Distribution System Handbook

DEVELOPING A *LEGIONELLA PNEUMOPHILA* MONITORING PROGRAM

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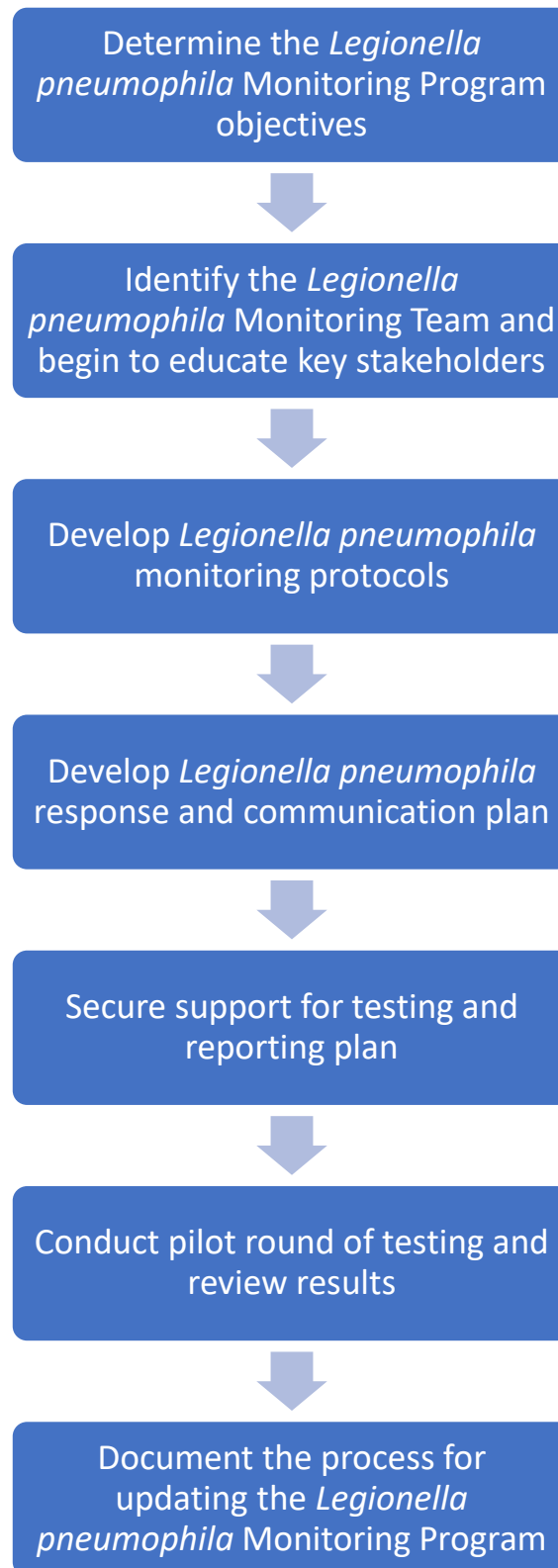Morrison, CO 80465

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Conduct pilot round of testing and review results

Document the process for updating the *Legionella pneumophila* Monitoring Program

Step by Step Checklist

1. Determine the *Legionella pneumophila* Monitoring Program objectives

2. Identify the *Legionella pneumophila* Monitoring Team and begin to educate key stakeholders
   - ☐ Identify key internal stakeholders
   - ☐ Identify key external stakeholders (public health, different city, county state, etc. regulators, businesses, media, key customers)
   - ☐ Begin to educate the community about facility owners' roles in reducing Legionnaires' disease risk

3. Develop *Legionella pneumophila* monitoring protocols
   - ☐ Determine sampling locations (TCR sites, reservoir/storage tank sites, other sampling sites: hospital, nursing home, senior community, municipal buildings)
   - ☐ Determine frequency of sampling (locations may vary month to month)
   - ☐ Select water quality data parameters (*L. pneumophila* and HPC, temperature, etc.)
   - ☐ Determine the responsibility for sample collection, delivery, and reporting
   - ☐ Conduct and document training and quality control activities

4. Develop *Legionella pneumophila* response and communication plan
   - ☐ Develop internal protocols for responding to *L. pneumophila* occurrence and concentration level
   - ☐ Develop an external communications plan for reporting *L. pneumophila* results

5. Secure support for testing and reporting plan
   - ☐ Review action limits and responses with the environmental/public health regulator
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6. Conduct pilot round of testing and review results
   - ☐ Conduct pilot round
   - ☐ Analyze results
   - ☐ Communicate findings
   - ☐ Make needed adjustments to control measures and/or plan

7. Document process for updating the *L. pneumophila* Monitoring Program, including
   - ☐ Updating distribution system information
   - ☐ Updating information on customer locations with potentially vulnerable populations
   - ☐ Deciding whether to incorporate testing results in the Consumer Confidence Report*

DETERMINE THE *LEGIONELLA PNEUMOPHILA* MONITORING PROGRAM OBJECTIVES

Background

Clarity on the objectives of the *Legionella pneumophila* monitoring program is important so that a consistent message can be presented to all stakeholders. These objectives may be multiple and can have different aims. Given that issues with *Legionella* occur almost daily in hospitals, hotels, nursing homes, and other buildings across the US, it is prudent that water utilities proactively address issues in their distribution systems before problems happen in their customer's premises.

Some of the objectives of a *Legionella* monitoring could include:

☐ To understand the adequacy of existing treatment to control *Legionella* in the distribution system

Water utilities want to be confident that the water they serve meets or surpasses all state and federal standards. Monitoring for *Legionella* can give them the confidence that their treatment processes are adequately controlling this organism – even though routine testing is not specifically required by current regulation. If the organism is ever detected, the data can provide the information needed to improve treatment and operational processes.

☐ To be able to better communicate with stakeholders on *Legionella* management

Hospitals and nursing homes should already have implemented processes to manage *Legionella*. Many hotels, commercial buildings, and apartments are also proactively taking measures to control *Legionella*. These customers look to water utilities as the authoritative source of information on water quality. Having a *Legionella* monitoring program would enable the utility to be better prepared to address their customers' questions.

☐ To become familiar with methods for *Legionella* monitoring

In the past, analytical methods for *Legionella* monitoring required specialized training and techniques. With the development of the Legiolert™ assay, utilities have the opportunity to use the procedures that are very similar to the techniques they already use in their coliform/*E. coli* monitoring. A study of US water systems reported that utility analysts found the Legiolert test easy to learn and use (LeChevallier 2019a).

