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## A method to predict pipe renewal impact on drinking water supply systems water losses

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# WaterLoss2022

19-22 June 2022

Praha • Prague



## A method to predict pipe renewal impact on drinking water supply systems water losses



Eddy RENAUD, Lucile CHOLET, Cédric FELIERS, David MAISONNEUVE

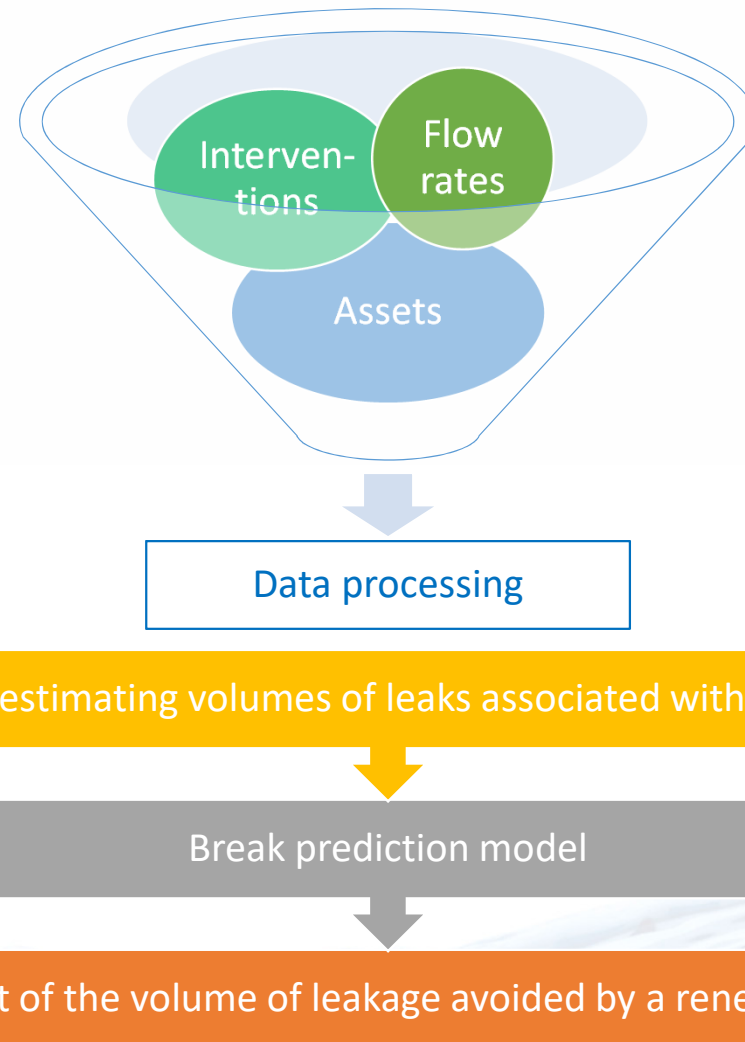


# Context and method

## Context

- INRAE / Veolia / Vedif research collaboration: "Effectiveness of actions to reduce losses from drinking water networks"
- First axis: Impact of pipes renewal on water losses
- Case study: Syndicat Mixte d'Adduction d'Eau Potable des Eaux de Loire - *Drinking Water Supply Service of "Eaux de Loire"* (EDL DWSS)

