VOLUME CONTROL
using
Inter-Event Dry Periods

Stormwater Management Academy
UNIVERSITY OF CENTRAL FLORIDA

O u t l i n e

- Why?
- Basic Principles
- Specifications and Regulations
- Watershed Abstractions
- The **VIV** curve, and the **REV** curve
- Performance in the “wet” year
- One year of Data
- Summary and Conclusions

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WHY, do volume control

1. Maintain groundwater recharge. Important in springsheds that control spring flow.
2. Reduce TMDL, retention of rainfall excess within a watershed retains mass.
3. Maintain the vegetation of an area.
4. Maintain micro climates for an area.
5. Save freshwater to be used as drinking water.
6. Reduce saltwater intrusion.
7. Reduce freshwater impacts on estuaries.
8. Supplement water used for irrigation.

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Historical 1 inch Rule

- Based on infiltration systems at rates of infiltration that exceeded 12 inch per hour.
- Based on an inter-event dry period of 4 hours (meteorological independence).
- Based on achieving 80% Solids removal similar to secondary treatment
- One inch of rainfall meet the 80% mass removal (no first flush) and was equivalent to a frequency of 90%.

What is a VIV curve

1. **V Volume reduction** (based on a yearly estimate)
2. **I Inter-Event Dry period** (based on the time for stated performance
3. **V Volume of storage** (for LID infiltration, on-site or regional ponds)

USED to specify infiltration storage volumes for a water budget or to reduce rainfall excess

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How do you

Maintain a water budget or volume control

1. On-site methods (LID or stormwater SMART development), example reduce DCIA, green roofs, infiltration, etc.
2. Off-site methods (regional facilities), example stormwater resue.

Based on:

1. Post = Pre volume control.
2. Historical data on rainfall

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STORMWATER MANAGEMENT

Some on-site (low impact developments) methods

1. **Pervious parking and driveways**.
2. **Parking lot bio-retention landscaping**.
3. **Cisterns (rainbowl)^{TM} for roof drains.**
4. **Reverse Berms (hold water on property).**
5. **Use plants that require little water**.
6. **Preserve depression areas for water storage**.
7. Non-compaction of building soils.
8. **Roadside exfiltration reactors**.
9. **Green Roofs.**

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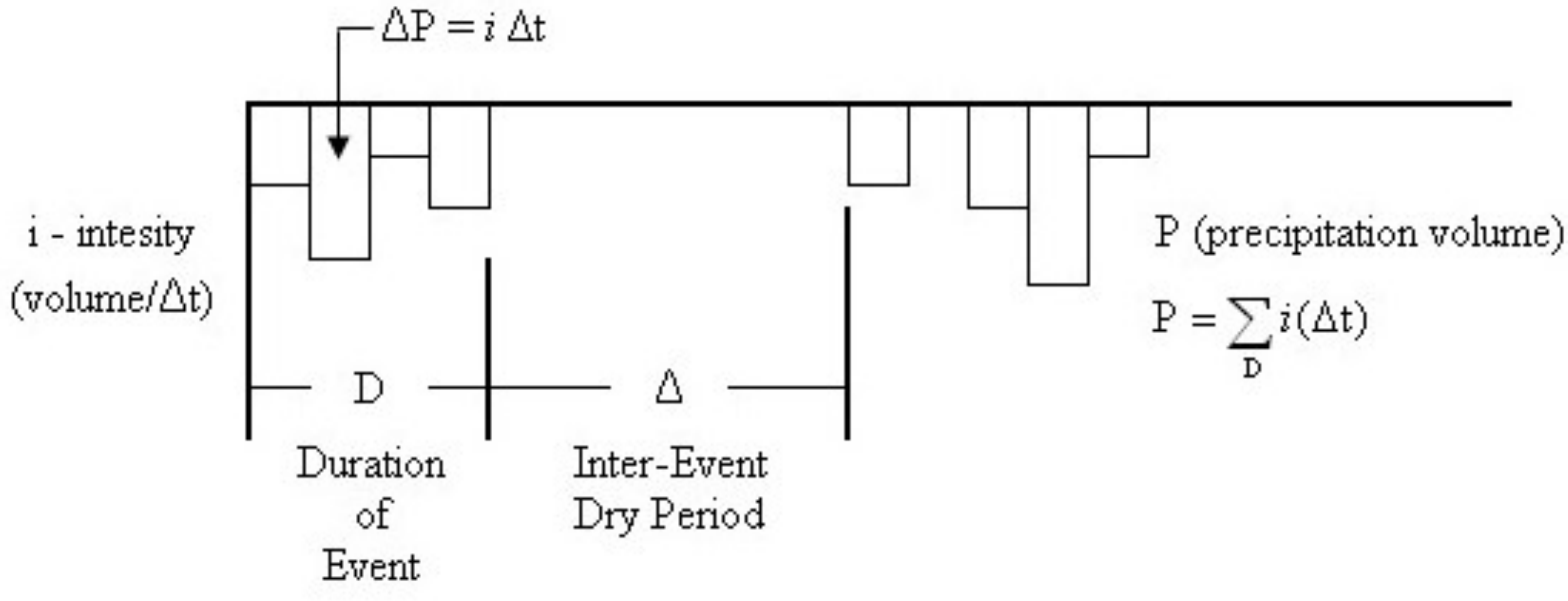
STORMWATER MANAGEMENT
Some off-site methods

1. **Regional ponds & Irrigation Utilities**
2. **Infiltration basins and trenches.**
3. **Exfiltration trenches.**
4. **Purchase of Lands for recharge**
5. **Swales and swale blocks**

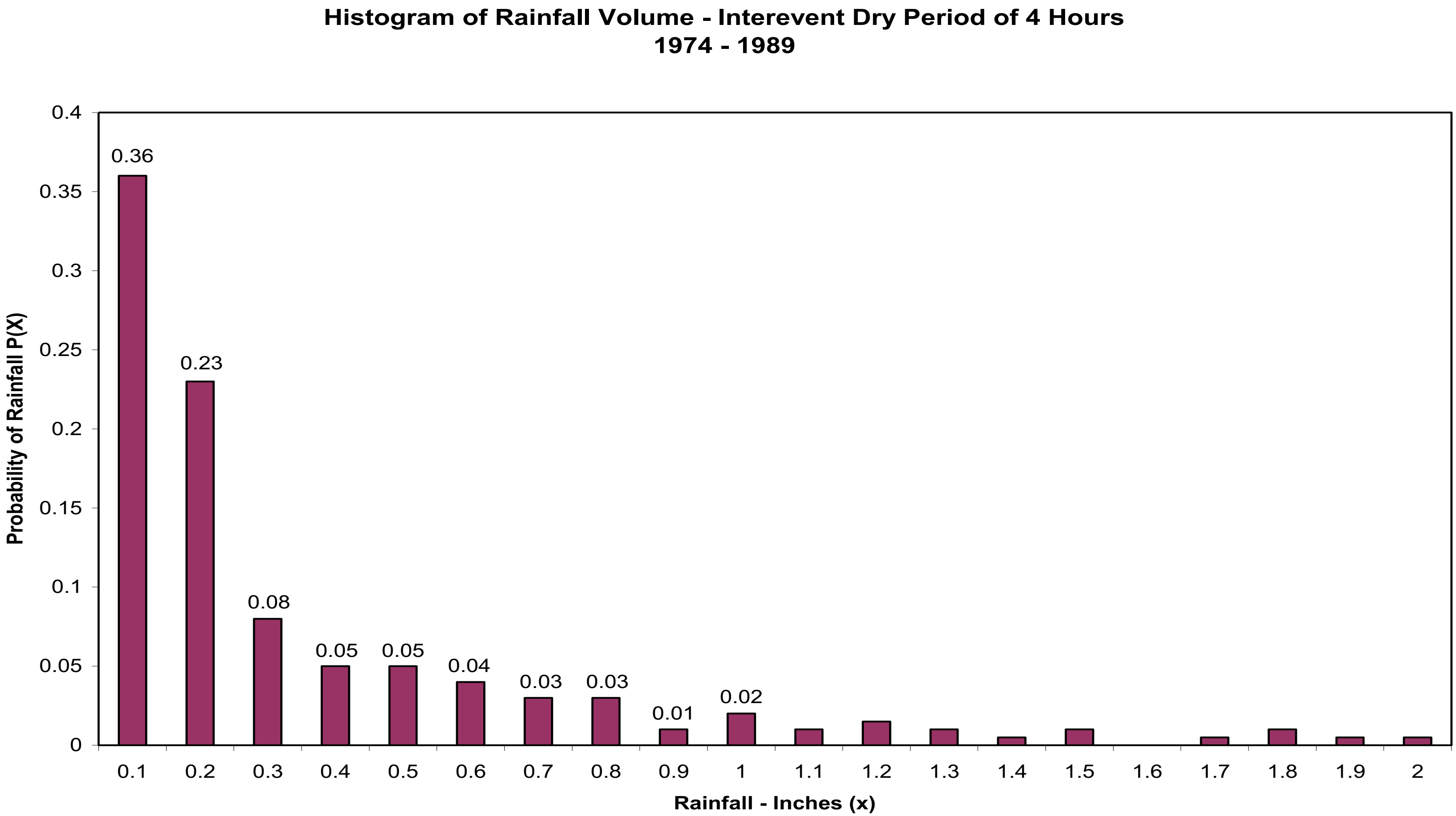
Basic Principles

- Inter-Event Dry Period



Histogram (Probability Distribution)