☐ To be proactive in advance of any future regulations

The 1989 Surface Water Treatment Rule included filtration and maintenance of a disinfectant as a treatment technique to control *Legionella*. During the Six-Year Review of the rule, the EPA indicated that they were reviewing the microbial components of the rule, including the definition of a "detectable" residual in the distributions system as a way to better control pathogens including *Legionella*. It is not clear when or if EPA will enact such a regulation but implementing a monitoring program for *Legionella* will provide information on management options.

☐ To be consistent with internal water quality goals

Many water systems have their own internal water quality goals that set control limits for proper treatment and distribution system operations. These limits are often time more stringent than state or federal regulations. Monitoring for *Legionella* can provide a higher level of water quality assurance than existing bacteriological testing.

☐ Other – describe other objectives for the monitoring program.

WORKSHEET

Document your primary objectives for the *L. pneumophila* Monitoring Program

☐ To understand the adequacy of existing treatment to control *Legionella* in the distribution system

☐ To be able to better communicate with stakeholders on *Legionella* management

☐ To become familiar with methods for *Legionella* monitoring

☐ To be proactive in advance of any future regulations

☐ To be consistent with internal water quality goals

☐ Other:

☐ Other:

☐ Other:

IDENTIFY THE *LEGIONELLA PNEUMOPHILA* MONITORING TEAM AND KEY STAKEHOLDERS

Background

It's important that all the key stakeholders are aligned on the objectives and benefits of the testing program. Valid questions will arise and must be addressed. Below are some of the key stakeholders to consider when developing the monitoring program:

Identify Internal Stakeholders

☐ **Senior management**. The commitment of senior management (CEO, General Manager, etc.) to the monitoring program is critical. They should see the program as best serving their customers interests and safety. Senior management should be able to articulate why monitoring for *L. pneumophila* is aligned with the mission and vision of the organization. Also, senior management should be aware of the potential capital and operational expenditures that could be necessary to the water system based on the results of the monitoring program.

☐ **Legal**. The potential for finding an opportunistic pathogen in the utility's water system will be a major concern for the legal department whose job it is to protect the utility from risk. However, not knowing about *L. pneumophila* risks has its own set of issues, particularly when simple methods are available and corrective actions can readily be implemented. Overall, the utility is better protected by identifying and dealing with risks than ignoring them. Legal will also want the environmental regulator and public health agencies aligned with the program and any corrective actions and communications agreed upon in advance.

☐ **Operations leads (Treatment, Distribution).** These might include treatment plant supervisors and network (distribution) supervisors. These groups should be aligned and prepared to make corrective actions if necessary. Maintenance of a disinfectant residual throughout the entire distribution system will be important for *L. pneumophila* control, so disinfectant residuals may need to be increased; turnover, mixing, and operations of storage facility might need to be altered, and increased corrosion control and flushing of the distribution system might be needed to improve the stability of the disinfectant residuals.

☐ **Communications**. Having effective communications before and during a *L. pneumophila* monitoring program is essential to the success of the effort. WRF Report #4664 can be an excellent resource as it has a number of prepared materials for various stakeholder groups and social media platforms. The report includes a template for website materials to educate various customer groups on the importance of facility owners reducing building water risk and can be expanded to explain how the utility is doing its part in conjunction with facility owners by setting

up a proactive routine monitoring program to detect and respond to any water quality risks. Decisions will have to be made on how to communicate the results through the Consumer Confidence Reports, web or social media format, or directly to affected customers.

☐ **Engineering**. Engineering should be aware of the monitoring program because the results could require physical or design changes to improve mixing and turnover in storage facilities and/or cleaning, lining, or replacement of water mains that create excessive disinfectant decay. Hydraulic modeling could be useful in identifying areas in the distribution system with long detention times, stagnation and poor circulation.

☐ **Water Quality & Laboratory**. The laboratory is a key stakeholder in the *L. pneumophila* Monitoring Program as this group will need the resources to complete the analyses. The number of samples and frequency of monitoring can depend on the available laboratory capacity. Some utilities spread the monitoring out by conducting a few samples each week over a prolonged period, while others complete their monitoring with an intensive sampling program over a few weeks at regular intervals. More details on sampling program options is found in the "monitoring protocol" worksheet.

☐ **Human Resources**. It's a good idea to include HR since all employees should be aware of the objectives and results of the monitoring program. In some organizations this task might be handled by internal communications. Employees are the ambassadors of the utility to the community and should be conversant on monitoring efforts and the implications. Periodic updates to employees through normal organizational communications channels is recommended.

Identify External Stakeholders

Coordination with internal stakeholders should probably precede outreach to some external stakeholders, but as mentioned above, final decisions will likely not be made until there is coordination between both internal and external groups. Some informal discussion with key regulators (environmental, public health, and in some cases, economic) is suggested before formal engagement is initiated just to better understand their positions and potential concerns. For a sample letter that could be sent to external stakeholders, see Appendix A.

☐ **Environmental regulator**. The environmental regulator may be interested in results from routine monitoring, study but also concerned that they may be placed in a position to have to interpret and/or respond quickly to the results – something that they may not be prepared to do. Therefore, it will be important to share the objectives of the monitoring and the guidelines for responding to positive results. It will be important to get their buy-in on the response. They will also want to know how the data will be communicated, so have these plans ready. Be open to accept

their input to all parts of the plan but be firm if not all of the suggestions meet the utility's objectives.

☐ **Public Health Agency**. Similar to the environmental regulator, it is important to have buy-in from the public health agencies. They also may be concerned that they will be placed in a position to have to interpret the results or take appropriate actions to protect public health – so it will be important to share the guidelines for responding to positive results and get their concurrence. At the same time that the utility is performing the monitoring, it would be useful to have the public health agencies carefully monitoring for cases of Legionnaire's Disease in the community.

☐ **Political**. Different utilities will have different relationships with political entities in the towns that they serve, but it may be useful to notify various political entities (e.g., mayor, city council, water authority board members, etc.) of the *L. pneumophila* monitoring program; the objectives and goals. Provide periodic updates as needed.

☐ **Customer advocates**. Some utilities may have a customer advisory board or some other customer advocate group. Notification of this group on the monitoring plans, utility responses, and communications can help build trust and support for the utility.

☐ **Large customers**. Large commercial, industrial and institutional customers (CII), may already be implementing *Legionella* management plans. Outreach to business leaders, rotary groups, and large CII customers can create strong partnerships for *Legionella* management and potentially reduce friction in the event that the facilities find *L. pneumophila* in their building water systems or are part of a Legionnaires' disease case investigation.

☐ **Media**. Engaging the media early in the process is recommended. Start by inviting them to tour the treatment plant and the laboratory (especially if they've never done this before).

