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TRIECA CONFERENCE
7th Annual TRIECA Conference
March 21 & 22, 2018

Design Storms and Parameters for Sustainable Drainage Systems

Gilles Rivard, ing. M. Sc.
Vice-President – Urban Hydrology (Lasalle-NHC)

SETTING THE CONTEXT

The world is my representation

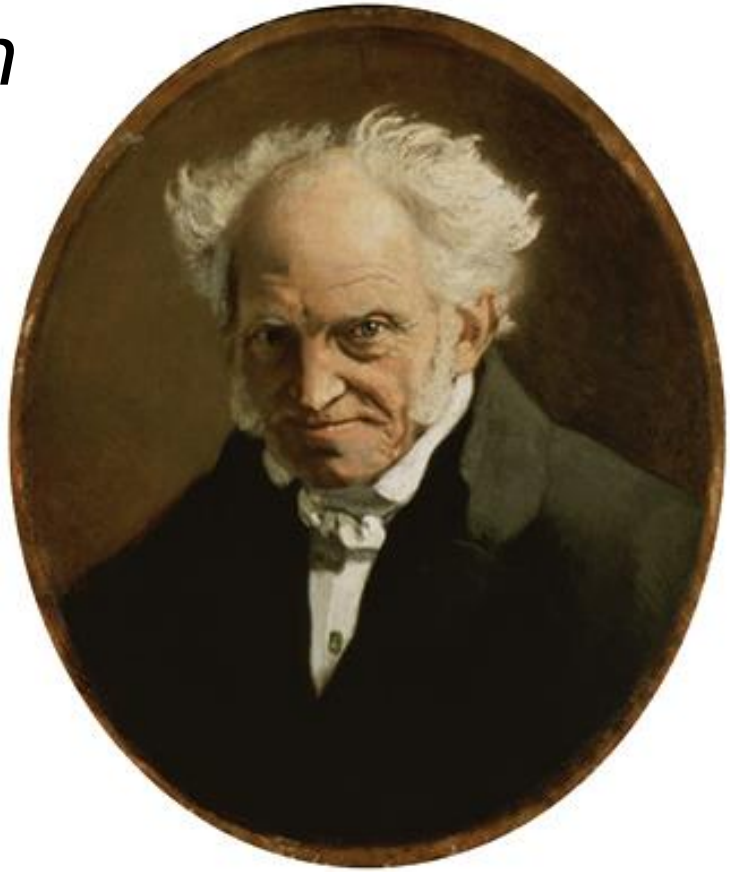
(The World as Will and Representation -1819)

NOUMENA

Facts as they are and in themselves – Reality

PHENOMENA

What can be known ***(our models)***



SCHOPENHAUER

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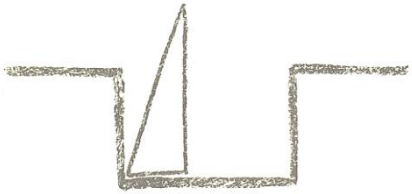
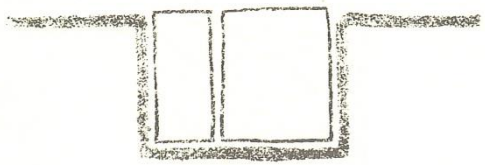
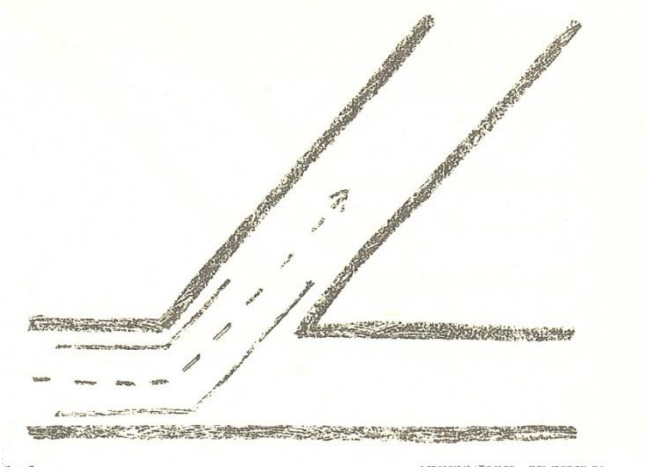
SETTING THE CONTEXT

Optimal Solutions





New paradigm



Recreate or maintain the natural processes for drainage instead of rapid and efficient runoff

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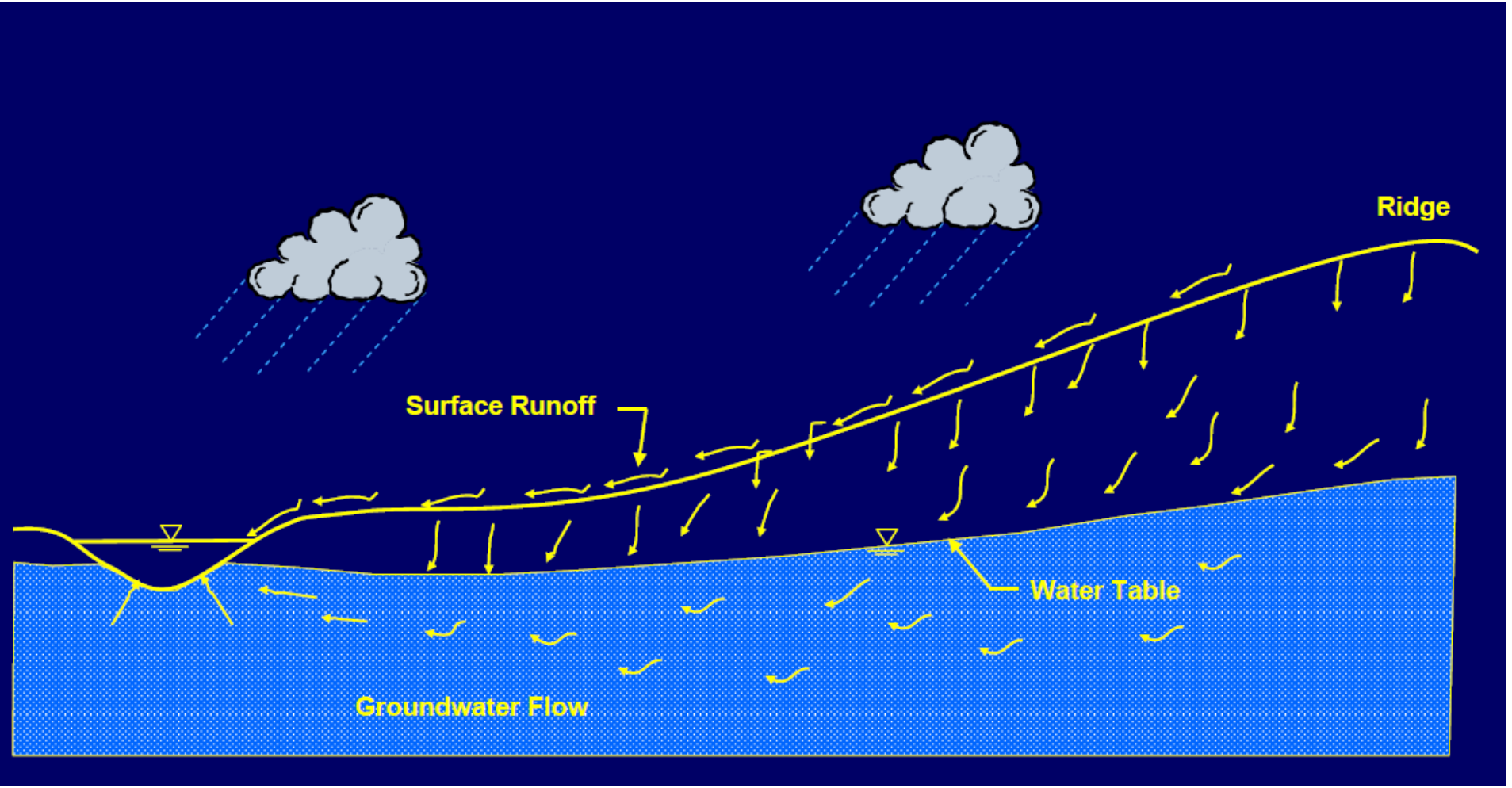
SETTING THE CONTEXT



