VirtualWater

Legionella Control and Water Quality Management and Awareness

Water Quality Management within the Built Environment

About Virtual Water Services

Water Hygiene & Compliance Specialists
Virtual Water Services are industry-leading experts in water treatment and Legionella control, helping businesses maintain safe, compliant water systems. We specialise in comprehensive risk assessments, temperature monitoring, and professional cleaning services that meet HSE regulations and protect your people.

Comprehensive Water Safety Solutions
From detailed Legionella risk assessments to water tank cleaning and disinfection, we provide end-to-end water hygiene services. Our accredited specialists deliver temperature monitoring, water sampling and analysis, plus showerhead descaling services - ensuring your facility stays compliant with regulations while minimising health risks.

Your Trusted Water Safety Partners
With deep expertise in HSE legislation and industry best practices, we guide businesses through complex water hygiene requirements. Our tailored solutions and proactive monitoring help you stay ahead of evolving regulations, giving you confidence that your water systems are safe, compliant, and protecting everyone who uses your facilities.

Agenda

Legionella Management

01	Background to the Disease & Organisms
02	Legislation – Health & Safety Law
03	Medical Aspects
04	Managing Water Systems
05	Sampling & Analysis
06	Biofilms
07	Monitoring & Maintenance Tasks
08	Course Test

Engineering out potential health issues

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Typical Public Health Issues Relating to Water Quality:

Microbiological

Drinking Water:
Coliforms, E Coli – contamination from maintenance works, leakage /ingress of waste water, back siphonage, leaking valves

Legionella:
stagnation & temperature, biofilm formation leading to contamination from pipe work, fittings, re-growth from dead legs, TMV's etc

Chemical

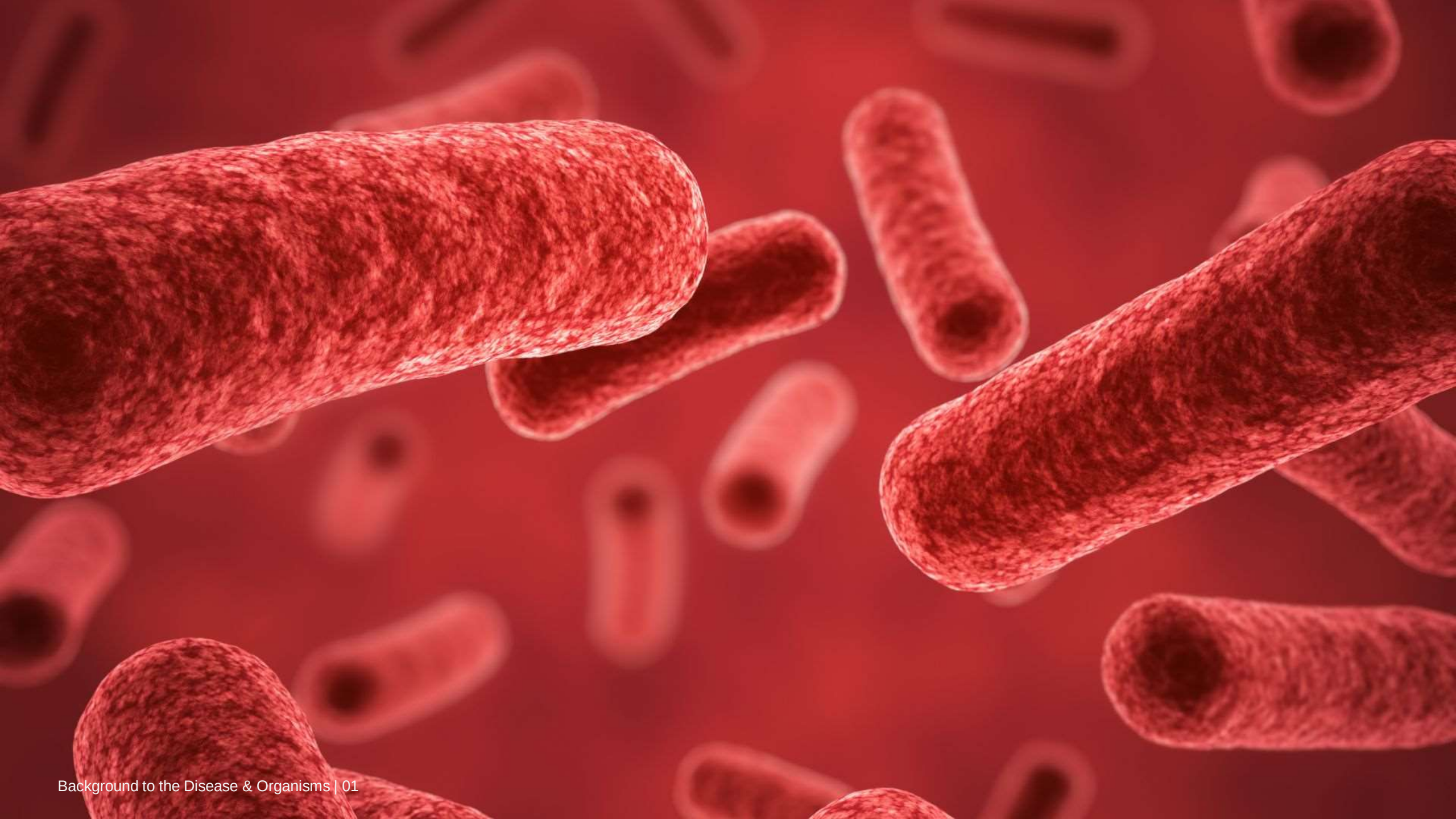
Copper corrosion:
blue green water

Sensory

Taste and odour problems:
disinfectant, stagnation, fungi

Background to the Disease & Organisms

01



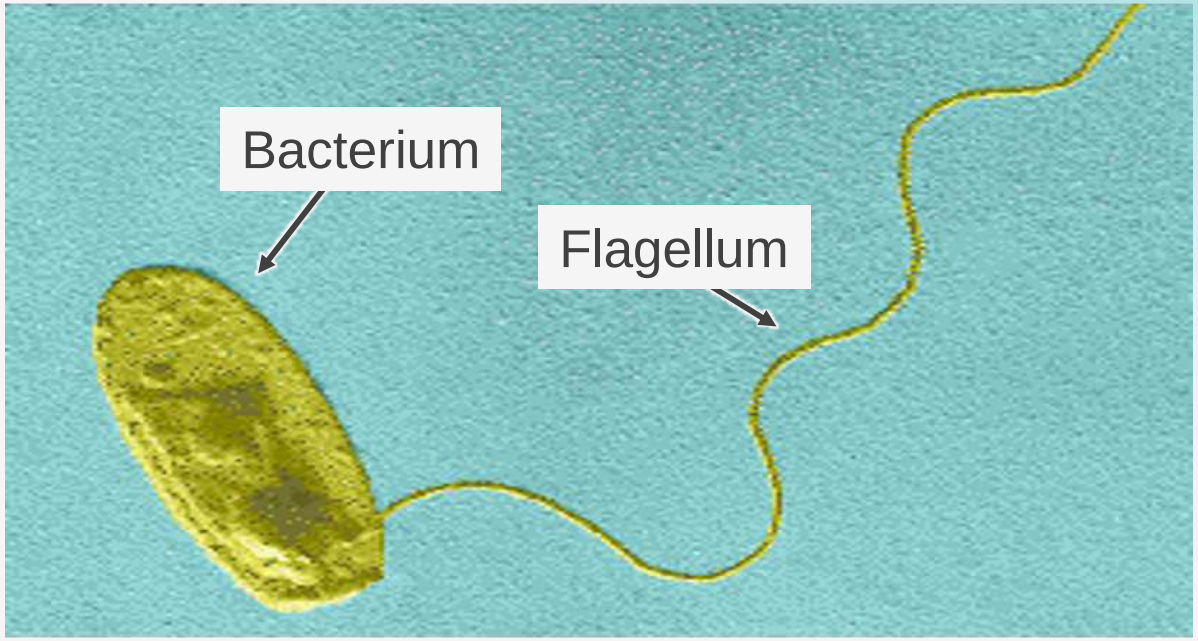
Why Legionnaires' Disease?

- First outbreak identified at 1976 conference for American ex-service personnel (known as *legionnaires*) in Philadelphia
- 34 deaths and 220 ill
- Pneumophila (Greek for 'Lung Loving')

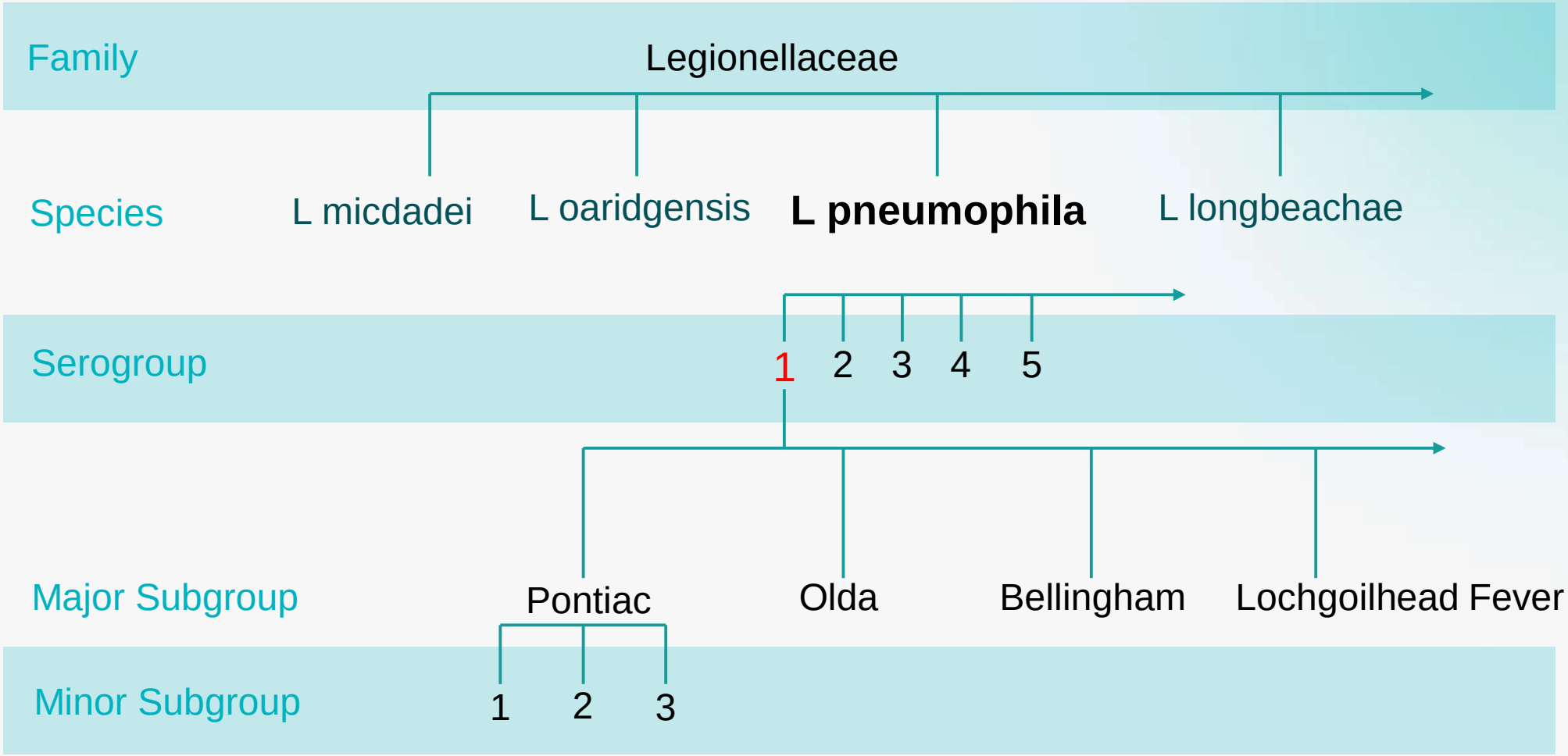
Bellevue-Stratford Hotel Philadelphia

What is Legionella?