## Method



# Data processing

Meter flows every quarter of an hour

Control of homogeneity and time regularity

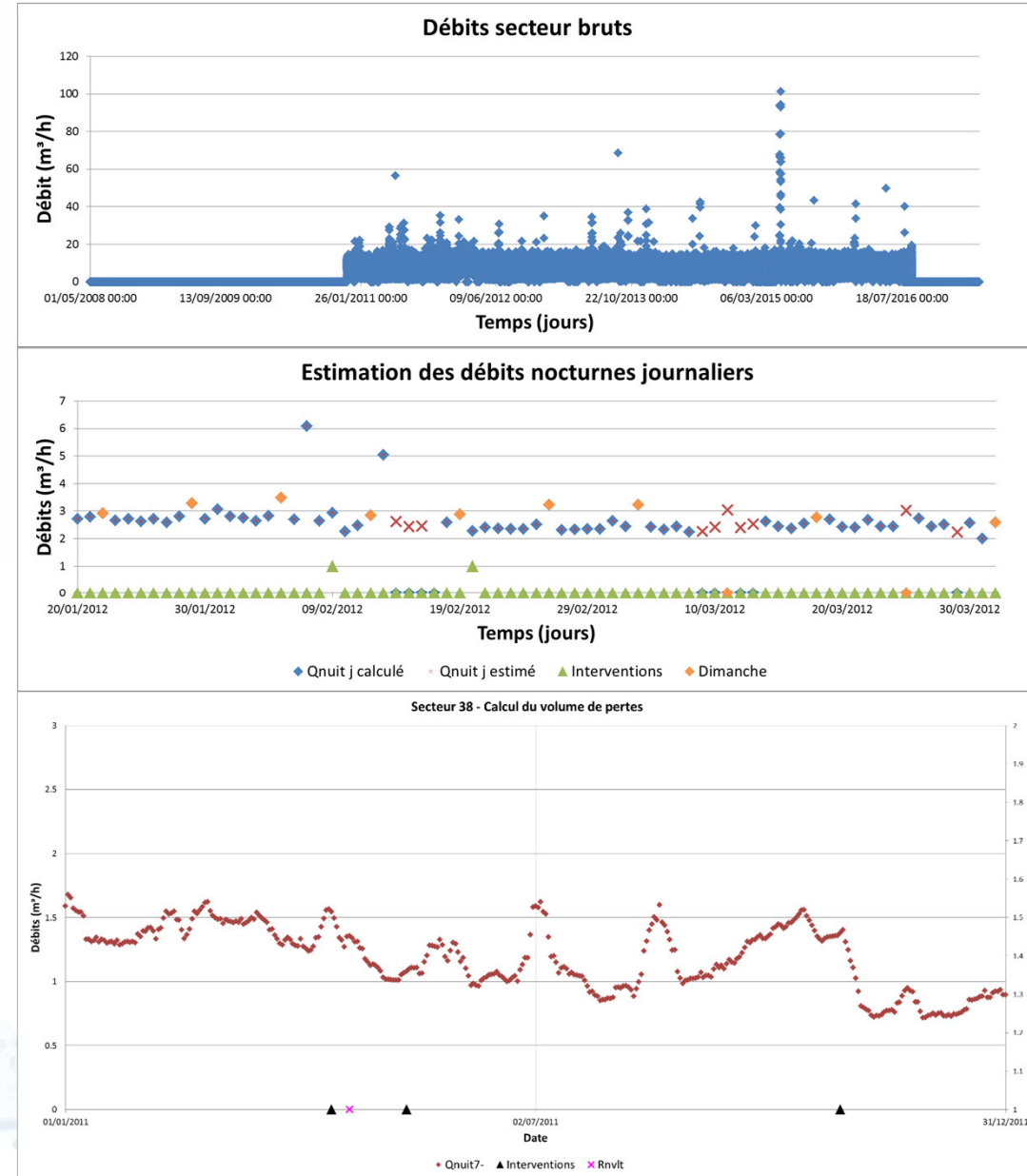
Filtering of null, negative or aberrant data

