SCOTTISH HOSPITALS INQUIRY

Bundle of documents for Oral hearings commencing from 13 May 2025 in relation to the Queen Elizabeth University Hospital and the Royal Hospital for Children, Glasgow

Bundle 39 - Impact and Infection Risk of QEUH and RHC site choice by Allan Bennett

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Impact and Infection Risk of QEUH and RHC site choice

Prepared by Allan Bennett

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1. Introduction

1.1. The site chosen for the construction of QEUH/RHC is in the former site of the Southern General Hospital (SGH) in the South West of the city. The site is bordered on two sides by industrial areas that includes the Shieldhall Waste Water Treatment works (SWWTW) and Shieldhall recycling facility (SRF). The site selection team were aware of odour issues from both these sites before deciding on the site location as is pointed out in the Environmental Statement as well as other associated document but did not consider its presence as an important issue that would affect the selection of this site.[1]

1. In subsequent years following the opening of the hospital staff have reported regular odour problems and staff and members of the public have postulated linkage between SWWTW to incidents of infections in the hospital. As a result of these concerns I have been tasked answering the following questions in a letter of instruction from 29th of October 2024. Whether the hospital's proximity to the Shieldhall Sewage Works creates a risk of infection to patients.
2. If you are aware of any precedents or studies that demonstrate the impact, including potential infection risk, on neighbouring buildings of being in close proximity to such sites.
3. Your assessment of the primary direct impact on the selected site of pathogens leaching from Shieldhall or airborne pathogens being carried by air currents.
4. The secondary impact of the selected site with regards to the impact on the overall ventilation strategy for the QEUH/RHC and the decision to have a sealed building reliant on a mechanical ventilation system.
5. Whether the use of mitigation measures, such as the use of carbon filters, would have been appropriate to address concerns regarding the effect of odours emanating from the Shieldhall Sewage Works.
6. Your assessment of the extent to which proximity to the Shieldhall Sewage Works and the Shieldhall Recycling Centre may have contributed to the risk of vermin, including pigeons, within the QEUH/RHC.

[1] A50065250 - New South Glasgow Hospitals - Environmental Statement April 2007 - Bundle of documents for Oral hearings commencing from 28 April 2025 in relation to the Queen Elizabeth University Hospital and the Royal Hospital for Children, Glasgow - Bundle 28 Documents referred to in Impact and Infection Risk of QEUH and RHC site choice expert report by Allan Bennett - pg 187

2. Approach

2.1. To answer the questions in the Direction Letter I have assessed the site selection process undertaken before construction in relation to the proximity to SWWTW and SRF and the impact of the location on the design of the ventilation system. I then review the scientific literature for evidence of health impacts of similar facilities and evidence for generation and spread of aerosols containing pathogens. Finally, I use this information to address the questions from the letter of instruction.

3. Limitations

- I have not visited SWWTW or the SWHF and rely on a limited amount of written information on SWWTW and minimal information about SWHF.
- I have had a limited time to put together this statement and this has prevented a full literature survey being carried out on health impacts of proximity to SWWTF and SRF.
- Due to the above I have not had time to analyse any species specific infection risks i.e. whether a specific agent causing a hospital infection could have any link to either of the facilities
- There are a number of information requests I would have made to clear up some issues if time had not been limited. These include details of processes undertaken at the facilities, official odour complaints made by QEUH/RHC and vermin control records.

4. Location of QEUH/RHC

4.1. The QEUH site is situated close to one the SWWTW one of the major Glasgow STW which is sited ca200 north of the QEUH/RHC site and ca300m from the wards. The Shieldhall recycling facility is sited 200-300m to the West of hospital and its wards. It is one of four serving the Glasgow Area. The area the hospital is situated in can be described as industrial/retail on the west and north with residential properties to the East and South.

4.2. The location of a hospital in a semi-industrial site seems to be unusual. I conducted an informal study of the location of all large hospitals in a range of UK cities of similar size to Glasgow (Newcastle, Leeds, Edinburgh, Nottingham, Bristol,

Liverpool, Sheffield, Birmingham and Manchester) using Google Maps. Each of these cities has 2-4 major hospitals. The only hospital with a similar proximity to an industrial area was Wythenshawe hospital in Manchester which was close to a light industrial area on one side including a recycling centre. I could not find any hospital facility that was close to a WWTW. Most were situated in residential or university campuses. It seems to be unusual for a hospital to be close to WWTW in the UK.

5. Site Selection for QEUH/RHC and Proximity to STW

5.1. The site selection process undertaken for the new South Glasgow hospital seems to have been focussed on proximities and the ease of obtaining the land required for the site and less on the site specifics and not at all on the proximity to a major sewage treatment facility. The final decision made was between the site of the former Cowglen hospital and the National Savings bank which is surrounded by parkland and residential development and the redevelopment of the Southern General hospital (SGH) site. The SGH option seems to have been selected for reasons of accessibility for patients, lower risks and running costs although the Cowglen site had an advantage in terms of speed of completion.[2]

5.2. It seems that as the Southern General Hospital had been situated close to SWWTW for decades meant that its proximity was not considered as a major factor in the site selection process as it was an accepted part of the site. This was acknowledged by the Board throughout the site selection procedure.

5.3. The board acknowledged that a high number of consultation responses raised concerns in relation to odour from Shieldhall sewage works – it was referred to as a significant reason why the hospital should not be located there.[3]

[2] A41318056 - Report on First Phase of Consultation (Sept.2000) (& Erratum) & Invitation to Respond to Phase 2 - Bundle of documents for Oral hearings commencing from 28 April 2025 in relation to the Queen Elizabeth University Hospital and the Royal Hospital for Children Glasgow - Bundle 28 Documents referred to in Impact and Infection Risk of QEUH and RHC site choice expert report by Allan Bennett - pg 271

[3] A41318056 - Report on First Phase of Consultation (Sept.2000) (& Erratum) & Invitation to Respond to Phase 2 - Bundle of documents for Oral hearings commencing from 28 April 2025 in relation to the Queen Elizabeth University Hospital and the Royal Hospital for Children Glasgow - Bundle 28 Documents referred to in Impact and Infection Risk of QEUH and RHC site choice expert report by Allan Bennett - para 17, pg 268

5.4. GGNHSB raised this with West of Scotland Water who informed them that they had invested in excess of £1 million in the past 18 months in odour control and had planned further investment and a programme of works to deal with odour proposed for 2001 and 2002. The board stated that, 'when this programme of work is completed, all of the presently identified significant sources of odour will be largely abated. Thereafter, there will be a further programme of measurement to ensure that there will be no outstanding odour generators.'[4] It was also noted that, 'the issue of the Shieldhall Sewage Works is not, in our view, a factor that should influence the decision about future strategic configuration of hospitals, particularly since by the time change occurs West of Scotland Water's investment programme will have been undertaken and its effectiveness monitored. If an odour nuisance remains it will be necessary to press for further measures by West of Scotland Water.'[5]

5.5. The GGNHSB regarded that the odour issues were under the control of the water company who would solve it using technology and if they did not solve it then the Board would be able to put pressure on them. While investment in odour control did occur, odour complaints still occurred. I have not found any evidence that the Board officially put pressure on West of Scotland Water. It appears that the Board do not seem to have realised the operational difficulties in completely removing all odour from the sewage generated by up to 800,000 Glaswegians.