- Motile bacterium (Flagellated)
- Opportunistic Pathogen
- Circa 48 known species
- Legionella Pneumophila sero-group 1 mainly associated with legionellosis



Legionellaceae



Incidence of Legionnaires' Disease

- Approximately 350 – 400 reported cases per year in the UK
- Number of cases thought to be underestimated by 90%

Incidence of Legionnaires' Disease in Scotland

TABLE 1: Cases of Legionnaires' disease reported by SHLMPRL to HPS 2000-2016

Year	Cases	Percentage male
2000	32	68.8%
2001	20	70.0%
2002	36	66.7%
2003	29	58.6%
2004	32	71.9%
2005	33	54.5%
2006	42	76.2%
2007	43	65.1%
2008	25	64.0%
2009	25	68.0%
2010	16	50.0%
2011	32	71.9%
2012	104	67.3%
2013	48	60.4%
2014	34	61.8%
2015	39	64.1%
2016	34	70.6%

Source HPS 2017

Incidence of Legionnaires' Disease in Scotland

TABLE 2: Number of Legionnaires' disease related deaths in Scotland reported to HPS 2000-2016

Year	Deaths	Case fatality rate
2000	3	9%
2001	2	10%
2002	2	6%
2003	2	7%
2004	4	13%
2005	1	3%
2006	3	7%
2007	1	2%
2008	6	24%
2009	3	12%
2010	0	0%
2011	6	19%
2012	6	6%
2013	2	4%
2014	4	12%
2015	2	5%
2016	4	12%

Source HPS 2017

Incidence of Legionnaires' Disease in Scotland

TABLE 3: Likely source of *Legionella* infection reported to HPS, 2015 and 2016

Year	Travel-related	Community-acquired	Hospital-acquired	Unknown
2015	27	12	0	0
2016	23	10	0	1
Total	50	22	0	1

Source HPS 2017

Incidence of Legionnaires' Disease Worldwide

TABLE 4: *Legionella* cases associated with travel (within UK or abroad), 2004-2016.

TABLE 4a: by continent.

Continent	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Europe	13	21	30	32	12	12	8	8	19	14	19	18	21
North America	0	0	0	1	0	0	2	1	0	5	3	2	1
South America	1	0	1	0	1	0	0	1	0	0	0	0	0
Africa	0	1	0	1	1	2	1	0	1	0	3	1	
Asia	2	2	4	1	1	1	1	1	0	2	6	5	5
Australasia	0	0	0	0	0	0	0	0	1	1	0	0	0
Not known	0	0	0	0	1	0	0	0	1	0	0	0	0
Cruise Ship/Off shore	0	0	1	1	1	0	0	0	0	0	1	2	1

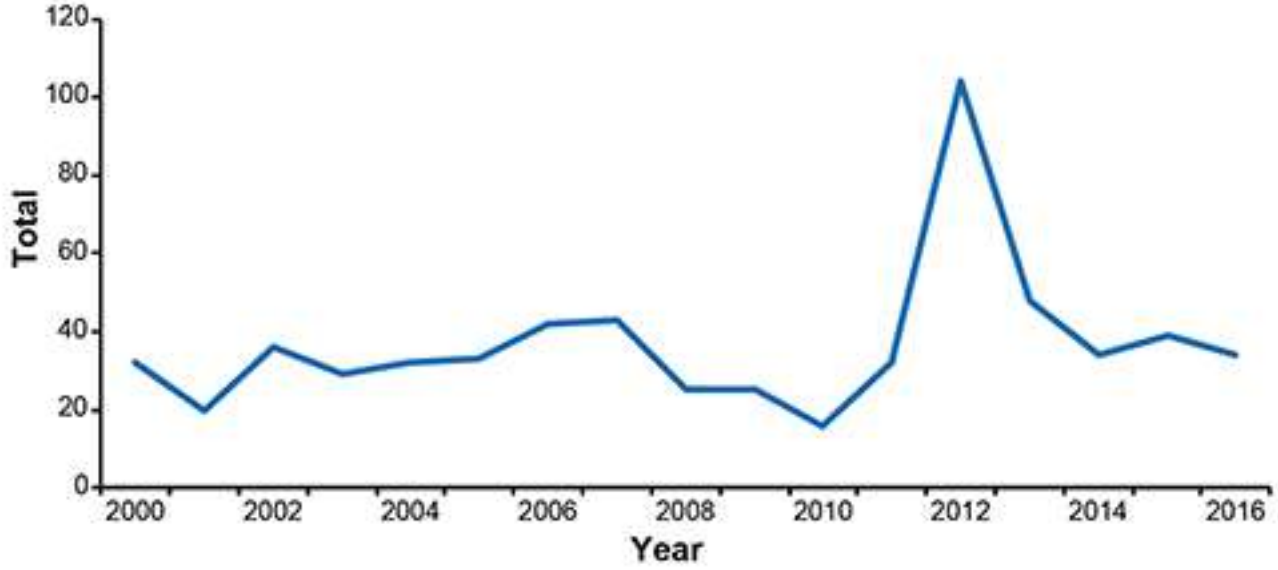
Table 4b: by destinations within Europe.

European destinations	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
UK	3	3	4	6	2	2	2	1	2	4	4	2	1
Spain	3	10	1	8	6	4	1	3	4	1	5	2	8
Italy	4	4	3	7	1	0	0	1	2	2	2	4	3
Greece	0	1	3	2	0	0	3	1	6	0	2	3	2
France	1	1	4	1	0	1	1	0	0	2	0	1	1
Turkey	0	1	1	1	3	1	1	1	2	2	3	1	3
Portugal	0	0	0	3	0	1	0	0	1	1	0	1	1
Bulgaria	1	0	3	1	0	1	0	0	0	0	1	0	0
Austria	1	0	1	1	0	0	0	0	0	0	0	0	0
Others	0	1	0	2	0	2	0	1	2	2	2	4	2

Source HPS 2017

Incidence of Legionnaires' Disease in Scotland

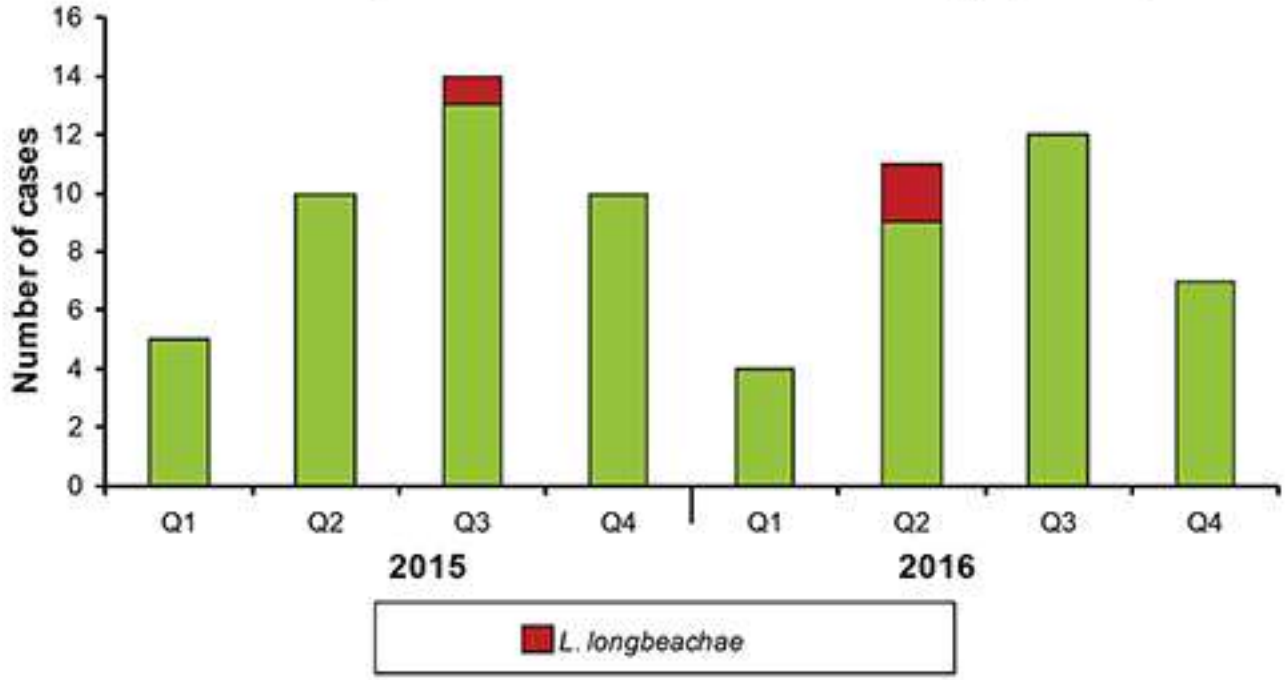
FIGURE 1: Enhanced surveillance of Legionellosis in Scotland: Annual total of cases reported to HPS 1995-2016



Source HPS 2017

Incidence of Legionnaires' Disease in Scotland

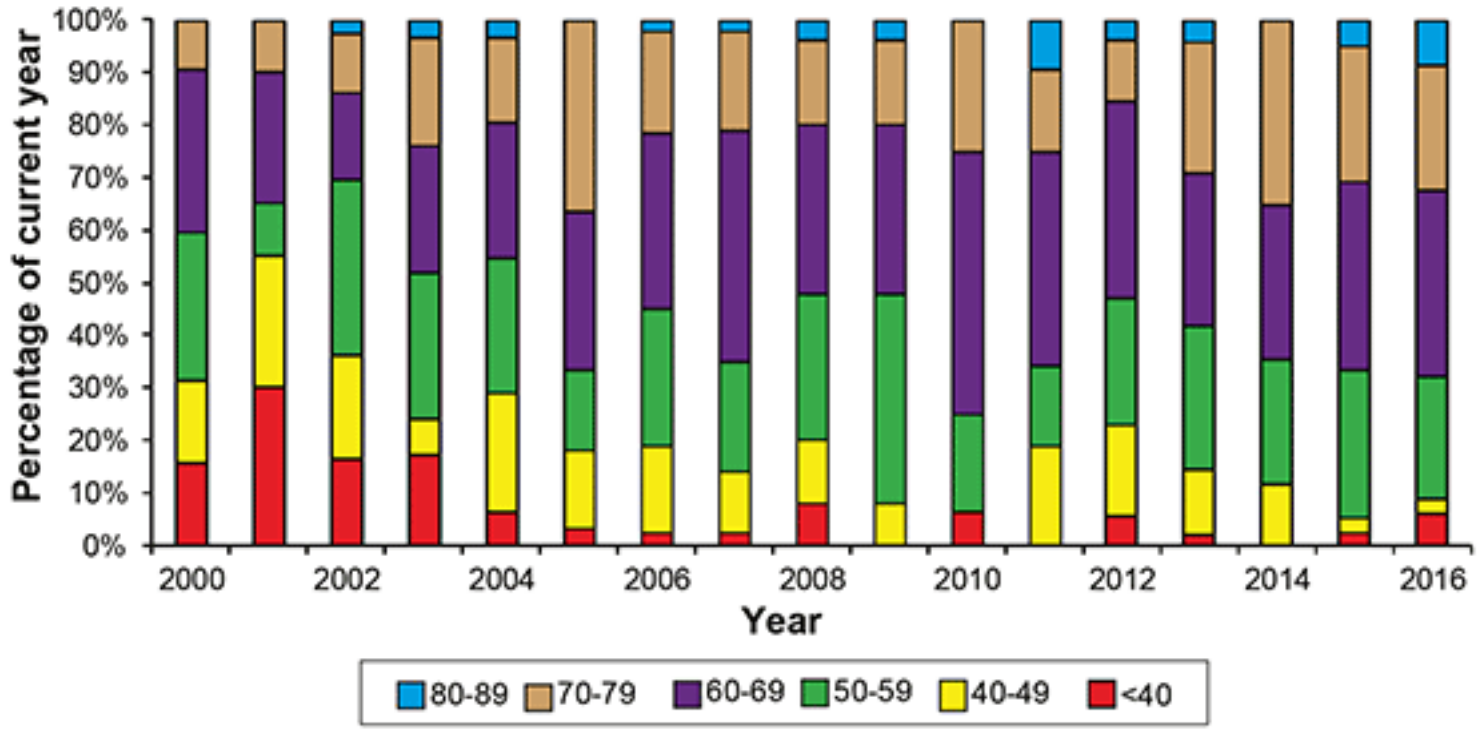
FIGURE 2: Number of cases of Legionnaires' disease in Scotland by quarters, in 2015 and 2016



Source HPS 2017

Incidence of Legionnaires' Disease in Scotland

FIGURE 3: Cases of *Legionella* reported to HPS by age group, 2000-2016



Source HPS 2017

Natural history of the legionella bacterium

- **Legionella bacterium are common and can be found naturally in environmental waters**
- Rivers, Lochs, Reservoirs, Ponds etc