- N=130 events per year



Volume Abstracted or Diverted

- Using probability basic principles

$$\text{Volume Abstracted} = \sum_{i}^{\text{Abstraction Vol.}} \text{P}(i)_i\, \overline{\text{x}}_i \text{n} + \sum_{i=\text{Abstraction Vol.}}^{\infty} \text{P(i)}_i (\text{Abstraction Vol.})(\text{n})$$

Where the first term is the Expected Value of the abstraction volume up to the abstraction depth,
and the second term the abstraction volume for all storm events greater than or equal to the abstraction depth.

Storage during small events (volume less than or equal to 0.10 inches)

- Based on the histograms for an inter-event dry period of 4 hours, about 36% of 130 events per year are less than 0.10 inches.
- If the 0.10 inch is keep on site (intentional or natural storage), about 20% of the yearly rainfall is abstracted, C=0.80 (10.66/51) with
- Volume Abstracted = (.36)(130)(.05)+

  (1-.36)(130)(.10) = 10.66 inches.
- Compares to Harper and Baker 78.2%

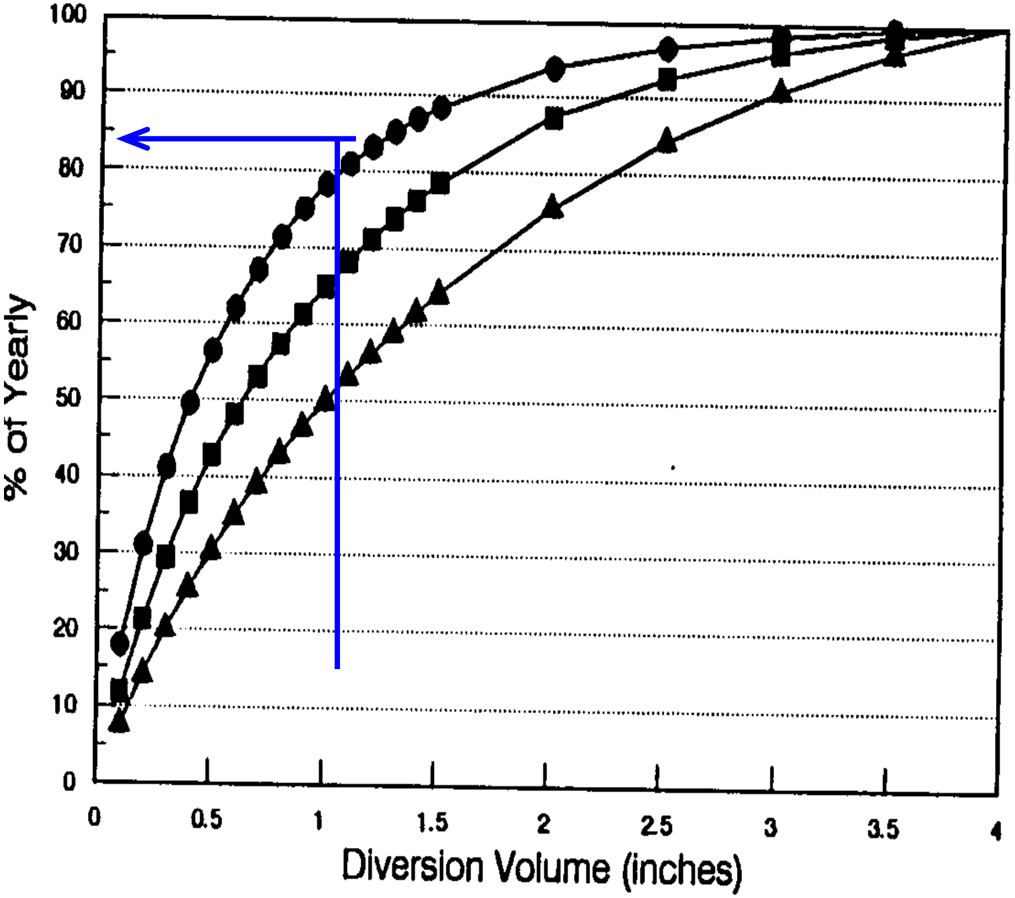
Now, lets divert ½ inch, 4 hour **D**

- Volume Diverted = (.36)(130)(.05) + (.23)(130)(.15) + +(.08)(130)(.25) + (.05)(130)(.35) + (.05)(130)(.45) + (1-.77)(130)(0.5) = 29.6 in

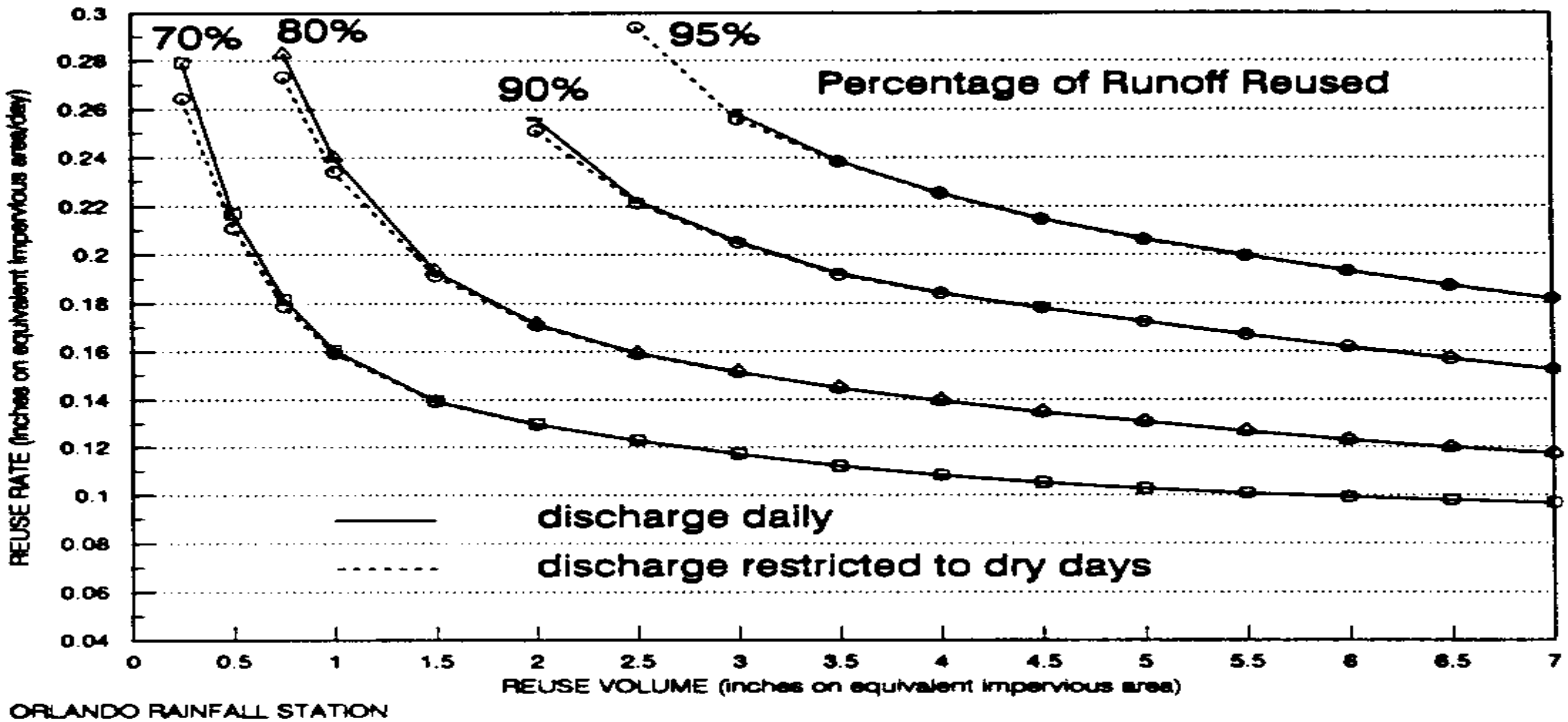
And 29.6/51= 58% of the yearly rainfall.

