DICKINSON BAYOU WATERSHED STEERING COMMITTEE

FINAL MEMBER
CRITERIA COMPARISON

JKC & Associates, Inc.

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INTRODUCTION

The Dickinson Bayou Watershed covers approximately 95.5 square miles and stretches from western Brazoria County to Galveston Bay in eastern Galveston County as shown in Figure 1, "Dickinson Bayou Watershed Map." This watershed contains part of the several jurisdictional entities within its boundaries including:

- Brazoria County,
- Brazoria County Conservation & Reclamation No. 3,
- Brazoria County Drainage District No. 4,
- City of Manvel,
- City of Alvin,
- Galveston County,
- Galveston County Consolidated Drainage District,
- Galveston County Drainage District No. 1,
- Galveston County Drainage District No. 2,
- City of Friendswood,
- City of League City,
- City of Santa Fe,
- City of Dickinson, and
- City of Texas City

Dickinson Bayou is extremely important to the local communities as this natural resource provides both recreational opportunities and drainage outlets for its citizens. Because of the Bayou's importance to local drainage, the entities within its watershed recognized the need for inter-local cooperation in establishing complimentary drainage management practices. To further this end, several of these entities established the Dickinson Bayou Watershed Steering Committee in the late 1980's and took on the task of studying and documenting the hydraulic characteristics of the watershed.

After completing the hydraulic study and publishing its results in the mid 1990's, the Steering Committee ceased meeting regularly until 2005 when several of these entities re-affirmed their commitment to the Committee and re-issued their inter-local agreements to work together. Upon re-organizing this committee, the members mutually agreed that the most efficient and effective administration of the common good could occur if each member understood the practices of the other members. Accordingly, the Dickinson Bayou Watershed Steering Committee retained the services of JKC & Associates, Inc. (JKC) to review and compare the individual storm drainage design criteria for each member of the Steering Committee, and this report summarizes this effort.

REVIEW PROCESS

JKC received and reviewed the current drainage design criteria, master drainage plans and floodplain management ordinances from each member entity (collectively referred to as design criteria) and compared the following characteristics of each:

1. Individual regulatory requirements,
2. Required design storm frequencies,
3. Approved calculation methods, and
4. Minimum structural design standards.

The member design criteria were remarkably similar for many of the entities, and for the sake of this comparison, JKC limited most discussion to major areas where there was some variability of requirement. The following discussion covers this comparison which is further summarized in Table 2, "Member Criteria Comparison."

Many of the members use common design criteria where there is jurisdictional overlap (i.e., Brazoria County and Brazoria C&R 3), and others have chosen to create and implement separate criteria even where there is common jurisdiction (i.e., Galveston Co. Consolidated Drainage District and City of Friendswood). The member entities included in this comparison and their respective design criteria include:

Table 1
Member Entities & Design Criteria

Member Entity	Design Criteria
Galveston County Consolidated Drainage District	"Galveston County Consolidated Drainage District, Drainage Criteria Manual" Jan 13, 2004
City of Friendswood	"City of Friendswood Community Development & Public Works Design Criteria Manual" Jan, 2005
Brazoria County & Brazoria Conservation and Reclamation No. 3	"Final Brazoria County Drainage Criteria Manual" Nov, 2003
City of Alvin	"City of Alvin Subdivision & Property Development Manual" Feb 6, 2006
City of League City	"General Design & Construction Standards City of League City" 1998 & "Master Drainage Plan, City of League City" June, 1990
Galveston County, Galveston County Drainage District No. 2, City of Dickinson, & City of Texas City	"Galveston County Standards for Subdivisions" Mar 3, 1997 & "Dickinson Bayou Drainage Criteria Manual" 1992
Brazoria County Drainage District No. 4	"Rules, Regulations and Guidelines, Brazoria Drainage District No. 4" Aug 1, 2004
Galveston County Drainage District No. 1 & City of Santa Fe	"Galveston County Drainage District No. 1 Criteria Manual" June 2005

REGULATORY REQUIREMENTS

The first comparisons dealt with the regulatory requirements from each entity including what submittals are required, is detention required, are pumped detention and drainage systems allowed, and is regional (i.e., off-site) detention allowed.

Submittal Requirements
The specific submittals required by each entity varied slightly between members from those requiring preliminary and final drainage plans and plats to those just requiring final drainage plans and plats.

Detention Requirements
As shown in Table 2, each entity requires detention to offset effects of new development within the Dickinson Bayou watershed. This column was included in the comparison because not all entities require detention throughout their service areas, but all uniformly require detention within the Dickinson Bayou watershed.

Pumped Systems
The general topography of the watershed surface is extremely flat and drainage gradients are small. A consequence is that much of the watershed is served by relatively shallow surface ditches, and development in these areas are extremely restricted by the available depth in adjacent drainage facilities. Pumped systems allow for development to occur in these depth restricted areas, but the pump systems themselves require on-going care and maintenance to work properly. Because of this continuing requirement for maintenance, several entities have chosen to disallow pumped systems altogether.