Calculation of DMAs' flows

Calculation of daily night flows

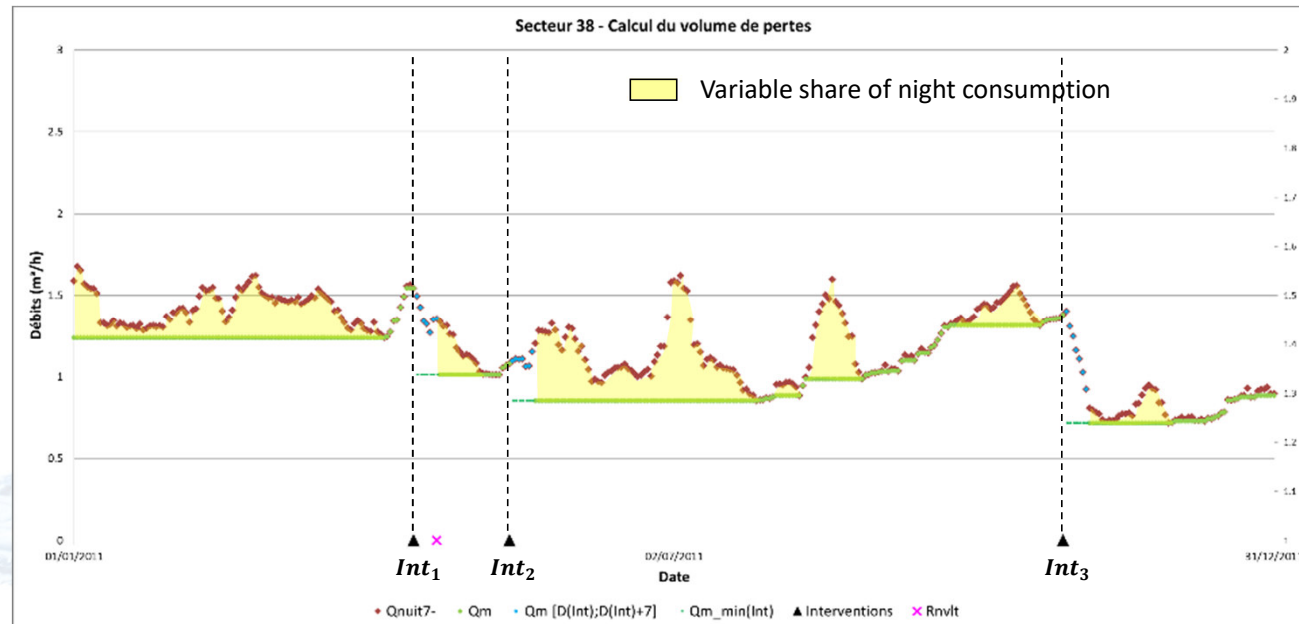
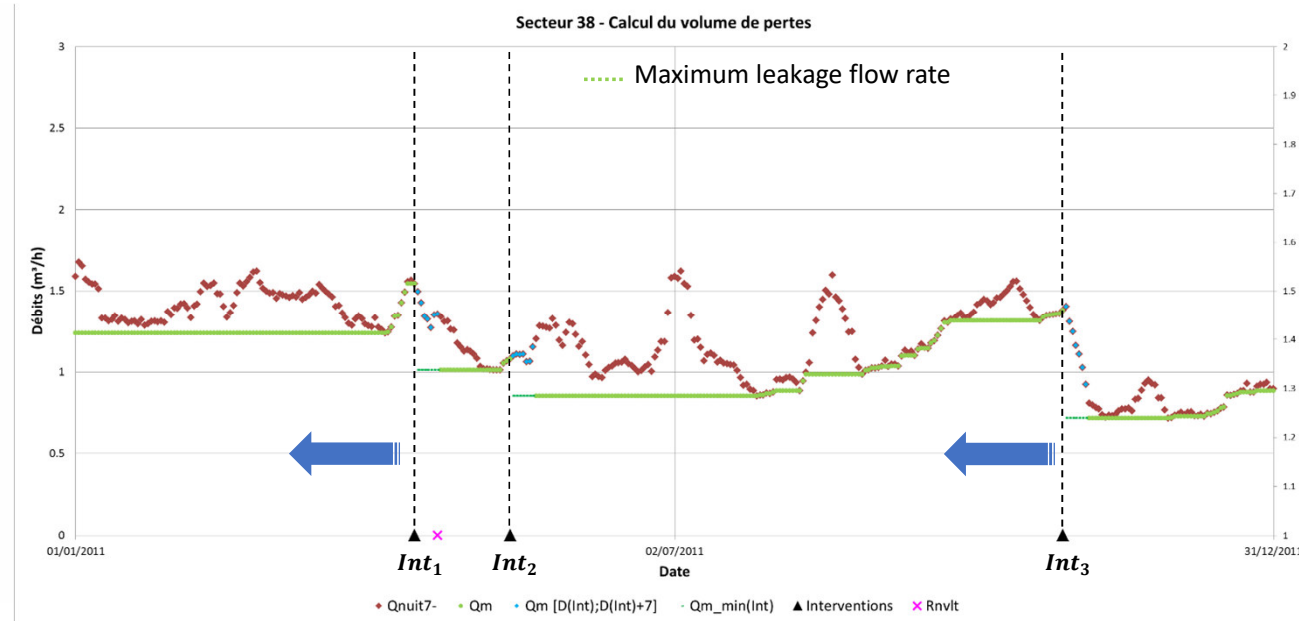
Data completion

