NSERC
INDUSTRIAL CHAIR
ON DRINKING WATER

POLYTECHNIQUE
MONTRÉAL

Optimizing water sampling in large building premise plumbing for the detection of opportunistic pathogens

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Opportunistic pathogens in large buildings water distribution systems

Favorable growth conditions :

- ✓ Temperature (20 – 50 °C)
- ✓ Stagnation
- ✓ Small diameter = ↗ S/V
- ✓ Biofilm and amoeba
- ✓ Materials
- ✓ Dead legs
- ✓ Absence of disinfectant
- ✓ Renovation & construction

Ideal growth conditions
+ exposition
+ vulnerable patients
= high risk of infection

Factors to consider when defining sampling plan in a large building

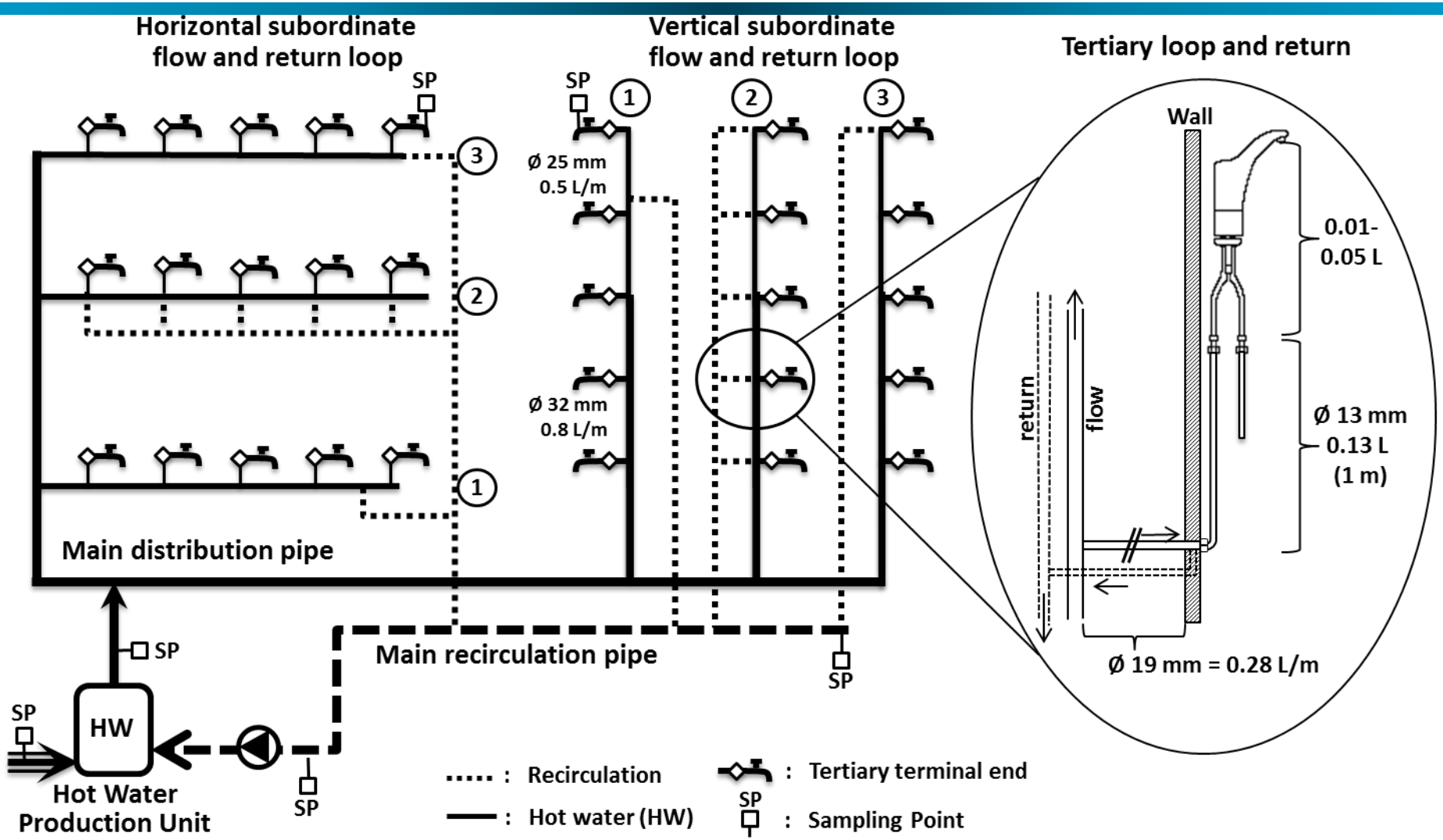
1) Understanding the system:

- Water distribution system design and architecture
- Data to locate risk areas: historical data, hydraulics, temperatures at point of use, user complaints
- Type of devices and impact water quality

2) Defining sampling parameters:

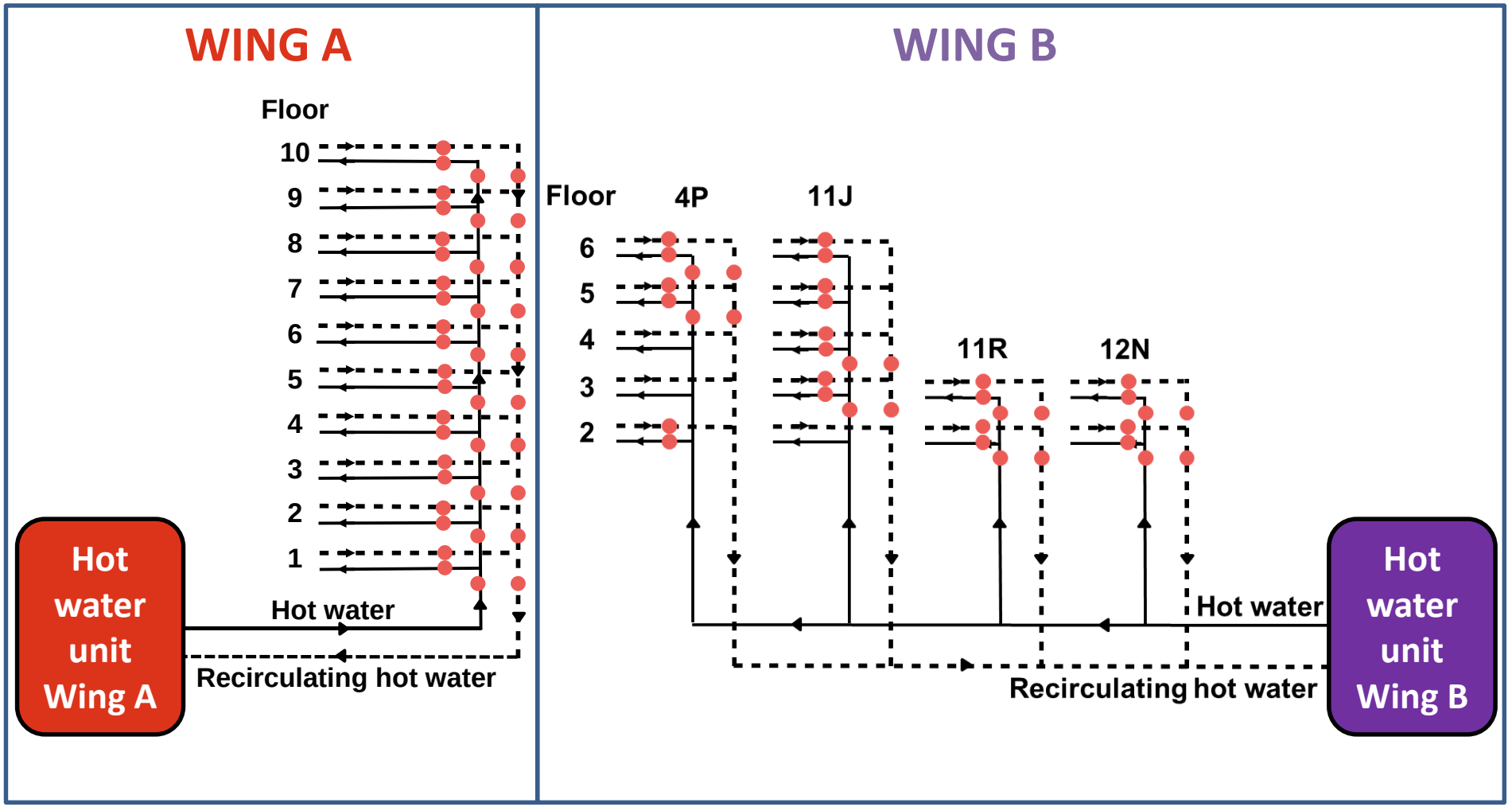
- Sampling objectives
- 1st draw or flushed samples
- Sampling volume to maximize recovery
- Detection method: culture or molecular methods