Educate the Community about Facility Owners' Roles in reducing Legionnaires' disease risk

In addition to identifying stakeholders, consider implementing educational campaigns for your community, particularly large customers and the media. A recent Water Research Foundation report (#4664 - *Customer Messaging on Opportunistic Pathogens in Plumbing Systems*) outlines materials that water utilities can use to proactively communicate with customers about *Legionella* in water (Masters *et al.*, 2018). Templates are provided for brochures, news articles, web sites, and social media campaigns. The messages are aimed at large commercial/industrial customers where growth of *Legionella* can occur in large complex plumbing systems. Information is also provided for homeowners, although cases are less commonly associated with single-family dwellings. Included in the messaging is the opportunity to communicate with customers about what the water utility is doing to manage *Legionella*. This would be a great

opportunity for water utilities to explain why they maintain a disinfectant residual, the necessity for infrastructure renewal, and the importance of regular cleaning and flushing of the distribution system. Large customers tend to use a lot of water, and therefore comprise a large portion of the overall revenue. Emphasizing the shared responsibility for *Legionella* management with this important customer category is good customer service.

Share web materials and customer education pieces developed from the WRF #4664 report (see Appendix B) as well as additional pieces you've developed and vetted with your other stakeholders about the utility's proactive stance on monitoring. Not every laboratory result needs to be made public, but the media can be contacted and be better prepared to deliver the right messages if action levels for high *L. pneumophila* results are exceeded and customers need to take specific actions.

WORKSHEET

Identify the *Legionella pneumophila* Monitoring Team

Skills to include on the *L. pneumophila* Monitoring Program Team
- ☐ Water quality analysis – microbiological and chemical
- ☐ Familiarity with institutional customer type and location
- ☐ Experience with RTCR Level 1 assessment and corrective action procedures
- ☐ Regulatory or government affairs
- ☐ External communications
- ☐ Senior management

Role *	Candidate Name	Candidate Title
Senior Management		
Legal		
Operation Lead Treatment		
Operation Lead Distribution		
Communications		
Engineering		
Water Quality and Laboratory		
Human Resources		
Other		

Not every team will need to fill every role listed

Identify the key external stakeholders

Role	Candidate Name	Agency
Environmental Regulator		
Public Health Agency		
Political		
Customer Advocates		
Large Customers		
Media		
Other		
Other		

DEVELOP *L. PNEUMOPHILA* MONITORING PROTOCOLS

Background & Checklist

☐ Determine sampling locations

There is no single right way to develop a *L. pneumophila* monitoring program. Since this is a voluntary testing program, the key here is to meet internal objectives. Keep the following suggestions in mind as you consider how to meet your organization's routine monitoring goals.:

1. *Total Coliform Monitoring Locations*

    Using already developed TCR monitoring locations can be a good way to plan your *L. pneumophila* testing program. This is a state-approved sampling plan that is representative of the finished water supplied to consumers. Moreover, the utility already has an extensive database of water quality data – from which any water quality excursions can be evaluated. This water quality database allows the *L. pneumophila* monitoring data to be placed into context of "normal" water quality data – compared to any excursions. In addition, extra sample bottles for *L. pneumophila* testing can be collected along with the regular TCR sampling.

    The extent and frequency of monitoring depends on the utility resources and the capacity of the laboratory to handle the additional monitoring. Although utilities found that the Legiolert assay was easy to use and interpret (LeChevallier 2019a), they did indicate that the extra number of samples is something the lab has to anticipate and manage. Depending on lab capacity, the utility could determine to conduct 10%, or 25%, or 50% of the number of samples required for TCR monitoring. In addition, the utility could focus on monitoring when and/or where water temperatures are likely to be >15°C since prior studies showed that *L. pneumophila* was not detected when water temperatures were cold (LeChevallier 2019b).

2. *Reservoirs, Storage Tanks*

    A *L. pneumophila* monitoring program could also target storage facilities since long detention times, low turnover, and sediment accumulation can provide opportunities for *L. pneumophila* growth. Lu *et al.* (2015) detected *Legionella spp.* by qPCR in 66.7% of municipal drinking water storage tank sediments from 18 sites. If using Legiolert, storage facility water samples can be processed using the Potable Water procedure but use the Non-Potable Water procedure if sediment samples are analyzed because of the potential for high HPC levels. See Appendix C. Note that the two procedures use different incubation temperatures. If sediment samples are analyzed, procedures should be used to desorb the

bacteria from the particulates before analysis (Camper *et al.*, 1985). Remove the sediments by decanting before the analysis.

3. *Locations of Potentially Vulnerable Populations*

A monitoring strategy could also consider targeting sites where potentially vulnerable populations might exist. These sites could include sampling locations near hospitals, nursing homes, senior centers, etc. Sampling could also target any known points in the system where water is stagnant or disinfectant residuals are known to dissipate. Areas near or downstream of main breaks, or construction or repairs of the distribution system, may be opportunities to detect *L. pneumophila* that may be released from biofilms due to flow changes or vibrational forces.

4. *DBP Monitoring Locations*

Another option could be to collect samples from the designated DBP monitoring locations, as these locations could better represent water age in the distribution system. One caveat would be to make sure that these sampling taps conform to specifications for collecting bacteriological samples.

5. *Municipal and utility owned buildings*

Municipal and other city or utility-owned buildings that serve the public are recommended to have water management plans (NASEM 2019). Some level of testing within the building plumbing system could be done as a means of validating the controls in their water management plan. The development of water management plans and monitoring to validate the plans would set the utility in a leadership role and an example to other business/buildings in the community for responsible public health safety.

☐ Determine sampling frequency

The frequency of sampling will depend on the availability of laboratory resources and the utility objective for the *L. pneumophila* Monitoring Program. However, the frequency of sample collection and analysis should be sufficient to evaluate trends and identify any changes in water quality over time. Monthly or quarterly sampling may be appropriate; however, sampling can be more intense during period of warm water (>15°C). One large city utility analyzed samples every month and rotated sampling sites over the course of a year in order to gather baseline data for 100% of its TCR sampling sites. The utility is now designing its ongoing sampling strategy based on these initial results.

☐ Select water quality data parameters

In addition to evaluating samples for the presence of *L. pneumophila*, the collection of additional water quality data can help to put the monitoring results into context. The type of data collected can be identical to the routine coliform monitoring, or additional data can be collected for this special study. As a suggestion, the following water quality data will could be collected:

Parameters to Test	Suggested Test Methods
L. pneumophila (MPN/mL)	Legiolert
TC/EC (MPN/mL)	Colilert
HPC (MPN or CFU/mL)	Simplate for HPC
Free/Total chlorine	DPD Method
Temperature	Thermometer
pH	pH strip or electrode
Total organic carbon	SM5310B

Chloraminated systems may wish to collect additional indicators of nitrification (nitrite, free and total ammonia). In all cases, the utilities should follow their established procedures and quality control protocols for these analyses.

