HORNE®

CASE STUDY: Driving sustainability whilst minimising risk to Patients from *P. Aeruginosa* Contamination at Water outlets.

James Donagain champions a move from *'we've always done it this way'* to big savings, wide-ranging benefits, and enhanced sustainability with simple change to Thermal Disinfection at the point-of-use.

To accompany the launch of its ILTDU, *In-Line Thermal Disinfection Unit,* Figure 1, to the market, Horne Engineering, experts in temperature controls since 1909, developed a narrated animation to help describe, illustrate and explain how effective the device is in resetting retrograde *Pseudomonas Aeruginosa* (PA) pathogen counts to zero, time after time.

Keeping tabs on early ILTDU trial results, and abreast of new findings as scientific research into PA, biofilms and retrograde contamination expanded, Horne also developed and began to roll out their CPD seminar: *Engineering vs Pseudomonas, Legionella and the retrograde contamination of domestic water systems.*

It was at one of these presentations, to the Estates Department at Hinchingbrooke Hospital in Huntingdon (a North West Anglia NHS Foundation Trust Hospital) that former Hard FM Manager, James Donagain, was first introduced to the ILTDU, and the concept of thermal disinfection *at a local level*, as an alternative to the often go-to, chemical treatment for Pseudomonas Aeruginosa.

James Donagain, CMIOSH
Thermal Disinfection & ILTDU Champion

With a background in facilities compliance, Health and Safety, and specialising in water hygiene, James was very motivated in expanding his understanding and was also open-minded to considering new technologies and techniques.

From an environmental perspective, James was also concerned about the over-reliance on, and associated cost of, consumable chemicals and point-of-use (POU) water filters - often employed, long-term, but rarely successful, for attending to *Pseudomonas Aeruginosa* contamination at taps and showers in hospitals. Could thermal disinfection, he speculated, operated locally at an individual outlet, allow for operational cost-savings, and a reduced environmental impact? Might it also impact positively on the delivery of healthcare and patient safety? Intrigued, James sought a suitable opportunity to test the ILTDU.

James Donagain, Authorising Engineer (Water) and Water Hygiene Specialist.

After delivering consultancy directly to a number of NHS Trusts, James then joined Zeta Compliance Services in February 2020, as Authorising Engineer and Consultant, and was soon advising a number of NHS Hospitals, including Kings College Hospital (KCH) in London. Here he was pleased to discover the Estates team had already purchased and installed a number of the Horne ILTDU, including their T4 and T9 type showers, Figure 2, which feature an integral ILTDU plumbed-in at the top of the panel.

Spotting an opportunity for comparison, he suggested to the KCH team that it could be a worthwhile exercise to thoroughly evaluate the ILTDU, and test if it really did stand up to the manufacturer's claims for its management of PA contamination.

As such, James developed and implemented a robust methodology to test the effectiveness of the ILTDU

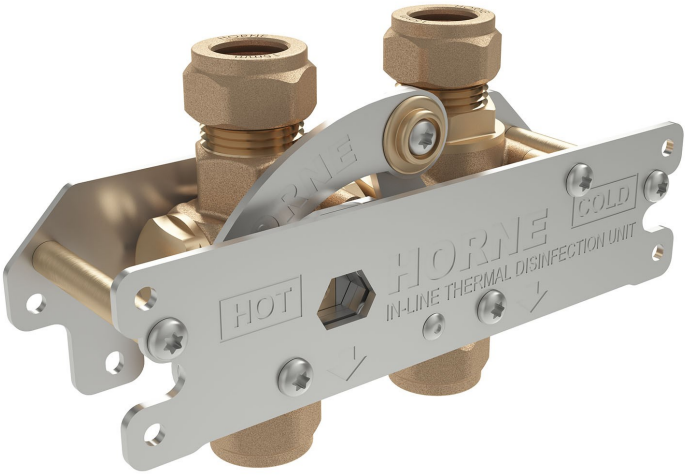

Figure 1. The patented Horne In-line Thermal Disinfection Unit, ILTDU.

