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re:	Comparison of the 85% Postdevelopment Volumetric Discharge Limitation to the Post-Pre Phosphorus Criteria	
date:	August 25, 2009	
from:	Devo Seereeram, TAC Member	

The following memo briefly discusses some issues regarding the water quality treatment volume calculations proposed in the draft FDEP Stormwater Quality Applicant's Handbook, and issues raised during meetings of the Technical Advisory Committee (TAC).

The primary goal in the methodology proposed in the new FDEP stormwater rule is to limit the postdevelopment nutrient loading to predevelopment conditions, i.e., no net increase in postdevelopment nutrient loading. A methodology has been developed based on long term continuous simulations (Harper, et. al.) which distills the nutrient loading calculations into a series of design tables, calculations, etc., intended to both simplify and standardize design calculations. The required stormwater retention depth for a dry pond, based on pre vs postdevelopment nutrient loading, is primarily a function of the following variables:

① Average annual rainfall conditions (distribution of storm events and rainfall intensity) depending on geographic location within the state of Florida. Five distinct climate zones are defined based on similarities in the rainfall distribution within those areas.

② Runoff basin characteristics (curve number and directly connected impervious area)

③ Average annual concentration of nutrients (nitrogen and phosphorous) in stormwater runoff as a function of land use.

It has been recognized that the primary goal of limiting the postdevelopment nutrient discharge to predevelopment levels will also result in a significant increase in water quality treatment volumes that need to be treated, resulting in a dramatic increase in the size of retention ponds required.

As a practical matter, it has been proposed that an upper limit be set in the required nutrient removal efficiencies, with a suggested upper limit of 85% removal of the postdevelopment nutrient loading. However, it has also been noted that this proposed postdevelopment limit is purely a volumetric consideration, independent of land use. For a dry pond, an 85% pond efficiency is achieved by retaining and infiltrating 85% of the runoff, regardless of what the nutrient concentration is in the runoff.

This memo looks at the general relationship between required removal efficiency vs retention depth, and compares the proposed 85% postdevelopment volumetric limit to limits applied on the pre vs postdevelopment discharge (85% and 90%), which would maintain a link to the nutrient concentrations in the runoff.

RELATIONSHIP BETWEEN EFFICIENCY AND RETENTION DEPTH

The relationship between removal efficiency and required retention depth is non-linear. Exhibit 1.1 shows the relationship between efficiency and retention depth for a CN of 65 and a DCIA of 25%, and Exhibit 1.2 shows the relationship between efficiency and retention depth for a CN of 75% and a DCIA of 40%, at representative cities and climate zones. For each representative city, the annual rainfall depth and climate zone is varied to representative conditions at that location.

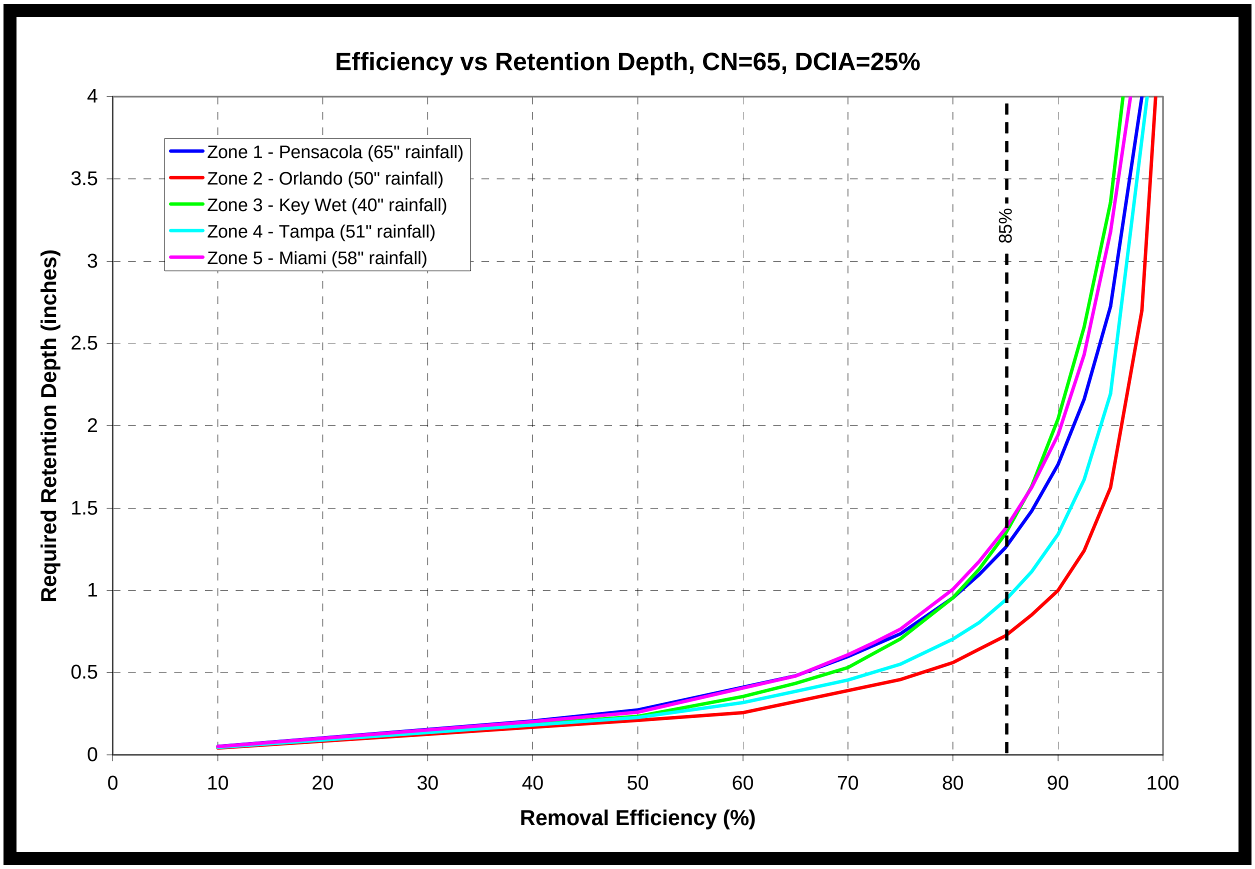

Exhibit 1.1. Efficiency vs Retention Depth at Several Locations for CN=65 & DCIA=25%

