SCOTTISH HOSPITALS INQUIRY

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Hearings Commencing
19 August 2024

Day 44
Friday, 8 November 2024
Mr Andrew Poplett

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10:02

THE CHAIR: Good morning. Good morning, Mr Maciver.

MR MACIVER: Morning, Lord.

THE CHAIR: We resume Mr Poplett but with a different topic.

MR MACIVER: We do. Mr Poplett on water today.

THE CHAIR: Good morning, Mr Poplett.

THE WITNESS: Good morning.

THE CHAIR: Now, yesterday you affirmed that you would tell the truth in relation to the evidence you gave yesterday. Can we confirm that that affirmation relates to the evidence you're about to give today?

THE WITNESS: Yes, it does.

THE CHAIR: Thank you. Now, Mr Maciver.

Mr ANDREW POPLETT, Continued
Examined by Mr MACIVER

MR MACIVER: My Lord. Good morning, Mr Poplett.

A Morning.

Q Given you were here yesterday, I don't need to do a long introduction that I would do for most witnesses. Yesterday you were speaking to us about ventilation. Today I'd like to ask you some questions about the water system at the Queen Elizabeth. In that regard, you've submitted two documents to the Inquiry, is that correct? Now, the first of those is your expert report, which should be at page 354 of that bundle. If you go on one page, perhaps. Do you recognise this document, this table of contents?

A I do.

Q Do you adopt this report as your evidence to the Inquiry today?

A I do.

Q Now, largely during the course of today's evidence, I'll be referring you to parts of this document, so it will come up on screen and remain on screen as I think your other reports did yesterday. But sometimes I'll be referring you to one or two other documents and they'll take its place, one of which documents might be the second document that you submitted, which was your response to a Direction 5 questionnaire. Do you recall that?

A I do.

Q If you bring that up on screen, that should be Bundle 21, Volume 6 at page 137, and do you see that page is a letter of instruction to you, and the next page, is this the start of your responses?

A Yes.

Q Do you adopt this as your evidence to the Inquiry (inaudible)?

A I do.

Q Thank you. Now, at the start of proceedings yesterday, there were some questions about your positions and expertise and specifically your-- the extent of your expertise and the limits to that expertise. In terms of this report, if we have the main report in front of us, you introduce yourself beginning at page 358, and 1.1.1 says that you're providing within Appendix 1:

> "… details on qualifications, experience, and knowledge to act as an expert witness in relation to healthcare domestic water systems."

I'll look at that in a moment, but just to continue through this paragraph, you state:

> "[You're] an Authorising Engineer and currently employed as an independent healthcare consultant…"

When you say authorising engineer, is that an authorising engineer in respect of water?

A It is, yes.

Q Are there other matters where you also act as an authorising engineer?

A Yes, ventilation.

Q Continuing that sentence:

> "[Your] role is to provide input/expertise to health facilities in relation to the design review, installation, validation and operational management of water and ventilation systems. As an AE, I act as an independent professional advisor to the healthcare organisation. I've been peer-reviewed and operate now as a registered AE for both water and specialist ventilation systems."

Is that correct?

A Correct.

Q

> **"**The peer review process (by the Institute of Healthcare Engineering and Estate Management) provides a level of assurance that I have been assessed by their peers to work and act in a manner and standard which meets the institute's code of practice and conforms to the requirements of the SHTM.
>
> I have over 35 years' experience of healthcare estates management working in that time as a contract installer, operational engineer and manager (within the NHS) and as an external independent consultant."

That's your authorising engineer position, is that correct?

A Correct.

Q Reference made in that

paragraph to Appendix 1. If we look at page 458 we'll see that. Again, I think you covered this yesterday, but this is the, in broad terms, trained and qualified as an engineer from '85 to '89, is that correct?

A Yes.

Q Your NHS employment starts in 1992, so the large paragraph on the page, at Newcastle, is that right?

A Yes.

Q You continued with the NHS until 2009 at Northumberland, and since then you have been an independent consultant with your own company, I presume, Andrew Poplett Enterprises.

A Correct.

Q Can I just ask you one thing about that? During that time at the NHS, were you engaged in water matters?

A Yes.

Q Was that throughout or for periods within those 17 years?

A It was throughout that period, at different levels and different roles. I was a responsible person for water during my time at Newcastle General Hospital, and as the-- at Northgate & Prudhoe and Northumberland, Tyne & Wear, I was engaged as a senior operational manager overseeing water issues and a member of the Water Safety Group for both organisations.

Q Thank you. To finish this off, to the next page, the very top of it records some memberships of professional bodies. I suppose this is-- some of which are water appointments, some of which are ventilation, is that right?

A Correct.

Q Which of those ones mentioned here are the water appointments?

A Specifically, it would be a member of the water technical platform of IHEEM.

Q Thank you. The other side of the coin to the expertise question is limits to your expertise. A couple of matters I'll put to you and you can tell me whether you consider your expertise does or doesn't extend to those matters. The first one is clinical expertise or experience. Would you consider yourself to have any expertise in that domain?

A I am certainly not a clinician and would never claim to be so. However, over the 17 years and, indeed, really, full 35 years plus of my career, I've worked in close cooperation with numerous clinical disciplines including some highly specialised clinical areas such as severely immunosuppressed paediatric units, bone marrow transplant, solid organ transplantation and highly contagious infectious diseases.

Q You, yourself, you've not been a doctor?

A No.

Q Would you accept that you don't have expertise in matters around quantification of risk or infection prevention or control?

A Again, I don't have specific qualifications in IPC areas but have advised and continue to advise numerous IPC departments within healthcare organisations and am a member of the Hospital Infection Society, now Healthcare Infection Society, and contribute to a number of their documentation and guidance standards.

Q Thank you. Can we go back to page 358, please? At paragraph 1.1.2, the lower half of the page, you set out the main two questions posed of you. I'll just read them out because they'll form the context of most of what I have to ask you today. Firstly:

> "From the point at which there were patients within the QEH/RHC, were the water systems (including drainage) in an unsafe condition, in the sense that it presented an additional risk of avoidable infection to patients?"

That's the first question, is that right?

A Yes.

Q And the second question:

> "Are the water systems no longer in an unsafe condition in the sense that they now present no additional avoidable risk of infection?"

A Yes.

Q Then one page on, 359, in a number of paragraphs you set out the duties of an expert with regards assisting the Inquiry. No doubt you mentioned these yesterday, but they're matters such as impartiality, independence, not exceeding one's expertise and so on. If you need to take a moment to remind yourself of what you said at this page, please do so, but I'd just like to ask you to confirm that you will continue to adhere to those duties.

A Happy to confirm, sir.

Q Thank you. Moving on now to the very end of the introductory section at page 362, you conclude the introduction by having a section about building overview at 1.5. Can I ask you, did you yourself have the opportunity to visit the hospital?

A I did, yes.

Q So when you give a description, as you do at 1.5.1, of it being "a 1,109-bedded adult hospital and 256-bedded children's hospital with large facilities," these are things you've seen for yourself, is that right?

A It is, yes.

Q I'd like to ask you a little bit

about the size of the hospital. Firstly, how did the size of it strike you when you visited?

A It is a very large facility made up of multiple buildings. It is increasingly common to find very large, centralised hospitals rather than what were more traditionally described as district general hospitals. But the hospital provides a high level of very specialist healthcare facilities, and co-location of those is not unusual, but it is a very large site.

Q What challenges are presented by a very large site such as that?

A With regards to water systems, the larger the system, the more complex it becomes. The water distribution has to be across all areas that require access to water and, equally, waste water systems to take the waste away. The larger the system, the more complex the system, the more challenging it can be to maintain adequate circulation and temperatures, particularly with regards to cold-- hot water and cold water systems through either latent heat gain on the cold water system or temperature loss on a recirculating hot water.

Q Is having a single domestic water system practical for a site that size – or for large sites – or does there come a point where it's no longer practical to run things off a single system?

A There are areas where it is required to have separate, smaller systems where there is a risk of backflow or increased need for backflow protection. So an endoscopy washer suite, as a prime example, will normally have its own dedicated segregated water supply.

If you have renal dialysis, you will want that water tret in a different manner to the general water distribution system and, therefore, it would be common to have it on a segregated water supply system. That system can be served from the primary system or you can break it down into smaller systems.

The most recent published update to HTM 04-01 – and I stress "HTM," not "SHTM," because I don't believe it has yet been adopted within Scotland – is the NHS England Estates Technical Bulletin 2024/03, and that highlights, in certain augmented care and high-risk areas, the benefit that can be considered from smaller dedicated water systems for the control of microbiological pathogens.

Q Okay. What I take from that is that there may be dedicated systems with separate needs, or needs additional to or simply separate from the general needs served by a domestic water system, and so there may be good reasons for that to have separate water systems for such units. Is that part of what you were telling

me?

A Yes.

Q My intention was to focus slightly differently on-- simply on sheer size of the system. You mentioned that larger sites mean that the system grows in complexity. Does complexity alone lead to a point where it becomes sensible to not try to run a single integrated domestic water system?

A It is a decision that needs to be taken at the design stage as to whether, a single system, the benefits outweigh the disadvantages. Any single distribution system has an inherent risk of single point of failure, which is that, if everything goes through a single pipe and that pipe bursts, you lose your entire water system. A single system can have a benefit of reduced storage, and reduced numbers of supplementary or subsidiary water storage facilities, and the more water that is stored, that can increase the risk of microbiological proliferation.

Q Now, later in the report, at section 4, perhaps if we simply go there – 397 is the page reference – you touch on what might be the same issue, might be a related issue. Here, at 4.1.3, you're touching on size, certainly, because you're noting the extensive provision of items such as handwash basins, and you say that that would, today, be considered potentially excessive. I wonder, could you tell us about that a little bit? Firstly, is that part of the function of the size questions that I posed to you a moment ago, or is this a separate but related issue that you have in mind?

A It's certainly a related issue. The very fundamental basic four principles of a domestic water system is, "Keep the hot water hot, keep the cold water cold, keep it all clean and keep it moving." Part of the "moving" is to have, in practical terms, as fewer outlets as possible as heavily used as possible, so we are looking to not have underused or little used outlets wherever possible because, if water is not moving and being, on the hot water side, recirculated and reheated, or, on the cold water side, it relies on usage to draw through, then there elevates the risk of temperature gain on the cold water or loss of temperature on the hot, and that can lead to conditions which will promote and support microbiological growth.

Q We know that, at the Queen Elizabeth, the general design philosophy was in favour of single-bed rooms. Is that an unusual approach, in your experience?

A No. Single-bed rooms have many advantages, particularly for patient experience. People will prefer to be in a single room rather than an open ward, in

general terms. It also improves the risk, or reduces the risk, of airborne transmission in terms of infection.

The downside is that it means that you normally need a greater number of nursing staff to monitor/undertake clinical observations. And, in many cases, single-bed rooms end up with the doors being wedged open just because it's easier to keep an eye and respond to patient need by nursing and clinical staff. But generally speaking, the NHS has moved towards single-bed rooms as opposed to the previous Nightingale open-ward design.

Q From the specific perspective of a water system, however, having 1,109 bedrooms as opposed to X number of wards, what are the implications for that upon number of outlets and operation of the water system?

A With each single bedroom, generally all having a dedicated en suite, you end up with one patient using those facilities if they are capable of using those facilities for their own needs. The result is that you get a far reduced flow rate or usage through those individual en suites.

If you had a 30-bedded Nightingale ward with one toilet block at the end of the ward, as the traditional design is, you had 30 people using one block of toilets, wash hand basins and showers. It got far more intensively used and therefore had a greater turnover of water.

Q Does it add at all to the complexity of the system in terms of pipework and so on?

A It does.

Q Consequences for maintenance?

A Again, if you've got to-- multiple thermostatic mixing valves on every whole-body submersion area or handwash basin, they have to be subject to maintenance every six months and every-- three times through stabilisation for changing, and then six monthly after that. All of those need physical access and maintenance.

The temperature monitoring, if it's not done through the building management system, involves a lot more people going around taking a lot more water temperatures and, indeed, where water sampling is undertaken, an awful lot more expense in terms of sampling.

Q Are there any other factors that you might wish to make us aware of that are important when it comes to having designed the hospital in the way it was: large number of beds plus single-occupancy bedrooms?

A The biggest challenge with any large, complex water system is getting it so it can be appropriately validated and balanced so we get the right water flow rates and a consistent movement of

water. In hot water systems, this frequently ends up in-- rather than just a primary hot water recirculating system, you end up with secondary and sometimes tertiary loops from the water systems, which can affect the temperature profile of the overall water system and can be difficult to balance effectively to make sure that all of the far extremities get adequate flow through to maintain temperature.

Q You mentioned a couple of times there an idea that I was going to come onto later, but I may as well tackle it now. It's the idea of system balancing. Can you tell us about that, please?

A Water, like anything else, takes the path of least resistance. Within a circulating system, it's important that we can achieve suitable water flow through all branches and elements of the system. Water will, as I say, take the path of least resistance, so where you come to a branch or T-piece, if it's from a larger-bore pipe, it will continue-- it will want to continue traveling down that rather than going down a small side street. Imagine it a motorway network versus B roads and C roads.

You use commissioning valves or double regulating valves or thermostatic mixing regulating valves to assist in terms of increasing the system resistance within the pipe to force the water down the prescribed route to, ultimately, what is described as the "index run" of a circuit, which is the furthest or most resistant leg of the pipework distribution system.

Q Does this speak to something inherent to the complexity of a water system in terms of, if it requires to be balanced, then that suggests that, no matter how good a job you do in the design phase, you can't necessarily know how it's going to operate in practice? For example, just where the water is going to go.

A The pipe sizing, i.e. the distribution pipework, is sized so based on demand requirements, but there are only a relatively few number of pipework sizes. So you've got to then do, if you like, fine-tuning of those smaller-diameter pipes to achieve ultimate balance and flow around the system.

Q You mentioned that valves might be part of the way of doing that. How does that work?

A A valve-- Valves have various functions depending upon their classification. They can be simple isolation valves, which are used to turn the water off and stop it going in one direction in totality, or you can have double regulating or commissioning valve sets, which are used to partially restrict the flow to increase the system resistance to promote the water flow at

the desired volume or flow rate throughout the system.

Q That whole process of balancing, is that part of the validation process?

A It's part of the commissioning process that is then confirmed through a validation process.

Q Thank you. I may or may not return to that point later on. But for now, sticking broadly to the scheme of your report, if we move back to section 3, which is at page 370, you begin-- here's your overview of the healthcare water system section.

You begin here by giving us an overview of something you've alluded to already, which is the key components of the NHS standard for water system management by reference to HTM 04-01. Now, firstly, I think we're all familiar with this by this point, but that's the English standard whereas the Scottish standard is the SHTM 04-01, is that correct?

A Correct.

Q How different are the two?

A When it comes to water, the content is broadly the same, but the structure of the documents are very different. The HTM, the English version, concentrates everything into three documents. The SHTM is broken down into far more detailed sections and a greater number of documents, albeit that its content is broadly similar.

