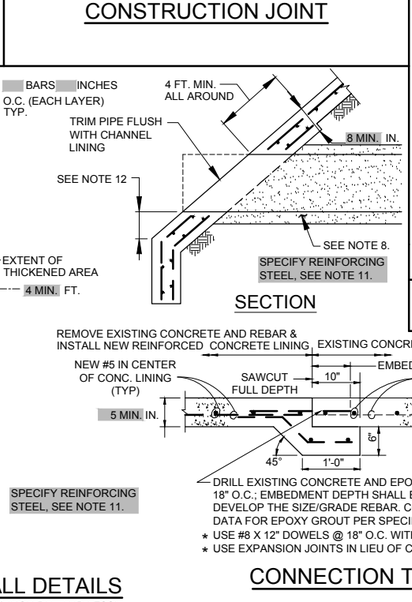
DETAIL B

PIPE OUTFALL DETAIL
(FOR RCP OUTFALLS 42 INCH DIA. AND LESS)



WHEN PLACING THROUGH EXISTING CHANNEL LINING, SAW-CUT FULL DEPTH AND REMOVE 4 FEET ALL AROUND.

PIPE OUTFALL DETAILS
(FOR RCP OUTFALLS 42 INCH DIA. AND LESS)



SECTION

DRILL EXISTING CONCRETE AND EPOXY GROUT IN PLACE 24" LONG #5 REBAR DOWELS @ 18" O.C.; EMBEDMENT DEPTH SHALL BE AS PER EPOXY MANUFACTURER TO FULLY DEVELOP THE SIZE/GRADE REBAR. CONTRACTOR TO SUBMIT MANUFACTURER'S PRODUCT DATA FOR EPOXY GROUT PER SPECIFICATION SECTION No. 01330.

★ USE #8 X 12" DOWELS @ 18" O.C. WITH 6" EMBEDMENT AND NO EPOXY @ EXPANSION JOINTS.

★ USE EXPANSION JOINTS IN LIEU OF CONSTRUCTION JOINTS WHERE DIRECTED BY ENGINEER.

CONNECTION TO EXISTING CONCRETE

REV	DESCRIPTION	DATE	APPR

PROJECT ID#

PROJECT TITLE

CONCRETE CHANNEL LINING DETAILS

PREPARED: | CHECKED: | APPROVED:

COMPANY INFORMATION AND LOGO GOES HERE

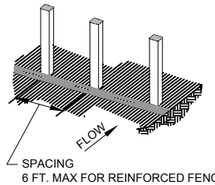
HARRIS COUNTY FLOOD CONTROL DISTRICT
9900 Northwest Freeway
Houston, Texas 77092

DATE: 6-13-18
SCALE: NTS

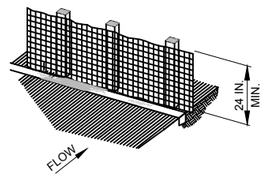
SHEET NUMBER
OF

S:\Operations\EngDiv\MED\ME Autocad\STANDARD DETAILS PILOT CHANNEL FOR STEVE F\CONCRETE CHANNEL LINING DETAILS.dwg

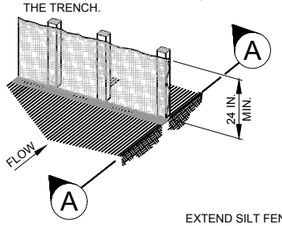
1. SET SUPPORTS AND EXCAVATE 4 IN. X 6 IN. TRENCH UPSLOPE ALONG LINE OF SUPPORTS.



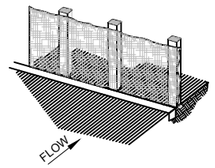
2. SECURE WIRE FENCING TO SUPPORTS.

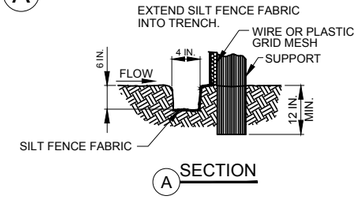


3. ATTACH SILT FENCE FABRIC TO WIRE FENCE AND EXTEND INTO THE TRENCH.



4. BACKFILL AND COMPACT THE EXCAVATED SOIL.



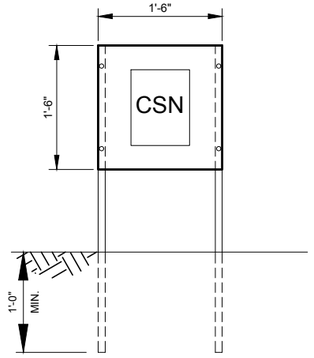


NOTE:

1. SEE SPECIFICATION SECTION NO. 02361-SILT FENCES.

RSF — SYMBOL — REINFORCED SILT FENCE

REINFORCED SILT FENCE

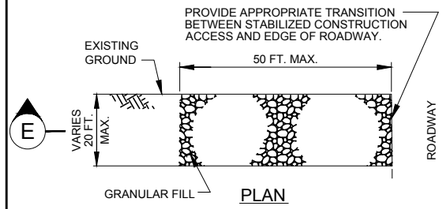


NOTE:

CONSTRUCT IN ACCORDANCE WITH HCFCD SPECIFICATION SECTION 01580 - PROJECT SIGNS.