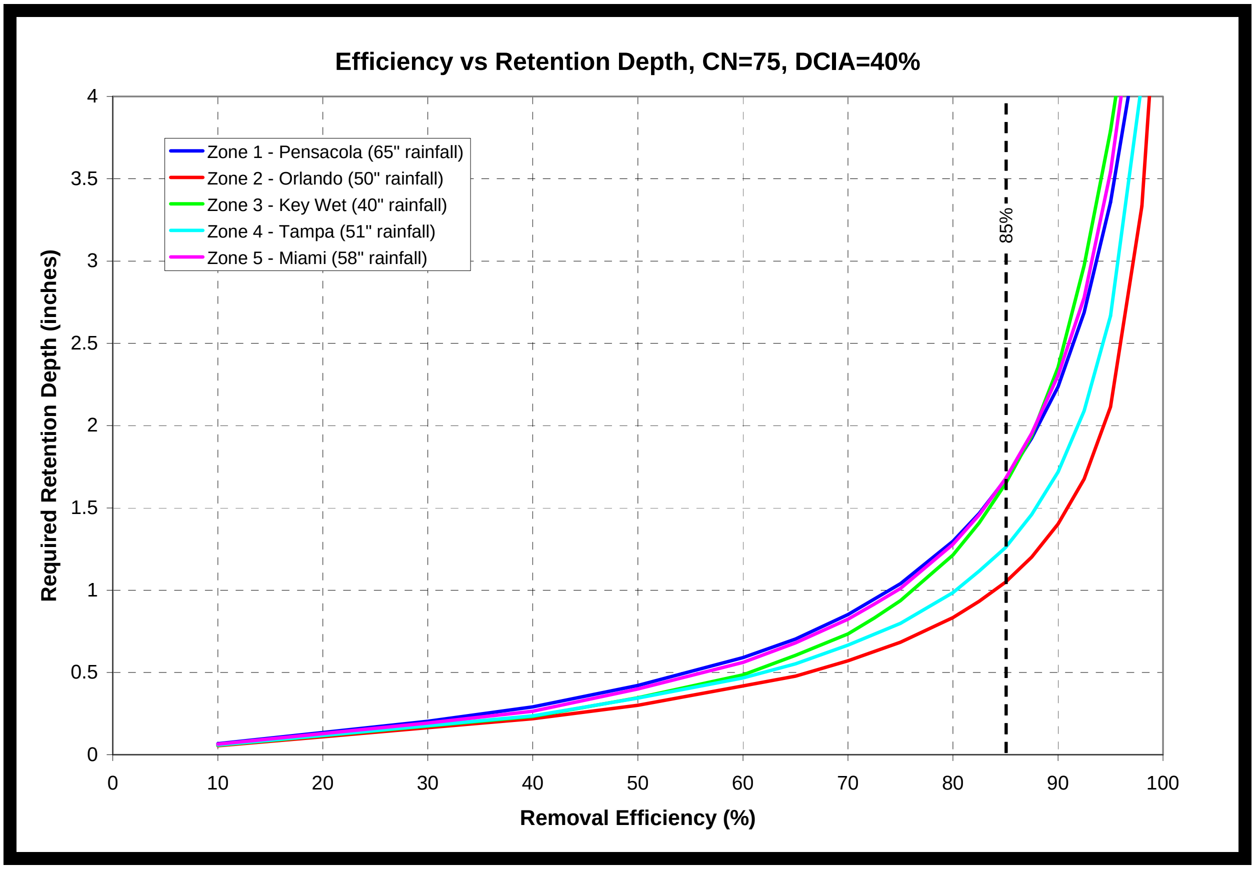

Exhibit 1.2. Efficiency vs Retention Depth at Several Locations for CN=75 & DCIA=40%

As seen in Exhibits 1.1 and 1.2, in the upper ranges of efficiencies, increasingly large retention depths are required to achieve small increases in the treatment efficiency of the pond. This occurs because the rainfall distributions typically contain a large number of small storm events, but a smaller number of large storm events. Runoff from the small storm events can easily be treated, and cumulatively the retention of the small storm events contributes a large portion of the overall efficiency. On the other hand, to increase efficiencies in the higher efficiency range (above say 85%) it is necessary to retain significant volumes from larger storm events.

Also, since the rainfall distribution changes for each climate zone, the efficiency vs retention depth relationship is slightly different for each zone. For the example shown in Exhibit 1.1, a retention depth of about 1 inch will give an efficiency of about 90% in Orlando, whereas in Key West or Pensacola only 80% efficiency is achievable for 1 inch of retention. (This suggests that the practical upper limit to the required efficiency could perhaps be a function of climate zone).

Also note that the efficiency curves for Key West and Pensacola are very similar, despite a large difference in the annual rainfall (40 inches for Key West vs 65 inches for Pensacola), as a result of the rainfall distributions at each location, with Key West being skewed towards more larger storm events.

Based on this example, the proposed 85% volumetric limit appears to be a reasonable compromise between maximizing the removal efficiency without incurring a severe penalty in the required retention depth (despite being independent of land use).

Alternative Criteria To Limit Upper Efficiency Limit

An alternative to the 85% postdevelopment (volumetric) efficiency criteria can be obtained by applying a reduction factor to the increase in pre vs postdevelopment nutrient loading, i.e.:

Design Efficiency = Reduction Factor x (Post - Pre)

This equation retains an implicit relationship to the land use since the required efficiency for the pre vs postdevelopment analysis is dependent on land use.

Note that for a standard pre vs post reduction analysis, the reduction factor is simply 1.0, or

Design Efficiency = 100% x (Post - Pre)

Examples are presented below which compare the effect of these various removal efficiency criteria for different development scenarios, at a range of locations. The criteria considered are:

① no net increase above predevelopment, i.e., Design Efficiency = 100% x (Post - Pre)

② Design Efficiency = 85% x Post (volumetric rule)

③ Design Efficiency = 85% x (Post - Pre)

④ Design Efficiency = 90% x (Post - Pre)

<u>Example 1</u>

A representative city in each climate zone was selected with rainfall appropriate for the chosen city:

Zone 1 - Pensacola, 65 inches of rainfall
Zone 2 - Orlando, 50 inches of rainfall
Zone 3 - Key West, 40 inches of rainfall
Zone 4 - Tampa, 51 inches of rainfall
Zone 5 - Miami, 58 inches of rainfall

Predevelopment conditions:

Area = 100 acres
CN = 65
DCIA = 0
Land Use = Undeveloped Rangeland / Forest

Postdevelpment conditions

Area = 90 acres (assumes 10 acres are devoted to stormwater facilities)
CN = 65
DCIA = 25%
Land Use = Low Intensity Commercial, Single Family and Multi Family

The following series of exhibits (Exhibits 2.1 through 2.5) compares the resulting retention depths for the various combination of postdevelopment land use and climate zones.