WORKSHEET

Determine Sampling Sites & Frequency

TCR Site Sampling

TCR Site ID	Sampling Frequency

Reservoir/Storage Tank Sampling

Reservoir/Storage Tank ID	Sampling Frequency

Other Sampling Site Candidates

Building Type (hospital, nursing home, senior community, municipal)	Vulnerable Population? (Y/N)	Existing TCR site? (Y/N)	Access to sampling point? (Y/N)	Include in plan? (Y/N)	Sampling Frequency?

Determine testing parameters

Parameter	Include (Y/N)	Frequency	Method
L. pneumophila (MPN/mL)			
TC/EC (MPN/mL)			
HPC (MPN or CFU/mL)			
Free/Total chlorine			
Temperature			
pH			
Total organic carbon			

Sampling Program Implementation

☐ Determine the responsibility for sample collection, delivery, and reporting

Once the nature of the *L. pneumophila* monitoring program has been determined, the schedule of samples can be programed into the laboratory information management system (LIMS). Personnel responsible for sample collection should be trained on the proper sampling methodology using appropriate sample bottles containing sodium thiosulfate. For the most part these procedures can follow the same as those for TCR monitoring (e.g., proper faucet selection, removal of aerators, flushing of the tap for 3-5 minutes before sample collection, etc.). An alternative sample collection protocol could collect samples without any flushing (e.g., first draw sample), but this procedure would primarily determine *L. pneumophila* in the tap – which may not be reflective of the levels in the water distributed by the utility.

Appropriate chain of custody forms should accompany the sample indicating the sampler's name, sample location, date, time and any other routinely collected information.

Samples should be transported at ambient temperature to the laboratory in insulated coolers as protection against extreme heat or cold. Analyses should be initiated as soon as possible or refrigerate samples that will not be processed within 24-48 hours from the time of collection. All sample handing data should be detailed in the chain of custody forms.

☐ Select Sampling Locations

Ideally, sampling locations should draw water directly from the distribution main or service connection (e.g., a tap installed after the meter at a building) to avoid collected water that has been exposed to conditions within internal plumbing that may promote the growth of *L. pneumophila* and are beyond the control of the water system. Water systems may consider installing dedicated sampling stations as part of the monitoring program. However, if sample taps are used within buildings, flushing of the tap for 3-5 minutes before sample collection is important. Even with flushing, there is a possibility that positive samples could be influenced by the building plumbing.

☐ Conduct and document training and quality control

For training and QC, it is recommended that laboratories analyze certified reference material comprised of defined positive and negative control samples for the testing they will perform. See Appendix C for more information on Legiolert QC procedures.

☐ Sample Collection Follow-up

Develop protocols so that any results of unusual or low disinfectant results can be communicated and followed-up immediately – without waiting for the 7-day incubation of the Legiolert samples. Chloraminated systems should have a nitrification monitoring plan so that samples with low monochloramine (or total chlorine) residuals or elevated nitrite detection can be quickly treated. In these cases, flushing of the areas of the distribution system with low disinfectant levels and can be done to restore normal residuals.

DEVELOP *L. PNEUMOPHILA* RESPONSE AND COMMUNICATION PLAN

Background

☐ Develop a response protocol for the occurrence and various concentrations of *L. pneumophila* in water supplies.

Conventional water treatment practices do not produce sterile water and it is possible that low levels of *L. pneumophila* may be occasionally present, even in the best water supplies. *L. pneumophila* is a normal inhabitant of the aquatic system, so the goal of the water supply is to try to manage the occurrence and the concentration of *L. pneumophila* to levels as low as possible. The following is an excerpt from a JAWWA paper by LeChevallier (2020):

'There is no clear guidance from the EPA or CDC on safe levels of *Legionella* in water. However, several national and international guidelines have guidance on how to respond to the detection of *Legionella* in public water systems. It should be noted that some of these guidelines are intended for building water systems, but the risk principles can be applied to utility distribution systems.

New York State regulations (subpart 4-2) require hospitals and health care facilities to monitor their potable water systems for culturable *Legionella* and institute control measures and notify authorities when 30% or more of the samples contain *Legionella spp.* (NYS 2019). The 30% guideline originates from the Allegheny County *Legionella* prevention guidelines (Allegheny County Health Department, 2014; Squier *et al*., 2005) that specifies that cultural results from hot water tanks and distal sites within a health care facility have less than 30% occurrence of *Legionella* when no cases of legionellosis are observed.

The American Industrial Hygiene Association (AIHA) provides guidelines (AIHA, 2015) for routine *Legionella* monitoring in the absence of any reported illnesses. Table 1 provides concentrations of *Legionella* in single samples that can be thought of as action levels for responses within a water management plan. For all water system types (except cooling towers), a measured concentration above 1 CFU/mL is considered to be at the action limit. Specifically, concentrations between 1-10 CFU/mL for potable water could be acceptable if elements of the water management plan are operating properly and there are no other deficiencies. For devices that generate aerosols (humidifiers, fountains, and hot tubs), concentrations between 1-10 CFU/mL would trigger actions to clean and disinfect the system. Higher concentrations of *Legionella* would indicate uncontrolled amplification of *Legionella* within the system and would trigger immediate steps to clean and disinfect the system and review and revise the water management plan. These values mirror those originally proposed by the Occupational Safety and Health Administration (OSHA, 2019) which had suggested guidelines for *Legionella* to assess the effectiveness for water system maintenance.

Table 1. AIHA Data Interpretation Guidelines

Sample Source	Non Detectable	Acceptably Low*	Action	Possible Amplification	Action	Indicates Amplification	Action
Humidifiers & Misters	<1 CFU/mL	<1 CFU/mL	1	1–10 CFU/mL	2	>10 CFU/mL	3
Decorative Fountains and Water Features	<1 CFU/mL	<1 CFU/mL	1	1–10 CFU/mL	2	>10 CFU/mL	3
Hot Tubs, Whirlpools and Spas	<1 CFU/mL	<1 CFU/mL	1	1–10 CFU/mL	2	>10 CFU/mL	3
Potable Water	<1 CFU/mL	<10 CFU/mL	1	10–100 CFU/mL	2	>100 CFU/mL	3
Industrial Working Fluids	<1 CFU/mL	<10 CFU/mL	1	10–100 CFU/mL	2	>100 CFU/mL	3
Cooling Towers & Evaporative Condensers	<10 CFU/mL	<100 CFU/mL	1A	100–1,000 CFU/mL	2A	>1,000 CFU/mL	3A

* May be limited by *Legionella* levels in the building source water supply (e.g., municipal water).
Action Levels (see AIHA 2015 for complete details):
1. Continue to monitor as per the plan.
2. If no cases of legionellosis, reassess maintenance and treatment plans; make adjustments as necessary. If cases of legionellosis occur, take immediate steps to clean and disinfect the system. Notify appropriate health authorities.
3. Take immediate steps to clean and disinfect the system. Adjust control plan as needed.

