1.0 Introduction

- ***Transition plan.*** A transition plan is provided.

2.0 Hydrology

- ***Hydrological model.*** HEC-HMS (version 3.0.1 or newer) shall be used instead of HEC-1.
- ***Runoff hydrograph methods.*** Drainage Area-Discharge curves for 0% impervious have been removed. Malcom's method shall be used only for small watersheds (not requiring downstream impacts analysis) with drainage areas < 640 acres.
- ***24 hour design storm rainfall.*** Intensity position of hyetograph will be offset by 67% in HEC-HMS if either the watershed is shared with Harris County or there is no existing model.
- ***Detention analysis.*** Detention analysis shall be done using the simple method for drainage areas ≤ 50 acres and HEC-HMS for larger areas.

3.0 Open Channel Hydraulics

- ***Hydraulic model.*** HEC-RAS (version 3.1.3 or newer) shall be used instead of HEC-2.
- ***Unsteady option in HEC-RAS.*** Unsteady option in HEC-RAS shall be allowed under certain conditions, such as when slopes are very flat.
- ***Frequency analysis.*** Analysis shall be done for 10% (10yr), 4% (25yr) and 1% (100yr) events.
- ***Channel design frequency.*** Open channels shall be designed to contain the runoff from the 100-yr frequency, 24-hr duration storm within the channel banks.
- ***Level of protection and freeboard.*** Channels shall be designed to have at least a 1% level of protection including 1ft of freeboard. All proposed structures shall have a finished floor elevation at least 1.5ft above BFE.
- ***No adverse impact.*** There shall be no increase in flow or WSEL at any node in models.
- ***Floodway analysis.*** Floodway analysis is required when changes are made to hydraulic models studied by FEMA.
- ***Floodplain management policies.*** No development in floodways is allowed which will result in an increase in BFE.
- ***Mitigation of floodplain fill.*** Any fill in the floodplain that decreases the conveyance of the stream shall be offset with a hydraulically equivalent mitigation volume. Fill in approximate zones (Zone A) shall be mitigated on a 1:1 basis.
- ***Channel location.*** Channels shall be located at a sufficient distance from existing and proposed infrastructure.
- ***Channel erosion protection.*** Where channels cross under roadways, adequate slope stabilization and erosion control measures shall be provided.
- ***Grass lined channels.*** Side slopes of grass lined channel shall not be steeper than 4:1(H:V).
- ***Concrete-lined channels.*** Side-slopes of concrete lined channel shall not be steeper than 2:1(H:V) and shall ensure inclusion of escape stairways. Slope protection on side-slopes shall be at least 5" thick.
- ***Riprap.*** The use of riprap as a channel lining has been removed.
- ***Back-slope drainage systems.*** The drain structure and swale centerline shall be 6 ft inside the channel ROW line. Swale side slopes should not be steeper than 3:1(H: V).
- ***Sloped drops.*** Sloped drops shall not be steeper than 3:1(H: V).
- ***Gradually varied flow.*** HEC-RAS shall be used to obtain flow profiles.
- ***Bends.*** Description of parameters in bend loss formula is added.
- ***Bridges.*** Bridge modeling in HEC-RAS is recommended. Additional information on HEC-RAS analysis of bridges and culverts shall be obtained from the hydraulic reference manual.
- ***ROW.*** New development shall provide the ultimate planned right-of-way width based on fully developed watershed. Fully developed watershed means undetained developed flows from the watershed with future conditions based on existing development patterns in the area.

4.0 Bridge / Culvert hydraulics

- **Design frequency.** Bridges shall be designed for 1% (100-year) and 10% (10-year) storms without causing adverse impacts or erosion problems in the channel or detention basin.
- **New bridges.** For new bridges, the low chord at the center of the bridge shall be set at least 1.5ft above either the existing or the ultimate 1% AEP water surface elevation, whichever is higher.
- **Replacing old bridges.** The low chord elevation and cross-sectional area of the bridge opening for a new bridge shall equal or exceed that of the old bridge; otherwise coordination with FBCDD is required.
- **Guardrails.** When rails or other structural members obstruct an access or maintenance easement, a minimum 15' of additional easement will be provided within the area obstructed.
- **Bridge design program.** HEC-RAS (version 3.1.3 or newer) shall be used.