Calculation of average daily night flows over 7 rolling days



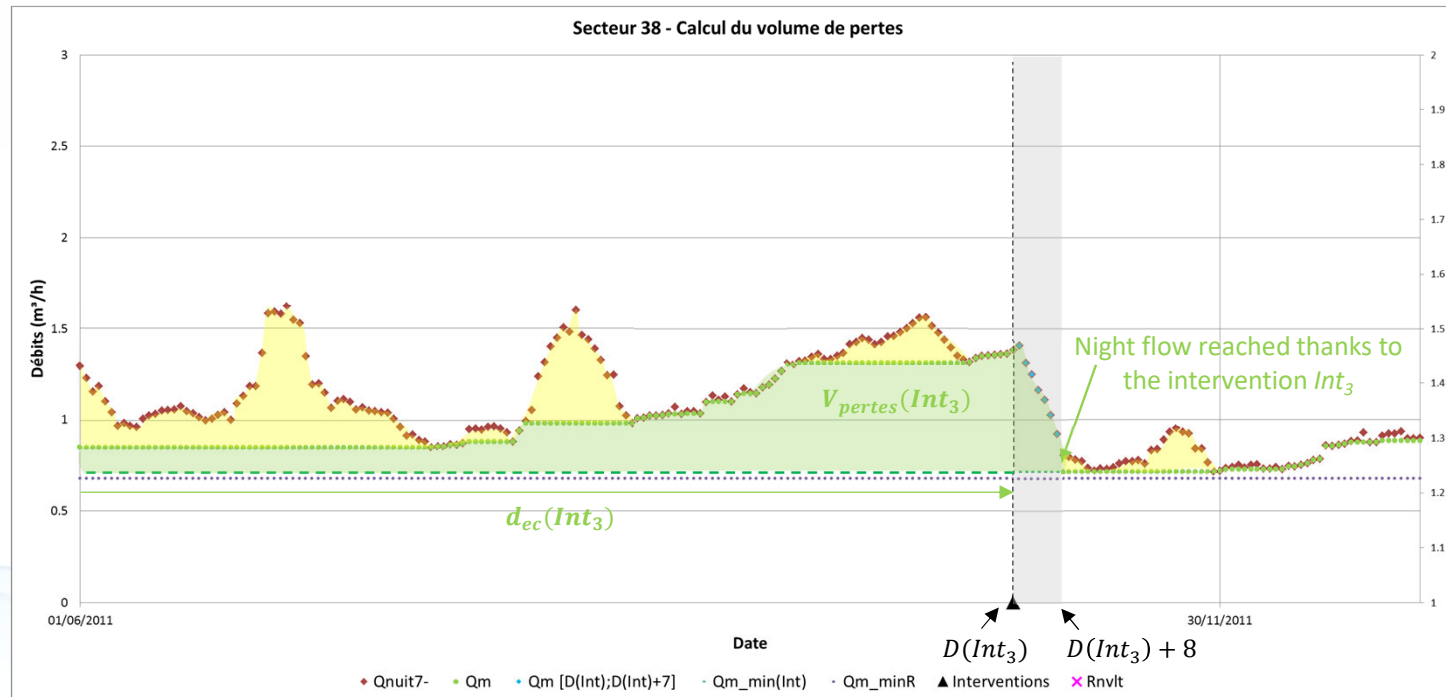
## Method for estimating volumes of leaks

- Strong assumption: The leakage flow rate cannot in any case decrease without intervention i.e. repair or renewal of pipe or connection
- The green line is built going back in time and is, in this way, always decreasing between two interventions
- The volumes between the green and red lines (in yellow) are considered as the variable share of night consumption (this includes leaks on the private parts of connections)