- Similar calculations for 1 inch shows 80% removal with a 4 hour **D**

VIV Curve Wanielista, inter-event publications



Reuse Curves SJRWMD Manual of Practice



Specifications and Regulations

1. **V V**olume reduction (80% - yearly estimate)
2. **I I**nter-Event Dry period (4hours for shallow ponds, 24-72 hours for deeper ones)
3. **V V**olume of storage (1 inch for LID infiltration, 3 inch for regional off line ponds)

USED extensively in the East Coast and Gulf Coast states. However… 1 inch does not apply to all situations, use rate of stormwater or infiltration rates should govern.

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How did the Wet 2004 Year affect the design removal target?

1. **V V**olume reduction (based on a yearly estimate, how much is the question?)
2. **I I**nter-Event Dry period (this is fixed and will remain the same, 4 or 72 hours in this case)
3. **V V**olume of storage (this is fixed by regulation, for LID infiltration, on-site, or regional ponds)

USED to specify infiltration storage volumes for a water budget or to reduce rainfall excess

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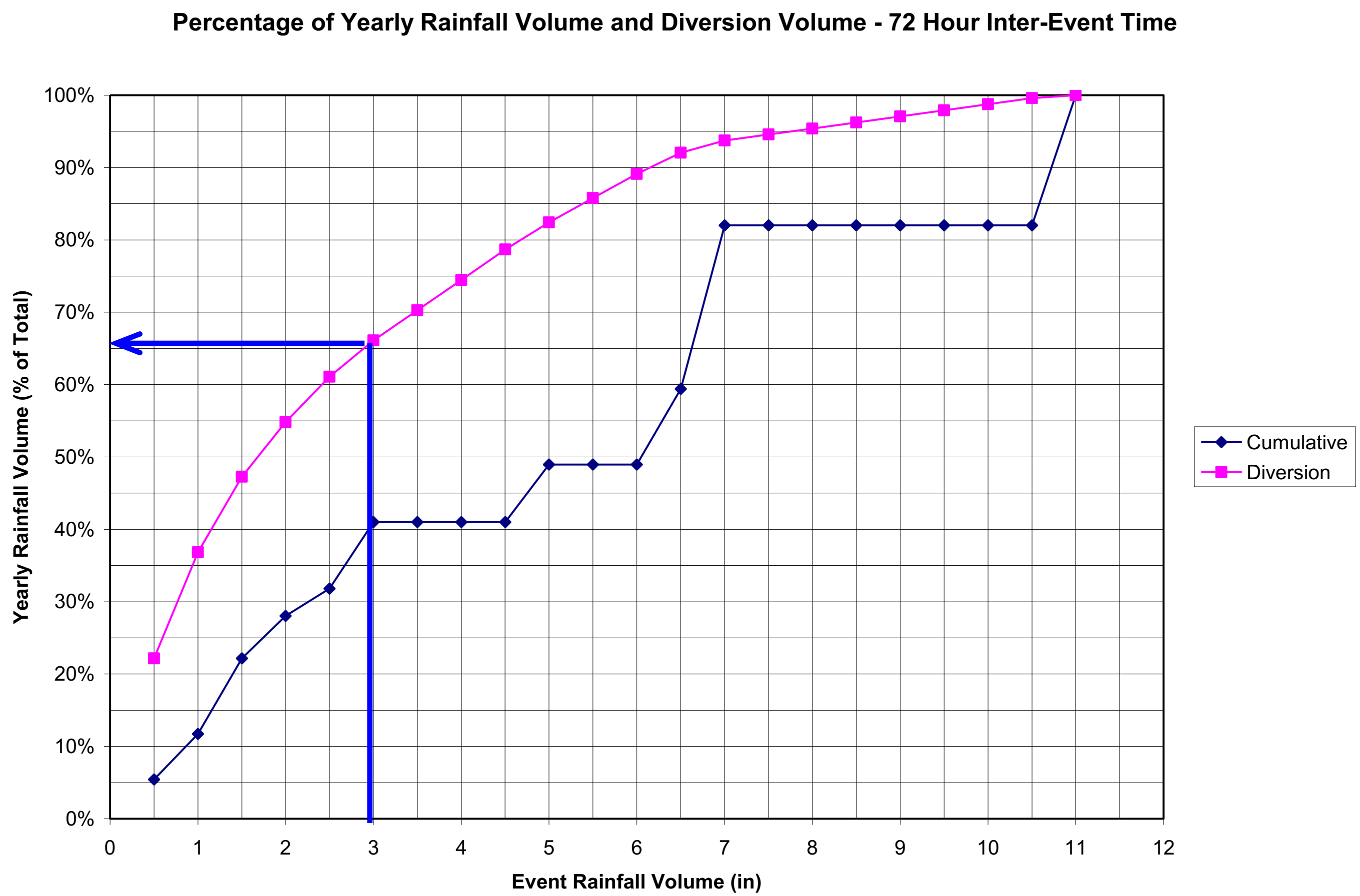
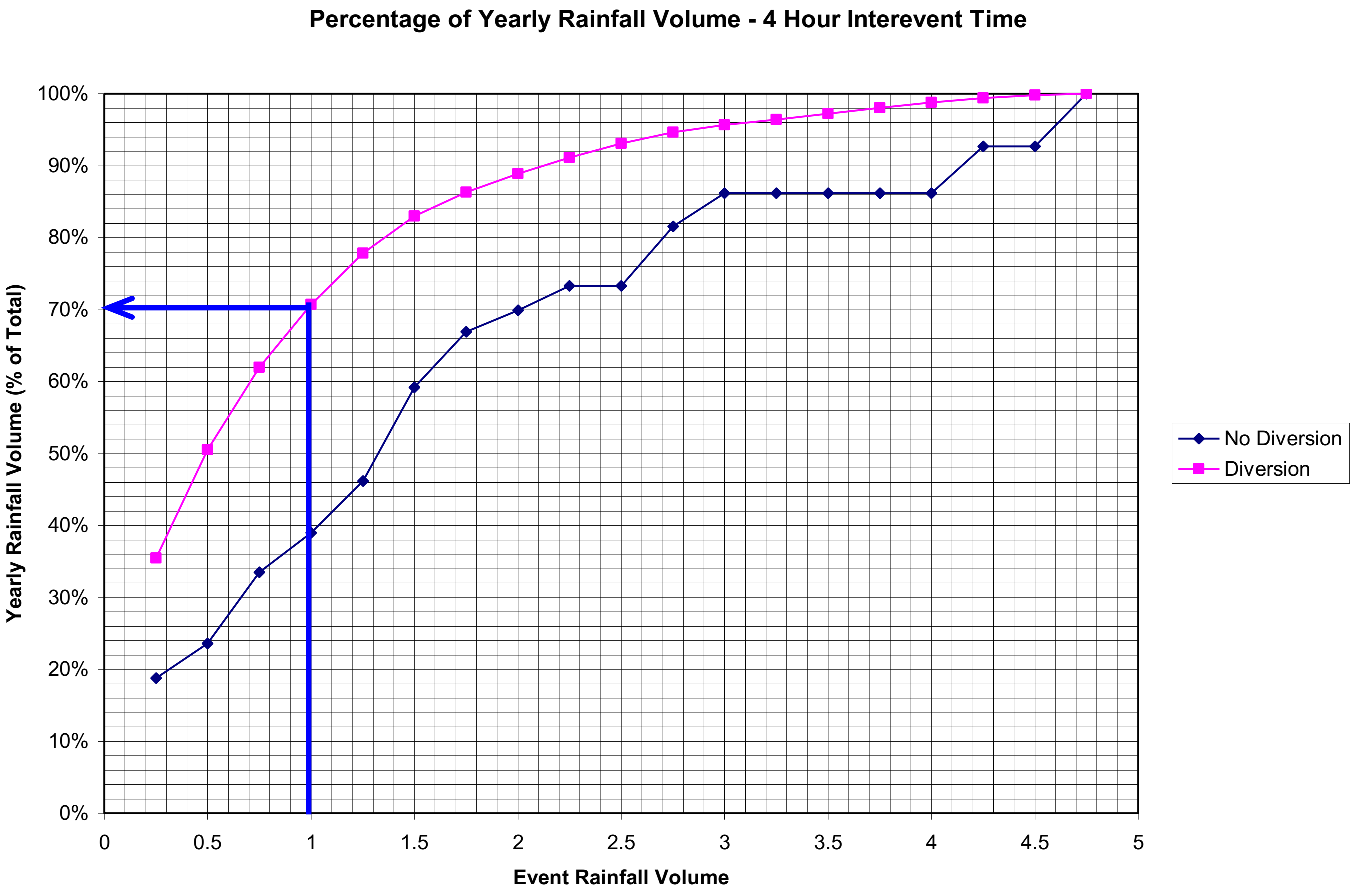
64 inch Wet Year,72 Hour D, 3 inch pond