CSN HOLDER

SWPPP / BMP SIGN AND CONSTRUCTION SITE NOTICE HOLDER DETAILS

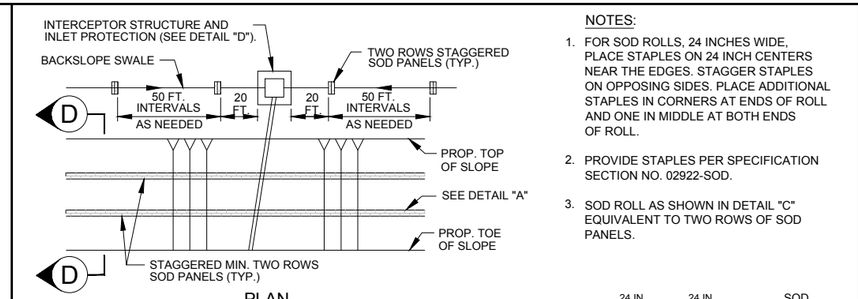


CONSTRUCTION NOTES:

1. SEE SPECIFICATION SECTION NO. 02365-STABILIZED CONSTRUCTION ACCESS.

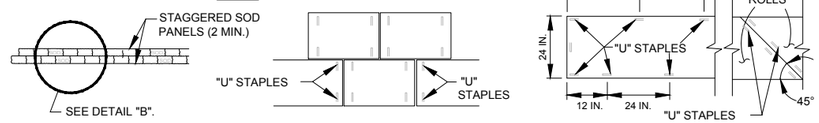
STABILIZED CONSTRUCTION ACCESS

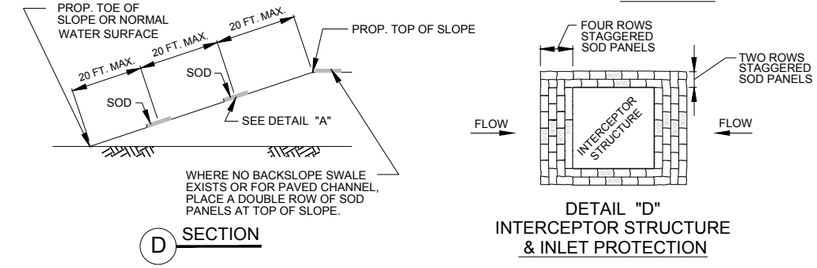
SCA — SYMBOL



NOTES:

1. FOR SOD ROLLS, 24 INCHES WIDE, PLACE STAPLES ON 24 INCH CENTERS NEAR THE EDGES. STAGGER STAPLES ON OPPOSING SIDES. PLACE ADDITIONAL STAPLES IN CORNERS AT ENDS OF ROLL AND ONE IN MIDDLE AT BOTH ENDS OF ROLL.
2. PROVIDE STAPLES PER SPECIFICATION SECTION NO. 02922-SOD.
3. SOD ROLL AS SHOWN IN DETAIL "C" EQUIVALENT TO TWO ROWS OF SOD PANELS.





SOD — SYMBOL

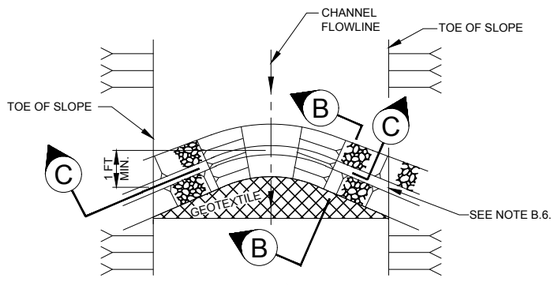
IP — SYMBOL

SODDING

FILTER DAM NOTES:

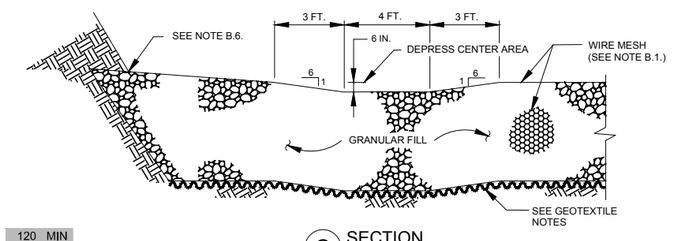
A. TYPES OF FILTER DAMS
   1. TYPE 1 - NOT USED BY HCFCD
   2. TYPE 2 (REINFORCED).
      a. HEIGHT - 18-36 INCHES. MEASURE VERTICALLY FROM EXISTING GROUND TO TOP OF FILTER DAM.
      b. TOP WIDTH - 2 FEET (MINIMUM).
      c. SLOPES - 2:1 (MAXIMUM).
   3. TYPE 3 - NOT USED BY HCFCD
   4. TYPE 4 (GABION)
      a. HEIGHT - 30 INCHES (MINIMUM). MEASURE VERTICALLY FROM EXISTING GROUND TO TOP OF FILTER DAM.
      b. TOP WIDTH - 2 FEET (MINIMUM).
   5. TYPE 5. AS SHOWN ON THE PLANS.

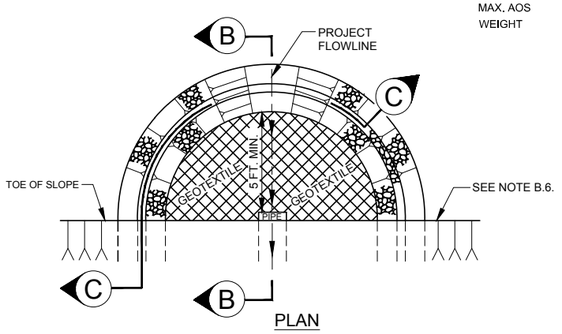
B. CONSTRUCT FILTER DAMS ACCORDING TO THE FOLLOWING CRITERIA UNLESS SHOWN OTHERWISE ON THE PLANS.
   1. TYPE 2 AND 3 FILTER DAMS: SECURE WITH 20 GAUGE GALVANIZED WOVEN WIRE MESH WITH 1 INCH DIAMETER HEXAGONAL OPENINGS.
   2. GRANULAR FILL:
      a. PLACE ON MESH TO HEIGHT AND SLOPES SHOWN ON PLANS OR AS SPECIFIED BY THE ENGINEER.
      b. 3-5 INCHES FOR ROCK FILTER DAM TYPES 2, AND 4.
      REFER TO GRANULAR FILL IN SPECIFICATION SECTION NO. 02378-RIPRAP AND GRANULAR FILL.
   3. WIRE MESH: FOLD AT UPSTREAM SIDE OVER GRANULAR FILL AND TIGHTLY SECURE TO ITSELF ON THE DOWNSTREAM SIDE USING WIRE TIES OR HOG RINGS.
   4. IN STREAMS: SECURE OR STAKE MESH TO STREAM BED PRIOR TO AGGREGATE PLACEMENT.
   5. SEE SPECIFICATION SECTION NO. 02364-FILTER DAMS.
   6. EMBED ONE FOOT MINIMUM INTO SLOPE AND AT SLOPE RAISE ONE FOOT HIGHER THAN CENTER OF DEPRESSED AREA.

