

# Risk analysis methodology of a deliberate contaminant event

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**DRESDEN 18<sup>th</sup> march 2015**



# Contributors & partners for WP 7

**E.N.G.E.E.S** was involved in this project with 2 research units:

- **Irstea-Engées GESTE** joint unit  
(Territorial Water and Environment Management)
- **UDS, CNRS, Engées, Insa ICUBE-fluid mechanics** team

## Contribution in the project

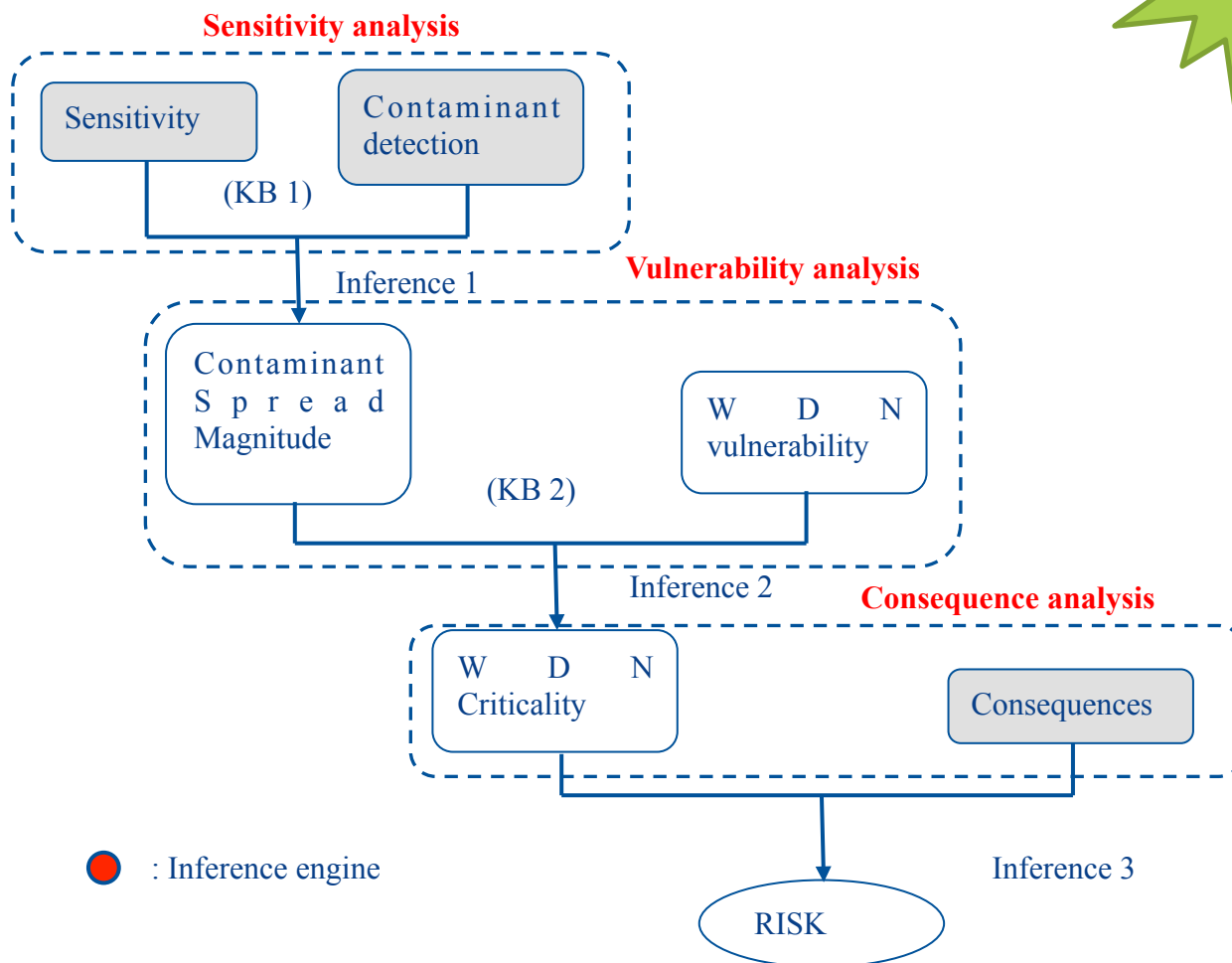
- **Hydraulic modelling on Strasbourg network**
- **Consumers' representation of drinking water: from perception to social mobilisation**
- **Risk analysis of intentional contamination**

