IBS Site Drainage: Senior Design Project

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OUTLINE

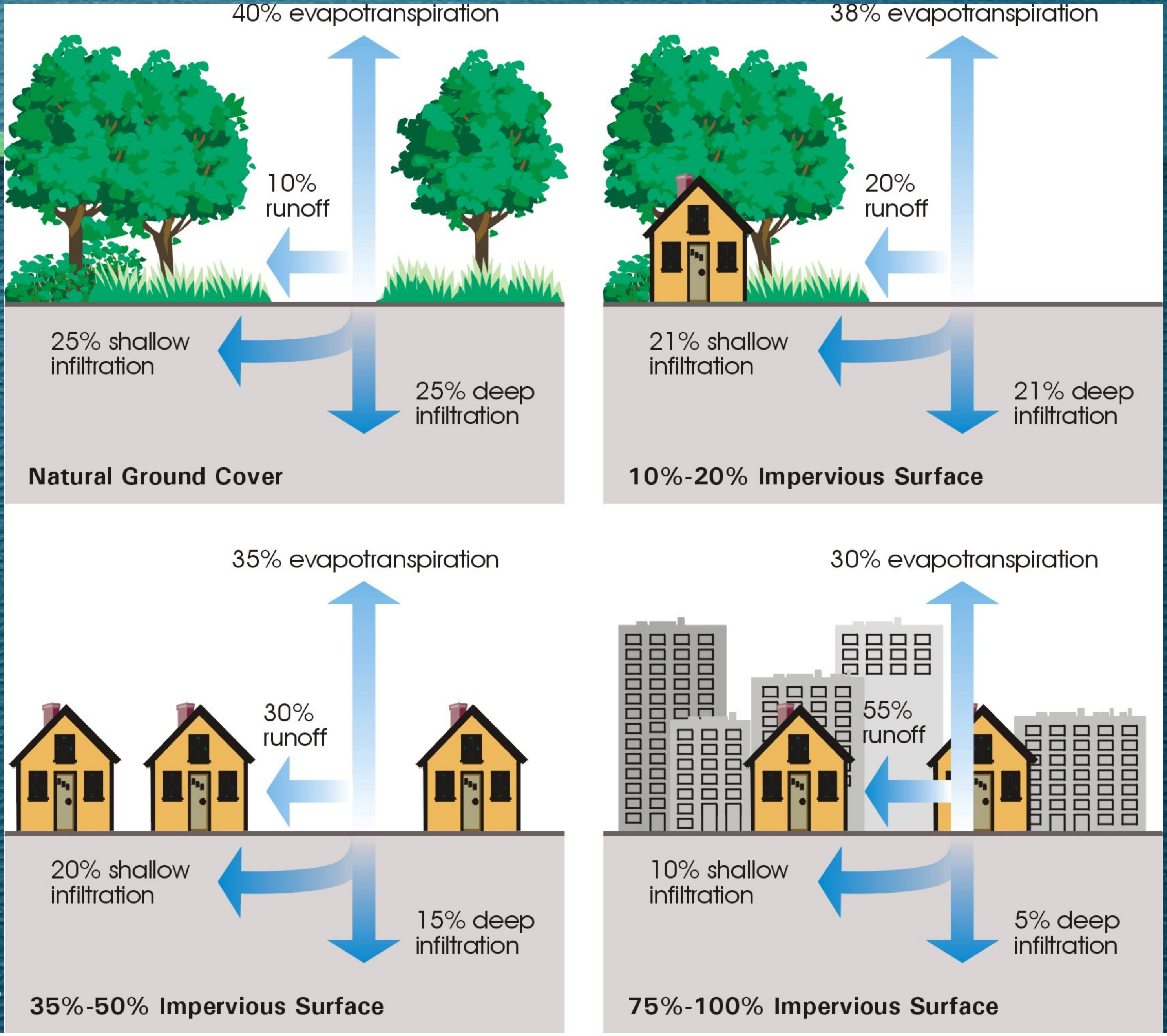
- Motivation for Stormwater Management
  - Quantity (both onsite, local, and watershed)
  - Quality (receiving waters)
- City of Boulder Stormwater Standards
- Suggested analytical methods to quantity-based design standards
- LEED standards
- Suggested analytical methods to meet LEED requirements
- State of the practice in sustainable drainage: concepts and examples

Motivation for Management of Quantity as well as Quality

- Relief of local flooding drove traditional drainage system design.
- Impervious surfaces combined with conveyance systems increase runoff volumes and peak flow rates downstream.
- Downstream flooding concerns drove designs to include detention facilities.
- Awareness of the impacts of NPS pollution to receiving waters.


Roadways, Paved Surfaces and Turf Used to Collect, Convey and Concentrate Runoff
"Good Drainage"
The the objective conventional site design is to increase runoff.

Idealized Impacts of Development



City of Boulder Stormwater Standards

Table 7-1: Design Storm Frequencies

Land Use	Initial Storm	Major Storm
Single Family Residential	2 Year	100 Year
All Other Uses	5 Year	100 Year
Detention Ponding Design	10 Year	100 Year

Suggested Analytical Methods to Satisfy Flow Rate Requirements

Rational Method for areas less than 160 acres (page 7-15 Boulder Design Standards).

(2) **Rational Method:** For all basins smaller than 160 acres, the Rational Method shall be used to calculate runoff for both the initial and major storms. A detailed description and in-depth discussion of the rational method and its components are presented in the UDFCD Drainage Criteria Manual. The formula for the rational method is as follows:

$$\mathbf{Q = CIA}$$

Where: Q = Flow Rate in Cubic Feet Per Second

C = Runoff Coefficient

I = Rainfall Intensity for the Design Storm (inches/hour)