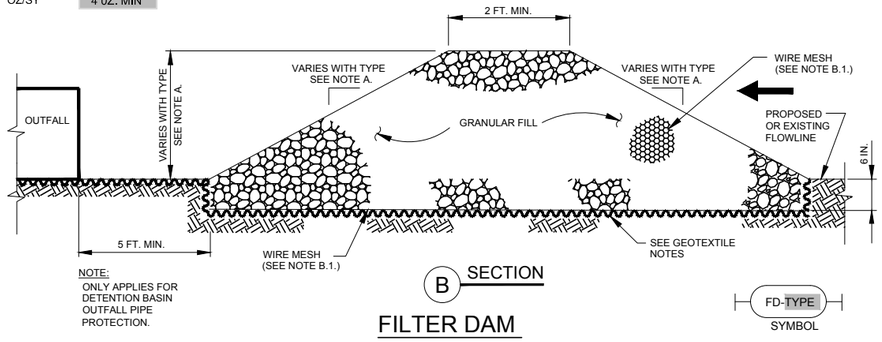


GEOTEXTILE NOTES:

MIN. AOS	SIEVE NO.	120 MIN
MAX. AOS	SIEVE NO.	50 MAX
WEIGHT	OZ/SY	4 OZ. MIN







NOTE:

ONLY APPLIES FOR DETENTION BASIN OUTFALL PIPE PROTECTION.

FD-TYPE — SYMBOL

FILTER DAM AT DETENTION BASIN OUTFALL PIPE

FILTER DAM

THIS DETAIL SHEET HAS BEEN PREPARED FOR USE ON HCFCD PROJECTS OR PROJECTS TO BE MAINTAINED BY THE HCFCD WHEN COMPLETED BY OTHERS. AN ENGINEER WHO INCORPORATES THE DETAILS ON THIS SHEET BECOMES RESPONSIBLE FOR ITS USE IN THE END PRODUCT IN ACCORDANCE WITH RULE 137.33 (b) AND (c) OF THE TEXAS BOARD OF PROFESSIONAL ENGINEERS.

DRAFT

P.E. SEAL AND SIGNATURE

ENGINEER - CONFIRM, CHANGE, OR FILL IN.

REV	DESCRIPTION	DATE	APPR

PROJECT ID#

PROJECT TITLE

STORMWATER POLLUTION PREVENTION DETAILS

PREPARED:

CHECKED:

APPROVED:

COMPANY INFORMATION AND LOGO GOES HERE

HARRIS COUNTY FLOOD CONTROL DISTRICT

9900 Northwest Freeway
Houston, Texas 77092

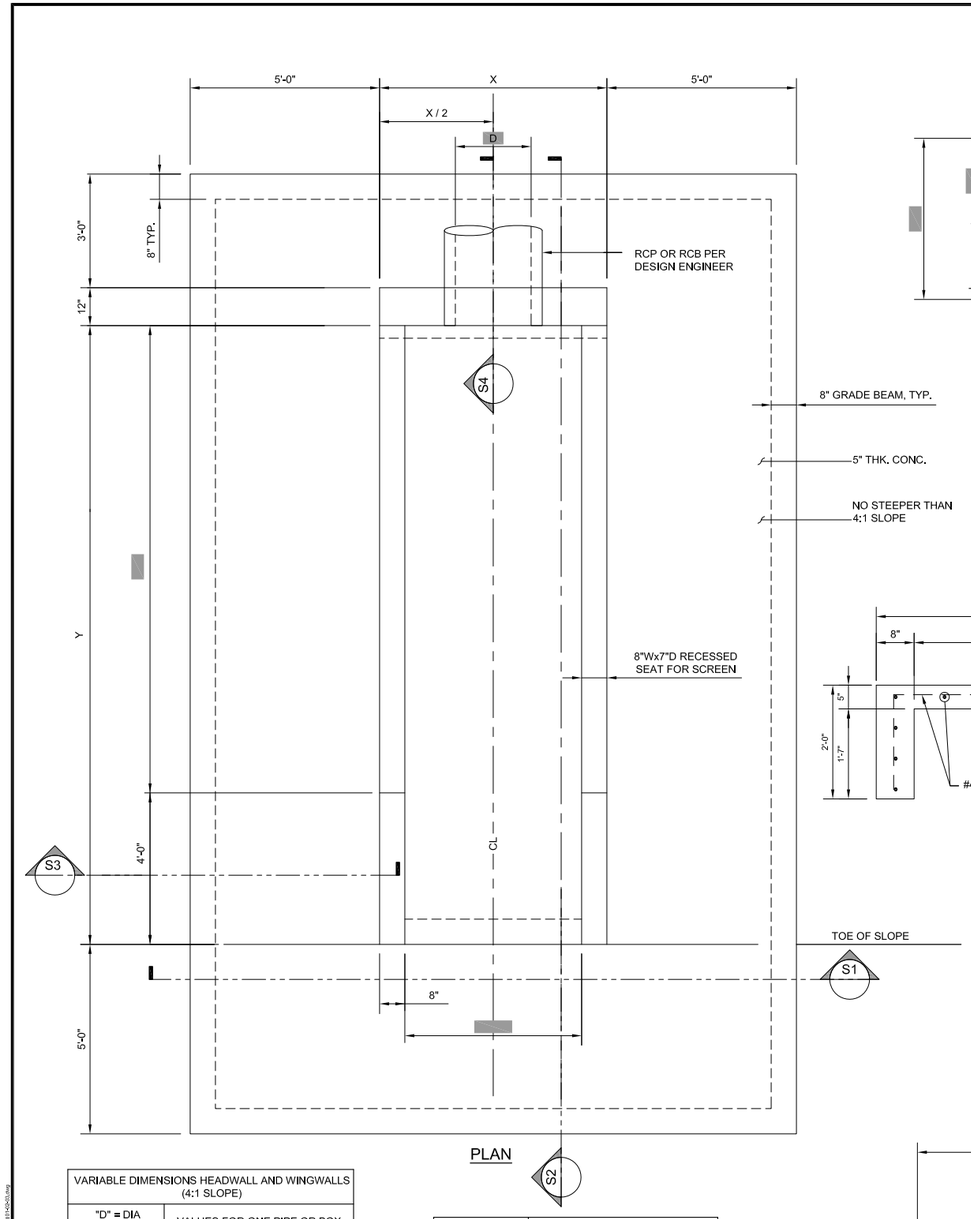
DATE: 6-13-18

SCALE: NTS

SHEET NUMBER

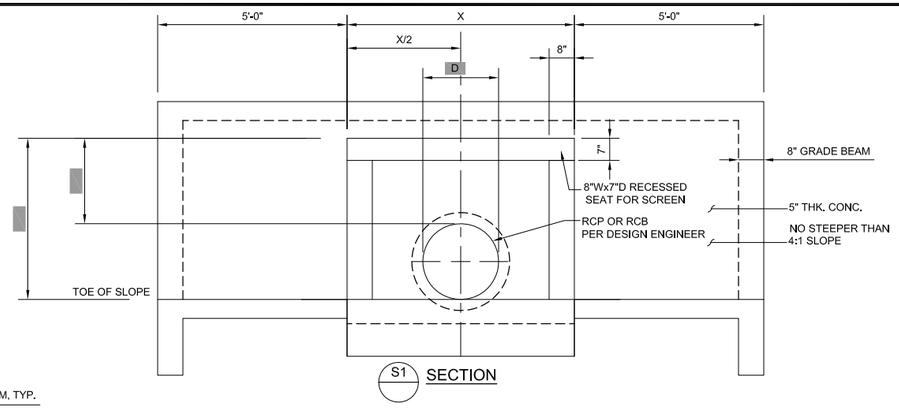
OF

S:\Operations\Engdiv\MEDME Autocad\STANDARD DETAILS PILOT CHANNEL FOR STEVE FI\Stormwater Pollution Prevention Details.dwg

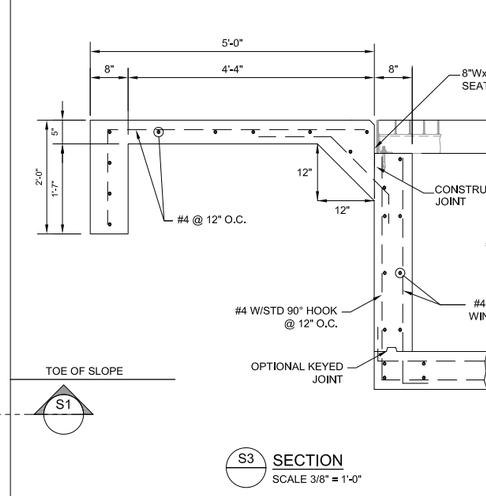


PLAN

S2



S1 SECTION

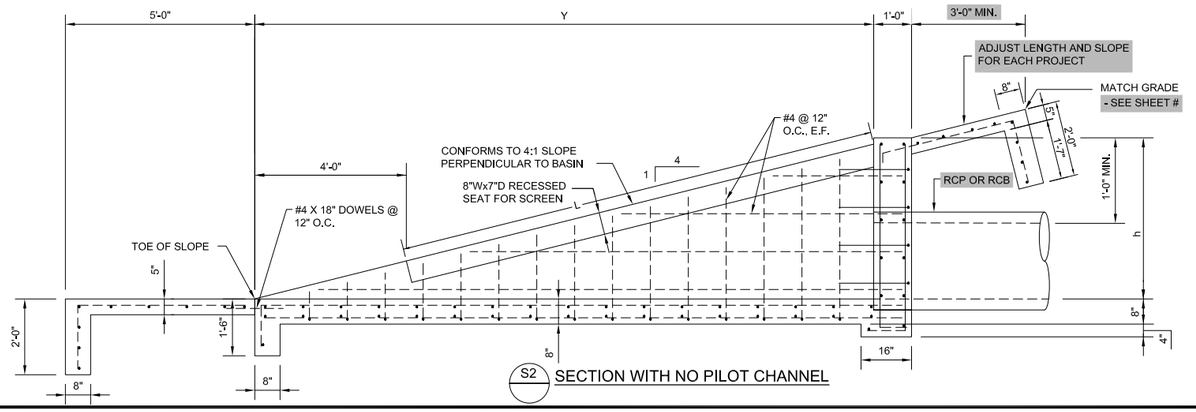


S3 SECTION
SCALE 3/8" = 1'-0"

S4 SECTION
SCALE 3/8" = 1'-0"

