

Clear Lake City Water Authority
Policy Manual

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**POLICY OF CLEAR LAKE CITY WATER AUTHORITY
REGARDING DRAINAGE AND FLOOD CONTROL FOR
NEW DEVELOPMENT**

1.01 INTRODUCTION

This Policy has been prepared to provide detailed criteria for the design of drainage and flood control facilities in the boundaries of the Clear Lake City Water Authority ("CLCWA" or the "Authority"), in Harris County, Texas. This policy will apply to all development projects within the boundaries of the CLCWA considered after this date.

1.02 BACKGROUND

In 1963, by act of the State Legislature, the CLCWA was created. As stated in the enabling legislation, the CLCWA was granted all rights, powers, and functions under the General Laws of the State pertaining to water control and improvement districts and is specifically granted the right, power, and authority to accomplish by any and all practical means drainage facilities or part of such systems or facilities and to make any and all necessary purchases, constructions, improvements, extensions, additions, and repairs thereto, and to purchase or acquire all necessary land, rights-of-way, easements, sites, equipment, buildings, plants, structures, and facilities and to operate and maintain same in accordance with §51.121 of the Water Code, and pursuant to its creation, the CLCWA has, among its founding purposes, "the control, storage, preservation, and distribution of its water and flood water and the water of its rivers and streams for irrigation, power, and all other useful purposes; and the control, abatement, and change of any shortage or harmful excess of water." The same section of the Water Code expressly states that the purposes for the creation of the CLCWA "may be accomplished by any practical means."

1.03 PURPOSE

The purpose of this drainage and flood control policy is to ensure that new development or redevelopment occurring within the jurisdiction of the CLCWA will provide appropriate mitigation measures so that storm drainage from the new development (including redevelopment) will not adversely impact existing problems. There are currently flooding and storm drainage problems located within the CLCWA's boundary. It is the desire of the Authority that these problems not be worsened or that any new problems not be created by proposed developments or by redevelopment of existing projects.

The Authority will utilize and rely upon the existing minimum criteria of other governmental agencies, such as the City of Houston and Harris County, who review and approve new development within the CLCWA's boundary. However, the Authority believes that certain aspects of the Harris County Flood Control District's ("HCFCD") minimum drainage criteria for new development contained within HCFCD's Policy, Criteria, and Procedure Manual need refinement to address the existing drainage and flooding conditions

already occurring within the Authority's boundaries. Therefore, the Authority has provided herein additional drainage criteria that must be met, besides those minimum criteria of the HCFCD and other governmental agencies, before new development will be approved by the Authority.

1.04 POLICY

It is the policy of the Authority as it relates to storm drainage and flood control that all new developments within the Authority's boundary shall fully mitigate any increases in runoff rates and volumes such that no new flood risk is created nor any existing flood risk is increased. This policy is consistent with the policies of Harris County and the City of Houston.

In the past, the Authority has relied upon the minimum drainage criteria of the HCFCD, Harris County and the relevant City to meet this policy. However, it is now the belief of the Authority that such minimum criteria need to be enhanced and supplemented in order to achieve the Authority's policy.

Therefore, in addition to the minimum criteria and requirements of the HCFCD, the County, and the relevant City, all new developments (including redevelopments) will be required to comply with the Authority's criteria as contained herein.

1.05 CRITERIA

When proposed developers seek approval from the Authority for their new developments (including re-developments), an additional requirement will have to be met by such developers, pertaining to storm drainage and flood control, in addition to the minimum requirements of the HCFCD, Harris County, and/or City of Houston (or any other city with jurisdiction) as follows:

(1) All proposed developments will be required to provide detention ponds in order to mitigate the increases in runoff rates and volume associated with such development (including redevelopments) as compared to undeveloped conditions so that no new flood risk is created nor any increase in flood risk will occur off-site. The preliminary design of such ponds, including their location, will be submitted to the Authority for its review and approval.

(2) The "Maximum Allowable Outflow Rates" associated with the required detention ponds will be restricted to the undeveloped 10- and 100-year flow rates of 0.075 cfs/acre and 0.125 cfs/acre, respectively.

(3) The "Minimum Detention Volume" required to be provided within the detention ponds, not including streets and culverts/pipes, will be 1.0 acre-feet per acre of area draining into the pond. All new development (including redevelopment) must drain into the pond, as well as any off-site drainage that had been or will be flowing into the area of the proposed development.

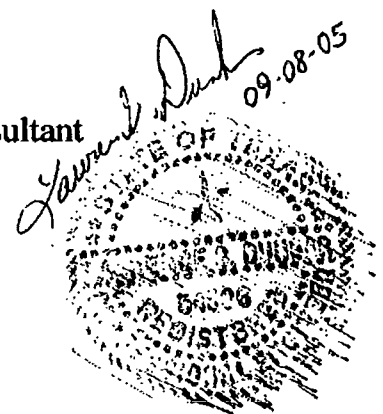
DESIGN CRITERIA
FOR
DETENTION PONDS
WITHIN
CLEAR LAKE CITY WATER AUTHORITY

Prepared for:

Clear Lake City Water Authority

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DESIGN CRITERIA
FOR DETENTION PONDS WITHIN
CLEAR LAKE CITY WATER AUTHORITY

1. INTRODUCTION

The Clear Lake City Water Authority (CLCWA) has the authority and the responsibility to control and regulate the storm drainage and runoff from new development within its jurisdiction. To provide such control and regulation of storm drainage and runoff, the CLCWA has in the past relied on the review and approval issued by the Harris County Flood Control District (HCFCD) relating to any potential impacts off-site due to such new development. With the completion of the TSARP study and the adoption of an updated criteria manual by the HCFCD, the CLCWA requested an independent review of this updated criteria as it pertains to the design of detention ponds to determine if any changes are needed to insure that new development within the boundary of the CLCWA will not cause any additional flooding.

2. BACKGROUND

The Harris County Flood Control District (HCFCD) adopted its Design Criteria Manual in 1984 to assist and guide developers and their engineers in the design of drainage facilities within Harris County, including detention ponds. This manual was recently updated in October 2004. As part of this criteria manual, detention pond design requirements for small drainage areas include a "Maximum Allowable Outflow Rate" and a "Minimum Detention Volume". These criteria have been established as "minimum" criteria that have to be met in order to obtain HCFCD approval of the proposed detention facilities.

The "Minimum Detention Volume" is the amount of storage capacity in acre-feet for which the detention pond must be sized in order to handle the runoff from a 100-year storm event. In the 1984 manual, this value was set between 0.45 and 0.55 acre-feet per acre of new development, depending on the size of the development. The updated manual has this value set at 0.55 for most situations (for 13.5 inches of rain in 24 hours). For comparison purposes, the corresponding value used in the drainage criteria manual of the Fort Bend County Drainage District is based on the percent of imperviousness, generally falling between 0.65 and 0.9 acre-feet per acre (for 12.5 inches of rain in 24 hours).