Under the SWTR, EPA regulates all *Legionella* species with a non-enforceable MCLG (Maximum Contaminant Level Goal) of zero. Similarly, the NY State monitoring requirements and Allegheny County guidelines specify monitoring for *Legionella spp*. However, the currently available culture media does not recover all species equally. The genus *Legionella* is comprised of > 50 species, consisting of 70 serogroups, and media originally developed to isolate *L. pneumophila* are not equally effective for recovery of all *Legionella* species (Lee *et al.*, 1993; Luck *et al.*, 2004; Descours *et al.,* 2014). Johnson *et al.* (2018) detected a wide range of *Legionella* species (16 different species in total) in reclaimed water by qPCR, but 96% of the isolates recovered on BCYE agar were *L. pneumophila*. So, there is little value in specifying culture methods for the whole genus *Legionella* when current methods largely target *L. pneumophila*. Because qPCR techniques cannot reliably determine the viability of detected isolates, the AIHA guideline specifies analysis of *Legionella* by culture (to determine the effectiveness of control strategies) and recommends that PCR techniques be used as a complementary analysis but that they should not replace culture-based methods.

One criticism of the AIHA guidelines is that they are not risk based but founded on practical experience in preventing legionellosis outbreaks. A recent quantitative microbial risk analysis (QMRA) examined *L. pneumophila* exposure through aerosols from showers, faucets, and toilets for both single exposure events and as an annual risk (Hamilton *et al.*, 2019). Risks were calculated as a probability of infection and for a dose that would cause illness (CSI – clinical severity index). Results presented in Figure 1 show that showering resulted in the greatest risk, with a 10^{-4} risk of illness (CSI) for a single exposure of 3.5×10^5 CFU/L for a conventional shower and a 10^{-4} risk of illness for an annual exposure of 1.41×10^3 CFU/L. A risk of infection, rather than illness, is a more stringent target and could be used in

"high risk" environments like hospitals or health care facilities. In this case, a 10^{-4} risk of infection for a single exposure was 4.13×10^2 CFU/L for a conventional shower and a 10^{-4} risk of infection for an annual exposure of 1.64×10^0 CFU/L. Therefore, these data support the AIHA guidelines in that single samples may be positive for *Legionella* but allow for corrective actions to be implemented to reduce further exposure.
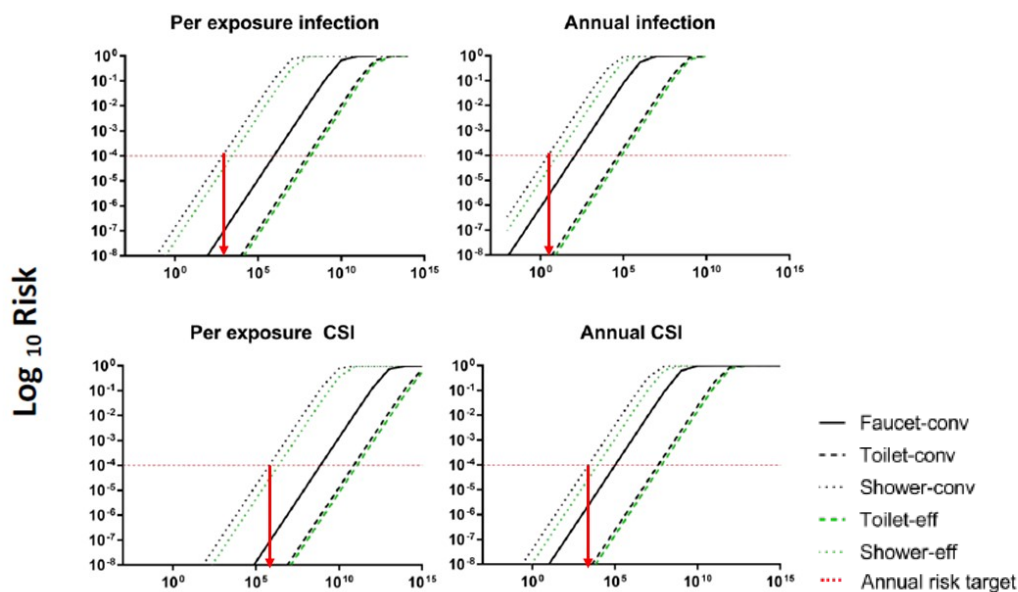

Figure 1. QMRA analysis of *L. pneumophila* exposure CFU/L) for conventional and high efficiency faucets, toilets and showers. Risks are calculated for single and annual exposures. Risk endpoints include infection and illness (clinical severity index). Adapted from Hamilton *et al*., 2019.

The European Union (EU) published proposed guidelines for the prevention, control, and investigation of infections caused by *Legionella* species (*European Technical Guidelines* 2017). The guidelines emphasize proper water management plans focusing on obtaining proper temperature, biocide, operations and maintenance programs. Monitoring to demonstrate the effectiveness of the plans should meet the values shown in Table 2. These goals incorporate both numerical threshold values like in the AIHA guidelines along with targets for frequency of exposure – like the NY State and Allegheny County guidelines. The EU guidelines emphasize the goal to achieve no culturable *Legionella* but acknowledges that occasional detection (<20%) of low levels of *Legionella* (< 1 CFU/mL) may be acceptable provided that other water quality values (e.g., temperature, disinfectant, etc.) and operational parameters were within the water management plan guidelines. Intermediate levels (1-10 CFU/mL) and high levels (>10 CFU/mL) would trigger a series of actions including resampling, disinfection, and overall review of the water management plan program. Triggering these remedial actions would result in prompt actions to protect public health – consistent with the QMRA results of Hamilton *et al*. (2019), while still providing flexibility for building owners and water systems to deal with low, sporadic detections of *Legionella* in water.

Recently, the National Academy of Sciences, Engineering and Medicine (NASEM) issues a report suggesting that a Legionella concentration of 50,000 CFU/L (or 50 CFU/mL) should be considered as an "action level" high enough to warrant immediate remediation (NASEM, 2019).

Table 2. European Action Levels for *Legionella* in Potable Hot and Cold Water Systems

Legionella CFU/mL	Action Required
Not Detected	Acceptable – continue monitoring
<0.1 to 1.0	Assure water quality values are within target
1.0 to 10	i) Resample if small percentage (10-20%) are positive; review control measures ii) If >20% positive, disinfection of system, risk assessment
>10	Resample, immediate review of control measures, disinfection of whole system

Source: European Technical Guidelines 2017.