Usual Modeling – Hortonian flow

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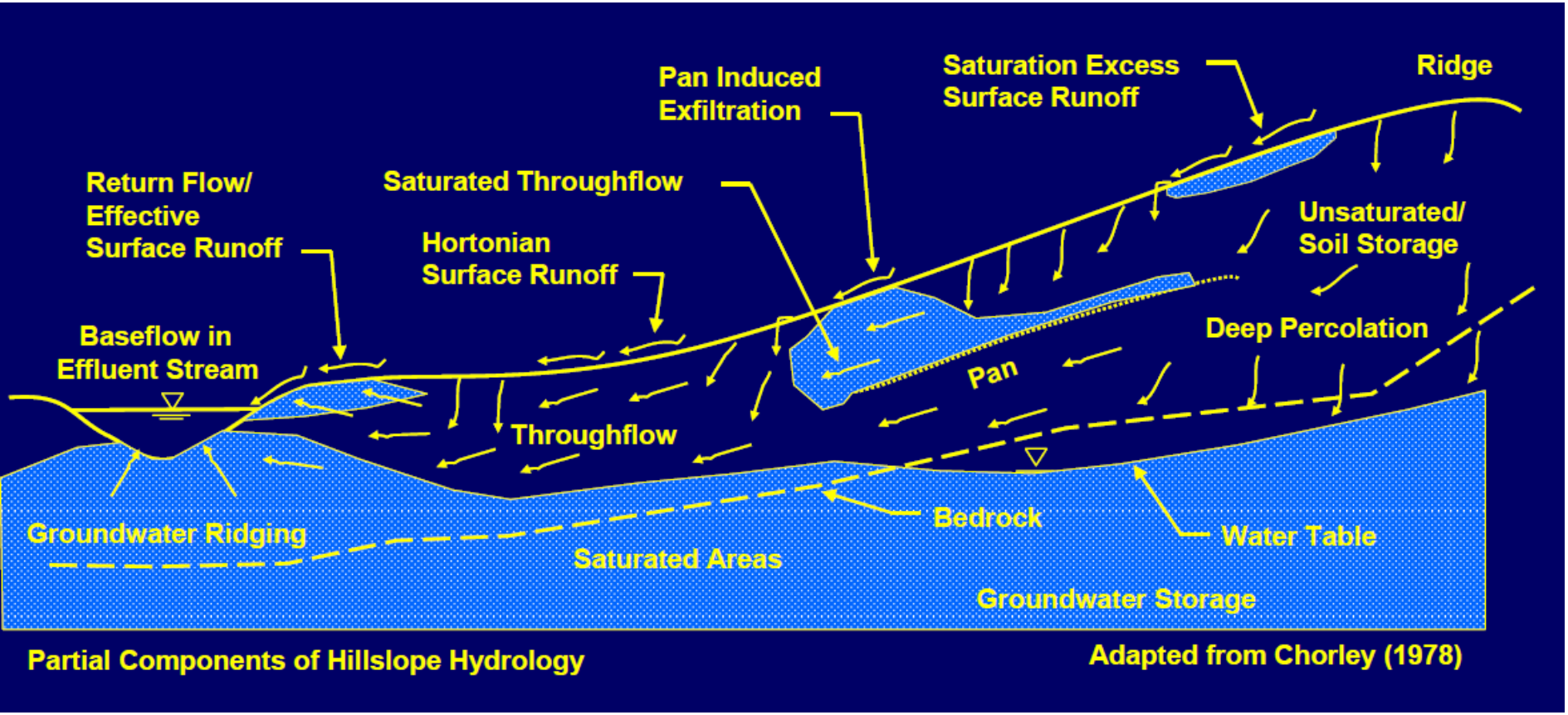
SETTING THE CONTEXT



Reality much more complex – different types of flow

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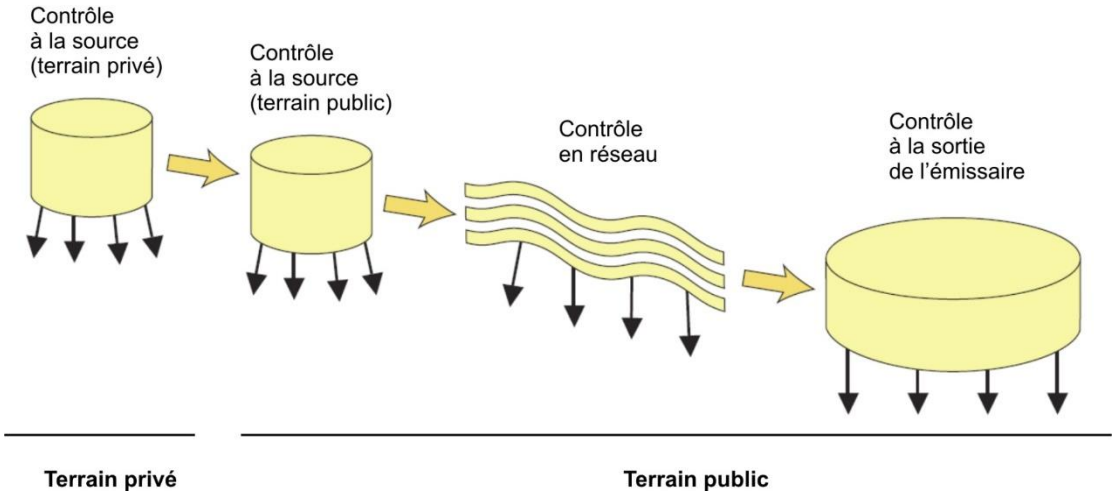
SETTING THE CONTEXT

NEW PARADIGM

- Treatment train



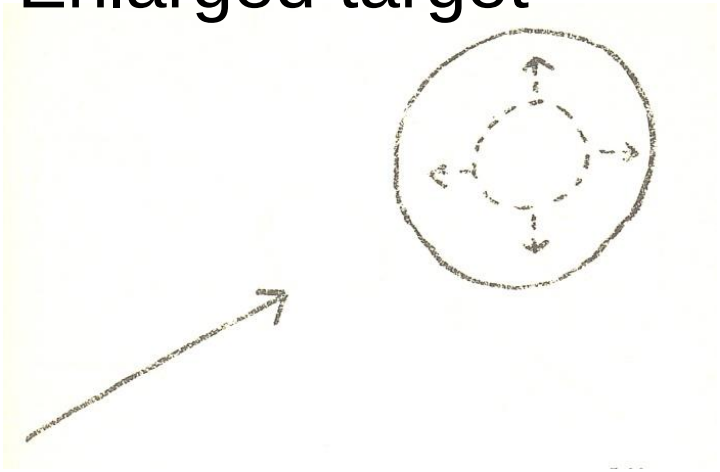
- Complete rainfall spectrum

- Runoff volume reduction

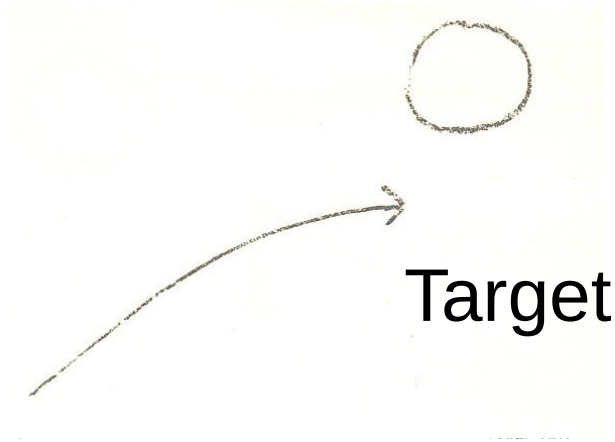
SETTING THE CONTEXT

DEFINING OBJECTIVES

Enlarged target



Wrong target



Target not reached

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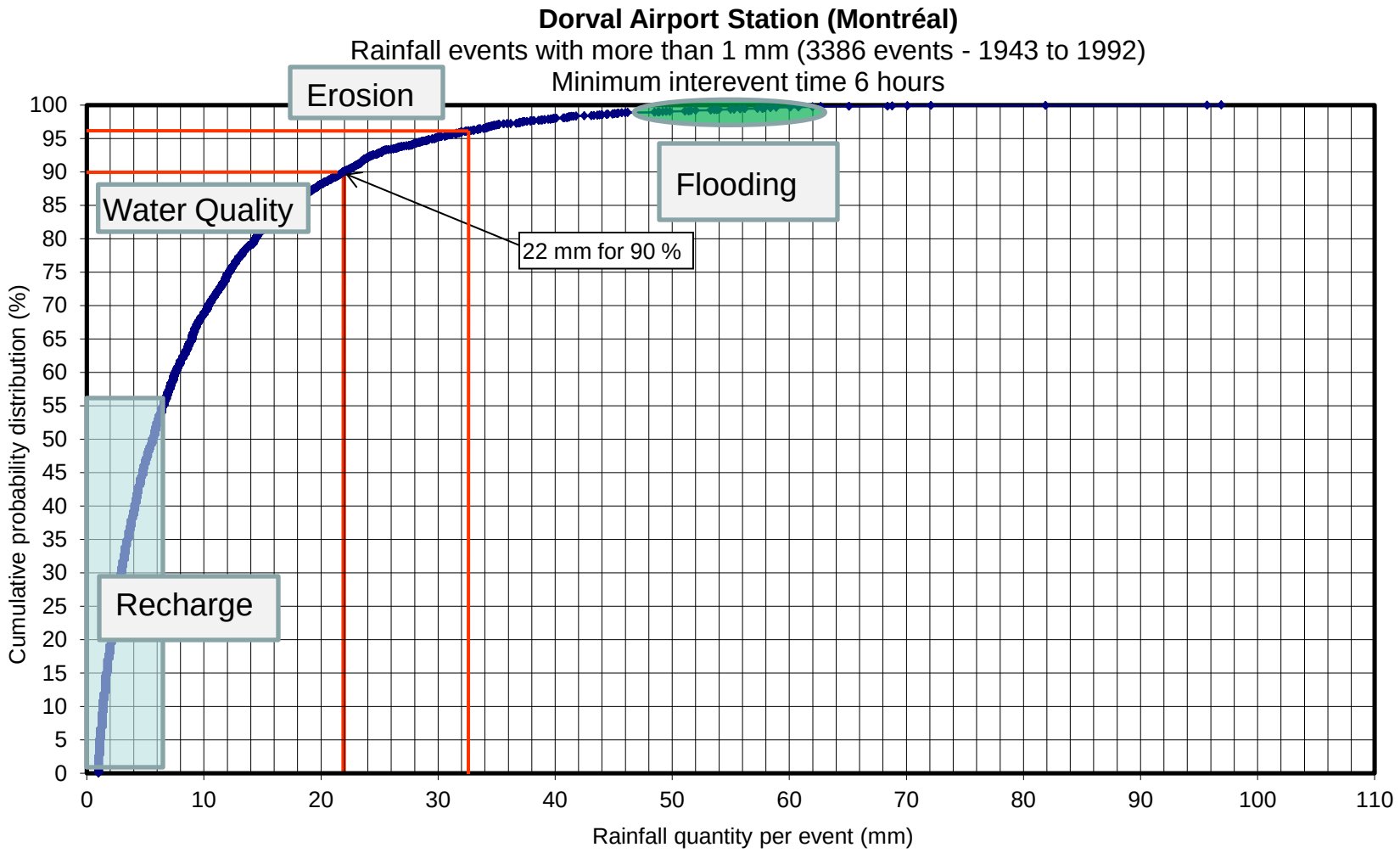
OUTLINE