Q Now, one difference that you do allude to in the report is the question of filtration, and that's a few pages further on at 376, section 3.5. At 3.51 here, you are setting out what's in the HTM, the English standard. This, I think, is a quote from 7.2 of Part A:

> "In exceptional circumstances, additional on-site filtration may be required as part of a multi-barrier point-of-entry treatment system. Advice should be sought from an appropriate undertaker on the need and form of such treatment."

Firstly, point-of-entry treatment system, what's that? Where does that occur?

A It is referring to the incoming water supply from the water authority.

Q So that's the mains input into the system?

A Yes.

Q 3.5.2 is different in that it's dealing with point-of-use filtration. Is that at the taps?

A It is.

Q In general, am I correct in understanding that the general approach is that there isn't a requirement for such things, but the installation may be done case by case following an individual assessment? Is that right?

A It is correct at the time of writing. It has been slightly amended since the Estates technical bulletin I referred to earlier for significant areas of augmented care, where filtration is now more actively encouraged and, rather than assessing to see if it's needed, there is an assessment to see if it shouldn't be installed as opposed-- So it now more closely mirrors the SHTM approach, which is filtration should be considered and not just discounted on cost basis.

Q Thank you. Setting perhaps that to one side, the specialist units of the augmented care units and the fact that it's very recent, does what you've reproduced here basically reflect an assumption that if you have-- the mains water will be wholesome and that will be good enough?

A Correct.

Q The Scottish approach, as I said, is different. At 3.6 – yes, just over the page – is where you set out a quote from Part A of the SHTM. 3.6.1:

> "5.4 On-site filtration has been regarded by some as an optional provision despite its inclusion being mandatory since 1999. It is stressed that opting out of installing such plant should not be the default situation. Any decision to exclude filtration would be dependent on careful consideration of the following issues [and you present five of those in bullets there]."

So, in Scotland, the default is to have filtration, is that right?

A Yes.

Q What's required is a risk assessment before opting out. Can you explain the difference? Presumably both jurisdictions have wholesome water in the main taps. Why should Scotland be different from England?

A I can't comment on what the logic was at the time when the two documents were written or the thought process. What I would say is that it should always be subject to an assessment. The inference is that in Scotland it should be, "Fit it unless you can justify not." In England, up until the end of August, it was, "Presume that it's not needed unless you can identify a specific reason why it is."

Q One of the points that you mention there, the last of the bullets, is that one needs to analyse samples of incoming water supplies. In the next paragraph, you say:

> "The last issue is particularly important. In existing premises, an examination of maintenance records would determine whether strainers were routinely becoming clogged as an

indicator of a history of suspended solids being present in the water authority's incoming supplies."

What are strainers? Are they different from filtration?

A No. A strainer is a type of filtration. Typically, it is a single-skinned, perforated metal plate or similar basket and designed to catch larger elements, whereas a filter can be multi-layered and slightly different construction. The best analogy I could probably draw is a strainer is a colander, whereas a filter is a sieve, in very, very crude terms. It's about the level of particles that they are designed to capture.

Q Okay, well, if we stick with that analogy, then if a strainer is like a colander – i.e. a single sheet with holes in it, something that looks a bit like that – whereas a sieve is a different type thing-- That's an interaction of layers or particular fibres, and you say that's what filtration is like. How does it work in terms of filtering matter to different levels, to different diameters, standards and so on? How is a filter actually put together?

A That is something for a filter specialist to give a detailed response to, but it is made up ostensively of multiple layers of fibres and it relies on a number of elements to capture particles at different stages through the filter. It's not a straightforward grade that it takes out the bricks first and the fine stuff later, but it is made up of multiple layers to ensure the efficiency of the filter to capture all particles that it's designed to.

Q Thinking again about your analogy of one being a colander, a single sheet with holes in it, and whatever can make its way through the holes can get through, a filter's not like that? A filter depends upon multiple layers or a more difficult path?

A In essence, yes. Again, filtration is something that-- you get different kinds of filters. If you have a hydrotherapy pool or swimming pool, you use a graded sand filter. So it is particle-- the water passes through a depth of very fine particles which capture other particles on the way through. So it gets into a very complex and scientific area in terms of design standards, but the basic principles are, it is designed to capture and remove particles of a given size at a given efficiency rate.

Q Over the page at section 3.7, there's some discussion of standards of filtration mentioned in the SHTM. Again, as you say, a complex matter. I don't, perhaps, need to go into this in very much detail, but at 3.7.3 you are giving some units that might help. So this is still a quote from Part E of the SHTM, but you're saying:

"To help achieve the above and minimise the formation of bio-films in pipework, the following guidelines should be followed in selecting appropriate levels…"

The first bullet relates to thermoplastics pipework and here we've got a cut-off of 5 microns. Does that presumably mean that, for that type of filter, things that are below 5 microns can get through but above 5 microns can't?

A Potentially, yes.

Q If we go over the page, stainless steel has a different cut-off here:

"[0.5 microns] can be relaxed to 5 microns on receipt of written guarantees from the pipework…"

Then, in the third bullet, again, 0.5 microns, but that's in relation to copper pipework. Can you tell us why these are different? Why would plastic pipework be working to a different level of filtration from metal pipework?

A The full technical reason I'm not au fait with. However, it is likely to result from the particles that can be shed or come from the pipework in use and the type of material used in the pipe-- in how the water is being-- what the water is being used for.

Q So this is in relation to things that might be shed from the pipe, the fabric of the pipe itself?

A Correct.

THE CHAIR: This is probably the very obvious, Mr Poplett, but the expression "maximum cut-off," do I take it-- Well, if we take the example of maximum cut-off of 5 microns, is that that no particle which is larger – have I got it the right way round? Yes – than 5 microns should be able to go through the filter?

A Correct.

THE CHAIR: Right. Thank you.

MR MACIVER: On the next page, at 3.7.8, you're taking a different source here. You're quoting from one of the employer's requirements:

"The Invitation to Participate in Competitive Dialogue [is saying that the] board requirements for potable water [are] to have 0.2 micron filtration…"

It's referring to SHTM criteria and you note that the specification of 0.2 micron-grade filtration is in excess of the guidance standard of 0.5 microns, and then:

"However, the original filter media pore size was specified and installed to a 0.02 micron size, which may have impacted the available flow rate of the incoming water supply."

The first question is, why might the numbers here be different? Again, why

might one go below-- If the SHTM standards are 0.5 microns for steel pipe, which we know was in the hospital, why would one wish to have 0.2 micron or, indeed, 0.02 micron size filtration?

A That is a question which I'm not in a position to answer. It was presumably a conscious decision by the design team and Health Board to go for that level of filtration.

Q Have you come across that level of filtration in your other hospital work?

A Not in general water supply scenarios, no.

Q If it's not in general supply, might some of the specialist supplies that we were talking about earlier require such tight filtration?

A It may be more appropriate in some of the more specialist supplies, but, again, in my experience, it would be very unusual to go down to 0.02 micron.

Q Given the picture, the mental picture, that we have now of a kind of tightening, squeezing net of-- as the filtration gets narrower, does it follow that there would be-- having filtration of that size would create implications for water flow?

A It could well have implications for water flow, although the filter should be sized not only based on grade of filtration but also desired flow rate. But it would almost certainly have an impact on the energy required to draw or force the water through the filter.

Q Just to do away on both those points, you talk about size of the filter. Is that physically? Is it as simple as being the physical size of it? If you make the filter-- the pore size smaller, then you can get around that by expanding the diameter?

A Yes, of the filter.

Q Thereby maintaining the same flow but through a much wider area. Consequences for energy, can you tell us a little bit about that, please?

A If you're going to-- The water comes in at a mains pressure rate. If that is fixed by the supply authority, then there is going to be a reduction in flow rate. To counter that, you could use a booster pump, but a booster pump will need to run to draw the water through the filter and maintain an increased flow rate.

Q Thank you. Now, we've discussed the differences between SHTM and HTM. A few pages further on, at 384, you touch on the perhaps thorny question of the precise status. It's probably not the time or place to try and solve that question, but I am interested in the question-- in the idea of how mandatory they might or might not be. You make some observations, three pages further on at 387, about

derogations. Here, you are discussing the language in terms of modal verbs, and that they give examples of, I think, when derogations might or might not be contemplated at all. Would that be right?

A Correct.

Q Going back one page to 3.12, here is when you're giving examples of when delegations should be considered:

> "Typically, there are many reasons cited to derogate from elements of even entire HTMs or HPNs, including but not limited to refurbishment, room allocation, costs, scope of project, [and over the page] omission of compliance issues at business case, or [the last one] we haven't done it before or had it agreed on a previous scheme."

The pages after that – and I won't take you through those – go on to provide a fairly detailed account of expected practice when it comes to actually taking a decision. I'm not going to ask you about expected practice, but I'm interested in your impression of what practice might or might not have been at Queen Elizabeth when it comes to considering derogations.

So if we move on to page 394, you have a section here that's marked "Assessment of Derogation Management at QEUH," and to summarise my reading of this, you've reached the view that there appeared to be a not-as-full-as-it-could-be process and that there was limited evidence of any managed or confirmed derogations.

You make reference there to one derogation that's recorded relating to air changes. Then the last two bullets relate to two water issues: wet testing and flexible hoses. Firstly, am I correct that your general view is that derogation management was not as it could have been?

A Correct.

Q What led you to that view?

A The lack of evidence that any process was consistently applied where standards were deviated from.

Q What would you have expected to find, had derogations been properly managed?

A There is no national or centralised guidance per se for the management of derogation, as discussed yesterday. The section within the report relating to derogations is the world according to Poplett, not necessarily the world according to everyone else, and I accept and acknowledge that.

But a process as laid out is what I would normally expect a good, robust derogation process to be based around: assessment of risk and consequence, and making sure that the ultimate decision-maker is able to sign off or

agree – or, indeed, reject – any derogation based on an informed position.

Q Is recording key to all of this?

A Absolutely critical.

Q Now, if we go back now to the overview section at page 370, you began with talking about standards. Then, at 3.1.2, you're noting that-- which, I suppose, is the essential purpose of HTM and SHTM:

"It draws together guidance and includes recommendations for the safe management of water systems…"

3.1.3 covers the first thing you mentioned, the Water Safety Group. I wonder if you can summarise what the formation or rather the-- What should a Water Safety Group consist of?

A A Water Safety Group should be a multidisciplinary team representing all stakeholders and act as a means of providing assurance to the organisation that the water systems are under appropriate control and operation.

It should also act as a focal point when things go out of specification or aren't in line. It should coordinate and review what actions to take and when to take them and to what extent and how they should continue until a resolution has been achieved and the systems are back within normal specification.

And finally, they should review any proposed modification, alteration or adaptation of the water system to ensure that all elements have been considered and the system remains safe and in compliance to the principal elements of the water safety plan, which also incorporates the water risk assessments.

Q Thank you, and in terms of who should comprise the Water Safety Group, you've got two bullets at the bottom of the page, that you say:

"... [would] typically include:

- Director/Head of Estates
- Estates Responsible Person (Water)
- Consultant Microbiologist, Infection Prevention and Control Doctor
- Head of Infection Prevention and Control
- Facility Services Manager
- Authorising Engineer [for] Water
- Other key representatives may be co-opted onto this committee as and when required."

Is it fair to say that that's fairly high-level participation that you're looking for?

A It is a combination of both high-level individuals with the necessary expertise and decision-making authority, but also operational level, who actually can report what is going on and what is progressing with any area.

Q Now, we know that there was a Board Water Safety Group for the Queen Elizabeth. Do you know if there are also other Water Safety Groups covering other specific sectors in the Greater Glasgow and Clyde area?

A I don't know.

Q In terms of your experience of Water Safety Groups, what degree of commitment do these typically require of those who participate in them?

A In terms of commitment----

Q In terms of time and in terms of occurrence----

A Oh, right.

Q -- and so on.

A You would typically expect a Water Safety Group to meet on at least a quarterly basis. Depending upon the size and complexity of a site or trust, you are probably talking about a couple of hours. If you have large capital projects or works progressing, then that can be extended or it can be done as a subgroup of the principal Water Safety Group.

And in a number of organisations which I support, because of the geographic nature and size, if you've got multiple hospitals within a healthcare organisation, it is not unusual to have an operational Water Safety Group based at a site level which then will send reports and representation to a strategic Water Safety Group, which will deal with policy and decision-making.

So it can, in a small trust, be a couple of hours four times a year. In a complex hospital with multiple Water Safety Groups in multiple sites, it can be replicated to increase that level, but broadly terms, it's four times a year for a couple of hours.

Q Thank you. Are these popular bodies to be part of, in your experience?

A From an engineering perspective, in many organisations, the Water Safety Group is seen, traditionally, as an Estates function. In the last 10 years, I've seen a significant increase in the level of interest and involvement by IPC. It can still, to this day, be challenging to get clinicians and senior consultants to attend because they do not necessarily see it as their issue to manage. They just want the water systems to work and be safe.

Q Are you in a position to say whether that was an issue which arose at Queen Elizabeth?

A I'm not.

Q (Inaudible), we did get an account from one of the witnesses, Mr Walsh, regarding his participation in the Board, and he was, for the initial period, the co-chair. His position was-- I'll just summarise. He was an infection control manager. Firstly, was that a suitable level of appointment that you'd expect to

see upon a Water Safety Group?

A I would normally expect that the chair of the Water Safety Group would be at a director level.

Q He went on to say that his involvement was, I think, relatively short term. He demitted from the Group and, in terms of representation of infection control on the Group, was replaced by an IC doctor and an IC nurse. Does that raise any concern with you as regard to level of participation?

A No. I think, given the size and complexity of the site, it may have been appropriate to have multiple representation, but if you've got a consultant microbiologist and an IPC nurse, then they will have the required level of knowledge of infection risk.

Q The final point that I noted from his evidence touches on a matter that we'll come on to separately, shortly, anyway.

THE CHAIR: Sorry, I wonder if I could intervene. Now----

MR MACIVER: Yes.

THE CHAIR: -- I just wonder if I've understood your answers. You're being asked about the membership of Water Safety Groups. Now, Water Safety Groups are a thing which is described and required not only by HTM 04-01 but also by SHTM 04-01. So if the starting position as to understand what it is is to look at the guidance, you're being asked about the appropriate choice of chair. Now, would I be right in thinking that the guidance doesn't deal with who should chair the Group?

A Correct.

THE CHAIR: Although I think it may point to who should be the members of the Group?

A Correct.

THE CHAIR: Right. Now, I've noted an answer when you said you would expect the chair to be at director level. Now, I take it that's you drawing from your experience elsewhere?

A It is.

THE CHAIR: Right. Final question. I'm not sure if I can square-- because I take it, director level, you have in mind on the Board of the Trust in England or the Health Board in Scotland?

A Yes, not necessarily an executive director, but certainly associate director or similar.

THE CHAIR: Right. Now, does that square with the answer that you gave that you have no concern if the chair is an infection control doctor and/or an infection control nurse? My problem there is I wouldn't necessarily see any infection control doctor or nurse necessarily to be a board member, so can you just help me with what I see as a sort of conflict there?

A My understanding was that the two individuals replaced the deputy chair, not the chair.

THE CHAIR: Right.