It is not the objective of this review to establish a regulation or standard for *Legionella* in water supplies, only to point out existing guidance and how the various programs are consistent or inconsistent with each other. This guidance can be used to develop protocols for responding to the occurrence and various concentrations of *L. pneumophila* in water supplies. Table 3 provides the protocol used in a recent study of *L. pneumophila* in public water systems (LeChevallier 2019a). The protocol was developed in collaboration with regulators from the State of Washington for responding to positive distribution system *L.*

Table 3. Protocols for Responding to *L. pneumophila* Occurrences in Potable Water Systems

1. Positive samples should be speciated/serotyped
2. Compare water quality data (free/total chlorine, etc.) for the site compared to historical levels. Determine if any anomalies exist.
3. A repeat sample should be collected from the sample site within 24 hours of reporting the positive sample.
4. If the repeat sample is negative, the site should be re-sampled at regular intervals as per study protocols.
5. Trigger levels (CFU/mL) can be established to prompt corrective actions
   a. <0.1 to 1.0   Assure water quality values are within target
   b. 1.0 to 10   Resample if small percentage (10-20%) are positive; review control measures
      Conduct a system assessment for events that could account for the positive result
      If >20% positive, disinfection of system, update control measures
   c. >10   Resample, immediate review of control measures, disinfection of whole system
6. Exceedance of the 1.0 CFU/mL threshold should trigger a system assessment to see if there are any recent events in the system that could have accounted for the positive result. Check in with DOH/regulator.
7. Flush the area near the positive site – particularly if disinfectant levels are low. If the positive is from a reservoir, consider draining, cleaning or disinfecting the reservoir.
8. Multiple detections/high densities of *L. pneumophila* in the water system should trigger close consultation between the operator and regulator regarding follow up actions and communication to other parties.

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pneumophila samples. The framework includes a "system assessment" if *L. pneumophila* levels exceed 1.0 CFU/mL (Table 3). The revised Total Coliform Rule (RTCR; USEPA 2013) requires a Level 1 assessment to be conducted by the public water system owner that assesses any mechanism that could provide a pathway for microbial contamination or any sanitary defect that indicated a failure of a protective barrier to prevent microbial contamination. In the context of *Legionella* contamination, such a similar assessment could include failures in treatment or disinfection, main breaks, failures in storage tanks or reservoirs, cross connections, backflow, etc. Similar to the RTCR, any deficiencies identified would be expected to be corrected, which could include flushing parts of the network with low disinfectant residuals, cleaning storage tanks, or boosting disinfectant levels within the distribution system."

The Team should consider adapting its existing system review processes and assessment forms so that they can be used to evaluate a potential *Legionella pneumophila* contamination and determine appropriate corrective actions.

WORKSHEET

Develop your response protocol

L. pneumophila Trigger level (MPN/ml)	Action Level	System Response	Internal Communication Needed? (Y/N)	External Communication Needed? (Y/N)
	No action			
	1			
	2			
	3			

☐ Develop a communications plan for reporting *L. pneumophila* results.

The utility's stated goal should be to achieve zero *L. pneumophila* in the distribution system. To do this the system should emphasize maintaining an effective disinfectant residual throughout the system, proper maintenance, and infrastructure renewal. Despite these efforts, research (LeChevallier 2019b) has shown that low concentrations of *L. pneumophila* can occasionally be detected even in properly operated systems. Table 3 includes suggested guidance on sharing *L. pneumophila* results:

<0.1 to MPN^ 1.0/mL. *L. pneumophila* at these levels may be transitory and repeat samples are often negative. Infrequent detection of *L. pneumophila* at these levels may not be of great concern if the other routine water quality data and system operations are normal.

>20% occurrence. Determination of the frequency of occurrence depends on the number of samples collected per monitoring event. Assuming that 10 samples are collected, then if more than two are positive during any particular sampling event, this would be an opportunity to notify the environmental/public health regulator and conduct a system evaluation. If any deficiencies are detected, they should be corrected.

1.0 MPN to 10/mL. *L. pneumophila* levels in this range indicate that conditions may be favorable for growth of the organism in the system. Actions should be taken to correct any low disinfectant residuals, water stagnation, or other conditions can could lead to the proliferation of the bacteria in the system. This would be an opportunity to notify the environmental/public health regulator and conduct a system evaluation. If any deficiencies are detected, they should be corrected.

>10 MPN /mL. *L. pneumophila* levels in this range indicate that conditions are favorable for growth of the organism and that immediate actions should be taken to reduce the bacterial levels. Disinfectant residuals should be increased, and positive areas of the system should be flushed until the elevated disinfectant residuals are achieved. After consultation with the environmental/public health regulators, consider issuing public notification to boil tap water. As a precaution, advise the elderly and immunocompromised to avoid showers and situations where water is aerosolized. The notification can be lifted, upon concurrence with the regulators once elevated disinfectant residuals are stable and *L. pneumophila* occurrence is eliminated. Given that it takes 7 days to culture *L. pneumophila*, prepare for an extended communications event.

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^ MPN stands for Most Probable Number, which is a statistical estimate of the microbial concentration in water. It can be thought of as being equivalent to colony forming units (CFU). See: https://www.idexx.com/en/water/resources/mpn-generator/

In a case study outlined by LeChevallier (2019b), a utility that had three positive *L. pneumophila* samples that ranged between 1 and 5 MPN/mL implemented a flushing program to bring chlorinated water into an area where stagnation had eliminated the free chlorine residual. After applying corrective actions to the system, the utility visited each customer in the affected area (there were only about 70 households) to explain what had happened and steps the utility was taking to correct the situation. In all, the customers seemed to appreciate the outreach, and no questions or complaints were raised. The health department was informed of the monitoring results and the utility's response, and it approved of the actions. The study made the utility better focus capital resources on improvements that will maintain disinfectant residuals throughout the distribution system (LeChevallier, 2019b).

Consider posting updates on the *L. pneumophila* monitoring program on the utility's web page, even if all the results are negative. Posting the action levels discussed above will allow stakeholders to know when alerts will be issued. Consider including a statement on *Legionella* in the annual (or bi-annual) Consumer Confidence Report. The Water Research Foundation report (#4664) included some samples that can be used. Interested stakeholders can be directed to the utility web page for more details.

WORKSHEET

Decide on communication plan

L. pneumophila level (MPN/ml)	Action Level	Stakeholders to include	Communication platforms	Template	Speed
	1				
	2				
	3				

SECURE SUPPORT FOR TESTING AND REPORTING PLAN

Background and Checklist

☐ Review action limits and responses with the environmental/public health regulator.