Figure 2. The ILTDU as a component of Horne's T4/T9 type pre-plumbed shower panels.

at KCH; base-line microbiological data across the site was first collected, followed by monthly monitoring over a 6 month period, both at ILTDU installations and at a similar 'control' group of installations, that did not incorporate the ILTDU.

Comparison of both data sets showed significant reductions in PA counts in the ILTDU group and gave firm validation for its effectiveness in resetting PA to zero. The successful outcome of the trial and its supporting data led Kings College Hospital to then include the ILTDU and T4/T9 showers in their *Standard Specification* for all future new build and refurbishment projects.

Whilst consulting at KCH, James also supported a portfolio of other NHS clients, including a large acute NHS Trust in the Midlands. Here he assisted both the Trust Water Safety Group (WSG), and their PFI provider, across 3 main Hospital sites. Early discussions with the WSG, highlighted an historical and unresolved *Pseudomonas Aeruginosa* (PA) problem - which presented a further opportunity for James to retest, demonstrate again and consolidate the efficacy of the ILTDU. First he needed to familiarise himself with, and review, this Trust's preferred procedure and historical water sample data.

Testing for PA was an on-going process; in accordance with HTM 04-01 Part C, internal IPC risk assessments, and the Trust's Water Safety Plan, it followed a set Standard Operating Procedure (SOP) for both sampling, and for any subsequent remedial action.

Sampling and Treatment Regime

Within Augmented Care settings, mixed-water tap and shower outlets, identified as high risk by the WSG, are sampled - pre-flush only - every six months, as per HTM 04-01 (2016), Part B, Figure D1. Positive outlets are resampled, Pre- and Post-flush, to confirm contamination as retrograde and not systemic. Point-of-use (POU) filters are fitted whilst remedial chemical disinfection takes place, and these filters remain in place until the outlet can be returned to normal service. Treated outlets must give 3 consecutive negative pre-flush results, after 3 days, (reinstate outlet) 2 weeks and then a further 4 weeks, before being returned to the standard six monthly sampling schedule.

Data Review

Reviewing 3+ years of collected sample data, James soon realised the results were highly variable and he became increasingly concerned that hot-spot areas for PA contamination remained. In fact, he concluded, the prescribed remedial action was ineffectual at consistently attending to the problems. Contrary to the HTM guidelines on the use of POU filters - they should only be used as a temporary protective measure - here was documented evidence of their prolonged use and replacement, and at significant cost and disruption. The inability to rectify problem outlets also incurred repeated consumption of costly chemicals alongside the significant burden on FM time. Often, and the last resort action, the PA problem would only be eliminated with complete hardware replacement - a costly and disruptive exercise for all concerned.

Scale of the problem

The sampling regime at the Trust highlighted that the PA problem was an issue of retrograde contamination, rather than a systemic problem; post - flush water sampling did not culture PA.

Summarising the data and trends, James noted a PA positivity rate of 3-4%, across all outlets. A small incidence, perhaps, yet **on average** each positive outlet (taps and shower fittings), would be out-of-commission for 6 months, consume six 30-day POU microfilters (changed to 92-day filters in 2021) and undergo repeated treatments with Sodium Hypochlorite (NaClO) - average 6 per outlet. Finally, the WSG would concede that the outlet was unrecoverably contaminated and the only option deemed available would be for its complete replacement – supply pipework, clinical handwashing tap or shower fitting. The cost burden of this approach is substantial - not only in terms of the cost of the consumable chemicals leading up to its replacement, but also the new hardware costs, and the considerable amount of FM time lost. In fact, James surmised, it's just not sustainable.

It was time for the Horne ILTDU to prove itself again - solve the PA problem, reduce operational expenditure and, crucially, improve patient safety.