Colonisation of water systems

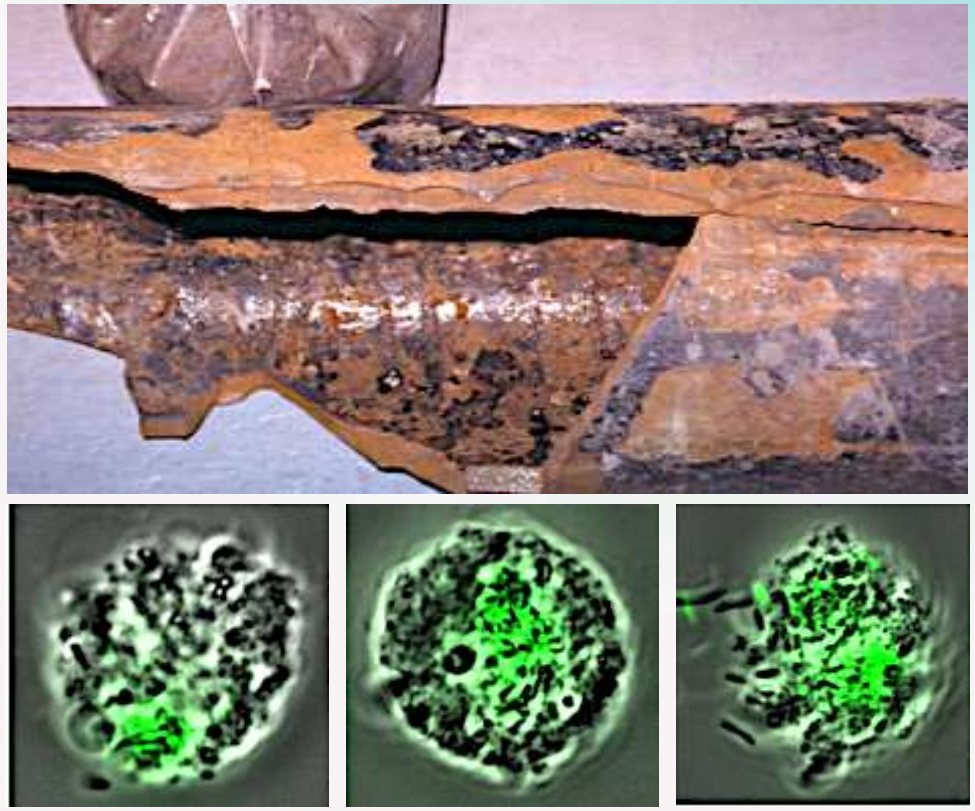
Legionella bacteria can enter manufactured water systems, eg

- Cooling towers
- Hot and cold water systems and other plant which use or store water

Legionella growth requirements

Examples of nutrient sources include:

- Algae, amoebae and other bacteria
- Sludge, scale, rust and sediments
- Biofilms



Multiplication of bacteria Exponential growth

Time	Number of legionella bacteria
0	100
2hrs	200
4hrs	400
6hrs	800
24hrs	409,600
2 days	1.68×10^9
3 days	3.44×10^{12}

Risk Factors Associated with Legionnaires' Disease

A number of factors are required to create a risk of acquiring legionellosis:

- The presence of legionella bacteria
- Conditions which favour the multiplication of the bacteria eg temperature (20ºC - 45 ºC) and a source of nutrients (eg sludge, scale, rust, algae etc)
- A means of creating and disseminating breathable droplets / aerosols

How is the disease normally contracted?

- **Inhalation of bacteria in water droplets, mists or aerosols**
- No evidence of person to person spread

Chain of Causation

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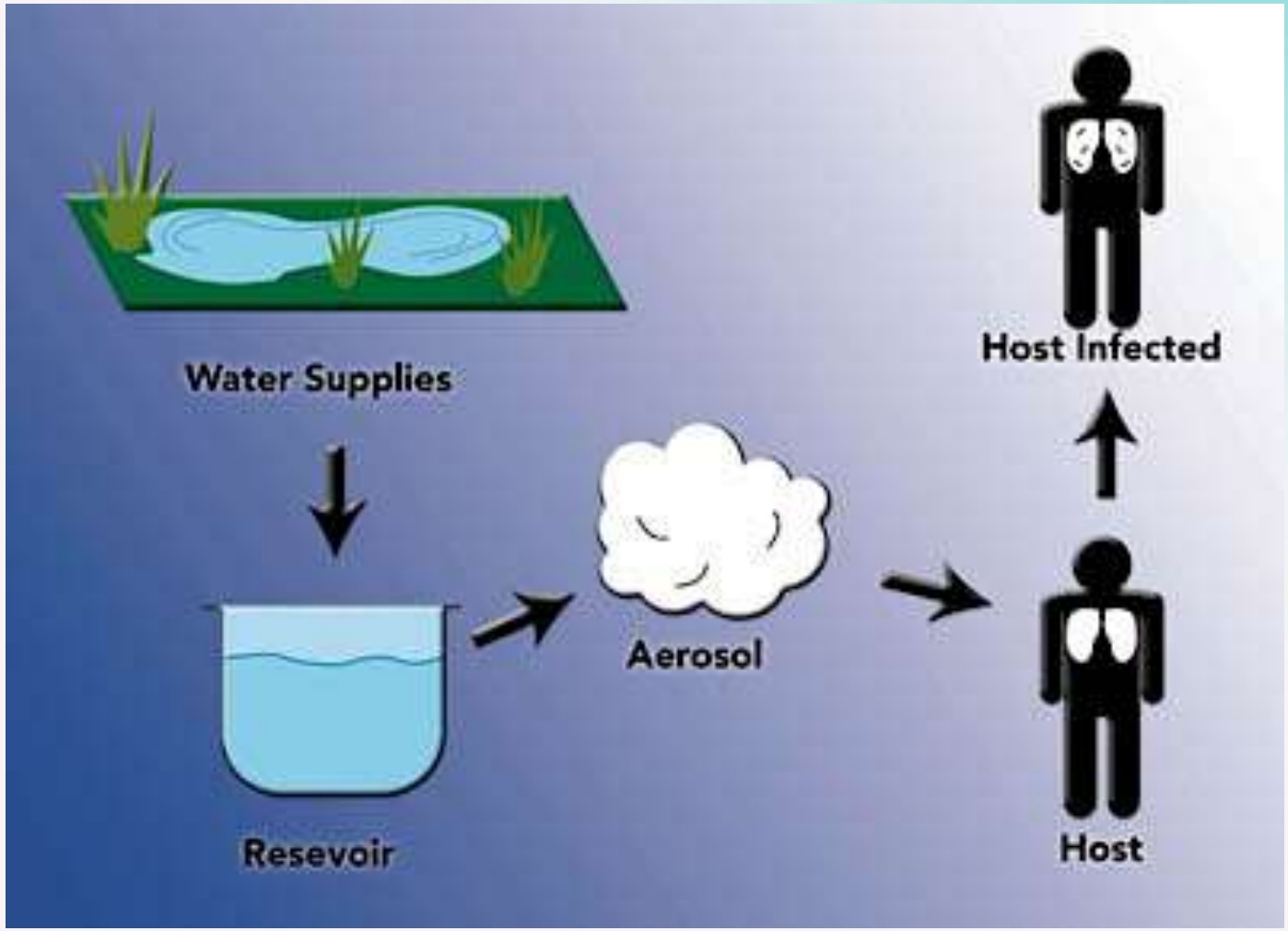
- Environmental Reservoir
- Multiplication
- Dissemination
- Hostility
- Infectious Dose
- Susceptibility



Legislation – Health & Safety Law

02

Legislation
Health and Safety Law

- The Health and Safety at Work Act 1974
- The Control of Substances Hazardous to Health (COSHH) Regulations 2000
- (L8 4th Edition November 2013) Legionnaires' Disease. The control of legionella bacteria in water systems. Approved Code of Practice & Guidance

Health & Safety at Work Act 1974

“Failure to comply with the Act or and Regulations made under it is a criminal offence and employer or even employee is liable to be prosecuted in a criminal court and punished by the imposition of a fine or imprisonment”

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Health & Safety at Work Act 1974

“Owner and occupiers of premises to ensure that there is a management regime for the proper design installation and maintenance of plant, equipment and system. Failure to do so is an offence even though an outbreak has not occurred.”

Regulation
HSE

HSE Inspector Powers:

- Offer information and advice including, failure to comply with the law
- Serve improvement or prohibition notices. This may result in work stopping or site closure
- Issue formal cautions

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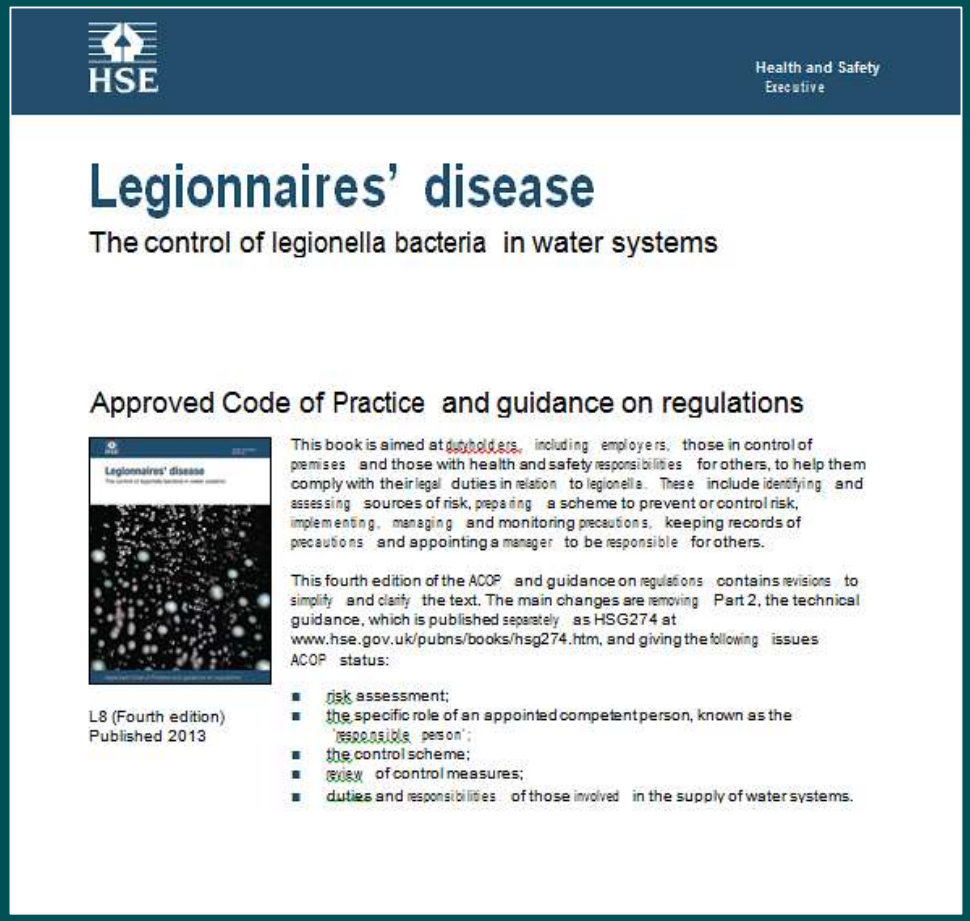
COSHH Reg 6 Identification and Assessment of Risk

“A suitable and sufficient assessment to identify and assess the risk of Legionellosis from work activities and any necessary precautionary measures”

BS 8580-1:2019

L8 4th Edition ACoP



HSE

Health and Safety Executive

Legionnaires' disease

The control of legionella bacteria in water systems

Approved Code of Practice and guidance on regulations

L8 (Fourth edition)
Published 2013

This book is aimed at dutyholders, including employers, those in control of premises and those with health and safety responsibilities for others, to help them comply with their legal duties in relation to legionella. These include identifying and assessing sources of risk, preparing a scheme to prevent or control risk, implementing, managing and monitoring precautions, keeping records of precautions and appointing a manager to be responsible for others.

This fourth edition of the ACOP and guidance on regulations contains revisions to simplify and clarify the text. The main changes are removing Part 2, the technical guidance, which is published separately as HSG274 at www.hse.gov.uk/pubns/books/hsg274.htm, and giving the following issues ACOP status:

- risk assessment;
- the specific role of an appointed competent person, known as the 'responsible person';
- the control scheme;
- review of control measures;
- duties and responsibilities of those involved in the supply of water systems.

L8 4th Edition ACoP

This Approved Code of Practice (ACOP) gives advice on the requirements of the Health and Safety at Work etc Act 1974 (the HSW Act)1 and the Control of Substances Hazardous to Health Regulations 2002 (COSHH)2 and applies to the risk from exposure to legionella bacteria (the causative agent of legionellosis, including Legionnaires' disease).