Volume Reduction = 65%



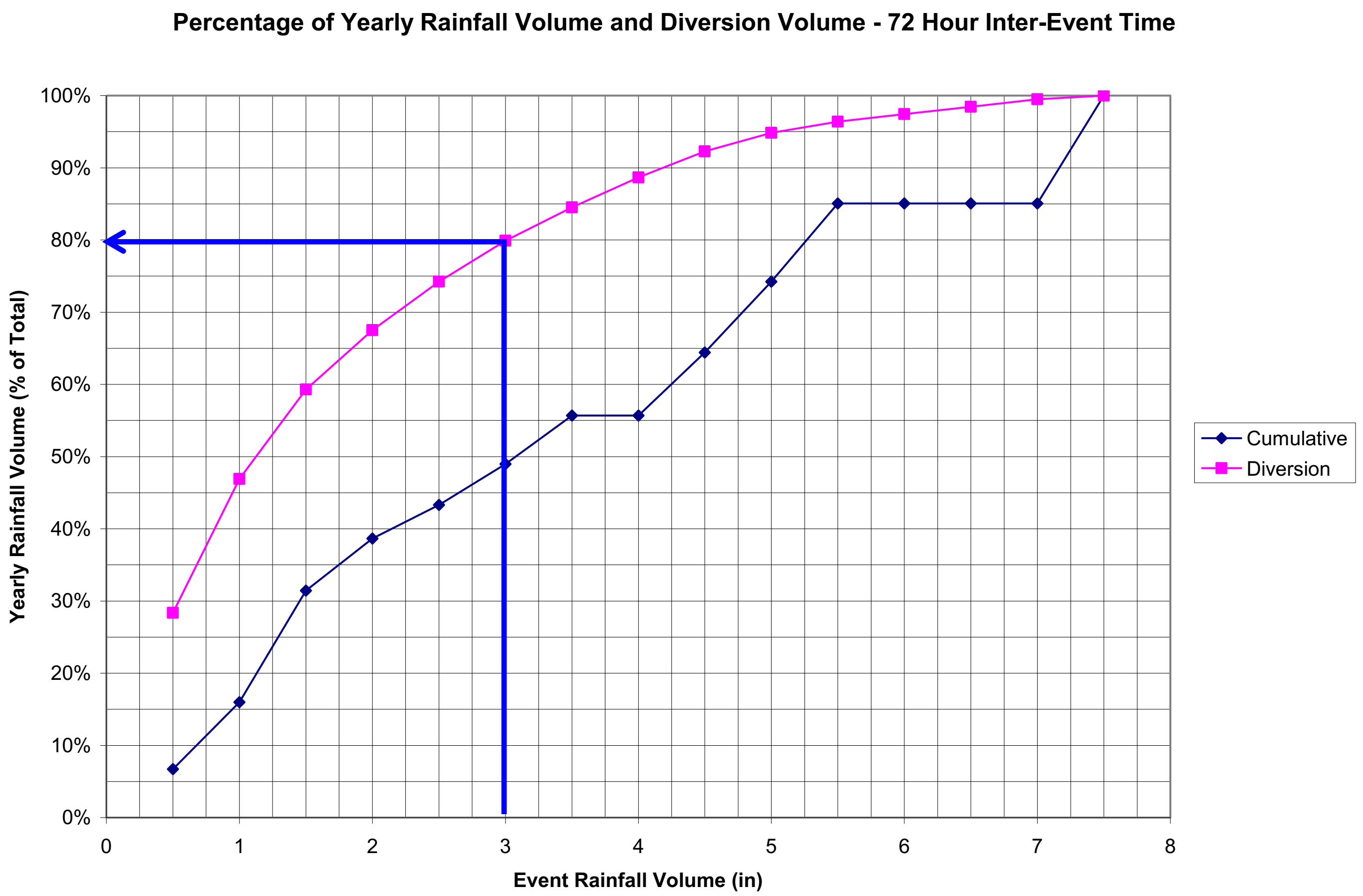
64 inch Wet Year,4 Hour D, 1 inch pond

Volume Reduction = 70%



48 inch Wet Year,72 Hour D, 3 inch pond

Volume Reduction = 80%



What if only one year of data are available for the VIV curve and that year is near the average volume?

1. **V** **V**olume reduction (based on a yearly estimate, how much is the question?)
2. **I** **I**nter-Event Dry period (this is fixed and will remain the same, 4 or 72 hours in this case)
3. **V** **V**olume of storage (this is fixed by regulation, for LID infiltration, on-site, or regional ponds)

USED to specify infiltration storage volumes for a water budget or to reduce rainfall excess

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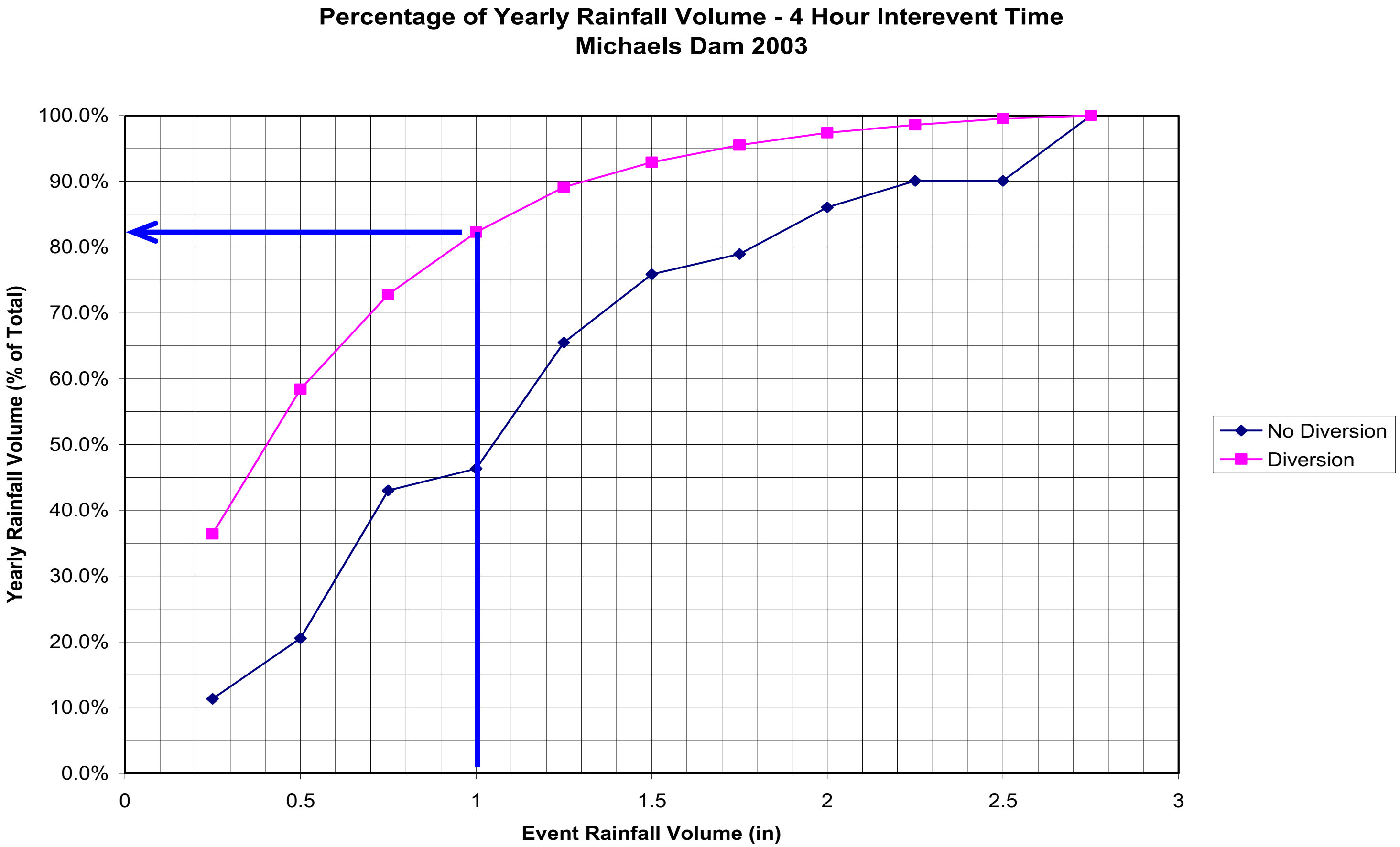
"Average" 53 inch rainfall year,4 Hour D, 1 inch pond volume