5.6. The presence of odour problems was still identified after the works of 2001 and 2022. For example, odour concerns were mentioned throughout the Environmental Statement of NHSG from 2007[6]

5.6.1. The adjacent Shieldhall Waste Water Treatment Works is currently a significant source of odour nuisance, although this is likely to reduce as a result of planned works within the next decade.

[4] A41318056 - Report on First Phase of Consultation (Sept.2000) (& Erratum) & Invitation to Respond to Phase 2 - Bundle of documents for Oral hearings commencing from 28 April 2025 in relation to the Queen Elizabeth University Hospital and the Royal Hospital for Children Glasgow - Bundle 28 Documents referred to in Impact and Infection Risk of QEUH and RHC site choice expert report by Allan Bennett - para 17, pg 268

[5] A41318056 - Report on First Phase of Consultation (Sept.2000) (& Erratum) & Invitation to Respond to Phase 2 - Bundle of documents for Oral hearings commencing from 28 April 2025 in relation to the Queen Elizabeth University Hospital and the Royal Hospital for Children Glasgow - Bundle 28 Documents referred to in Impact and Infection Risk of QEUH and RHC site choice expert report by Allan Bennett - para 17, pg 269

[6] A33010678 - NSGH environmental Statement: Chapter 13: Air Quality - Bundle of documents for Oral hearings commencing from 28 April 2025 in relation to the Queen Elizabeth University Hospital and the Royal Hospital for Children Glasgow - Bundle 28 Documents referred to in Impact and Infection Risk of QEUH and RHC site choice expert report by Allan Bennett - pg 337

5.6.2. The Scottish Pollutant Release Inventory lists several installations within a distance of 1 mile of the hospital site (www.sepa.org.uk/spri/index.htm). These include the Shieldhall Wastewater Treatment Works (WWTW) which is immediately to the north-west of the site, at a distance of less than 200 m at the closest point. The WWTW is listed by the Scottish Executive as being amongst the 35 WWTWs with the greatest record of public complaint about odour. There was a discernible sewage odour within 300 m of the WWTW on a blustery March day when the site visit was undertaken. Odour nuisance on warmer, stiller days would be expected to be considerably greater. Work to upgrade in order to reduce odour emissions is scheduled to be undertaken between 2010 and 2014.

5.7. SRF was also identified as a source of odour (and dust)

5.8. The civic amenity site is a potential source of odour and dust nuisance with odour clearly discernible when the site visit was undertaken.

5.9. The potential for infection risk from either premises not regarded as an issue.

5.10. The odour issue from the STW was also raised in the Design Solutions Report from July 2007 in which it is stated that[7]

5.10.1. The works are situated approximately 400 meters from the proposed development (see Figure 28). The works are the largest Waste Water Treatment Works in Scotland, serving 800,000 people (this is very large). Conversation with Scottish Water have revealed that there are issues with five storm tanks each of which hold 1,000,000 gallons of storm water. In adverse weather, all water and raw sewage is diverted here. It then needs to be processed but the tanks are too large for odour to be contained and a lot of odour is created and released. This generates a large volume of complaints, especially in the summer. They have attempted to empty the tanks at night but are often compelled to empty them more frequently to allow for more storm water. All normal sewage inlet channels are covered but money for more comprehensive odour control such as containment of the storm water tanks requires significant capital investment. There are plans to upscale a project

[7] A48943284 - Design Solution Report - 2007 - Scottish Hospitals Inquiry - Hearing Commencing 19 August 2024 - Bundle 17 - Procurement History and Building Contract PPP - Page 1729

injecting an enzyme into the sludge which is claimed to dramatically reduce odour. Scottish Water is looking at options for containment on the site or even relocation but there is no certainty with respect to either scope or program for this at present.

5.11. Finally, they state (paraphrased)

5.11.1. An odour problem will be present at time on the proposed site of the NSGH caused by the STW. Odour is best treated at source and measures to control odour at the site could be implemented by the Scottish Government and Water Authority.[8]

5.12. In the Full Business Case from 2010 there are many references to clean and safe environment and to pleasant healing environment and engaging but not mention of STW or odour mitigation. The impact of SWWTW on the environment of the hospital was not taken into consideration.

5.13. In the NSGH site masterplan from 2009 it is stated that “the adjacent SWWTW is currently a significant source of odour nuisance, although this is likely to reduce as a result of planned works within the next decade”[9]

5.14. In FMR Report - Children's Hospital Consultation Event Summary Report - May 2006 - pg. 7[10]

5.14.1. The proximity of the Southern General to sewage works and the potential risks this may present was also raised. Medics present reassured participants that no links between sewage works and infections in this way had been proved. It was recognised that the related odour may not be pleasant but

[8] A48943284 - Design Solution Report - 2007 - Scottish Hospitals Inquiry - Hearing Commencing 19 August 2024 - Bundle 17 - Procurement History and Building Contract PPP - Page 1729
[9] A35186608 - New South Glasgow Hospitals Masterplan 2009 - Bundle of documents for Oral hearings commencing from 28 April 2025 in relation to the Queen Elizabeth University Hospital and the Royal Hospital for Children Glasgow - Bundle 28 Documents referred to in Impact and Infection Risk of QEUH and RHC site choice expert report by Allan Bennett - para 9.9.1, pg 420
[10] A50285760 - FMR Report - Children's Hospital Consultation Event Summary Report - May 2006 - Bundle of documents for Oral hearings commencing from 28 April 2025 in relation to the Queen Elizabeth University Hospital and the Royal Hospital for Children Glasgow - Bundle 28 Documents referred to in Impact and Infection Risk of QEUH and RHC site choice expert report by Allan Bennett - para 2.2.6, pg 435

that this could now be addressed under new legislation (as it is now classified as a public nuisance).

5.15. The Scottish Government issued a Code of Practice on Assessment and Control of Odour Nuisance from Waste Water Treatment Works in April 2005[11]. This states

5.15.1. It is acknowledged at the outset that these facilities are likely to produce odours from time to time. This Code of Practice (CoP) provides a framework within which Scottish Water and its contractors, other WWTW operators and local authorities can operate to minimise the impacts of such odours and identify steps to tackle odours of a significant nature.

5.15.2. This document details complaints procedures and methods in which odours can be reduced from WWTW processes using “best possible means”.