In particular it gives guidance on sections 2, 3, 4 and 6 of the HSW Act and regulations 6, 7, 8, 9 and 12 of COSHH. The Code also gives guidance on compliance with the relevant parts of the Management of Health and Safety at Work Regulations 1999 (the Management Regulations)

L8 4th Edition ACoP

The approved Code of Practice places responsibility on employers and others to:

- Identify and assess sources of risk
- Prepare a scheme for preventing or controlling the risk
- Implement and manage precautions
- Keep records of the precautions implemented

Management, Responsibilities and Competence of Personnel

- **Inadequate management, lack of training, poor communication are all contributory factors in outbreaks of Legionnaires Disease**.
- People involved in assessing the risk and implementing precautions are ‘competent’ and aware of their responsibilities.
- One person to be responsible, of manager or similar status, with correct supervision of involved staff
- Lines of communication to be properly defined and ‘fail-safe’

Fundamentals of Legionella Risk Assessment BS 8580.2010 Nov 2010

Identifies and evaluates the source of risk

- Remedial actions
- Control measures
- Frequency of inspections
- Monitoring regimes
- Record keeping
- People at risk

Written Scheme

Preventing or minimising the risk from exposure to Legionella

“Any work that leads to exposure should be avoided so far as is reasonably practicable. If not there should be a written scheme for minimising the risk from exposure”

Record Keeping (COSHH Reg 6&9)

“The appointed person shall ensure that appropriate records are kept”

Record Keeping/Documentation

All work relating to the control of legionella must be documented

- Records should be kept for a minimum of 5 years
- Corrective measures/remedial actions
- Inspections/Tests
- Analytical test results
- Monitoring
- Control measures
- All actions must be dated and signed

Record Keeping/Documentation

- **Names and positions** of responsible persons
- **Assessment of risk**
- **Written program** of control
- **Persons involved** in operating program of control
- Lines of **communication**

Responsible Persons

Role	Name	Contact Details (include information available to include address, email address, and telephone number)	Further Action Required
Statutory Duty Holder			
Appointed Responsible Person			
Site Responsible Person			
Site Deputy Responsible Person			
Water Treatment Provider			

HSE Prosecutions

Year	City	Venue	Source	Cases	Deaths	Fatality rate	Notes
1976	Philadelphia, US	Philadelphia Legionnaires' disease outbreak	Air conditioning	221	34	15.4%	The first recognized outbreak of legionellosis, although earlier cases were later discovered as far back as 1947. The Philadelphia outbreak, however, had the highest death rate.
1985	Stafford, UK	Stafford District Hospital	Air conditioning	175	28	16%	In April 1985, 175 patients were admitted to hospital with chest infection or pneumonia. 28 people died. Medical diagnosis showed Legionnaires' disease was responsible and investigation traced the source to the air-conditioning cooling tower on the roof of Stafford District Hospital.
1999	Bovenkarspel, Netherlands	Bovenkarspel legionellosis outbreak	Hot tub	318	32	10%	In March 1999, an outbreak occurred during the Westfriese Flora flower exhibition. 318 people became ill and at least 32 died. There is a possibility that more died (which might make it the deadliest recorded outbreak) but these people were interred before the infection was recognised. The source was a hot tub in the exhibition area.

HSE Prosecutions

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Year	City	Venue	Source	Cases	Deaths	Fatality rate	Notes
2000	Melbourne, Australia	Melbourne Aquarium	Cooling tower	125	4	4.2%	In April 2000, an outbreak of *Legionella pneumophila serogroup 1* in Melbourne resulted in 125 confirmed cases of Legionnaire's disease, with 95 (76%) hospitalised. It is reported that 4 died. Investigation traced the source to the cooling tower at the newly opened aquarium. Since this outbreak, legionella infection statistics are required to be reported as a notifiable disease. Stringent regulations were introduced by the state to control legionella in 2001.
2001	Murcia, Spain	Hospital		800	6	0.8%	The world's largest outbreak of Legionnaires' disease, in July 2001 with patients appearing at the hospital on July 7, in Murcia. More than 800 suspected cases were recorded by the time the last case was treated on July 22: 636-696 of these cases were estimated and 449 confirmed (so, at least 16,000 people were exposed to the bacterium) and 6 died. A case-fatality rate of approximately 1%.

HSE Prosecutions

Year	City	Venue	Source	Cases	Deaths	Fatality rate	Notes
2002	Barrow-in-Furness, UK	2002 Barrow-in-Furness legionellosis. outbreak	Air conditioning	172	7	4.1%	In 2002, Barrow-in-Furness suffered an outbreak of Legionnaires' disease. Six women and one man died as a result; another 172 also contracted the disease. The cause was a contaminated cooling tower at the town's Forum 28 arts centre. Barrow Borough Council became the first public body in the UK to be charged with corporate manslaughter but were cleared. They were, however, along with architect Gillian Beckingham, fined for breaches of Health and Safety regulations in a trial that ended in 2006.
2012	Calp, Spain	AR Diamante Beach Hotel	Plumbing system	18	3	17%	Large hotel with solar water heating system for spa and domestic hot water. A month before the deaths, local government authorities may have known about the problem, but were accused of not alerting the public to avoid disruption of the tourism industry.

HSE Prosecutions

Year	City	Venue	Source	Cases	Deaths	Fatality rate	Notes
2012	Edinburgh, UK	South west of Edinburgh	Possibly cooling towers	92	4	3%	56 confirmed cases, with a further 36 suspected cases, bringing the total number of people affected to 92. Four people are known to have died from the outbreak.
2012	Chicago, US	JW Marriott Hotel	Decorative Lobby Fountain	10	3	30%	8 confirmed cases with people who stayed at the JW Marriott Chicago during July-August 2012.
2012	Auckland, New Zealand	Unknown	Water Source and/or Air Conditioning	11	1	9%	The number of people affected in a major outbreak of Legionnaires' disease in Auckland, which has claimed one life, has risen to 11.
2012	Stoke-on-Trent, UK	Warehouse, Fenton	Hot tub	19	1	5.2%	Infection began in warehouse hot tub. 17 of the confirmed cases visited the warehouse a couple of weeks before becoming ill.

HSE Prosecutions

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HSC
Health & Safety Commission

Defendant:
Liverpool Heart and Chest Hospital NHS Trust

Offence date:
2007

The NHS Trust pleaded guilty to breaching Sections 2(1) and 3(1) of the Health and Safety at Work etc Act 1974 by putting employees and the public at risk. It was fined £35,000 and ordered to pay costs of £12,862 at Liverpool Magistrates Court on 8 October 2009.

- The investigation found unsafe levels of legionella in the water supply system for the showers, baths and sinks at the hospital. But it was not able to conclude whether two patients, who both contracted legionnaires' disease before their deaths in early 2007, were infected at the hospital or elsewhere.
- Liverpool Magistrates' Court heard that the NHS Trust had stopped testing the water supply for legionella, despite high levels of the bacteria being found in the Audrey Leigh wing in May 2002.
- HSE criticised the NHS Trust for failing to put suitable control measures in place, and senior management for failing to take responsibility for overseeing the control of the bacteria.

HSE Prosecutions

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HSC Health & Safety Commission

Defendant:
Kepak UK Ltd – Butchery Processing

Offence date:
2009

- Sept 2006 – 2 staff ill with Legionnaires' disease
- RA in 2001, no monitoring or control
- Fined £25,000
  - Legionella found in pressure washer,
  - Apron Wash shower point
  - Pressure washer header tank

HSE Prosecutions

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HSC
Health & Safety Commission

Defendant:
Piperdam Golf and Leisure Resort near Dundee

Offence date:
2008

Piperdam, whose turnover was £3.67million last year, pleaded guilty to a lack of suitable and sufficient risk assessments and lack of a safe system for managing and controlling of the risks from legionella bacteria.

- legionella bacteria had been found in the hot tub and two shower heads at a lodge
- The court heard boss Phil Mulholland, 56, discounted the threat of legionella because all the systems on the site were new.
- Total Fine: Fined £120,000 after admitting responsibility for the death of Grandfather Eddie Warnes in 2008

HSE Prosecutions

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HSC
Health & Safety Commission

Defendant:
Piperdam Golf and Leisure Resort near Dundee

Offence date:
2008

- His family have launched a civil action against Piperdam - but it emerged in court that the company is uninsured for his death.
- If the claim is successful, damages could top £1million and threaten the resort's future.

HSE Prosecutions

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HSC Health & Safety Commission

Defendant:
HP Bulmer and its water treatment contractor Nalco

Offence date:
2003

Offence: Breaching the Health and Safety at Work Act. Each been fined £300,000 over a fatal outbreak of Legionnaires' disease and ordered to pay £50,000 each in costs.

- Legionella bacteria were found in two cooling towers following 28 cases of Legionnaires' disease and the deaths of an elderly man and a 56-year-old woman in the winter of 2003.
- Nalco had failed to comply with its contractual obligations to Bulmer by failing to adequately clean the towers and had also carried out an inadequate risk assessment on behalf of the cider-maker.

HSE Prosecutions

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HSC
Health & Safety Commission

Case:
Legionella outbreak Barrow-in Furness, Cumbria

Offence date:
2002

Legionella outbreak 2002 Barrow-in Furness, Cumbria. Seven Deaths, 172 Infected.

- Council Fined £125,000 and ordered to pay Court Costs of £90,000 for breaching the Health and Safety at Work Act.
- Gillian Beckingham Fined Personally £15,000
- Maximum penalties possible:
- Life Imprisonment
- Unlimited fines

HSE Prosecutions

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HSC
Health & Safety Commission

Case:
Legionella outbreak Barrow-in Furness, Cumbria

Offence date:
2002

- Richard Macauley, 88
- Wendy Milburn, 56
- Georgina Somerville, 54
- Harriet Low, 74
- Elizabeth Dixon, 80
- June Miles, 56
- Christine Merewood, 55

all from Barrow.

HSE Prosecutions

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HSC
Health & Safety Commission

Case:
Legionella outbreak Edinburgh

Offence date:
2012

Legionella Outbreak Edinburgh in June/July 2012.

- 4 Deaths
- 45 requiring hospital treatment
- 101 Infected

Source still not confirmed

Multiple private law suits

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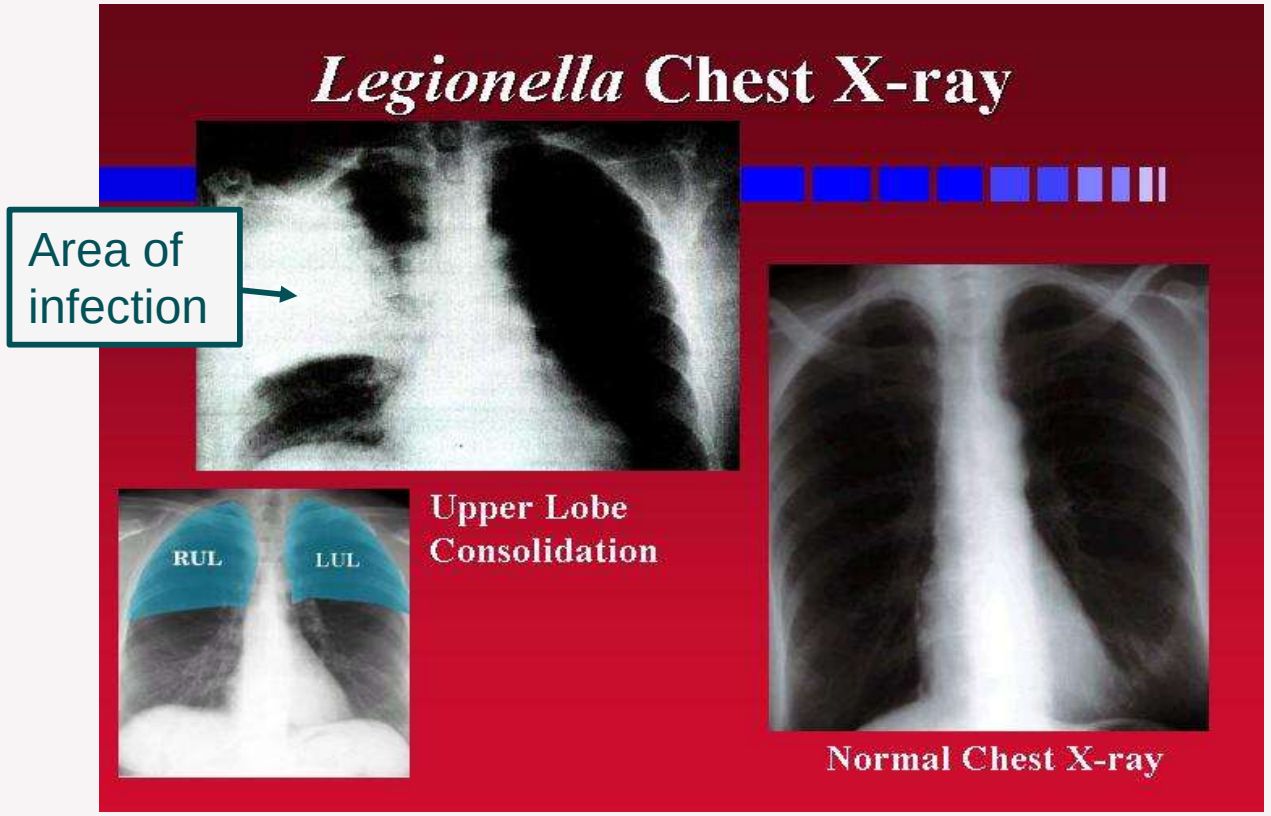
Medical Aspects