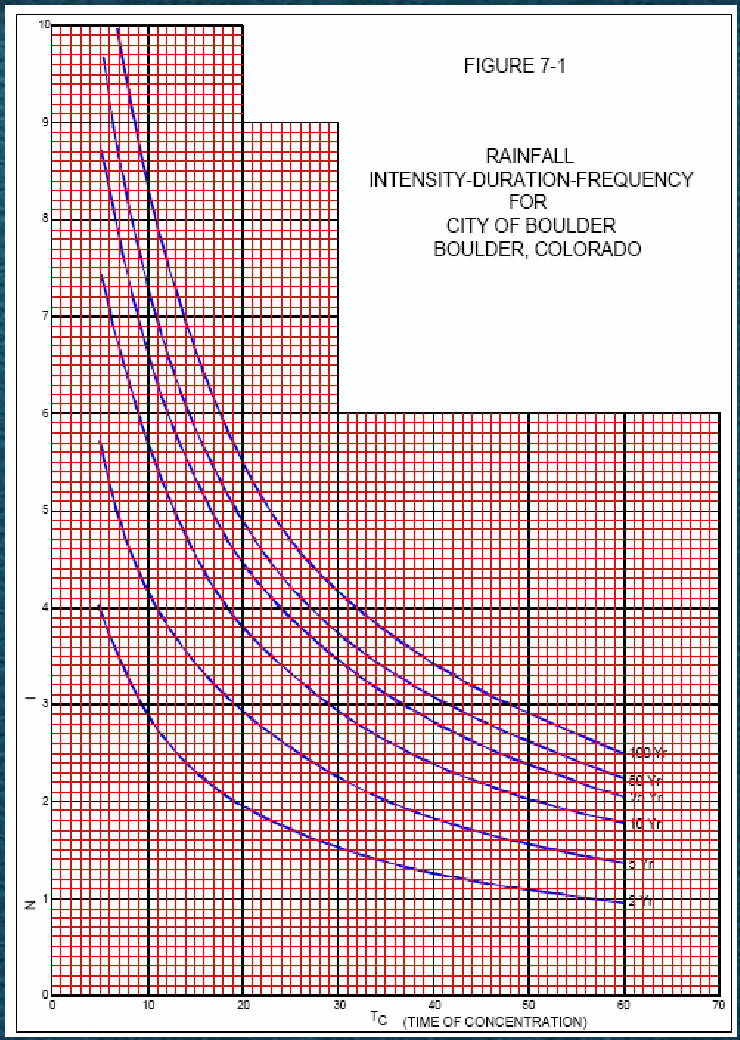
A = Drainage Area (acres)

Rational Method

- $Q = CiA$
- C is a function of land cover, soils
- i is the rainfall intensity (inches/hour) for a specified time of concentration
- A is the total area in acres contributing runoff.

City of Boulder IDF Curves

- Based on UDFCD rainfall analysis
- Ordinates are Rainfall Intensities (in/hr)
- P. 7-17 of Boulder's Design Standards



City of Boulder Detention Requirements

Runoff Volume considerations muddy the waters!

For basins under 160 acres, use triangular or trapezoidal Unit hydrograph, or FAA method outlined in UDFCD vol. 2.

(B) Design Frequency, Release Rates, and Storage Requirements

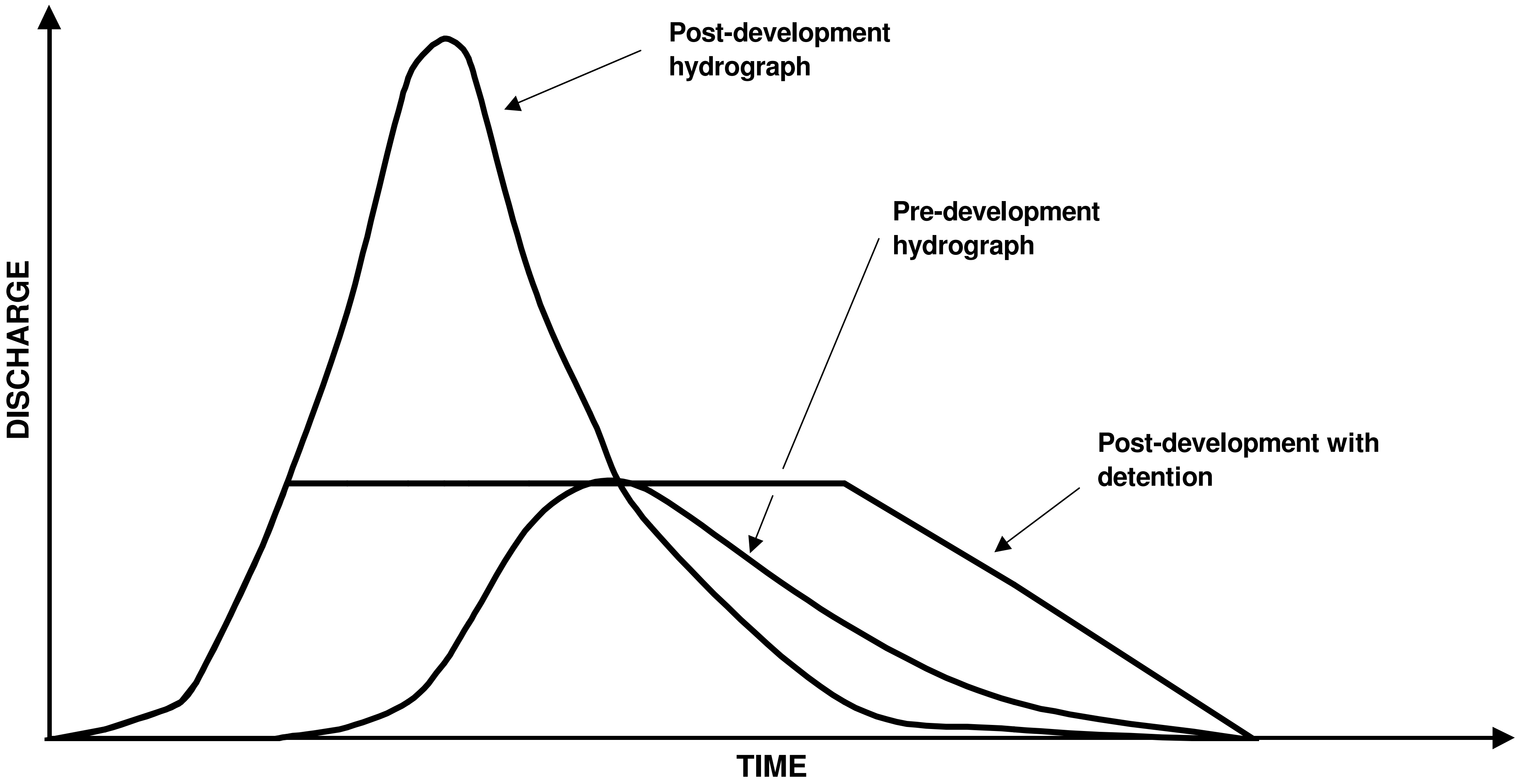
(1) **Design Storms:** Detention ponds shall be designed for the initial and major design storms, as a combined facility, and shall satisfy the separate storage and release conditions for each storm event. The design release rates shall be restricted such that runoff from the entire parcel and tributary basin to be developed or redeveloped does not exceed the maximum runoff, or historic runoff, for the initial and major storm that occurred prior to the proposed development or redevelopment. Where existing downstream facilities have been designed for a storm with a lesser frequency than required by this document, additional storage may be required to maintain historic release rates during that lower frequency storm event.

(2) **Storage Volume:** The storage volume of runoff to be detained on-site shall be sized to contain 110 percent of the difference between the historic runoff and the initial and major storm runoff projected for the ultimate developed conditions of the entire parcel and tributary basin to be developed or redeveloped.

LEED Design Criteria

- 6.1 Quantity Control: Post development peak *AND* volume must not exceed predevelopment levels for 1 and 2 year 24 hour runoff.
- 6.2 Quality Control: 90% of Average Annual <u>RAINFALL</u> (NOT runoff based!).