5.0 Storm Sewers and Overland Flow

- **Downstream impact consideration.** Developments shall not be allowed to increase flows into the receiving channel, ditch or drainage system without the approval of the FBCDD.
- **Grading.** Grading of the development or lots shall conform to the plans for the development or project. Grading shall be done from back of the lots to the front or to its designated drainage system. If grading of the rear lots is performed to drain into an adjacent channel (through the backslope interceptor system), that amount of the back of the lot draining to the channel shall be minimized and coordinated with the FBCDD to avoid steep fill or embankment at the right-of-way.
- **Storm sewer design flow.** To obtain the design storm peak flow, the Rational Method shall be used for drainage areas less than 200 acres. Drainage Area – Discharge curves and HEC-HMS shall be used for larger drainage areas.
- **Storm sewer design.** No more than one storm sewer outfall shall be designed per 1000 feet of channel or one per smaller tract shall be used at each side of the receiving channel, detention or waterway.
- **Erosion protection features.** All storm sewers that outfall into ditches, channels, streams or detention ponds shall include erosion protection features.
- **Polymer coatings.** Polymer coatings shall be used in lieu of asphalt coatings.
- **Details and Specifications.** All pre-cast concrete pipe storm sewers, bedding, and inlets shall conform to Fort Bend County standards and details.
- **Street drainage of storm sewer overflow.** Extreme event swales are added as a key component of conveyance systems.
- **Maximum allowable ponding.** The maximum allowable ponding level for a new street is the lowest of 12" above natural ground, 12" above top of curb, or 12" below the lowest slab elevation.
- **Surface swale for extreme event flows.** The extreme event swale within the ROW of detention ponds and outfall channels shall have a minimum 6 ft bottom width and the side-slopes shall not be steeper than 6:1 (H:V). Interlocking blocks or slope paving shall be used as erosion protection measures.
- **Ditch capacity.** Developments that drain to roadside ditches are only allocated their pro-rata share of the existing ditch capacity.
- **Design criteria.** Computations shall include the effect of future driveway culverts sized according to the design flow and ditch depth. The computed WSEL of the ditches shall be a minimum of 0.5 ft below finished grade along the street edge of pavement.

6.0 Storm Runoff Storage

- *Master plans.* If a master plan is not available for a watershed, localized master planning information related to project location within the watershed shall be developed by coordination with the FBCDD.
- *For drainage area > 640 acres.* HEC-HMS shall be used in place of HEC-1.
- *Impacts.* There shall be no increase in peak flow and WSEL at any point along the channel using HEC-HMS and HEC-RAS.
- *Design tail-water depth.* Detention evaluated using computer models shall use a variable tail-water stage hydrograph based on the frequency storm being analyzed. The variable tail-water stage hydrograph can be developed using the rating curve and flow hydrograph at the tail-water location.
- *Release rates and maximum allowable discharge.* For drainage areas < 50 acres, the maximum release rate shall be calculated with the tailwater at the top of the downstream end of the outfall pipe. When outfalling into a roadside ditch, the release rate shall be limited to the proposed developments pro-rata share of the bank full capacity of the receiving ditch. While using the simplified method, maximum release rate of 0.125 cfs/ac can be used.
- *Downstream impact analysis.* Analysis using HEC-HMS and HEC-RAS shall be done through the entire downstream channel section for the 10, 25 and 100 yr events, which shall not have any increase in peak flow rates. If the outfall channel has less than a 10-yr storm capacity, the analysis shall also be done for the 2-year event.
- *Final sizing of pond storage and outflow structure.* Detention basins and storm sewer outfalls shall be placed 1 foot above the flow-line of the downstream receiving channel, creek, or detention pond. The minimum recommended outflow pipe diameter for a detention facility is 24". A minimum of 18" outflow pipe may used when out-falling into county roadside ditches with 1-ft of stabilized sand around the pipe. Outflow pipes shall include a restrictor (outside FBCDD ROW) for compliance with the allowable release rate.
- *Erosion controls* The erosion protection shall include adequately designed concrete slope paving, erosion control blocks or paving sections. Owner of the facility shall make appropriate repairs/corrections to the design or construction to fix any erosion problems, when observed.
- *Multipurpose land use.*
  Parking lots may be used as part of the detention system. The maximum depth of water over the inlet in parking lots shall not exceed 9" and the maximum depth in the parking stall shall not exceed 6".
  Underground detention, wet detention basins, walking paths or jogging trails (minimum of 8 ft wide) and other amenities can also be designed with adequate design consideration upon approval by FBCDD.
- *Maintenance.* Each development with detention shall make provisions for adequate future maintenance in accordance with the original design. A 30ft wide access and maintenance easement shall be provided and reasonable provision shall be made to ensure unblocked access.
- *Storm water quality (SWQ).* FBCDD encourages the use of SWQ Best Management Practices (BMPs).
- *Low impact development (LID).* FBCDD encourages using the LID features.

7.0 Leveed Areas

- **Design requirements.** All levees should be designed in accordance with the U.S. Army Corps of Engineers (COE) Engineer Manual EM 1110-2-1913 (30 April 2000, or most current edition).
- **FEMA requirements.** The FEMA requirements shall be met. The minimum levee height requirement is one foot above the FEMA minimum.
- **Design details.** Pipes through levees shall have antiseepage designs, flap gates, and slope protection.
- **Pump station.** Levees along the Brazos River shall be analyzed independently (coincidental events, criteria 7.3.1.1) and all other levees shall be analyzed dependently (same events, criteria 7.3.1.2). The Brazos River profiles for performing this analysis have been updated to the profiles included in the preliminary hydraulic release from FEMA.

8.0 Drainage Design Criteria for Rural Subdivisions

- **Grading.** Other than lot line swales and building pads, lots shall not be significantly graded.
- **Design criteria and submittals.** The minimum slab elevation shall be 18" above the 100-yr floodplain elevation, at least 2ft above natural ground, or 1ft above the crown of any down-gradient roadway, whichever is higher.
- **Newly added sections.**
  Technical analysis of detention requirements for rural subdivisions
  Analysis of runoff volume
  Analysis of runoff rate
  Determination of required detention