A So the DIPC, the director of Infection Prevention and Control, I would assume, and perhaps wrongly, should have been the chair of the Water Safety Group or the director of Estates, with the deputy chair being consultant microbiologist, infection prevention doctor or lead IPC nurse.

MR MACIVER: I may inadvertently have introduced a lot of confusion in my questions if it didn't come across clearly. The reference I had in mind was to Mr Walsh's role representing infection control on the Group as having been replaced by a combination of the infection control doctor and Infection Prevention and Control nurse.

But that's not necessarily, and I'm not in a position, I'm afraid, to fill in as to whether his role as co-chair of the Group was also inherited by those two. I'm drawing a distinction between his representation by his presence as representative of infection control and his presence in the role of acting as co-chair.

THE CHAIR: Right.

A Could I also just clarify or add that, subject to the very recently published Estates Technical Bulletin, there's now further clarification on that when it comes to project-specific Water Safety Groups that they must be chaired by a director level. So it's not in the current versions of HTM or SHTM, but in the latest supplementary guidance note it has added further clarification to that point.

THE CHAIR: For England?

A For England.

THE CHAIR: Right.

MR MACIVER: Third, final point that I'll just allude to from Mr Walsh's evidence touches on a point I was going to come on to separately, but he'd spoken to not accepting it was his responsibility when on the Board to have noticed that there'd been a specific failing, which was the failure to have appointed a designated person for water on the basis that that particular appointment failed to be made by the Estates and Facilities team. Can you comment upon that understanding of responsibility? Does that strike you as correct?

A The duty holder should either accept or fulfil the role of the designated person or, more commonly, delegate that to an identified designated person at Board level to hold accountability and responsibility for the management of, in this case, the water systems.

The designated person is the individual within the organisation who

appoints the authorising engineer, who the authorising engineer ultimately reports to and is also responsible for the appointment of any authorised persons within that engineering discipline, in this case, water.

Q Well, perhaps to put the question more broadly, that may be who has the job of making those appointments, but if the Water Safety Group is not noticing that those appointments have not been made, is that an issue?

A Yes.

Q On the same page, you talk about the second institutional document that you mentioned. It's the Water Safety Plan. At 3.1.4, you're introducing that, and at 3.1.5, you describe its contents:

> "… a series of modules which provide guidance and procedures for effective management of hospital water systems… typically [consisting] of the following modules [in the bullet list there]."

If we look at those, we see that second and third are "Legionella prevention" and "Pseudomonas prevention." There are other entries related to water sampling, disinfection and so on. So in terms of specific pathogens, the focus here seems to be on Legionella and on Pseudomonas, is that correct?

A Correct.

Q Now, we've heard material, and you may be aware of the fact that at QH there were other pathogens, other microorganisms also identified – Cupriavidus, for example. Does that suggest that a more comprehensive plan would be acquired for the Queen Elizabeth given that there was a history of other gram-negative bacteria and atypical Mycobacteria?

A It may well do. It should be part of the risk assessment process in developing the water safety plan for the Water Safety Group to agree the level, range and nature of any water sampling that is undertaken.

Q You've spoken a few times about the development of standards over the years. In terms of water safety plan, is that standard developing such as to make this more likely, or is the general requirement to risk assess what is required a suitable catch-all for determining what should go in a water safety plan?

A The water safety plan is a collection of documents and it draws a number of strands together. There is a requirement for a water risk assessment. That water risk assessment has within it prescribed content, but you also have water management policies, operational

procedures, sampling plans, etc., so the water safety plan is intended as the umbrella catch-all for all things water. So in terms of-- It is not necessarily a single document as such because, as I say, it's made up of multiple elements up to and including maintenance records, but it is, I believe, intended to widen the remit of the management of water beyond that of simply an Estates function.

Q A third document that we have heard about on a number of occasions but isn't mentioned in this page is a written scheme. Can you give me a summary of what that is and how it fits into these Water Safety Group, water safety plan, if at all it was mentioned?

A A written scheme is an element of the water risk assessment that, in its simplest terms, describes the elements that make up the water system. It should also include what levels of control or management are involved. It should also form part of the risk assessment process in that you've got to know what you've got and how you're using it and what the relevant risks are to then establish an appropriate management approach.

Q Thank you. One page further on, at 372, you move on to the next section, which is about control measures. At 3.2.1, you set out a list of temperatures. I wonder if you can just talk us through this works. These are, as I understand it, the Legionella temperatures. Can you illustrate what you're explaining to us here?

A Yes. In simple engineering terms, Legionella bacteria, as an organism, is dormant if the water temperature is below 20 degrees centigrade, so it will not die but it will not multiply. As the temperature increases, its ability to multiply increases to its optimum temperature of 37 degrees, which is also commonly known as body temperature.

At 37 degrees, a Legionella bacteria will multiply approximately every 15 minutes, but the organism or the bacteria itself probably has a typical life expectancy of around 72 hours. However, after 72 hours of exponential growth every 15 minutes, the level of colonisation is highly significant, so it grows very, very quickly.

As the temperature continues to increase, the rate of replication decreases and, if you reach 50 degrees centigrade, if you expose the bacteria to a temperature of 50 degrees centigrade, it will die within two hours. If you increase that temperature to 60 degrees, it will be dead within two minutes.

And just because of the iteration, it works at 70 degrees; it will be dead after two seconds. It is practically

instantaneous at that temperature, and that is the fundamental underpinning of why the ethos for water is, if we can keep the cold water cold and the hot water hot, then the control of Legionella as a bacterium is not or shouldn't represent a significant problem.

Q Thank you, that's very helpful. Now, hot water hot, cold water cold, I understand that for Legionella, but it's not quite as simple for Pseudomonas at 3.2.2. Can you tell me about that, please?

A Yes. Pseudomonas aeruginosa is a bacteria that, again, cannot survive in hot water and dies at a slightly lower temperature than that of Legionella but, more worryingly, can multiply at any temperature above half a degree centigrade. So if you sample, for example, ice-making machines or cold water outlets, you can find Pseudomonas aeruginosa in it even though the temperature is below 20 degrees centigrade.

Q That appears to me to invite the question of what one can then do in a cold water system to control for Pseudomonas if it's in there. I note at 3.2.3 you're introducing the idea of chemical treatments, biocides, and you say:

> "Filtration is principally used for Pseudomonas aeruginosa on cold water systems with temperature control cannot be practically used."

I wonder if you can square that for me. If it can proliferate above half a degree-- Presumably cold water systems are in the range below 20, but certainly above half degree?

A Yes.

Q How does one control for Pseudomonas, bearing in mind what we said at the start about filtration not being a necessary component of water system?

A The way that you manage Pseudomonas proliferation is through usage. So where cold water temperature can't be to stifle or minimise multiplication, if the water is regularly turned over, then it ceases to be at a level which represents a significant risk.

In general terms, not exclusively, but pseudomonas colonisation of a water system is from an outlet or a waste water contamination being transferred to a water outlet. It is not generally found within a water system and grows from the incoming supply to the outlet; it grows from the outlet back into the water system.

So regular usage, regular flushing, gets rid of that degree of colonisation in terms of concentration. To clear it if it becomes colonised, then you are looking normally at a chemical disinfection

process.

THE CHAIR: You've been asked specifically about Pseudomonas because I think it's one of the microorganisms in respect of which there is specific guidance, but can one generalise from what you've said? I say "generalise;" the first step would be that not every microorganism will have the same reaction to a specific temperature.

You mentioned Legionella because, again, the guidance is sort of structured specifically by reference, but, having taken that step, would it be, generally speaking, true of microorganisms that not all will be controlled by a water system which keeps within the Legionella parameters? In other words, cold below 20, hot above 55, so they won't all be controlled.

However, as a matter of generality, would it be true to say that regular flushing and throughput of a system should sufficiently reduce the concentration of other microorganisms? Or, alternatively, is it not possible to make a generalisation like that?

A That would be, I would suggest, a question for a microbiologist rather than an engineer, but in general terms, I would say that if the system was in regular usage, the temperatures were controlled within the parameters set for Legionella, then you will, in general terms, see few problems with Pseudomonas as well, subject to the other external or potential source management: wastewater, cleaning methodologies, contact with outlets, etc.

THE CHAIR: Right, but the question is perhaps outwith your specific expertise? Right, thank you.

MR MACIVER: In passing, I mentioned a different alternative method, chemical treatments. What's your general view on the use of chemical dosing as a means of controlling water supply?

A Personally speaking, I'm not a massive fan. I would rather keep the water systems clean and within temperature range and in regular use. Chemical disinfection, either through continuous dosing arrangements, can be highly effective, but it does not provide any opportunity to relax other temperature controls or flow rates.

It can have impact on lifespan of pipework. If you introduce a chemical such as chlorine dioxide to an existing water system, it can promote the failure of those pipework infrastructure through pin-holing and, in some cases, the scale is the only thing holding the pipe together and if you strip all of that away, then you end up with a sprinkler system, not a water distribution system.

So it is suitable in some aspects. I

personally favour temperature control and usage as a primary means of control unless specialist areas exist where it is needed.

Q We do know that a point came at the Queen Elizabeth where chlorine dioxide was considered to be necessary and was used and has been used since. Any views on that particular method of biocide?

A It can be highly effective and useful. It is expensive to install and manage and it brings with it additional levels of complexity and, again, highlights that the water distribution system has got to be appropriately balanced to make sure that the dosage makes it through to all of the elements of the pipework system at a sufficient and appropriate level of concentration.

There are also some areas where you would not want to use chlorine dioxide-dosed water for certain activities. One of the common areas of concern would be mixing of baby milk formula is-- there is some concern and questions over its appropriateness. But, in general terms, it can be highly effective if appropriately managed.

Q Thank you. Moving on one page, you're bringing together much of what you've told us into the top paragraph there, where you describe design philosophy:

> "... minimise storage, and ensure good throughput and avoid stagnation."

You may have covered this already, but why are those the key points?

A In particular for Legionella, if you can keep the cold water cold, it won't grow. If you can keep it above a certain temperature, it will die, and if it's in regular use and used, you will not get a build-up or concentration of a microorganism and that is true for not only Legionella but other microorganisms. So it's a case of regular usage and, if water stagnates, you also then challenge the effective "keeping the cold water cold and keeping the hot water hot."

Q The last three bullets are dealing with flushing. Can you explain the significance of that, please?

A Flushing is a necessary evil, I would describe it as. Ideally, you want all of the outlets that you have to be in regular use. If you cannot guarantee that they are in regular use, then flushing is used to, in effect, stimulate movement within the water systems. So it is there in place of identified outlets that may be little used but are still required to be there to have water movement through them on a regular basis to avoid or minimise the risk of stagnation.

The issue about recording it is that you need to be able to demonstrate that

you've got a schedule of little-used outlets. That schedule needs to be kept under constant review and management by the Water Safety Group, or through the Water Safety Group, to ensure that as occupation or activity within the premises changes, the flushing schedule may well need to change.

If an area becomes regularly used, it can be taken off the flushing regime, but if an area is taken out of activity or has a reduced activity, then flushing may need to be introduced. So that is basically flushing. It needs to take place for a minimum period of time and an appropriate frequency depending upon the clinical area involved in a hospital.

Q If I attempt to summarise that, we could imagine an ideal water system where there was flow through all of the pipework because that's how the outlets and the inputs were designed such that natural passage of the water would take it everywhere.

A Correct.

Q Flushing is, in effect, an artificial substitute to cover areas where you can't rely on that happening?

A Yes.

Q The importance of recording it is because it's an artificial substitute that one can't rely on normal day-to-day activity for doing that work, so there's no particular way to tell that it's been done, therefore you need to have it written down?

A Correct.

Q Thank you. There's a bold heading halfway down the page where you move on to an overview of the cold water system. It's quite technical. I'm not going to go to very much of this, but over several pages you've set out the journey of the water to the tanks through the filtration units, which we've mentioned, and then through pumps to serve the building.

At 3.4.7 on 374, you've got, again, a technical description of pressure and how this happens. I don't need to ask you about that specifically, but I will tell you about one point that we have heard in evidence – you may be aware of that already – is that, at a point before occupation, there had been a bypass pipe set up which ran from the mains input to some point beyond the booster pumps. Are you aware of that general issue?

A I am.

Q It might actually be useful to look at the entry that records it on the DMA reports. If we have Bundle 6, Document 29, page 122 up, please. Now, have you seen this document as part of your review?

A I have.

Q This is the 2015 DMA Canyon

L8 Risk Assessment. The reference to the bypass occurs on page 206. If we see the larger of the paragraphs, where the cursor went to immediately, the description there:

> "There was bypass pipework set up to run from the Hardgate Road mains to the domestic (Bulk) water supply system connecting in after the Booster Pumps. This was noted [through] DMA's initial site walk round and reported to Estates."

Just to fill you in, that initial site walkaround, I think Mr Watson recorded that as being perhaps just before Christmas in 2014:

> "DMA again noticed this during the site survey on 2 April 2015 and again reported this to Estates. DMA were advised in mid-April this had been removed by Mercury/Brookfield. This line could potentially have introduced debris to the distribution system, which would otherwise have been removed by the filtration units and could be a contributory factor to any out-of-specification microbiological results."

Now, setting the microbiology to one side, I'm interested in the actual mechanism or the actual physical effects of the bypass. We heard evidence from a witness, Mr MacMillan, who, having discussed it and having had, I think, some role in having-- possibly in having removed it or seen to its removal, when asked about what the purpose of it might be was slightly at a loss, but he speculated that it might be a futile means of attempting to fill the upper floors of the system. Futile because of inadequate pressure. It's recorded on page 146 of his transcript, my Lord. Does that seem right to you----

THE CHAIR: Sorry, my fault. You gave a reference to Mr MacMillan's evidence in the transcript. Could you just----

MR MACIVER: 146.

THE CHAIR: 146, thank you.

MR MACIVER: Now, that was my attempt to summarise his speculation of what the bypass pipe might have been for. Can you comment on that? Does that seem a possible explanation for why it was there? Can you think of any better reason?

A It may well be that it was introduced to wet the system, to facilitate wet pressure testing, but if the incoming water mains pressure was not sufficient to reach the upper floors, then it would never have reached it. It requires a boosted pump set that operates at a greater pressure than that of normal mains water distribution.

As I say, it may have been introduced for wet testing purposes, which, again, is not recommended within healthcare premises anyway, but other than that, I can't think why you would introduce a bypass onto a system that was designed to cover the height of building that the hospital has, knowing that the incoming pressure was not sufficient to reach the upper levels.

Q Two points from that I can maybe ask you about: on the pressure point, presumably the pressure would get the water part of the way up the building but not all the way up it? On my rudimentary understanding, and please correct me if I'm wrong, that would mean that the water became less active the further up you went or the less mobile. Perhaps not the right way of putting it, but whether that's right or not, what would be the consequences of having attempted to fill the upper floors in this way, if that had been what was done?

A The water system will find a natural level that its pressure permits, so the lack of circulation or activity would be dependent upon-- it would only be created by either circulation pumps or people opening outlets at the lower levels which were wetted, which would then get some flow through the pipework systems, but the upper systems which didn't have any water in-- it wouldn't make any difference if you opened the tap.

