CHURCH CREEK WATERSHED DETENTION SUMMARY REPORT

Background

Church Creek Watershed located in West Ashley, South Carolina has experienced reoccurring residential flooding within the past 10 years. This watershed is approximately 8.5 square miles in size and drains to the Ashley River. The landuse is comprised mostly of residential neighborhoods with undeveloped land and some industrial and commercial development. Over the past 10 years, the upper half of the watershed has undergone rapid residential development and there is still more than 2 square miles of undeveloped land planned for future development. During this same time period, there have been numerous yards that have flooded and several houses inundated with storm water on more than one occasion. As a result, the City of Charleston hired Woolpert to analyze the flooding problems and to create a Storm Water Master Plan for the Church Creek Watershed.

The Storm Water Master Plan involved looking at the impacts that future development would have on the watershed, the effectiveness of the current storm water detention requirements, and determining if landuse restrictions or modifications to the detention requirements would be beneficial. To accomplish this, an ICPR computer model of the watershed was developed to simulate how fast storm water runoff travels and at what levels the water rises at different locations within the watershed for different types of storm events.

Existing Results

Finish floor elevations for 44 houses and 6 townhouse buildings, which contained a total of 32 units, were surveyed in order to determine the number of houses and townhouses effected by flooding and the frequency of this flooding. These houses and townhouses were selected because they were documented as having existing flooding problems or were identified to have potential problems due to the results of the computer model when run with existing landuse conditions. The model results showed that 2 houses have finish floor flooding in the 10-year storm event while 23 houses and 32 townhouses have finish floor flooding in the 100-year storm event. Table 1 summarizes the potential existing flooding impacts to the houses and townhouses that were surveyed as determined from the model.

Table 1. Existing Flooding Impacts

Flooding Impact	Number of Finish Floors Inundated – Existing Condition					
	2-year	10-year	25-year	50-year	100-year	500-year
Houses	0	2	8	15	23	24
Townhouse Units	0	0	22	32	32	32

Policy Modification Alternatives

Since October of 2000, a moratorium on development has been in place in the Church Creek Watershed. Due to the extent of the existing flooding and the potential of future flooding in the watershed, a change in policy and requirements may be a solution to the problem. Woolpert has investigated 6 possible policy modification alternatives. They are as follows:

1) No detention required,
2) Control peak flow rates only,
3) Detain the excess 24-hour, X-year storm rainfall runoff at the peak detention elevation,
4) Detain the excess 24-hour, X-year storm rainfall runoff until Z-time,
5) Detain the excess 24-hour, X-year storm rainfall runoff at the peak detention elevation and control peak discharge rates, and
6) Detain the excess 24-hour, X-year storm rainfall runoff until Z-time and control peak discharge rates.

X-year = given storm frequency (i.e. 2-year, 10-year, 100-year)
Z-time = given time (i.e. 24-hours)

Policy modification alternative #1, No detention required,

- This alternative would not require future development to provide detention, allowing direct release of all runoff.

Policy modification alternative #2, Control peak flow rates only, (Current Policy)

- This alternative would implement the current policy of requiring detention facilities to detain runoff and release the post-development peak flow rates for the 2- and 10-year 24-hour storm events to the pre-development peak flow rates. See Figure #1.

Policy modification alternative #3, Detain the excess 24-hour, X-year storm rainfall runoff at the peak detention elevation,

- This alternative would require detaining the excess runoff volume difference between the pre-development and post-development conditions for a given storm frequency X (100-year storm event recommended). This excess volume would occupy the peak storage volume in the detention facility. See Figure #2.

Policy modification alternative #4, Detain the excess 24-hour, X-year storm rainfall runoff until Z-time,

- This alternative would require detaining the excess runoff volume difference between the pre-development and post-development conditions for a given storm frequency X (100-year storm event) for a certain time period Z (24-hours). The storage volume within the detention facility would be required to occupy the excess runoff volume and the volume required to detain this excess volume for the desired time period. See Figure #3.