VARIABLE DIMENSIONS HEADWALL AND WINGWALLS (4:1 SLOPE)			
"D" = DIA OF PIPE OR BOX SPAN (IN.)	VALUES FOR ONE PIPE OR BOX		
	"X"	"Y"	"h"
24	6'-0"	12'-0"	3'-0"
30	6'-6"	14'-0"	3'-6"
36	7'-0"	16'-0"	4'-0"
42	7'-6"	18'-0"	4'-6"
48	8'-0"	21'-0"	5'-3"
54	8'-6"	23'-0"	5'-9"
36x18	7'-0"	12'-0"	3'-0"
36x24	7'-0"	12'-0"	3'-0"
36x36	7'-0"	16'-0"	4'-0"
48x24	8'-0"	12'-0"	3'-0"
48x36	8'-0"	16'-0"	4'-0"
48x48	8'-0"	21'-0"	5'-3"

RCP OR RCB (IN.)	SCREEN SIZE	
	W = WIDTH	L = LENGTH
24	5'-11"	8'-2"
30	6'-5"	10'-2 1/2"
36	6'-11"	12'-3"
42	7'-5"	14'-4"
48	7'-11"	17'-5"
54	8'-5"	19'-6"
36x18	6'-11"	8'-2"
36x24	6'-11"	8'-2"
36x36	6'-11"	12'-3"
48x24	7'-11"	8'-2"
48x36	7'-11"	12'-3"
48x48	7'-11"	17'-5"



S2 SECTION WITH NO PILOT CHANNEL

BAR SIZE #	MINIMUM LAP - SPLICE & DEVELOPMENT LENGTHS
4	1'-9"
5	2'-2"
6	2'-7"
7	3'-5"
8	4'-6"

NOTES:

1. FOLLOW REQUIREMENTS OF THE LATEST EDITION OF THE STANDARD SPECIFICATIONS BOOK OF THE HARRIS COUNTY FLOOD CONTROL DISTRICT (HCFCD), AS DISCUSSED BELOW.
2. STRUCTURAL EXCAVATION AND BACKFILL SHALL CONFORM TO REQUIREMENTS OF HCFCD SPECIFICATION SECTION 02316. SUBGRADE PREPARATION AND SOIL STABILIZATION SHALL FOLLOW REQUIREMENTS OF APPLICABLE SPECIFICATIONS REFERENCED IN SECTION 02316.
3. CONSTRUCTION OF THE CONCRETE HEADWALL AND WINGWALLS SHALL CONFORM TO REQUIREMENTS OF HCFCD SPECIFICATION SECTION 03310 (CAST-IN-PLACE CONCRETE, CLASSIFICATION: STRUCTURAL). THE REINFORCING STEEL SHALL CONFORM TO REQUIREMENTS OF ASTM A 615 OR ASTM A 775, GRADE 60. SUBMIT SHOP DRAWINGS OF PROPOSED REINFORCING STEEL, IF DIFFERENT FROM THAT SHOWN ON THE AGENCY STANDARD DRAWINGS.
4. CONSTRUCTION OF ACCESS CONCRETE PAVEMENT AROUND CULVERT CHANNEL SHALL ALSO CONFORM TO REQUIREMENTS OF HCFCD SPECIFICATION SECTION 03310 (CAST-IN-PLACE CONCRETE, CLASSIFICATION: STRUCTURAL). THE REINFORCING STEEL SHALL CONFORM TO REQUIREMENTS OF ASTM A 615, GRADE 60.
5. PROVIDE REINFORCED CONCRETE PAVED SURFACE ON ALL SIDES OF CULVERT CHANNEL FOR USE BY MAINTENANCE PERSONNEL.
6. UTILIZE STRUCTURAL DETAILS SHOWN ON SHEET 2 FOR SCREEN HEADWALL AND WINGWALLS OF THE CULVERT CHANNEL.
7. FOR MULTIPLE SCREENS SIDE-BY-SIDE ALONG THE LENGTH OF THE SCREEN, SUBMIT SIGNED AND SEALED DESIGN DRAWINGS TO HCFCD FOR APPROVAL PRIOR TO CONSTRUCTION.
8. SCREEN IS DESIGNED FOR A MAXIMUM TRACTOR WHEEL LOAD OF 3,000 LB. THEREFORE, THE DIMENSIONS SHOWN IN THE ABOVE TABLES SHALL NOT BE EXCEEDED WITHOUT REDESIGN OF THE SCREEN.
9. ALL STRUCTURAL STEEL OF THE SCREEN SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE AISC "STEEL CONSTRUCTION MANUAL", LATEST EDITION.
10. ALL STRUCTURAL STEEL PLATES AND ANGLES USED IN THE SCREEN SHALL CONFORM TO ASTM A36 (MIN. YIELD STRENGTH = 36 KSI).
11. UNLESS NOTED OTHERWISE, ALL BOLTS SHALL CONFORM TO ASTM A325. ALL ANCHOR BOLTS SHALL BE A307 HEX HEAD BOLTS WITH FLAT WASHERS. ALL BOLTS AND WASHERS SHALL BE HOT-DIP GALVANIZED.
12. ALL WELDED STEEL CONNECTIONS SHALL CONFORM TO AWS "STRUCTURAL WELDING CODE-STEEL," D1.1, LATEST EDITION. WELDING ELECTRODE TO BE E70-XX, LOW HYDROGEN. UNLESS NOTES OTHERWISE, USE 3/16" CONTINUOUS FILLET WELD.
13. ALL SCREEN MEMBERS AND SUPPORT STEEL ELEMENTS SHALL BE HOT-DIP GALVANIZED.
14. MAXIMUM SCREEN WIDTH FOR THIS DETAIL IS 8'-5".

P.E. SEAL AND SIGNATURE

ENGINEER - CONFIRM, CHANGE, OR FILL IN.