- Urban Runoff Quality Control in Context
- Approaches and Parameters for Design Storms
- Designing and Validating Design Storms with Continuous Simulations
- Conclusion

URBAN RUNOFF QUALITY CONTROL



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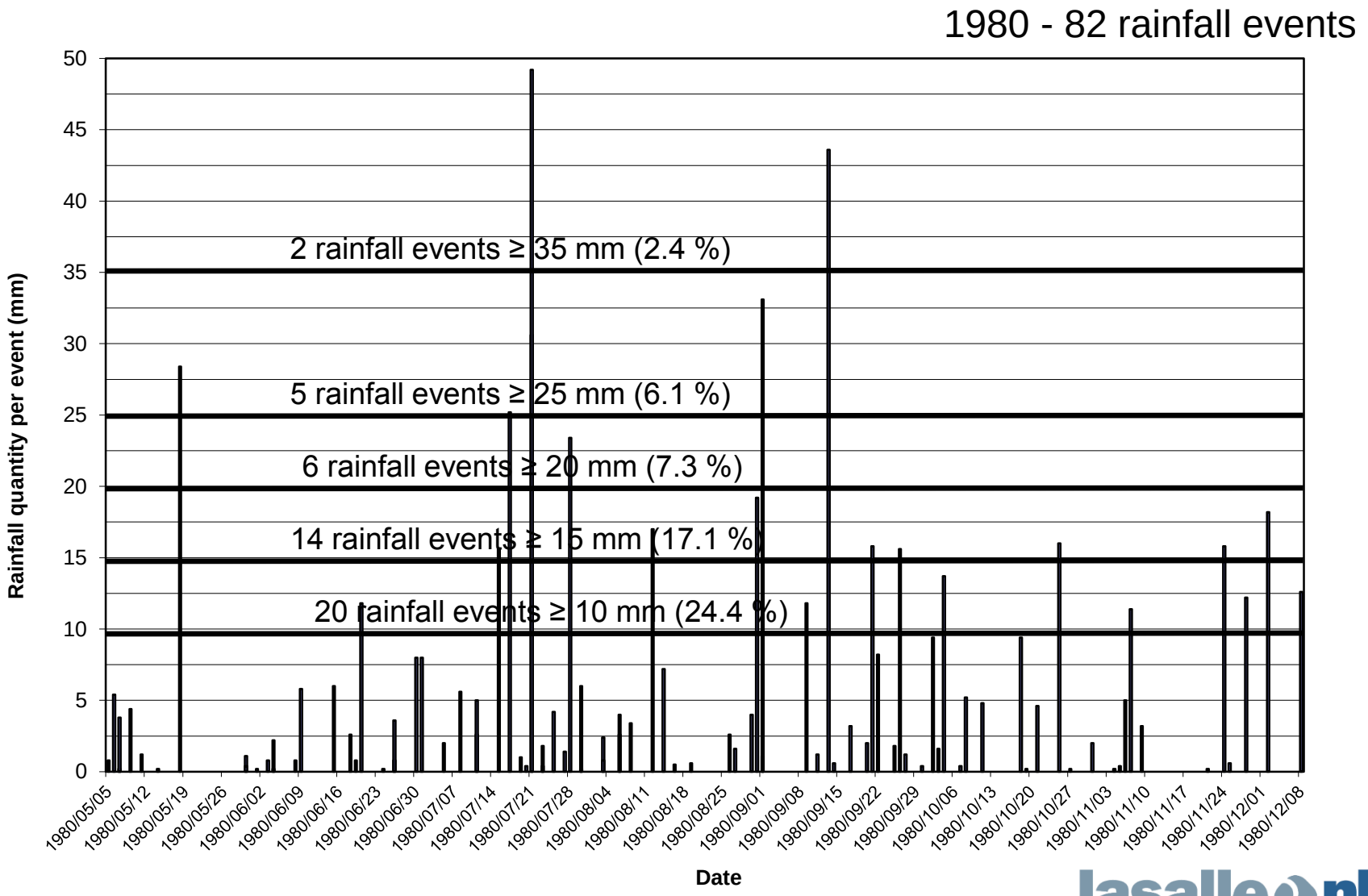
URBAN RUNOFF QUALITY CONTROL



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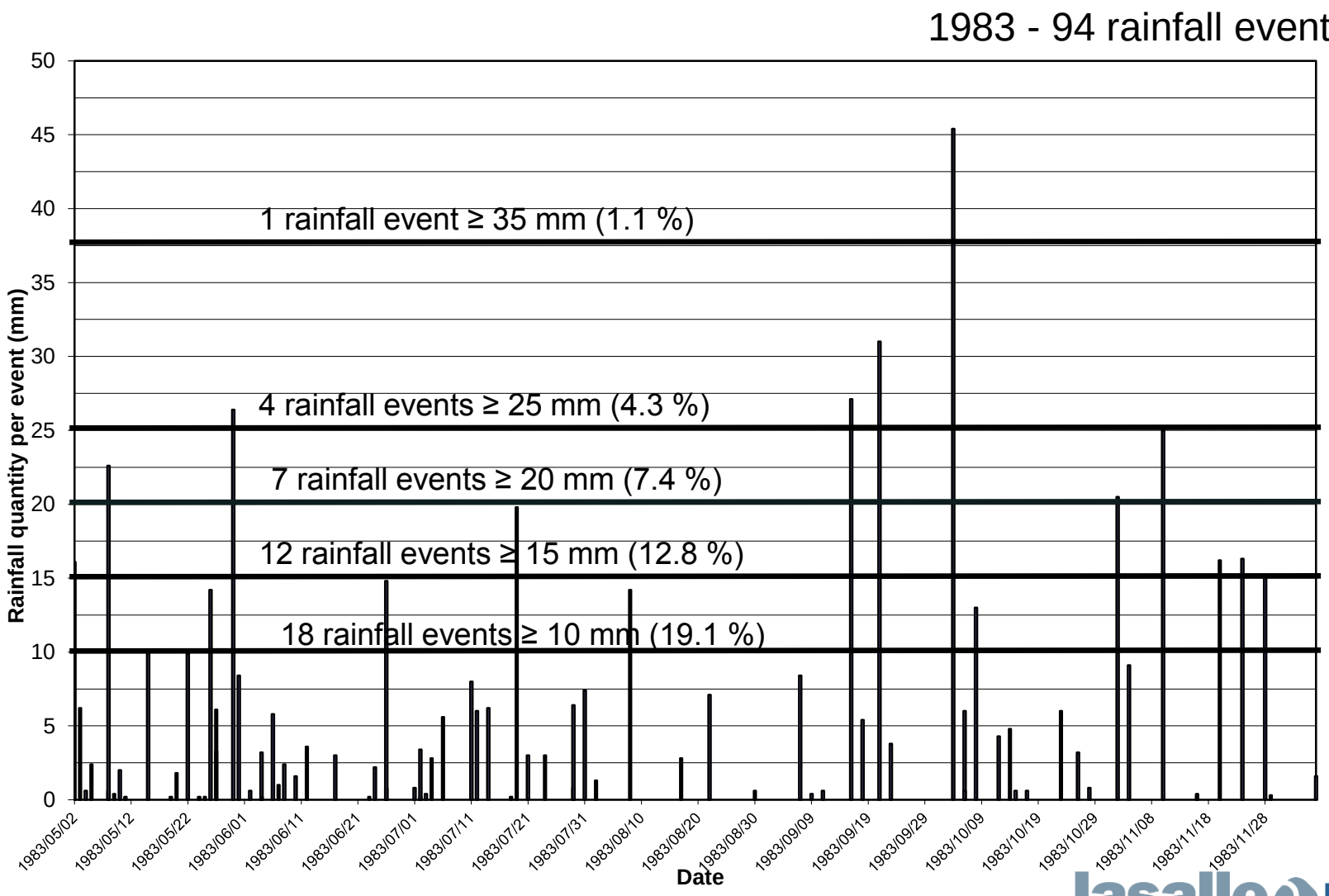
URBAN RUNOFF QUALITY CONTROL



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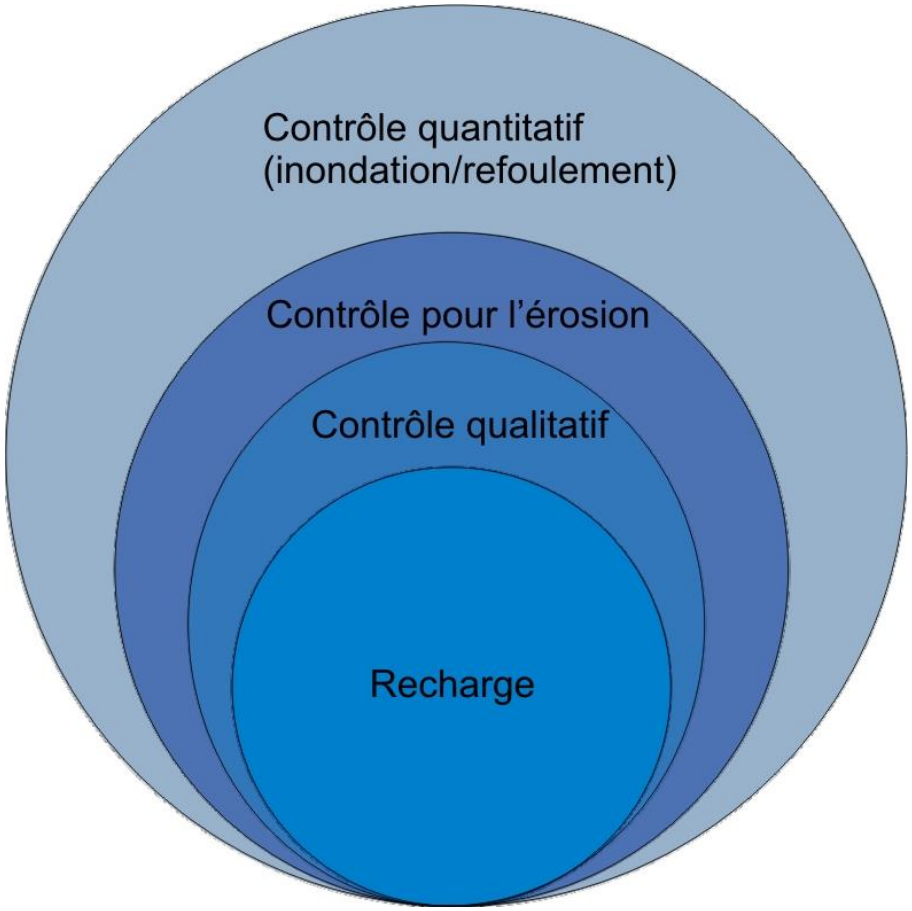
URBAN RUNOFF QUALITY CONTROL