In terms of wetting a system partially or wetting it and then draining it down after, as soon as a system is wetted, it will be capable of microbiological growth. So the SHTM and HTM lay out the recommendation that all pressure testing should be done with medical-grade air and pneumatically tested rather than wet tested using water, which will prove that the pipework doesn't leak, which is the purpose of the pressure test, without risking colonisation of the water system. Once it is wet, it needs to be kept wet and it needs to be, at that point, managed actively through flushing or temperature control as appropriate.

So an example would be, I had a site, constructed a 12-theatre block with mortuary. Everything was perfect. The water results were perfect. No problems whatsoever until we connected the dissection tables in the mortuary, and suddenly there was high counts of microbial activity. On checking with the provider of the mortuary dissection tables, they wet tested them all in their factory and then drained them down, wrapped them in plastic and shipped them all over the place, and by the time it arrived at the hospital and was plumbed in and connected, it then seeded the rest of what had been, prior to that point, a very clean water system.

Q I think you've probably anticipated and ambushed my question, which was that if the bypass has been there for a number of months, what might happen? Anything else to add to the mortuary tables?

A No.

Q Back to the report on the next page, 375. As I understand it, 348 and 349 here are essentially talking about the-- part of what's initially cold water but then becomes the hot water system, is that correct?

A Yes.

Q I'll come back to that topic in a moment, but at this point, I just want to notice that, at the end of 349, the last three lines are referring to something called Kemper thermostatic balancing valves. What are they?

A They are the valves I described earlier, which are a means of balancing or inducing a system line resistance to promote water flow in one-- in a preferred direction. They operate on a temperature basis, so it is, if there is sufficient temperature at that point in that branch, it will throttle down and the hot water will go in the alternate direction that the valve is controlling and it will generally-- what's normally described as "hunt" until it finds a fixed point, at which point it will provide a steady state based on water temperature to establish flow.

Q Are flow and temperature, therefore, inherently linked?

A Yes.

Q Because the aim is to have the whole system at the same temperature, give or take?

A Correct.

Q Does it follow from that that it's similar to balancing-- or it is, indeed, balancing – balancing is in the name – but the balancing here is to make sure that the temperature is the same in different parts because the flow is the same in different-- because the flow is appropriate in different parts and, if you get all of that right, then both parameters will be correct together.

A Correct.

Q Is that a reasonable explanation? Do you have anything to add to that?

A No. One relies on flow rate manipulation, for want of a better term, the other relies on temperature manipulation, but if you get them right, you end up with the right flow rate because you've got the desired temperature. If you get the right resistance, then you get the right temperature because the flow rates are correct.

Q Does that hold for both hot and cold water systems?

A No, you can't firmly balance

cold water systems because cold water systems don't recirculate.

Q Thank you. 3.4.11 is about the design philosophy of ensuring turnover. I think it's the same issue that we spoke about before, making sure that water is constantly moving from one end to the next or constantly moving within the hot water system as appropriate. Is that correct?

A Correct.

Q 3.4.12, we are on to filtration again. We've covered that already, but there's one point I wanted to ask about the focus of this paragraph. Is the focus here about filtration within individual parts rather than filtration as regards to the system as a whole?

A Yes, the filter basket or strainer within a thermostatic mixing valve is typically there to protect the seat of the valve from any physical contamination which might prevent it from fully closing on its seat.

Q So that's to protect the valve, and if we go over the page at the top, there is, I think, a different type of filter, point-of-use filters, you're considering. You say:

> "Point-of-use filters can also be considered, but these should only be considered if there is a significant operational issue and as a temporary protection precaution to users/patients whilst an issue is being addressed."

Do you see that?

A Yes.

Q Now, in broad terms – you're familiar with these – they fit over the tap, is that correct?

A (No audible response).

Q But you make a couple of points here. The first one is they're temporary, is that correct?

A In my opinion, they should be considered as a temporary solution.

Q Secondly, they themselves can present a risk?

A Yes.

Q Or are capable, at least, of doing so. Just to interrogate that a little bit, are you aware of situations where point-of-use filters have been placed in the long term as a control measure?

A Not on a long term as a permanent solution. I have seen them deployed for periods of months whilst rectification work is undertaken to underlying infrastructure issues.

Q At the end of the paragraph, you're making reference to the risks of leaving the filters in situ for a long period:

> "If left in place for extended periods of time, they can also become colonised with

microbiological contamination and can potentially act as a 'seed bed' for further system colonisation."

Do you see that?

A Yes.

Q Firstly, when speaking about "extended periods" here, what do you have in mind? Is it long term and subject to manufacturers' instructions for replacement, or long term when there's no replacement and replacement has been forgotten?

A All of the manufacturers of point-of-use filters will give a recommended life expectancy for that filter. An example would be if you have in your own domestic home a fancy, American-style fridge freezer that's got a water dispenser of chilled water in it. There will be a water filter within that line and you will get a light up on your fridge door telling you when it's got to be replaced.

More often than not, when you look on Amazon and see the price of them, you go, "I can live with a light" and leave it there. The problem is that a filter acts as a concentrator of the organisms that it may be filtering out and, in the right temperature conditions, those organisms will multiply.

So leaving a filter in situ that is beyond its recommended change period can act as a source of proliferation of a particular microorganism. Equally, when you fit a point-of-use filter to an outlet, it restricts the water flow through that outlet because the water now has to overcome the resistance of the filter.

So in the reference I made to a reasonably long-term deployment of point-of-use filters, one of the areas that they were fitted to were shower outlets because they are at increased risk of Legionella because of the aerosolization of the water particles through the shower head.

Unfortunately, if you fit a point-of-use water filter to a system that was designed without a point-of-use water filter in place, the water flow rate took you about 10 minutes to get wet enough to lather up, so the flow rate through the outlet was significantly impaired by the provision of the filter.

You also still need to water sample to check as to see whether remediation has been effective. You can test the water, having passed through the point-of-use water filter, to provide assurance that the filter is operationally efficient, but, ultimately, you want to test the water prior to the point-of-use filter to know whether it's safe or not to remove.

In doing that, you've got to be very careful of potential false positive readings that, if you remove the water filter to then take the water sample-- that water filter is

then introduced to the surrounding area and can be contaminated. If it is then refitted to the tap, if the manufacturer permits that, then it can lead to false positive results rather than a true reflection of the water sampling of the raw water condition at the outlet.

Q Right, thank you. You were, I think, alluding there to potential contamination, presumably also of the surrounding area by touching from a used filter. I'd understood the reference at the end of that paragraph to the seed bed to be a slightly different issue. What do you have in mind there?

A If the filter is left in place for longer than its recommended period, then the concentration of the microbiological agent present can, in effect, act as a culture for that microorganism. It's getting low flow through. It can grow through the filter if left long enough, but it can also feed back into the water system as a source or seeding root of the microorganism that's present in the filter.

Q Right. Perhaps if we look at both of those when you're talking about if it's left long enough then-- I think the backwards route you're envisaging a scenario where it can-- whatever organism it is, can grow from the filter back towards the water source into the system. You mentioned also potential for growing through the filter. Filters are very fine – microns, less than a micron. How would that happen?

A Because it breaks down over time with exposure to the water and the organism. The analogy I would use is an ivy plant. It will find a way through pretty much anything and a microorganism, if it proliferates, will penetrate through a filter. A filter cannot be completely sealed because it's got to let water through, so it can also grow through-- If given enough time in situ, organisms will grow through.

Q An important factor there is enough time.

A Yes.

Q So, therefore, in the cases that you're describing here – potentially acting as a seed bed or becoming colonised – both of those are predicated upon filters having-- a particular filter having been left in place for too long.

A Yes.

Q I.e. not replaced when it should have been. Just specifically in terms of seed bed or seeding, are you aware of any scientific studies that have shown filters as a locus of seeding of a system?

A No.

Q My Lord, that's the end of that particular section of questioning. It's mid-morning.

THE CHAIR: We'll take our coffee break now, Mr Poplett. If I could ask you

to be back for five to twelve? Thank you.

(Short break)

THE CHAIR: Now, Mr Maciver.

MR MACIVER: Thank you. Just before I move on, Mr Poplett, we were speaking about point-of-use filters just before the break there. One point I didn't put to you was that, if point-of-use filters are still present in the hospital today, does that indicate anything to you?

A It indicates that the evidence should still support that there's an ongoing problem with the management of water because, in a well-designed, well-installed system, they shouldn't need to be a permanent feature.

Q (After a pause) Now, we've just been through a long section about overviews of the, I think, cold water system. One point we passed by was – we'll go to it since we've had a break – 3.4.9. Previous page, 375. I may have read out that last sentence already, but:

> "There are Kemper thermostatic balancing valves installed on the system in line with the design to ensure hot water is available within two minutes at every outlet."

You've told us about how the balancing valves work, but the reference here to "ensuring hot water is available within two minutes at every outlet"-- I wonder, can you reconcile for me the idea that I think I picked up of the ideal state being hot water everywhere in the hot water system with the idea that it might take two minutes for hot water to reach the outlet?

A I would actually acknowledge that that is a typo and it should be one minute for hot water. It's two minutes for cold water.

Q Thank you. Notwithstanding that, why the gap?

A Right. The hot water circulates continuously to maintain its temperature. However, the pipe that connects to the tap has a single-pipe connection, so you should get the return point as close as practically possible to the outlet, so the shortest length as possible of potentially stagnant hot water exists. And the reason why it should be one minute is, because that is constantly flowing around the system, it should take a short period of time, ideally far less than a minute, to achieve the hot water temperature.

Cold water temperature does get two minutes because the cold water system is a non-recirculating system, so you only get movement in the cold water system when somebody opens an outlet, and therefore the time when that temperature is at the outlet has an

allowance of two minutes in place of one minute.

Q Specifically in respect of the hot water, I've certainly picked up a picture of the hot water system as operating perhaps by means of a loop of pipework somewhere either in the walls or in the ceiling. The outlets are not on that loop – they are at chest level, hand level, waist level, wherever – but, in order to get to the outlets, you need a spur from the main loop to the tap. When you're talking about one minute to get hot water, does that effectively indicate-- mean that you get one minute for the spur to empty?

A In effect, yes. You are looking to make it as short as possible, but the general rule of thumb is it must be less than two metres in length because, if it's a 15 mm-diameter pipe, which is the standard pipe size for terminal pipework, that will clear within that one-minute time period.

Q So, effectively, if you have a two-metre pipe and you open the tap at one end, then, to get rid of all the water that was originally within that pipe should be a minute or less?

A Yes. To give some context to that, within a domestic dwelling, you will probably have what's called a "combination boiler." That does not generally recirculate a hot water system, so, when you go to shave in the morning and you turn the tap on, it takes a couple of minutes for the hot water to come out the hot water tap. That is clearing that length of pipework on a non-recirculating system to reach temperature. It's exactly the same principle, but, in the hot water of a non-domestic, then have a circulating system, so the pipe length should be considerably shorter.

Q So because the sources are different-- In the hospital, the source is the loop, the nearest point in the loop, wherever the spur is attached to. In my house, it's the loft.

A Yes.

Q Moving onto page 381, this is where we go into the overview of the hot water-- domestic hot water system. Midway down the page, you begin discussing temperature results in 2015. There are two temperatures mentioned here, but perhaps I'll read it just to put them in proper context:

> "In 2015, at the pre-occupation water risk assessment process, distribution temperatures were almost invariably above 50 degrees at all outlets, with direct hot feeds above 55 degrees Celsius. The return temperatures recorded at calorifiers were consistently below 55 degrees, which were advised as the control set point for these,

> though when calorifiers were at full temperature, the turns were reaching 50 degrees centigrade.
>
> This performance was below the recommended limits within the SHTM and the control set points were amended to achieve a return temperature of 55 degrees Celsius as part of the process to address the identified compliance issues from the initial pre-occupation risk assessment."

Quite a lot in that, it seems to me. Could you give us as brief a summary of it as you can?

A Yes. During the pre-occupation water risk assessment, water sample or water temperature tests were taken and observed to be below 55 degrees. Within the SHTM, it makes the recommendation that all water-- hot water returning to the calorifier or plant room area should be 55 degrees or above. It was set to only-- It was performing to only reach 50 degrees, so I would imagine that the calorifier set points were increased to elevate both the flow temperature and, by direct correlation, the return temperature by five degrees so the return temperatures were then receiving-- returning to the plant room at the 55-degree level or above.

Q Okay. So again, if we imagine the overall loop – one end of the ceiling, right around the hospital and back to the calorifiers at the other – because it's a loop and because we're dealing with hot water, you would expect, during-- due to natural entropy, the temperature will be lower when it gets back than it is when it sets out?

A Correct.

Q The specified temperature for when it gets back should be 55. Are you saying here that, in practice, when it's set out at 60 degrees, it was coming back not at 55 but 50? Is that right?

A That was the indication from the risk assessment results.

Q A way of curing that would be to set it out not at 60 but at 65, and you still get the same heat loss but now it's arriving at the magic number, at 55 Celsius?

A Technically, you will get a slightly higher rate of heat loss the higher the temperature differential. The total heat energy which the water contains is a fairly straightforward equation of the mass flow rate of the water, the specific heat capacity of water and the temperature differential, so if you increase the temperature differential, you will increase the energy if the flow rate remains constant and the specific heat capacity remains constant.

So without getting overly technical,

yes, if you increase the flow, you will get a higher rate of return if all other things remain constant. It is not a straight-line graph because the rate of heat exchange or heat loss is determined by the temperature differential, so as you increase it, it obviously increases that temperature differential.

Q Okay, so to correct myself, if it went out at 60 and was coming back at 50, then, to get it coming back at 55, you might need to set it out at 66?

A Yes.

Q That may be what's happened here in the last couple of lines, when you're saying the control set have been adjusted.

A Yes.

Q The next paragraph makes an observation about unintended or perhaps intended consequences of increasing temperatures. First sentence, you're saying:

> "It was also noted that increasing the calorifier temperatures may have the beneficial effect of increasing cold water usage as more cold water will be required at [valves] to blend water to the [valve] set point and so may assist in reducing the high cold water temperatures being recorded within the system."

I think we're touching again there upon the link between movement and temperature. Is that correct and could you explain that?

A Yes. The thermostatic mixing valve, if it is set to deliver water at 43 degrees centigrade-- If the hot water is at 65, to get the water down to 43, you will require a smaller percentage of the hot water and an increased percentage of the cold water to be blended through the thermostatic mixing valve to achieve the 43. So the higher the flow temperature on the supply, the natural occurrence is that you end up using a slightly increased level of cold water to bring that temperature down to the set point of the TMV.

Q If there is a broader point, perhaps it's as simple as the fact that, at least to the layman like myself, water systems appear to be inherently complicated and, to some extent, perhaps unpredictable. Is that fair?

A I think complicated is certainly fair, or they certainly can be. The predictability is dependent upon how thoroughly it's designed and how complex it gets, but they can be fairly reliable and repeatable results can be achieved, so the predictability of performance can be achieved. Forecasting that a-- moving from a design to an actual real-life scenario can always

bring challenges.