The "Maximum Allowable Outflow Rate" is the flow value in cubic feet per second (cfs) used in designing the outlet structure to the detention pond such that when the level in the pond is at its highest, the maximum rate of flow that should be able to leave the pond is not to exceed this value. In the 1984 HCFCD manual, for areas less than 50 acres, this value was set at 1.2 cfs per acre if the new development discharged directly into a HCFCD ditch; otherwise, the value was 0.5 cfs per acre, for the 100-year event. For larger areas up to 2,000 acres, curves were provided that generally set the value at about 1.5 cfs/acre. The updated manual provides 10-year and 100-year curves ("Site Runoff Curves") from 1 to 640 acres, producing a maximum outflow rate of between 2.0 to 1.2 cfs/acre, respectively, for the 100-year event. For comparison purposes, the value used in the Fort Bend County manual, adopted in 1987, is 0.125 cfs per acre for the 100-year event. It was determined in Fort Bend County that its value would result in outflow rates from its detention ponds that would more closely maintain the existing 100-year flow conditions within the County. In 1990, Brazoria County adopted the same maximum 100-year outflow rate value as Fort Bend County.

Since the mid-80's when these criteria manuals were adopted, development has continued to occur throughout these counties. Fort Bend County has not reported any significant increases in flow rates in its bayous and creeks as a result of new developments having detention ponds whose outflows are restricted to the County's value. However, the same cannot be said for Harris County. Recent floodplain studies (TSARP) conducted throughout Harris County in updating the previous studies that were done in the early 1980's show a general trend of increased flow rates in areas where development has occurred. This is also true for Horsepen Bayou, where the recent TSARP study by Harris County shows an increase in the 100-year peak flow rate of about 20% compared to the floodplain study of the bayou in 1991.

In a recent study conducted by the U.S. Army Corps of Engineers along Clear Creek, it was estimated that based on current development controls, the 100-year peak flow rates along Clear Creek would be expected to stay the same in Fort Bend County, but would increase by as much as 10% downstream through Harris County. The attached tabulation of "Computed Flow Frequency For Four Sample Locations" is from the Corps' June 2003 Hydrologic Analysis of Without Project Conditions for the Clear Creek General Reevaluation Report shows these peak flows along Clear Creek at various locations. The increases in peak flows in Fort Bend County for the more frequent events (2-year to 25-year) is a result of the County only having a Maximum Allowable Outflow Rate for the 100-year event, which tends to allow more outflow than should be allowed for smaller storms.

These increases in flow rates that have occurred in the past and are projected to occur in the future as a result of new development following the HCFCFCD criteria are of concern to the Clear Lake City Water Authority ("CLCWA"), which is authorized and has the responsibility to control storm drainage and flood waters within its boundaries. The CLCWA has been relying on the HCFCFCD and its review and approval of new development within the boundary of the CLCWA to insure that new development did not worsen existing drainage and flooding problems in the area. Based on this new information, and the fact that other surrounding counties that have different criteria have not experienced the same kind of increases in flooding, the CLCWA requested a review of the HCFCFCD criteria for designing detention ponds to determine if different criteria should be used by the CLCWA in its review and approval of new development, so that flooding is not increased.

3. REVIEW OF HCFCFCD'S UPDATED CRITERIA FOR DETENTION PONDS

The Site Runoff Curves for the 10- and 100-year frequency storm events that are included in Section 3 of the HCFCFCD's Policy, Criteria, & Procedure Manual (October 2004), Exhibits 3-1 and 3-2, respectively, are provided for engineers in the design of detention ponds to serve new development within Harris County which is less than 640 acres (i.e. one square mile). These Peak Flow Rate vs. Drainage Area curves, attached hereto, can be used to calculate the peak flow rate expected to run off from the proposed development, depending on the amount of impervious cover anticipated for the new development.

In addition, these curves are also used to determine the "Maximum Allowable Outflow Rate", which is the peak flow that would be allowed to be released from the proposed detention pond. In designing the detention pond for the 10- and 100-year events, the Peak Flow Rate value for the appropriate drainage area of the new development is selected using the 0% Impervious Cover curve, supposedly representing undeveloped conditions. This then becomes the Maximum Allowable Outflow Rate for the detention pond that will serve the new development and prevent excess runoff from leaving the new development too quickly and adversely impacting off-site properties.

For areas less than 20 acres, this 0% Impervious Cover curve produces an outflow rate of 2 cfs/acre for the 100-year event. For areas greater than 20 acres, the rate is gradually reduced to about 1.2 cfs/acre for an area of 640 acres.

The "Minimum Detention Volume" for proposed detention ponds is now set at 0.55 acre-feet per acre of new development, according to Section 6.9 of the HCFCD manual. This is the value that establishes the size of the detention pond so that during the 100-year storm, the volume of runoff generated will be held inside the detention pond while waiting to be released through the outlet structure of the pond.

A review was made of these two minimum criteria of the HCFCD to determine if they are appropriate for use in designing detention ponds for new developments within the CLCWA's jurisdiction, which consists primarily of the Horsepen Bayou Watershed, so that no increase in flooding will result.

4. REVIEW OF HCFCD'S "SITE RUNOFF CURVES"

A review of the Site Runoff Curves that are provided in Section 3 of the HCFCD manual, and attached hereto, indicates that the upper curves representing higher levels of imperviousness produce peak flow rates consistent with the flow rates generated by the hydrologic model for the Horsepen Bayou Watershed developed during the recent TSARP study for areas depicting significant amounts of development. Thus, these curves can be used to calculate the peak flow rate entering the detention pond for a proposed development project, when such is needed in using the HCFCD criteria and procedures.

However, there is concern in using the 0% Impervious Cover curves to represent the pre-developed (or undeveloped) condition for establishing the Maximum Allowable Outflow Rate for the proposed detention pond. Fort Bend County's value for this is about one-tenth the amount allowed by Harris County for the 100-year event (0.125 cfs/acre versus 1.2 cfs/acre). A review of the HCFCD Site Runoff Curves and their development was undertaken to determine why there is such a large difference between these two counties' criteria for release rates from detention ponds.

In reviewing the HCFCD criteria and its development, it was revealed that the 0% Impervious Cover curve is based on the assumption that the pre-developed condition is one in which the area is already well-drained. As such, no natural storage areas (e.g. wetlands), referred to as depression storage, were assumed to exist on the property so that there is little increase in the volume of runoff generated by the proposed development. This is confirmed when comparing the amount of runoff volume produced for pre-developed conditions according to the two criteria. Based on the HCFCD criteria, about 80% of the 100-year, 24-hour

rainfall (13.5 inches for Horsepen Bayou) becomes runoff for pre-developed conditions, whereas, according to the Fort Bend County criteria, less than 60% of the 100-year, 24-hour rainfall becomes runoff.

In addition, the HCFCD criteria assumes that the time of concentration for the area reflects a well-drained area and will not be further reduced significantly as a result of additional development activities (e.g. adding impervious cover). This "time of concentration" is the time it takes runoff to travel across the entire watershed. A longer time of concentration produces a lower peak flow rate. The Fort Bend County criteria was based on the recognition that the time of concentration is extremely long for pre-developed conditions in the county, due to the relatively flat topography, the existence of significant depression storage, and the lack of extensive, major drainage facilities.