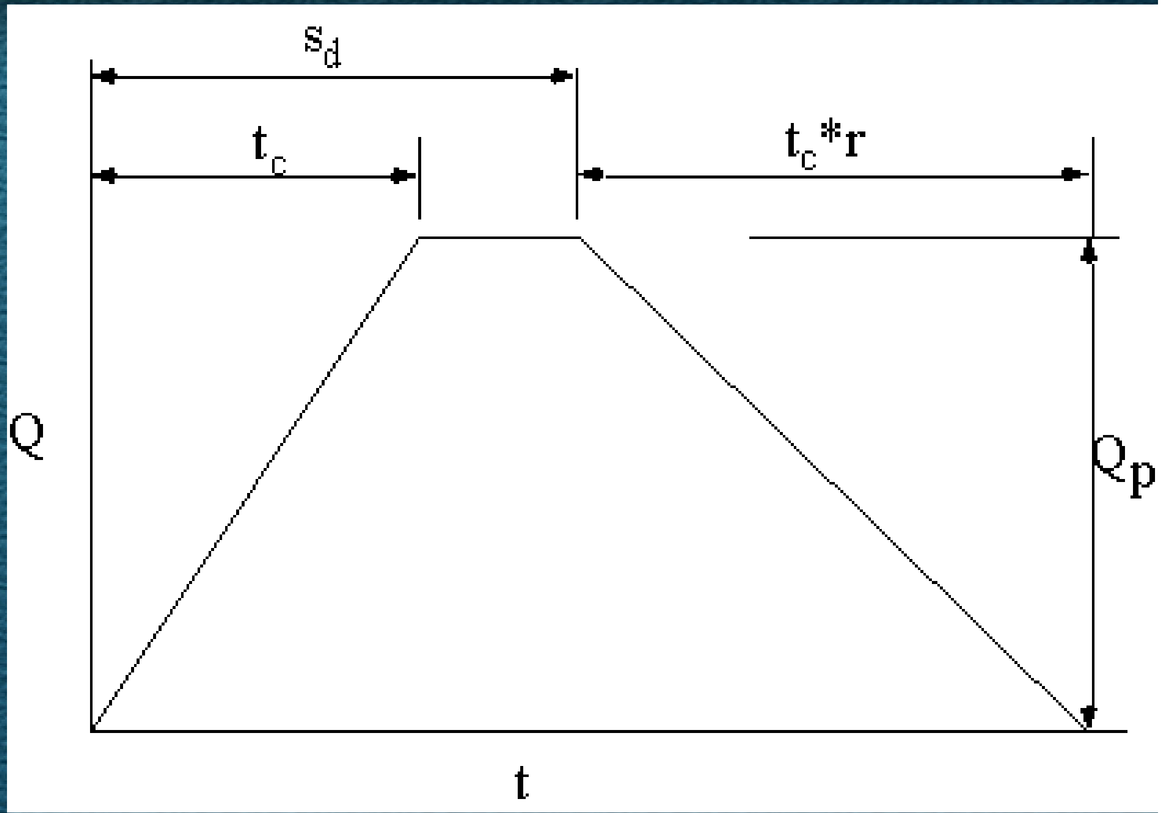
Idealized Urban Runoff Hydrograph



Analytical Methods to Satisfy both LEED and Boulder's Detention Requirements

- Must estimate pre and post development volumes as well as peaks
- Rational formula is peak flow only.
- Simplified hydrograph analysis is required (ie NOT just rational method).

Trapezoidal Synthetic Unit Hydrograph



where:

tc = time of concentration.

Q = Flow at time t, in cfs.

Qp = Peak flow.

r = falling limb coefficient

sd = storm duration

UDFCD Methods Suggested by City of Boulder: FAA Method

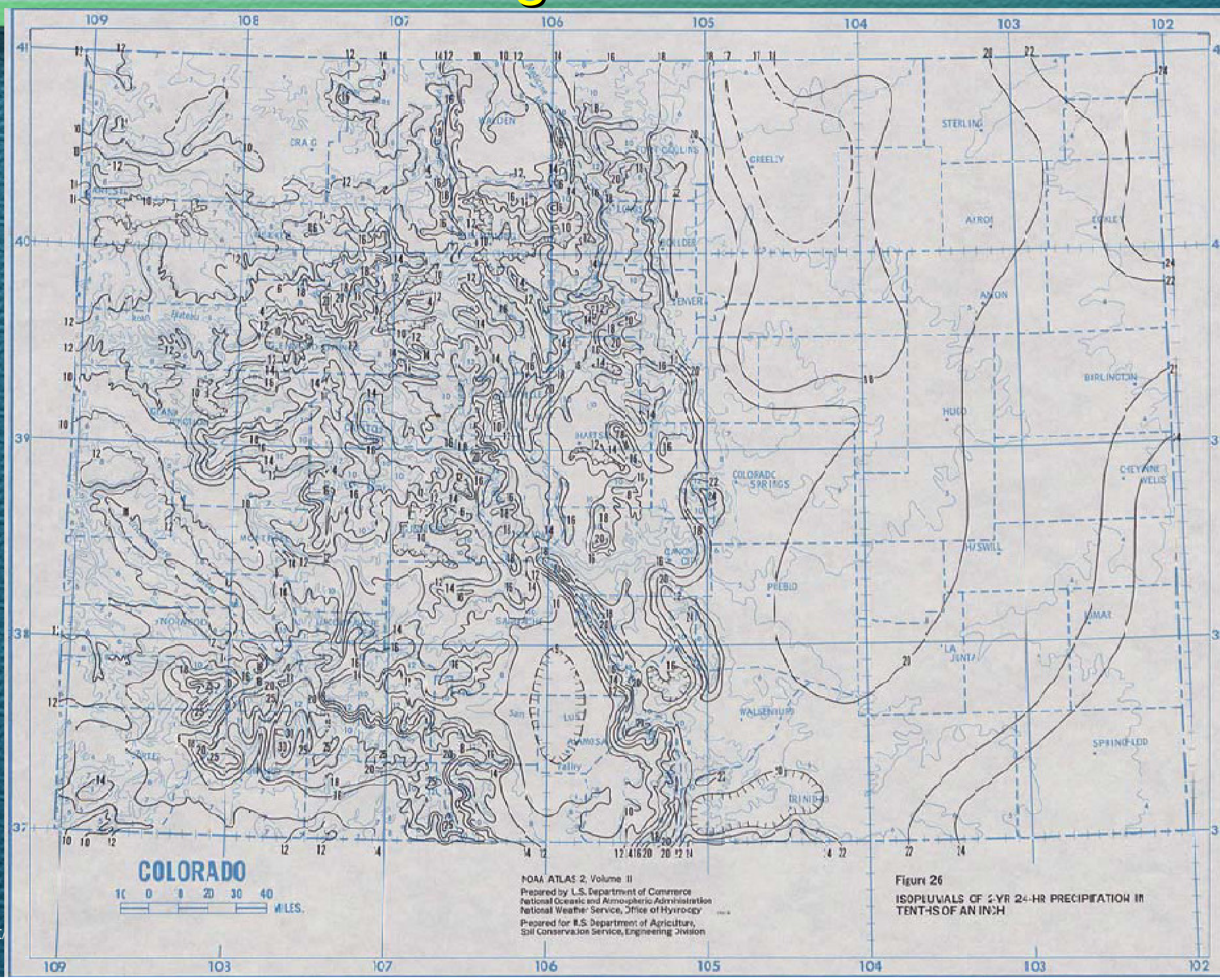
- UDFCD.org “Downloads” “Technical Downloads”
- FAA
- Rainfall analysis
  - UDFCD
  - NOAA IDF maps