- Recharge – 5 à 10 mm
- **Quality** – 90 % of annual runoff
- Channel protection – 1:1 y with 24 to 48 hours
- Quantity – 1:2 y, 1:10 y and 1:100 y as for pre-development conditions

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APPROACHES AND PARAMETERS

DRAINAGE NETWORK COMPONENTS ARE DESIGNED WITH DIFFERENT PARAMETERS

- **Volume** (retention basin, bioretention)

- **Discharge** (pipes, swale, hydrodynamic devices)

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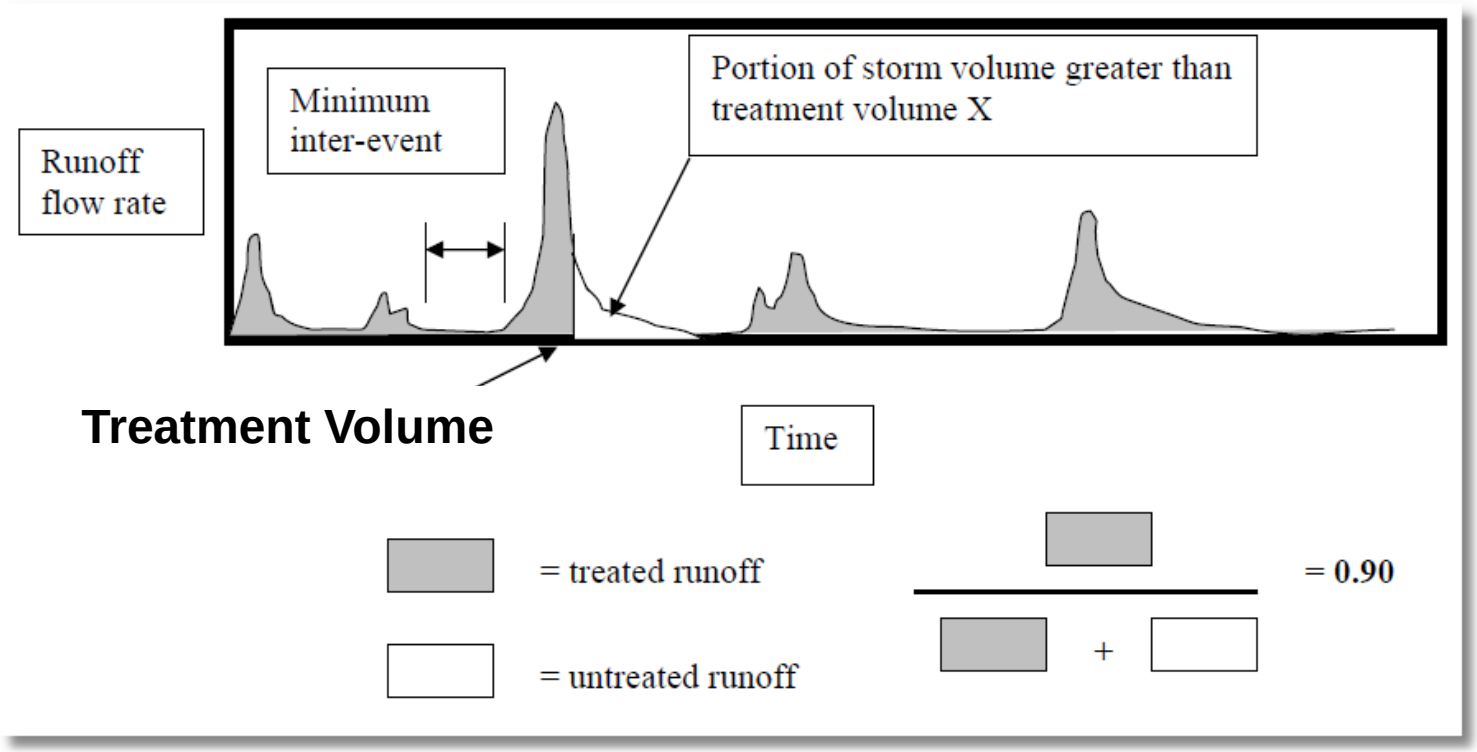
APPROACHES AND PARAMETERS

Volume based treatment systems



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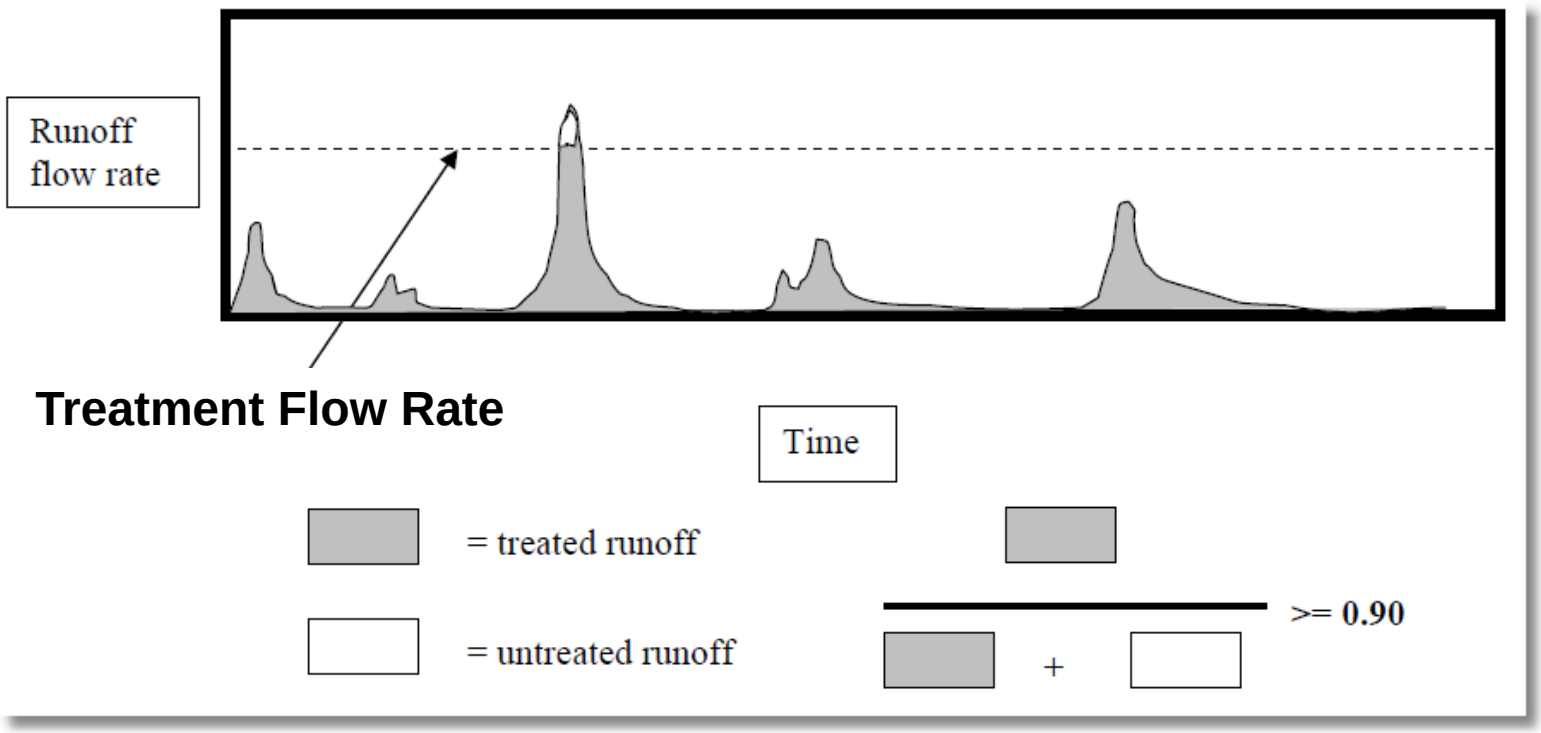
APPROACHES AND PARAMETERS

Rate based treatment systems



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APPROACHES AND PARAMETERS

Volume based treatment systems

$$\text{WQ Volume} = R_v \times P \times A$$

Where R_v = Volumetric runoff coefficient

P = Precipitation for 90 % of the storms

A = Tributary area

- Basic assumption – runoff volume (and not peak discharge) is the main parameter for water quality control
- **Application in design**: retention basin; bioretention