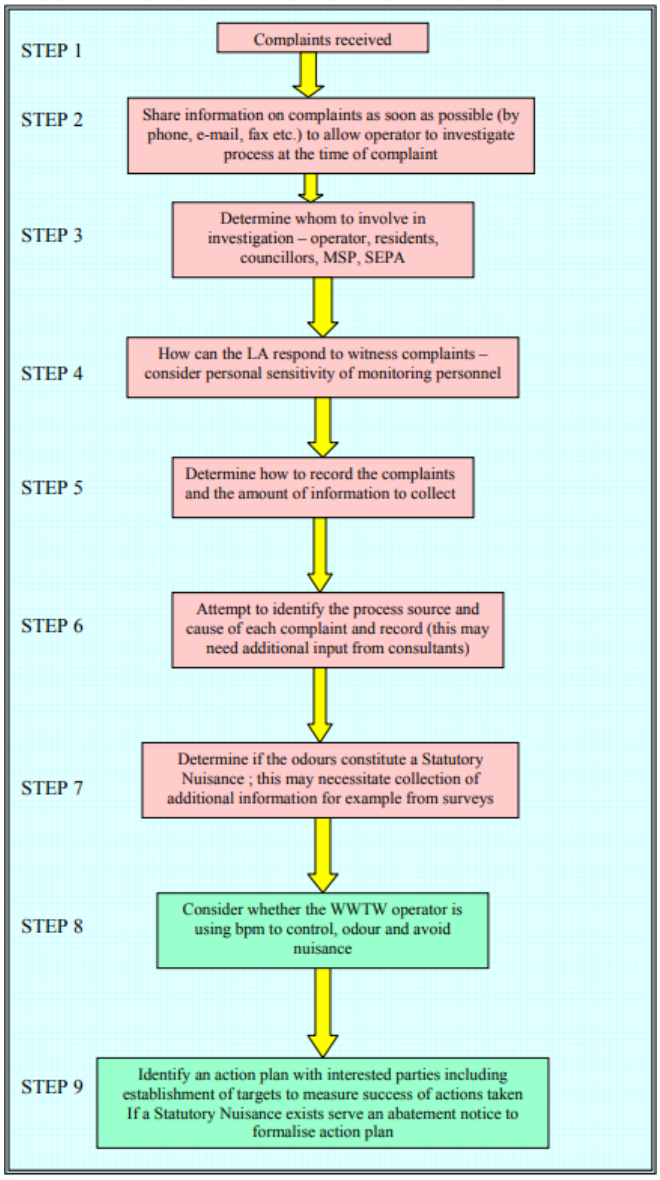
5.16. It states that

5.16.1. The locality of a process site will influence the assessment of the potential for odour impact – for example the location of a very sensitive land use such as a school or hospital close to a WWTW would result in a different threshold for establishing the presence of a nuisance compared to a commercial land use.

5.16.2. A flow chart is included for dealing with complaints

[11] Code of Practice on Assessment and Control of Odour Nuisance from Waste Water Treatment Works - https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2005/04/code-practice-assessment-control-odour-nuisance-waste-water-treatment-works/documents/0011715-pdf/0011715-pdf/govscot%3Adocument/0011715.pdf - Para 1.1, pg 5 - [Accessed 25/10/2024]

FIGURE 2 – ODOUR INVESTIGATION FLOW CHART



5.17. It is not known whether this complaint mechanism was initiated on behalf of QEUH/RHC throughout the construction and operation phases, how many times it was initiated and what action was taken.

5.18. It is clear from the range of witness statements and the oral hearings that the odour from the SWWTW was a major concern at QEUH/RHC and continues to be. For example,

> 5.18.1. there were smells coming constantly, really sickening smells to the fact that you're actually walking and you're actually going to vomit, it's that bad, from the sewage site next door[12]

[12] A34945117 - Hearing Commencing 20 September 2021 - Day 13 - 07 October 2021 - AM Session - Transcript - Aneeka Sohrab - https://www.hospitalsinquiry.scot/inquiry-document/transcript-aneeka-sohrab-7102021 - column 33, pg 19

5.19. There seem to have been assumptions that with time the sewage odours would have been prevented by incorporation of technology through capital works at SWWTW and that the QEUH would be able to pressure for such work if the odour nuisance continues.

6. Impact of Odour Issues on Hospital Ventilation Design

6.1. While the odour issues from the SWWTW did not impact on the site selection process it did impact on the design of the hospital ventilation systems. The Design Solutions report document states:

> 6.1.1. Increasingly stringent national and European environment regulation on air quality has resulted in the development of new filters to reduce and remove odours and chemical fumes from the workplace. An odour problem will be present at time on the proposed site of the New South Glasgow caused by the WWTW at Shieldhall. Odour control is best treated at source and measure at source could well be implemented by the Scottish Government and Water Authority, if odour control at the hospital is deemed necessary, activated carbon filtration is the most suitable technology both in terms of effectiveness and cost. However, it would rely on a sealed building with a mechanical ventilation system throughout any odour treated areas.
>
> 6.1.2. It is proposed that mechanical ventilated systems are fitted with activated carbon filters to remove odour from ventilation air. The buildings are to be made air tight to reduce infiltration of untreated air.

6.2. The Brookfield User Guide stated

> 6.2.1. The issue with the problem of odours from the adjacent sewage works in association with the design of the mechanical ventilation has been addressed with the provision of carbon filters on the fresh air side of the air handling units[13]

6.3. and

> 6.3.1. The building is largely sealed with limited openable windows in order

[13] A36337710 - Brookfield - Ventilation and Air Treatment Design Strategy - Volume 3 - Section 3.9 - Bundle of documents for Oral hearings commencing from 28 April 2025 in relation to the Queen Elizabeth University Hospital and the Royal Hospital for Children Glasgow - Bundle 28 Documents referred to in Impact and Infection Risk of QEUH and RHC site choice expert report by Allan Bennett - pg 446

to control the internal environment within the spaces and limit the impact of odours from the Scottish Water works adjacent to the site[14]

6.4. And from the NSGH employee's requirement document

6.4.1. 8.1.8.6. Consideration shall be given to the odours from the adjacent sewage works and appropriate filtration shall be included to reduce odours entering the facility.

6.4.2. 8.1.8.7. Special consideration shall be given to the reduction of strong smells within the Children's hospital in accordance with SHPN23[15].

6.5. And from ZBP ventilation specification

6.5.1. The building is largely sealed with limited openable windows in order to control the internal environment within the spaces and limit the impact of odours from the Scottish Water works adjacent to the site Space for the future installation of impregnated carbon filters shall be provided in all supply AHUs due to the Hospital site being in the same district as the Scottish Water sewerage works.

6.5.2. Due to the Hospital site being in the same district as the Scottish water Sewerage works it is considered that large amounts of natural ventilation is not a practical solution. The Sub-contractor shall allow for a specialist consultant to test the air and advise on the type of impregnated carbon to be utilised Carbon filters shall remove gases and vapours from the air stream and are graded according to the range of substances they can remove. Carbon filters shall be impregnated carbon suitable for the atmosphere on the site. The carbon used shall have the correct dwell time for the conditions. This shall include the sewage works and the helicopter exhaust[16].

6.6. Therefore, the proximity to Shieldhall WWTW and the odour issues has been a major contributing factor in proposing a design of a fully sealed mechanically ventilated hospital with the planned use of activated carbon filters to avoid ingress of

[14] A34297009 - Brookfield Multiplex: Building Users Guide (General) - Bundle of documents for Oral hearings commencing from 28 April 2025 in relation to the Queen Elizabeth University Hospital and the Royal Hospital for Children Glasgow - Bundle 28 Documents referred to in Impact and Infection Risk of QEUH and RHC site choice expert report by Allan Bennett - pg 538

[15] A33010628 – NHS GGC, 'NSGACL - Invitation to Participate in Competitive Dialogue Volume 2/1 Employer's Requirements (Hospitals)' - Scottish Hospitals Inquiry - Hearing Commencing 19 August 2024 - Bundle 18 - Documents referred to in the expert report of Dr J.T. Walker - Volume 1 (of 2) - Page 991

[16] A36939897 – ZBP Engineering Services Specification - August 2012 - Scottish Hospitals Inquiry - Hearing Commencing 19 August 2024 - Bundle 23 - Queen Elizabeth University Hospital and Royal Hospital for Children, Isolation Rooms – Page 98

odours.