Trial of the ILTDU

In November 2020, a persistently contaminated boxed shower valve identified for complete replacement - pipework, thermostatic mixing valve, strainers, head & hose - was selected for the ILDTU trial installation. This was a typical PA positive outlet; the shower valve had recorded PA positive results for approximately 8 months, and had undergone 6 unsuccessful NaClO treatments. The local hot water supply serving it was confirmed as able to deliver water at an appropriate temperature (>60C) and thus could facilitate effective local thermal disinfection.

Installation

Prior to installation, and as per the existing SOP instructions for hardware replacement, the ILTDU, all tools and other components were sanitised with NaClO for one hour, then rinsed in filtered water.

Once installed, the downstream shower's standard function and performance was verified, and the water supplies checked for flow and temperature suitability.

Thermal Disinfection

Using the bespoke operating key with large red warning sign, the ILTDU was transferred from Passive Mode into Disinfecting Mode, Figure 3, and the outlet opened.

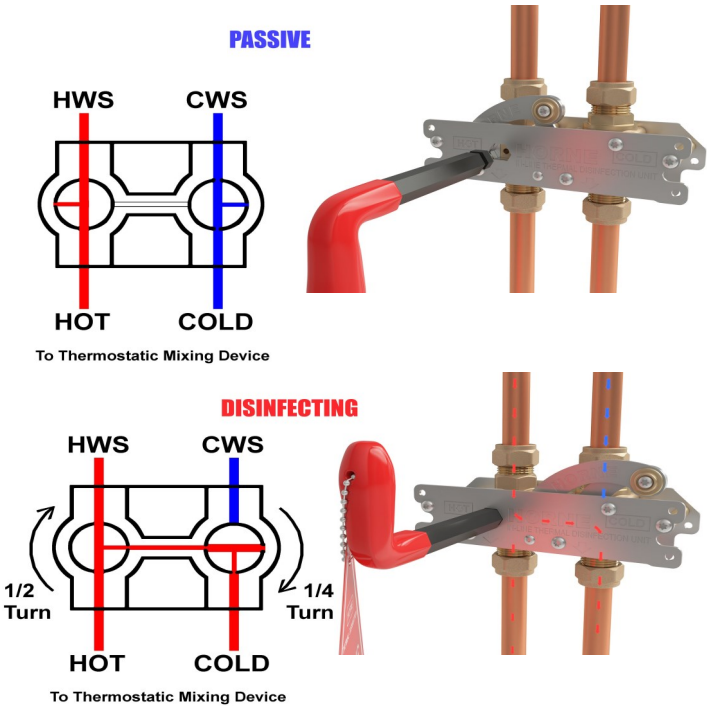

Figure 3. Operating principal of the Horne ILTDU, which utilises two 3-way ball valves and 4-way link mechanism to transfer from Passive mode to Disinfecting mode, and redirect system temperature hot water down the cold supply pipework.

The temperature of water discharging at the outlet was recorded (64°C recorded, >60°C recommended by Horne) and the shower allowed to run for a full 10 minutes, also as recommended from Spinks, 2006, PA Thermal Inactivation Curve, Figure 4.

After returning the ILTDU to Passive mode, cold water was run through the shower to return its surface to a safe temperature (41°C).

At 3 days following thermal disinfection, pre- and post- flush samples were collected and sent for lab analysis.

Lab Results

Much to the surprise of the WSG, and for the first time in many months, the shower outlet finally returned a negative test result for PA. It did so again, after the SOP prescribed 2 week interval, and again after a further 4 weeks.