Policy modification alternative #5, Detain the excess 24-hour, X-year storm rainfall runoff at the peak detention elevation and control peak discharge rates,

- This alternative would require detaining the excess runoff volume difference between the pre-development and post-development conditions for a given storm frequency X (100-year storm event) and release the post-development peak flow rates for the X-year storm event to the pre-development peak flow rates. The storage volume within the detention facility would be required to occupy the excess runoff volume and the volume required release the post-development peak flow to the pre-development peak flow rates. See Figure #4.

Policy modification alternative #6, Detain the excess 24-hour, X-year storm rainfall runoff until Z-time and control peak discharge rates,

- This alternative would require detaining the excess runoff volume difference between the pre-development and post-development conditions for a given storm frequency X (100-year storm event) for a certain time period Z (24-hours). The storage volume within the detention facility would be required to occupy the excess runoff volume, the volume required to detain this excess volume for the desired time period and the volume required to release the post-development peak flow to the pre-development peak flow rates. See Figure #5.

Table 2 shows a comparison of the pros and cons of the policy modification alternatives.

Table 2. Policy Modification Alternative Pros and Cons

Policy Option	Pros	Cons
1	Easiest approach	Results in increased downstream volume, increased flow elevations and increased peak discharges.
2	Current practice, easy understanding for design community	Results in increased downstream volume, and increased flow elevations.
3	Excess runoff volume created from development is captured	Post- peak flow rates could be larger than the pre- rates (excess volume could be captured before peak flow is reached, excess volume may be less than required volume to control peak) Larger post- runoff volume could travel downstream sooner than pre- runoff volume
4	More than excess runoff volume is captured at peak detention elevation (excess volume + drawdown volume)	Post- peak flow rate could be larger the pre- rates (excess volume could be captured before peak flow is reached, excess volume may be less than required volume to control peak)
5	Excess volume is captured Peak discharge is controlled	Larger post- runoff volume could travel downstream sooner than pre- runoff volume (post- shape of hydrograph may have centroid sooner) If drawdown time is large, detention facilities could stay full for long periods of time.
6	Same Z-hour volume is released for pre- and post- conditions, and the post- peak flow rates will be equal to or lower than the pre- peak flow rates	Requires the most detention volume of the 6 options. Detention facilities will stay full for longer periods of time due to smaller outlet control devices.

Policy Modification Results

Using the ICPR computer model, different future landuse scenarios and different detention policy options were evaluated to determine the resulting impacts on future flood elevations. Model results for several of the detention options are shown in Table 3.

Table 3. Policy Modification Alternatives and Future Flooding Impacts

Policy Modification Alternative	Number of Finish Floors Inundated Per Condition				
	2-year	10-year	25-year	50-year	100-year
Houses					
Existing Conditions	0	2	8	15	23
Alt #1 –Future Conditions	0	4	9	19	24
Alt #2 –Future Conditions	0	3	9	18	24
Alt #3 –Future Conditions	0	2	9	17	24
Alt #6 –Future Conditions	0	2 or less	8	15	23
Townhouse Units					
Existing Conditions	0	0	22	32	32
Alt #1 –Future Conditions	0	22	32	32	32
Alt #2 –Future Conditions	0	10	32	32	32
Alt #3 –Future Conditions	0	4	32	32	32
Alt #6 –Future Conditions	0	0	22 or less	32	32

Recommendation

Based on the results of the computer model simulations it is recommended that detention policy alternative number 6 be implemented for future development. This alternative was selected because it provides the most protection against flooding for the future landuse conditions as shown in Table 3. This would also allow developers the freedom to develop at any impervious density while maintaining no flooding impacts to downstream properties.

Figures 6, 7, 8, and 9 show existing stage hydrographs at several locations upstream of the railroad. The peak stages at these locations occur between hours 21 to 25 depending on the location and remain near peak stage for approximately 3 to 6 hours. Therefore, we recommend setting the time period for pre-volume release control to 24-hours. This should prevent any excess runoff volume due to new development from traveling downstream until after the peak stage at the railroad has begun to reside. We also recommend that all storm events up to the 100-year storm event should be controlled for both excess volume and peak rates.