APPROACHES AND PARAMETERS

Rate based treatment systems

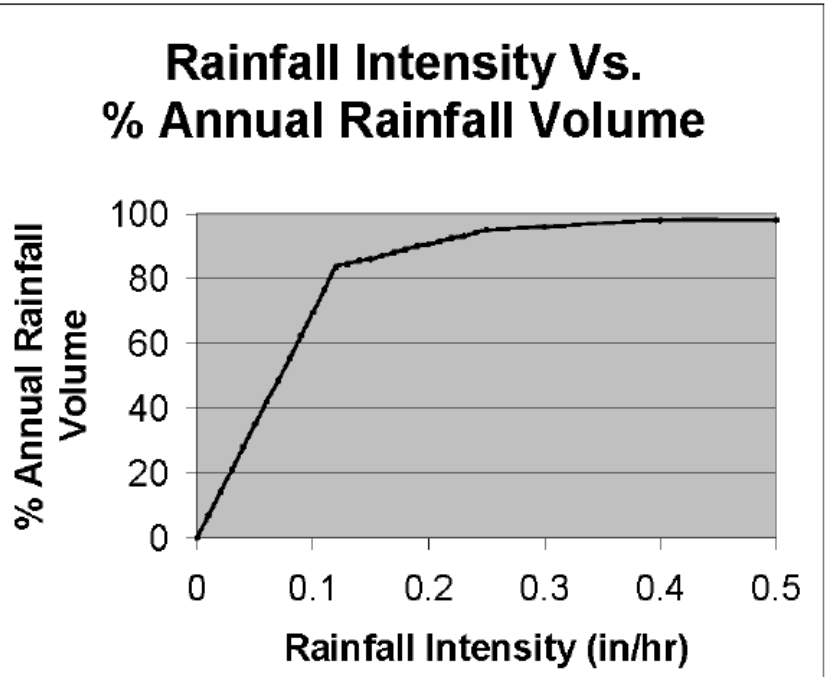
Approach	Advantage	Disadvantage
Uniform rainfall intensity	Simplest method	Doesn't take into account rainfall patterns or statistics
Rational method	Simple method	Need specific IDF curves (high occurrences)
Modelling with design storms	Intermediate complexity	Need to determine design storms (could be different for peak Q or Volumes)
Modelling with continuous simulation	Optimal approach, both for volume and rate based treatment systems	Data might not be available

APPROACHES AND PARAMETERS

Example with uniform intensity

Figure 4: Rainfall Intensity Versus Percentage of Annual Rainfall Volume — 8/12/2004
Rainfall data taken from each of four Portland quadrants, then averaged. — Fancher

5-minute intensity in/hr	% Annual Rainfall Volume
0	0
0.01	7
0.02	14
0.03	21
0.04	28
0.05	35
0.06	42
0.07	48.5
0.08	55.5
0.09	62.5
0.1	69.5
0.11	76.5
0.12	83.5
0.13	84.5
0.14	85.5
0.15	86
0.16	87
0.17	88
0.18	89
0.19	90
0.2	90.5
0.21	91.5
0.22	92.5
0.23	93
0.24	94
0.25	95
0.3	96
0.4	98
0.5	98



90 % : 4.8 mm/hr

(too low ??)

Portland (Oregon) SWM Manual

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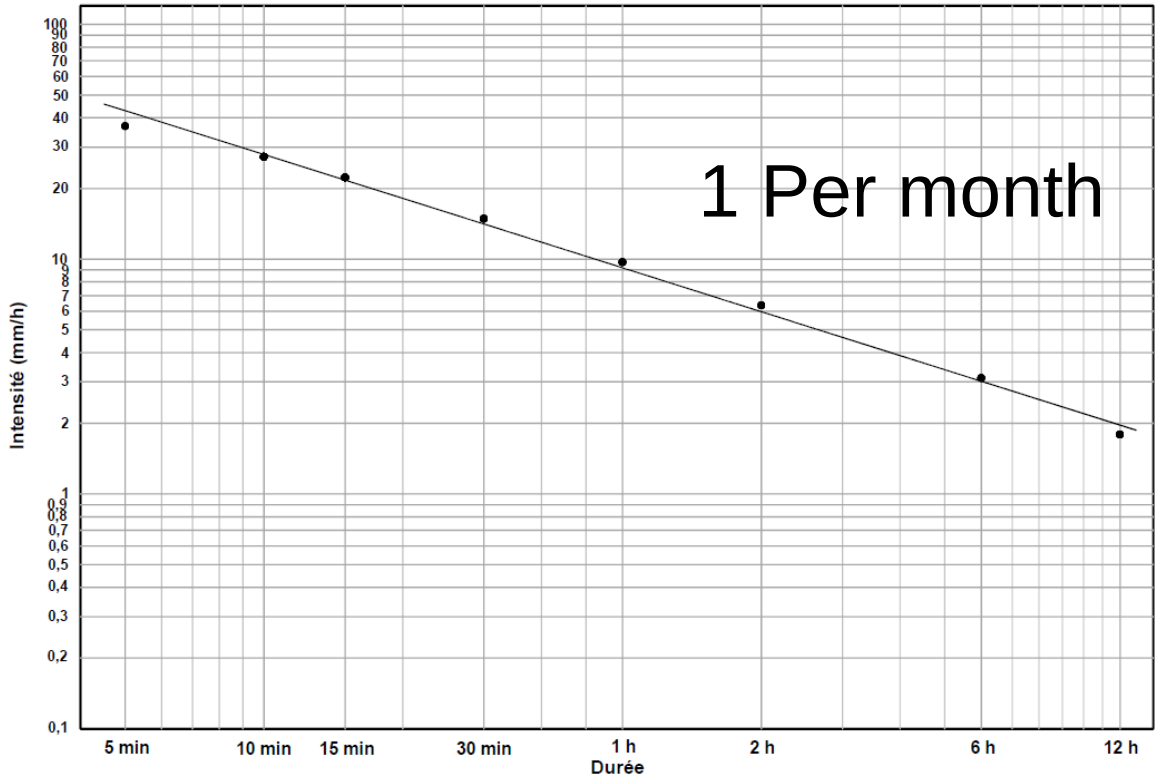
APPROACHES AND PARAMETERS

Use with rational method (Q = CIA/360)

High occurrence IDF curves

Développement durable, Environnement et Lutte contre les changements climatiques
Québec

INTENSITÉ, DURÉE, FRÉQUENCE (IDF) DES PLUIES DE GRANDES RÉCURRENCES



Station : Saint-Jérôme
7037400

Latitude : 45° 48' 23" **Altitude :** 169 m
Longitude : 74° 02' 22"

Période disponible : 1981-2010

Récurrence demandée : 1 fois par mois

Tableau des valeurs

Durée	Récur. max.	Int. (mm/h)	ln(Int.)	
			Valeur	Erreur type
5 min	8,75	36,86	3,61	0,03
10 min	9,74	27,28	3,31	0,01
15 min	9,97	22,27	3,10	0,02
30 min	10,34	14,86	2,70	0,02
1 h	10,53	9,70	2,27	0,02
2 h	10,65	6,36	1,85	0,02
6h	10,77	3,11	1,14	0,03
12 h	10,79	1,79	0,58	0,02

Tableau des paramètres de Montana

Paramètre	Valeur	Écart-type
ln(a)	4,76	0,10
b	0,620	0,018

Équation de la courbe IDF

$$\text{Intensité (mm/h)} = a \cdot [\text{Durée (min)}]^{-b}$$

Quebec Ministry of Environment

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APPROACHES AND PARAMETERS

Selected approaches (Quebec Provincial Guidelines)

- Small Systems
  - Volume based — WQ Volume = R_v x P x A
  - Rate Based — Rational method; IDF Curves (65 % of 2 yr IDF)
- Larger Systems
  - Design Storms both for Volume and Rate based SCM

Both approaches should give similar results !!...

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DESIGNING DESIGN STORMS

An old problem…

RELIABILITY OF DESIGN STORMS IN MODELLING

BY

BEN URBONAS
CHIEF, MASTER PLANNING PROGRAM
URBAN DRAINAGE AND FLOOD CONTROL DISTRICT
DENVER, COLORADO

SEMINAR ON THE DESIGN STORM CONCEPT

ECOLE POLYTECHNIQUE, UNIVERSITY OF MONTREAL

MAY 23, 1979[a]

1979

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DESIGNING DESIGN STORMS

An old problem…

Design Storm Events for Urban Drainage Based on Historical Rainfall Data: A Conceptual Framework for a Logical Approach

Gilles Rivard

…1996

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DESIGNING DESIGN STORMS

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Design Storm Events for Urban Drainage Based on Historical Rainfall Data: A Conceptual Framework for a Logical Approach

…1996

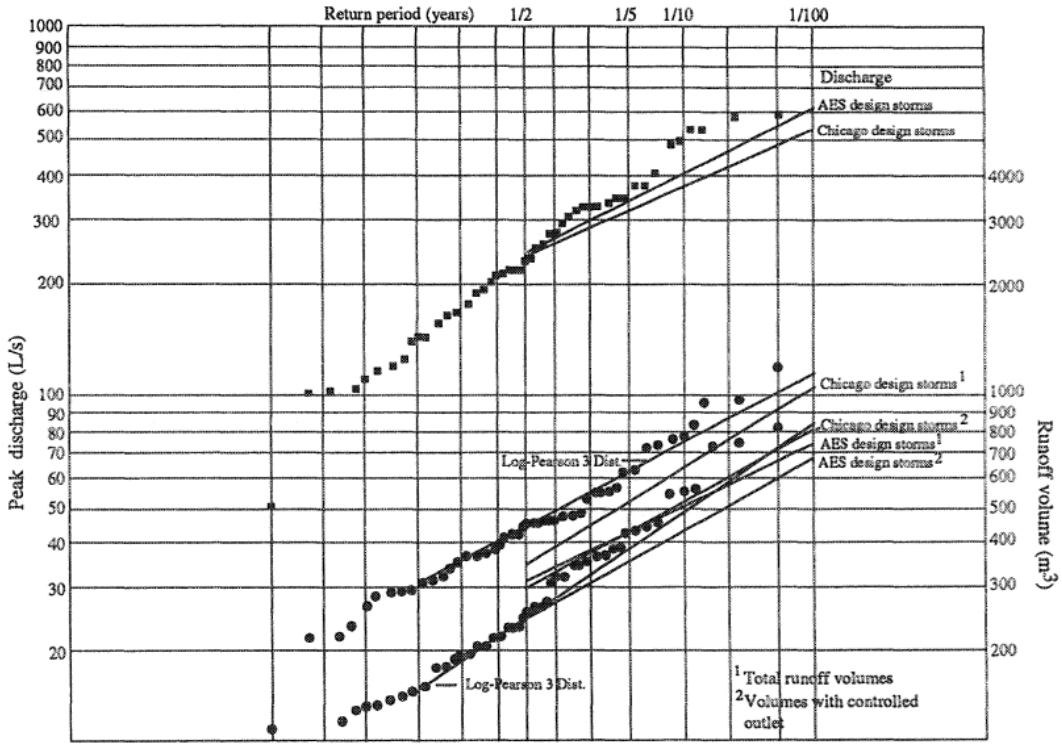

Figure 12.5 Statistical analysis for commercial or industrial lot (1.5 ha 100% impervious).