As such, when the Site Runoff Curves were developed for Fort Bend County, the 0% Impervious Cover curves were specifically noted as not to be used for establishing the existing or pre-developed peak flow rate for the proposed development, nor for setting the "Maximum Allowable Outflow Rate" for a detention pond; otherwise, the resulting outflow rates from the pond would be far in excess of actual pre-developed conditions that exist in the County. Instead, the Fort Bend County criteria established the peak flow rate of 0.125 cfs/acre as a reasonable approximation of the runoff associated with existing (primarily undeveloped) 100-year flow conditions.

5. REVISION OF "UNDEVELOPED" SITE RUNOFF CURVES

Based upon the above review, it was apparent that the Site Runoff Curves needed to be revised in order to produce an appropriate curve to more appropriately represent undeveloped conditions for areas within the CLCWA's boundary, which exhibit similar characteristics to those in Fort Bend County and Brazoria County (i.e flat topography that is not well-drained with depression storage areas). In order to determine the appropriate peak flow rate for pre-developed (undeveloped) conditions that can be used to set the Maximum Allowable Outflow Rate for detention ponds within the boundary of the CLCWA, the Rational Method was selected as an appropriate method to be used in this study. This method is widely used throughout the country and recognized as an appropriate method for calculating the peak flow rate from small drainage areas less than one square mile (Ref. "Hydrology and Floodplain Analysis" by Dr. Bedient, 3rd edition, 2002).

The Rational Method is based on the equation $Q=ciA$, where Q is the peak flow rate in cfs, c is a runoff coefficient, i is the rainfall intensity in in/hr, and A is the drainage area in acres. For flat areas having clay soils, like those in the Horsepen Bayou Watershed, a runoff coefficient of about 0.2 is appropriate for undeveloped conditions (Ref. "Hydrologic Analysis and Design" by Dr. McCuen, 1989). The rainfall intensity, i , is a function of the time of concentration, T_c . The Soil Conservation Service (SCS) Lag Formula was used to compute the T_c for all of the subareas within the Horsepen Bayou Watershed, based on parameters obtained from the TSARP study. This SCS Lag Formula was developed specifically for undeveloped areas less than 2000 acres, and utilizes the length and slope of the watershed, as well as the SCS Curve Number, CN (Ref. McCuen 1989). For this study, a CN of 60 was selected to reflect the amount of runoff volume generated from an undeveloped area within the CLCWA boundaries, based on the runoff volumes developed in the Fort Bend County manual.

The resulting 100-year peak flow rates representing undeveloped conditions for subareas within the CLCWA's boundary using the Rational Method are presented in Table 1 attached hereto. These 100-year peak flow rates were also plotted onto the HCFCD's Site Runoff Curves, as shown in the attached Figure 1, and compared to the HCFCD and Fort Bend County criteria for obtaining the Maximum Allowable Outflow Rate for designing detention ponds.

Based on these results, an undeveloped 100-year peak flow rate of 0.125 cfs/acre is a reasonable and appropriate value to use within the CLCWA's boundary for establishing the Maximum Allowable Outflow Rate in the design of detention ponds for areas less than 640 acres. This value is consistent with the 100-year value used in the Fort Bend County manual for areas less than 640 acres.

In order to control the release rate from detention ponds for events smaller than the 100-year, say the 10-year, so that no increase in flooding will occur during these smaller events, a Maximum Allowable Outflow Rate for the 10-year event is also appropriate.

Since the 10-year peak flow rate is approximately 60% of the 100-year rate, the Maximum Allowable Outflow Rate for the 10-year event should be set at 0.075 cfs/acre (60% of 0.125 cfs/acre).

Based on the above analyses, in designing a detention pond in accordance with the HCFCD criteria manual, Exhibits 3-1 and 3-2 from that manual should not be used in determining the Maximum Allowable Outflow Rate. Rather, the above values

of 0.075 cfs/acre and 0.125 cfs/acre should be used for the 10-year and 100-year events, respectively. This new criteria has been established in an attempt to reflect the storm water runoff contribution from undeveloped areas within the CLCWA's boundary in order that new development, with detention releases restricted to the values above will not create new or additional flooding problems downstream.

6. REVISION TO "MINIMUM DETENTION VOLUME"

In conjunction with the above criteria for establishing the Maximum Allowable Outflow Rate, the Minimum Detention Volume is set at 1.0 acre-feet per acre. This is based on the HCFCD's estimated runoff volume for a typical development in the CLCWA boundary, being between 12 and 13 inches of runoff, depending on the amount of impervious cover. Therefore, between 1.0 and 1.1 acre-feet of runoff is generated off of each acre of development. Given the allowable outflow rate presented above, the estimated amount of detention capacity needed to store the excess runoff volume is about 95% of the total runoff volume generated, namely about 1.0 acre-feet per acre.

7. CONCLUSION

Based on the above analyses, the minimum criteria of the HCFCD for the design of detention ponds needs revision in order to avoid new development within the CLCWA's boundary from increasing the existing flooding conditions in the area.

As such, the "Maximum Allowable Outflow Rate" from the detention pond is to be set at 0.125 cfs/acre for the 100-year event, and 0.075 cfs/acre for the 10-year event. In addition, the "Minimum Detention Volume" within the detention pond is 1.0 acre-feet/acre.