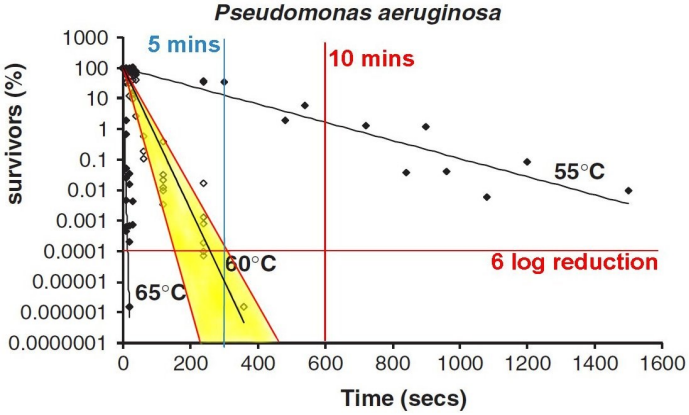

Figure 4. Annotated thermal inactivation curve for Pseudomonas Aeruginosa from Spinks, A.T., Dunstan, R.H., Harrison, T., Coombes, P., Kuczera, G., 2006. Thermal inactivation of water-borne pathogenic and indicator bacteria at sub-boiling temperatures. Water Research 40, 1326-32.

Now considered PA free, the shower was returned to normal service and follow-up sampling rescheduled for 6 months' time.

The ILTDU had proven itself 100% effective, in a single operation, and allowed a ***persistently contaminated****, and marked for replacement, shower outlet to return to full service.*

Since that initial ILTDU trial, other problematic shower and tap outlets have also reverted back to PA negative after a single thermal disinfection treatment. James is now convinced the method is fully validated, having also witnessed a shower passing '*golden coloured water*' during the thermal disinfection. This he attributes to the biofilm being '*cooked off*' the internal pipe walls. He has never noted this during any chemical disinfection.

How do the costs stack up?

Let's reiterate the statistics that James provided earlier from his review of 3 years of collected sampling data: On average, each PA positive outlet will consume 2 No. 92-day point of use filters, undergo 6 rounds of NaClO treatment, and could also need to be replaced in its entirety. The number of water samples taken for analysis could be as many as 20. The outlet chosen for the trial, therefore, was a fairly typical example.

Table 1 provides a cost comparison to return a long-term 'problem' outlet to PA negative through a *single cycle*, either with (eventual) hardware replacement or ILTDU installation and thermal disinfection. These costs assume the outlet returns to PA negative after replacement of the hardware. In reality, further costs; sampling, analysis (as per SOP) and re-treatment would be anticipated at some stage in the remaining lifespan of the new installation. It is worth noting that, once installed, the ILTDU can be operated at any time, over and over again, to quickly reset a PA positive result to zero, without disturbing the building fabric, or diminishing the availability of the shower or handwash station.

	Chemical Disinfection (NaClO)	**Thermal Disinfection**
POU filter (hardware) cost	**£140** (2 No. 90-day)	**£70** (1 No. 90-day)
Water Sampling Cost (labour)	**£30.83** (10 x 5* mins x £37ph)	**£12.33** (4 x 5* mins x £37ph)
Water sampling analysis cost	**£220** (10 @ £22 each) 7 +ve, 3 –ve	**£88** (4 @ £22 each) 1 +ve, 3 –ve
Chem Treatment costs (labour)	**£222** (6 x 1 hour contact time)	n/a
Chem Treatment cost (consumables)	6 units NaClO (cost unknown)	n/a
Test strips	24 No. (cost unknown) 6 x 4 per disinfection (every 15 minutes)	n/a
Post Chem Neutralise costs	6 units Sodium thiosulphate $Na_2S_2O_3$ **£64.75** (6 x 15 mins)	n/a
Pre-hardware installation chemical disinfection (tools & components)	**£43.17** (10 mins prep & 1 hour contact time) 1 unit NaClO	**£43.17** (10 mins prep & 1 hour contact time) 1 unit NaClO
Test strips	4	4
Neutralise	**£9.25** Labour (15 mins) POU filtered water	**£9.25** Labour (15 mins) POU filtered water
Replacement Hardware costs	**~£800**	**£160** (ILTDU & check valves)
Replacement Hardware install labour cost	**£74** (average 2 hours*)	**£55.50** 1.5 hours (one-time cost)
Thermal disinfection	n/a	**£9.25** labour (15 mins: 5 mins prep, 10 mins disinfection) Hot water - optimised flow rate
TOTAL	**£1604** **7 Units NaClO / Na2S2O3**	**£447.50** **1 unit NaClO** **<80 Litres (max flow rate 8 lpm for 10 minutes) 60C water**