# WP 7: Risk analysis and Impact assessment.

## Demonstration of dedicated module for consequences evaluation

# Conceptual framework

New



## Potential consequences (non-exhaustive list)

Type of consequence		Way to assess it (indicator)	Scale	Acronym	Unit
Consequences on water utility	Asset contamination	Cost of cleaning, repairing or renewal	Node or scenario of contamination	ACR ARR	€
	Loss of income	Unsold water per day or during contamination period	Node or scenario of contamination	DLI	€
	Water delivery by substitution	Cost of elementary volume of water delivered by alternative way (bottles, tank,etc)	Node or scenario of contamination	WS	€
	Loss of confidence and brand image	Consumer behaviour changing	Scenario of contamination	LCBI	€
Consequences on third parties	Human health	Number of ill persons	Node or scenario of contamination	$n_{\text{ill person}}$	#
	Loss of wellbeing	Willingness to pay	Node or scenario of contamination	<i>NWTP</i>	€
	Water pollution	Released contaminated water	Scenario of contamination	WP	m <sup>3</sup>
	Loss of income for non-domestic users	Loss of daily operating income due to partial or total interruption or perturbation of water delivery	Node or scenario of contamination	OI <sub>daily</sub>	€

# Consequence analysis settings

## 1) Consequences on water utility

	Settings	Unit	Value
WDN asset cleaning and reparation	Cleaning unit cost	€ / linear meter	
	Cleaning water volume per length of pipes	m3/linear meter	
	Water used for cleaning - treatment cost	€/m3	
WDN asset renewal and rehabilitation	Renewal cost	€ / linear meter	
Daily loss of Income	Cubic meter water price	€/m3	
Emergency Water delivery	Daily emergency water delivery cost	€/pers/day	
Lost of confidence and brand image	Daily volume of water used for drinking and cooking	Liter	

## 2) Consequences on third parties

	Settings	Unit	Value
Loss of life condition and well-being	Demand price elasticity		
	Substitution water price	€/m3	
	Uncompressed water volume for domestic uses	Liter	
Water pollution	Portion of sanitation use	%	



# Consequence Analysis

Consequences on water utility and third parties

**1) Consequences on water utility**

- ☐ WDN asset cleaning and reparation
- ☒ WDN asset renewal and rehabilitation
- ☐ Daily loss of income
- ☒ Water delivery by substitution
- ☐ Loss of confidence and brand image

**2) Consequences on third parties**

- ☒ Loss of economic activity for non domestic users
- ☐ Loss of life condition and well-being
- ☐ Water pollution

OK! Cancel

Contaminant characteristics definition

☐ Chemical

☒ Microbiological

Cryptosporidium parvum  
**Giardia Lambia**  
 Rota virus  
 Campilobacter jejuni  
 E.Coli O157:H7

OK Cancel

Contaminant characteristics definition

☐ Chemical

☒ Microbiological

Cryptosporidium parvum

Initial Concentration?

OK

Contaminant Initial Concentration

C0 ? (mg/L or CFU/mL)

OK Cancel

100



# Microbiological contamination

## STEP 2:

Contaminant definition

### Contaminant characteristics

Microbiological	Chemical
<b>Francisella tularensis</b>	
<b>1) Dose response model</b> <i>Exponential model</i> $P(\text{Inf/day}) = 1 - \exp(-rd)$ $r = 1.33\text{E-}07$	<b>1) Dose response model</b> <i>Reference dose (mg/kg/day)</i> $Rfd =$
<i>Beta-poisson model</i> $P(\text{Inf/day}) = 1 - \text{power}((1+d/B); -A)$ $A =$ $B =$	
<b>2) Probability of illness if infection</b> $P(\text{Illness/Infection}) = 1$	
<b>3) Reference Level of Risk of disease (RLR)</b> $RLR = 0.001$	
<b>4) Exposition duration (day)</b> $n = 1$	
<b>5) Contaminant initial concentration (mg/L or CFU/mL)</b> $C0 = 100$	