03

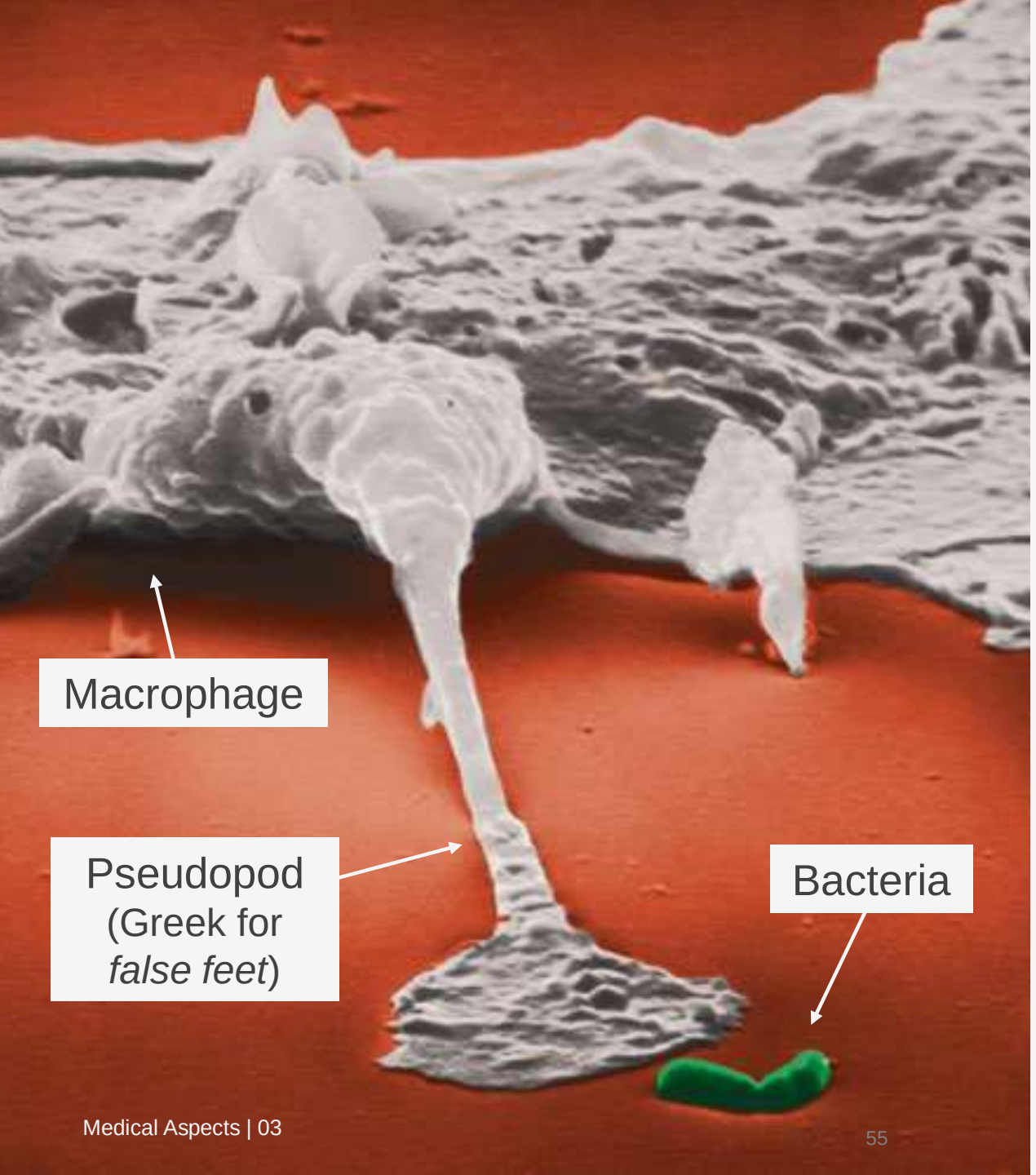
Water Quality Management within the Built Environment


NARKOMED



Legionnaires' Disease

Potentially fatal form of pneumonia



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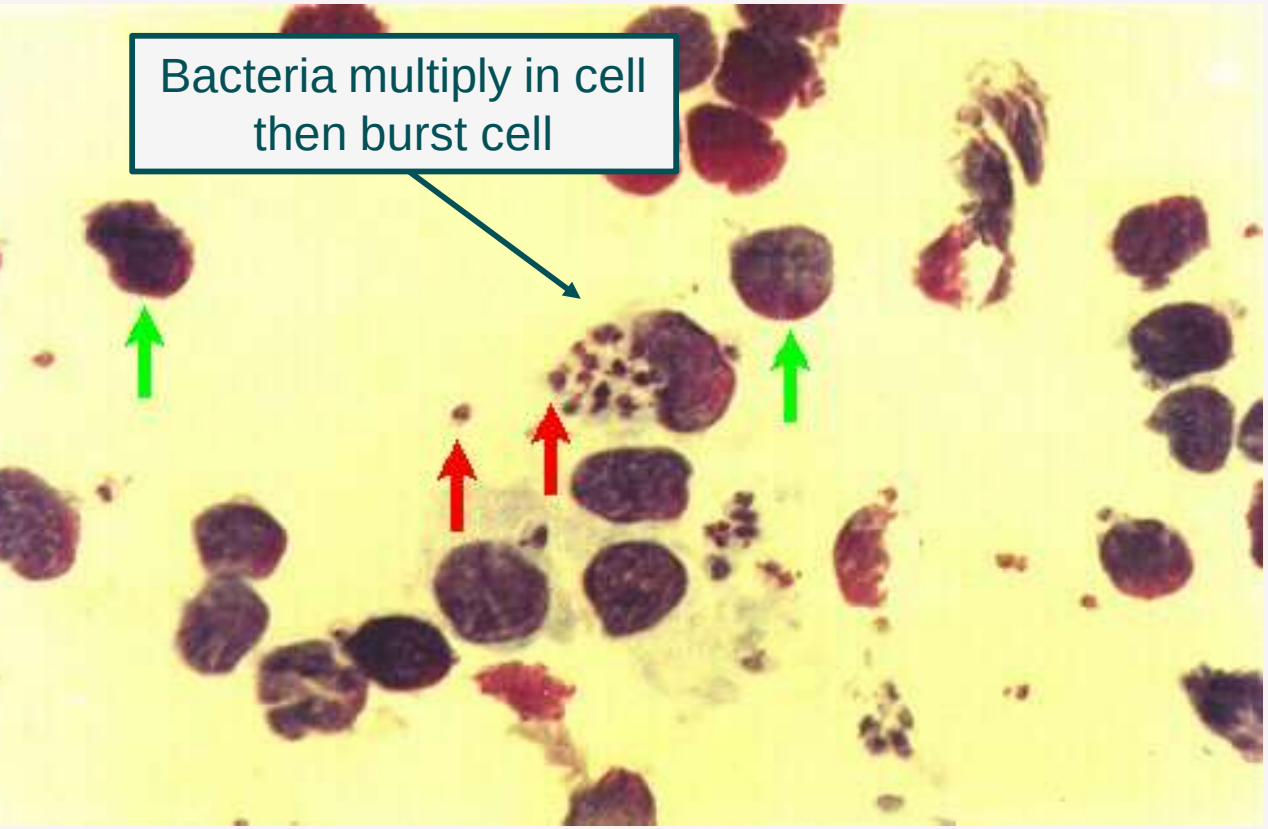
Macrophage in action
Phagocytosis



Cell Rupture

Medical Aspects

Incubation period

2-10 days
(usually 3-6 days)

Symptoms

- High fever
- Breathlessness
- Chills
- Dry cough
- Headaches
- Muscular aches
- Diarrhoea
- Vomiting
- Confusion/delirium
- **Death**

Individual Risk Factors

- **Number / type of legionella** in water at point of use
- **Production of aerosol / mist**. Risk increases with reduction in droplet size
- **Exposure to risk**, time / volume
- **Increasing age**, particularly above 45 years
- **Gender** - males circa three times more likely to be infected
- **Health**
  - Existing respiratory disease
  - Cancers, diabetes, kidney disease, alcoholism, smoking
  - Renal dialysis, use of immuno

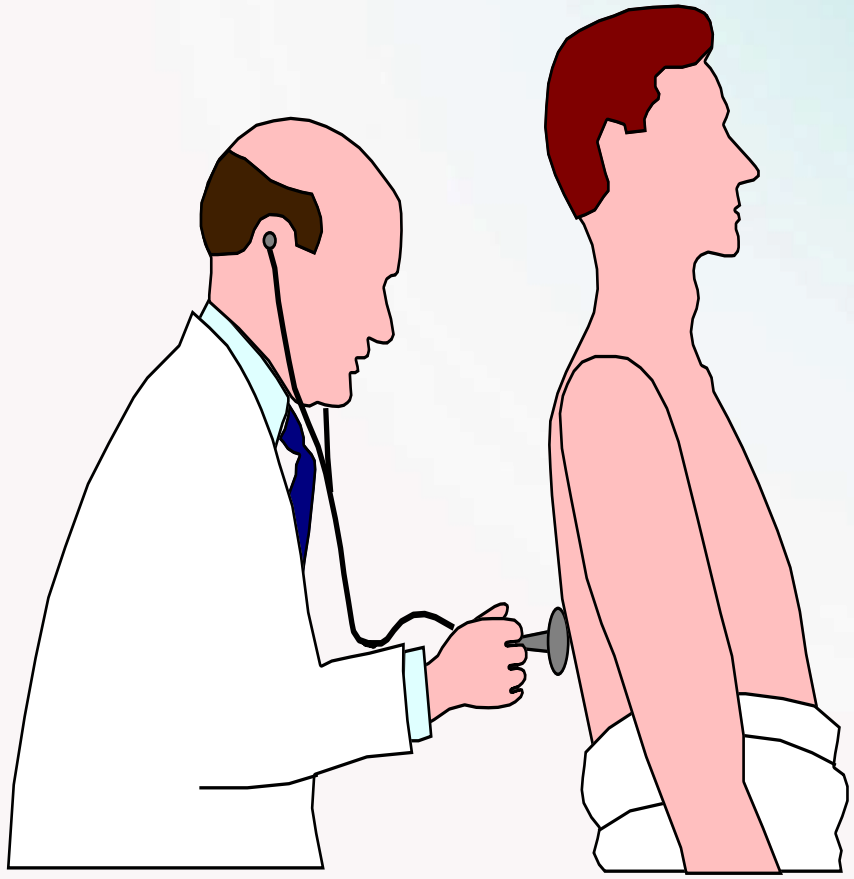
Treatment

Use of appropriate antibiotics, if diagnosed in time.

Treatment

Once bacteria enter macrophages they are protected against action of antibiotic.

It is therefore crucial that diagnosis is quick.



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Managing Water Systems

04

Water Quality Management within the Built Environment

Water Systems

- Cold water services
- Storage cisterns
- Hot water services
- Hot water storage vessels
- Air conditioning systems

Miscellaneous Systems

- Hose reels
- Fire sprinkler systems
- Ornamental fountains
- Deluge showers
- Trolley / Vehicle wash systems and procedures
- Agricultural sprinkler systems
- Ice making and Vending machines
- Hydrotherapy pools

Controlling The Risk From Exposure to Legionella Bacteria

- Action to ensure the correct and safe operation and maintenance of the water system
  - Avoidance of water temperatures and conditions that favour the proliferation of legionella bacteria and other micro-organisms (20°C-45°C)
  - Maintenance of the cleanliness of the system and the water in it
  - Avoidance of water stagnation
  - Controlling the release of water spray
- Avoidance of the use of materials that harbour bacteria or provide nutrients for microbial growth
- Use of water treatment techniques

Typical Water Systems Issues Encountered

Difficult Access

Fire exit and general thoroughfare

Typical Water Systems Issues Encountered

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Difficult Access

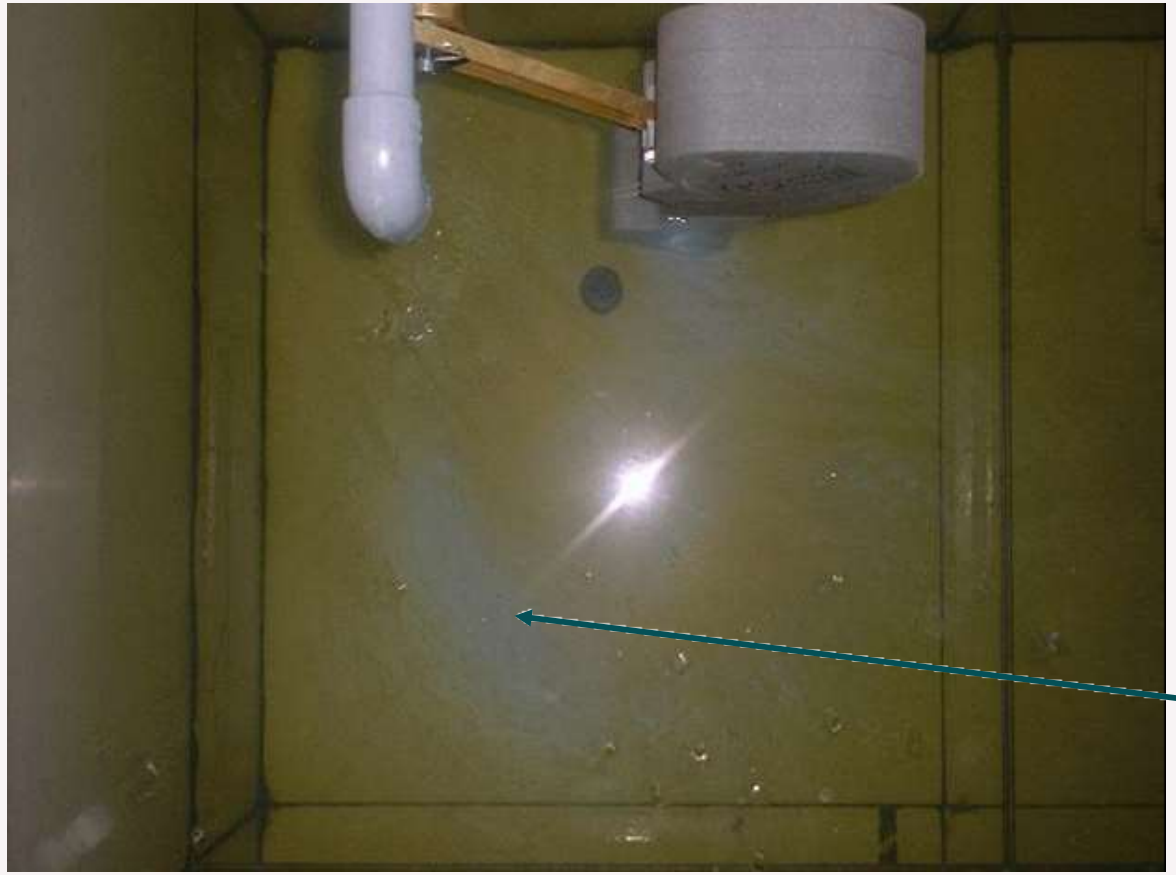
No access to CWST
1st Floor above stairwell