(Volume Reduction = 82%



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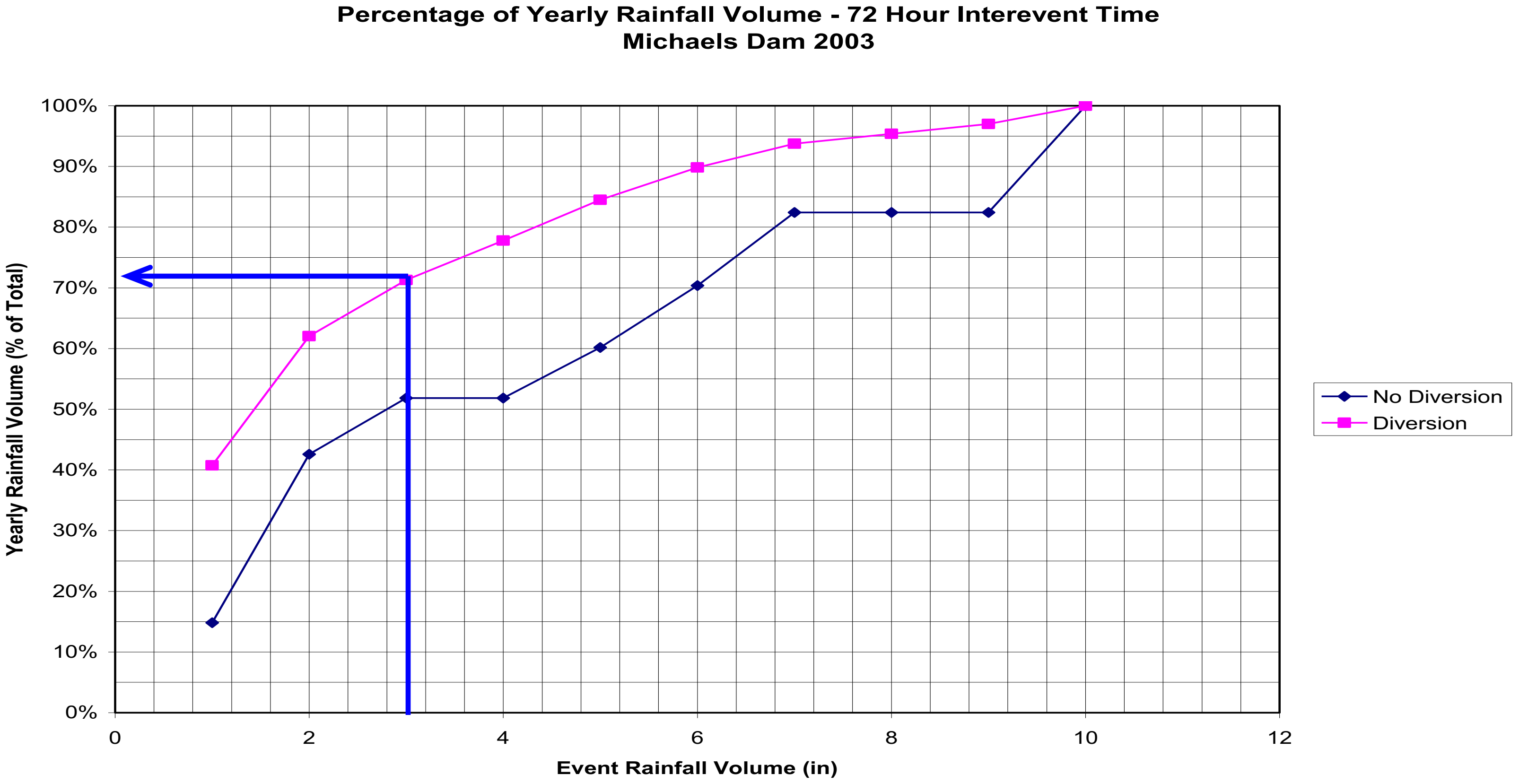
“Average” 53 inch rainfall year,72 Hour D, 3 inch pond volume

Volume Reduction = 72%



Single Family Development

Watershed Conditions:

Total Size: 100 Acre, "A" Type Soil

Pre Condition, mixed forest / rangeland
CN = 50, no impervious area

Post Condition, 100 single family units
CN = 69, DCIA = 13.5 Ac
Total Impervious = 20 Ac

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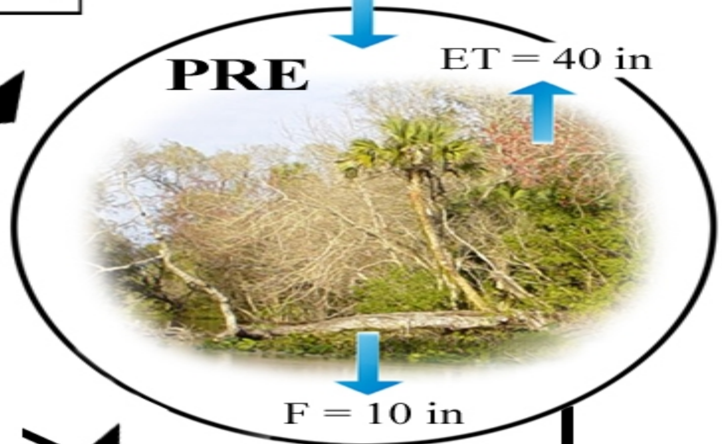
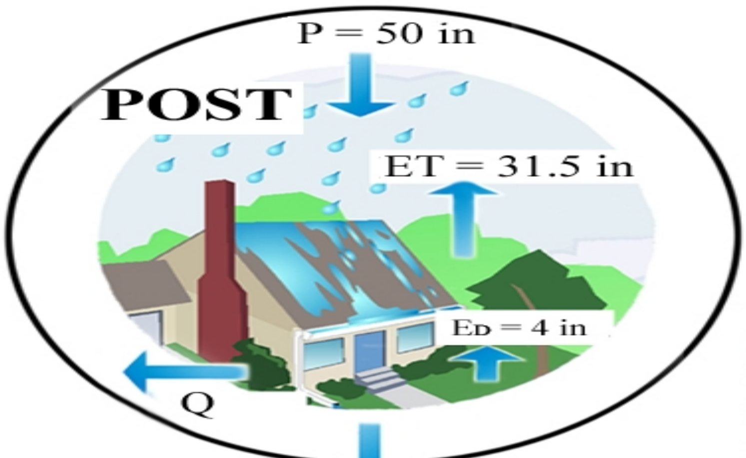




Yearly Volume Balance:

Pre Excess = 10 in/yr

Post Excess = 14.5 in/yr
(no stormwater management)

Design (Post = Pre Recharge):