Understanding the system: Large Building Water System

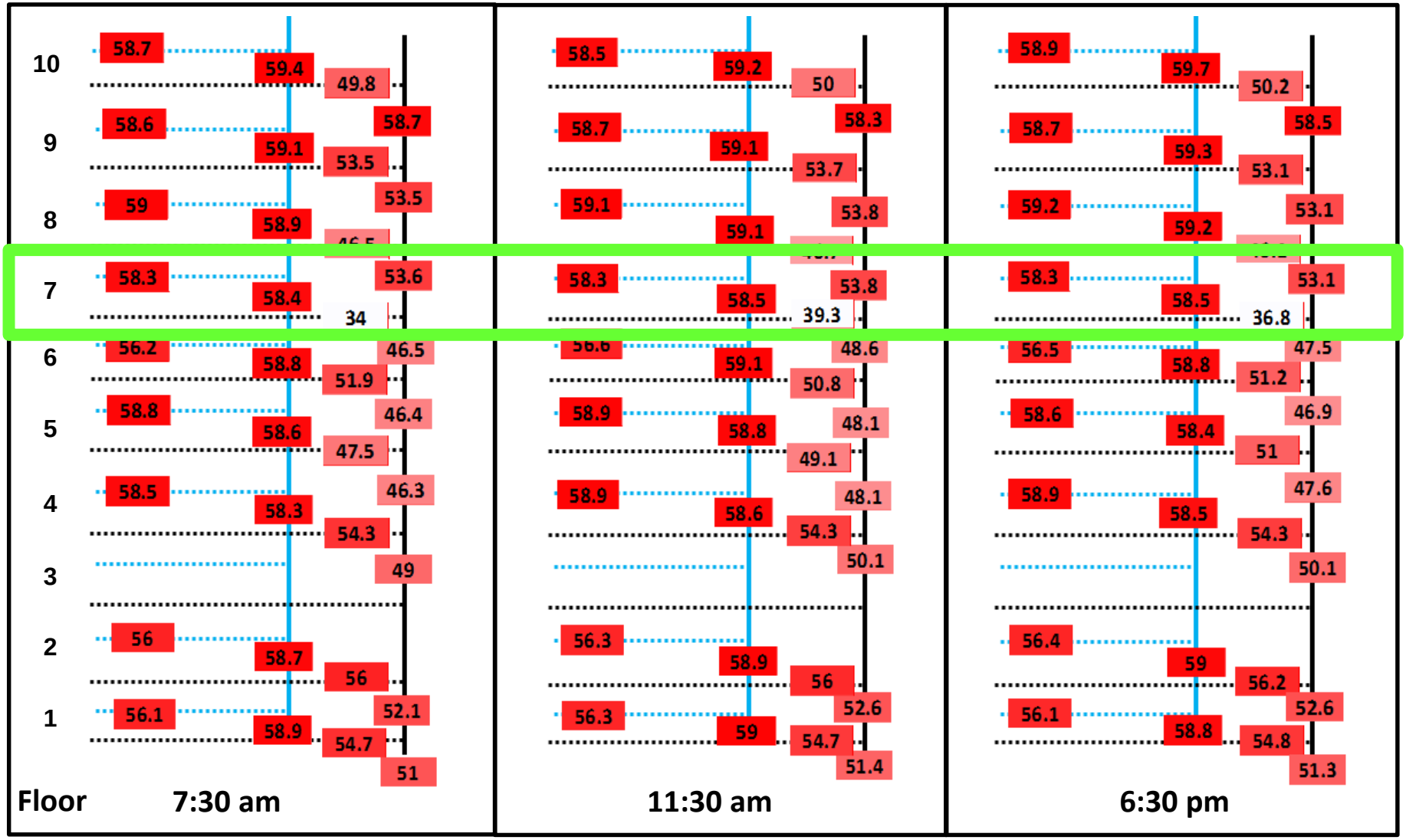


Bédard et al. 2015

Understanding the system: Hot Water Distribution System

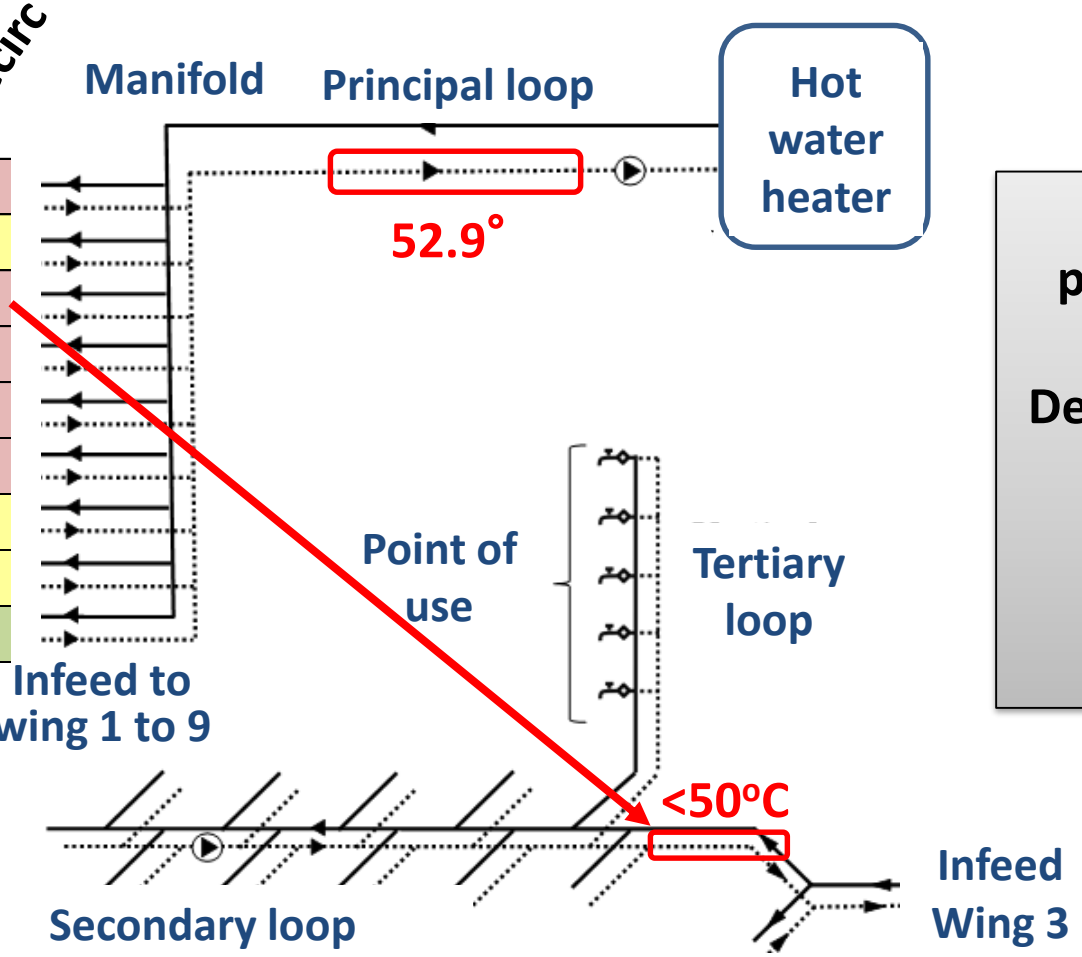


Understanding the system: Differences between floors



Understanding the system: Temperature distribution

Wing	T° recirc
1	46
2	50
3	48
4	45
5	38
6	38
7	52
8	50
Cuis.	58

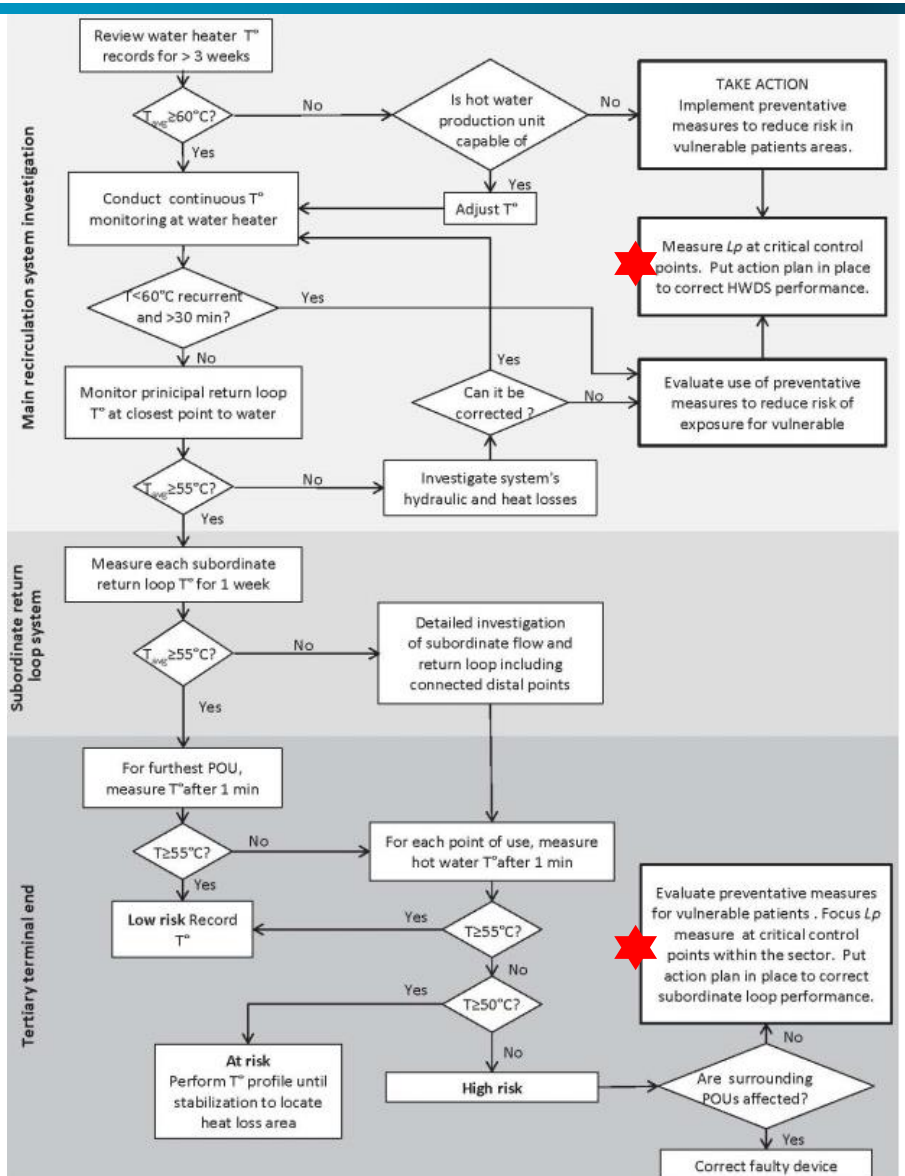


Hot water production at T ≥ 60° C BUT Deficient hydraulics
RESULTS:
Risk areas for opportunistic pathogens

Consumer complaints in Wing 3 – unable to get hot water

Bédard et al. 2016

Diagnostic flowchart to interpret temperature diagnostic results



- Step approach starting from the main recirculation system that indicates the overall system risk level,