7. Decision to Remove Carbon Filters from the Supply Air System

7.1. Throughout the design stage of the QEUH project the use of carbon filters had been proposed to reduce odour nuisance from the SWWTW. However, when the hospital was constructed carbon filters were not installed in ward supply air systems. From documents Early Warning 38

> 7.1.1. The Board advise that they do not want carbon filters installed in the new A & C Hospitals. The Board however wish to retain the option to have carbon filters installed into the Air Handling Units.

7.2. A later Early Warning suggests that thus may have been done for reason of cost

> 7.2.1. The Board advise that they do not want carbon filters installed to the A&C Hospitals. (Cross reference EW 036). The Board wish to understand the cost saving of a) not fitting carbon filters to Air Handling Units which allow for the Carbon Filters to be (sic)

7.3. Another document suggests that another reason for removing the carbon filters was to reduce the Carbon usage of the hospital[17].

7.4. The final decision was taken in Project Manager Instruction No. 157: Carbon filters

> 7.4.1. Delete provision and installation of carbon filters and filter support infrastructure for the Adult and Children's Hospitals. All associated air handling equipment should be re-sized to suit, and this may include fan motor size. Please provide associated cost saving.

7.5. Therefore, carbon filters were removed from the design for reasons of cost saving, environmental factors and potentially, an assumption that the odour generated from the WWTW would be reduced due to measures taken by the water company.

8. Odour Generating Sources in Vicinity of QEUH/RHC

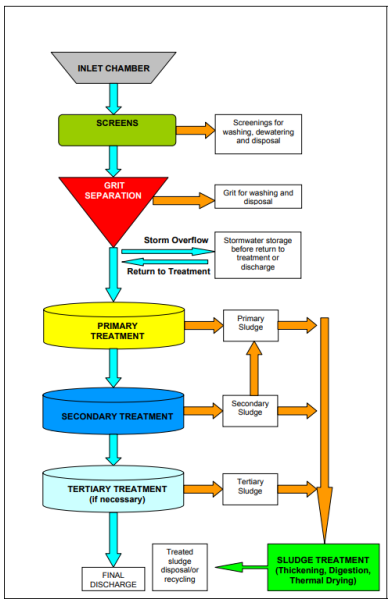
[17] Ecoteric LTD low carbon tracker seventh contract issue - https://www.jacobs.com/projects/shieldhall-tunnel - [ACCESSED 25/10/2024]

8.1. Shieldhall WWTW

There is only limited information openly available on SWWTW and I was unable to visit the site. Web sources state that SWWTW were originally constructed in 1910 and rebuilt in 1980[18]. In 2018, a huge tunnel was built (Shieldhall Tunnel) to support waste coming from areas served by Shieldhall WWTW. In 2019, Shieldhall WWTW itself had major upgrades to "improve wastewater and sewage treatment"[19]. There are also further ongoing upgrade works[20]. One of the main sewer lines which runs to Shieldhall is currently being upgraded (expected to end Nov 2024)[21].

8.1.1. It is difficult to obtain information on the processes undertaken at SWWTW. The best source has been the "Crew Odour management and monitoring in Scottish waste water treatment plants" paper from 2016 which

FIGURE 1 – WWTW PROCESS FLOW SHEET



assesses five Scottish WWTW including Shieldhall. It included the following figure which gives a useful overview to the type of sewage treatment processes undertaken at Shieldhall.

8.1.2. They describe SWWTW as a large works dealing mainly with domestic

[18] The Glasgow Library - Shieldhall Sewage Works - https://www.theglasgowstory.com/image/?inum=TGSE00323&t=2 – [ACCESSED 25/10/2024]
[19] Glasgow's wastewater modernisation goes with the flow - ECS Engineering Services - https://www.ecsengineeringservices.com/glasgows-wastewater-modernisation-goes-with-the-flow/ 20 - [ACCESSED 25/10/2024]
[20] WGM Engineering project - Shieldhall Preliminary Works - https://wgmengineering.co.uk/projects/shieldhall - preliminary-works/ - [ACCESSED 25/10/2024]
[21] Kings Inch Road Sewer Upgrade - Scottish Water - https://www.scottishwater.co.uk/About-Us/News-and-Views/2024/01/290124-Kings-Inch-Road-Sewer-Upgrade - [ACCESSED 25/10/2024]

effluent. Odour control is provided for its sludge handling . The inlet works (screening and grit removal) is covered but without odour control. Significant investment investment in odour control was noted.

8.1.3. It is stated that due to its proximity to QEUH odour problems do occur especially in summer months and are considered inevitable when treating a large quantiy of sewage close to a hospital. Engagement with neighbours was encouraged to create a dialogue

8.1.4. The type of processes undertaken may include those described below

- Screens – Raw sewage is put through screens to remove solid material (e.e condoms, sanitary products, wet wipes that will interfere with downstram processes. These solids may be removed by an operator from screens by hosing them off the screens whch can generate an aerosol or can be removed mechanically. Since this is done with raw sewage there is the potential for the presence of pathogenic agents assocated with faeces. This is carried out in buildings on the Shieldhall site

- Grit separation – This can be done by sedimentation

- Primary treatment – wastewater sits in primary clarifiers to allow impurities to settle to the bottom or float to the to top to be skimmed off.

- Secondary Treatment – biologicial processes are used to further remove solids. In SWWTS it appears an aerated systems is used[22] in which air is introduced to facilitate biological processes.

8.1.5. Waste Handling Facilities at Shieldhall Recycling Centre, Renfrew Road, Glasgow, G51

8.1.6. One of the four Glasgow recycling centres is located ca250m to the west of the QEUH site. This centre collects a wide range of waste from city residents which it collects and sorts, re-packages and send to waste sites. This includes garden waste. It seems possible from visual evidence on Google maps that this is also a waste transfer facility where the waste from domestic waste trucks is repacked in containers before taken to a landfill sites. These

[22] A49919150 - Odour management and monitoring in Scottish waste water treatment plants - Bundle of documents for Oral hearings commencing from 28 April 2025 in relation to the Queen Elizabeth University Hospital and the Royal Hospital for Children Glasgow - Bundle 28 Documents referred to in Impact and Infection Risk of QEUH and RHC site choice expert report by Allan Bennett - chapter 3, pg 457

processes can cause aerosolization of microorganisms found in domestic waste which will be discussed later.

8.1.7. Potential odour problems from this site were mentioned by CREW in 2016[23].

9. Infection Hazards from Waste Water Treatment Works and Waste Handling Facilities

9.1. There have long been concerns about the impact of working in WWTW and WHF on worker health and for those in the vicinity. These concerns can be broken down into those associated with infections and those associated with exposure to high levels of non-pathogenic agents resulting in immunological conditions such as occupational asthma and other allergic symptoms. The former conditions are the only ones relevant to the potential for hospital infection. More recently there are concerns that WWTW may play a role in the exchange of genes for antibiotic resistance mechanisms (Environmental Agency 2023). In a recent report they state that "WWTWs are 'mixing pots' of AMR and antibiotic-laden waste from humans and animals, and treatment of sewage involves various aerosolising processes". An additional concern about having a hospital close to a WWTW or WHF is that there will be a population of immunocompromised patients who have increased susceptibility to opportunistic pathogens present in these facilities.