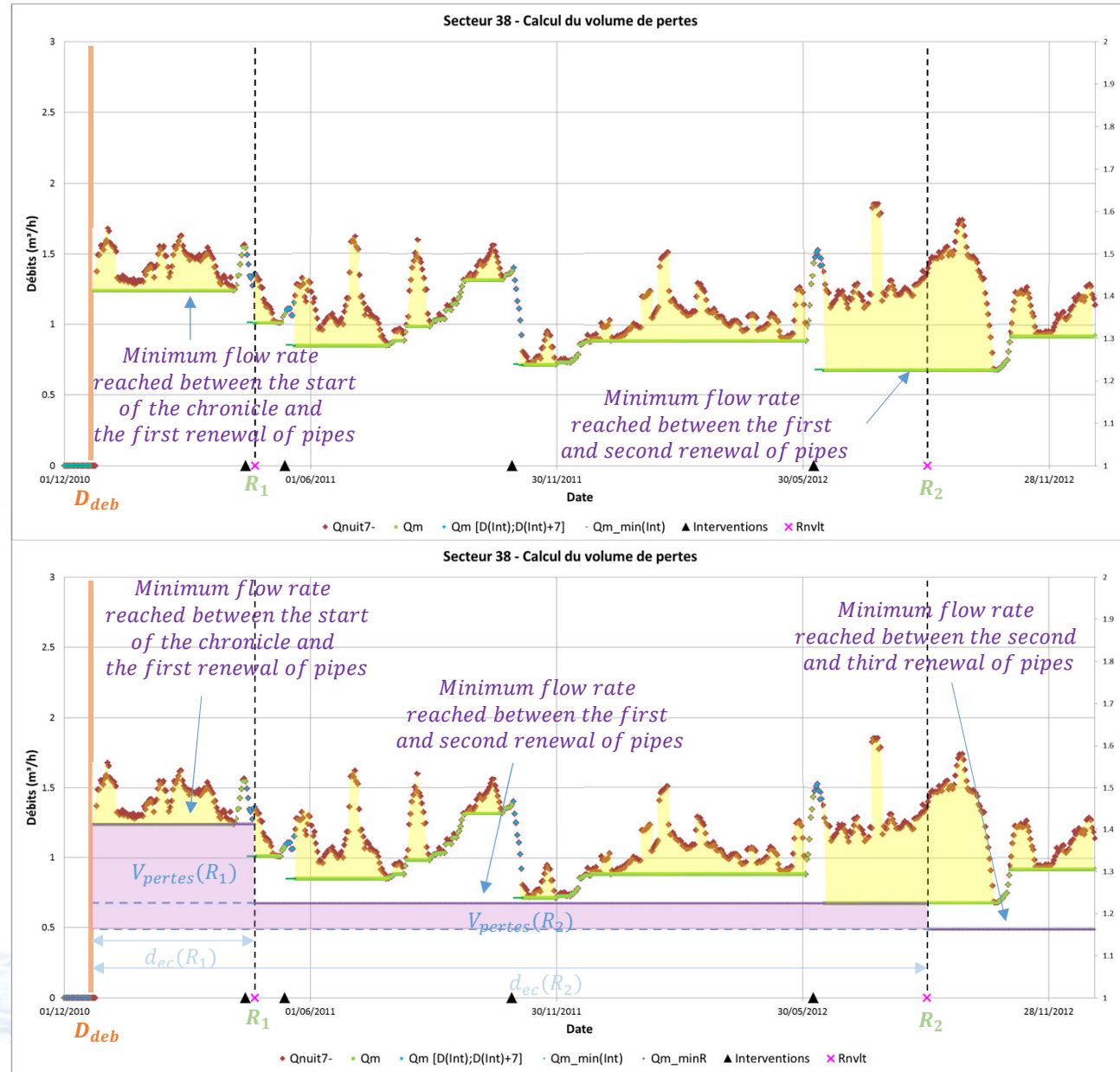
# Method for estimating volumes of leaks

- The volume associated with a repaired leak (in green) is bounded by the green line up to the previous intervention and the straight line corresponding to the minimum of the green line after the repair
- The duration of the leak is determined by looking in the past for the first night flow below the minimum of the green line after the repair