- Progressively to the subordinate return loops to identify large building areas or sectors at risk
- Finally to the tertiary terminal ends, to identify local issues with defective faucets or showers
- Staged response in terms of corrective and preventative actions, including *Lp*

Bédard et al. 2015

Understanding the system: Hydraulics

System investigation:

- Recirculation pumps
- Temperature monitoring for each wing
- Identify hydraulically deficient areas (T°)
  - Dead legs
  - Usage pattern change
  - Customer complaints
- Identify the type of devices in the system (faucets, showers, heat exchangers)

Bédard et al. 2016

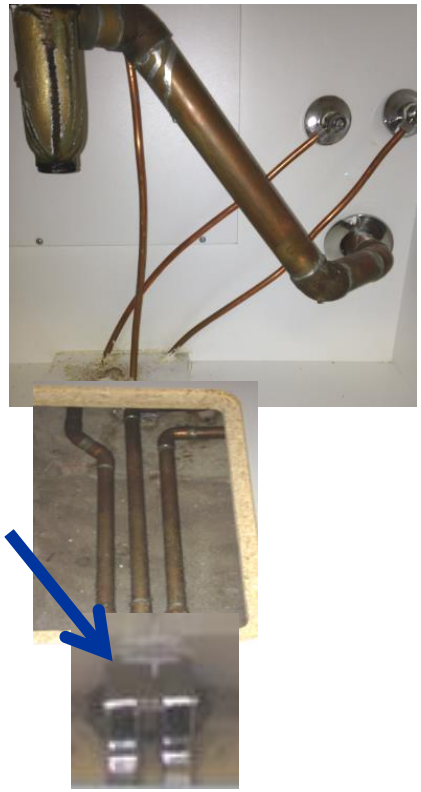
Understanding the system: Type of faucets