Therefore, the recommended detention standard shall require permanent stormwater management systems, associated with new development, to be designed and constructed to maintain the post-development peak flow rates at or below the pre-development peak flow rates; and to detain the excess runoff volume difference between the pre-development and post-development conditions for the design storms having a duration of 24-hours and frequencies of 2-, 10-, 25-, 50- and 100- years for a time period of 24-hours. Tolerances for the 25-, and 50- year storm event peak flow rates will be plus or minus ten percent. All other post-development peak flow rates must be at or below the pre-development peak flow rates. Detention facilities meeting these standards must be designed and constructed to contain the excess volume for the 24-hour period and the volume required to release the post development peak flow at or below the pre-development peak flow rates.

Figure 7-1 Alternative #2 - Control Peak Flow Rates

Pros: Current Practice
Cons: Increased volume downstream,
Increased elevation downstream,
Increased discharge downstream

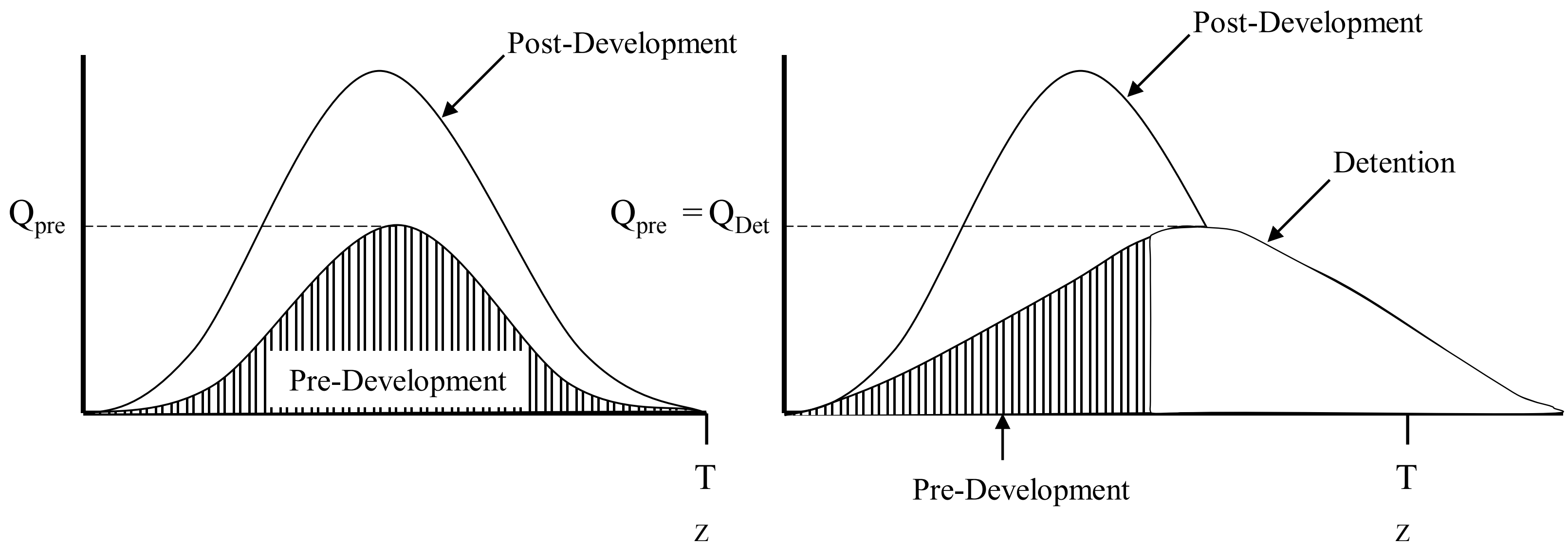


Figure 7-2 Alternative #3 - Detain the excess 24-hour, X-year storm rainfall runoff at the peak detention elevation