Analytic Methods for Estimating Storm Volumes

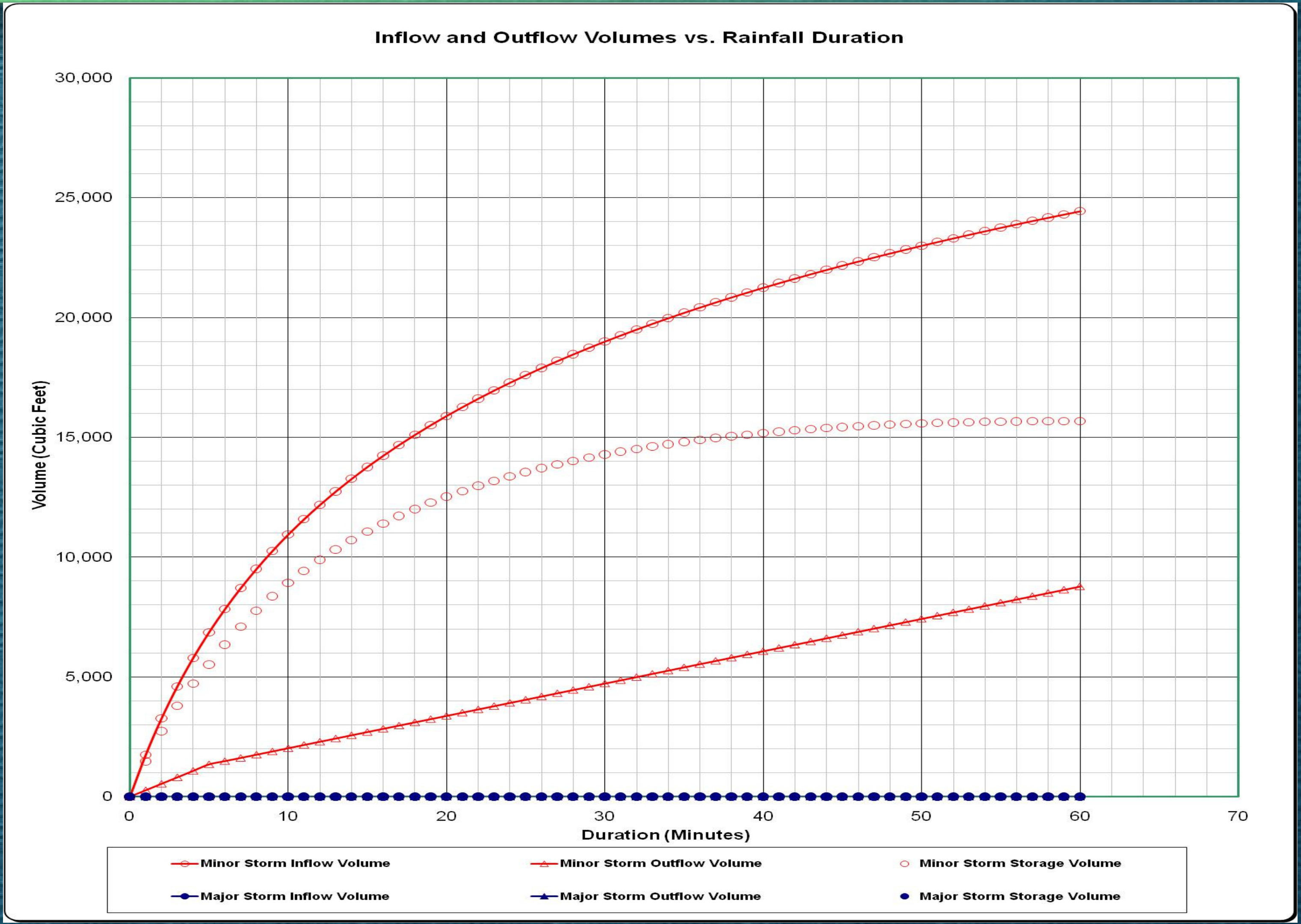
1. Use NOAA Atlas 2 Volume 3 maps as input to “UD-Rainzone.xls”
2. Use UDFCD “UD-Rainzone.xls” to estimate the 1 hour rainfall depth for the designed frequency.
3. Use the 1 hour precipitation values as input to the UDFCD “UD-Detention” spreadsheet to estimate the storage volume and release rate requirements.

NOAA Atlas 2, Volume 3 (Colorado) from

http://hdsc.nws.noaa.gov



Output of the FAA UDFCD Spreadsheet Analysis



LEED Points: Water Efficiency

- Credit 1.1, Water Efficient landscaping - 1 point
- Credit 1.2, Water Efficient Landscaping - 1 point