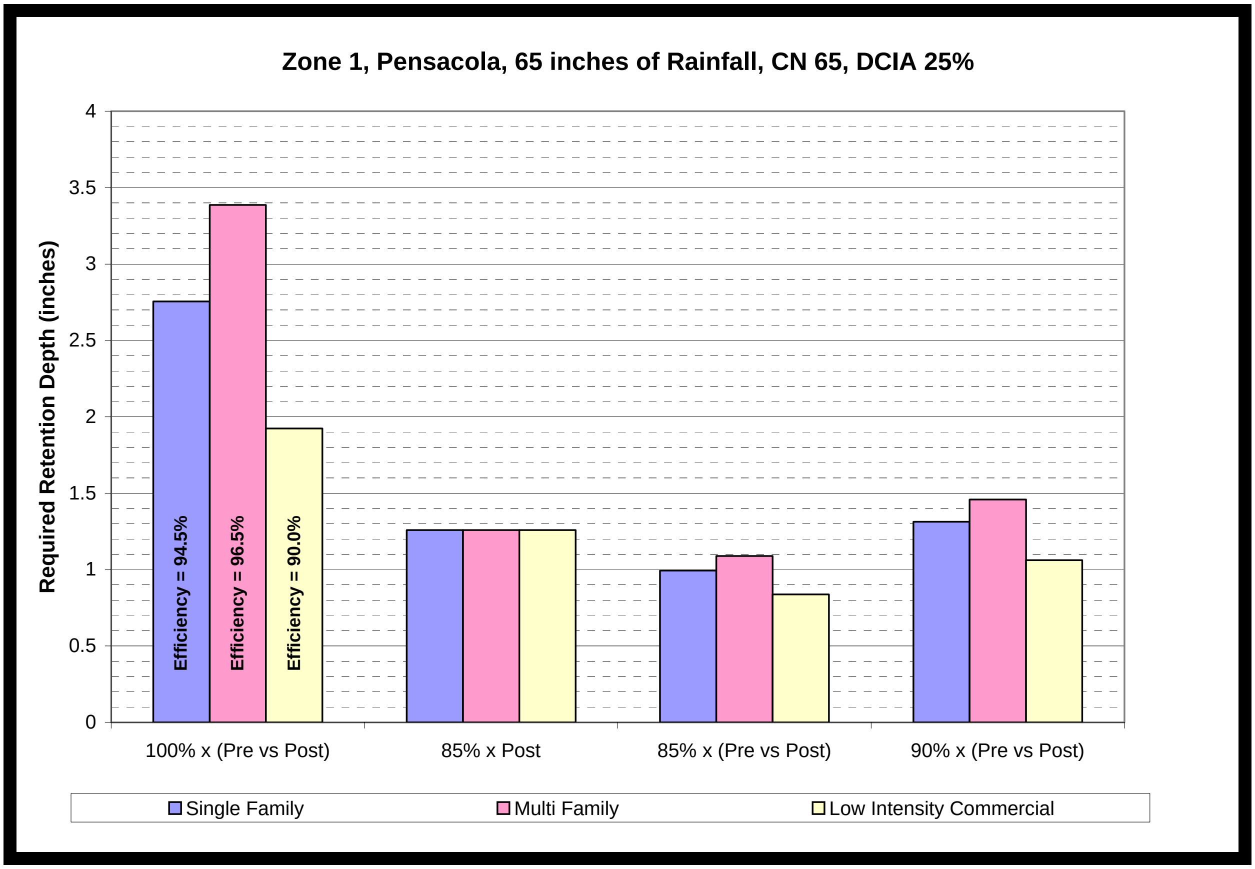

Exhibit 2.1. Example 1, Zone 1 - Pensacola, CN=65, DCIA=25%

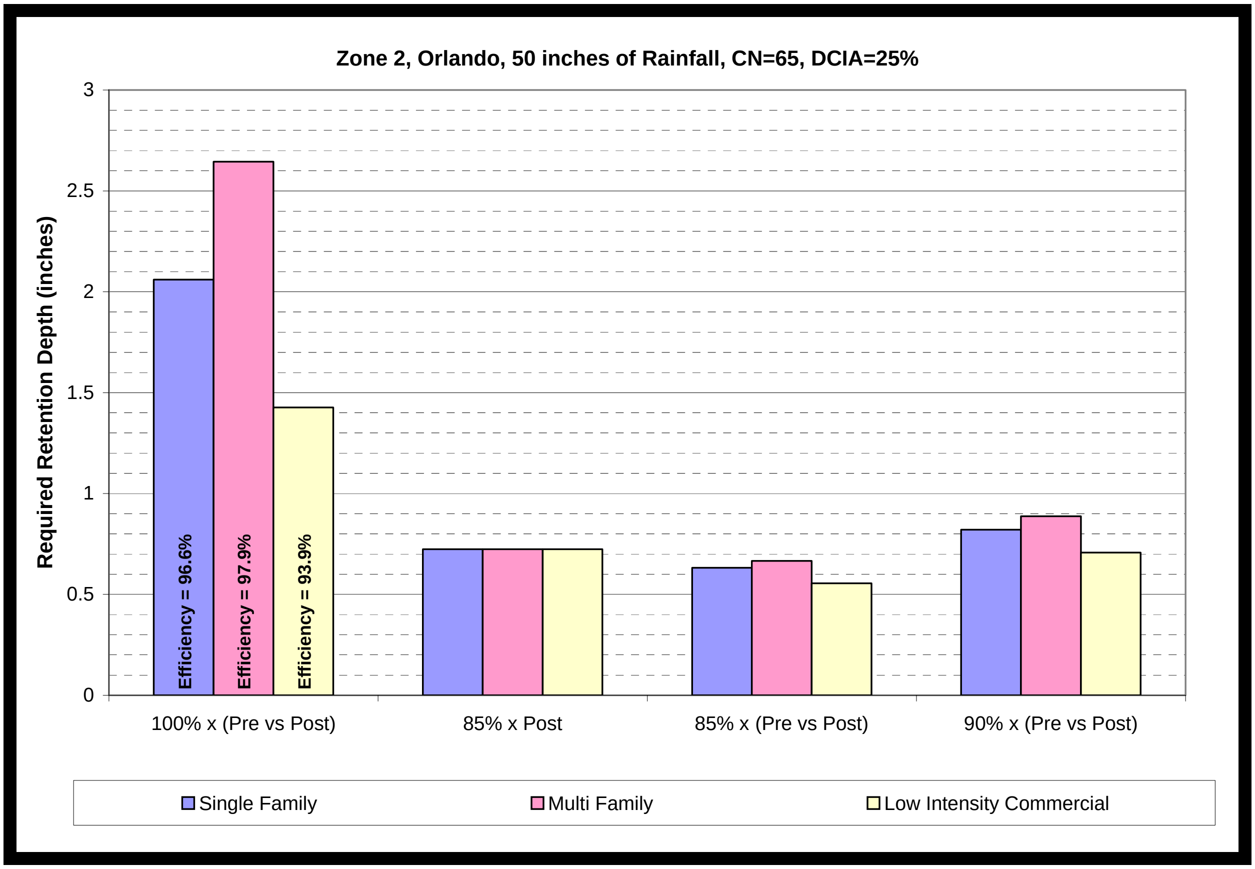

Exhibit 2.2. Example 1, Zone 2 - Orlando, CN=65, DCIA=25%

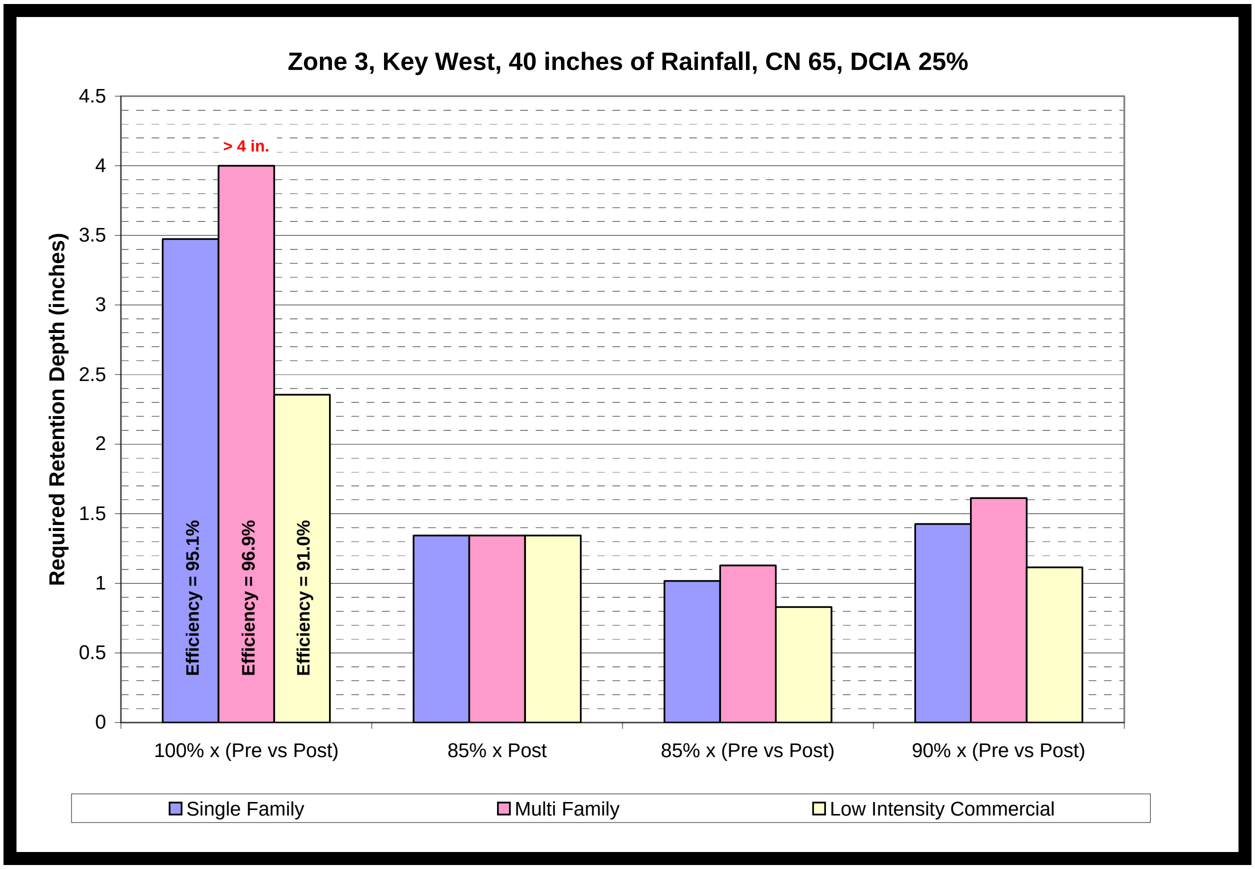

Exhibit 2.3. Example 1, Zone 3 - Key West, CN=65, DCIA=25%

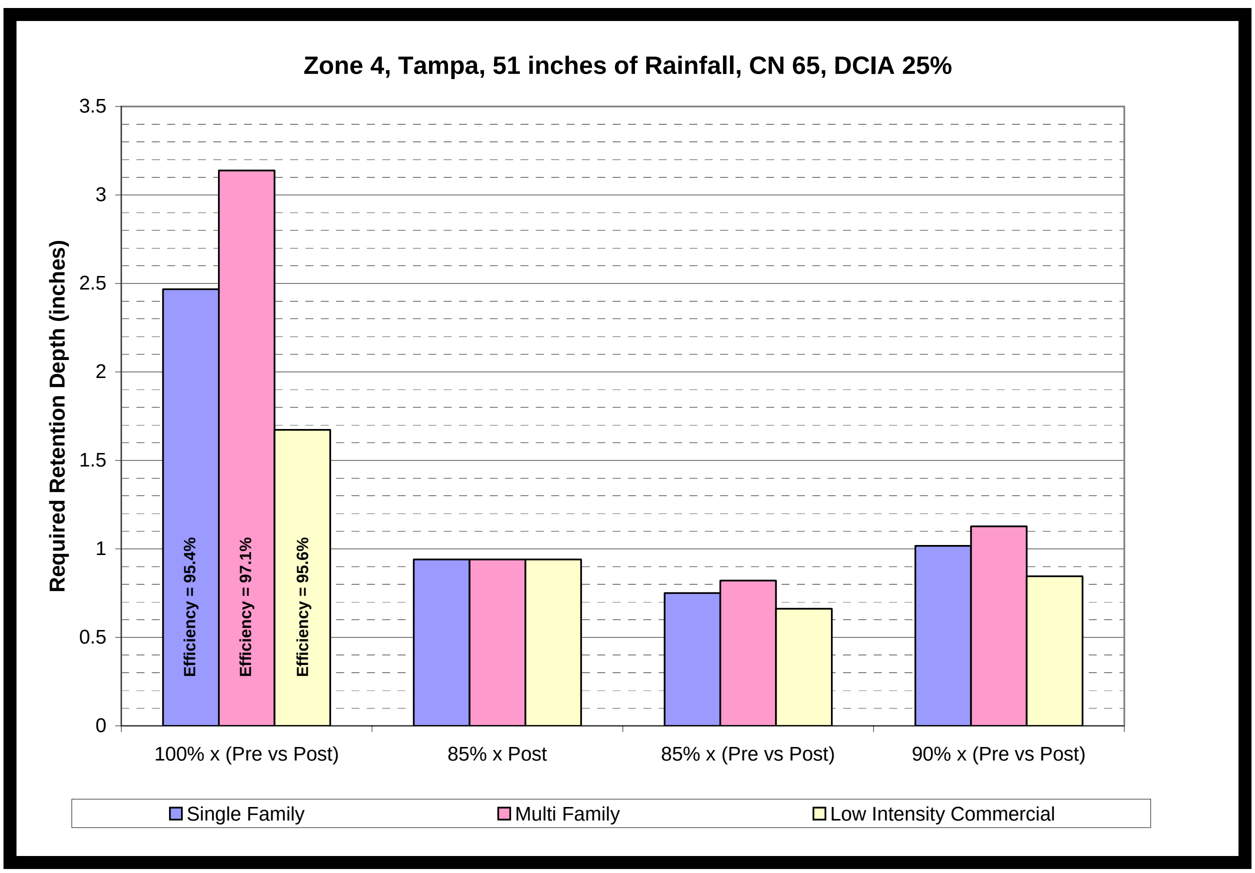

Exhibit 2.4. Example, Zone 4 - Tampa, CN=65, DCIA=25%