THE CHAIR: I have to say, I was-- didn't immediately see the purpose of your reference to "predictable," so----

MR MACIVER: That was probably the wrong----

THE CHAIR: -- can you help me? At a certain level, I would have thought an engineering system such as a water system, theoretically, is predictable in its operation, so it was really just to make sure that I'm following your line of thinking, Mr Maciver.

MR MACIVER: I think, perhaps, my line of thinking is less important than the witness's line of thinking. That's certainly what I understood from the answer of the question, my Lord.

THE CHAIR: I see.

MR MACIVER: If there's an error in the question or a wrong assumption----

THE CHAIR: No, no, no, no.

MR MACIVER: -- in the question, and if it's----

THE CHAIR: No, it's----

MR MACIVER: -- produced a good answer, then I don't think I need to pose it again.

THE CHAIR: No doubt the fault is mine.

MR MACIVER: (To the witness, after a pause) You did mention in your response that, if the system were modelled/engineered correctly or to a particular standard, then it would be possible to get replicable outcomes and, therefore, to that extent, "predictability" is the wrong word for me to have used.

But to think from the point of design or inception or thinking up the concept of the water system in the first place, thinking from there to the end point of actually turning on and water coming out – and bearing in mind that the answer must surely differ between simple systems and complex systems – how much confidence-- or can one ever have 100 per cent confidence that what is designed will be replicated when the system is actually built and put into operation?

A I personally wouldn't say that you can be 100 per cent certain. Obviously, these are based around long-established design standards and methodologies, and you can be fairly confident that it will work. However, if you could be 100 per cent, then you would argue that you wouldn't necessarily need to commission or validate, and that is intrinsically required to any system to prove that what you predicted would happen at design stage has actually happened in the real world.

Q I follow that. I suppose my question is, really, to put it in its broadest terms, how much value can one place in the modelling of a system, in the fact that

something ought to have worked in theory?

A If you undertake modelling of a system at design stage prior to installation, it can provide a level of assurance that, in principle, the general parameters will work, but any modelling exercise requires a multitude of variables and if any single variable is outside of that that the model was based upon, it can result in different results in real world.

So if you're looking at computer thermal modelling of a distribution system, this is how it should work, according to our design. That is still having to be confirmed at the validation stage of, "Does it work as we anticipated it would?"

Q But the point is that's the importance of validation?

A Yes.

Q Now, quite a way further on at page 400, you do return to hot water temperatures in a different context because here, you're speaking – at 4.1.15 – about set results obtained in measurements taken in 2018. Now, the issue here, first, if I start reading from the end of the fourth line:

> "It identified that the control set points for the hot water temperature control had been adjusted from 60 degrees to 65 degrees [perhaps that's the change that we were alluding to a few minutes ago], however this change had not been appropriately recorded."

You've mentioned the importance of recording before. Can you comment on not recording the change in the output in the set point here?

A Yes, it is a requirement of the water safety plan that any adjustment, alteration, maintenance activity which is undertaken should all be recorded so there is a clear audit trail of what has been done, ideally with an explanation as to why it was done and evidence of the results of any alteration.

Q You then go on to describe the actual results:

> "From information observed during the forensic analysis, evidence was recorded that although this adjustment had been made, the flow temperatures were at times as low as 58.1 degrees. Whilst this is a clear non-conformity set-point performance, it should be noted that at no time did the return water temperature fall below 53.2 degrees Celsius, which provides evidence of suitable and safe overall water temperature control."

Then some remarks again about recording. With respect to the temperature specifically, I wonder if you can summarise the important points

there, from the actual temperatures not reaching the level that were expected but nevertheless not falling as far as the 53.2 degrees value?

A It supports the previous statement in terms of the temperature of the water flowing out is referenced by the temp or is directly linked to the temperature of the water returning. It does fall below the set parameters of 55, but it doesn't drop below 50, so it is not unsafe, as such, and, at that point of return, is immediately prior to the water effectively being reheated as it re-enters the plate heat exchanger/calorifier to regain the temperature.

But it should, ideally, obviously as the set point is set at 65, not be coming off that at 58.1. It should be coming off at 65, at which point the return temperature would be, in all likelihood, well above the 55 degree recommended minimum.

Q Setting the recording issue to one side, what concerns occur to you as a result of that?

A The hot water rate of recovery is based on how much hot water is drawn off at any given point at any outlet. On a very large, complex hospital site, the water flow rate can be significant, and if the lower temperature coming back in-- it's the rate of recovery that the plate heat exchanger or calorifier can achieve can be impaired if the return water is low.

Certainly, on this evidence, the set point being at 65 but only sending out at 58 would suggest that the plate heat exchanger wasn't capable of raising the water to the required set level at 65.

Q Where does that problem come from?

A The more people who open hot water taps around the hospital, the more cold water you've got to reintroduce to get the volume of the system back up, and in exactly the same way as a TMV works, the calorifier works in the same basis. If you've got a certain volume taken out of hot water, that volume is made up of cold water which naturally lowers the temperature, and the heat exchanger or calorifier is then required to raise it from a lower set point. If the return water is also below the 55, that only exacerbates the problem.

Q So we have a heater part of the calorifier that is not, for whatever reason, capable of producing the output that was specified, but does it follow that we can't know the root cause of that because it may depend upon how many hot water taps were open?

A Yes.

Q Now, we've moved from paragraphs beginning with 3 into paragraphs beginning with 4. That's because we're into the "Design, Installation, Commissioning and

Validation" section that started at, I believe, 397. You start off this section by, at 4.1.1, describing the system as built to be "generally in line with the principles set out in the … SHTM 04-01." Do you see that? First couple of lines.

A Yes.

Q But you then go on to identify three things indicating areas of concern, and they are instalments: subsequent requirement to install ultrafiltration and water treatment. Then you also mention failure to take account of tap selection and failure to take account of implications of point-of-use filters. Now, just to reconcile that, you're talking there about subsequent development. You start off the paragraph by saying this: the system that's built is "generally in line" with guidelines, but then you go on to indicate areas of concern and they're evidenced by subsequent developments, as I understand. Is that right?

A It is.

Q Then, at 4.1.2, you approach matters from a different angle, saying here that:

> "The site has a very complex water distribution system, and during commissioning and pre-occupation risk assessment review process, a number of significant installation issues were identified which could have been designed out at an early stage."

Now, firstly, the reference to the risk assessment, is that, again, a reference to the 2015 DMA Canyon Report?

A Yes, it is.

Q As I read it, I was having slight difficulty reconciling the three time perspectives in these two paragraphs. I wonder if you can reconcile them for me? You're talking about design at the start of 4.1.1, saying it's "generally in line" with the guidance. You then move on to making reference to subsequent developments indicating problems.

Then, at 4.1.2, you're talking about things which might have been designed out, suggesting to me – and correct me if I'm wrong – that there were parts of the design that were not as good as they could have been. Is that too simple or-- which seems to place matters back into the, "Do we look at whether things were in line with the guidance at the time in concluding that maybe they weren't?" Am I garbling that? Would you like to make that clearer?

A I will endeavour to do so. I think the design, in principle, was in line with SHTM guidance. I think there are certain elements of the installation, such as the deployment of flexible hoses, that shouldn't have taken place in strict accordance to the SHTM and they were

installed.

When I talk about design, I'm looking at the high-level design philosophy rather than the minutiae detail of an installation specification and the materials that can or can't be installed. So through any preoccupation risk assessment of a new facility, as an AE, I would expect – at least hope – that there would be no defect or remedial actions identified. Because, on a brand-new system, given that the rule book is known, there's no reason why there should be defects identified. That was not the case in this instance.

The later modification or adaptation of the system in terms of the ultrafiltration and water treatment – chlorine dioxide systems – came as a follow-up and perhaps, I don't know, as a reaction to address some of the operational issues that were identified when the system was live. Has that clarified it and cleared it at all?

Q I think so. I think it's the reference to "generally in line with the principles as set out in the guidance." If that's a high-level assessment of the system, then it would appear to follow that the matters in 4.1.2, such as high temperature gain or at certain cold water outlets or the hoses-- you wouldn't consider those to be high-level problems there?

A No, no.

Q So to take one of those, for example, the temperature gain resulting in the installation of dump valves to increase water flow, it would follow that you don't consider that to be a high-level problem, but if it's an issue that can be fixed by installing some dump valves, is that necessarily a problem at all?

A It is in that it actually breaches another HTM, 07-04, which is the unnecessary wastage of water. So it depends upon if the system is designed in such a way that the usage is high enough to prevent the excess temperature gain on the cold water, then dump valves shouldn't be needed. If they are needed in operation and it's identified that they're needed in operation, it is an accepted method to do so, to install them, and it will address the issue.

I have always interpreted that the requirement for a safe patient environment will supersede any requirement of energy conservation or wastage issues, so the fact that 07-04 says you shouldn't waste water, I acknowledge, and it is a derogation of that, but if the result of not doing it would increase risk to patient, then I would place conformance to 04-01 above that, to 07-04.

Q Okay, thank you. Moving over the page to paragraph 4.1.5, here you're

identifying a problem in relation to-- well, in general, you're making a judgment on the system. I'll read it out rather than attempting to summarise and garbling it myself:

> **"**The classification and vulnerability of the patient group was clearly well understood and the impact of water systems in regard to the risk of system colonisation, transmission to patients and the appropriate measures to minimise these risks through the design, installation, commissioning and validation process through to the initial occupation and operation can best be described as sub-optimal."

Then you go on to give evidence for this, including but not limited to:

> "… the use of 'wet' pressure testing, the lack of comprehensive flushing of systems once wetted, the failure to adequately protect pipework from contamination during installation, and the poor performance of the cold water distribution pipework to maintain appropriate outlet water temperatures."

Now, apart from the last of those, the references here are to a matter which we've heard some evidence about: to summarise, the way the system was constructed, in part being that it was filled early, drained, refilled and then, essentially, remained in that condition perhaps for as long as nine months before occupation and operations commenced around the time it opened.

Just to help me make the best possible sense of this paragraph, I wonder if you can describe or comment on each of the failings you're identifying here? The first of them you've done so already, I think, 'wet' pressure testing, and you told us about gas pressure testing earlier and why that would be a preferred alternative. The second point I've drawn out is the lack of flushing once the system was wetted. You may have answered that already, but, for completeness, can you tell us what the problem is there?

A Once the system is wetted, it should be kept wet, and we then use flushing to basically replicate the system being in use. So as soon as you've wetted the system, it then goes into a programme of all outlets being flushed on a regular basis to ensure avoidance of stagnation. There are no records present to say that that was undertaken during the construction stage having wetted the system, and, indeed, the system was wetted, drained, left for an extended period of time and re-wetted.

The problem with that is that the damp system, for want of a better term, the wetted and then drained, has residual

water and residual material that will promote microbiological growth. And in a completely separate hospital which I work with, they had a building built 15 years ago where this was done, and they still have repeated problems, and no level of disinfection, frequency of disinfection or even turning the temperatures up to 70 have been able to completely cure it.

So it is incredibly difficult, once you get a systemic colonisation, to clear it, and if you've got a wetted and then drained system, that promotes significantly, in my opinion, a systemic colonisation potential.

Q The third point you mentioned was the failure to adequately protect pipework from contamination during installation. That would seem to be part and-- part of what you're telling us about, but could you elaborate on that a little bit?

A When pipework is installed, or prior to being installed and delivered to site, it should be sealed; plastic end caps, normally. It shouldn't be left outside in the mud and contaminated. Once installed, at the end of each period of installation, ends should be, again, sealed so as to not to act as a point where contamination can ingress to the pipework system prior to it being sealed, as it were, or completed.

Q It may be an obvious point, but what sort of contamination are we talking about? What's the problem with that?

A The biggest problem is soil, which is absolutely laden with bacteria, but also open ends. Where you are doing other building works in the area, you will create dust, you will release fungal spores, you will potentially open it to any manner of contaminants.

Q And have no control?

A Have no control over what goes in it, and clearing it out requires flushing, but you don't flush until you've completed everything, at which point you've put restrictions on the system. So it's not like clearing out an open hose pipe; it is-- had to go through valve seats and valve assemblies, and hence the proliferation and spreading of that potential contamination throughout the system.

Q The last problem that you mentioned at that paragraph was poor performance of cold water distribution pipework. I think you've covered that already, but that's a different order of problem to the build problems that you've identified previously in that sentence.

A Yes.

Q Is there anything more to say about that than you've said already?

A No, I don't think so.

Q All right. Setting that to one side and just thinking about the pipework, the wet testing and so on, how obvious

ought it to have been, from your perspective, during construction and installation that these are things to be avoided?

A It is standard practice and has been for many years within healthcare that you do not wet pressure test, and it's been built into the HTM for a considerable period of time, so it surprises me that it was wet pressure tested at all.

Q What about protection of the pipework?

A Harder to achieve and is often a challenge on any building site, particularly one as large and complex as this, but again, it is-- it's very basic stuff. It's making sure the end of the pipework is capped at the end of the working day, and then uncapped-- It's not difficult to do, but it's difficult to provide assurance that it is done.

Q I skipped over the lack of flushing once it had been wetted. How obvious would it have been to you that that ought to have been done?

A If there's no evidence or records to show it has been done, the assumption is that it hasn't.

Q Over the page at 399, you're mentioning a different type of issue at 4.1.11 at the foot of the page. Here you're mentioning specialist clinical areas and, to summarise that, you're saying that you'd have expected to see specific design-stage risk assessments to ensure that those services' stakeholders had been fully consulted on what's required, and you hadn't seen evidence of that. What conclusions did you draw from that?

A My conclusion is that didn't take place because there's no evidence that it did, and the preoccupation risk assessment was not specific to clinical-- or different precautions or different levels of risk in different areas of clinical activity.

Q What consequences could flow from that?

A Where you've got high-risk patients or patient care facilities, then specific reference should be made, and potentially supplementary precautions taken, to ensure that adequate protection is provided and provide safe systems. Again, it is reflected in the recent NETB update that that is now a requirement.

Q You do go on, over the page to-- in fact, a number of pages further on, 402, to make reference to the two risk assessments that were carried out by DMA Canyon. We've already looked at 2015, and you say there was another one in 2017. Now, given the length of them and the nature of them, I don't want to bring them up necessarily, but here you have identified, among other things, the headline numbers.

So in the third line of 4.2.1, you're saying that the review – that's the 2015 review – resulted in a detailed water risk assessment identifying a total of 494 issues or defects, and then classifications of them into high, medium and low risk, and you then say:

> "Given this was a then brand-new installation which was designed and built to be fully compliant to the relevant healthcare SHTM standards, this level of defects is considered completely unacceptable."

Do you want to or feel the need to elaborate upon that at all?

A I don't think I could put it any stronger.

Q You give examples of some of those issues below, and they relate to some things we looked at: hoses, aerations, a new issue, hot/cold water temperatures and then hot outlets not complying to latest regulations.

At the next paragraph, you are referring to the 2017 report. Numbers are different, lower, but still 168 remaining to be addressed, and there's classification of them into high, medium and low risk. Here you give examples, remaining issues being evidence of heat gain and a defective flushing regime. The words used in the second line are "some significant improvement," but at 4.2.3, you're saying that:

> "For a new system, which had been designed to fully conform to the then current … standards, this is considered as a highly unsatisfactory situation, although it does provide evidence of positive progress to identify and address issues by the … Estates team."