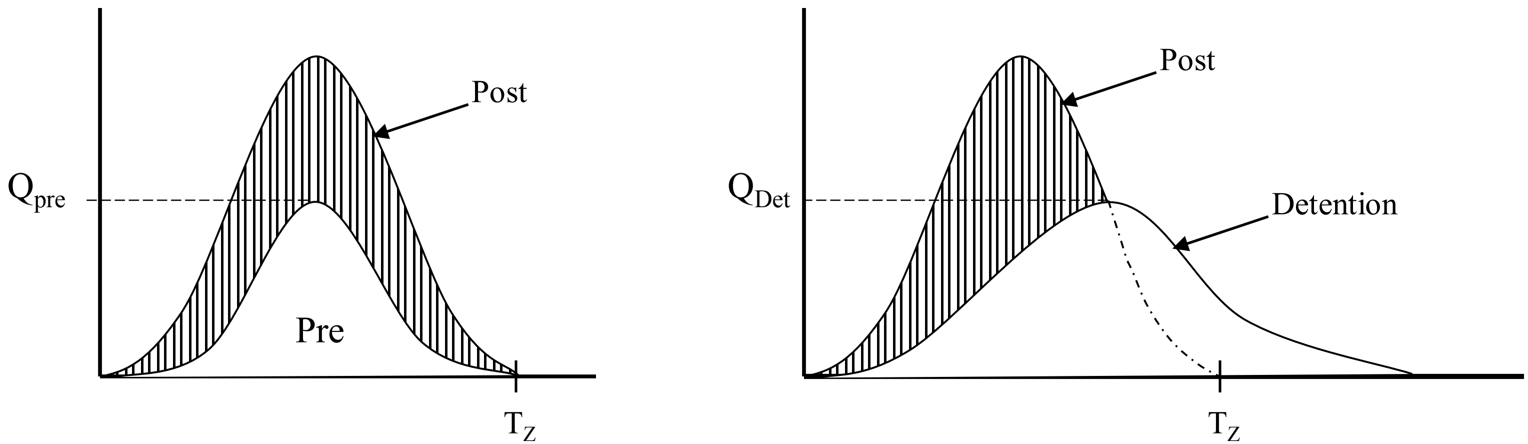
Pros: Excess volume is captured

Cons: Peak rates could be larger than existing

*(excess volume is captured before peak)

Larger volume could travel downstream sooner than existing

*(shape of hydrograph may have centroid sooner than existing conditions)

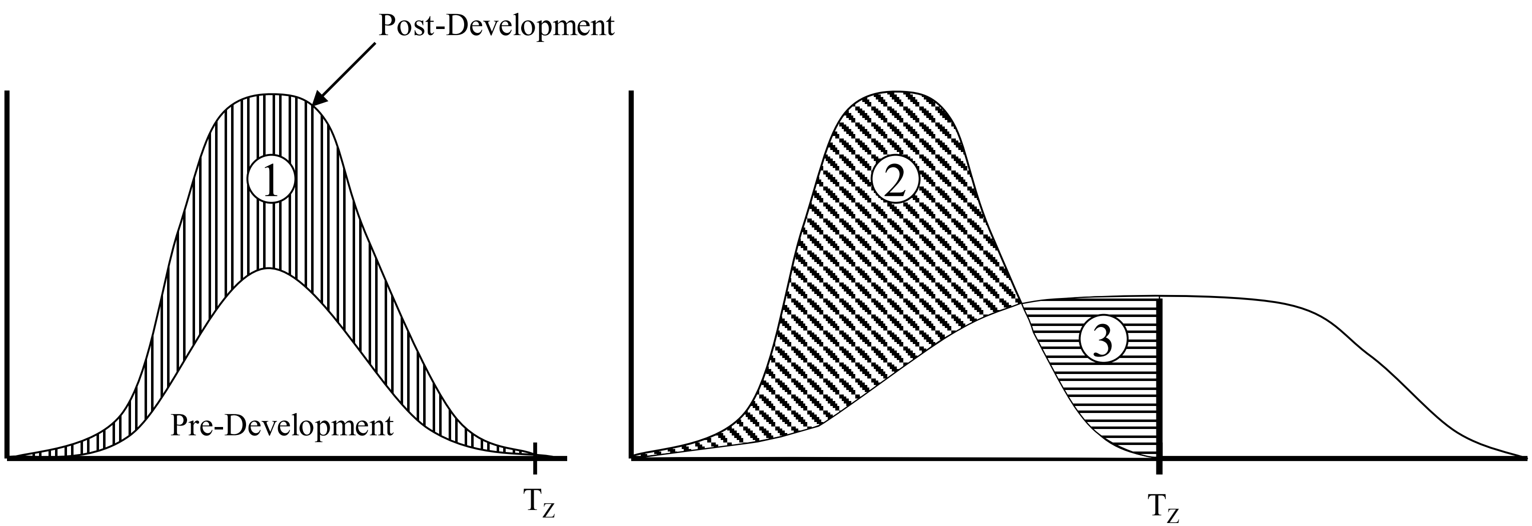


$$A_{Excess} = A_{Storage}$$

Figure 7-3 Alternative #4 - Detain excess 24-hour X-year rainfall until Z-time

Pros: At peak detention elevation there is more than excess runoff volume
(excess volume + drawdown)