Off-line Retention (2.5 in) Pond Area* = 2.1 Ac	F = 10 in Q = 4.5 in
Irrigation (based on 3 in) Pond Area** = 2.4 Ac Irrigation Area = 27 Ac	F = 10 in Q = 4.5 in

Existing Design Comparisons:

Off-line Retention (0.75 in) Pond Area* = 4.7 Ac	F = 11.6 in Q = 2.9 in
On-line Retention (1.50 in) Pond Area* = 9.4 Ac	F = 13.7 in Q = 0.8 in

* Depth of Pond = 2.0 feet ** Depth of Pond = 5.0 feet

LEGEND:

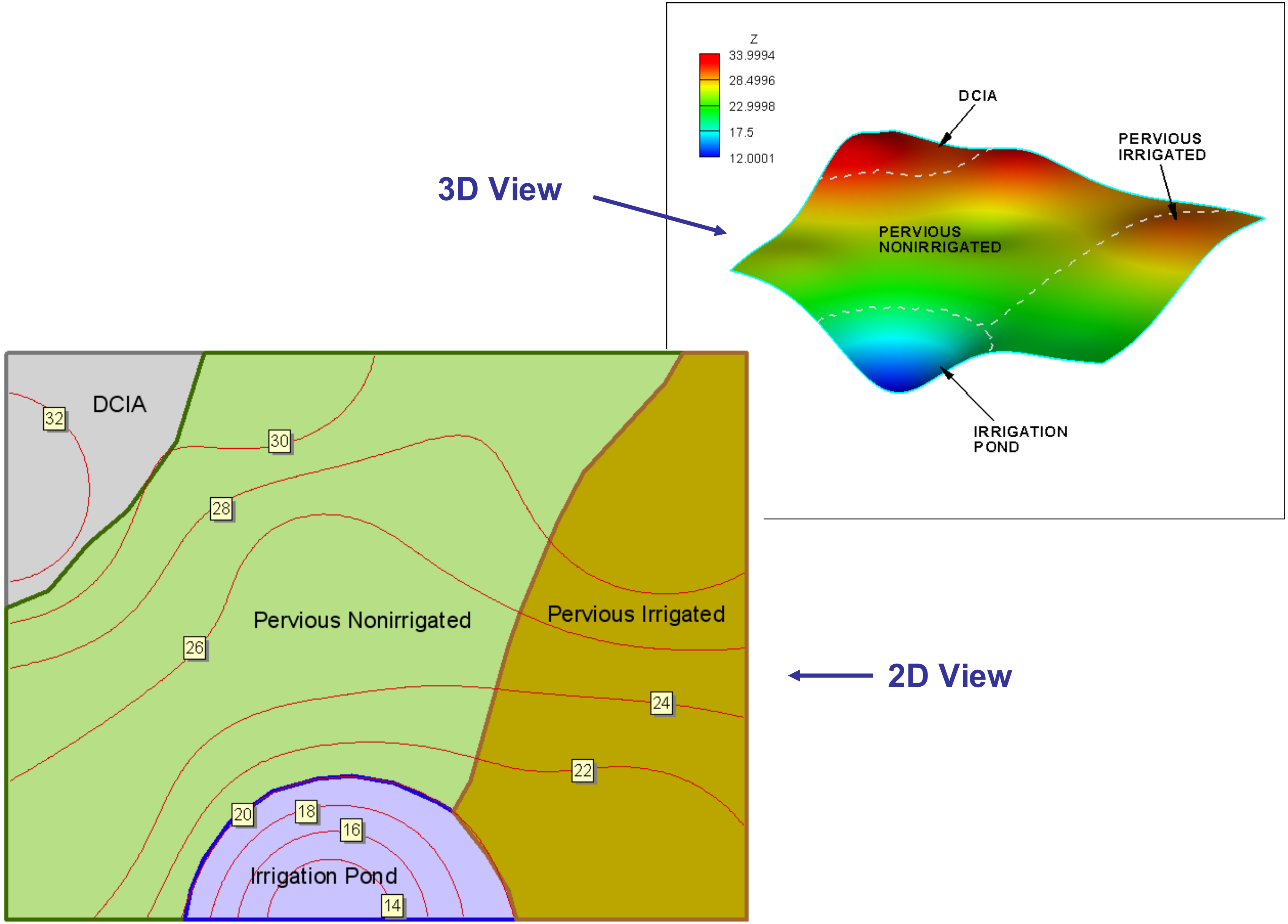
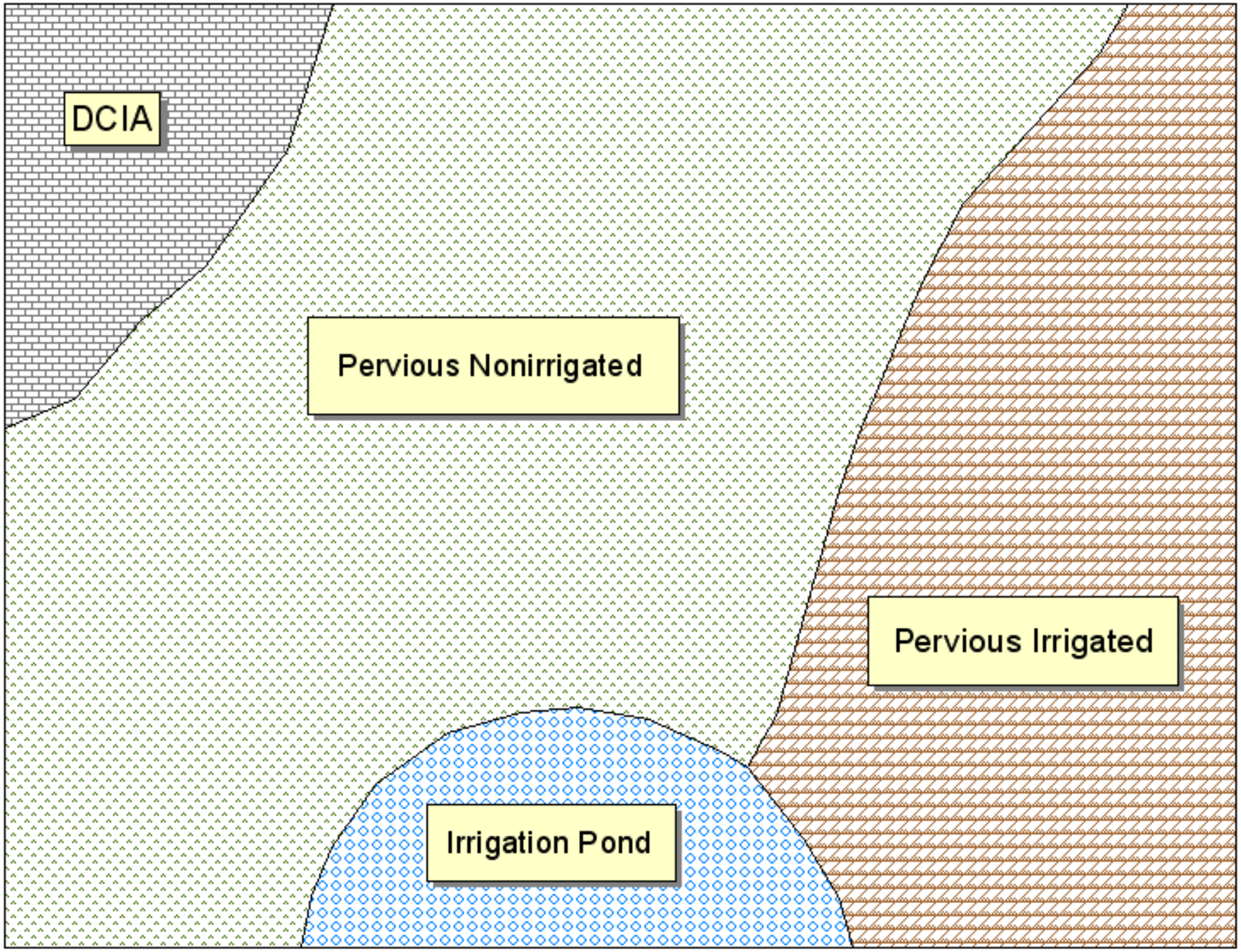


Figure 1: Land surface elevations for a closed basin (unit: feet NGVD)



<u>Total Watershed</u>:

9.97 acres

<u>DCIA</u>:

0.78 acre

<u>Pervious Nonirrigated</u>:

5.49 acres

<u>Pervious Irrigated:</u>

2.84 acres

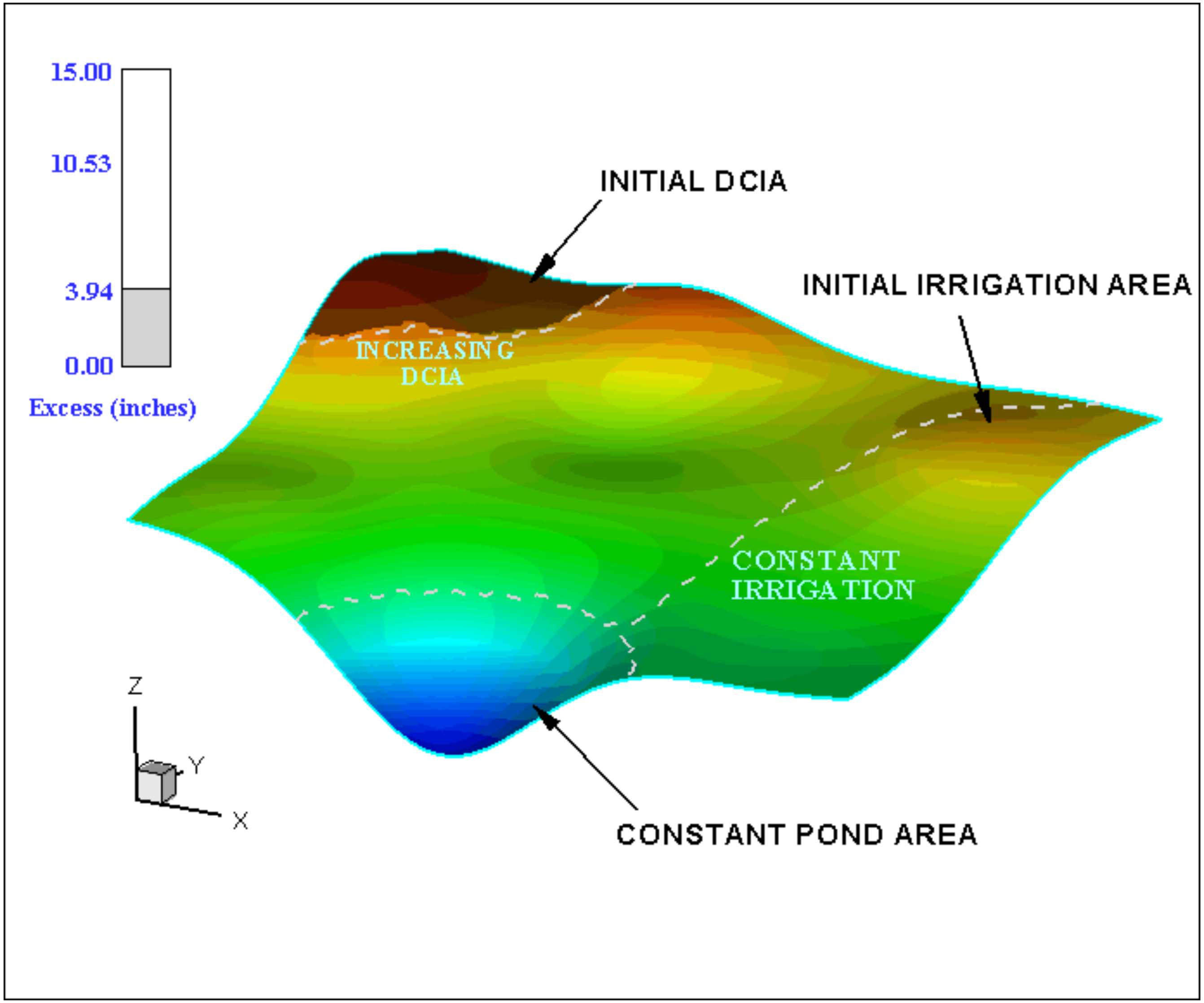
<u>Irrigation Ponds:</u>

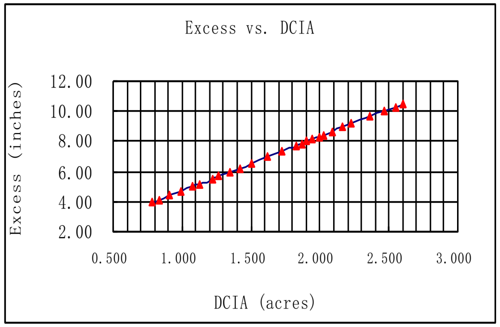
0.86 acre

<u>Pervious + Irrigation Excess</u>:

3.94 inches

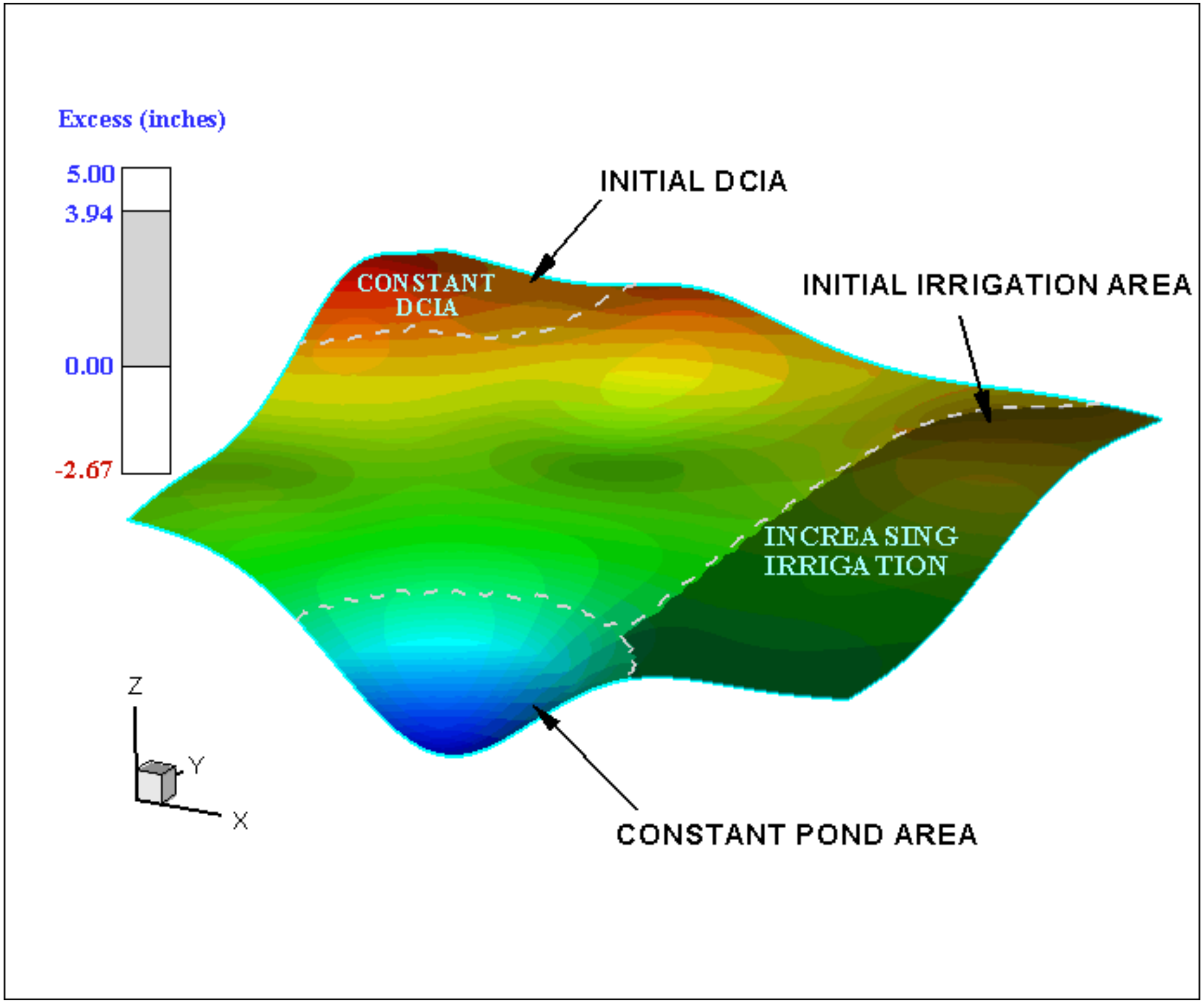
Figure 2: Land Use before tremendous urbanization for a closed basin (P = 50.0, E = 44.0, ET = 40.0, IET = 30.0, IA = 4.0, unit: inches/year)