9.2. The predominant hazard to those outside the facilities will be exposure to aerosols of opportunistic pathogens generated through procedures being undertaken at these facilities which will be carried from the facility into surrounding areas. In the case of QEUH/RHC this will be a distance of ca300m from a ground level source to the hospital and to the air intakes for the wards which are 12 floors above the ground level. For an aerosolised microorganism to make this journey the following factors play a role

- **Dissemination and dilution** – Most air sampling data for aerosols generated in these facilities are measured at the source. As distance increases from the source the concentration will reduce as the air mixes with cleaner air. This will be weather dependent varying with wind speed and direction.

[23] A49919150 - Odour management and monitoring in Scottish waste water treatment plants - Bundle of documents for Oral hearings commencing from 28 April 2025 in relation to the Queen Elizabeth University Hospital and the Royal Hospital for Children Glasgow - Bundle 28 Documents referred to in Impact and Infection Risk of QEUH and RHC site choice expert report by Allan Bennett - chapter 4.1, pg 468

- **Deposition and particle size** – There is a relationship between the size of an aerosol particle and its deposition velocity. The larger a particle the quicker it will fall back to the ground and shorter the distance it will travel.

- **Aerosol survival** – Airborne micro-organisms can lose viability by the stresses of aerosolization (drying, oxidative stress) and by environmental factors such as UV, pollution and humidity. However, some microbial have evolved resistant structures such as fungal spores which facilitate airborne dissemination and long distance transmission of pathogen such as *Legionella* have been reported from epidemiological and meteorological evidence. (Nhu Nguyen et al 2006)

9.3. To assess possible infection hazards from SWWTW and the WHF I have carried out a short unstructured non-comprehensive review of openly available information (openly published full texts or in some cases only abstracts) on microbial aerosol generation from such facilities. I have aimed to focus on papers either measuring or modelling airborne microbial levels downwind of these facilities. I have searched for epidemiology papers monitoring health impacts in the vicinity of such plants but was unable to find any relevant papers.

9.4. Airborne micro-organisms generated from WWTW

9.4.1. A limited number of studies have been conducted to assess generation of airborne micro-organisms from WWTW in countries such as USA, China, Poland etc. Such studies are subject to multiple variables such as those associated with the sampling method (equipment, method, duration) sampling site, sampling time (time of day, time of year,), sampling position (which process, downwind or upwind etc) and organisms of interest (virus, bacteria, fungi). There are also many different ways of processing sewage and different volumes of throughput so there are not direct comparisons to the facilities located at Shieldhall. There is no perfect set of data and data is lacking for the UK, so we are reliant from data from countries such as the US. China and Poland which may have different types of WWTW. Nevertheless, these studies can give us an indication of any potential hazards caused by such facilities. However, it has to be borne in mind that there is often inherent bias in these

studies and researchers are often inclined to overstate the risk posed by these facilities.

9.4.2. In 2011 Korzeniewska carried out a comprehensive review of the current knowledge of bacteria and fungal emission from wastewater treatment plants. Her data suggest that the air downwind of WWTW has a higher concentration of Enterobacteriaceae up to 200m from WWTP as compared to control sites or upwind sites (Table 1). However, the significance of this increase and the quantification is uncertain. Korzeniewska reports that the Citrobacter, Enterobacter, Klebsiella, Serratia and Pantoea were the predominant bacterial species in the air around the WWTF. However, at longer ranges only limited species of Enterobacteriaceae were detected. Fungal species and concentrations sampled upwind and 200m downwind of the WWTF were similar with Mucor and Aspergillus represented in both samples as was the case with yeasts such as Candida and Cryptococcus suggesting an alternative environmental source of fungal and yeast aerosols. On the basis of this data, it is difficult to specify a risk or quantify any risk posed by WWTW as the contribution of other factors to the microbial population is unknown.

9.4.3. A further paper from the same group (Gotkowska-Płachta 2013) did not detect any Enterobacteriaceae or yeasts outside the perimeter of the WWTF.

9.4.4. Fannin et al (1977) detected ca 100 coliforms per m^2 at an activated sludge plant in the US. Fannin et al (1985) showed that when a WWTF was started up the total levels of bacteria found 250m downwind of the facility increased by c4 fold using one air sampling method but not with an alternative method. Total bacteria levels were not high ca200 per m^3. However, the concentration of potential pathogens such as faecal coliforms, enterococci in the air etc were always low less than 10 per cubic metre and there was no evidence of elevated levels at over 150m from the plant. In fact, levels were less than 1 per m^3 at this distance.

9.4.5. Brandi et al (2000) also looked at the impact of a new WWTW on airborne microbial levels. They found increases in the levels for total bacteria to

400-600 per m^3 , to 1000-1200 for total fungi, 150 for coliforms, 35 for enterococci and 50 for *E. coli* after plant operations. They measured levels at 2m and 20m downwind and did not find significant decrease in microbial aerosol between these distances.

9.4.6. Blatny et al (2008) detected *Legionella pneumophila* in the air 200m downwind from a biological treatment plant. However, this was not a domestic WWTW but an industrial facility for wood processing.

9.4.7. There are dispersion models available that can be used to predict the dissemination of micro-organisms and other materials from a site, and these have recently been reviewed by van Leuken et al (2016). Li et al (2013) combined air sampling results for mesophilic bacteria taken downwind of a rotating brush aerator with a Gaussian plume model. With this combined approach they measured the potential exposure of adults and children at 100m and 300m from the plant (Interestingly they mention that the Chinese government regulation imposes a building restriction of 300m from sewage treatment facilities). They found by air sampling that there was a drop off in concentration of airborne total bacteria from 3.3 x 10^4 per m^3 at source down to 20 per m^3 at 100m downwind (Air velocity 0.4 m/s). They used this data in their dispersion and exposure modelling to show that the exposure at 300m was ca 10,000 times less than at source.

9.4.8. Stellacci et al (2010) carried out a QMRA assessment of an Italian WWTW based on plume modelling and found that the local setback distance from the plant (300 m) appears generally adequate to minimize health risks for nearby residents. They mention that the Italian national regulations were for a 100m setback of buildings from sewage treatment plants.

9.4.9. A more recent concern is the potential for WWTW to act as places facilitating transfer of antibiotic resistance genes and their subsequent dissemination. Gaviria-Figuorea (2019) state that preliminary Antibiotic resistance gene (ARG) dispersion modelling of a WWTW estimated an ARG emission rate of ~10,620 genes per hour from the liquid sludge and indicated that the bioaerosols have the potential to be carried kilometres away from the

WWTP source based on wind speed. The overall results from this study suggest that bioaerosols generated during WWTP processes can aid in the emission and dispersal of bacteria and ARGs, resulting in a possible route of human exposure and deposition into surrounding environments. Korzeniewska and Harnisz (2013) sampled the air at a WWTP for extended-spectrum beta-lactamase (ESBL)-positive Enterobacteriaceae and found that 23.8% of samples were positive.