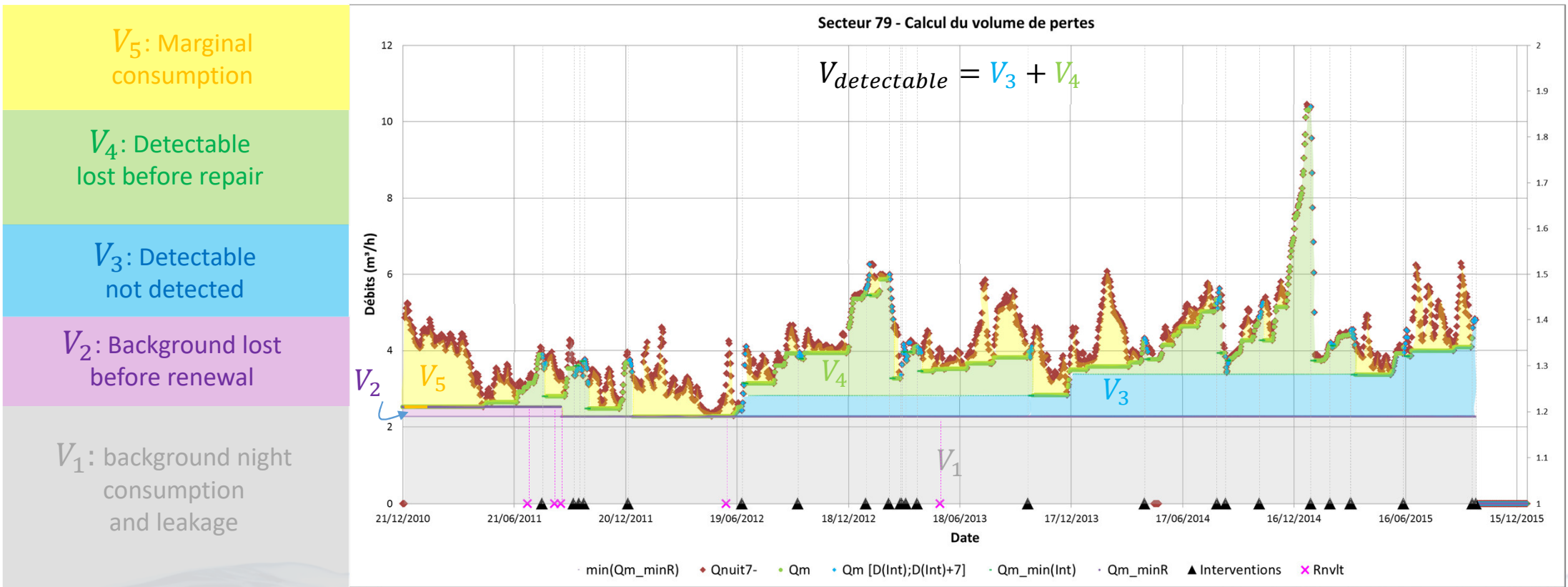


# Method for estimating volumes of leaks

- The volume associated with a renewal of pipes (In purple) is bounded by lines associated to the minimum flow rates reached between two successive renewals or between the start of the chronicle and the first renewal



# Method for estimating volumes of leaks associated with interventions





## Application to "Eaux de Loire" DWSS

- 30 DMAs totaling 713 kilometers of pipes and 11,700 connections.
- Flow measurements data on interventions available between 2009 and 2015

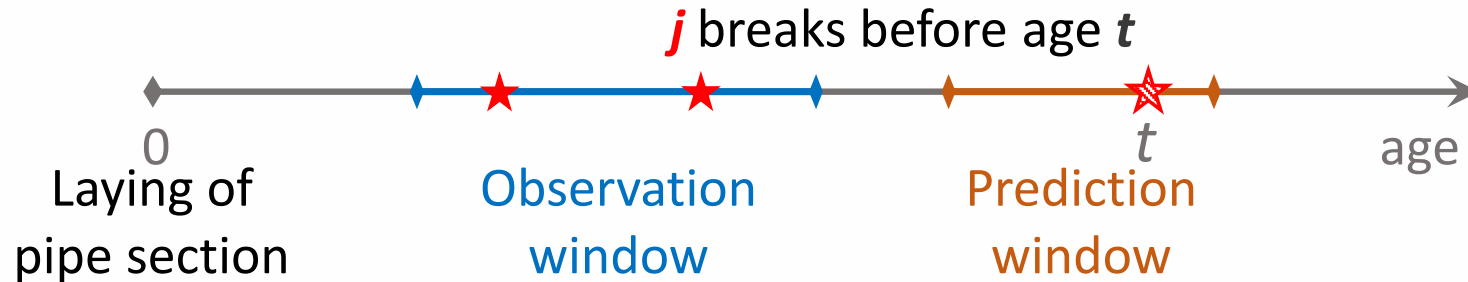
### Summary of average volumes of observed leaks

Support	Matériau	Diameter (mm)	Number	Volume (m <sup>3</sup> )
Pipes	PVC	< 80	82	1 141
		≥ 80	40	1 366
	Cast Iron	< 80	56	1 506
		≥ 80	58	1 871
	Other	All	14	1 067
Connections	All	All	274	1 173

# Break prediction model



<https://casses.inrae.fr/en/>



$$E(dN(t)|N(t-) = j) = (1 + \alpha j) \times (\delta t^{\delta-1}) \times (e^{z^T \beta})$$

Risk of breakage at age *t*       $\alpha$  Previous breaks       $\delta$  age       $\beta$  other factors