Manual

One-lever

Two-lever

Foot-operated



Electronic

= Mixing zone location

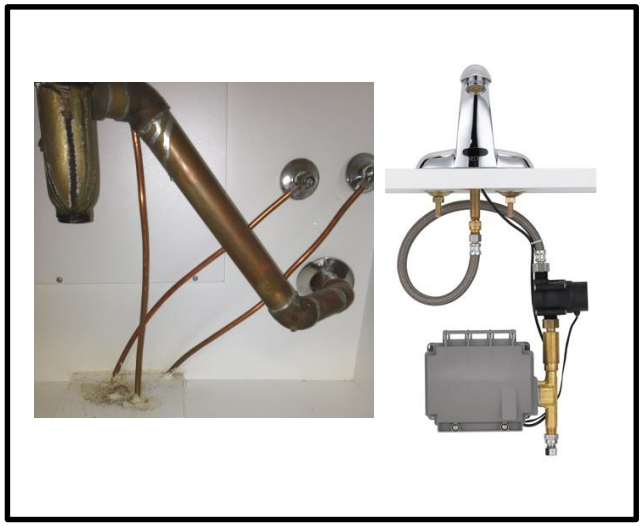
Understanding the system: Type of faucets

% *Pseudomonas aeruginosa* positivity at the faucet in a multi-hospital study

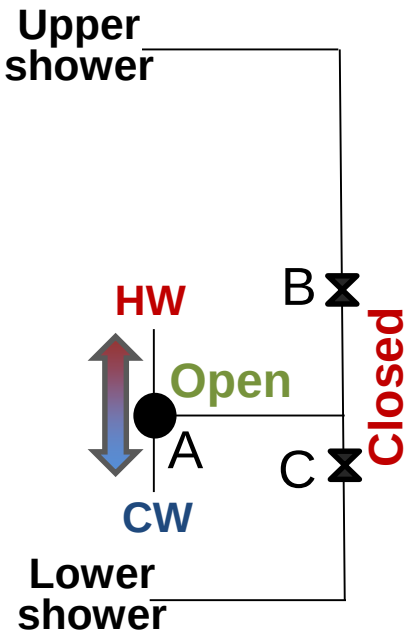
Types of faucet	Nb sampled	Nb positive for P*a*	% contaminated
E faucets	92	13	14%
	13	4	31%
Manual	90	13	14%
Pedal activated	14	4	29%

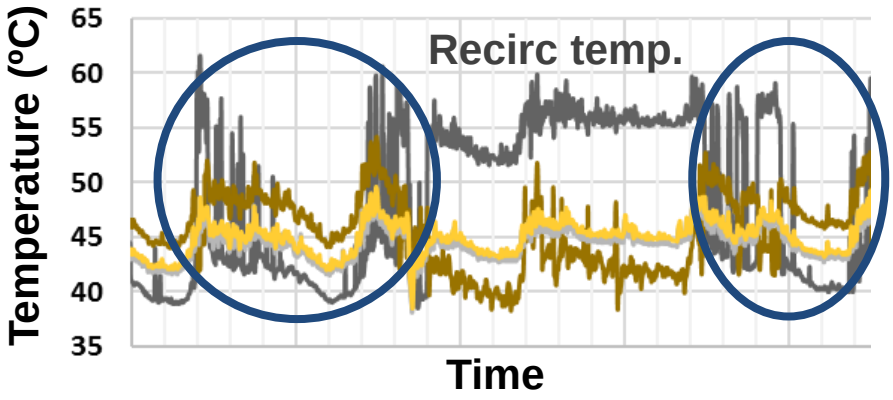
Charron et al. 2015

versus



Understanding the system: Showers

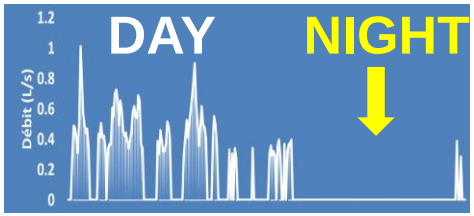


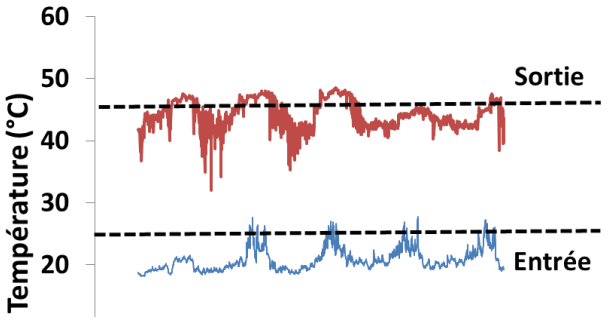


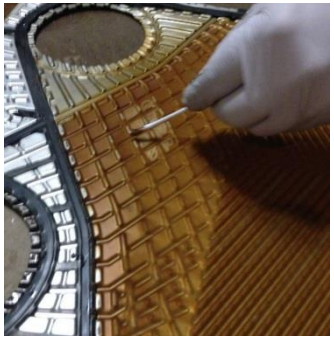
Understanding the system: Energy recovery or saving devices

Example: Heat exchangers in hot water distribution system:

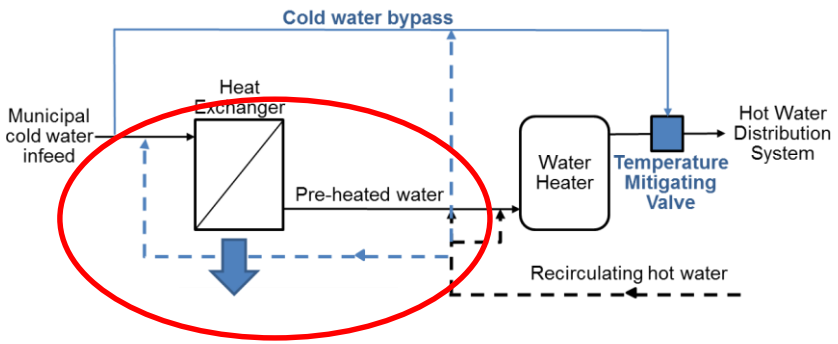
STAGNATION ✚ **TEMPERATURES** ✚ **SURFACE**







✚ **CONTAMINATED WATER**



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Description du prélèvement	Résultats *L. p…ila* Cul…	
Frottis 1ère plaque		
Frottis plaq…		…sitif
Frott…		< LD
	+++	Positif
	++	Positif
…ngeur	510	4600
…res échangeur	88 000	85 000
Eau purge de l'échangeur	5 000	22 000

DANGER

Bédard et al. 2016

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2) Defining sampling parameters:

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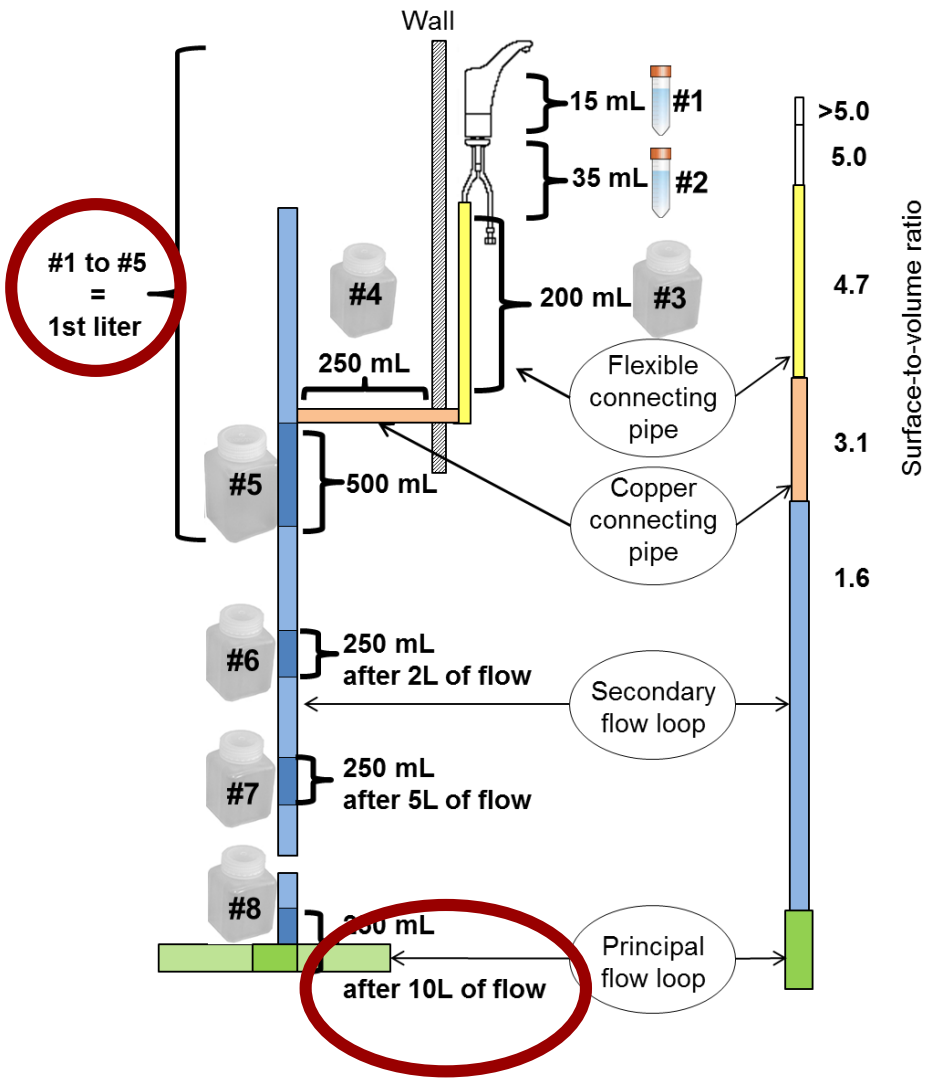
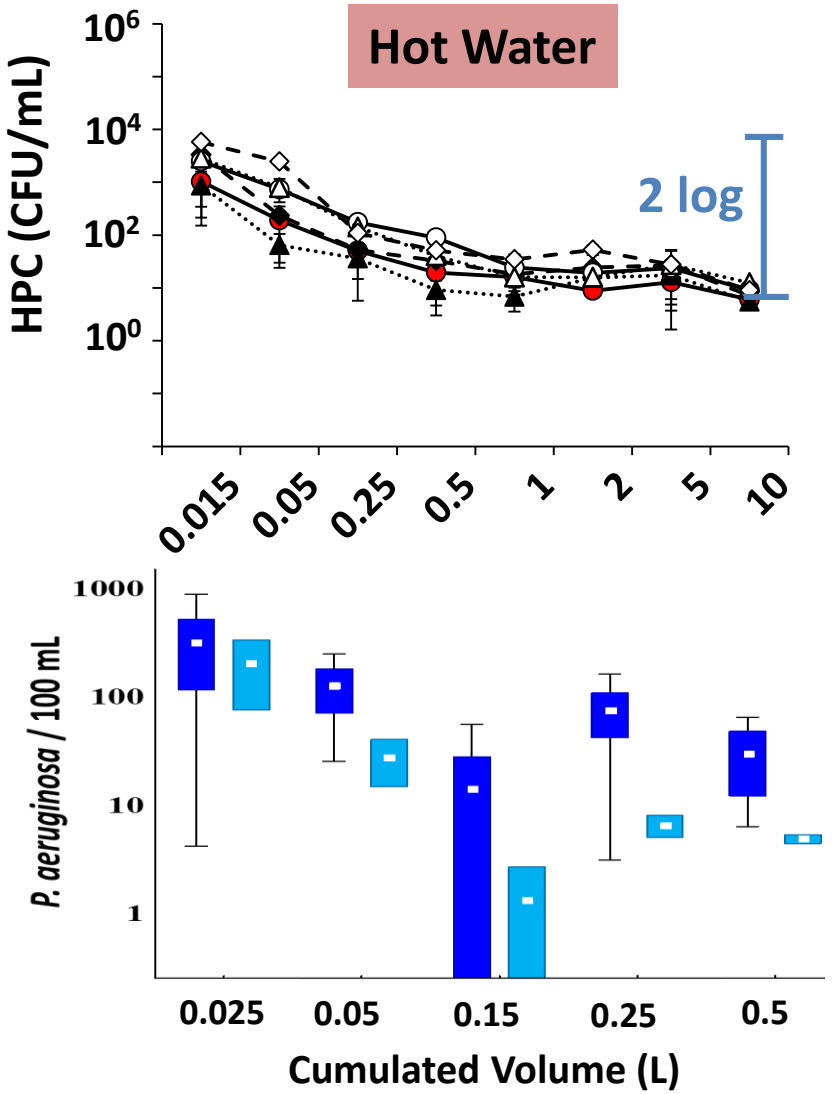
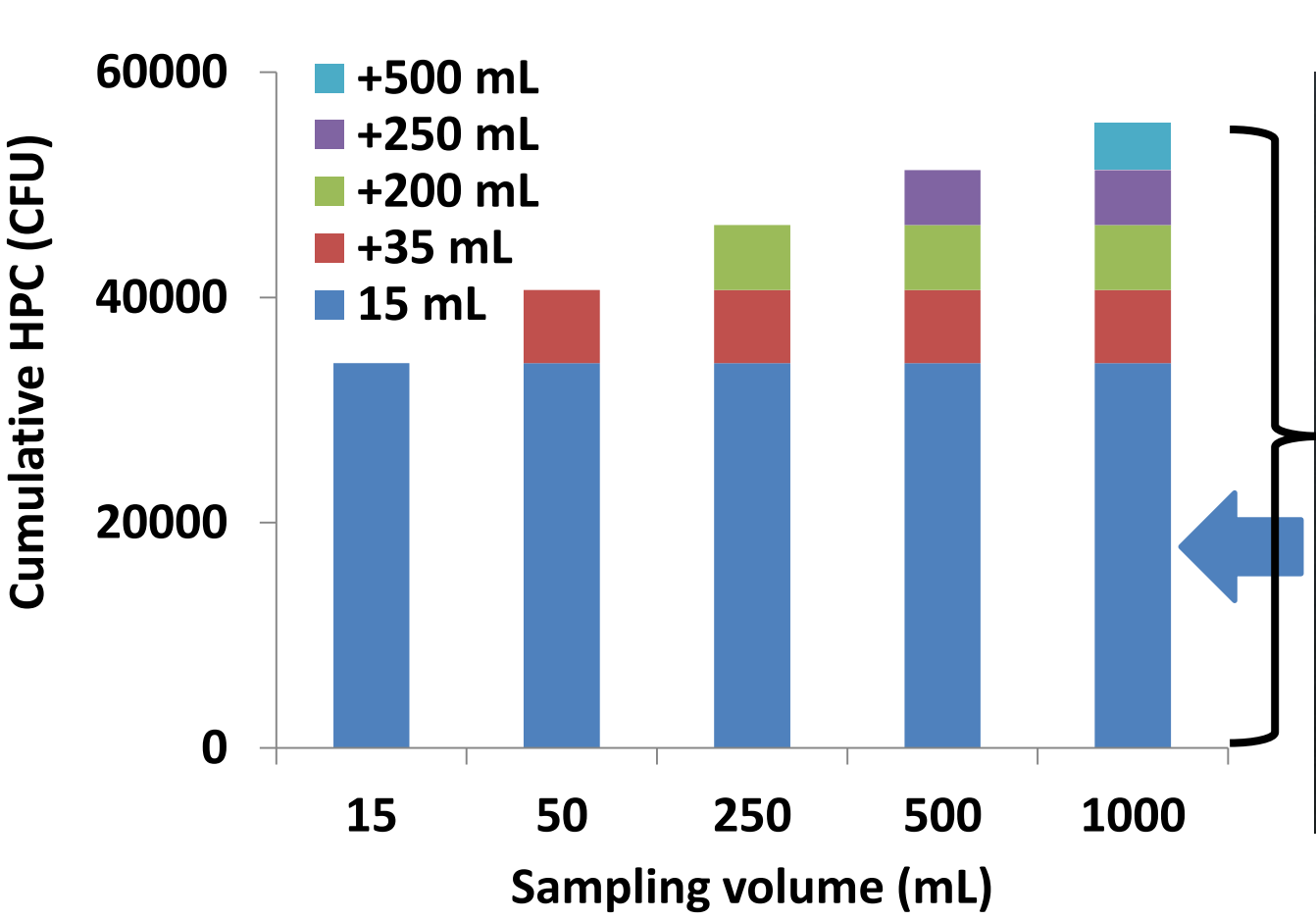
- **1st draw or flushed samples**
- **Sampling volume to maximize recovery**
- **Detection method: culture or molecular methods**