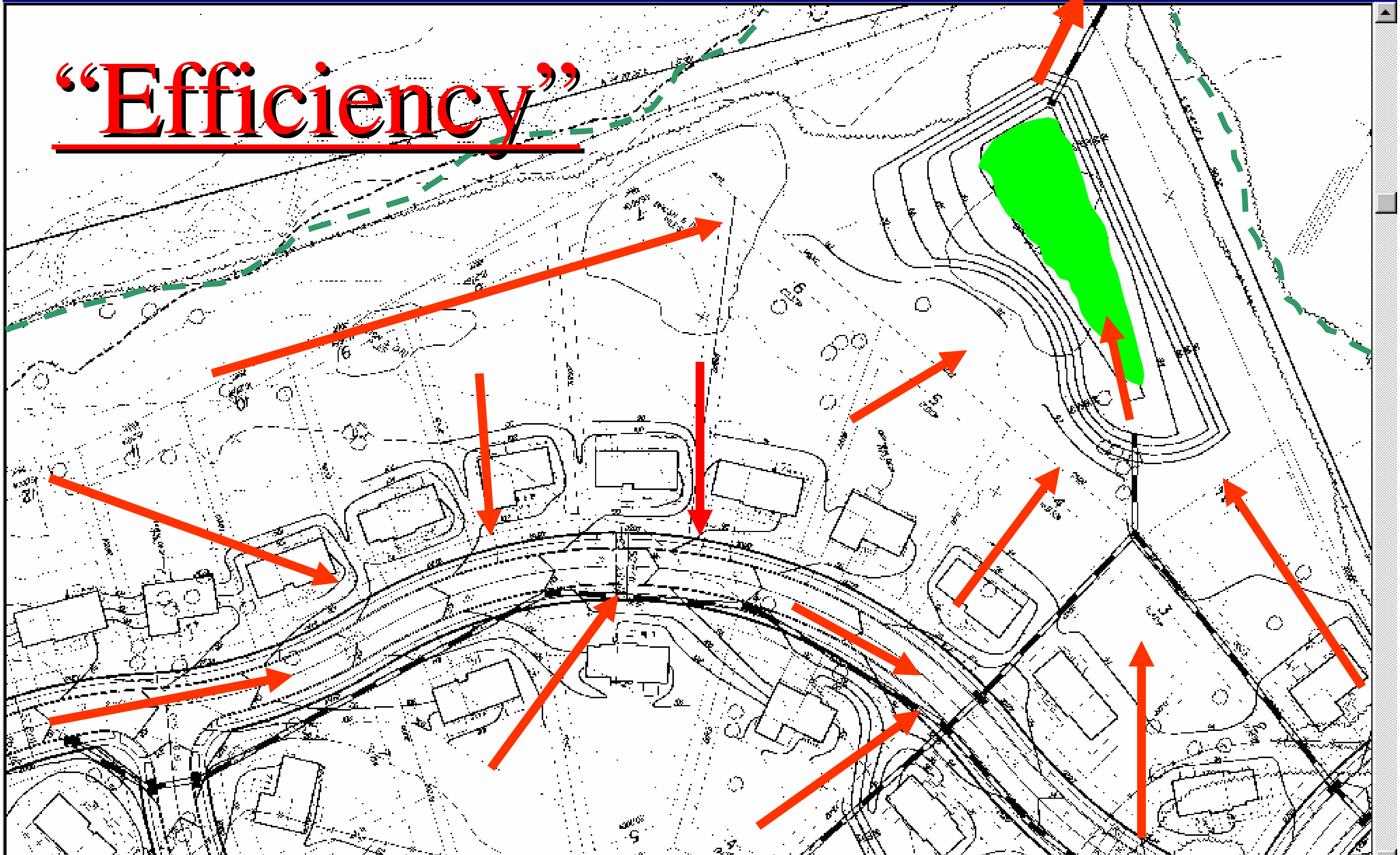
Sustainable Drainage Design Low-Impact Development (LID)

- Traditional urban drainage designs are based on large, rare events, with return frequencies from 2 to 100 years. These are termed major (10-100 yr) and minor (2-10yr) events.
- 95% of rain events have a return period less than 2 years for Denver, CO. This is reflected in the LEED Water Quality requirement 6.2 to “capture and treat” 90% of the average annual rainfall.

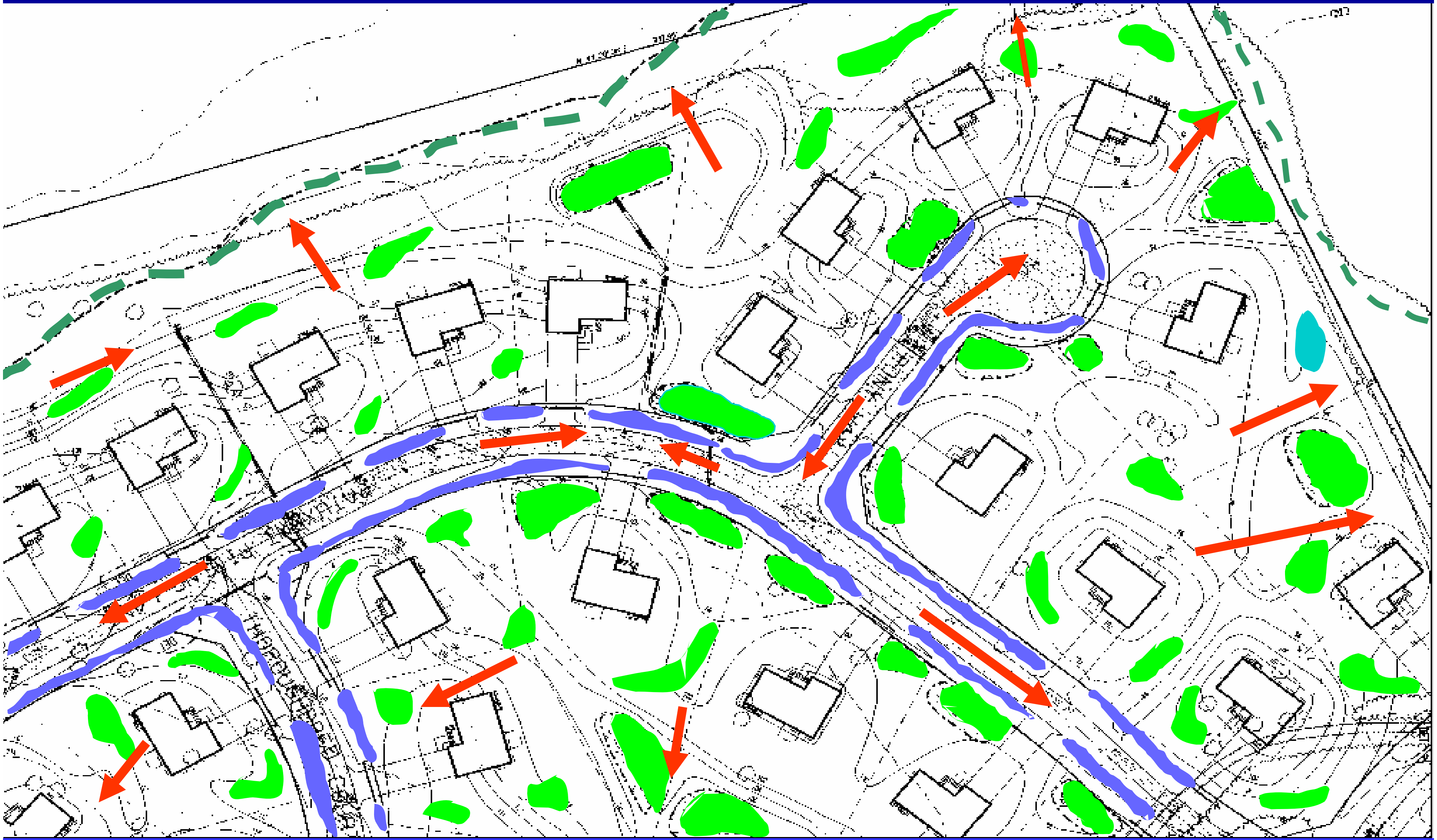
Sustainable Drainage Concepts – A Sea of Acronyms!