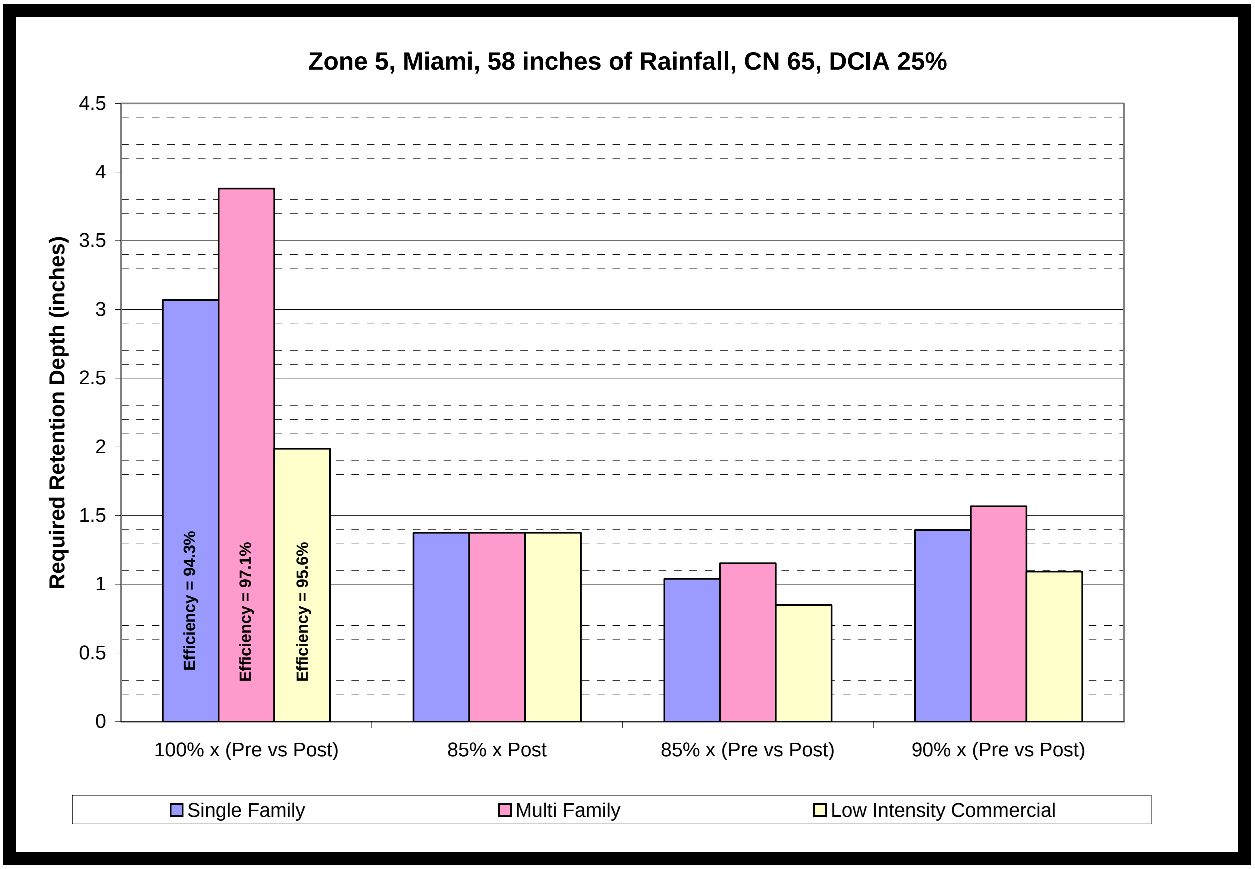

Exhibit 2.5. Example 1, Zone 5 - Miami, CN=65, DCIA=25%

As seen in this example, applying a reduction factor (in the range of 85% to 90%) to the pre vs post development increase in nutrient discharge gives a result which is similar to the 85% postdevelopment volumetric limit (while maintaining an implicit relationship to the land usage).

This is not entirely unexpected since the postdevelopment nutrient loading (controlled by phosphorous in this example) tends to dominate in the pre vs postdevelopment analysis, and as the predevelopment nutrient concentration approaches zero, an 85% reduction in pre vs postdevelopment loading is equivalent to 85% reduction in postdevelopment loading.