Peak discharge

Runoff Volume

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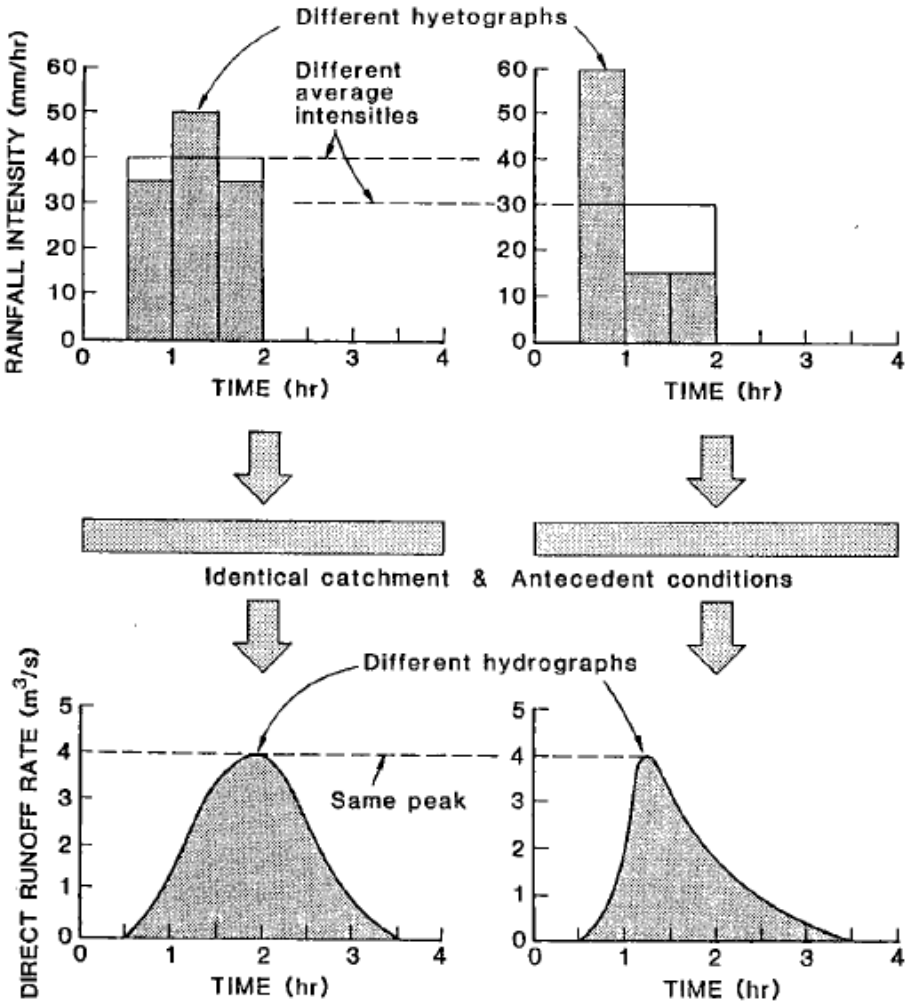
DESIGNING DESIGN STORMS

Many conceptual difficulties…



Design Storm Pathology

Barry J. Adams[1] and Charles D.D. Howard[2]

Different rainfall with same catchment conditions

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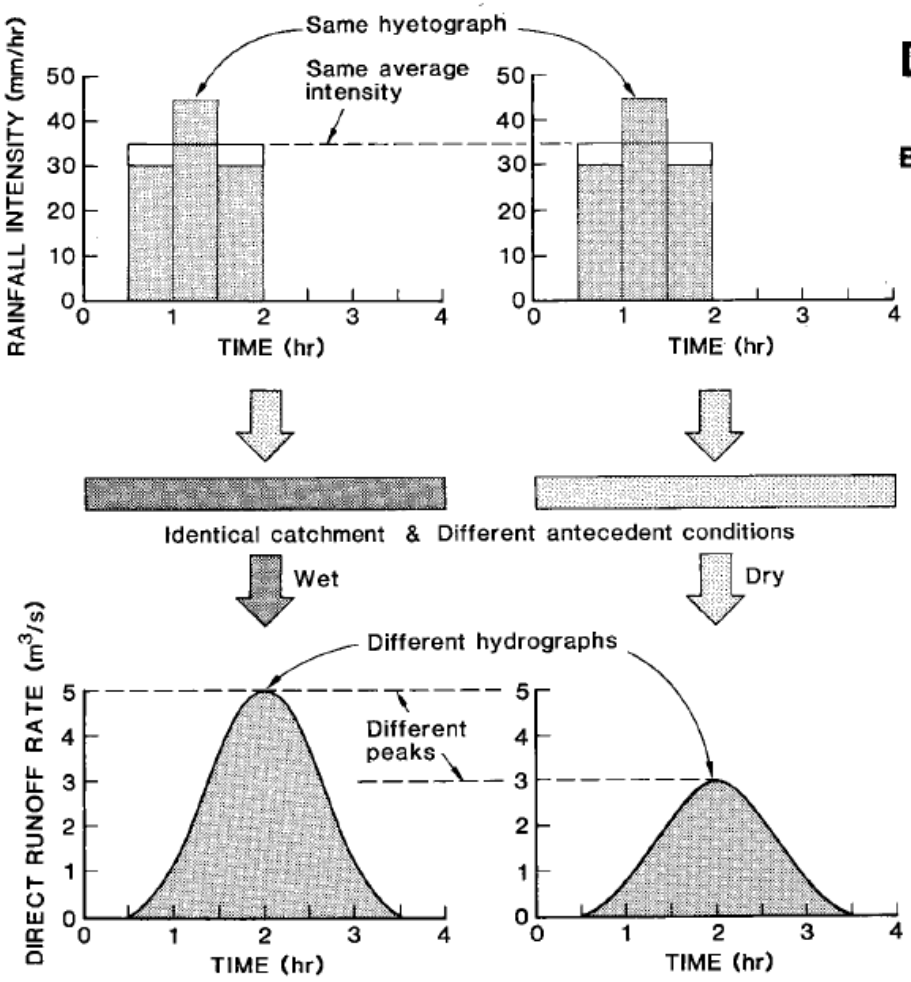
DESIGNING DESIGN STORMS

Many conceptual difficulties…



Design Storm Pathology

Barry J. Adams[1] and Charles D.D. Howard[2]

Same rainfall with different catchment conditions

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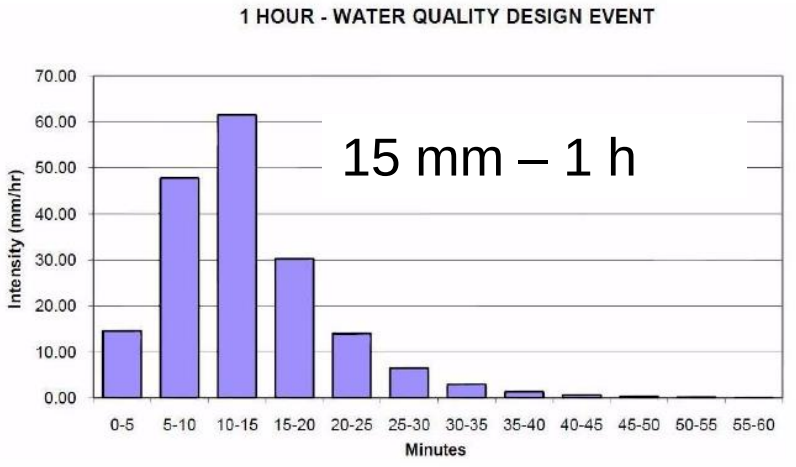
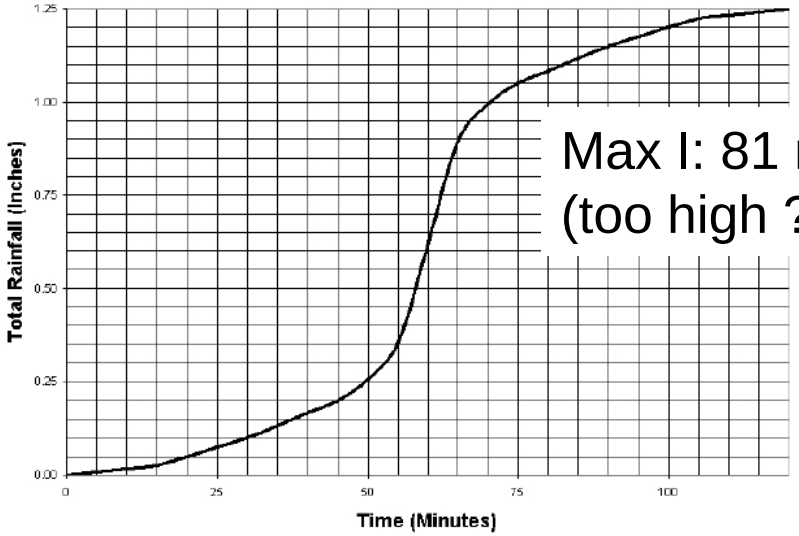
DESIGNING DESIGN STORMS

Suggested design storms for water quality

- Calgary, Canada (2011)



- New Jersey, USA (2004)



- Ontario, Canada (2003)

25 mm 4-hr Chicago-type storm (ponds)

25 mm 2-hr Chicago-type storm (swales)