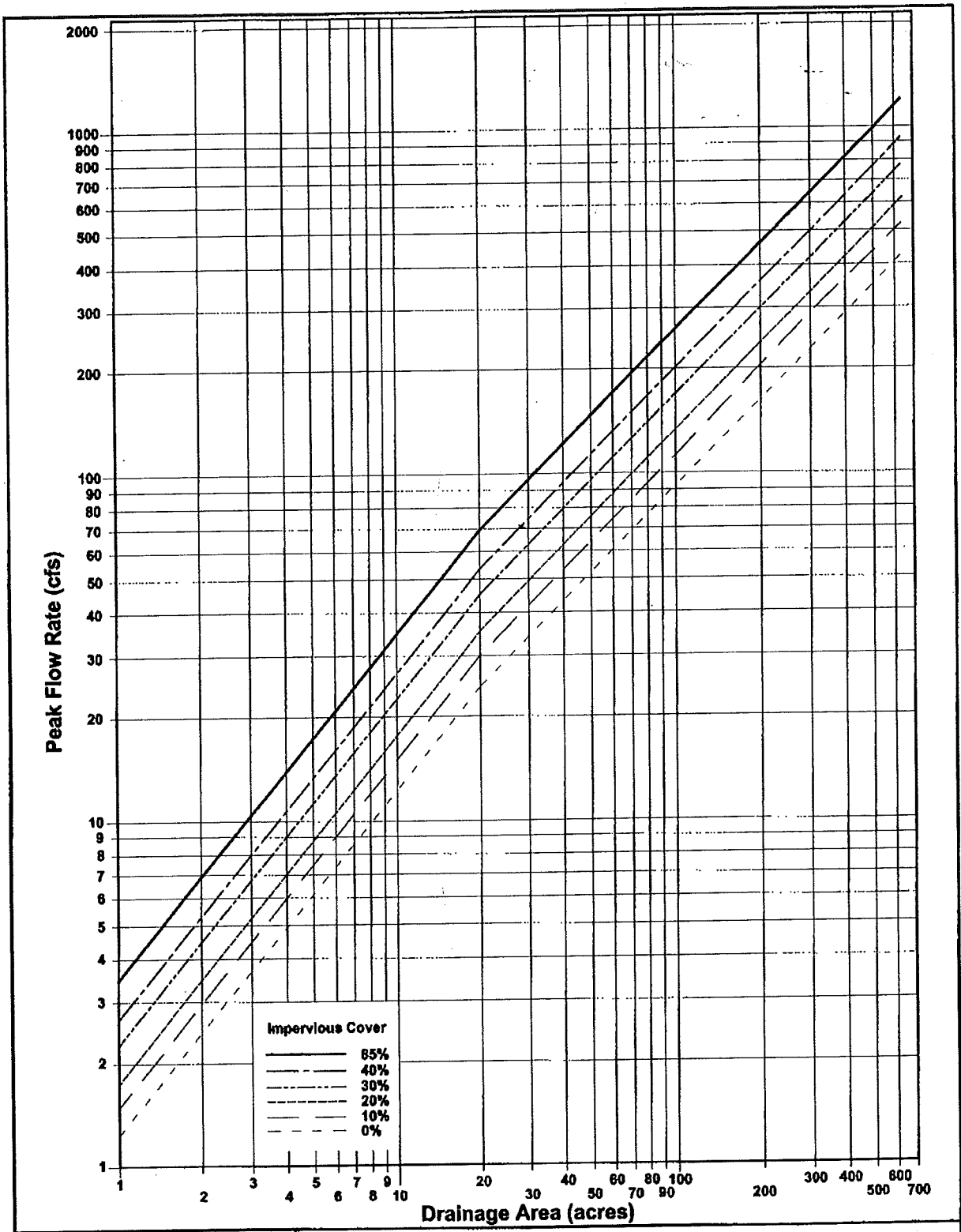
This revised criteria is intended to control the increase in runoff rates and volume that occurs with new development, or re-development, so that no additional flooding problems are created off-site.

**COMPUTED FLOW FREQUENCY
FOR FOUR SAMPLE LOCATIONS**

Four Locations: (Upstream to Downstream)	Watershed Condition	Peak Flow (CFS) for Eight Different Percent Chance Exceedance Frequencies										
		50 (2-Yr)	20 (5-Yr)	10 (10-Yr)	4 (25-Yr)	2 (50-Yr)	1 (100-Yr)	.4 (250-Yr)	.2 (500-Yr)			
		At Fort Bend Co. Line	1980	268	475	656	793	906	1,058	1,247	1,295	1,296
At State Highway 35	1980	1,036	1,506	1,909	2,439	3,022	3,681	4,561	5,271			
	2010	1,198	1,686	2,224	2,834	3,407	4,008	5,005	5,628			
	2060	1,219	1,818	2,360	2,940	3,531	4,087	5,138	5,727			
	2060UC	1,326	2,010	2,628	3,263	3,842	4,478	5,465	6,298			
At FMS28	1980	5,352	8,347	10,775	12,679	14,365	16,328	18,837	20,503			
	2010	5,604	8,570	11,006	12,858	14,554	16,532	18,996	20,629			
	2060	6,383	9,632	11,817	13,507	15,350	17,394	19,918	22,053			
	2060UC	7,081	10,579	12,802	14,487	16,705	19,106	22,372	24,925			
Outlet at Galveston Bay	1980	8,220	13,824	20,576	25,340	31,665	37,546	44,482	49,805			
	2010	8,509	14,508	21,317	26,544	32,628	38,313	45,253	50,753			
	2060	8,673	17,617	24,523	31,406	36,542	41,978	49,584	54,692			
	2060UC	9,671	20,732	27,314	34,199	39,582	45,393	53,493	58,782			

Explanation: This table provides a sample of the peak flood flows computed in the hydrologic analysis. Peaks are shown for four different watershed conditions. This reveals the growth in flood peaks that were computed to occur through 2060 and reflect current development controls. The "2060UC" condition represents the uncontrolled future condition, i.e. 2060 conditions that would exist if detention requirements for new development were never institute.

Source: Clear Creek GRR "Hydrologic Analysis of Without-Project Conditions" June 2003