Table 1. Cost comparison chemical disinfection versus thermal disinfection.
* See Appendix A for supplementary comment on above figures and assumptions made.

Revising the Standard Operating Procedure (SOP)

The ILTDU trial therefore demonstrated significant savings: 92% reduction in Chemicals (units), 70% reduction in FM time and 71% reduction in hardware/consumable/analysis costs. Even at a very simplistic level, every outlet protected by a Horne ILTDU would save in the region of £1000, and its downtime (i.e. time out of service) reduced from many months to a handful of days. Appreciating the effectiveness of the method, the significant time and cost savings, as well as the additional positive implications for patient safety that using the ILDTU brings, James determined that the obvious next step was to update the Trust's HTM 04-01 Standard Operating Procedure; swapping chemical disinfection for thermal disinfection.

The revised SOP was implemented in March 2021 and rolled out across all three Hospitals within the NHS Healthcare Trust.

Limited, at first, to Augmented Care areas, and as per the current HTM 04-01 guidance, when routine 6 monthly sampling and analysis returns a PA positive result at a clinical handwashing tap, or a patient shower, the new SOP instructs for installation of the Horne ILTDU and thermal disinfection to be the default remedial action. The summarised new procedure* follows:

- *92 day point-of-use filter installed*
- *ILTDU installation – valve, tools and other components all pre-sanitised with NaClO*
- *Rinse tools & components in filtered water*
- *Thermal disinfection – 10 minutes at >60C*
- *Resample and analyse*
- *Outlets must return 3 consecutive negative results, at 3 days, 2 weeks, and additional 4 weeks.*
- *Resample in 6 months*
- *Thermally disinfect as required*

James also reviewed other aspects of the SOP. Previously, when an outlet was identified as PA positive, an engineering review of the installation was conducted; identifying and remediating if connected hoses or other non-metal fittings, e.g. outlet flow conditioner, were suitable and approved to UK Water Regulation 4 (non-metallic materials in contact with potable water).

Expanding the Standard Operating Procedure

Extensive reading around the subject has also led James to consider other contributory factors, such as incorrect staff / patient / visitor usage, and poor, or absent cleaning practices. Therefore, with involvement from the WSG, and in addition to the standard Engineering Survey, the revised SOP also includes a Review with clinical, nursing and cleaning staff. This sharing of information and collaborative problem-solving has also strengthened relations between the various parties within the WSG, FM/ Estates and Infection Prevention and Control teams. Case-by-case audits aim to identify what interactions (staff/patient usage or lack of, hand-hygiene and cleaning practices) have perhaps contributed to its contamination. Outputs from this additional collaboration has led to the development of new training materials, for usage and cleaning protocols, leading to better understanding and ownership of the shared responsibility for maintaining the 'health' of the water supply. On occasion, where usage of an outlet has been identified as being particularly low, the multi-disciplinary team have determined that the most appropriate course of action is removal of the water fitting entirely, along with all of its associated supply pipework - cut back to the main distribution pipework to eliminate redundant pipework.

The revised SOP has now been operational across the Trust's 3 hospitals since March 2021. The number of ILTDUs installed is steadily increasing and, with that, the bank of associated sampling results also expands, and this data continues to confirm the effectiveness of local thermal disinfection. Firmly convinced that the ILTDU is a game-changer for the management of PA contamination, James has taken this further - proposing quarterly thermal disinfection treatment at ILTDU covered outlets as part of a PPM, Planned Preventative Maintenance regime. In the case of shower outlets, this is particularly easy to incorporate into the plan, alongside the established programme of quarterly descaling.