9.4.10. In summary, I have only found very limited, low quality data on the microbial aerosol generated by sewage treatment plants. The limited literature in this field is suggestive that the hazards of sewage treatment are mainly contained in the plant. The general consensus from these studies is that the risk of dissemination of significant concentrations of micro-organisms from these facilities is low at distances of 200/250m. Risk assessment modelling carried out suggests that exposure risks will be greatly reduced at 100m and 300m downwind of the plant.

9.5. Airborne micro-organisms generated from WHF

9.5.1. Waste handling facilities will vary greatly in size, amount and types of waste handling and the type of processes undertaken. As previously mentioned, I have very little information about processes undertaken at Shieldhall recycling centre. I have limited my searches to papers on domestic waste handling and have ignored papers on subjects such as waste composting and landfill sites. As with sewage facilities most research has focussed on exposure of workers to pathogens during work processes and there is limited information about dissemination of airborne micro-organisms beyond the perimeter of the site. However, there is more data available in this area particularly from the UK and Northern Europe.

9.5.2. Poulsen et al (1995) reviewed the state of the area on microbial air sampling of waste transfer and separation concentrating on worker exposure. They included studies from various European countries such as the UK, Denmark, Sweden and Holland. The levels of airborne micro-organism per cubic metre were highly variable with the concentration of total bacteria varying

between 0-10^6, Gram negative bacteria 0 – 2 x 10^5, Enterococci 0-10^4 and fungi from 10^2 to 10^6. In the Swedish/Danish study level of bacteria were 10^3 - 8 x 10^4 Gram negatives from 0- 2 x10^4 and fungi from 0 to 10^5. Peak levels are higher than those reported from WWTW.

9.5.3. Madsen et al (2019) measured worker exposure in an indoor waste handling facility for cardboard and found that workers were exposed to 1,000 fungal spored per cubic meter, one of the species detected was *Aspergillus niger* a known cause of opportunistic infections in hospitals. Ghanbarian et al (2020) also found similar levels of *Aspergillus niger* in a waste processing facility in Iran.

9.5.4. A large review of studies carried out by Madsen et al (2020) on waste collection worker exposure to microbial hazards using personal samplers, from the collection of waste to its handling and sorting showed that workers were generally exposed to levels of 10^4 bacteria and 10^5 fungi per cubic metre during collection and sorting of various types of waste.

9.5.5. Lavoie and Guertin (2001) carried out a programme of microbial air sampling around three waste handling facilities in the summer and winter. Their methods were based on an ASTM standard (ASTM 2017). Samples were taken inside the plant, 300m upwind and 100m downwind of the plant. In the plant samples they found levels of bacteria per cubic metre varied from 530 to 2.2 x 10^4, fungi from 450 - 1.9 x 10^4 and Gram negative bacteria from 0 to 520 The levels of micro-organisms found downwind and upwind of the plant were always of the same order of magnitude and their seemed to be no significant difference between these levels suggesting that the plants was not causing significant increases of microbial aerosol 100m downwind from its perimeter.

9.5.6. Abromaitis et al (2010) carried out air sampling inside and outside a waste sorting building in Lithuania on five separate dates from July to September. They found levels of airborne bacteria averaging 3.8 x 10^4 per m^3 inside and 3.1 x 10^3 outside.

9.5.7. Mat et al (2023) found average bacteria concentration per m^3 of 1.0 x 10^4 at 5 m, 7.4 x 10^3 at 10m and 4.0 x 10^3 at 15m from the sorting plant. They report finding 39 species of potential pathogens. However, another study by Liu

et al (2024) of four WTS found lower levels of bacteria between 50 and 250 cfu.m^3

9.5.8. Lu et al (2022) detected ARG in the air of a waste sorting station in China.

9.5.9. Ncube et al (2017) attempted to systematic critical review of epidemiological studies on public health concerns of municipal solid waste handling. Their conclusions was that overall epidemiological evidence in reviewed articles is inadequate mainly due to methodological limitations and future research needs to develop tools capable of demonstrating causal or non- causal relationships between specific waste management operations and adverse health endpoints. In their review they did not find any papers looking at impacts of proximity to waste handling stations.

9.5.10. In summary, waste handling is capable of creating high concentrations of airborne micro-organisms to which workers are regularly exposed including *Aspergillus niger*, an important hospital pathogen. Despite lack of high-quality studies, it seems likely that these levels will be sporadic and process linked. There is limited evidence that these levels are reduced outside such facilities and only one study of long distance spread.

9.5.11. However, WHF do have the potential for generating high concentration of fungal opportunistic pathogens species such as *Aspergillus niger* which could potentially be hazardous to immunocompromised patients.

9.6. Can airborne micro-organisms from Shieldhall waste sites enter the hospital ward supply air.

9.6.1. SWWTW is situated to the North of QEUH hospital site. It is closer to non-clinical areas of the hospital such as the laboratory buildings, which seem to be more prone to odour nuisance, which will partially block any flow of air

from the SWWTW to the wards of the QEUH/RHC. The prevailing winds in Glasgow are from the west to south west and northerly winds are rare[24]. It would seem unlikely that under normal air conditions that many airborne micro-organisms would be carried in wind currents from the SWWTW to the air intakes of the hospital. Even under stagnant air conditions dilution, deposition and loss of viability is likely to reduce any potential transport of significant levels of potential pathogens generated at the SWWTW to enter the air supply of the hospital.

9.6.2. The location of the SWHF is directly west from the wards of RHC/QEUH. The prevailing wind direction is from the SWHF to the RHC/QEUH and there are no significant buildings in between. This would allow a theoretical path for airborne micro-organism from this facility to the wards and possibly under some situation towards the air intakes. However, I cannot make any comments on the likelihood of this occurring for the following reasons.

- Lack of knowledge of processes undertaken in the facility and the likelihood of them generating aerosols
- Lack of data on dissemination of microbial aerosol from such a facility over distance
- Inability to calculate likelihood of the air from the facility entering hospital air supplies

9.6.3. However, most of the work within the SRF seems to be carried out indoors which would reduce the amount of aerosol that would leave the premises and the dispersion studies for WWTW mentioned above suggest significant dilution of aerosol at 300m from the source. However, there is a potential for generation of aerosols of fungal pathogens from WHF processes such as *Aspergillus niger* in such a site which could be a concern where immunocompromised patients are housed. However, due to the distance from SWHF and the unknown levels of these fungal opportunistic pathogens in

[24] Wind & weather statistics Glasgow Airport - Windfinder - https://www.windfinder.com/windstatistics/glasgow - [ACCESSED 25/10/2024]

urban air it is difficult to state conclusively this is an infection risk for the hospital. However, if there is an infection risk it is heightened when immunocompromised patients are not housed in HEPA filtered rooms.