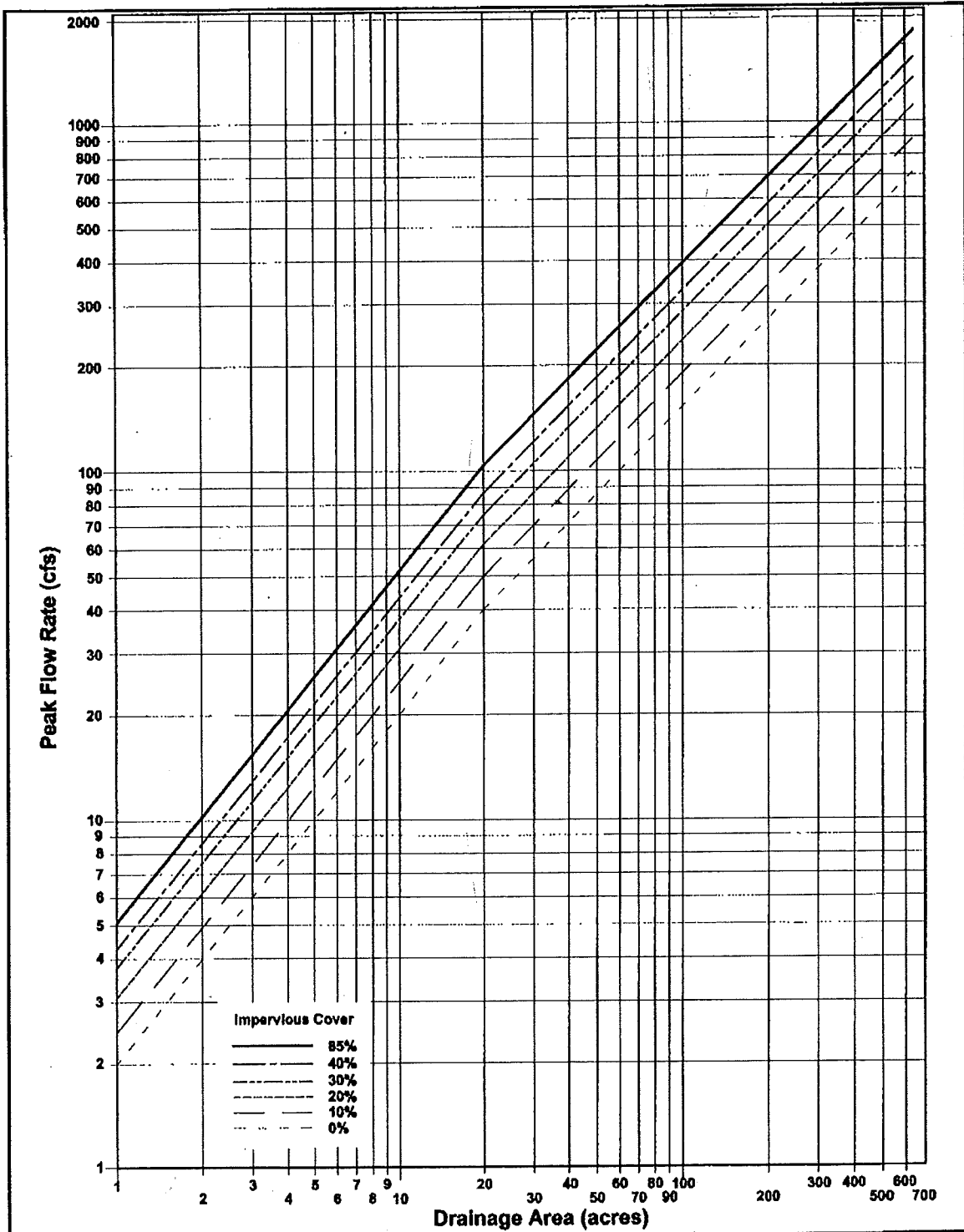


**POLICY,
CRITERIA, &
PROCEDURE
MANUAL**

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

DATE: 10/5/04

EXHIBIT 3-1



**POLICY,
CRITERIA, &
PROCEDURE
MANUAL**

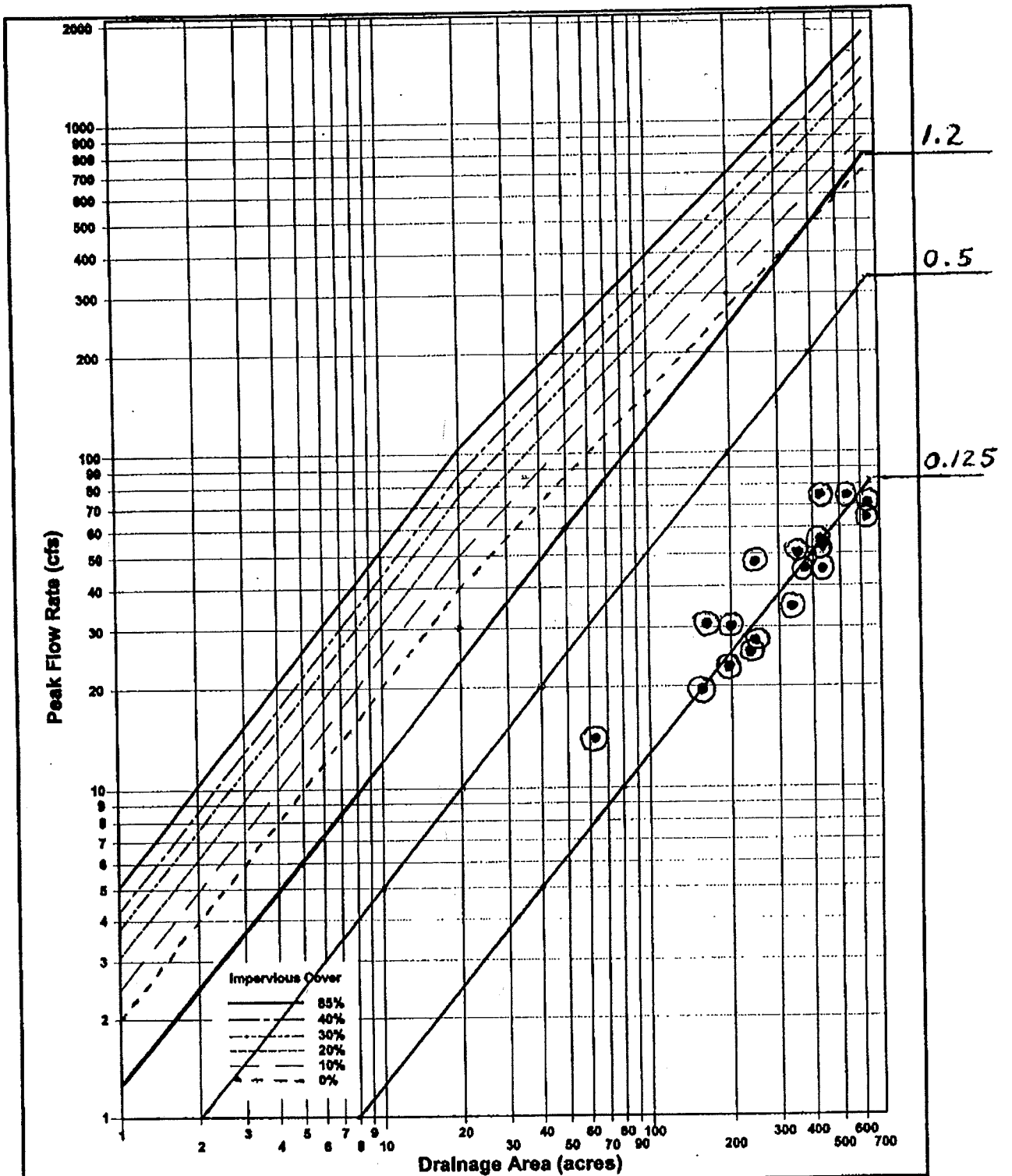
**SITE RUNOFF CURVES FOR 1% EXCEEDANCE
PROBABILITY (100-YEAR FREQUENCY) STORM**

DATE: 10/5/04

EXHIBIT 3-2

Table 1. Undeveloped Runoff Rates for Horsepen Bayou Subareas

<u>Subarea</u>	<u>D.A. (ac)</u>	<u>L (mi)</u>	<u>S (ft/mi)</u>	<u>CN</u>	<u>Tc (hr)</u>	<u>i (in/hr)</u>	<u>Q100 (cfs)</u>
B104A	442	1.048	2.0	60	22	.60	53
B104C	630	2.403	2.6	60	38	.50	63
B104D	428	1.964	6.0	60	21	.62	54
B104E	337	1.589	2.5	60	28	.52	34
B104F	423	1.209	7.2	60	13	.90	76
B104G	62	0.416	3.6	60	8	1.25	15
B104H	168	0.771	3.6	60	13	.90	31
B104I	200	1.082	3.6	60	17	.75	30
B104J	163	1.258	2.6	60	23	.58	19
B104K	198	1.275	2.6	60	23	.58	23
B104L	236	1.379	2.2	60	27	.52	25
B104M	245	1.290	2.2	60	25	.55	27
B104N	437	1.571	2.2	60	30	.50	44
B10401A	357	1.050	3.0	60	18	.70	50
B10404B	379	1.661	3.9	60	23	.60	46
B10404C	643	1.763	3.9	60	24	.55	71
B10404D	253	1.324	12.6	60	11	.95	48
B10405B	527	1.921	8.1	60	18	.70	74



**POLICY,
CRITERIA, &
PROCEDURE
MANUAL**

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

DATE: 10/5/04

EXHIBIT 3-2

Figure 1

TECHNICAL GUIDANCE
FOR
CLCWA'S DRAINAGE AND FLOOD CONTROL POLICY
(December 14, 2006)

1. INTRODUCTION

The Clear Lake City Water Authority (CLCWA) adopted a drainage and flood control policy on September 8, 2005 for all new development and redevelopment within the boundaries of the CLCWA in an effort to ensure that such development would not worsen any existing flooding problems or create any new flooding problems.