The language you've used, "highly unsatisfactory" or "completely unacceptable," you say, is very strong, but you do balance that out a little bit by talking about positive progress. The positive progress that you've seen by 2017, does that cure at all, or mitigate at all, the "completely unacceptable" view that you'd reached as regards to 2015?

A It demonstrates that there were-- issues that had been identified were being addressed. The fact is that, in a brand-new system, there shouldn't have been issues to be addressed. Significant improvement had been achieved and made within that, but it doesn't negate the fact that, if you'd bought a brand-new car and it didn't work very well and had hundreds of defects after two years, would you still be happy if it still had at least over a hundred defects? So it all stems back to the original installation was non-compliant.

Significant progress had been made, but significant progress still remained to be made, including 65 high-risk elements.

Q To think back to the first key question that the report was all about – which was essentially, "From the time of occupation, was the water system in a safe condition?" – at the point, 2015, what's the answer to that question?

A As I have expressed before, it is very difficult to put a binary answer to, "Is something safe or unsafe?" It was certainly suboptimal and it certainly didn't comply to all of the requirements of SHTM standard.

Q In relation to 2017?

A Improved, but still not compliant.

Q Now, you deliberately aren't putting that in terms of "safe" or "not safe."

A Correct.

Q Why not?

A Something is safe or unsafe dependent upon multiple variables, so a system-- a water system that is never used is not unsafe. It is not what you want, and if you then use it, it would be unsafe because it had sat for a long period of time being unused. So the safety or lack thereof is a sliding scale, not a black and white binary "something is safe or unsafe."

So it requires a combination of events for a system to have an adverse impact. It equally cannot be ever described as completely safe because there are inherent microbiological risks with water.

THE CHAIR: When you use the expression "adverse impact," could you just-- what are you thinking about?

A Without wishing to be flippant, if this was a hotel which was handling healthy people with no immunosuppression and all the rest of it, would it be as risky as it were a hospital? No, it wouldn't. The compliance or non-compliance of it would still be the same, but the exposure of that hazard and likelihood of resulting risk would alter.

So seeing it in its context as a highly specialised acute healthcare provision – probably one of the most vulnerable user groups possible – is why it was non-compliant and unsafe, both at the time of occupation and arguably safer in 2017, but still not fully compliant.

THE CHAIR: Now, the instances of non-compliance, by their nature, are things that need not have been so. I mean, that's not a well-put question, but when we're talking about instances of non-compliance, the starting position is that, if there's a requirement to comply, therefore, it is possible to comply. The instances of compliance you've been drawing attention to are intended to

reduce infection risk.

A Yes.

THE CHAIR: So what was identified by DMA Canyon in 2015 and in 2017 were a number of instances where measures that could have been taken to reduce risk and were required by current guidance to be in place were not in place?

A Correct.

THE CHAIR: Now, it seemed to me that that takes us to a position where, if measures that could have been taken, should have been taken to reduce risk are not in place, then the hospital presented a greater risk to patients than it need have done.

A Yes.

THE CHAIR: Right. Whether that actually resulted in adverse instances is, of course, a different matter.

A Yes.

MR MACIVER: While it's on the screen, we have "Ancillary Considerations" at 4.3, and this was dealing with a separate question that was asked of you, whether the hospital's proximity to Shieldhall waste water treatment works created a risk of infection to patients. This was in relation to a sewage plant nearby to the hospital site, am I correct?

A Correct.

Q Your answer is straightforward here, which is no.

A Yes.

Q Just to be clear about that, you're expressing your view in relation to the water system.

A Correct.

Q You're not in a position to make comment on whether there's any other conceivable nexus of transmission?

A No.

Q We see, at the bottom of that page, the "Commissioning at handover" section begins. 5.1 is about commissioning, and I think you've explained to us already the importance of commissioning and the linked validation process.

You set out over the following four pages-- and I won't go through these in detail. If we go on to the next one, we've got a list of typical steps, which I think-- It's slightly difficult to tell because the font is the same on all pages, but this, I think, is a direct lift from the requirements of SHTM, is that correct?

A It is.

Q One or two that I'll perhaps get you to just explain the significance of: number 6. We've almost touched on this before, but it's talking about flushing and you're saying there:

> "... should be undertaken following pressure testing and should be the first action once a system is

'wetted' for the first time, after which the system should be subject to regular twice-weekly simulated 'in use' flushing to ensure stagnation of the system is minimised."

My question is, what's the significance of the first flush in particular?

A It was intended to say that, as soon as the system is wetted, flushing should commence. There should be no time delay between wetting the system and commencing a flushing programme.

Q Why is that important? If we move on to a system of twice-weekly flushing, flushing every three or four days, why is it different for the first flush? Why does it have to be done immediately?

A It's more a case of it's trying to emphasise that it needs to start-- If you wetted the system and did the pressure test and commenced flushing within two days, that would be the first flushing. It's not intended as immediate, but it should be commenced as soon as the system has been wetted and continue until occupation and full use.

Q Thank you. Over the page, point 8 is about "temperature control and checking":

"… for cold water systems … to ensure no excessive heat gain is experienced… For hot water systems … to ensure appropriate circulation and design…"

That may or may not be the same issue as we've spoken about beforehand. It appears to me that the expression might be different in that one might be about getting up to temperature and the other is concerned about heat gain. Am I wrong about that? Is there anything specific to understand about point 8?

A No, the thing with point 8 is that the design should ensure that the incoming water temperature does not achieve more than 2 degrees C temperature gain throughout the course of the system.

Q Why is that 2 degrees heat gain-- what does that tell us?

A It keeps the water system within a safe operational parameter for the control of microbiological proliferation for Legionella, and that's not easy to say. So it is designed to make sure that the system throughput doesn't experience excessive heat gains.

Q Is that linked to the point that you've started out explaining, that temperature and movement are inherently linked?

A It is. It's also the fact that heat gain on a cold water system isn't a steady graph. If you miss a section of thermal insulation from one part of the cold water pipe and heat it up, by the time it then goes back into and blends with other cold

water that was fully insulated, you will get a subtle increase but not the same temperature as the uninsulated pipe. So the overall gain across the entire system is designed to acknowledge that but keep it to within safe operational parameters.

Q Over the page, 407-- in fact, two pages further on (inaudible). 407 has point 10. You're talking about initial disinfection. Now, I spoke about chemical dosing in a kind of broader, more permanent context earlier. Do you understand this initial disinfection to be a different, separate process?

A It is.

Q Can you explain that to me?

A Yes. When a system is first wetted, it gets what would be typically described as a shock disinfection, so these are higher concentrations of a chemical disinfecting agent, higher than would be safe to be present for a system in use but designed to act to kill any present microorganisms in the system from a starting point so you start with a clean water system.

Q Now, after having set out these steps, you move on, at 5.2.1, to dealing with system pressure testing and flushing. Then you start out by considering the construction phase, capping of pipes is mentioned there, and you've covered that already.

5.2.2 you may have covered, but I'm not quite sure, so I'm going to ask the question, and if you've only answered it do tell me. You make a reference there, again, to wet testing, and you talk about "... in some cases then drained down and left." Is there a specific problem that arises from draining down as opposed to filling a system too early and leaving it filled?

A Filling a system too early and leaving it filled is a problem if it's not then subject to regular flushing to avoid stagnation. Wetting the system, getting all of the surfaces wet and then draining down, there is some research that says that promotes microbiological growth activity because the organisms grow more strongly in a damp environment rather than a completely wetted environment.

Q Thank you. Over the page at 5.2.3 and 5.2.4, here you're drawing attention to a mismatch between dates, I think, and there's inconsistency-- more than one date available to you to indicate when flushing might have taken place. What's the point from these paragraphs?

A It's really just evidence of, or lack of evidence of, consistent regular flushing of the systems.

Q Just give me a moment, please. (After a pause) The next page has, at the foot of it, 5.4. Again, we're

returning to the matter we touched on in part: TMVs, thermostatic mixing valves, and thermostatic mixing taps, TMT commissioning. Can you tell us about these? You told us about the valves already. You may have alluded to but I think not explained the taps. Can you tell us about these items?

A A TMT is ostensibly the same as a TMV, but the mixing process takes place within the tap body rather than as a separate valve component prior to the tap outlet. Do you want me to explain how a TMT/TMV works?

Q Yes, if you can.

A In basic terms, it will take a volume of hot water and a volume of cold water to create a desired temperature at the outlet, typically 43 degrees for a wash hand basin. As we've spoken, the flow temperature may well be, of the hot water, at 60 or above. The cold water should hopefully be less than 20. So the proportion of mixing is controlled by a bi-metal strip, typically, that expands and contracts to a required level of opening of the two valves to get the desired flow temperature.

Both the hot and the cold water supplies to the valve, whether it be a TMV or a TMT, are installed with backflow protection devices to make sure that you can get no cross-contamination of cold water into the hot water or hot water into the cold, and they are also fitted with strainers to remove large particulates to ensure that the valve seat appropriately works.

One of the testing-- one of the required tests for these devices is what's referred to as a "cold water shut-off test." So in the event that the cold water failed, there was a burst, the valve must stop all flow within a prescribed time period to ensure that untempered water cannot be released through the valve and, therefore, potentially pose a scalding risk to a user.

Q Right. I don't have the paragraph reference, I'm afraid, but I recall it was in there: later on in your report, you refer to that scalding risk as a "never event." It may be obvious, but please explain what that is.

A The NHS have designated that scalding is an avoidable risk and, therefore, should never occur within its premises.

Q And the valves are the means of achieving that?

A They are one of the means of achieving it.

THE CHAIR: (After a pause) Could I just ask you to repeat that last point? "Scalding is an avoidable risk and, therefore, the NHS..." and I failed to note what you went on to say.

A Have classified it as a "never

event". Again, back-- and it has always been, it should never happen. One of my job or career progressions when I first became a head of Estates was at a learning disabilities trust who had operated for a number of years without a head of Estates.

There was an incident involving a patient with severe learning disabilities being scalded to death by being placed in a bath where the TMV had failed and it hadn't been picked up. So the consequences of scalding-- while some people might think, "That's a bit hot and pull your hand out of it" is fine, but where there is impairment, then it can be extremely serious and up to and including fatal.

THE CHAIR: Thank you.

MR MACIVER: (After a pause) Just to cover the last two lines on the page:

> "Evidence reviewed, including samples of … testing records, shows that while TMVs have been subject to routine testing and maintenance, the level of information recorded and the stabilisation testing of replaced TMV or TMT cartridges does not follow the current SHTM standards."

What conclusion do you draw from that?

A This is where I run the risk of getting very nerdy, so I apologise in advance. Thermostatic mixing valves have always had a requirement for six-monthly in-use testing. That testing is undertaken. I can't remember the exact date, but the DoH standards for testing of thermostatic mixing valves were adjusted and altered, I believe, in 2017, where they made alterations to the prescribed test methodology.

The function testing was still the same, but specific volumes of water over specific time frames as part of the cold water shut-off test were included. There is no evidence within the records to say that that volumetric measurement and testing took place on the TMVs, but the TMVs were subject to routine testing.

When a TMV is first installed, there is a requirement within the SHTM to undertake what are called stabilisation tests. So you put it in, you commission it, you make sure it's working to the correct parameters. Six to nine weeks later, you go back and check that it is still operating within those parameters.

Twelve to 15 weeks after that, you go back and check that it is continuing to work within its specified parameters. Thereafter, it gets incorporated into the regular 26- or six-monthly testing cycle. The stabilisation phase of testing I have not seen evidence of being completed.

Q You told us about the potential

consequences of scalding. Does that elevate the degree of concern that one would have around the process, or lack of completion of a process, that you've just described to us?

A Certainly, for any area of whole-body submersion, it would be a serious concern to me.

Q So we know there are baths, for example, for some patients. If, as you're describing, there's a lack of recording of full testing, validation, whatever, of the valves, of the taps, then that would be a serious problem?

A It would, although the healthcare organisation would typically have a bathing policy, and that bathing policy should include a fail-safe manual check of any full-body submersion water temperature prior to a cognitive-impaired user using it. So there are fail-safes built in that are not reliant on the mechanical device in the pipework.

THE CHAIR: (After a pause) My fault entirely, Mr Poplett. You've set out, at 5.4.2, the testing regime of TMVs and draw particular attention to the test to cover the possibility of cold water failure and, therefore, scalding risk. It's just, I'm trying to locate that point in the paragraph. In other words, could you just help me with what particular test, as recorded in your report, you had not seen documentation of the test being carried out?

A It is covered under 5.51, at the top of page 412. So part (b) on the bottom of 411 says:

> "Isolate the cold water supply [of] the mixing valve and observe the mixed water outlet."

So having turned the cold water off, you check the tap.

> "If there is a flow stream after 5 seconds, then collect any water discharging into a suitably graduated marked vessel for 60 seconds; [and] if that volume of water collected is greater than 120 millilitres, then recommissioning or service work is needed."

So that is describing, in a measurable means, whether the valve has passed or failed its cold water shut-off.

THE CHAIR: And that is what you did not find having been recorded?

A Correct.

THE CHAIR: Right, thank you.

MR MACIVER: I have nothing additional about valves, so this would be a convenient point to stop, my Lord.

THE CHAIR: Right. It might be a time to take our lunch break, Mr Poplett, so could I ask you to be back for two o'clock?

(Adjourned for a short time)

THE CHAIR: Good afternoon, Mr Poplett. Now, Mr Maciver.

MR MACIVER: We closed before lunch by talking about incomplete testing for the thermostatic mixing valves. You recall that. There's what may be a similar issue a few pages further on at 4.14 in your report. You start-- There's section 5.9 on validation and you considered various items within that, and then, on the next page, at 597 and 598, you are, as I understand it, talking about water samples and failed results at this point. Is that correct?

A Correct.

Q You describe at 597 samples that were taken December 2014, dates in the document having shown that disinfection had been carried out 24 hours previously, on 20-- or one day previously, 20 December 2014, and a fallow period of 48 hours is required between disinfection and water sampling, and then, at 598:

> "The reports provide to show evidence of failed samples. Most of the failed areas were retested and passed on 25 January 2015 and 11 February 2015. However, there are no certificates to verify the three failed samples that are referenced as being retested on 18 January, no evidence that the system was fully re-sterilised despite the RAMS stating that to be the process following failed samples."

First question, what's RAMS?

A Sorry, risk assessment method statement.

Q The second point is that-- I ran the two paragraphs together but, in fact, I think the issues are separate. 597, you're talking about lack of a fallow period, or short fallow period.

A Yes.

Q Why is that a problem?

A Because the British Standard requires that there is 48 hours between the disinfection process and the sampling or resampling of the water systems.

Q The problem, at 598, is different, which is that where you have-- what I think you're saying is, where there's a failed sample, then not only should there be retesting of it but there should be a re-sterilisation process that takes place. When? In-between the two events?

A Yes, when you get the failed sample, depending upon the level and in line with the Trust's water policy, it specifies resampling and the number of resamples that are required before declaring a system back into full specification.