DRAFT

SCALE: 1/2" = 1'-0" (22"x34")
1/4" = 1'-0" (11"x17")

REV#	DESCRIPTION	DATE	APPR

PROJECT ID#

PROJECT TITLE

FLOATABLES COLLECTION STRUCTURE
DETAIL SHEET 1 OF 3

PREPARED:

CHECKED:

APPROVED:

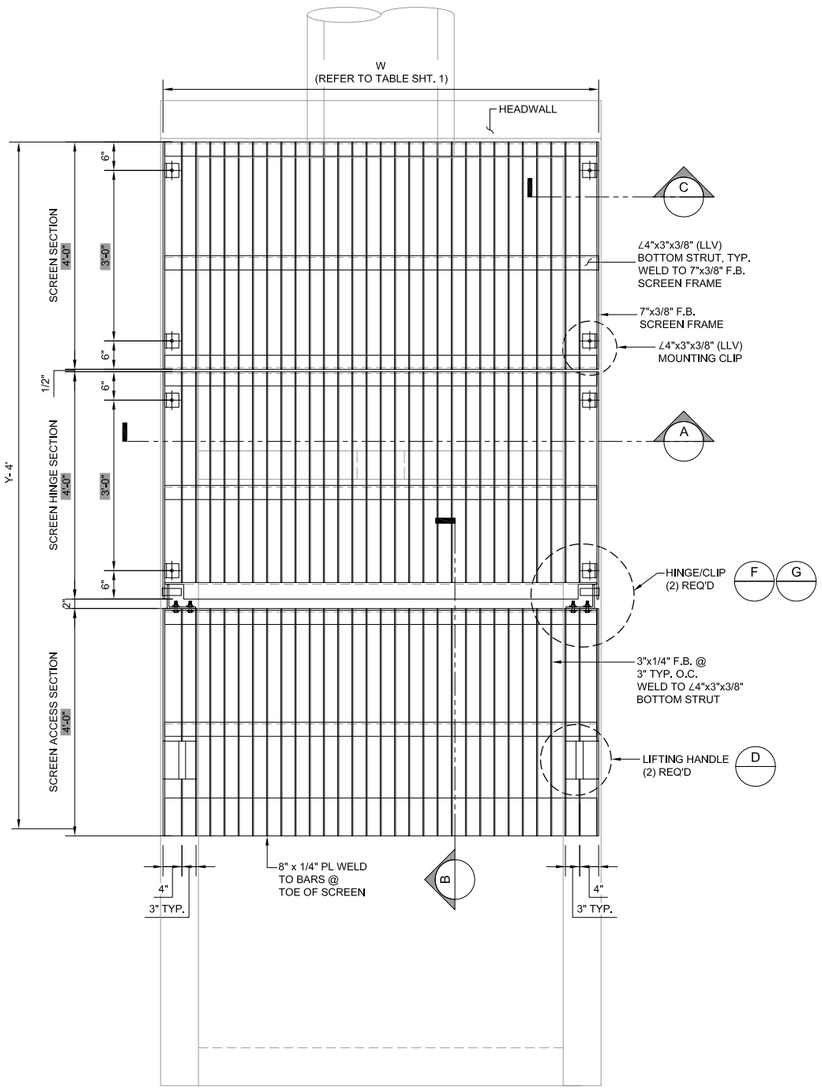
HARRIS COUNTY FLOOD CONTROL DISTRICT

9900 Northwest Freeway
Houston, Texas 77092

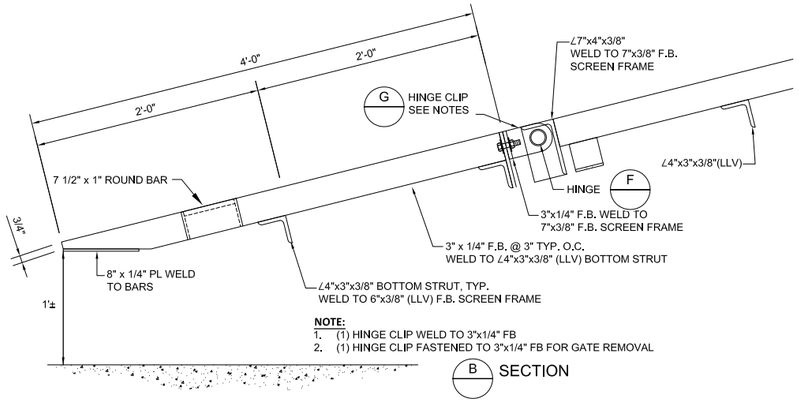
DATE:
7-25-18 DRAFT

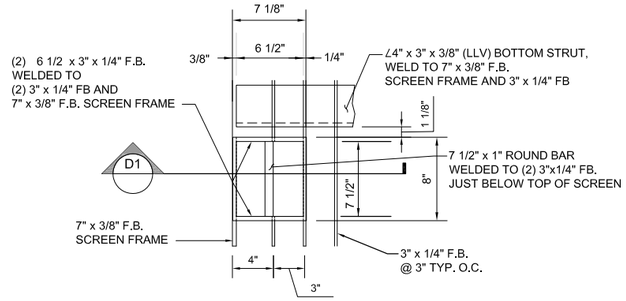
SHEET NUMBER

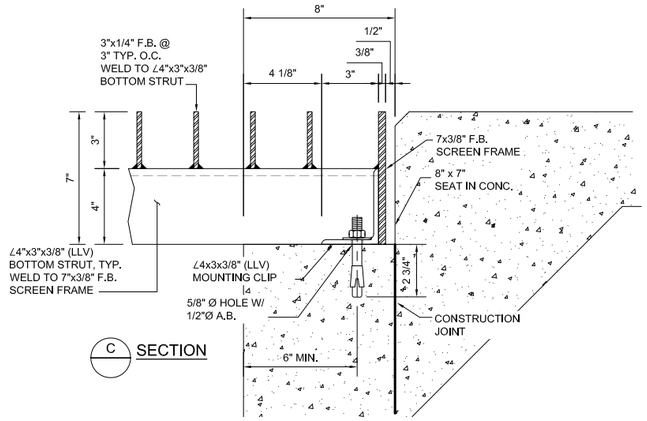
OF

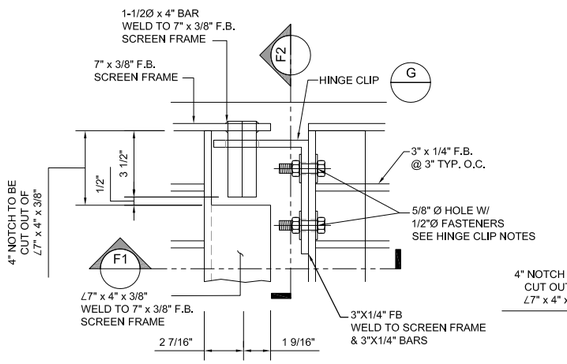


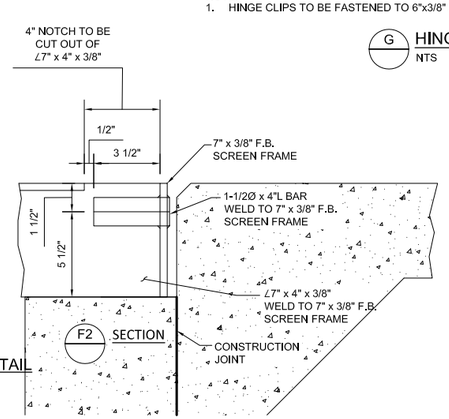
FLOATABLES SCREEN PLAN