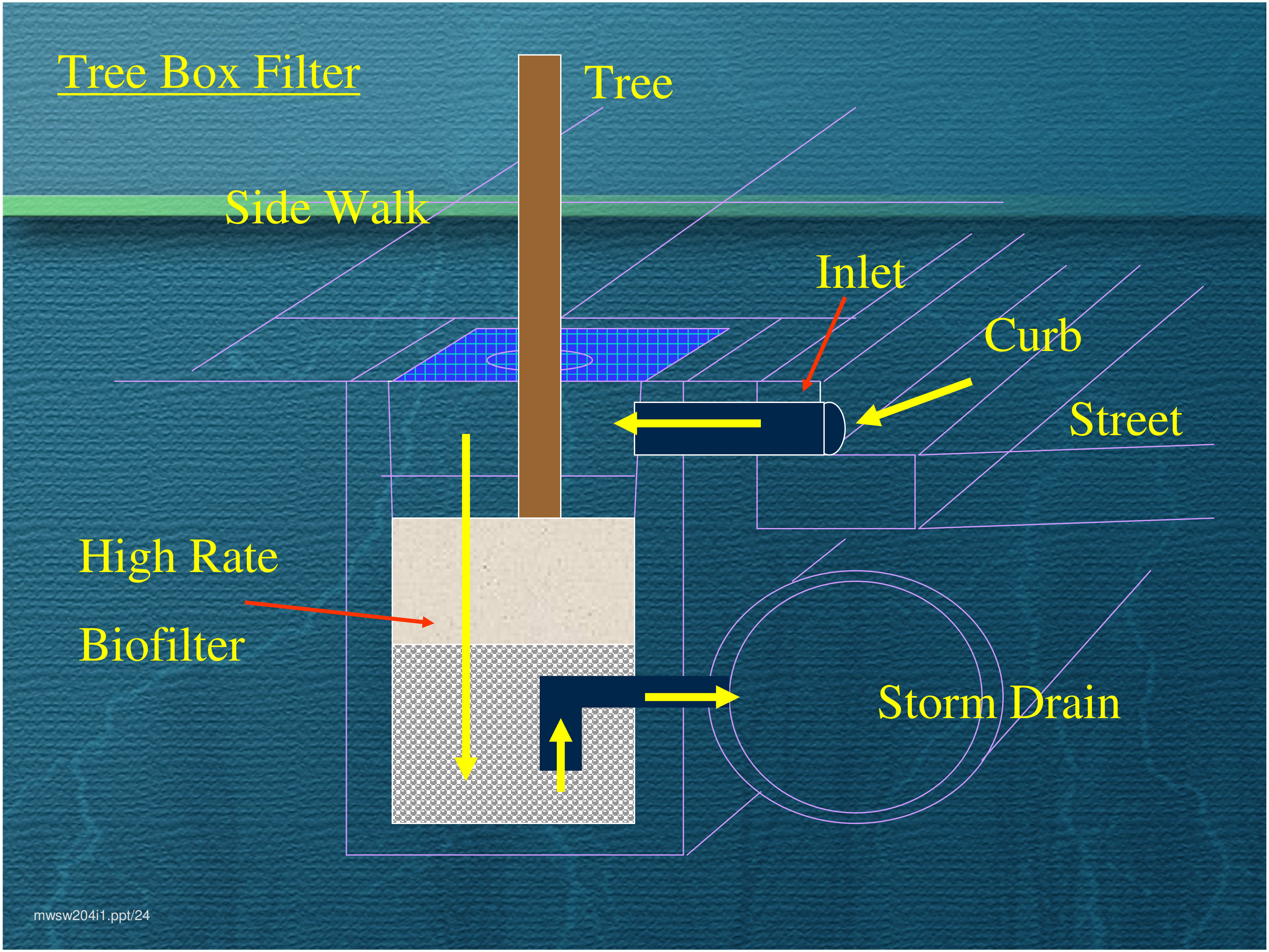
- BMP : “Best” Management Practices.
- SUDS: UK term, “Sustainable Urban Drainage Systems”.
- LID: Low Impact Development. Over-arching design philosophy to minimize the hydrologic impact of development.