Planned Preventative Maintenance

Once installed across the pipework supplies to (any make) thermostatic tap, tmv or shower, it becomes very simple to operate the ILTDU, pre-emptively, and without the need for water testing, as part of a preventative regime (PPM). It may take as little time as 15 minutes per outlet.

Where the installation allows, Horne also recommends regular flushing of the water supplies at high velocity - to shear excess biofilm from the walls of the supply pipework and remove it to drain.

Even in the absence of a PPM regime, however, the savings continue to apply, freeing up operational expenditure and man-hours to attend to other pressing issues elsewhere.

* See Appendix A for detailed comparison between old and new SOP methods.

There is, therefore, scope to ultimately eliminate chemical and POU filter consumable costs. It is also conceivable that water sampling, collection and analysis, costs could also be greatly minimised as the method is ratified.

Wider Benefits abound

James has now had time to observe, and reflect upon, the wider impact of the change from chemical treatment to thermal disinfection. At a time when the NHS, as a whole, is facing exceptional resourcing challenges, James purports that other benefits, beyond freeing up a bit of FM time and budget, have also become apparent.

FM Team benefit:

- There is now a reduced requirement to conduct patient-area risk assessments (RA) for the use of high-potency chemicals. RAs require assessment, validation and authorisation from various agencies. A time-heavy exercise has been removed from the process, and delays for remediating PA contaminated outlets are now much reduced.
- There's a reduced need to store large volumes of chemicals.
- With more time and budget available, attention can return to addressing the maintenance backlog

Healthcare staff benefit:

- handwash stations and patient showers are no longer out of action for months at a time
- Useable Handwash stations are more accessible – increasing compliance with hand hygiene protocols and freeing up time for patients
- Invasive and disruptive 'works' at handwash sinks and showers is much diminished
- Reduction of number or hand wash events taking place under contaminated water, and propagated to patients
- Improved awareness, ownership and stake in minimising contamination through collaboration, understanding and training, leading to improved behaviours and practices

The Trust benefit:

There is a reduction in the regular discharge of NaClO and $Na_2S_2O_3$ chemicals into the hospital drainage system (especially without first mechanically cleaning the drain), and out into the wider environment. This demonstrates better environmental responsibility and stewardship whilst also mitigating the evolution of antimicrobial resistance. This too:

- further reduces opportunities for retrograde contamination of the hospital water system by resistant pathogens.
- Significant reduction in expenses from consumable chemicals and capital expenditure
- Reputationally, as patient safety improves and the maintenance backlog can be addressed.

Patients benefit**:**

- All of the above lead to improved health outcomes for patients
- trust in the service, and delivery of healthcare, improves - and amongst the wider public

The **local environment** benefit

- Chemical effluent is reduced, slowing the development of anti-microbial resistance beyond the hospital environment.

The **global environment** benefit:

Reduced reliance on chemicals, which are becoming increasingly expensive, but manufacturing across the globe may also contribute to microbial resistance and to climate change.

Reduced chemical usage helps to reduce heavy shipping and its associated emissions in the global transportation of chemicals.

Conclusions

James reiterates that a better solution was needed and applauds how sustainable the ILTDU solution is. After a one-off, and relatively low-cost installation, thermal disinfection can be conducted quickly and simply, time and time again, and with minimal disruption to the building fabric or to the delivery of healthcare, thus ensuring on-going and enhanced patient safety. Actually, because the ILTDU can be used time and time again, these cost savings continue to increase over the extended lifetime of its operation. It should also be noted that the ILTDU requires no maintenance.

For James, the easy, simple and sustainable solution is (installed) in the ceiling.