Q So, on looking back at sample records from the turn of 2014-2015, you're able to identify these two separate types of irregularities or gaps in the sampling record?

A Yes.

Q How concerned are you by those?

A It could be as simple as a typo, in which case I wouldn't be excessively concerned. However, it could be that the testing sample wasn't being followed as specified, which could have significant impact on the results.

Q At this remove, is there any light that could be shed upon either of those?

A I couldn't comment on that.

Q The next full paragraph, at 5.10, which is over at page 416, you are going on to consider here the key information necessary prior to occupation. You set out in the first bullet point list a number of assurances on-- a number of topics on which assurances would be expected to be obtained. Is that correct?

A Correct.

Q But then, below that bullet list, you are noting that there was some information that was not available or present at the time of handover.

A Correct.

Q First bullet is records relating to flushing; second is water-related-- full water-related operating maintenance information; third bullet, over the page, is the lack of an initial water safety plan, including comprehensive water risk assessment; and the fourth is evidence of Water Safety Group records. Can you explain the significance of each of those being missing, please?

A Yes. In terms of the flushing records, I think we've covered in some detail but, again, if you count evidence that the flushing took place once the system was wetted and remained wet, then that would give me serious areas of concern of potential systemic colonisation.

Operating and maintenance information, if you don't get that, ideally before the system goes into use, how can you then run and maintain it in accordance with the requirements that the O&M manual lays down? There are standard PPMs, and it is covered in other areas but, certainly for specific areas of plant, there may be specific requirements in those O&Ms, and they need to be detailed, understood, assessed and then appropriate maintenance instructions put in place prior to occupation.

An initial water safety plan should have been part of the plan at design stage. So it's not something that you think about when you hand it over, you

think about it when you are designing it and building the necessary paperwork with that respect.

Finally, the Water Safety Group terms of reference and assurance of meetings, audits, again, should all be in place prior to a system going live. It shouldn't be that you walk into a finished hospital cold and start from a standing start. You can get a lot of this work and a lot of the processes in place through the design stage so you hit the ground running, to coin a phrase.

Q Thank you. The middle of that page is a description of things that we've covered adequately already, flushing dump valves. The bottom of the page, you mention that you're going to go on to discuss four principal areas for concern in a water system and, therefore, where control is appropriate. Is that-- Am I reading that line correctly?

A Yep.

Q "Temperature flow, usage, or turnover and cleanliness." I think we've probably covered those adequately but there, the next three paragraphs and the top of page 419, is the last of those, cleanliness, but then there's another section on provision of backflow protection, 5.11.8. You mentioned backflow a little bit earlier in the context of the thermostatic valves. Over the page, at 420, there is an unnumbered paragraph where you're making reference to specific findings on backflow protection:

> "February 2020, Scottish Water bylaws inspection was undertaken which identified a significant number of instances where inadequate backflow protection issues were present, 42 items, including a number of multiples.
>
> In March 2023, a return visit was completed, and this demonstrated a significant number of areas remained to be addressed [35]. These reports and the level of progress achieved provides evidence of poor progress in rectifying identified areas of non-compliance to statutory obligations of Scottish Water bylaws."

The point you make in the last sentence is specifically about compliance. It shows that where compliance is required, it hasn't been universally adhered to. Now, presumably, that's a problem of its own?

A Yes.

Q This is all in the context of backflow and, although we touched on it earlier in terms of mixing valves, what's the backflow issue being discussed at this section of the report? Is it the same

one or something else?

A It is the same basic principle that backflow protection is, in effect, a one-way valve. So it makes sure water can flow in one direction but can't reverse and flow backwards, or back against itself.

Q Why is that important?

A There are different classifications of backflow protection. The principal one, for the TMVs, is that it is designed to prevent the mixing of hot and cold water and limit the blended water temperature to the delivery side of a TMV to the outlet. So we don't get pockets of blended water in either the hot or the cold water pipework. So the primary supply of both hot and cold remains uncontaminated, or unblended, and it's only blended at the point of use.

Q So that would prevent the temperature from feedbacking on itself and being thrown off?

A Correct.

Q Correct.

A You can also require backflow protection where you have pressure differentials within the system or you have it where the method in which you are using the water requires a backflow protection. The simplest example of that is a toilet cistern.

You have the water delivered through a float valve but there is a clear air gap between the water that sits in the toilet system and the incoming water supply. It's to make sure the water that has been stagnant in a toilet cistern cannot backfeed into the mains water feed and then go onto another area of the water distribution system.

Q So, in that paragraph that I read out to you, there isn't any specification of what the 42 or the 35 items were about. Should I understand the concern as being primarily about record-keeping than-- rather than about the-- or rather-- excuse me, about the general compliance issue rather than about any specific incidences of backflow protection which you are aware?

A The Water Supply (Water Quality) Regulations require the Water Supply Authority to undertake rolling inspections to ensure that non-domestic services are safe and appropriate. That inspection was first undertaken on 28 February and a report, which I believe is in evidence, identified the 42 areas of concern that they had in terms of compliance to those regulations. A year later or just over-- sorry, three years later, they returned and identified that 35 remained to be addressed. So it is breaches of the-- potential breaches of the Water Supply (Water Quality) Regulations, which are the responsibility of, in this case, Scottish Water Authority

to address in terms of the level of seriousness. I'm merely reporting that evidence has shown that limited progress has been made over a three-year period, reducing 42 down to 35.

Q Thank you. Two pages further on at 422, we've got a section that begins on drainage and wastewater systems. Just to summarise this, at 5.11.24, you are noting that there's a risk from the drainage system, or a potential risk, and then at 5.11.25, you give a view on how drainage should be treated and you say:

> "For this reason, in my opinion, it's essential to include elements in the internal drainage systems under the remit of the Water Safety Group and as such to include essential elements of waste management into the water safety plan and policies of the organisation."

Are you aware of whether or not the Water Safety Group now includes internal drainage systems in its agenda?

A I don't know.

Q Are you aware of any policies specifically relating to drainage system?

A Again, it is now included as part of the Estates technical bulletin issued by NHS England but I am not aware of any current amendments to policy to specifically cover internal above-ground drainage.

Q Three pages further on, at the top of page 425, you touch on drains briefly as part of a paragraph about routine cleaning. You've just made a note here that:

> "The 2007 specification advises that routine cleaning of showers, handwash basins, sinks etc., should include a surface clean of the drain and removal of any visible debris hairs by the use of tweezers."

We've heard in evidence some conflicting views or that there exist conflicting views as to the extent to which drains should be subject to cleaning at all. What are your views about cleaning disturbing drains? What should one-- How should one approach them?

A It's a very difficult topic because the problem with any disinfection process is that you can clean and disinfect a drain but the first time that it is then reused, it is re-contaminated. By their very nature, they handle wastewater with-- carrying potential contamination within them. So the efficacy of continual cleaning process is currently unproven and very difficult to be prescriptive at what frequency would be effective and, indeed, what method would be effective. Obviously, disinfecting drains is-- also has an environmental

impact, in that you are potentially adding huge quantities of disinfectant to a wastewater system, which ultimately goes through to the very closely located sewage works. So excessive disinfection is almost impossible to deliver and of limited evidence-based research to be effective.

In critical areas, current thinking is that reducing the location of drainage or water outlets, so we minimise any cross-contamination or splash from them in the immediate vicinity of clinical or patients, is the preferred option. In some cases, routine sterilisation or cleaning has been undertaken but it is incredibly difficult that the-- one of the bugs – and, I apologise, I only know it as CPE, it has an extremely long Latin word to describe it – basically comes from and lives within faecal matter, urinary. It comes from human beings. If you have a shower in a shower tray, you will wash that down into the drain. It can live and multiply very happily in that drain. The next person who enters into that shower will potentially stand on that drain cover, have their conditioner, body wash, whatever on the floor of the shower, and then colonise themselves with the infection from the previous occupant. To effectively clean and sterilise a drain in between every usage is impractical and, as I say, carries with it other considerations.

So the real final answer to that is evidence needs-- further evidence needs to be compiled and from a microbiological perspective, the efficacy and extent of cleaning needs to be agreed. There isn't currently a fixed method other than that outline which I reference within my statement.

Q Thank you. The lower half of that page is, again, dealing with types of valves and you spoke to us about that at the start but then over the page you come to the conclusion on this section of the report. So, summing up in the design, installation, commissioning process, again, in the first sentence:

> "Domestic water systems at the point of handover, patient occupation, were in a sub-optimal condition..."

You set out issues which we've looked at. You speak, the first bullet points, about filtration. Reference in the second half of that first bullet is something that I don't think we mentioned but I understand to be:

> "...very high-grade secondary ultrafiltration that was brought in as part and parcel of the change to bring in chlorine dioxide dosing in 2019..."

You note in the last sentence:

> "The reason and need for this

very high grade of filter has not been provided."

Do you have any comments to make on the installation of high-grade secondary ultrafiltration at that point at all? Does it make sense to you?

A I haven't seen any evidence of the thought process or decision process in the recording as saying-- in terms of determining that that level of filtration was required.

Q Does it make sense to you that extra filtration of any grade would be part and parcel of introducing chlorine dioxide?

A No.

Q Second bullet is, I think, a reference back to the list of-- the list or lists identified by DMA Canyon. You make reference there to preoccupation risk assessment. Is that correct?

A Correct.

Q Then three is about the commissioning process involving-- including wet testing, and you've covered that. Lack of validation is four. Five is the TMT and TMV, the valves and taps, thermostatic mixing and there's where the phrase "never event" appears and I can find earlier in the last two lines. Over the page, you identify that:

"...overall, system was not fully compliant. Issues were known and acknowledged but the system was accepted into operation. At that time, NHSGGC did not have all the necessary controls or processes in place to manage or address the potential risks as detailed in the following section."

That was section 6. Excuse me. Go back, please. The paragraph below that, just for completeness, is a different issue again. This is a specific substantive issue:

"Types of components installed within the water systems didn't minimise the number of components or elements within components and this may have provided additional surface areas or nooks and crannies where microorganisms could colonise and produce biofilm."

What do you have in mind there?

A It's an observation based upon-- that the fittings used, a number of them would have areas which could promote or at least harbour microbiological activity.

Q Which fittings?

A Flexible connections as one, the types of taps and the internal surfaces of tap outlets. Anything that had unnecessary complexity or rough surfaces all give potential for colonisation

or collection of biofilm scale and, therefore, microorganisms.

Q We've heard from other witnesses about taps and the internal surfaces of taps. Flexible connectors or flexible connections, what's the issue with those?

A Again, they are lined with different types or can be lined with different types of material and over time they can crack, which gives, again, a nook or cranny, for want of a better term, where biofilms can lodge and seed.

Q Does that include flexible hoses or----

A It does.

Q It does. The last issue you mentioned was presence of rough surfaces or unnecessary complexity. Do you have any particular fittings or pieces of kit in mind?

A Primarily taps.

Q Then the last paragraph on the page there is about backflow protection, which we've dealt with. Now, that's the end of your section 5. Section 6, over the page starts, "Maintenance and operation of the water system." So, from this point on in the report, as I read it, you are beginning to assess material regarding how the system is operated after handover?

A Correct.

Q Having, before then, looked at handover-- up to handover itself. Section 1 is dealing with the water safety plan of weak policy and you're tracing out here the evolution of those documents since 2015. Is evolution a normal process in keeping a water safety plan over premises?

A Yes, it should be considered as a live document which is continually reviewed and updated.

Q I'm particularly interested in the last paragraph of that, section 6.1.5, you're noting here:

> "Following a review of the current policy and written scheme, they appear satisfactory and comprehensive..."

Although, you're noting:

> "...a potential query relating to frequency of TMV-ETMT testing, which detailed below is six-monthly, which is compliant but referenced as quarterly within the written scheme."

Is there a substantive problem there or are you just simply noticing a discrepancy?

A Just a discrepancy.

Q You had mentioned at 6.1.4 that the written scheme is the most detailed source of instruction. You make reference there to the 2023 version of that scheme in the last line, revision H. Is that correct?

A Yes.

Q Now, among the documents that I had for you today is a slightly later version which should be in bundle 27, volume 1, at page 276. Now, it was revision H in the paragraph which I read. This is revision J, 2024. You won't, I think, have seen this. Is that correct?

A Correct.

Q But in terms of comprehensiveness of the document, which is what you were talking about when we first raised it, do we get some idea of that from-- if we go to-- on two pages, 278, is where the contents pages start and we see various items: general overview, four items; recording, five items; management arrangements and a host of sections going down to the bottom of the page, and then over the next page, there's maintenance procedures and perhaps 20 entries under that.

The one I'm interested in-- I've got a specific question about this. Well, firstly, does this indicate, in your eyes, a suitably comprehensive water written scheme for these premises?

A Without a detailed review, and considering the size of the document, it is impossible to state, but on the basis of the contents page, it looks to be comprehensive.

Q Yes, my apologies. I should have made that clear on the basis of what you can see here. This covers the sort of thing you'd expect to see. What I'm interested in is 4.1.8, which is the entry for sampling plan. If I'm right, that should be at 325 of this document. Lower half here is detailing a significant sampling regime within the QEUH campus. The block of text, the four lines there, are indicating the types of things that-- the types of organisms that are tested for, and we see some that we've mentioned – Legionella, Pseudomonas and Cupriavidus are mentioned there. It's larger now. Can you see that?

A Yes.

Q Below that we've got bullet list, "Circumstances under which samples are taken," prior alterations, handovers, part of cleaning and so forth. And then detailing of control measures in the three text-- the last three lines below that, or the fact that there should be control measures and they are a main supply sample. Now, firstly, on the basis of that relatively brief information, does that indicate that the written scheme properly addresses sampling?

A Potentially, yes. It says when they should be sampled. It says details what should be sampled for. The critical part of sampling is what to do if the results aren't as they should be and outside of control measures. So that information would be needed to comment

appropriately on the adequacy but, on the face of it, yes, it looks comprehensive.

Q There is at least one other GGC document that addresses sampling. That'll be at bundle 18, volume 2, that should be at page 459, and we see here the Greater Glasgow and Clyde logo in the top right and the heading, "Standard Operating Procedure," and the document number WQS-017, "Procedures in the event of out-of-specification sample for Legionella and other monitored bacteria..." It starts with a list of references which I don't think would be anything surprising in those nine, will there? Then heading, "Sampling and monitoring," mention of external service providers to carry that out. Do you see that?

A Yes.

Q That's specified in point one as being DMA who are designated NHS specialist water service providers to "carry out sampling within the QEUH estate of outlets on a rotational basis as follows." Then there's a table, and the table is addressing in the left-hand column particular wards or areas. Second column, particular frequency. Third, there are notes indicating various things, how many samples should be taken and so forth, and fourth is headed, "Analysis." I take that to be the which organism analysis it should be subjected to once taken. Am I correct about that?

A I don't know. It's not my document, but I would make the same presumption. I've had a very brief review of this, and I am surprised that in Ward 1D of PICU Legionella doesn't appear to feature, whereas it does appear to feature in every other clinical area listed, and I am unclear on what the analysis of "potable" relates to. Other than that, it seems extremely comprehensive and frequencies exceed the minimum standards specified in SHTM.