Typical Water Systems Issues Encountered

Difficult Access

CWST
Access only possible by
“Cherrypicker”

Typical Water Systems Issues Encountered

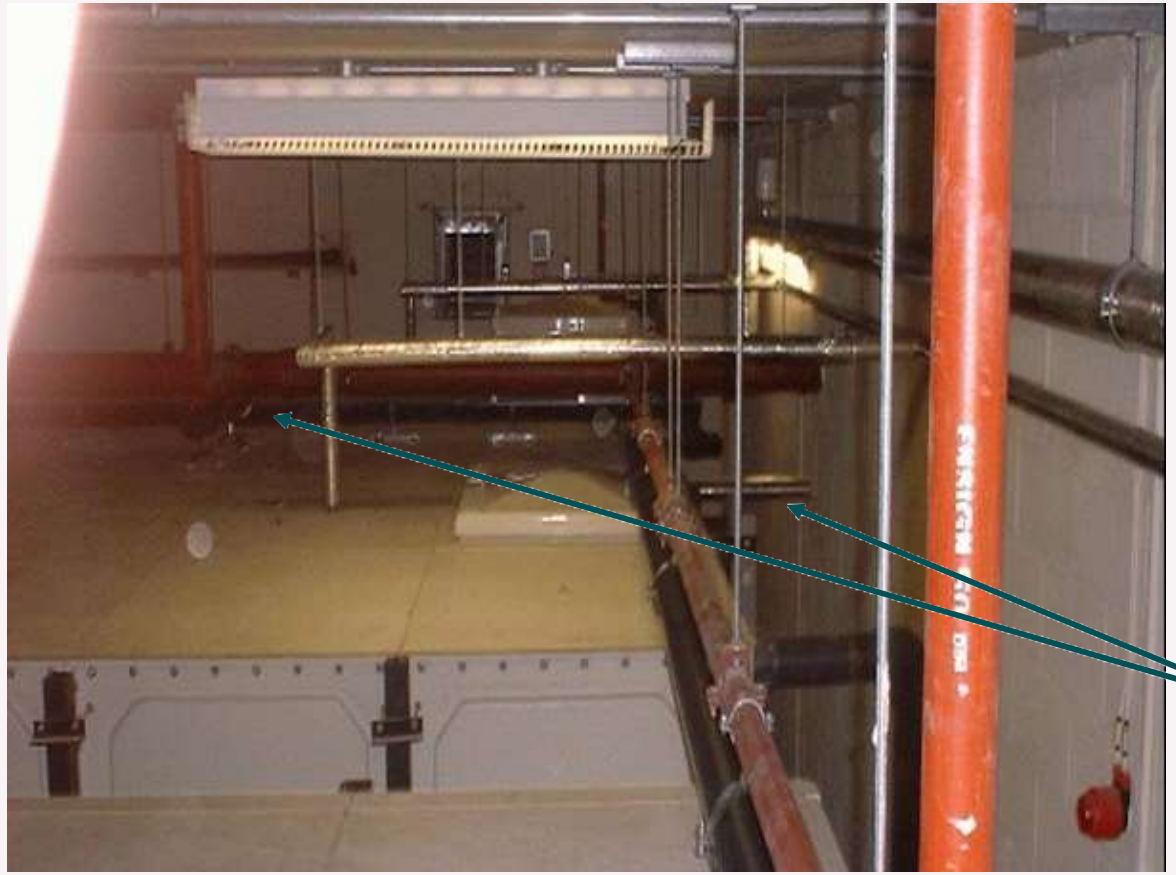


Water Storage Tank Contamination

Film on water surface

69

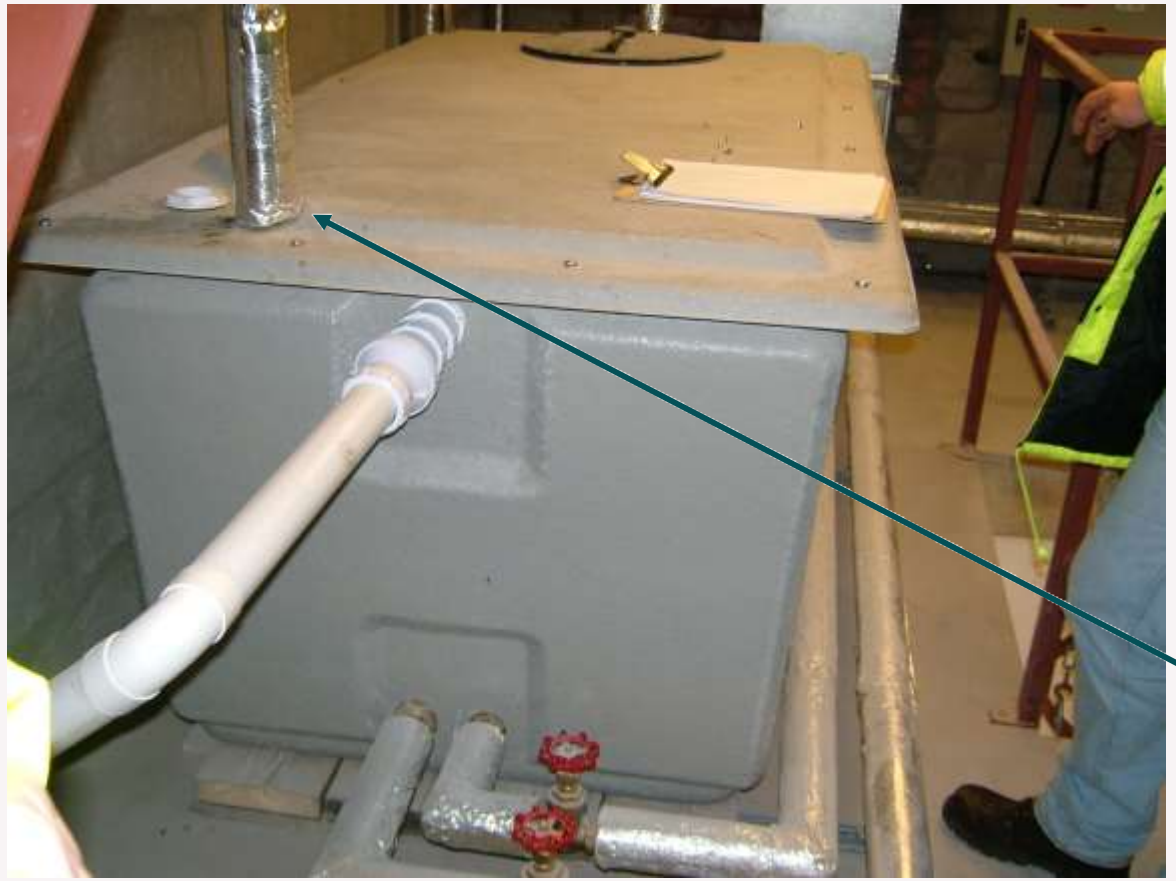
Typical Water Systems Issues Encountered