Specifically, the CLCWA adopted criteria that require all new development and redevelopment provide detention ponds in order to mitigate the increases in runoff rates and volume associated with such development. The Maximum Allowable Outflow Rates from the detention pond are to be restricted to 0.125 cfs/acre and 0.075 cfs/acre for the 100-year and 10-year storm events, respectively. Additionally, the Minimum Detention Volume to be provided within the pond is set at 1 acre-foot/acre of area draining into the pond.

After the adoption of this policy and criteria, various technical questions were raised by developers and their engineers concerning certain aspects in the implementation of this policy and criteria. This Technical Guidance is provided in order to address some of these questions and assist developers and their engineers in the implementation of this drainage and flood control policy and its corresponding criteria. This Technical Guidance may be periodically updated as new or better information and/or technology become available.

2. VARIANCE REQUESTS

Requests for a variance to the CLCWA policy and criteria presented above can be made in recognition of unusual circumstances or characteristics associated with the proposed development. The following procedures are provided as a recommendation for the type of analyses that will be required in order to obtain such a variance. Other procedures and/or analyses will be considered on a case-by-case basis as appropriate.

A. BACKGROUND

To determine the Maximum Allowable Outflow Rates for a detention pond serving small areas in unincorporated Harris County, the existing (pre-developed) peak runoff rates for the 10-year and 100-year storm events are generally used and are obtained from the Site Runoff Curves from HCFCD's Policy, Criteria and Procedure Manual. For "undeveloped" areas, the 0% impervious curve is used to obtain the peak runoff rates for this condition. However, these standard curves do not allow for any recognition of differences in drainage characteristics for any particular piece of property to be developed, other than size of area and percent imperviousness. In addition, this 0% impervious curve is based on the assumption that the area already has a well-developed drainage system, which is normally not the case in small areas within the CLCWA boundary. Finally, using the existing peak runoff rate as the release rate for the pond does not prevent downstream flooding due to the increase in runoff volume associated with development and the cumulative effect of small developments on downstream flows.

Therefore, the CLCWA adopted release rates (and a corresponding detention volume) that reflected drainage conditions and characteristics representative of undeveloped conditions in this area, being generally poorly drained, and in recognition of the need to be lower than undeveloped runoff rates in order to prevent downstream impacts. Thus, in the event a tract of land to be developed has drainage characteristics that are significantly different than what was assumed in developing the CLCWA's release rates, then a request for a variance may be considered.

B. REQUEST FOR NO DETENTION

If the developer/engineer believes that his/her proposed development will not cause any adverse impacts without providing any detention, a request can be made for a variance to the CLCWA's drainage and flood control policy requirements, with an appropriate analysis to be submitted in support of this request. The following is the recommended procedure for such an analysis:

- (1) Evaluate any and all reasonable storm scenarios, including storm surge, demonstrating that no adverse impacts will result from the proposed development without detention.

(2) TSARP models should be used, as may be appropriately updated and/or modified by the CLCWA or other governmental agency, to evaluate any potential impacts within the watershed.

(3) Evaluate the 10-year, 100-year and 500-year rainfalls and storm surges for the watershed area with and without the proposed development.

(4) Consider moving storms across the watershed.

(5) Evaluate all undeveloped areas (and developed areas with detention) within the subarea of the proposed development as being fully developed without detention to determine potential impacts within the watershed down to Clear Lake.

C. REQUEST FOR DIFFERENT RELEASE RATES

If the developer/engineer believes that his/her proposed development will not cause any adverse impacts with its proposed detention by releasing more storm water as required under the CLCWA's policy and criteria discussed above, a request can be made for a variance to the CLCWA's drainage and flood control policy requirements, with an appropriate analysis to be submitted in support of this request. The following is the recommended procedure for such an analysis:

(1) Compute the "existing" peak runoff rates from the proposed development for the 10-year and 100-year storm events using the Rational Method. The "existing" runoff is based on land conditions as they existed as of September 8, 2005. (Note: These "existing" peak runoff rates may not be used as the release rates for the proposed detention pond without adjusting them in recognition of the increase in runoff volume associated with the proposed development and the cumulative effect of small developments on downstream flows).

(2) To adjust the "existing" peak runoff rates in order to obtain appropriate release rates for the proposed detention pond, plot the "existing" peak runoff rates on the Site Runoff Curves from HCFCD's Policy, Criteria and Procedure Manual. Extend a line from these plotted points parallel to the lines on these curves (between 20-640 acres) up to the drainage area size of 640 acres (see attached curves for an example). Determine the peak

runoff rate for 640 acres using this extended line, and compute a cfs/acre runoff rate. Apply this cfs/acre runoff rate to the size of the proposed development. This "adjusted" peak runoff rate would become the requested Maximum Allowable Outflow Rate for the 10-year and 100-year storm events, respectively, for use in designing the required detention pond for the proposed development.

(3) Use the Small Watershed Hydrograph Method and the requested 100-year Maximum Allowable Outflow Rate determined above for computing the Minimum Detention Volume to be requested for the proposed pond (see attached example).

3. ASSUMED TAILWATER CONDITIONS

In determining whether the proposed detention pond release rates are in compliance with the Maximum Allowable Outflow Rates as set forth in the CLCWA's policy discussed above, a tailwater condition must be assumed. The tailwater condition to be assumed should be such that, at the maximum design water level in the pond, the minimum head is 2 feet and 0.7 feet for the 100-year and 10-year events, respectively.