After the details of the sampling, methods, QA/QC, and communications plans are developed it is important to review and discuss these plans with the regulators. In some states the Public Health Department has responsibility for regulating water systems, however; in many states environmental regulations and public health responsibilities reside in different agencies. It is recommended to engage both departments, either in a single meeting or separately. It is important that this meeting not be the first time these agencies are hearing about the utility's plan to monitor for *L. pneumophila*, as the utility should have already laid the groundwork with some type of pre-communication (either by letter, phone, or in-person meeting) about the utility's intent and goals for monitoring *L. pneumophila*. Anticipate the need to educate these agencies by providing background information – such as prior publications of utility *L. pneumophila* monitoring programs (see LeChevallier 2019 a, b, and LeChevallier 2020).

Many public health and environmental agencies will be supportive of the utility's desire to monitor for *L. pneumophila* but may have concerns about the implementation of the program and the specific actions that would be taken in response to detection of the organism in water supplies. Start with the shared objectives of all the stakeholders to better protect public health and better serve the public. Outline the monitoring program, the QA/QC plans, and how the results will be shared and communicated. The purpose of the meeting is to open a dialog and solicit input into the plans. Constructive ideas are welcomed, but if any objections can't be resolved, additional planning and development may be necessary. If objections are raised, try to ask the stakeholders what would be needed to resolve these objections. It is important to have the support of the public health/environmental regulators and accommodate their relevant input.

Agree on what on-going communication will happen during the *L. pneumophila* monitoring program. This could be periodic updates to the regulator or could be limited to an agreement to supply information when certain action levels are reached. Try to enlist the regulator's support in any subsequent discussion with other stakeholders (e.g., political, community groups, media, etc.).

☐ Review plans with key internal stakeholders

Employees are the ambassadors of the water utility in the community. As such, they should be aware of the objectives of the monitoring program and have background information on *Legionella* in water. In a prior case study (LeChevallier, 2019b), the only questions about the *Legionella* results came from employees who wanted to be able to explain the program

to neighbors and friends. Therefore, periodic program updates should be made to employees through normal organizational communications channels.

Additional training and talking points should be prepared for customer service agents so that they address routine customer inquiries. If the utility has a program for outreach to large commercial, industrial and institutional customers (CII), this customer training could include information on water management plans that these customers could implement to also manage *Legionella* issues in building water systems. Research has shown (Masters *et al*., 2018) that outreach by the utility can prompt CII customers to consider implementing water management plans, thus creating a strong partnership between the utility and the customer.

☐   Engage other Stakeholders on the monitoring and communications plans.

After securing the support of the public health/environment regulators, subsequent discussions can be held with other important stakeholder groups. These discussions can be approached as a "inform and advise" format – where the purpose is primarily to inform the stakeholders of the program. This communication can start with just general information on *Legionella* in water and the importance of implementing water management plans. Still, it is important to be open to hear and respond to any concerns expressed by the stakeholders – after all that this overall reason for the interaction.

Consider the sequence of engagement; with political, business, and customer advocates contacted before discussions with the media. It makes a powerful statement to the media that the utility, regulators, politicians, business, and advocates are aligned on a voluntary, proactive program to better protect public health. Moreover, the program also sends a positive message to building owners to address *Legionella* issues in their premises.

CONDUCT PILOT ROUND OF TESTING AND REVIEW RESULTS

Checklist

☐ Conduct pilot round

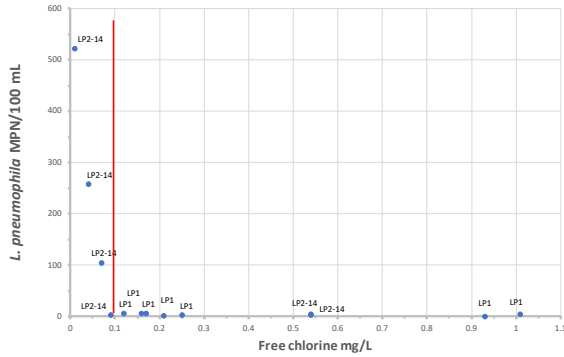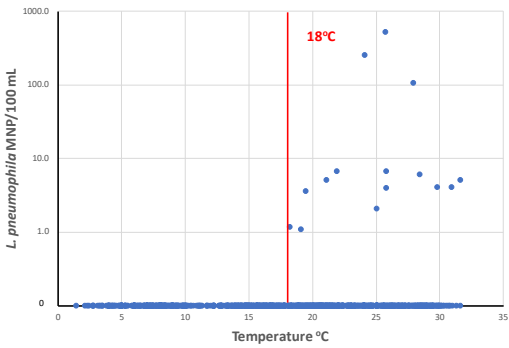After all the preparations, it's time to implement the *L. pneumophila* monitoring program.

    ☐ Order all necessary supplies and check the expiration dates on any existing materials to ensure that all are ready to be used.

    ☐ Consider performing a "dry run" of sampling and analytical methods on a few sites to make sure that samplers and analysts are familiar with the protocols.

    ☐ Ensure that all the sampling sites are accessible, and the sampling faucets are appropriate for bacteriological sampling (e.g., dual handle, removable aerators, short neck, etc.). This may be particularly important for sites that are not part of a routine TCR sampling program. In all cases, it is recommended to select sampling faucets that are not too far removed from the water main, although this may be difficult in large buildings like hospitals. The reason for this recommendation is to minimize the impact of building plumbing biofilms on the sampling results.

    ☐ If dedicated sampling stations are available, it might be advisable to select these locations to minimize the impact of building plumbing biofilms on the sampling results. If a mix of sampling sites are used, it is advisable to note these distinctions (e.g., dedicated, building) in the database.

    ☐ Note any construction or distributions system activities nearby to the sampling sites as disturbances from these activities could dislodge biofilms and influence the *L. pneumophila* results.