"it's so easily used, over and over again, and without significant downtime or disruption – it's uniquely effective and therefore so much more sustainable. Plus, we don't need to *pump our [water] systems full of chemicals that have been shipped half way around the world*'.

Further Reading and Resources:

- Horne ILTDU Brochure (hyperlink)
- Illustrative narrated animation
- A New Approach to Pathogen Control - Background
- ILTDU at St Richard's Hospital, Chichester (Case Study)

APPENDIX A: Notes relating to Table 1 cost comparisons.

1. For simplification, and to make the comparison between disinfection methodologies more meaningful, the 5 minutes time allocations for water sample collection and POU filter fitting give an approximate task duration *after* the FM operative has reached the outlet location. In reality, these tasks could be completed together (doubled up), the number of outlets to be attended may vary – affecting the time required per outlet - and there may also be variance in the time required to travel to different Augmented Care ward areas. James has indicated that the actual time required for each task could be as much as 30 minutes per outlet. All other tasks also assume the task duration from arrival at the relevant outlet fitting. These factors will vary from Hospital to Hospital and are worth considering separately when forecasting expected costs at a new hospital site.
2. Volume per chemical disinfection (NaClO and $Na_2S_2O_3$) will vary depending on the type of outlet being disinfected so referred to as a Unit for simplicity.
3. Hardware installation cost averaged: for shower replacement expected time duration is 3 hours, but only 1 hour for clinical tap and pipework replacement.

APPENDIX B: Comparison of Old and New SOP methods

Standard operating Procedure (with NaClO treatment)	**New SOP (with local thermal disinfection)**
Outlets returning positive PA pre-flush (confirming retrograde contamination) results treated as follows	Outlets returning positive PA pre-flush (confirming retrograde contamination) results treated as follows
Post flush water sample collected to confirm local retrograde contamination	Post flush water sample collected to confirm local retrograde contamination
92 day point-of-use filter installed (changed, if necessary, at 90 days)	92 day point-of-use filter installed
Daily 'Duty Flush' instigated	Daily 'Duty Flush' instigated
Engineering Survey: Investigate any contributing factors for adverse results and remediate (e.g. Flexible Hoses, aerating outlet fittings, temperature control, etc.)	Engineering Survey: Investigate any contributing factors for adverse results and remediate (e.g. Flexible Hoses, aerating outlet fittings, temperature control, etc.)
	WSG to review outlet usage, including consultation with IPC, Soft FM and clinical teams.
Re-sample pre- and post-flush (POU Filter Removed for sampling).	Re-sample pre- and post-flush (POU Filter Removed for sampling).
Sodium Hypochlorite, NaClO, treatment • 50ppm NaClO • Tap/shower outlets stripped to component level – Dip disinfection, submerge in a chlorine bath in a dedicated plant room then wash with POU Filtered water.	**One-time only** ILTDU installation - valve, tools and other components all pre-sanitised with 50 ppm NaClO then rinsed with filtered water ahead of installation.
• Pipework treatment: isolate, pump through until purged at outlet. Close outlet • 1 hour contact time, with chlorine levels checked every 15 minutes (chlorine strips) • Neutralised with Sodium Thiosulphate and purged.	*Thermal disinfection.* *>60°C for 10 minutes.*
New POU Filter installed, and outlet flushed.	New POU Filter installed, and outlet flushed.
Re-samples arranged, pre– and post-flush	Re-samples arranged, pre-and post-flush
Outlets that continue to return a positive result would be treated again with NaClO, as above. >5 unsuccessful NAClO treatment, then replace outlet and fittings (Tools and hardware disinfected prior to install).	
Re-sample (pre- and post- flush) until 3 *not-detected* results; after 3 days, 2 weeks, and 4 weeks.	Re-sample (pre- and post- flush) until 3 *not-detected* results; after 3 days, 2 weeks, and 4 weeks.
Reschedule for routine sampling in 6 month's time.	Reschedule for routine sampling in 6 month's time.