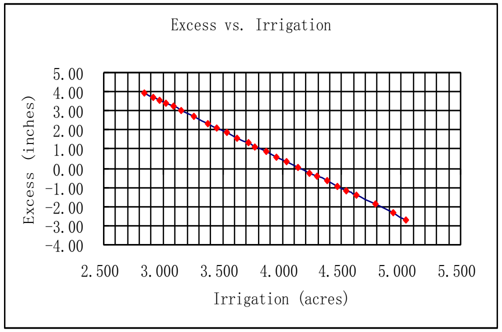




DCIA (acres)	Excess (inches)
0.784	3.94
0.838	4.14
0.912	4.40
0.990	4.69
1.079	5.01
1.129	5.19
1.218	5.51
1.262	5.67
1.343	5.96
1.420	6.24
1.505	6.55
1.619	6.96
1.722	7.33
1.826	7.71
1.873	7.87
1.905	7.99
1.948	8.15
2.000	8.33
2.031	8.45
2.088	8.65
2.168	8.94
2.228	9.16
2.359	9.63
2.462	10.00
2.547	10.31
2.607	10.53

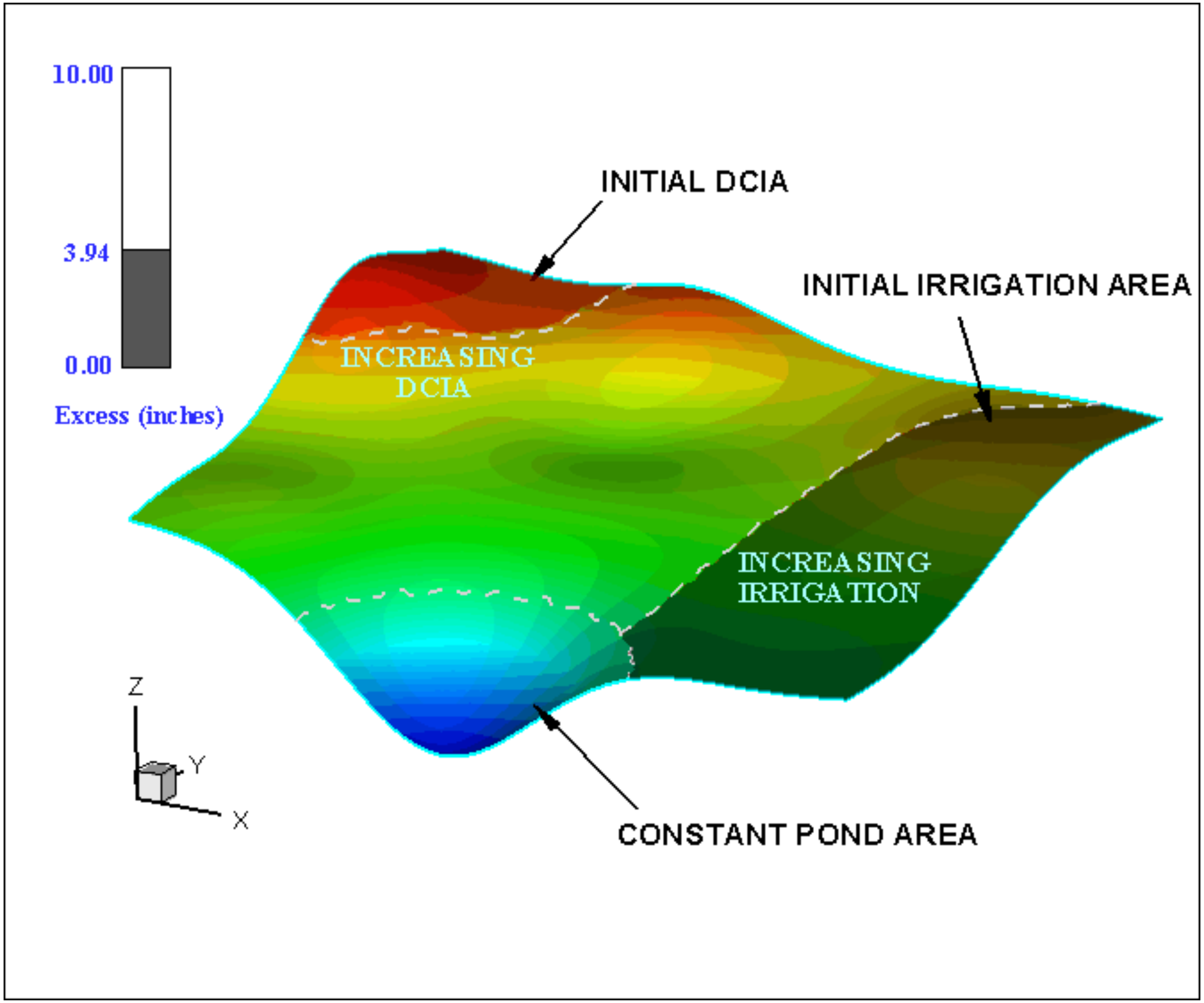
Figure 3: Excess vs. increasing DCIA and constant Irrigation for the closed basin

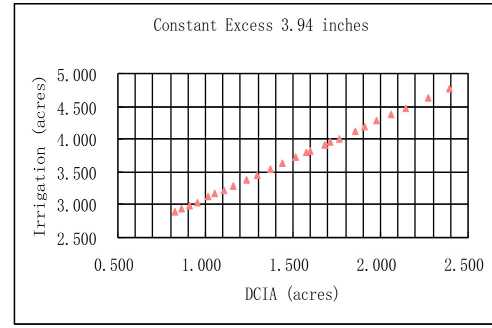




Irrigation (acres)	Excess (inches)
2.840	3.94
2.916	3.71
2.967	3.56
3.021	3.40
3.085	3.21
3.156	2.99
3.260	2.68
3.376	2.33
3.452	2.10
3.531	1.86
3.620	1.60
3.715	1.31
3.772	1.14
3.869	0.85
3.955	0.59
4.033	0.35
4.130	0.06
4.229	-0.24
4.298	-0.44
4.375	-0.68
4.463	-0.94
4.536	-1.16
4.626	-1.43
4.783	-1.90
4.932	-2.35
5.036	-2.67

Figure 4: Excess vs. increasing Irrigation and constant DCIA for the closed basin
(Note: negative excess means water needs to be introduced into the basin)





DCIA (acres)	Irrigation (acres)
0.829	2.895
0.865	2.936
0.912	2.995
0.952	3.043
1.016	3.120
1.055	3.164
1.103	3.222
1.162	3.293
1.235	3.382
1.296	3.454
1.372	3.546
1.437	3.625
1.517	3.720
1.577	3.790
1.599	3.818
1.682	3.920
1.714	3.958
1.762	4.015
1.859	4.130
1.906	4.188
1.980	4.275
2.057	4.370
2.147	4.475
2.275	4.630
2.392	4.770

Figure 5: Excess vs. increasing both DCIA and Irrigation for the closed basin

Conclusions

1. Basic principles of Probability can be used to specify design storms for both volume control and for pollution control.
2. All stormwater designs should consider the recovery or treatment time, which is the minimum inter-event dry period (**D**).
3. An initial abstraction of 0.10 inches of each and every storm can result in about 20% of the yearly rainfall not being discharged
4. **VIV** curves are useful to size LID infiltration areas, stormwater use ponds, and regional infiltration areas.

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Conclusions

5. 1 inch of diversion for infiltration or stormwater use results in 80% of the rainfall excess not being discharged given a 4 hour **D.** This is the basis for the 1 inch rule.
6. A 72 hour **D** requires an event volume of 3 inches to achieve an 80% reduction in rainfall excess.
7. During a wet year (2004) with 64 inches of rainfall, the % reduction in rainfall excess efficiency decreased to 65% with a **D** equal to 72 hours.
8. REV curves can be used to design reuse ponds for irrigation.

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Thank you. For additional information, see www.stormwater.ucf.edu

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