## Intensity function of the LEYP model

*Linear Extended Yule Process, [Le Gat, 2007]*

# Calibration of break prediction models

	Pipe model	Connections model
Alpha	2.9231	3.4141
Delta	1.0000	1.0000
DIA	-0.0024	-0.0018
Log(LNG)	0.3326	0.2329
MAT [Cast Iron]	0.0000	0.0000
MAT[PVC]	-0.6116	0.3983
MAT[Other]	-0.4785	0.2046
IP[[01/01/1900;01/01/1951[]	0.0000	0.0000
IP[[01/01/1951;01/01/1971[]	0.6813	0.8098
IP[[01/01/1971;01/01/1981[]	0.4256	0.4108
IP[[01/01/1981;01/01/2001[]	0.2633	0.3706
IP[[01/01/2001;26/10/2015[]	0.2956	0.3223

++ ++  
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 - -  
 + +  
 - +  
 - +  
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- A significant effect of previous breaks ( $\alpha$ )
- No direct effect of ageing ( $\delta=1$ )
- The risk decreases when the diameter (DIA) increases and increases with the length of the pipe section (LNG)
- Cast iron pipes break more than those made of other materials and connections on cast iron pipes break less than those on pipes of other materials (MAT)
- When the installation date is known, the older the installation period (IP), the greater the risk (which clearly reflects an aging effect)

# Forecast of breakages and associated leak volumes over the period 2018-2022

Observation period: 2009 - 2015

	Nb Pipes	L Pipes	Nb pipe breaks	Pipes fail rate	Nb Cnct breaks	Cncts fail rate
Cast Iron	4 451	558	603	0.157	344	0.090
PVC	17 915	2 601	734	0.041	748	0.042
Other	2 068	252	71	0.051	84	0.060
<b>TOTAL</b>	<b>24 434</b>	<b>3 411</b>	<b>1 408</b>	<b>0.061</b>	<b>1 176</b>	<b>0.051</b>

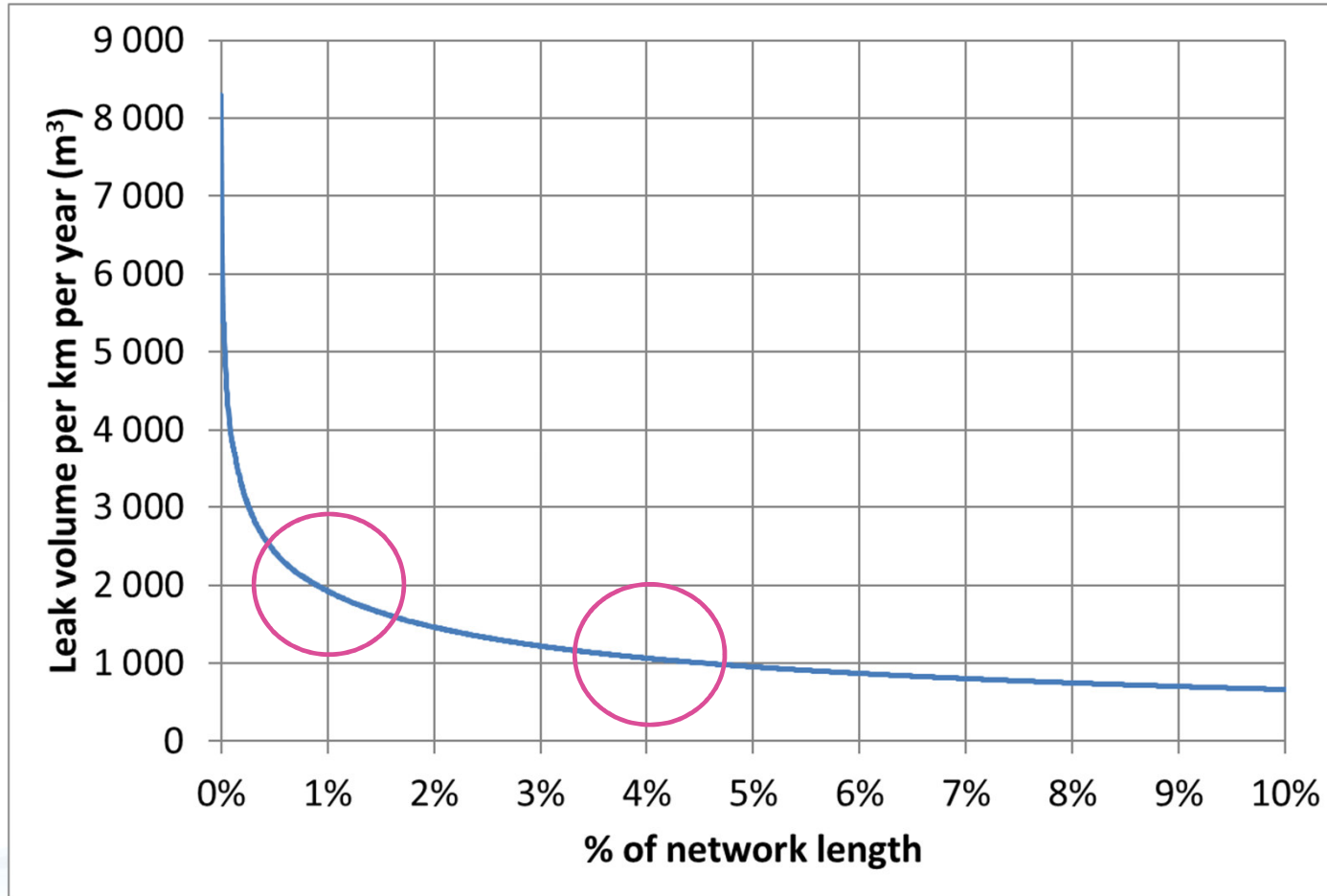
- Break rates on pipes and connections are rising