Conventional Pipe and Pond Centralized Control



Distributed Small-scale Controls




Tree Box Filter
Tree
Side Walk
Inlet
Curb
Street
High Rate
Biofilter
Storm Drain
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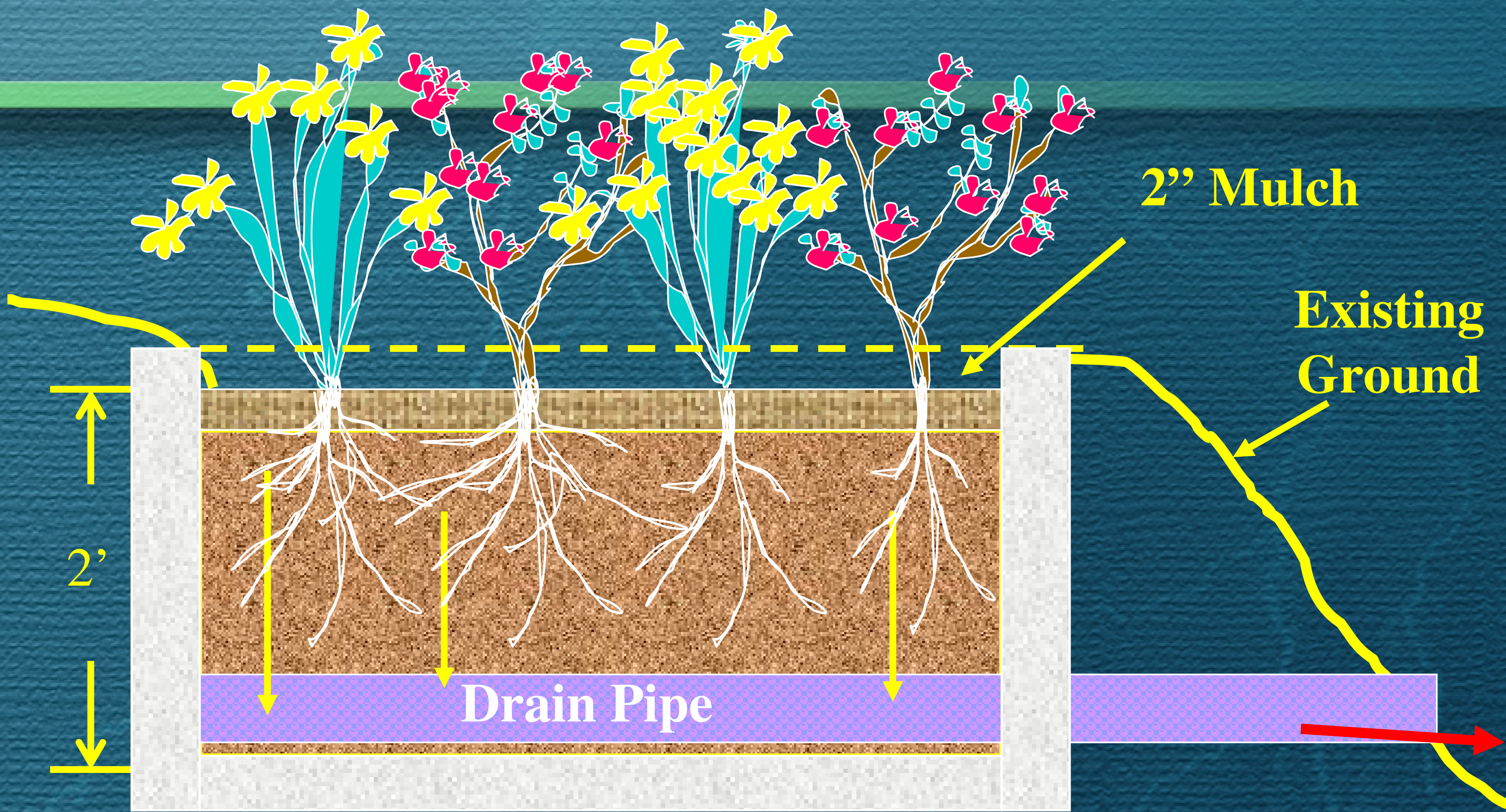
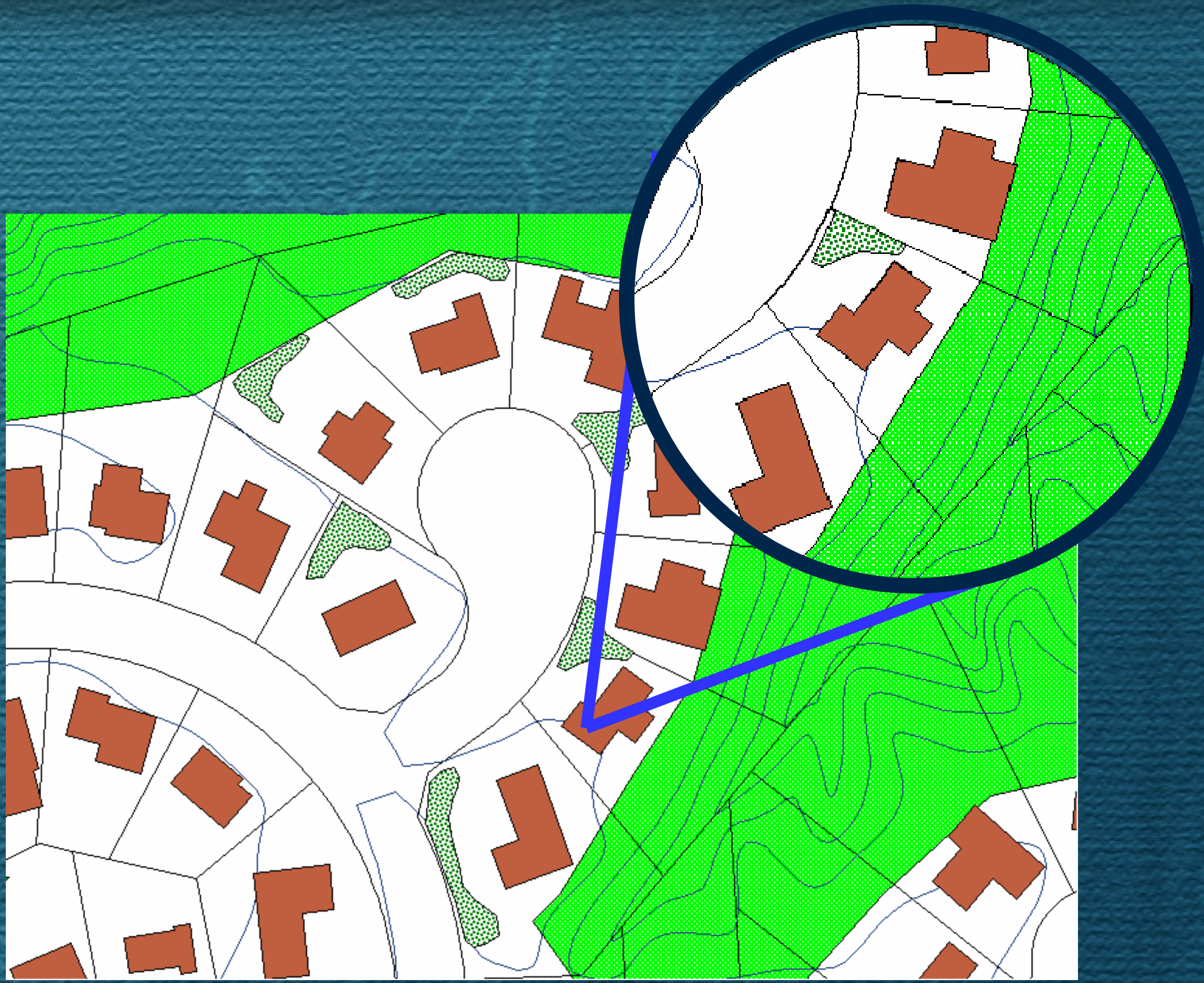
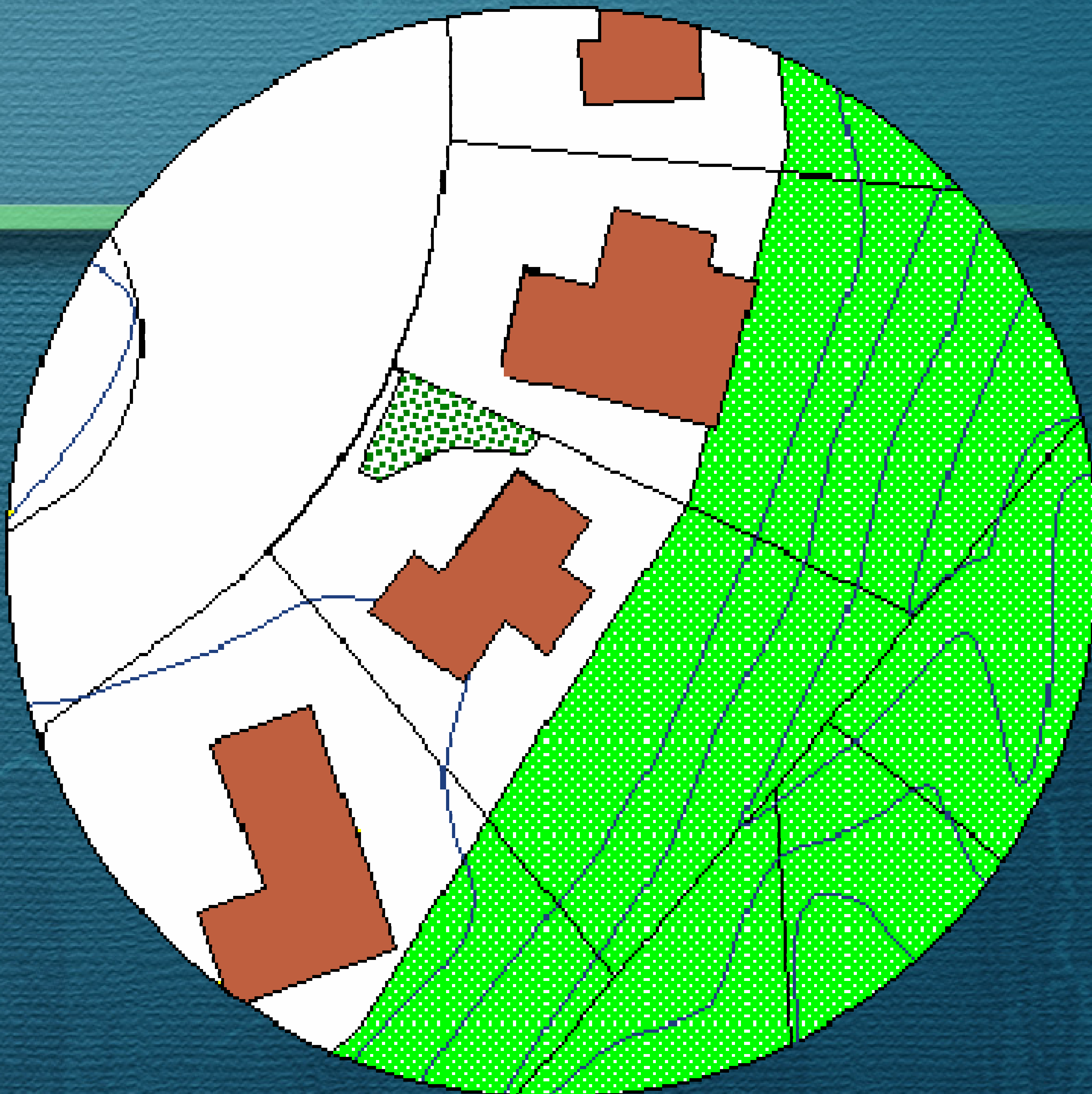
Filtration System