Cons: Peak rates could be larger than existing
*(excess volume is captured before peak)
Excess volume may be less than volume required to control peak



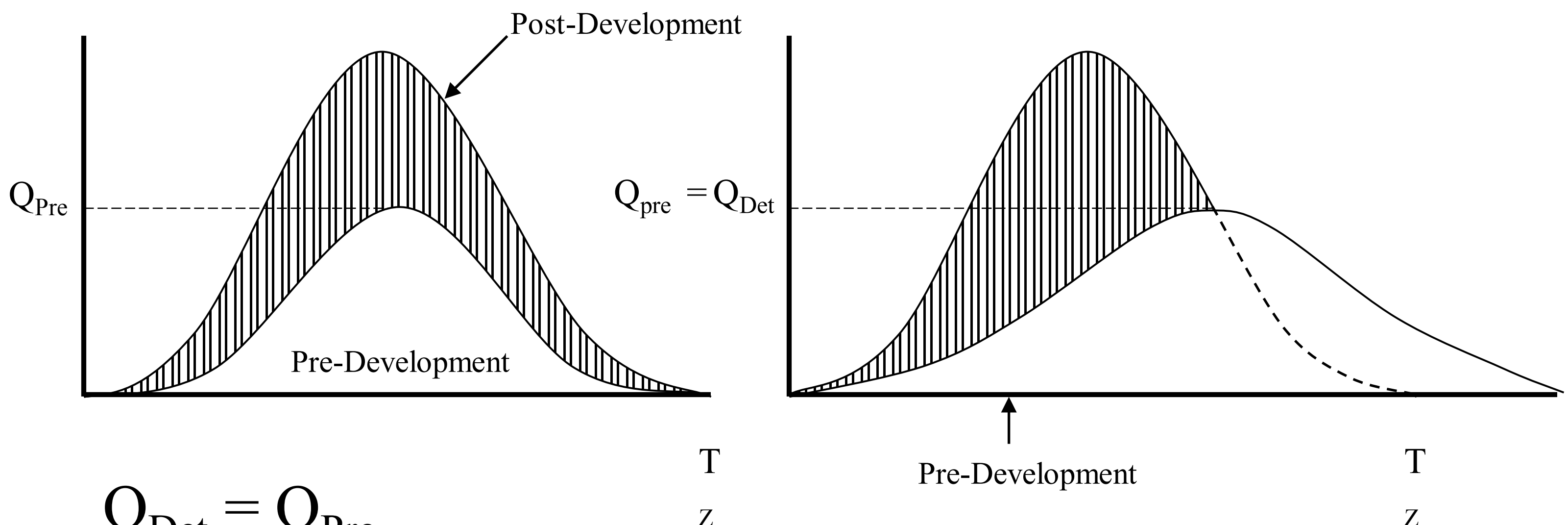
$$A_1 = A_2 - A_3$$

$$A_{Excess} + A_{Drawdown} = A_{Storage}$$

Figure 7-4 Alternative #5 - Detain excess 24-hour X-year at peak detention elevation and control peak discharge

Pros: Excess runoff volume is captured
Peak discharge is controlled

Cons: Larger volume could travel downstream sooner than existing
* (Shape of hydrograph may have centroid sooner)
If drawdown time is large, pond stays full



$$Q_{Det} = Q_{Pre}$$

$$A_{Storage} \langle A_{Excess}$$

Figure 7-5 Alternative #6 Detain excess 24-hour X-year until Z-time and control peak discharge

Pros: About the same X-hour volume is released for pre- and post- conditions
Peak discharge will be lower than or equal to existing peak flows
Cons: Requires more detention volume
Ponds may stay full longer due to small outlet devices