Vermin control SWWTW and recycling centre

9.7. I have no information about the processes undertaken in the SWWTW or SRF and vermin control at these sites. If domestic waste is being handled or other food waste at the SRF then there is a potential to attract vermin including rodents, pigeons and gulls. However, this should be controlled by good hygiene, monitoring and cleaning practices. The same holds for the SWWTW. Without site visits or site records of vermin activities and vermin control I cannot comment. However, the independent review authors visited SWWTW and stated that Scottish Water maintains the facility effectively to agreed standards which suggest that vermin control was in place[25].

10. Other Opinions From Hearing Transcripts and Witness Statements

In written witness statements and transcripts from the hearings several participants expressed views on issues surrounding the proximity of QUEH/RHC to the SWWTW. Most of the participants views can be expressed as concern about the impact of the nuisance odours but also acceptance of a lack of a link between the SWWTW and infections in the hospital. Dr Inkster, has considered the infection risk but states that

> While the smell of the sewage works at the QEUH site is unpleasant, I am not convinced the proximity of these works is a problem in terms of infection risk. The outbreaks/incidents I managed all had much more viable hypotheses than a neighbouring sewage plant.[26]

Sandra Devine also did not believe that SWWTW was an infection risk and indicated that the smells from the SWWTW were climate and wind direction dependant.

[25] A32385767 – Independent Review Report - June 2020 - Scottish Hospitals Inquiry - Hearing Commencing 19 August 2024 - Bundle 27 - Miscellaneous Documents - Volume 9 - Page 188
[26] A49611376 - Dr Teresa Inkster - Witness Statement - Final - Glasgow 3 hearings - 09 August 2024 – Scottish Hospitals Inquiry - Hearing commencing 19 August 2024 - Witness Bundle - Week Commencing 30 September 2024 - Volume 7 - Pg 145

Annette Rankine also states that when she worked at the Southern General Hospital between 1985 and 1995 that

> she was aware of the smell when working at the Southern General but was "absolutely not" aware of infections that people working there at the time sought to attribute to the sewage[27]

The recollection of Penelope Redding about working in the Southern General Hospital was similar. However, Dr Redding raised issues of potential contamination of the hospital water supply from leaking sewers while accepting that she was not qualified in this area. Dr Peters also brings up the possibility ofcontamination of the ground with sewage contamination and also says

> I do think that there could be the risk of airborne microbes in the air. Whether that's enough of a bio-burden in the air to reach, when there's so much wind up there, to be enough to get in through the ventilation system to cause infection, that would require some pretty careful study
>
> I think it's theoretically possible, but I don't think it's-- it doesn't jump out at me.[28]

Dr Tom Makin, an independent water consultant expressed concern about the location of the hospital next to the SWWTW. He stated

> I was concerned regarding possible implications for the hospital and its patients arising from potential increased transmission of microorganisms from the sewage treatment facility. Airborne transmission of microorganisms from sewage treatment works is well documented.[29]

And

> There's lots of papers on this and so to actually have a hospital that contained highly immunocompromised patients within a couple of hundred metres – maybe 300, 400 metres maybe-- I never actually paced it out, but it looked very close to me. To have a sewage treatment work so close to a hospital that

[27] A49953868 - Hearing Commencing 19 August 2024 - Day 10 - 3 September 2024 - Annette Rankin - https://www.hospitalsinquiry.scot/inquiry-document/transcript-annette-rankin-03092024 - Pg 15
[28] A50117619 - Hearing Commencing 19 August 2024 - Day 15 - 11 September 2024 - Dr Christine Peters - https://www.hospitalsinquiry.scot/inquiry-document/transcript-dr-christine-peters-11092024 - Pg 10
[29] A49397708 - Dr Tom Makin - Witness Statement - Final - Scottish Hospitals Inquiry - Hearing Commencing 19 August 2024 - Witness Bundle - Week Commencing 26 August 2024 - Volume 2 - Pg 10

had such immunocompromised patients, to me, seemed an unacceptable risk, really, so I was surprised by that."[30]

He suggests that the SWWTW still poses a risk and that air sampling for micro-organisms would be warranted to investigate. Interestingly, Tim Wafer seems to indicate that microbial air sampling was undertaken by NHSGGC on one of their sites to investigate potential microbial contamination of air close to a sewage treatment work.

I assume that the papers referred to by Dr Makin are those referred to in this report and when he refers to "Airborne transmission" he means dissemination of airborne micro-organisms and not transmission from air derived from sewage works to those located at a significant distance from the plant.

The difference in views between Dr Makin and the other witnesses may explained by a different approach to risk assessment based on available evidence and uncertainty. It could be argued as Dr Makin seems to do and, Dr Peters may refer to, that a well designed microbial air sampling study could be carried out to once and for all determine whether there is a feasible route of microbial aerosol transport from SWWTW[31]. However, this would be an expensive and difficult project as it would have to ensure that a sampling is undertaken during different weather conditions and sewage treatment processes.

I note that no witnesses addressed proximity to the SRF.

11. Conclusions

11.1. My summary responses to the questions posed in the direction letter based on the evidence given above are as follows:

11.2. Does the hospitals proximity to the Shieldhall Sewage Treatment Works creates a risk of infection to patients.

11.2.1. I will consider the potential for airborne infection only as I have no knowledge of any other routes. The hospital is located 200m from the Shieldhall WWTW at the closest and the patient wards are 300m from the nearest point. There are high level air intakes for the supply air to these wards. There is limited evidence of spread of pathogens from WWTW and none that

[30] A49823314 - Hearing Commencing 19 August 2024 - Day 6 - 27 August 2024 - Transcript - Dr Thomas Makin and Dennis Kelly - https://www.hospitalsinquiry.scot/inquiry-document/transcript-tom-makin-27082024 - Pg 27

[31] A49823314 - Hearing Commencing 19 August 2024 - Day 6 - 27 August 2024 - Transcript - Dr Thomas Makin and Dennis Kelly - https://www.hospitalsinquiry.scot/inquiry-document/transcript-tom-makin-27082024 - Pg 28; A50117619 - Hearing Commencing 19 August 2024 - Day 15 - 11 September 2024 - Dr Christine Peters - https://www.hospitalsinquiry.scot/inquiry-document/transcript-dr-christine-peters-11092024 - Pg 10

model risks in high level air. These studies do not provide incontrovertible evidence of raised levels of environmental pathogens at these distance from WWTW and no evidence of significant spread beyond 200m downwind. Since the potential for northerly winds in Glasgow is low the chances of air containing significant levels of microbial aerosols moving from the SWWTW to the QUEH/RHC wards is low then any risk of infection by this means must be regarded as being very unlikely. I cannot comment on any other potential infection risks such as through leaching.

11.3. If you are aware of any precedents or studies that demonstrate the impact, including potential infection risk, on neighbouring buildings of being in close proximity to such sites.

11.3.1. No. A rapid informal literature survey has not detected any infection risks from proximity to such sites in the UK or similar countries. I have found that at least two countries (Italy, China) seem to have regulations that prevent building close to WWTW with setback distance of 100m or 300m being proposed but am unaware of the rationale between this guidance.

11.4. Your assessment of the primary direct impact on the selected site of pathogens leaching from Shieldhall or airborne pathogens being carried by air currents.

11.4.1. I cannot directly answer the leaching question due to lack of information and expertise and think the question has been answered in section a. I think there is a theoretical potential for airborne pathogens, in particular fungi, from the Shieldhall Recycling Centre to be carried by the prevailing wind to QEUH/RHC but without more information about the processes undertaken at that site it is difficult to quantify the significance of this route.