☐ Analyze results

Prepare your data sheets in a manner that will aid in the final analysis of the data. Collect all the data from a single sampling sites in one row in the datasheet. Avoid using "less than" or "greater than" symbols in the data. Record non-detect results as "0" (zero) and "greater than" results as the highest value.

    o An example Excel spreadsheet is available in Appendix D

    o An examination of *L. pneumophila* results with respect to temperature and disinfectant residual will be some of the most informative analyses. Scatter plots and summary data can be used to examine any relationships within the data. Some examples from LeChevallier, M.W. (2019b) are shown below:

	Free Chlorine	Chloramine
N samples	317	258
N *Legionella* +	13	1
% Positive	4.1	0.39
Avg. *Legionella* MPN/100 mL	3.04	0.02
Avg. Disinfectant Residual mg/L	0.82	1.98
Avg Temp (°C)	23.1	22.6
Avg pH	8.04	8.02
Avg TOC (mg/L)	1.77	3.1

☐ Communicate findings

Follow the guidelines established for reporting *L. pneumophila* developed in the communications plan and agreed to with the regulators.

o Consider giving presentations on what you're learning at local, regional, and national water industry conferences and symposia. Sharing the experiences in setting up and implementing the monitoring program will help other water utilities navigate the same path. It will demonstrate industry leadership for your utility.

o Considering publishing a report in an industry journal like *JAWWA* or *AWWA Water Science*. Having peer reviewed publications influences EPA and other regulators when considering any future regulation for *L. pneumophila* in water.

☐ Make needed adjustments to control measures and/or plan

It is important in any project to perform a "after study analysis" to consider the items that went well, those that did not work, and items that could have been performed better. Areas of review can include planning, communications, sampling, analysis, documentation, and continuous improvement. Operational changes such as minimum disinfectant residuals, tank turnover, flushing, corrosion control, etc. should be included to "embed" the learning into the daily activities of the utility.

DOCUMENT PROCESS FOR UPDATING THE *L. PNEUMOPHILA* MONITORING PROGRAM

<p align="center">Checklist</p>

☐ Update distribution system information

　☐ Update the distribution maps/database based on new information learned in the *L. pneumophila* monitoring program. Any changes in the sampling locations (faucet type, plumbing materials, etc.) can be noted.

　☐ Update databases on areas of low disinfectant residual or prolonged stagnation. These areas might be scheduled for periodic flushing and/or improved corrosion control.

☐ Update information on customer locations with potentially vulnerable populations

　☐ If not already noted, update the monitoring plans with information on potentially vulnerable populations, including hospitals, nursing homes senior centers, and other critical locations.

　☐ Update records of key stakeholders and contact information in case these groups need to be contacted for any reason.

☐ Decide whether to incorporate testing results in the Consumer Confidence Report

　o If not already agreed upon in the communications plan, consider adding some information on *Legionella* risks in your periodic Consumer Confidence Report. By regularly communicating about *Legionella* in water systems, you prepare and educate customers about *Legionella* issues prior to any events that might occur in the distribution system.

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APPENDIX A. Sample letter for key external stakeholders

February 7, 2020

State Drinking Water Administrator
State Public Health Office

The purpose of this letter is to inform you that our utility will be implementing a routine *Legionella* monitoring program using the Legiolert assay - a test specific for *Legionella pneumophila* (https://www.idexx.com/water/products/legiolert.html). The simplicity of the test now enables water utilities to easily conduct monitoring of community water systems to ascertain the effectiveness of current treatment processes and disinfectant residual levels to control *Legionella pneumophila* in potable water.

If your agency wishes, we can notify you of any positive result and keep you informed of any corrective actions and subsequent results.

Our expectation is that most samples will be negative for *Legionella pneumophila*, but believe it is prudent to explore all possible scenarios and contingencies. Ultimately, this monitoring program will give us greater confidence in the adequacy of current treatment systems for *Legionella* control. The USEPA has not established acceptable levels of *Legionella* in water outside of the MCLG, so our system will be going through a process to determine appropriate thresholds and actions.

Please let us know how you would like to be informed. We plan to initiate this monitoring as soon as possible.

Sincerely,

_____

APPENDIX B. Sample educational pieces for community

Source: Customer Messaging on Opportunistic Pathogens in Plumbing Systems Report, The Water Research Foundation Project #4664

<u>**Sample Social Media Posts**</u>

The following are sample Facebook or Twitter messages that can be used anytime, and in particular (1) when *Legionella* is a part of your local news cycle due to an outbreak or a sickness reported within your service area or (2) when you are promoting water quality.

- Did you know that *Legionella* accounts for 66% of all drinking waterborne outbreaks? Learn more. [link to your web page]
- You have a role in maintaining the quality of water inside your home. Learn more. [link to your web page]
- The water we deliver to you is disinfected, but once inside your home, your plumbing has an impact on its quality. Learn more. [link to your web page]
- *Legionella* was in the news today, find out whether your home or business is at risk. [link to your web page]

<u>**Sample CCR Text**</u>

Water Quality and Your Plumbing
Safe water is our top priority and a responsibility we share with you. The water we deliver to your property meets all federal and state regulations and water quality standards, but water quality can change once the water leaves our network of pipes and enters your building or home's plumbing. Residents and facility managers have an important role to maintain the quality of water after it leaves our pipes. Guidance is available at [INSERT UTILITY WEBSITE].

<u>**Resources for Imagery for *Legionella* Communications**</u>

Resources Online

- AWWA – a collection of royalty-free industry images on CD is available for purchase at http://www.awwa.org/store
- Creative Commons – Free images available at http://search.creativecommons.org/
- Center for Disease Control – Free images, graphics, and videos specific to *Legionella* https://www.cdc.gov/*Legionella*/materials.html
- Free stock photos – http://www.pexels.com
- Free stock photos – http://www.pixabay.com
- Free stock photos – https://unsplash.com/

For additional examples and resources:

APPENDIX C. Legiolert Protocol Information

The most up to date information on the Legiolert culture test is always available from the manufacturer, IDEXX Laboratories.

The protocols for analyzing potable and nonpotable samples for *Legionella pneumophila* are available here. Instructional videos and answers to frequently asked questions are available at www.idexx.com/legiolert.

The on-line MPN Generator program for Legiolert is available at https://www.idexx.com/en/water/resources/mpn-generator/

For additional details on QC procedures, see the product insert and the "Using Legiolert with Non-environmental Samples" document or contact WaterTechnicalService@idexx.com.

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APPENDIX D. Sample Data Collection and Analysis Worksheet

Date collected	Date tested	Sample	Sample Site	Water Protocol (potable/nonpotable))	Notes (TCR site, other routine site description)	Large	Small	Vol. tested in Legiolert	Legiolert MPN/ 100mL	TC/EC (MPN/mL)	HPC (MPN/mL) R2a media	Total chlorine	Free chlorine (mg/L)	Temp. (C)	pH	Total organic carbon
1/5/2020	1/6/2020	1	TRC 1	Potable	TCR Site	0	0	100	0							
		2	TRC 2	Nonpotable	Source Water	0	0	1	0							
		3	Finished (CT-out)	Potable	Entry to Distribution	0	0	100	0							
		4	Gatehouse (untreated)	Nonpotable	Source Water	0	0	1	0							

Request template spreadsheet with embedded MPN look-up table by emailing WaterSafety@idexx.com