Regional Detention
Recognizing the significant burden for providing on-site detention on smaller sites, many entities have allowed for participation in regional detention facilities, assuming the developments meet certain qualifying characteristics. The “Regional Detention Allowed” column in Table 2 shows which entities will specifically allow for regional detention in their criteria. However, of all the entities that do allow regional detention, only one (Brazoria Co. C&R 3) is actively developing regional detention in the Dickinson Bayou watershed.

DESIGN STORM FREQUENCIES

Each of the member design criteria specify the minimum storm return intervals for use in designing specific improvements. The following paragraphs contain summaries of the requirements for detention facilities, storm sewers and road culverts.

Detention Facilities
There was unanimous consensus that detention facilities should be designed to accommodate flows from the 100-year design event. Additionally, for those members

who routinely construct and maintain large open ditches (i.e., the county and drainage district members) the main channels are to be designed for 100-year events.

Storm Sewers
The design requirements for sizing of storm sewer pipes varied across members from 2-year to 5-year storms.

Road Culverts
In cases where open ditches cross roadways, the design storm requirements varied greatly among member entities. Some members have minimum sizes for all circumstances that varied from 2-year to 5-year return intervals. The remaining members require the culvert design to be based upon the size of the upstream drainage basin; so that culverts serving small areas would be sized for fairly frequent events (i.e., 5-year) and those serving large areas would be designed to convey up to the 100-year event.

CALCULATION METHODS

As stated earlier, all member entities require detention to off-set negative impacts attributable to new development in the Dickinson Bayou watershed. This section of the member criteria summary covers how each entity quantifies this hydraulic impact and the resulting detention storage required to negate that impact. A hydraulic impact evaluation requires quantifying critical site-specific parameters including time of concentration of the site, design storm intensity, peak runoff rates, and required detention volume.

Time of Concentration
The time of concentration of a project site is defined as the time it takes a drop of water to travel from the most hydraulically remote portion of the site to its outfall. The time of concentration is dependent upon the size and shape of the site, the relative impermeability of the surface, the slope of the surface, and the extent and efficiency of the drainage infrastructure (i.e., surface ditches, storm sewers, etc.). Every member criteria included a method of estimating the time of concentration using an overland flow model. This method includes the following steps:

1. Determine the runoff travel path from the most remote location to the outfall;
2. Divide this travel path into its constituent flow domains [i.e., overland flow across a lawn, flow in street gutter, flow in a storm sewer, etc.];
3. Determine the length of flow in each domain [L_i in feet];
4. Determine the average velocity of flow in each domain [V_i in feet/minute];
5. Determine the time a drop of water would spend in each flow domain [L_i/V_i in minutes];
6. Sum the individual flow times [$\Sigma(L_i/V_i)$ in minutes]; and
7. Add a constant to account for initial delay for the system to begin producing runoff.

This Overland Flow Method takes the following mathematical form:

$$Tc = \sum_{i=1}^{n} (Li / Vi) + C$$

There are some minor variations in the actual application of this methodology between member criteria including the value of the initial delay constant (C) which ranges from 0 minutes in Brazoria Co. and Galveston Co. criteria to 15 minutes in Brazoria DD #4 criteria. League City criteria has simplified this further by making some generalized assumptions and producing a time of concentration graph from which appropriate values could be read directly.

Most of the member criteria contain typical values for average velocity given surface cover, slope, channel or pipe characteristics, etc., so this is a fairly simple method to apply. The only constraint to the application of this method includes the validity of the simplifying assumptions that flow is actually best described as overland in nature.

Additionally, two of the member criteria provide an alternate empirical to estimate time of concentration. This method estimates time of concentration directly for the size of the drainage basin (A in acres) and takes the following form:

$$Tc = 10 * A^{0.1761} + 15$$

Note that this method will underestimate the time of concentration when applied to sites where overland flow is predominate, so care should be used in applying this alternate method.

<u>Storm Intensity</u>

The design storm intensity is estimated for the specific site based upon the time of concentration and the desired storm return interval (I in inches/hour). Alternate methods for determining storm intensity include a graphical Intensity-Duration-Frequency Curves (I-D-F Curve) and a direct calculation from an empirical equation in the form:

$$I = \frac{b}{(Tc + d)^e}$$

Those entities that allow the direct calculation method also provide the appropriate region specific values of b, d and e for use for various storm return intervals.

Peak Runoff
To determine an appropriate peak runoff, the industry standard is to apply the Rational Method equation in the form:

$$Q = Cf * C * I * A$$

This method is usually restricted to smaller basins where flow is typically overland, and there is not significant channelization of flow (usually restricted to sites between 100 to 200 acres or smaller). In the member criteria, appropriate values for C_f and C are given.