Prediction period: 2018 - 2022

	Predicted pipe breaks	Pipes leak volume (m <sup>3</sup> )	Predicted Cnct breaks	Cncts leak volume (m <sup>3</sup> )	Total leak volume (m <sup>3</sup> )
5 years	1 155	1 660 947	961	893 019	2 553 966
1 year	231	332 189	192	178 604	510 793
Fail rate (breaks/km.year)	0.068		0.056		
LLI (m <sup>3</sup> /km.day)		0.27		0.14	0.41

- Detected leaks are responsible for **0.4 m<sup>3</sup>/km.day**
- Knowing that the linear losses index of the DWSS is close to 1.0 m<sup>3</sup>/km.day, it can be estimated that background or undetected leaks represent approximately 0.6 m<sup>3</sup>/km.day

# Leakage accumulation



Pipe sections being sorted by decreasing risk of leakage, the volume of detectable leakage avoided per km of network renewed decreases rapidly:

- 2,000 m<sup>3</sup> / km.year for the first 1%
- 1,000 m<sup>3</sup> / km.year for the first 5%

% Network length	% predicted breaks	% Detected leaks volume
1%	11%	13%
2%	17%	20%
3%	21%	24%
4%	25%	28%
5%	28%	32%

## Disparity of leaks according to the types of pipe

	CI[0;80[	CI[80;400]	PVC[0;80[	PVC[80;400]	Other[0;80[	Other[80;400]
% Network length	2%	14%	52%	25%	4%	3%
% Predicted leaks volume	13%	32%	33%	15%	4%	2%

- Small diameter cast iron pipes represent 2% of the network length but are responsible for 13% of the volumes lost by detectable leaks.

# Conclusion

## Results

- A data processing method at DMA level that makes it possible to associate a duration, a flow rate and a volume of water loss with each intervention has been developed;
- Coupled with a break prediction, it makes it possible to prioritize the sections according to their risk of leakage and to assess the volume of detectable leaks that a renewal program can avoid.

## Limits and prospects

- The volumes associated with diffuse leaks could not be reliably estimated;
- To go further, it is necessary to capitalize on the information associated with the renewal of pipes and connections (dates of decommissioning, technical characteristics of the renewed element, etc.)

# Thank you for attention

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The logo for INRAE, featuring the letters 'INRAE' in a bold, teal, sans-serif font.The logo for ETTIS, with 'ETTIS' in a bold, multi-colored font (blue, red, yellow). Below it, the text 'Environment Territories in Transition Infrastructures Societies' is written in a smaller, teal font.The logo for VEOLIA, featuring a red circular icon with a white dot inside, followed by the word 'VEOLIA' in a bold, red, sans-serif font.The logo for VEOLIA Eau d'Ile-de-France, with 'VEOLIA' in a bold, dark blue font, 'Eau d'Ile-de-France' in a smaller, blue font, and 'Délégataire du SEDIF' in a very small, dark blue font below.