Defining sampling parameters: 1st draw vs flushed





Defining sampling parameters: Sample volume

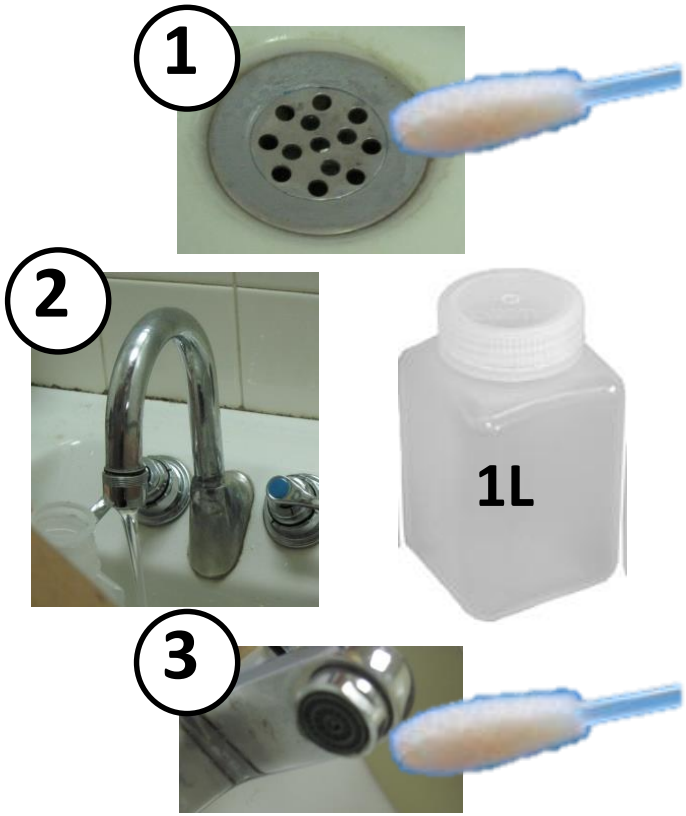


Monolever faucet

Mixing Chamber

Defining sampling parameters: Sink and faucet sampling case study

28 sinks



- ***Detection of P. aeruginosa:***
  - **Culture (ISO 16266)**
  - **qPCR (*gyrB*)**

Defining sampling parameters: Detection methods

	Water	Aerator	Drain	ALL
Culture	7%	3.5%	57%	0%
qPCR	50%	64%	89%	21%

culture = qPCR (+)

culture (+) = qPCR (+) except 1 drain

Positive at all 3 sites

Aerator

Complex

Simple

qPCR positivity > Culture
Low aerator positivity → metal & simple structure

Bédard et al. 2015

Defining sampling parameters: Detection methods

Culture vs qPCR :

- **Low *P. aeruginosa* water contamination detected by culture based methods vs 50% by qPCR**
- ***P. aeruginosa* exposed to Cl_2 and Cu^{2+} at drinking water concentration levels unlikely to be measured by standard culture methods or enzyme based assay**
- **Environmental strains may be stressed and require more time to grow on media**

Defining sampling parameters: Detection method

Experimental study with longer incubation times (up to 10 days):

Swabs from drain, splash area and faucet
15 (n=60) confirmed positive samples :
8 drains (D), 4 splash areas (S) & 3 faucets (F)

➢ ***40% of positive samples detected after 48h (ISO 16266 incubation)***

Lalancette et al. 2017

Conclusions
Impact of sampling plan on results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REVIEW
WILEY MicrobiologyOpen
Pseudomonas aeruginosa in premise plumbing of large buildings
Emilie Bédard[1,2] | Michèle Prévost[1] | Eric Déziel[2]

Multiple studies, variable parameters:

- **Type of sample – swab vs water**
- **Volume sampled – 50 to 250 mL**
- **Study context – outbreak vs prospective (after renovation or device replacement)**
- **Number of taps sampled**
  - **> 25 faucets → 0 to 18% positivity**
  - **≤ 25 faucets → 58 to 100% positivity**
- **Technical information on the faucet and sink environment: mixing volume, connection material, length of connection, sink design, type of aerator, …**

Conclusions

- Understand the objectives of the sampling
- Understand the water distribution system architecture to identify hydraulically at risk sectors
- Select sampling points based on microbial risk:
  - Consumer complaints (temperature, flow, drainage)
  - Vulnerability of users
  - Devices/areas favorable to microbial growth
- Select detection methods based on expected contamination levels, environmental stressors, target microorganisms and type of sampling (once OR routine monitoring)

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Questions?