4. MINIMUM OUTLET PIPE/RESTRICTOR SIZE

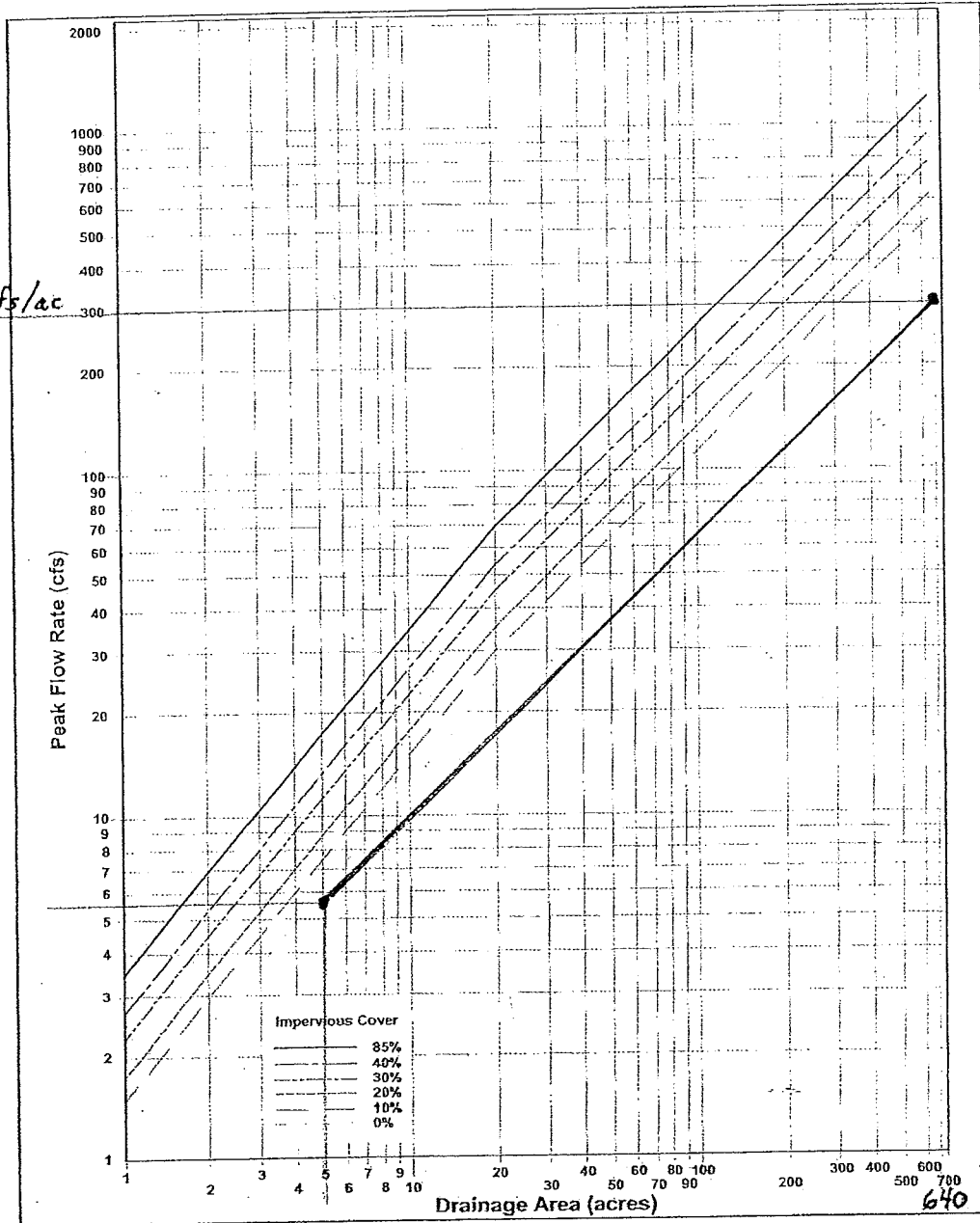
According to the Harris County Flood Control District's Drainage Criteria Manual, the minimum outlet pipe/restrictor size is a diameter of 6 inches to prevent clogging. However, the CLCWA believes that a smaller pipe size (down to 3 inches in diameter) can be used without causing a serious problem with clogging. Therefore, if the calculated outlet pipe/restrictor size needed to maintain the Maximum Allowable Outflow Rates discussed above is less than 3 inches in diameter, then the outlet pipe/restrictor size should be set to 3 inches.

This adjustment to the outlet pipe/restrictor size can be justification for requesting a variance to the Minimum Detention Volume of 1 acre-foot/acre, by using the Small Watershed Hydrograph Method and demonstrating that a smaller sized pond can handle the design storm.

5. FREEBOARD

A minimum of 1 foot of freeboard is required for detention ponds. The Minimum Detention Volume required under the CLCWA's policy and criteria as discussed above is to be measured from the crest of the emergency spillway down to the bottom of the pond, and therefore does not include any freeboard.