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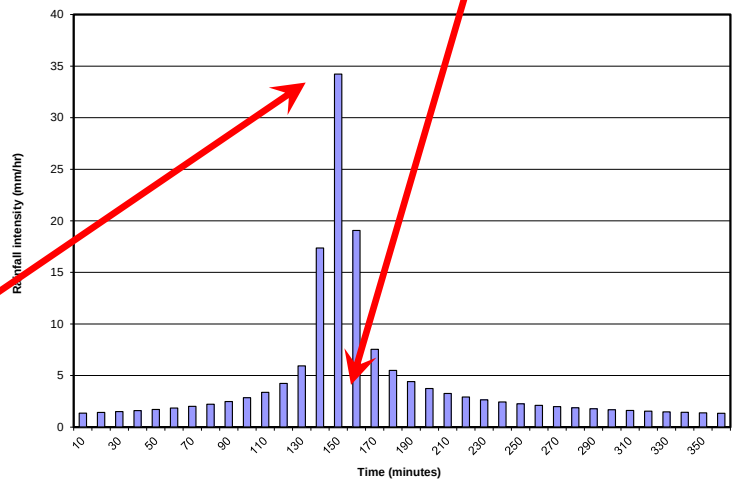
DESIGNING DESIGN STORMS

QUEBEC APPROACH

- Total rainfall quantity: 22 to 26 mm for different regions (90 % of annual rainfall)
- Chicago-type Design Storm for time distribution
  - Duration: 6 hrs
  - $Ratio_{TimeToPeak}$ r = 0.45
  - Peak intensities to be adjusted

Total Rainfall Quantity:
22 to 26 mm



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DESIGNING DESIGN STORMS

CONTINUOUS MODELLING

Rainfall series

Continuous Simulation

Simulated Hydrographs

Discharge series **Volume series**

Statistical analysis **Statistical analysis**

DESIGN STORMS VALIDATION

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DESIGNING DESIGN STORMS

CONTINUOUS MODELLING

IDF Analysis for actual storms with less than 25 mm (and higher than 10 mm)

Event	Date	Duration (h)	Maximum Rainfall (mm/hr)	Mean Rainfall (mm/hr)	Total Rainfall (mm)
2	2001-05-12 13:10	11.75	4.8	0.9702	11.4
7	2001-06-02 4:45	10.58	8.4	1.606	17
10	2001-06-04 4:10	22.5	22.8	0.88	19.8
17	2001-06-22 8:25	5	25.2	2.96	14.8
18	2001-06-22 20:10	28.67	10.8	0.8198	23.5
47	2001-08-20 4:35	5.33	13.2	2.119	11.3
48	2001-08-20 23:15	2.83	50.4	4.588	13
50	2001-08-26 17:15	13.75	14.4	0.9164	12.6
60	2001-09-20 13:10	26.33	10.8	0.5203	13.7
72	2001-10-17 3:30	29.25	7.2	0.3521	10.3
75	2001-10-23 15:30	11	9.6	1.345	14.8

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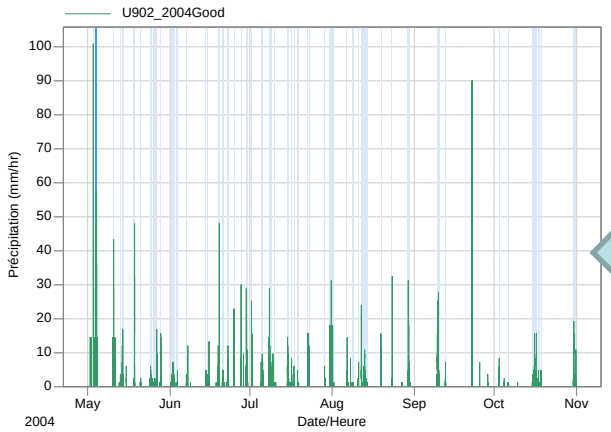
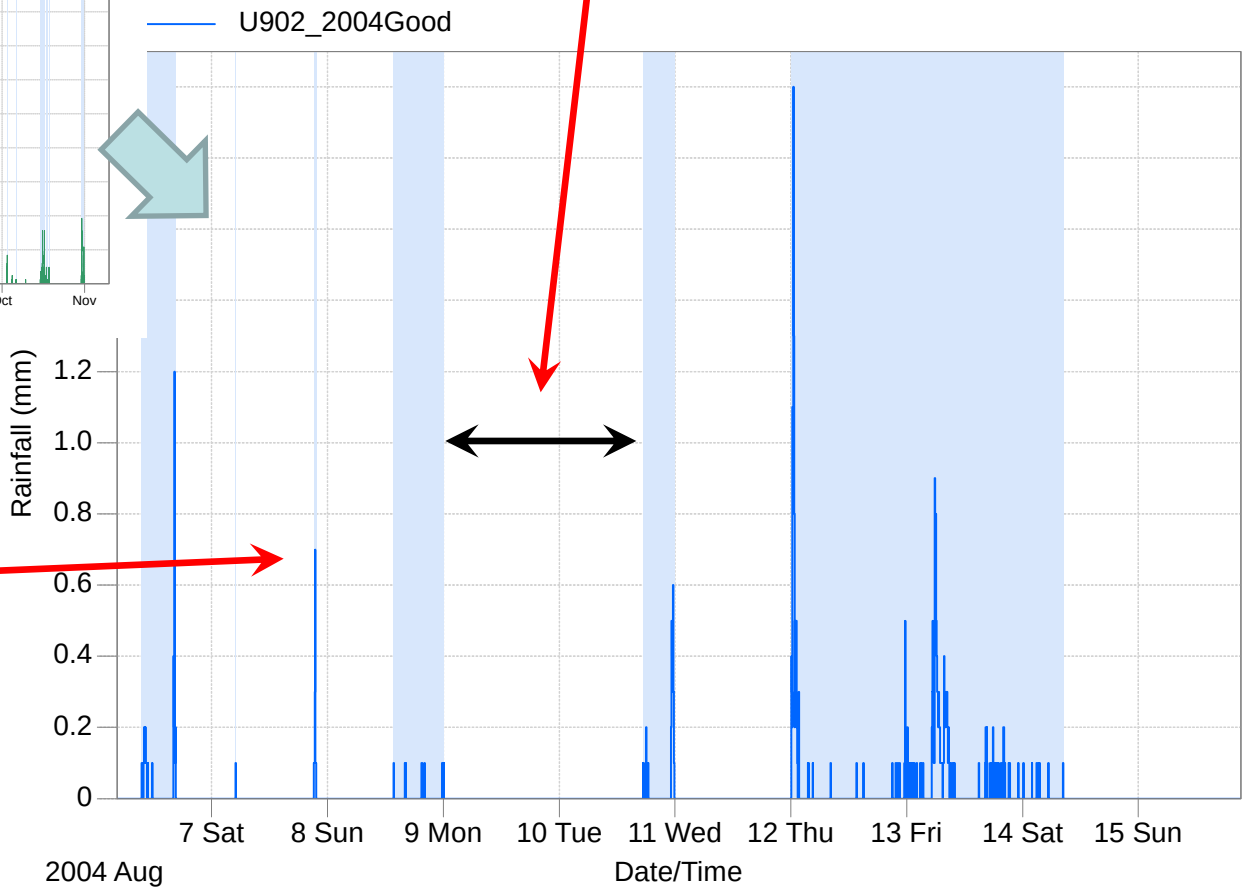
DESIGNING DESIGN STORMS