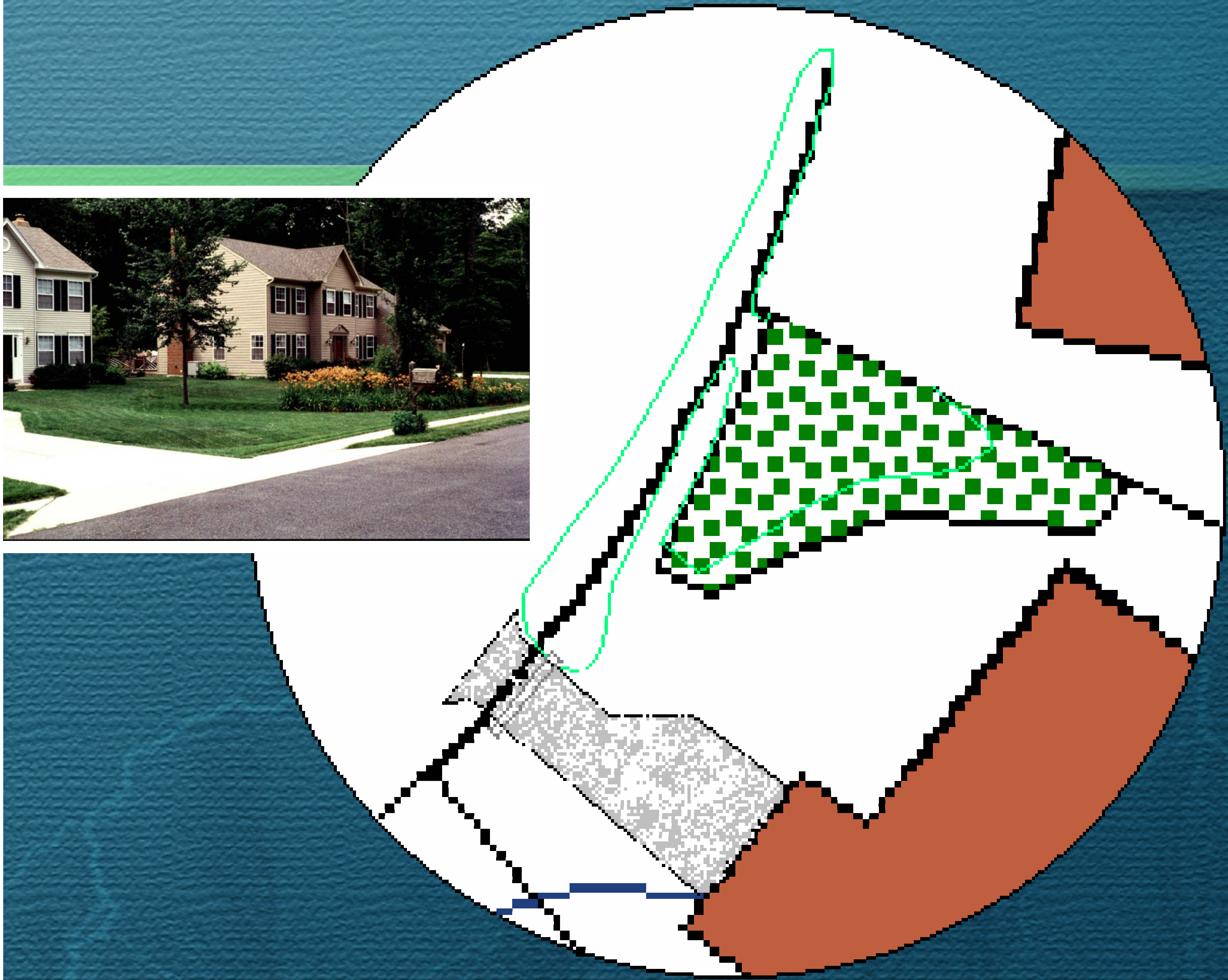


Bioretention in a Box

Lot Detail







Side View of Bioretention Area

Environmental Center of the Rockies, Boulder Colorado

- One of 25 demonstration projects funded by the National Geographic Society, The Conservation Fund, and the USGS
- Designed by Bill Wenk and Joan Woodward
- Studied by Wright Water Engineers and the University of Colorado
- Designed to contain the 3 yr runoff event onsite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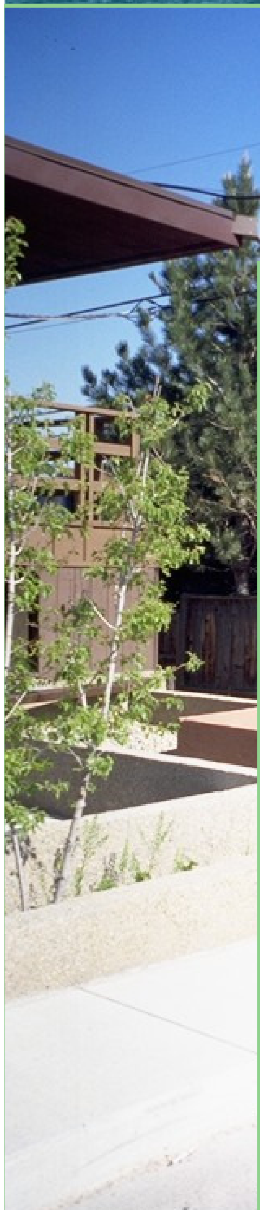

Site Scale Experience

- Use of water on-site has real value
- Micro climate is an essential component
- Hardscape storage was expensive