A few member criteria had sufficient historical rainfall runoff data, or adequate hydrologic/hydraulic models, that they could provide simplifying Drainage Area Curves which depict runoff peaks for a range of basin sizes under different levels of development. These graphs usually span basins that range from hundreds of acres to several thousands of acres.

Finally, for large basins (typically defined as greater than 100 or 200 acres), each member criteria requires determination of peak runoff values using the Corps of Engineer's HEC-1 or HEC-HMS model.

Detention Sizing
Most criteria attempt to give the developer some flexibility in selection of method for use in determining detention facility sizing based upon the relative size of the project. Generally, the options available include:

Small Projects

- The Coefficient Method includes applications where volume is calculated as the product of a specified constant and the project area. The coefficient used varies across member entities between 0.45 and 0.65, and the project area is in units of acres. This method is restricted to projects with a maximum of 2 to 5 acres.
- The Modified Rational Method includes application of a computer program and is restricted to sites of 1 to 2 acres or less where allowed.
- Brazoria County criteria includes an empirical method that determines storage volume as a product of the square root of the percent impervious and the total area of the site. This methodology is reserved for sites with less than 50 acres.

Medium Projects

- The Triangular Hydrograph Method uses simplified triangular shaped hydrographs of the pre-developed and post-developed conditions to calculate required detention. This method is subject to the constraints of the Rational Method, so it has a validity for sites smaller than 100 to 200 acres.
- The Small Watershed Method uses more realistic (but still synthetic) hydrographs of the pre-developed and post-developed conditions to calculate required detention. This method is also subject to the constraints of the Rational Method, so it has a validity for sites smaller than 100 to 200 acres.

Large Projects

- All the member design criteria evaluated require the use of the Corps of Engineer's HEC-1 or HEC-HMS models for large projects. The definition of "large project" varies from about 100 to 200 acres and up.

MINIMUM STRUCTURAL DESIGN STANDARDS

Each of the member design criteria specified the minimum structural requirements for proposed drainage facilities. The following paragraphs contain summaries of the requirements for maintenance berms, freeboard, bank side slopes and minimum elevations for structural slabs.

Maintenance Berms
Most members have requirements to provide a minimum maintenance area adjacent to drainage ditches and detention facilities that vary from 15 feet to 30 feet. More than half of the members require a variable berm width that depends upon the depth and/or width of the adjacent drainage facility.

Freeboard
Freeboard is the additional storage or conveyance required in the design of new drainage facilities to provide an extra level of certainty that the facilities will perform as required, especially when actual conditions do not match those of the design assumptions. Not all members require this "factor-of-safety," but those that do usually require an additional 4" to 12" of space between the calculated 100-year water surface elevation and the top of bank of the drainage facility. The actual freeboard requirement depends upon the relative size of the proposed drainage facility in many of the member criteria.

Bank Side Slopes
The design requirements for side slopes on ditches and detention facilities varied between 3:1 to 4:1 for all entities. Many entities would allow a steeper slope if the steeper slopes are stabilized with adequate surface erosion control and bank stabilization measures (i.e., concrete slope paving, interlocking block pavement, retaining walls, etc.).

Minimum Slab Elevations
In addition to the safety factors provided by the freeboard, many members require a minimum slab elevation in relation to the base flood elevation (BFE), the elevation of the adjacent natural ground (NG), and the elevation of any down-gradient roads (road centerline for open-ditch roadways or top of curb for curb-and-gutter streets). Generally, developers are required to set slabs to minimum elevations that are between 1 and 2 feet above the BFE, NG or the adjacent road, whichever is higher. Those members that do not have a minimum slab elevation requirements overlap other jurisdictions that do have an elevation requirement, so effectively there are minimum standards throughout the Dickinson Bayou watershed.

SUMMARY

The results of the preceding comparisons are shown in Table 2, "Dickinson Bayou Watershed Member Criteria Comparison." In most cases, member requirements were remarkably similar. In instances where criteria differed, the differences were usually not major in nature. In summary, JKC did not find criteria from any entity that was in such conflict with those of neighboring entities to cause operational or managerial issues for the members or for the regulated public.