Q Just to illustrate comprehensiveness, the next page, the table continues. It continues for a few pages more but basically the pattern is the same: area, frequency, notes and analysis. Returning to the report, at 432, we may have covered this already, but the bottom of page 432 is where you make a point that I think-- and correct me if I'm wrong, but I think you referred to this morning that:

> "Temperature control regime is the preferred strategy for reducing the risk from Legionella and other waterborne organisms in water systems. This will require monitoring on a regular basis."

Just to clear about that, when you say "monitoring on a regular basis," are you referring to monitoring for presence

of Legionella or monitoring for whether that is still the best system to use?

A Neither. I'm referring to monitoring of temperatures.

Q Thank you, and you have indication that that's happening?

A Yes.

Q 435 is where we move from there into section 7, "Post-completion works/improvements to address identified issues present from handover." In here, the exercise is, in the first instance, to record some works that have been carried out over the period. It suffices, I think, for me to note what these are, unless you have any comments to make, and I'll give you the opportunity. Do you have anything further to say about what's said here about domestic hot water expansion vessels?

A No.

Q 7.2 is the March 2019 filtration system. We've covered that but do you have anything to-- any comments to make on it?

A No.

Q A redesign of wards 2A and 2B in March 2022 is at 7.3.

A Nothing to add.

Q And over the page at 7.4, there's a change because here you start discussing "verification of operation for water systems since handover," and by "verification", am I right in saying you simply mean the checking to make sure that things are working as they should?

A Yes.

Q 7.4.3 records an appointment made. It mentions, firstly:

> "NHSGGC had an authorising engineer for water for all properties under control of the Board. The AEW recommends the appointment of an APW."

Authorised person for water. Is that right?

A Correct.

Q However, there's no record of an APW being appointed in writing for QEUH and RHC until June 2018.

> "From handover in 2015, management implementation of planned and reactive tasks relating to water systems was undertaken by Estates officers and the Estates managers who had transferred to the new facility from other locations."

First point there is that there was an appointment that should have been made and hadn't been. Can you comment on that, please?

A No, other than there was no evidence of the appointment until the June 2018 date.

Q My fault for asking the question. Can you comment on the

significance of there being an appointment that ought to be made and hadn't been?

A It boils down to if the Estates officers and Estates managers were from previous locations and were well versed in the requirements of the management of water systems, it is probably fair to say that it is a paperwork error and wouldn't have any major impact. However, given the size, complexity and type of water systems designed and installed, the fact that the individuals who ran the system for approximately three years had no formal assessment of competency could give rise to serious concerns about the maintenance activities in those times.

Q But whether or not those were met-- those concerns were met, is not a matter that you can presumably----

A I can't.

Q -- advise on?

A No.

Q The rest of the section is where you're tracing through, among other things, the-- or you're tracing through the history of the period via among other things authorising engineers' reports. You, yourself, are an authorising engineer for water.

A I am.

Q Now, there are a number of those, and I'll take you, I think, to just one of them. If we look at 7.4.7 on the next page, you're recording firstly a written scheme being developed through the early part of 2018, and then on the sixth line, the last beginning recommendation, the sentence beginning:

> "The annual AEW [Authorising Engineer for Water] audit was undertaken in July 2018 in which the auditor noted that 'there have been significant improvements and advancements in the delivery of the water system risk reduction processes and since the previous audit was completed in 2017'."

Do you see that?

A Yes.

Q Thereafter, we've got a recording of authorised person appointments finally being made in June and August of that year. Now, in terms of the authorising engineer audit, if we go to bundle 18, volume 2, we should find at page 909-- Is this that audit?

A Yes.

Q The executive-- This audit starts with-- the date of it 23 July 2018, and that page starts with recording the previous survey and begins the general description of the site. It continues over to page 910 and then there's an executive summary recording that in the first two paragraphs-- the first paragraph that there had been a previous audit and

since then a microbiological issue in the hospital. But then noting in the last two paragraphs:

> "[It's] pleasing to note, and is worthy of positive comment, there have been significant improvements and advances in the delivery of the water-based risk reduction processes since the previous audit was completed in 2017. While improvements are to be commended, there still remain a number of issues that should be addressed. Many of these are required in the task, definition and delivery area. As an example, these include issues such as clearly defining, delivering a little used outlet flushing regime that meets the requirements of the SHTM and HSG standards."

Firstly, is that direction of progress broadly what you had noted yourself, regarding the DMA Canyon risk assessments from 2015-2017?

A Yes.

Q If we go on two pages, 912, this is where we note the recommendations. We note that on this page there's the first three of the recommendations and they're marked yellow. Yellow would indicate the lowest level of risk. Is that correct? In fact, you may not be able to answer that question.

A It's not my audit format. I couldn't comment.

Q Yes, but we have a series of recommendations on this and following pages concluding at 916-- sorry, 916 is not the conclusion. That's where it turns red. 922 should be the conclusion. Concludes with number 35. So there's a recommendation about the Water Safety Group here.

Now, I shan't take you through the other audits in the same way, but if we move back to your report, what you're doing at 747, then over the page, 748, is noting that wasn't an audit in 2019. 749 is noting the audit for 2020, and you've given a narrative about that, about many of the tasks being completed, however, with recommendations for record-keeping. Then, paragraph 10, DC 2021, another audit and the auditors reporting there was now significant improvements in all aspects of water management. Do you see that?

A Yes.

Q And over the page, again, first couple of lines of paragraph 11:

> "In 2022, the now routine audit was undertaken and the auditor reporting a high-level completion of required tasks [and further narrative]."

Then at 12:

"In 2023, the audit was undertaken and the auditor reported in regards to water systems at the hospitals that delivery of required risk reduction processes and procedures was virtually complete."

Presumably, that's a good thing?

A It is.

Q Does that show clear progress, from your point of view, throughout that period?

A Definitely, yes.

Q In fact, if we look over the page at 440, these nine-- these are the nine recommendations from the 2023 audit. The next page, 441, is returning to the question of the Water Safety Group. 7.5.1 is noting that:

"The Group should have been in place at the design stage which, failing, it should have been at handover."

Correct me if I'm wrong, but I think you referred to that earlier on as being the expected standard for the Water Safety Group. Is that right?

A Correct.

Q But then you note at 752:

"It was understood the WSG was effectively founded in 2017."

But, again, at the close of that paragraph, you're noting that:

"Since then, management of the systems and progress to address them has significantly improved."

7.6 is moving onto different questions, staffing questions. First sentence here:

"For the evidence provided and findings from the AEW audit reports, it would appear the site was handed over and became operational without an appropriate planned preventative maintenance programme in place."

And then you're going on and saying here and over the page that while there's progress you still have "concerns about resourcing and extent of staff training". Can you comment on that? What are your concerns here?

A It's more highlighting the need that as a water AE, my attitude is one that you can never have enough people to do the job. It's also to do with individuals holding multiple AP roles and not being accorded sufficient time or resources to fully or adequately complete all of their duties.

Q Over the page, at 7.7, you make a specific recommendation which is that:

"There ought to be a quarterly report from the authorised person to

the Water Safety Group."

Why quarterly?

A Two reasons, really. If you rely purely on the annual AE audit, then you could have had a problem for eleven and a half months without addressing it. A quarterly status report provides ongoing evidence of continual improvement and it also satisfies the requirements of initiatives such as the Premises Assurance Model within NHS risk management. So it's, in my opinion, a good format to keep things fresh and high on the agenda and provide written evidence that management processes are in place and continue to function appropriately unless reported by exception.

Q I think you said at the start of our discussions this morning that the default assumption you were making about the meeting period for a Water Safety Group was quarterly.

A Correct.

Q And it would tie in with that.

A Exactly.

Q So we'll look at the next page and we'll see that this closes off your consideration of operation management since occupation and then, at the page after, 445, you get to conclusions related to maintenance and operation of the water system. The first three paragraphs on that page are your summary of the

past of the system and you're noting there "defects at handover". Is that right?

A Correct.

Q Before, at 7.9, you're moving on to the separate question of the current condition and potential issues and risk.

A Yes.

Q 7.91 is noting that there are "still a number of issues in the latest authorising engineer audit" and I think there were the nine that you'd reproduced but you're downplaying – is that the right way to put it – to-- you're stressing that these issues are not uncommon. You have any comment to make about that?

A No, other than, as the water safety plan is a live document, the water systems can be seen as a live and ever-changing clinical environment. So it's something that needs constant review and adjustment as the usage of a hospital evolves and develops over time.

Q You say there that "generally the level appears to be satisfactory".

A Yes.

Q 7.92, you are saying, "The Water Safety Group is in place and operating effectively", and I think we discussed that this morning. Is that right?

A Correct.

Q Anything to add to that?

A No.

Q 7.93, noting:

> "Current water safety plan policies considered appropriate and suitable for the management of water systems at Queen Elizabeth. However, given the issues identified in the design and construction handover process, it's considered appropriate to recommend a review of the water system provision as outlined below."

And you go on to give details of what that review may consist of in the following paragraphs. Are there any particular comments that you wish to make about your suggestions there?

A No.

Q That leaves me only the final question which is-- we've dealt with the past, the second question dealt with the present. The question is, is the system no longer in an unsafe condition or is the-- What's the condition of the system now? Is it in an unsafe or safe condition now?

A As I've said previously, I think it is incredibly difficult to give a binary answer as to whether a system is safe or unsafe. What I can say is that the current maintenance practices, on the evidence that I've reviewed, appear satisfactory and the systems, subject to some underlying design issues, are being appropriately managed and maintained.

Q You mentioned two things in the last sentence there, underlying issues and appropriate maintenance-- operation and maintenance of them. Does it make sense to think about matters in these terms that one can have a system that may have flawed parts within it but so long as one works out a way to neutralise, mitigate, bring down the level of those flawed parts, then one can bring it into acceptable realms?

A Yes, with the proviso that you've also got to factor into that the other variables, such as clinical risk profiles, how various areas of the hospital are used and other interactions with water systems. So, the short answer, yes. The long answer is it needs to be kept under continuous review to ensure that the condition remains satisfactory.

Q So far as you can tell, the current means of operation and maintenance of the system are doing so?

A Yes.

Q No further questions at this point for this witness, my Lord.

THE CHAIR: Thank you, Mr Maciver. Mr Poplett, as you'll recollect from yesterday, I need to check that there are no further questions. So if I can ask you to return to the witness room and we should be able to reconvene in about 10 minutes. Thank you.

(Short break)

THE CHAIR: Mr Maciver.

MR MACIVER: There will be some questions, my Lord.

THE CHAIR: We have some additional questions, Mr Poplett. Mr Maciver.

MR MACIVER: Thank you. The first question is one where I'm in the slightly unusual position of picking up an issue that was raised in yesterday's evidence. So we're in ventilation territory. If you recall this, as part of your evidence, you were asked about newly installed ventilation into Ward 2A and it was suggested to you that there was now a separate supply and extract system had been installed in that ward. Do you recall that?

A Yes.

Q You were asked to agree whether as a result there was no risk of any cross-contamination, and you agreed with that. Do you recall?

A Yes.

Q If there were another ward where there was not a separate supply and extract ventilation system, following from that, would it mean that there was a risk of cross-contamination in that ward?

A Not necessarily. It would be determined by pressure differentials between the two adjacent spaces for

cross-contamination to exist but also if systems were isolated – supply was isolated and extract wasn't, or extract was isolated and supply was – then there-- is possible that if it serves multiple areas, there can be a risk of cross-contamination via that route. But, ostensibly, the supply continues to blow and the extract continues to suck, so it is a small theoretical risk. The greater risk is from a differentiation of pressure differentials between adjacent areas.

Q Okay, thank you. That, I think, is enough on that question. The last two questions are about the water system. The first topic is about something that we did cover which was within the report at page 428. There was a section addressing thermostatic mixing valves. It's at the bottom of the page, 621 goes on to that, and the top of next page makes clear that you're also considering the need to replace TMVs and the tap version of thermostatic medicine taps, and information of that not having been recorded. Firstly, are you aware of the Horne Optitherm taps?

A Aware of-- Not incredibly familiar with them, but, yes, aware of them.

Q Well, do they fall within the category of TMTs?

A Yes, they do.

Q Are you aware that such taps

were present at the Queen Elizabeth?

A I wasn't, but it wouldn't cause me undue concern.

Q Insofar as you do have knowledge of the taps, are you aware of whether they have specific cleaning instructions separate from the pressure testing requirements that you're describing at the passage that we've just looked at?

A That would have to be something that I did a detailed review on the O&M instructions for the particular model of tap being deployed. The general test methodology as laid out in the SHTM would not change.

Q When you're talking about testing at this passage of the evidence, are you talking about pressure testing or about cleaning or about both?

A Pressure testing is a term that was included for a brief period of months in the HTM. I would not be able to be absolute that it was included in the SHTM where pressure testing was included as part of the six-monthly testing of the TMVs. Unfortunately, it was identified after publication that the provision of in-service pressure testing would require the installation of pressure test points, which themselves could offer an area where microorganisms could settle and proliferate.

So the requirement for routine pressure testing was removed from the six-monthly requirement and it relates now to temperature, water temperatures, individual both hot and cold, blended temperatures, the fail-safe connection and a requirement to clean and clear any debris from the strainer baskets.

Q Just to focus on the cleaning question, did you see any evidence during your completion of the report that that cleaning process had been carried out with respect to either those taps or taps like those?

A From recollection, and I am working from recollection, there was a specific question on the TMV testing sheet that related to the cleaning of the strainer baskets and that indicated that it was undertaken.

Q We did hear some evidence about specific cleaning facility having been built at some point to carry out this work. Do you have any awareness of this?

A No.

Q **F**inally, if there had been-- the evidence was that that was done in around 2018. As a result of that, there was a period from 2015-2018 in which the cleaning wasn't carried out, would that be a matter of concern for you?

A Yes.

Q Any particular reason for that?

A There are multiple complex

components and parts within a thermostatic mixing valve or tap mixing valve that would give rise to potential colonisation. The six-monthly clean is one method used to make sure that they remained clear, clean and functional. So if that wasn't undertaken for three years, that would be a concern and a potential source of elevated microbial action.

Q Thank you. The last question which I have relates to a topic that you referred to very briefly in passing, a question of corroded valves and/or pipe work. Did you see any evidence of corrosion having occurred at Queen Elizabeth?

A Not from the evidence that I've reviewed.

Q Thank you. That concludes my questions, my Lord.

THE CHAIR: Mr Poplett, I feel that your evidence is now finished. So, once again, thank you very much for your attendance today and yesterday and answering questions and thank you for the preparation of your reports, but you're now free to go, but thank you again.

THE WITNESS: Thank you.

(The witness withdrew)

THE CHAIR: Well, that, I think, concludes for today, Mr Maciver. We reconvene on Tuesday, perhaps with Mr Mackintosh.

MR MACIVER: Correct, my Lord, with Drs Dempster and Mumford, I understand.

THE CHAIR: Well, I wish everyone a good weekend, and we'll see each other, all being well, on Tuesday.

(Session ends)

15:20