EXAMPLE - 2004

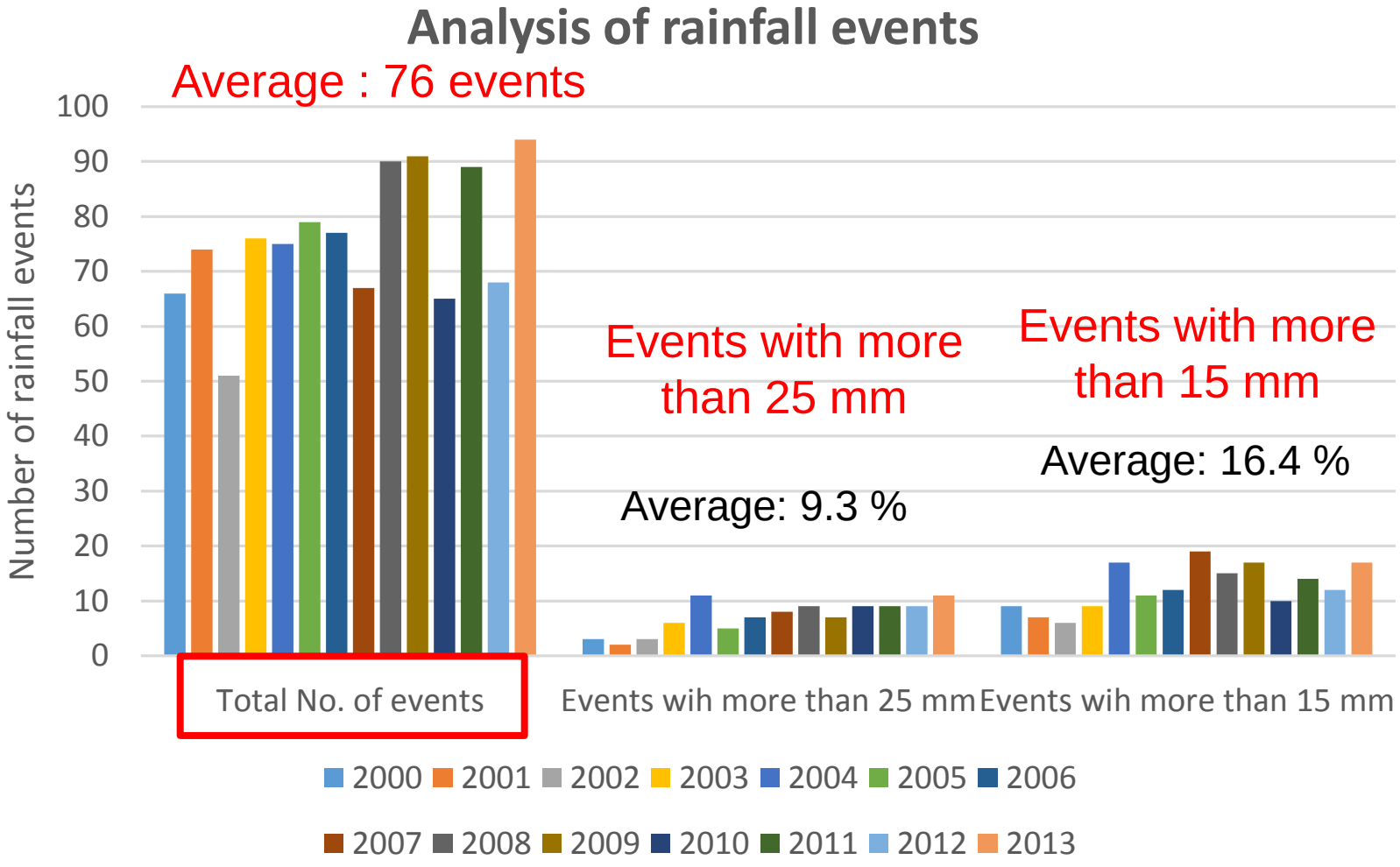


Min Interevent = 6 hours

Min P = 1 mm



DESIGNING DESIGN STORMS



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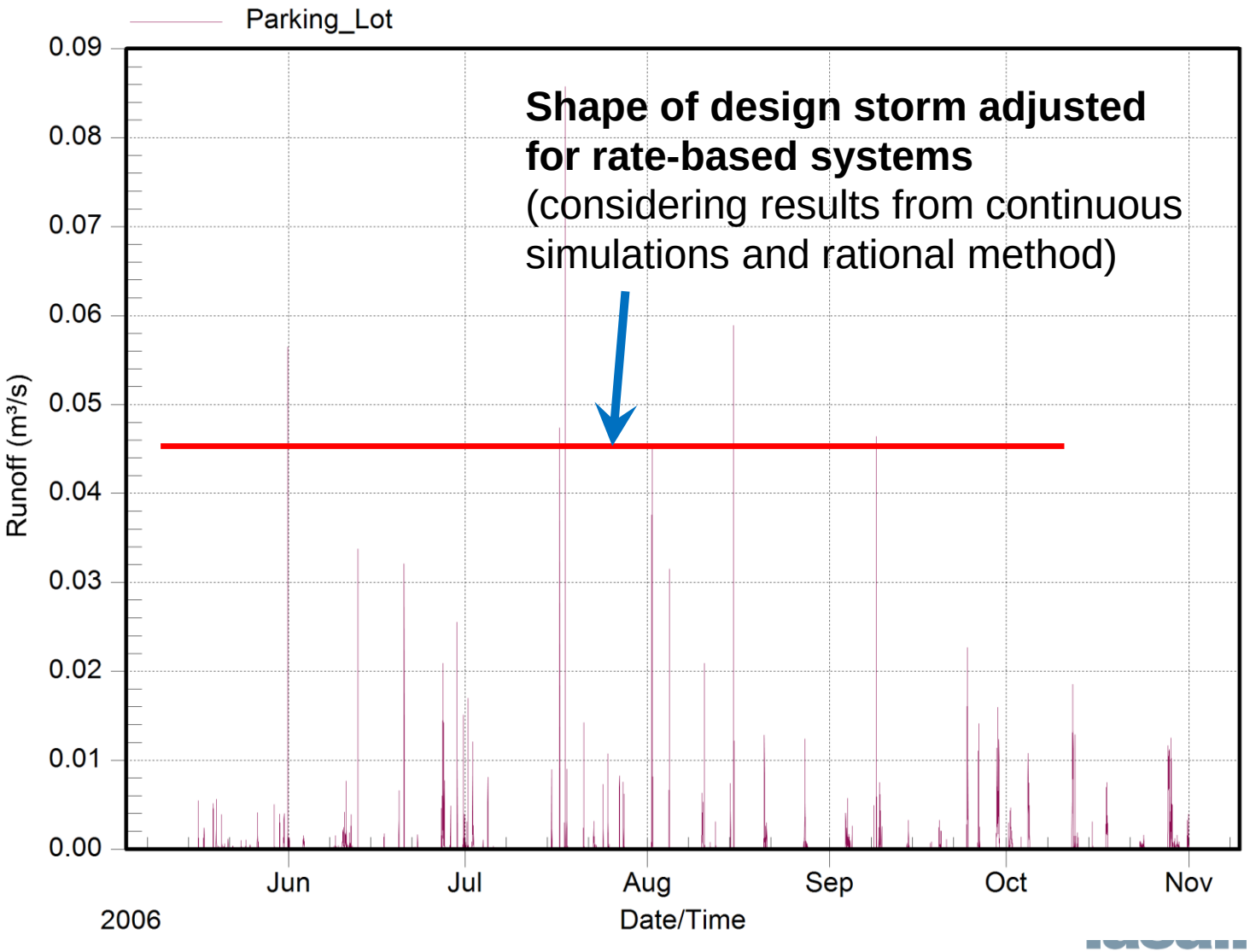
DESIGNING DESIGN STORMS

Generic types of land use defined

- Small Parking Lot
- Medium-size high density residential
- Medium-size low density residential

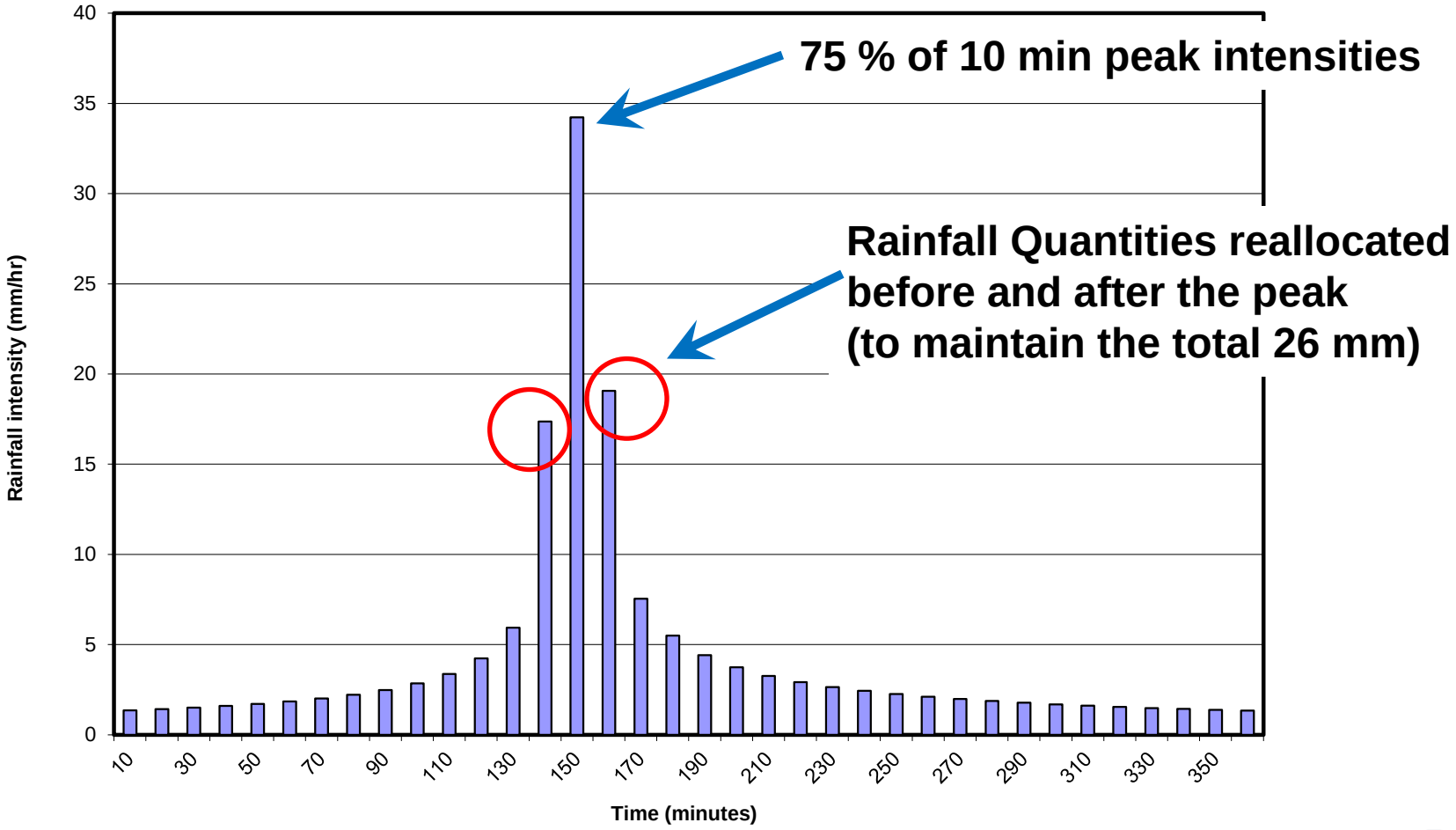
Continuous modelling used to adjust the shape of the design storm

DESIGNING DESIGN STORMS



DESIGNING DESIGN STORMS

Design storm adjustments for rate-based systems



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SUMMARY – THE WAY FORWARD

- Urban Runoff Quality Control

Small Storms

- Design Tools adapted to types of SCM (Volume or Rate Based)
- Design Tools adapted to scale and complexity of project
- Ideally use actual rainfall series where available

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7th Annual TRIECA Conference
March 21 & 22, 2018

Design Storms and Parameters for Sustainable Drainage Systems

Gilles Rivard, ing. M. Sc.
Vice-President – Urban Hydrology (Lasalle-NHC)

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