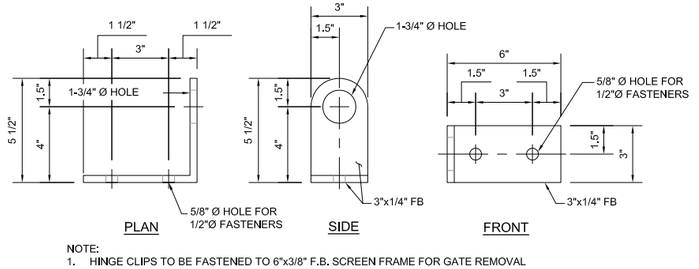


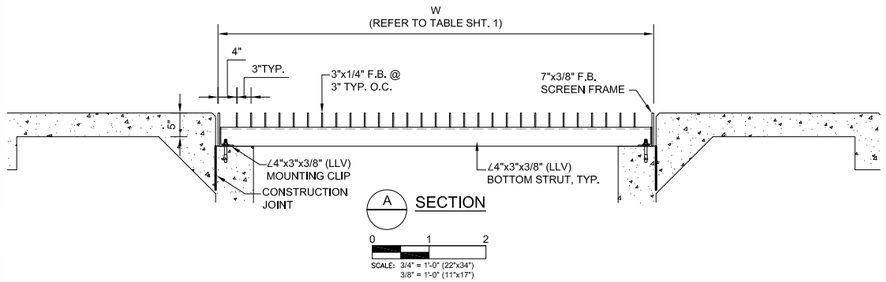












THIS DETAIL SHEET HAS BEEN PREPARED FOR USE ON HCFCD PROJECTS OR PROJECTS TO BE MAINTAINED BY THE HCFCD WHEN COMPLETED BY OTHERS. AN ENGINEER WHO INCORPORATES THE DETAILS ON THIS SHEET BECOMES RESPONSIBLE FOR ITS USE IN THE END PRODUCT IN ACCORDANCE WITH RULE 137.33 (b) AND (c) OF THE TEXAS BOARD OF PROFESSIONAL ENGINEERS.

DRAFT

P.E. SEAL AND SIGNATURE

ENGINEER - CONFIRM, CHANGE, OR FILL IN.

APPR	DATE	DESCRIPTION	REV#

PROJECT ID#

PROJECT TITLE

FLOATABLES COLLECTION STRUCTURE
DETAIL SHEET 2 OF 3

PREPARED: | CHECKED: | APPROVED:

HARRIS COUNTY FLOOD CONTROL DISTRICT
9900 Northwest Freeway
Houston, Texas 77092

DATE:
7-25-18 DRAFT

SHEET NUMBER
OF

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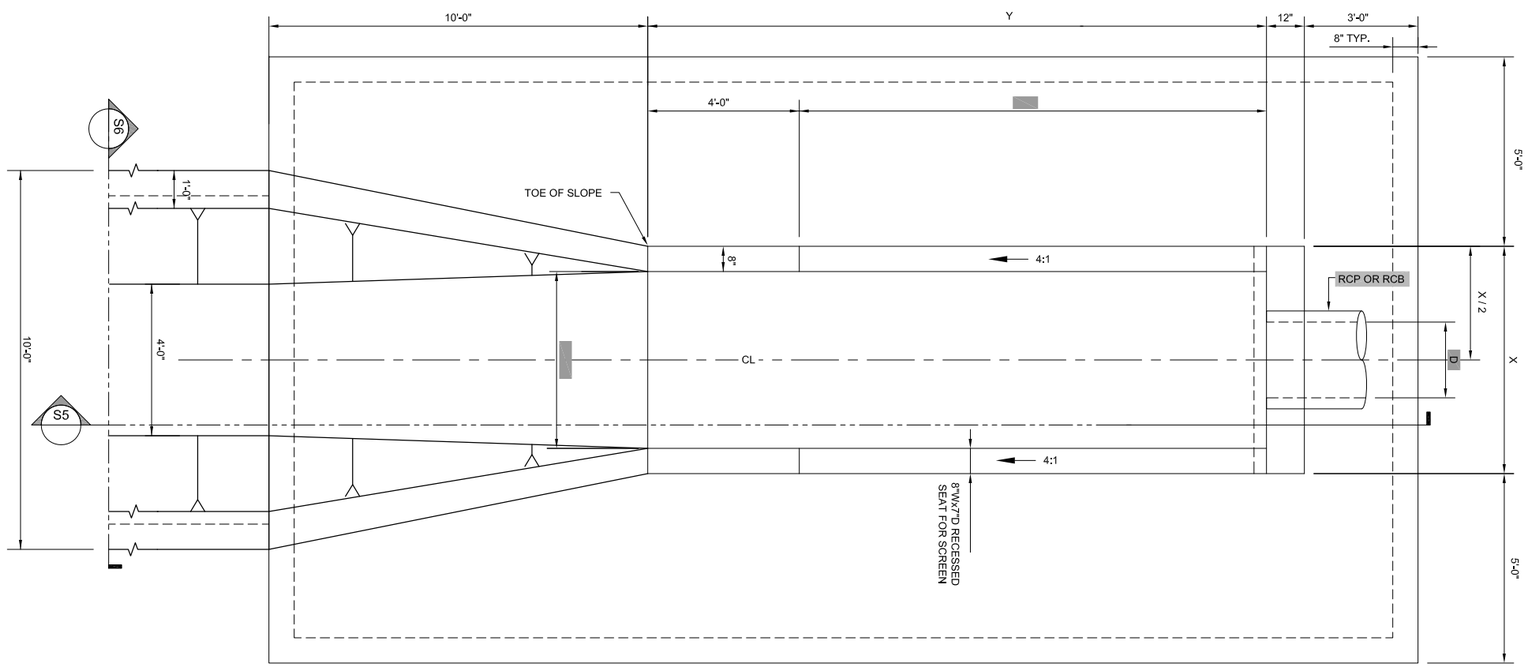
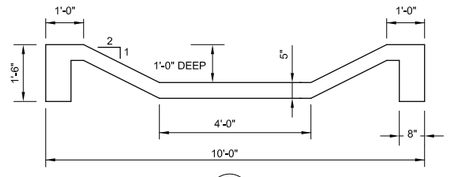
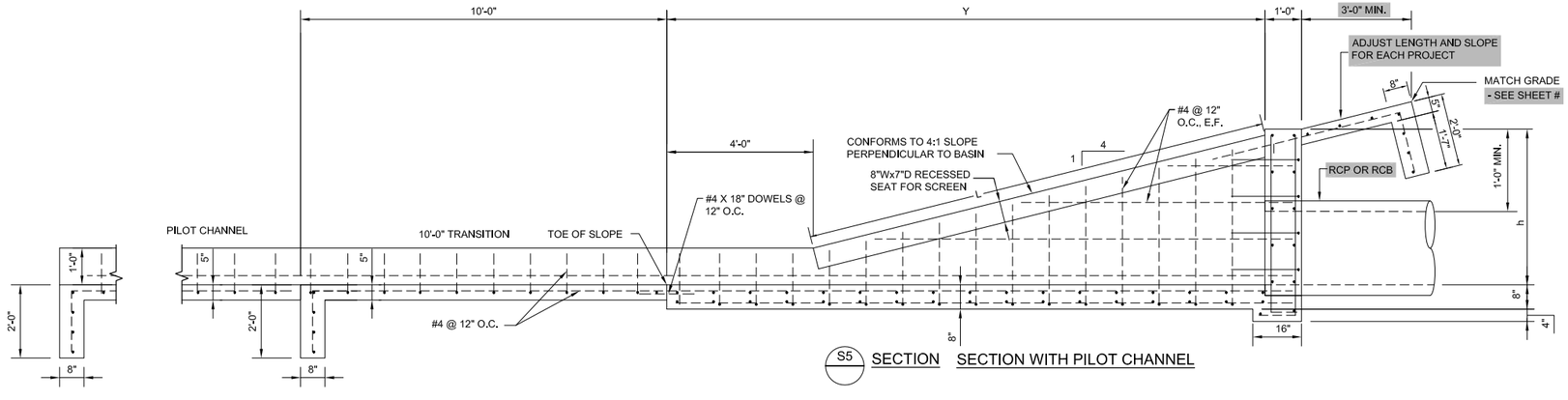


PLAN WITH PILOT CHANNEL



S6 SECTION



S5 SECTION SECTION WITH PILOT CHANNEL

SEE SHEET 1 AND 2 OF 3 FOR DETAILS, DIMENSION TABLES, AND NOTES.

THIS DETAIL SHEET HAS BEEN PREPARED FOR USE ON HCFCD PROJECTS OR PROJECTS TO BE MAINTAINED BY THE HCFCD WHEN COMPLETED BY OTHERS. AN ENGINEER WHO INCORPORATES THE DETAILS ON THIS SHEET BECOMES RESPONSIBLE FOR ITS USE IN THE END PRODUCT IN ACCORDANCE WITH RULE 137.33 (b) AND (c) OF THE TEXAS BOARD OF PROFESSIONAL ENGINEERS.

P.E. SEAL AND SIGNATURE

ENGINEER - CONFIRM, CHANGE, OR FILL IN.

DRAFT

0 2 4
SCALE: 1/2" = 1'-0" (22"x34")
1/4" = 1'-0" (11"x17")

REV#	DESCRIPTION	DATE	APPR

PROJECT ID#

PROJECT TITLE

FLOATABLES COLLECTION STRUCTURE
DETAIL SHEET 3 OF 3

PREPARED: | CHECKED: | APPROVED:

HARRIS COUNTY FLOOD CONTROL DISTRICT
9900 Northwest Freeway
Houston, Texas 77092

DATE:
7-25-18 DRAFT

SHEET NUMBER
OF

S:\Standard Drgs\MEW\ Autocad\Standards\ DETAILS FILES\ DWGS\ FOR REVIEW\Floatables Collection Structure Detail 07-25-18.dwg