Design/Build Problems

Drainage pipes above CWSTs

Typical Water Systems Issues Encountered

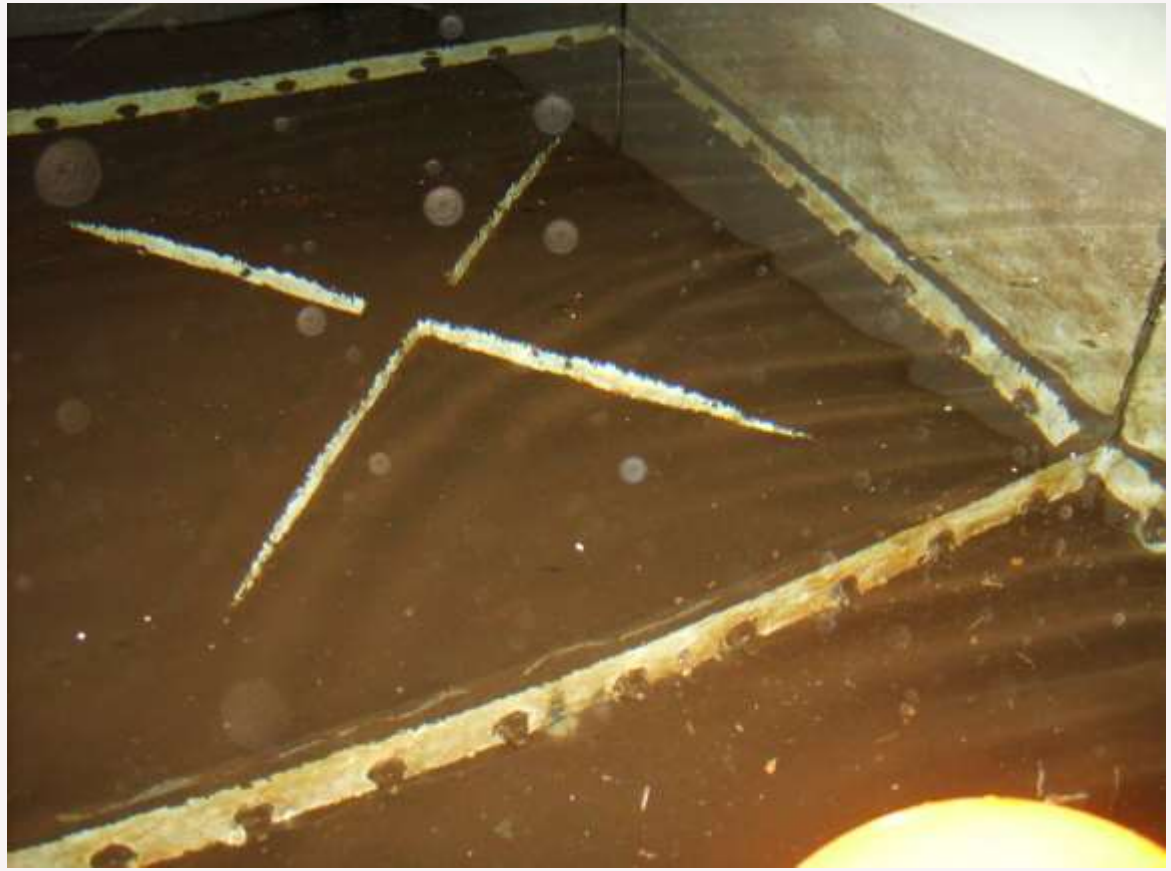


Undesirable Installation

Typical Water Systems Issues Encountered

Bird Droppings on Tank Lid

Typical Water Systems Issues Encountered



Interior of CWST

Typical Water Systems Issues Encountered

Hole in CWST Lid allowing ingress of bird

Typical Water Systems Issues Encountered

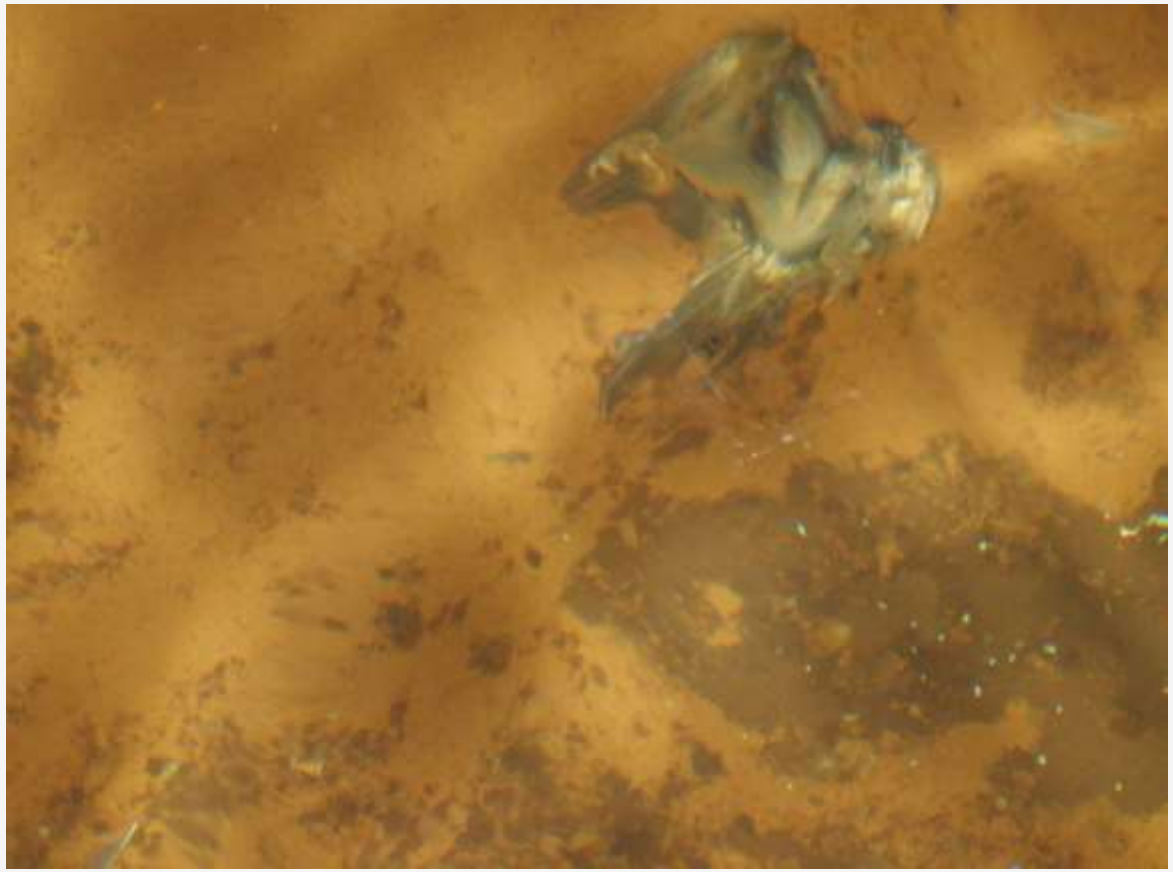
Bird in CWST

75

Typical Water Systems Issues Encountered

Corrosion in Galvanised CWST

Typical Water Systems Issues Encountered



French delicacy in Tank

Typical Water Systems Issues Encountered

Rat Bones

Typical Water Systems Issues Encountered

Stagnation and contamination

Typical Water Systems Issues Encountered

Stagnation and contamination

Typical Water Systems Issues Encountered

Stagnation and contamination

Typical Water Systems Issues Encountered

Stagnation and contamination

Typical Water Systems Issues Encountered

Bird in Tank

Typical Water Systems Issues Encountered

Dead-Leg

Typical Water Systems Issues Encountered

Dead-Leg

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Sampling & Analysis

05

Sampling/Analysis

Analysis of water samples for legionella should be carried out by a UKAS accredited laboratory.

Legionella colonies growing on BCYE agar

Sampling/Analysis

Water systems may be sampled for legionella when:

- Water systems are treated with biocides where storage and distribution temperatures are reduced from those recommended
- In systems where control levels of the treatment regime (eg temperature, biocide levels) are not being consistently achieved
- When an outbreak is suspected or has been identified
- Sites where ‘at risk’ people have been identified
- After invasive work on water systems has been carried out
- As a measure of the efficacy of control measures

Sample Bottles

1 Litre sample bottle (Legionella)

Sterilisation seal

Batch number and expiry date

500ml sample bottle (Bacto)

Sample bottles contain a chemical (sodium thiosulphate) which neutralises residual chlorine in order to preserve the sample until analysed

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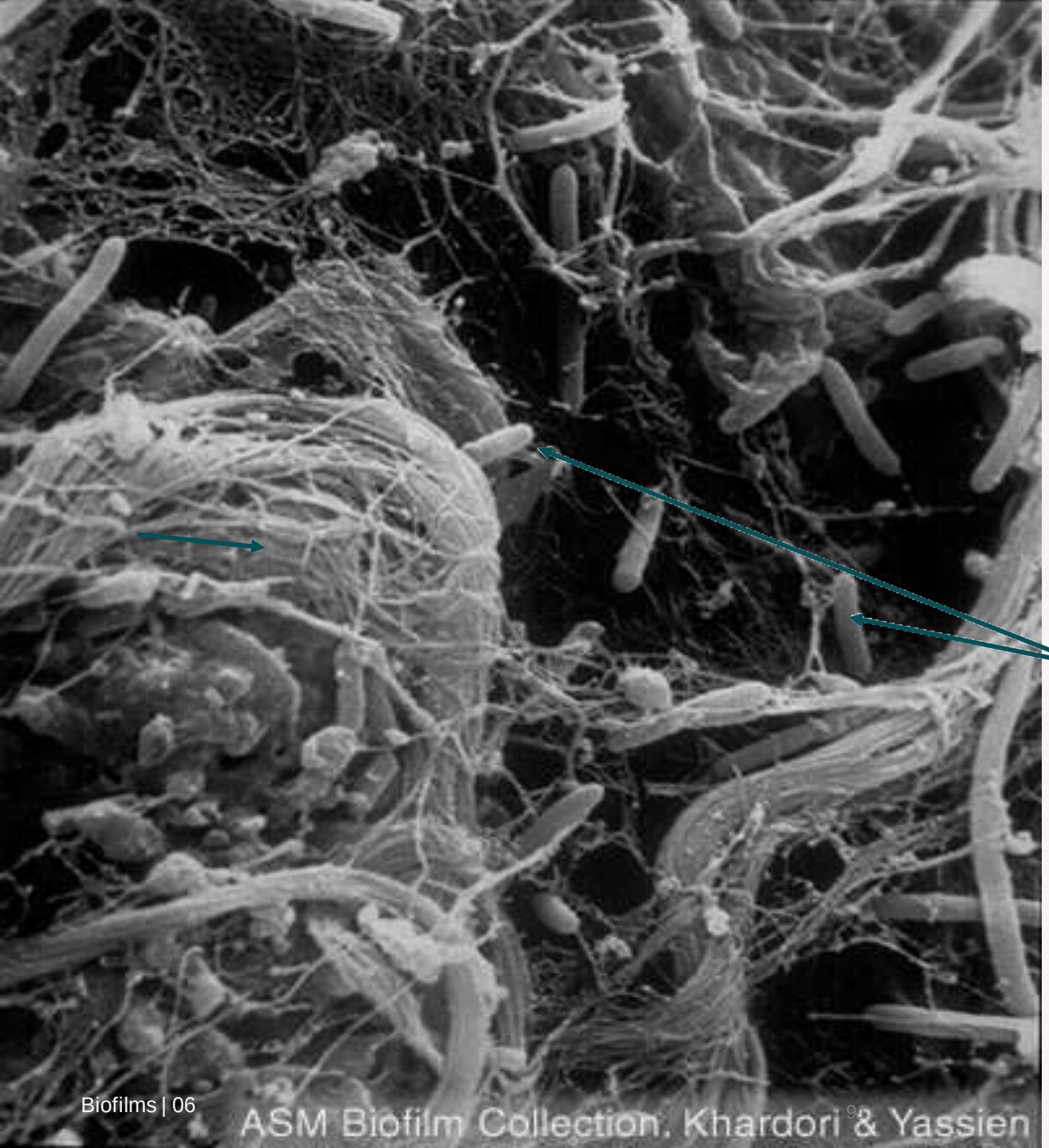
Biofilms

06

Water Quality Management within the Built Environment



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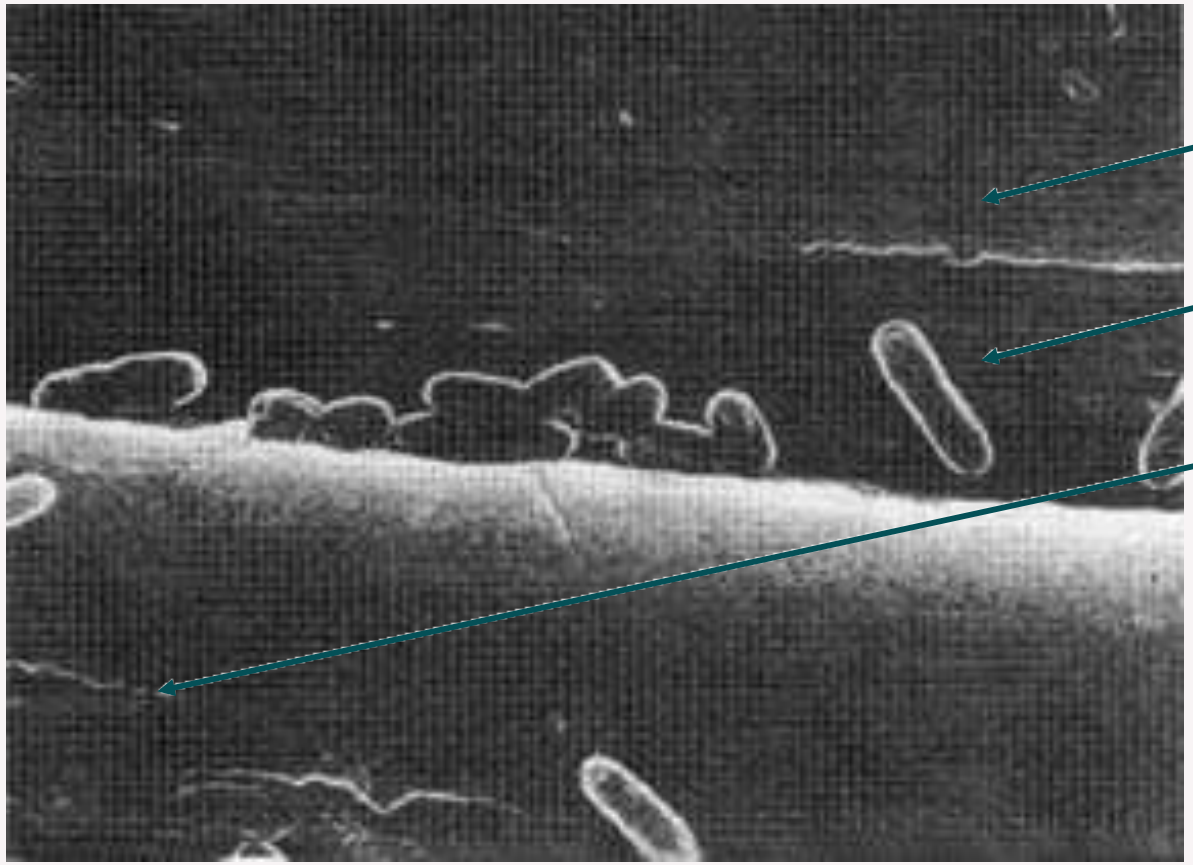
Biofilms in water systems

Bacteria

How does a biofilm form?