Example 2

Example 2 assumes the same locations and predevelopment conditions as Example 1 but increases the postdevelopment curve number from 65% to 75% and increases the DCIA from 25% to 40%.

The following series of exhibits (Exhibits 3.1 through 3.5) compares the resulting retention depths for the various combination of postdevelopment land use and climate zones. The results are qualitatively similar to Example 1, although the required retention depths are slightly larger because of the increased runoff volume generated as a result of the higher CN and DCIA.

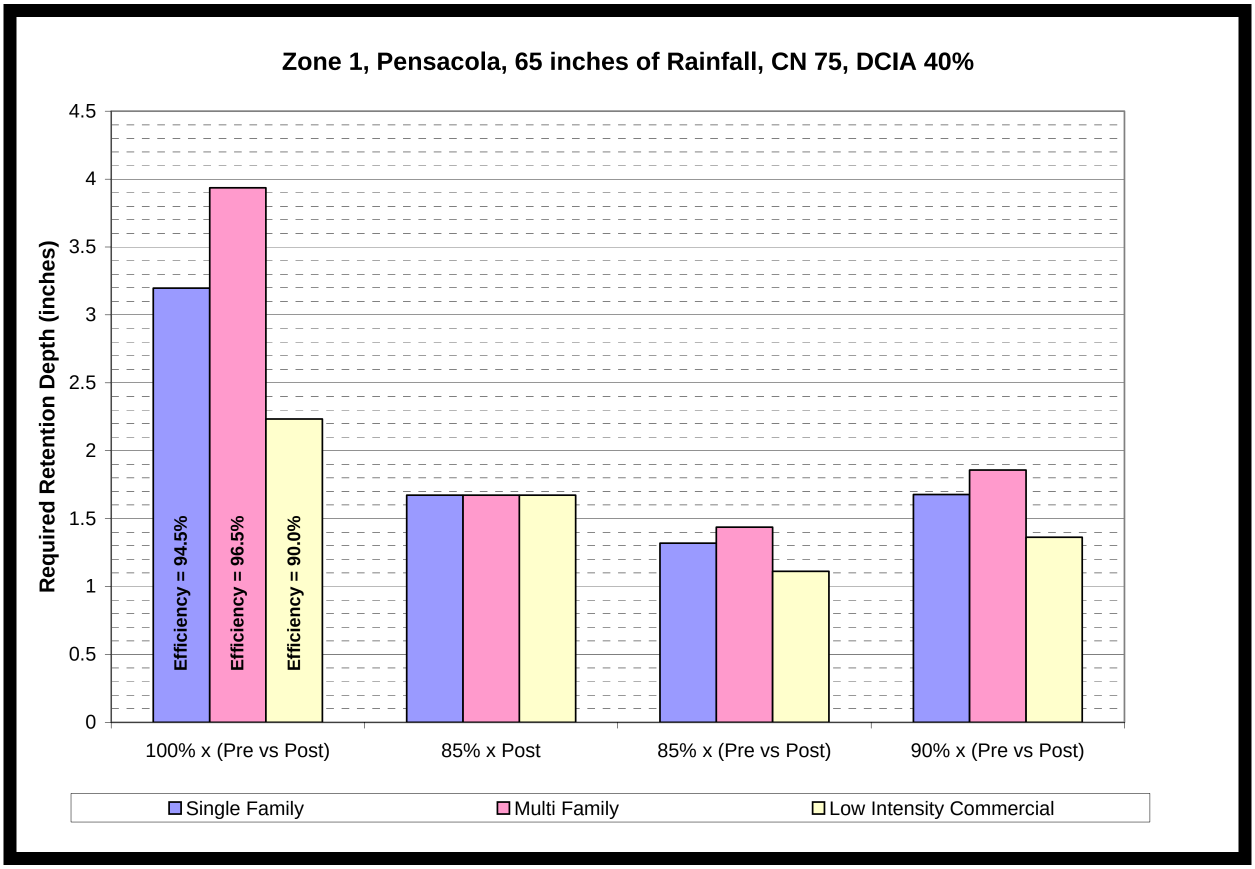

Exhibit 3.1. Example 2, Zone 1 - Pensacola, CN=75, DCIA=40%

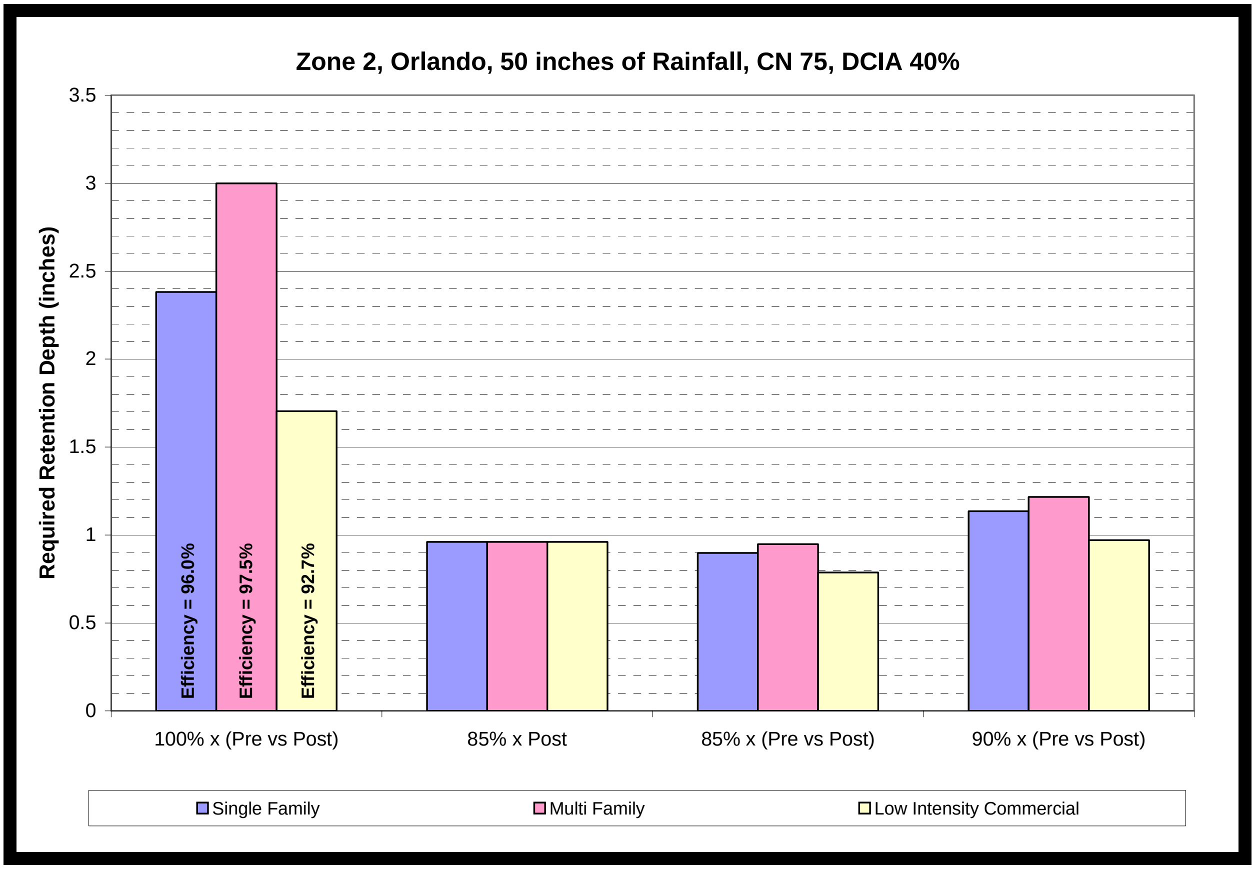

Exhibit 3.2. Example 2, Zone 2 - Orlando, CN=75, DCIA=40%

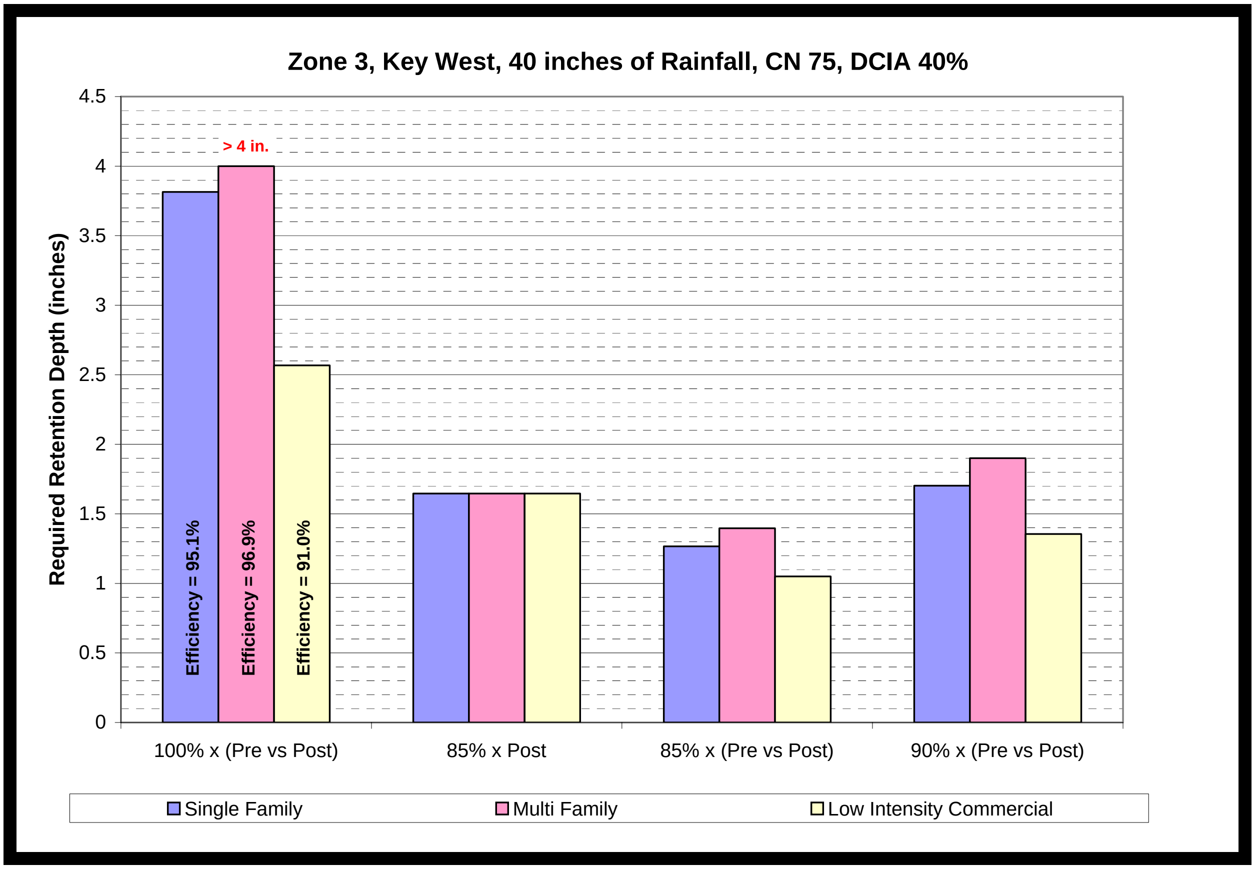

Exhibit 3.3. Example 2, Zone 3 - Key West, CN=75, DCIA=40%

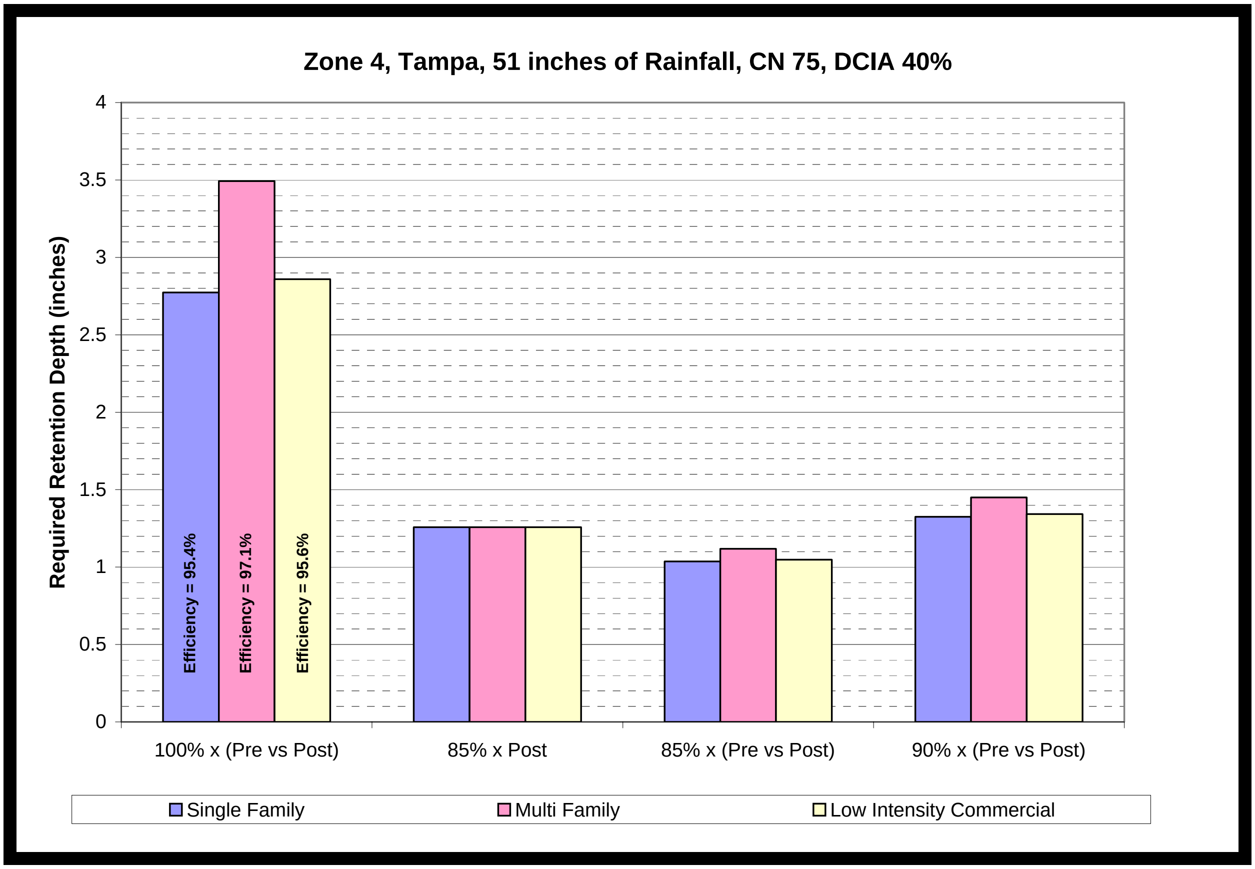

Exhibit 3.4. Example 2, Zone 4 - Tampa, CN=75, DCIA=40%

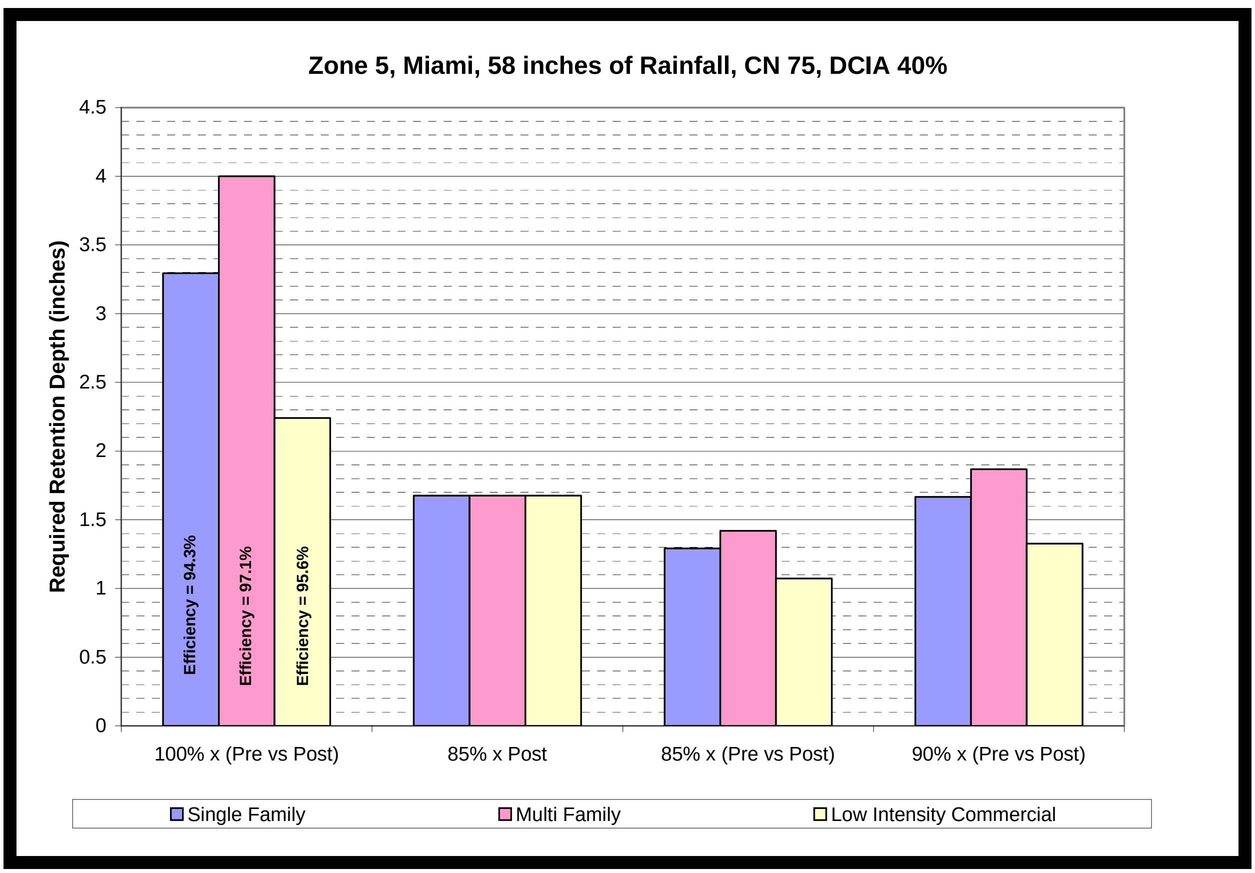

Exhibit 3.5. Example 2, Zone 5 - Miami, CN=75, DCIA=40%

Conclusion

Based on the examples considered in this memo, applying a reduction factor to the pre vs postdevelopment increase in discharge can provide a result which is similar to the 85% volumetric reduction of postdevelopment discharge, while maintaining a relationship to the land use. Based on these examples, the 85% volumetric reduction appears to be qualitatively similar to applying a reduction factor to the increase in pre vs postdevelopment discharge of between 85% and 90%.