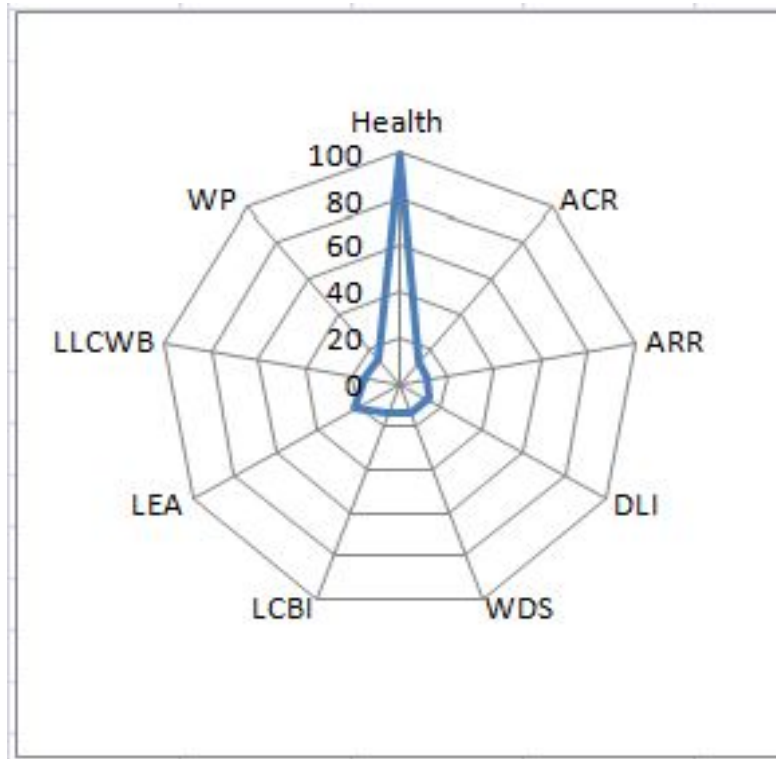
# Consequence assessment: settings

Settings	Unit	Value	Comments
Cleaning unit cost	€ / linear meter	3.5	Average cost
Cleaning water volume per length of pipes	m3/linear meter	0.06	Twice the volume of 1 linear meter of pipe
Water used for cleaning - treatment cost	€/m3	10	
Renewal cost	€ / linear meter	300	Average cost
Cubic meter water price	€/m3	1	the drinking water price without purification price and taxes
Daily emergency water delivery cost	€/pers/day	5	Based on 50 liters per persons at 0.1 €/L
Daily volume of water used for drinking and cooking	Liter	10	-
Demand price elasticity		-0.15	Ranges from -0.1 to -0.2
Substitution water price	€/m3	100	0.1€/L
Uncompressed water volume for domestic uses	Liter	50	-
Portion of sanitation use	%	97	-

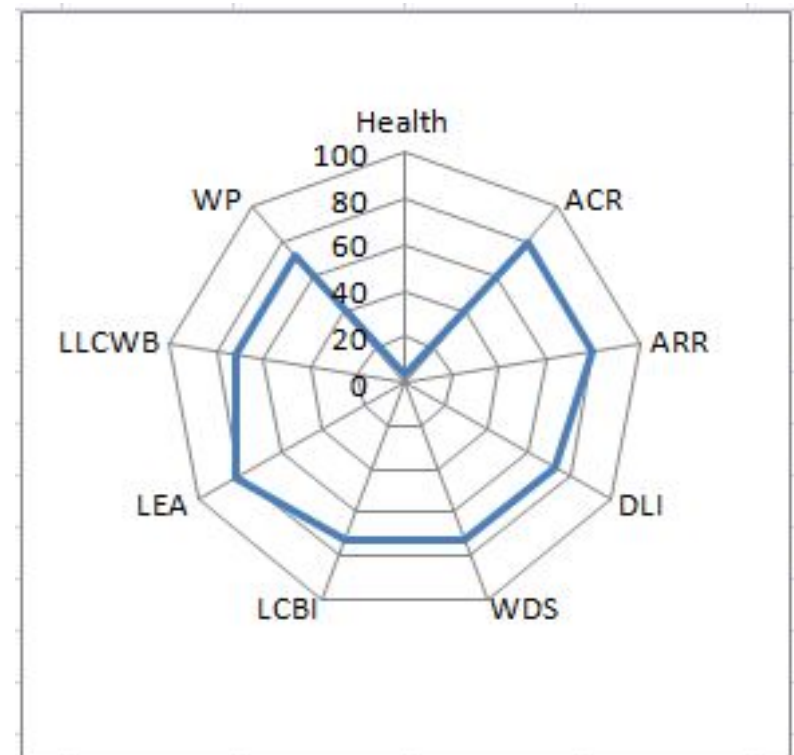
# Consequence assessment

Category	Consequences	Unit	Min	Max	Average
Impacts on water utility	WDN asset cleaning and reparation	€	0	2560 211	341577
	WDN asset renewal and rehabilitation	10 <sup>6</sup> .€	0	219	29
	Loss of income	€/day	2	4545 8	6919
	Water delivery by substitution	€/day	72	1515 258	230629
	Loss of confidence and brand image	€/day	0	3031	461
Impacts on third parties	Impact on health	# pers	0	298	33
	Loss of economic activity for non domestic users	10 <sup>6</sup> .€	0	60	10
	Loss of life condition and well-being	€/day	42	8756 18	133273
	Water pollution	m <sup>3</sup>	2	4409 4	6711

# Most risky contamination scenario profiles



“Maximal sanitary risk “profile”



« Maximal risk for water utility and economic activities » profile.

## Conclusion

- Complete and comprehensive methodology for risk assessment
- Implementation done step by step and possible exploitation of intermediate results for sensitive users and WDN vulnerability
- External and Internal consequence assessment regarding to water utility
- Risk assessment and matching of the most vulnerable intrusion points regarding to the actual WDN state