- Conditioning
- Adhesion of "pioneer" bacteria
- Glycocalyx or "slime" formation
- Secondary colonisers
- **Fully functioning biofilm**

Comparing surface profile to the size of bacterial cells

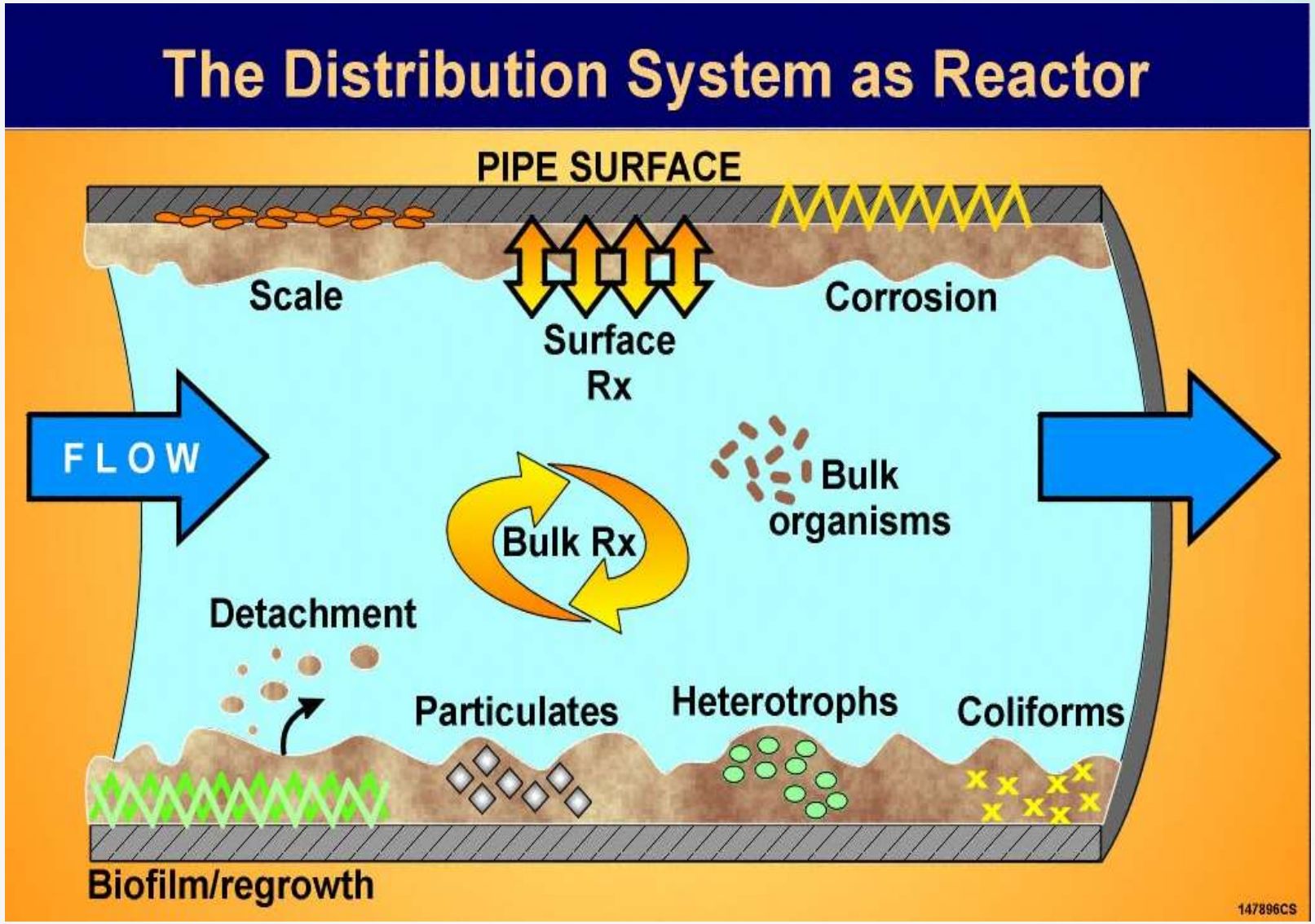


SEM x5000 of water pipe
Notice scratches are large enough to harbour bacteria.

Biofilms

The development of a mature biofilm may take;

- Several hours to several weeks
- *Pseudomonas aeruginosa* has been found to adhere to surfaces (including electropolished, stainless steel) within 30 seconds of exposure.



Biofilms in drinking water systems

Biofilms

Endoscope Picture of
Biofilm in pipe

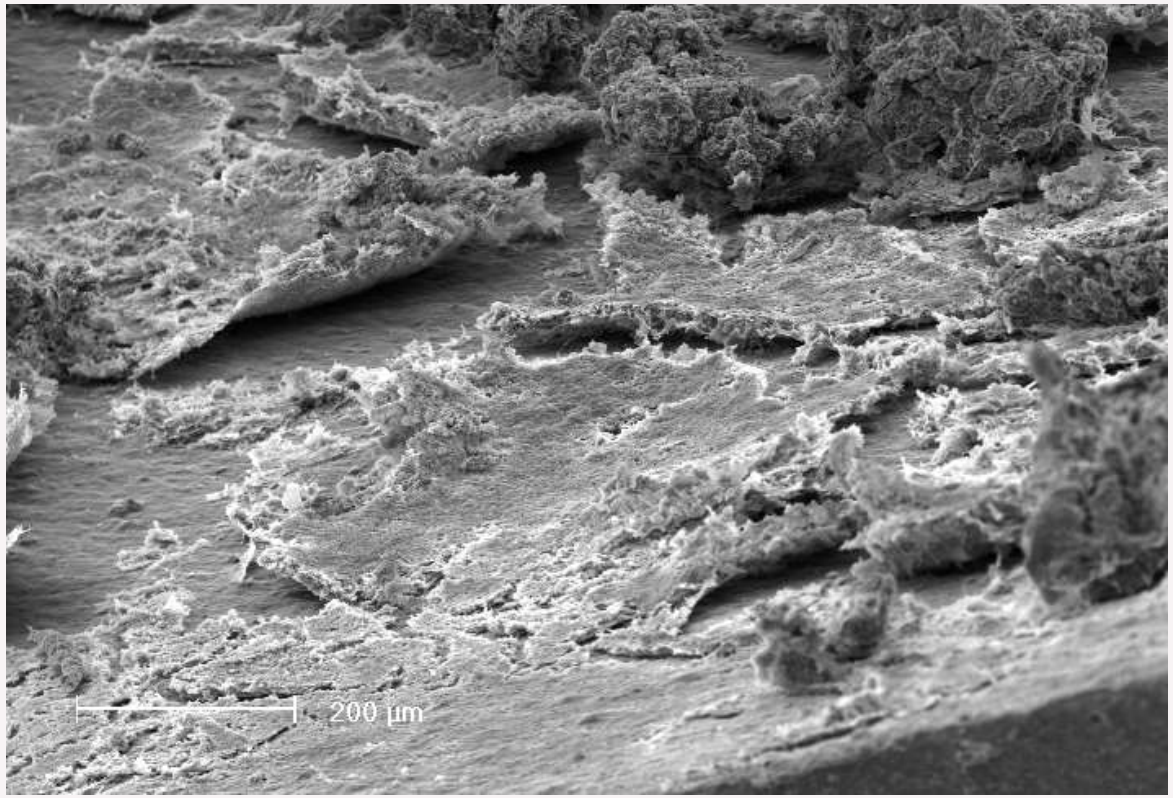
Biofilms

Biofilm on TMV Filter

Biofilms

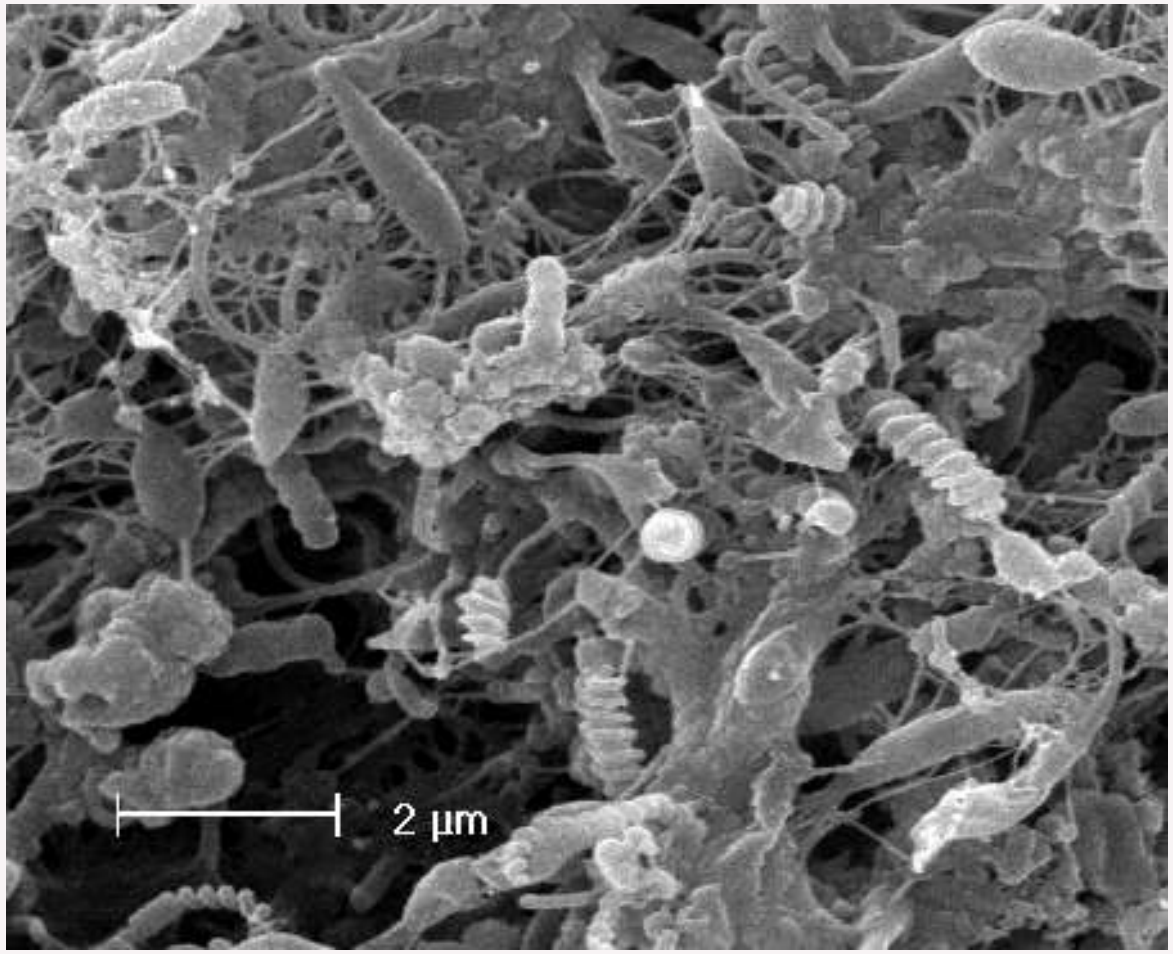
Biofilm in CWST

Biofilms



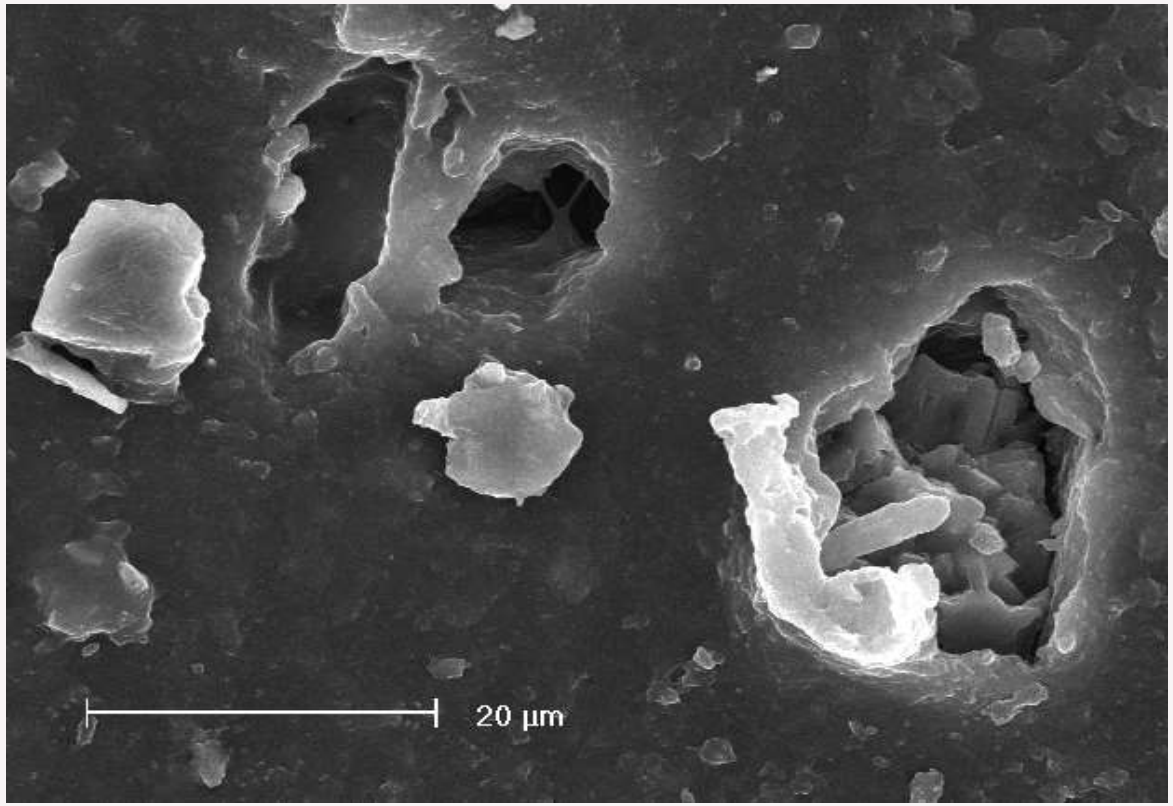
Plaques of biofilm on the internal surface of an EPDM flexible hose

Biofilms



Higher magnification electron micrograph showing the variety of bacteria comprising biofilm growing on an EPDM flexible hose

Biofilms



Microscopic cavities in the inner surface of an EPDM hose.

The cavities are around 10 to 20 microns wide and could conceal many legionella and pseudomonas bacteria which are around 2 microns in length and 0.5 microns wide

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Monitoring & Maintenance Tasks

07

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Course Test

08

Water Quality Management within the Built Environment

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For more information

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Legionella Control Association
KEEPING WATER SYSTEMS SAFE