TABLE 2

DICKINSON BAYOU WATERSHED STEERING COMMITTEE

Final Member Criteria Comparison

Date: May 25, 2006

		Regulatory Requirements				Design Storm Frequencies			Calculation Methods				Minimum Structural Design Standards			
Entity	Criteria	Submittal Requirements	Detention Required	Pump Systems Allowed	Regional Detention Allowed/Available	Detention Facilities	Storm Sewers	Road Culverts	Time of Concentration	Storm Intensity	Peak Runoff	Detention Sizing	Maintenance Berm Width	Freeboard Requirement	Side Slopes	Minimum Slab Elevations
Galveston Co. Consolidated Drainage District	"Galveston Co. Consolidated Drainage District, Drainage Criteria Manual," Jan 13, 2004.	Preliminary & Final Drainage Plan and Plat	yes	no	yes / no	100-yr	5-yr	5-yr to 100-yr	Σ(Li/Vi) + 10	I-D-F Graph	Rational Method & HEC-1/HEC-HMS	Coefficient Method, Modified Rational, Triangular Hydrograph, Small Watershed Method, & HEC-1/HEC-HMS	15' to 30' or 10' private	4" (< 1 ac) or 12" (> 1 ac)	4:1	Not Addressed
City of Friendswood	"City of Friendswood Community Development & Public Works Design Criteria Manual," Jan, 2005.	Preliminary & Final Drainage Plan and Plat	yes	no	yes / no	100-yr	5-yr	25-yr to 100-yr	Σ(Li/Vi) + 10	Empirical Equation	Rational Method & HEC-1/HEC-HMS	Coefficient Method, Modified Rational, Triangular Hydrograph, Small Watershed Method, & HEC-1/HEC-HMS	Not Addressed	4" (< 1 ac) or 12" (> 1 ac)	4:1	Highest of: 24" above BFE, 24" above NG, or 18" above road
Brazoria County & Brazoria Conservation & Reclamation No. 3	"Final Brazoria County Drainage Criteria Manual," Nov, 2003.	Preliminary & Final Drainage Plan and Plat	yes	yes	yes / yes	100-yr	5-yr	25-yr	Σ(Li/Vi)	I-D-F Graph & Empirical Equation	Rational Method, Drainage Area Curves, & HEC-1/HEC-HMS	Empirical Method, Graphical Method (rural res), & HEC-1/HEC-HMS	15' to 30'	12"	4:1	Highest of: 24" above BFE, 24" above NG, or 12" above road
City of Alvin	"City of Alvin Subdivision & Property Development Manual," Feb 6, 2006	Preliminary & Final Drainage Plan and Plat	yes	yes	yes / yes	100-yr	5-yr	5-yr	Σ(Li/Vi) + 10	Empirical Equation	Rational Method & HEC-1/HEC-HMS	Coefficient Method, Empirical Method, Modified Rational, Small Watershed Method, Triangular Hydrograph & HEC-1/HEC-HMS	20'	12"	3:1	12" above BFE
City of League City	"General Design & Construction Standards, City of League City" 1998. "Master Drainage Plan, City of League City," June, 1990.	Preliminary & Final Plat, & Drainage Plan	yes	yes	Not Addressed	100-yr	3-yr	5-yr	Graphical Method	I-D-F Graph	Rational Method, Drainage Area Curves, & HEC-1/HEC-HMS	Coefficient Method, Small Watershed Method, & HEC-1/HEC-HMS	20'	Not Addressed	3:1	18" above BFE
Galveston County, City of Dickinson, Gal Co. DD No. 2, & City of Texas City	"Galveston Co. Standards for Subdivisions," March 3, 1997 "Dickinson Bayou Drainage Criteria Manual" 1992.	Preliminary & Final Drainage Plan and Plat	yes	yes	yes / no	100-yr	2-yr	2-yr	Σ(Li/Vi) & 10*A^0.1761+15	I-D-F Graph & Empirical Equation	Rational Method, Drainage Area Curves, & HEC-1/HEC-HMS	Coefficient Method, Triangular Hydrograph, & HEC-1/HEC-HMS	15' to 30'	Not Addressed	3:1	Highest of: BFE, or 18" above road
Brazoria Co. Drainage District No. 4	"Rules, Regulations and Guidelines Brazoria Drainage District No. 4," Aug 1, 2004.	Preliminary & Final Drainage Plan and Plat	yes	no	yes / no	100-yr	Not Addressed	Not Addressed	Σ(Li/Vi) + 10 or Σ(Li/Vi) + 15	I-D-F Graph	Rational Method & HEC-1/HEC-HMS	Coefficient Method, Small Watershed Method, & HEC-1/HEC-HMS	10' to 30'	12"	4:1	Not Addressed
Galveston Co. Drainage District No. 1 & City of Santa Fe	"Galveston Co. Drainage District No. 1 Criteria Manual," June 2005.	Final Drainage Plan and Plat	yes	Not Addressed	yes / no	100-yr	3-yr	5-yr to 50-yr	Σ(Li/Vi) + 10 & 10*A^0.1761+15	Empirical Equation	Rational Method & HEC-1/HEC-HMS	Coefficient Method, Small Watershed Method, & HEC-1/HEC-HMS	20'	6" (< 2 ac) or 12" (> 2 ac)	4:1	Highest of: 18" above BFE, 12" above NG, or 12" above road