0.5 cfs/ac



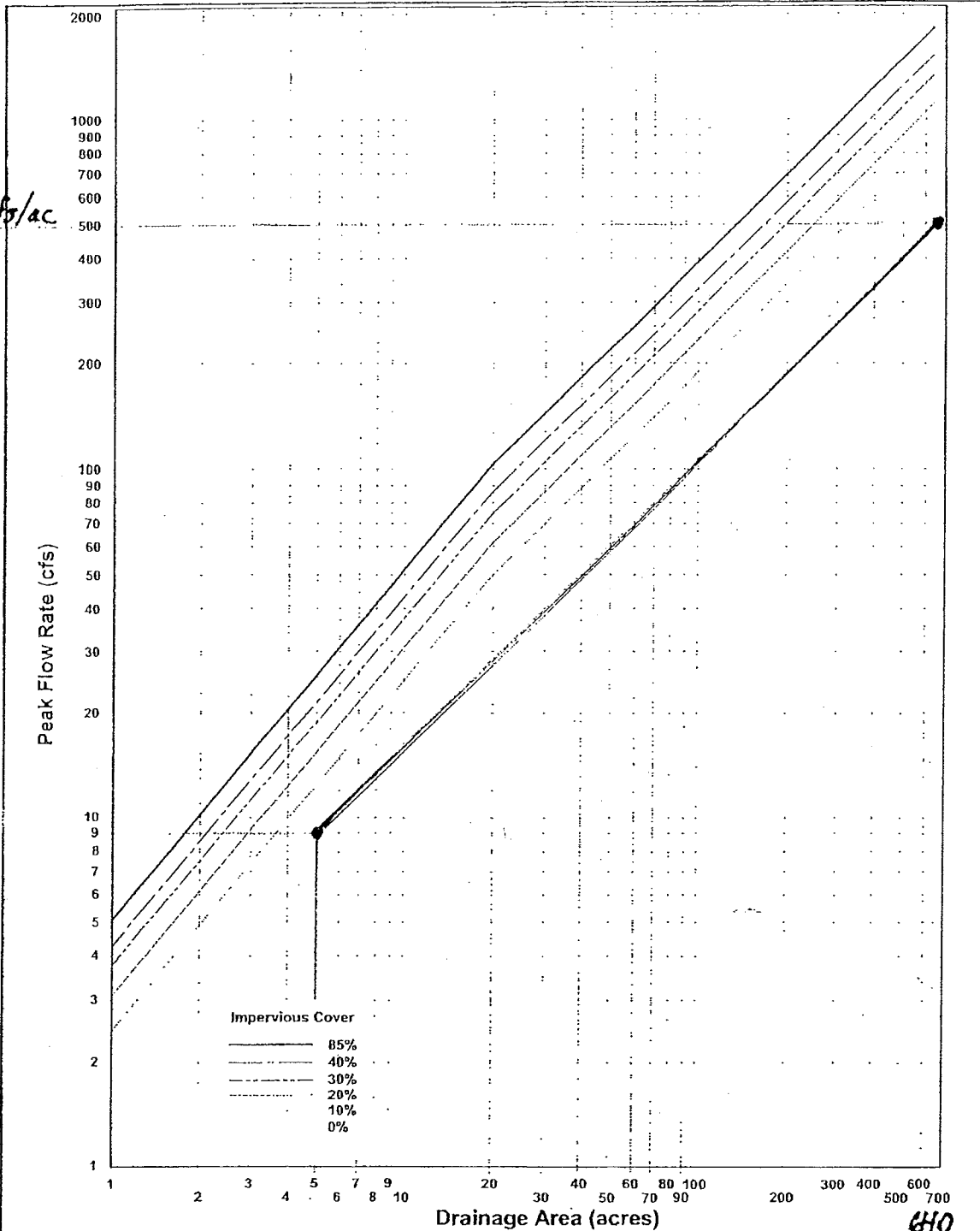
POLICY,
CRITERIA, &
PROCEDURE
MANUAL

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

DATE: 10/5/04

EXHIBIT 3-1

0.8 cfs/ac



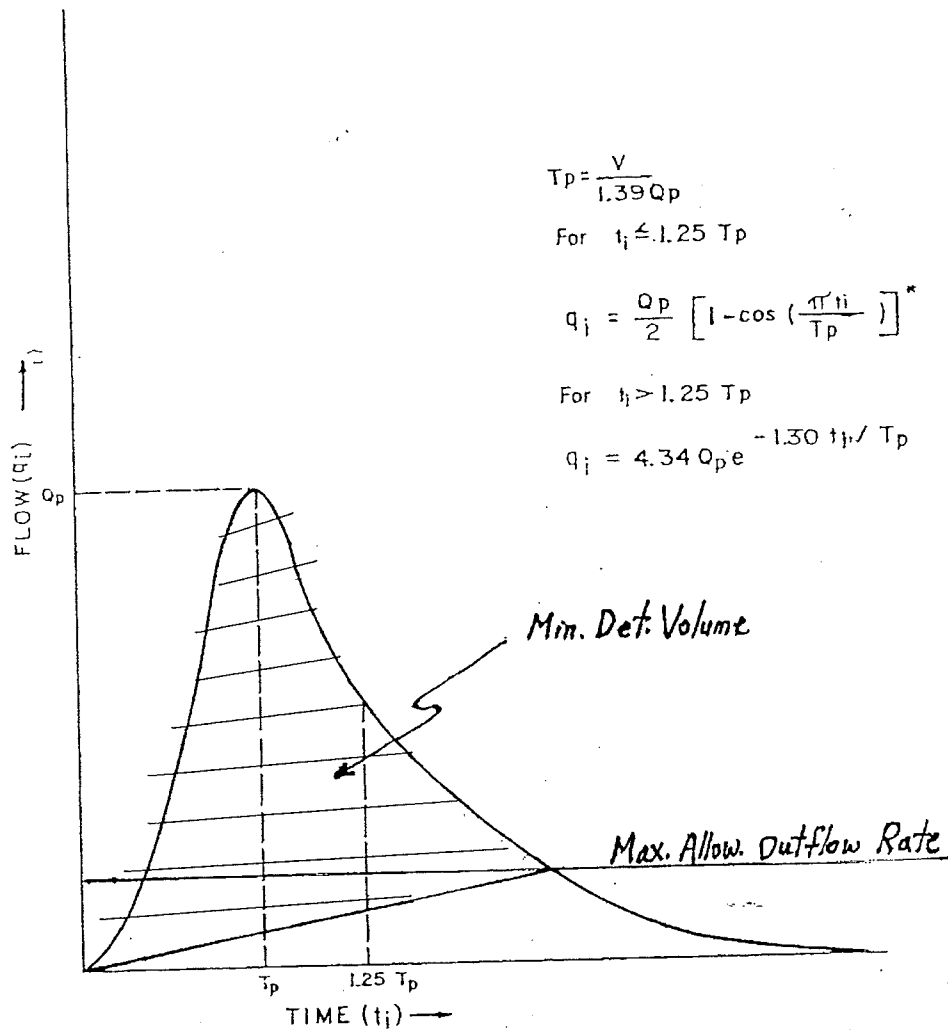
Harris County
Flood Control District

POLICY,
CRITERIA, &
PROCEDURE
MANUAL

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

DATE: 10/5/04

EXHIBIT 3-2



* With calculator in radian mode.



**SMALL WATERSHED METHOD
 OF
 HYDROGRAPH DEVELOPMENT**

EXHIBIT B-2

August 10, 2006

Parameters for Challenging Need for Detention Ponds within Clear Lake City Water Authority

By

Philip B. Bedient, Ph.D., P.E., F.ASCE

June 12, 2006

1. Background

The objective of the Clear Lake City Water Authority design criteria is to have no adverse impact from any development that could cause any increase in offsite flooding. Houston and Harris County are well known as flood-prone areas, ranking high on the list of repetitive flood loss communities in the U.S. Following Tropical Storm Allison in 2001, enormous flood damages occurred throughout the county, including over \$5 billion in property damages. Thus the need for policies to control increases in flood flows has never been more important. The Clear Lake City Water Authority has the responsibility to control and regulate storm drainage and runoff from new development within its jurisdiction. In the past they have relied on review and approval from HCFCD relating to any potential offsite impacts. With the completion of the TSARP study and the adoption of an updated criteria manual by HCFCD, the Clear Lake City Water Authority requested an independent review of the updated criteria.

The review from Lawrence .G. Dunbar, P.E. resulted in revised design criteria for detention ponds within the Clear Lake City Water Authority area. The conclusion of that review yielded a maximum allowable outflow rate from a detention pond to be set at 0.0125 cfs/acre for the 100-yr event and 0.075 cfs/acre for the 10-yr event. In addition, the minimum detention volume within the pond is 1.0 acre-ft/acre. The revised criteria are intended to produce no additional flooding problems created offsite from new developments.

2. Evaluation and Need for Detention

Most of the Horsepen Bayou watershed is within the boundaries of the Clear Lake City Water Authority and was analyzed as part of TSARP. The watershed area has seen an increase in peak flows and an increase in flood plain extent since the earlier flood plain study of 1996. It is generally accepted that any development that includes an increase in imperviousness or improved drainage conditions (ie sewers, roads, grading, etc.) will cause an increase in flows at the property boundary. This is the basis for most detention pond policies across the state and nation. Based upon a review of hydrology and flooding in the Horsepen and Armand Bayou watershed areas, and given its flat slope and proximity to Galveston Bay, there appears to be no capacity to accept any additional flows into the receiving waters at this time.

In reviewing the TSARP model and the analysis of elevations of land with respect to flood plain elevations in the area and the possibility of storm surge, I conclude that any

new proposed development would need some level of detention/retention to mitigate against increased flows in the system. Storage in traditional detention ponds built near the outlet for a developed area or in oversized storm sewers within the area is acceptable and supports the stated objective of the policy. The Authority has established a firm detention criteria, as listed earlier in this document, and that criteria is based upon a Rational Method analysis of runoff curves applicable to the Clear Lake City area.

3. Parameters for Challenging the Need for Detention

If a developer chooses to challenge the need for any detention based on a belief that no adverse impact will occur from their development, they must demonstrate this fact based on any and all reasonable storm conditions/scenarios, and including a consideration of storm surge in the area, given its proximity to the coast and to Galveston Bay. Given the above issues, the following methodology would be acceptable to evaluate development impacts.

- 1) TSARP models can be used as a basis for hydrologic analysis.
- 2) At least the 10-, 100-, and 500- year rainfalls should be evaluated for the watershed area in question for with and without development considered.
- 3) Moving rainfalls across the watershed must be considered as one possible realistic scenario.
- 4) If a portion of a subarea within the TSARP model is to be evaluated for possible development without detention, then full development of that subarea must be evaluated and reported to the Authority. In this way, the Authority is better able to evaluate not only the proposed development but also potential cumulative impacts that might occur into the future.

Approved 8/10/2006