11.5. The secondary impact of the selected site with regards to the impact on the overall ventilation strategy for the QEUH/RHC and the decision to have a sealed building reliant on a mechanical ventilation system.

11.5.1. It is well documented that the proximity to the Shieldhall WWTW and odour concerns were commonly raised in the consultative process. This was a major driver for the sealed mechanically ventilated design chosen as well as suggesting the use of carbon filter initially.

11.5.2. This is stated by many of the designers and contractors. It seems likely that if an alternative site was chosen then natural ventilation systems would have been chosen for some of the hospital especially since environmental sustainability was a major consideration in the design of QEUH/RHC. The completely mechanically sealed design most likely raised the energy utilisation of the hospital, and it may be that this was a driver for other decisions made such as reductions in ACH and lack of HEPA filtration in order to meet agreed targets to get an excellent BREEAM rating.

11.6. Whether the use of mitigation measures, such as the use of carbon filters, would have been appropriate to address concerns regarding the effect of odours emanating from the Shieldhall Sewage Works.

11.6.1. Carbon filters and other alterative odour reduction techniques would have reduced odour concerns from the ward environment but not from the hospital and its environs as a whole. There appears to have been assumptions made that the SWWTW upgrades would remove or at least greatly reduce odour problems in the area.

11.7. Your assessment of the extent to which proximity to the Shieldhall Sewage Works and the Shieldhall Recycling Centre may have contributed to the risk of vermin, including pigeons, within the QEUH/RHC.

11.7.1. This is outwith my area of expertise. The management of sewage facilities and recycling centre should incorporate vermin control to limit site infestation by vermin including pigeons. I have no evidence that the sewage works and recycling centre have vermin problems but without visiting the sites, seeing their policies etc I cannot give a conclusive answer.

12. Declaration

- I understand that my duty is to help the Inquiry on matters within my expertise and that this duty overrides any other obligation.
- I have stated the substance of all material instructions, on the basis of which the report is written. My evidence is my independent product, uninfluenced by external pressures.
- The opinions I have expressed are objective, unbiased and based on matters within my own expertise and I have not adopted the role of an advocate. I have made clear if a question or issues falls outwith my area of expertise.
- I have considered whether there is a conflict of interest and declared any potential conflict identified.
- I have given details of any literature or any other material relied on in making the report.
- I have set out the substance of all facts which are material to the opinion expressed in this report or upon which my opinions are based.
- I have said when there is a range of opinion on a relevant issue and summarised the range of opinions and I have formed my own independent view as to the appropriate point in that range applicable to this case and given reasons for that view.

12.1. I have made clear which of the facts stated in the report are within my own knowledge. Those that are within my own knowledge I confirm to be true. The opinions I have expressed represent my true and complete professional opinions on the matters to which they refer.

…… [redacted] …….

Date: 17/12/2024

Mr Allan Bennet

13. References

1. Abromaitis, Vytautas, Inga Urniežaitė, and Dainius Martuzevicius. "Assessment of Bioaerosol Distributions in Municipal Solid Waste Transfer Station." *Linnaeus Eco-Tech* (2010): 439-446. kbradm,+Tidskriftens+administratör,+47+Assessment+ofn+the+bio-aerosol+distribution+in+Solid+Waste+Transfer+Station+doi.pdf
2. ASTM International E884 Standard Practice for Sampling Airborne Microorganisms at Municipal Solid-Waste Processing Facilities (astm.org)
3. Blatny, J. M., Reif, B. A. P., Skogan, G., Andreassen, O., Høiby, E. A., Ask, E., ... & Caugant, D. A. (2008). Tracking airborne Legionella and Legionella pneumophila at a biological treatment plant. *Environmental science & technology*, *42*(19), 7360-7367. 361191.pdf (knowledgearc.net)
4. Brandi, G., Sisti, M., & Amagliani, G. (2000). Evaluation of the environmental impact of microbial aerosols generated by wastewater treatment plants utilizing different aeration systems. Journal of Applied Microbiology, 88(5), 845-852.
5. Evaluation_of_the_environmental_impact_o20160514-28594-3fsblc-libre.pdf (d1wqtxts1xzle7.cloudfront.net)
6. Environment Agency (2023) Antimicrobial Resistance in Bioaerosols: Towards a National Surveillance Strategy. Environment Agency, Bristol. Antimicrobial resistance in bioaerosols: towards a national surveillance strategy - GOV.UK (www.gov.uk)9
7. Fannin, K. F., Gannon, J. J., Cochran, K. W., & Spendlove, J. C. (1977). Field studies on coliphages and coliforms as indicators of airborne animal viral contamination from wastewater treatment facilities. *Water Research*, *11*(2), 181-188.
8. PII: 0043-1354(77)90124-5 (umich.edu)
9. Fannin KF, Vana SC, Jakubowski W. 1985. Effect of an activated sludge wastewater treatment plant on ambient air densities of aerosols containing bacteria and viruses. Appl Environ Microbiol 49:.
10. https://doi.org/10.1128/aem.49.5.1191-1196.1985
11. Gaviria-Figueroa, A., Preisner, E.C., Hoque, S., Feigley, C.E., Norman, R.S., 2019. Emission and dispersal of **antibiotic resistance genes through bioaerosols generated during the treatment of municipal sewage. Science of The Total Environment 686, 402– 412.** https://doi.org/10.1016/j.scitotenv.2019.05.454
12. **Ghanbarian, M., Ghanbarian, M., Ghanbarian**, M., Mahvi, A. H., & Hosseini, M. (2020). Determination of bacterial and fungal bioaerosols in municipal solid-waste

processing facilities of Tehran. *Journal of Environmental health science and engineering*, *18*, 865-872.

13. Determination of bacterial and fungal bioaerosols in municipal solid-waste processing facilities of Tehran (nih.gov)
14. Gotkowska-Płachta, A., Filipkowska, Z., Korzeniewska, E., Janczukowicz, W., Dixon, B., Gołaś, I. and Szwalgin, D. (2013), Airborne Microorganisms Emitted from Wastewater Treatment Plant Treating Domestic Wastewater and Meat Processing Industry Wastes. Clean Soil Air Water, 41: 429-436. https://doi.org/10.1002/clen.201100466
15. Ewa Korzeniewska. Emission of bacteria and fungi in the air from wastewater treatment plants – a review. *Front. Biosci. (Schol Ed)* 2011, 3(2), 393–407. https://doi.org/10.2741/S159
16. Korzeniewska, E., Harnisz, M., 2013. Extended-spectrum beta-lactamase (ESBL)-positive Enterobacteriaceae in municipal sewage and their emission to the environment. Journal of Environmental Management 128, 904–911. https://doi.org/10.1016/j.jenvman.2013.06.051
17. Lavoie, J., & Guertin, S. (2001). Evaluation of health and safety risks in municipal solid waste recycling plants. *Journal of the Air & Waste Management Association*, *51*(3), 352-360. Evaluation of Health and Safety Risks in Municipal Solid Waste Recycling Plants (tandfonline.com)
18. Li, Y., Zhang, H., Qiu, X., Zhang, Y., & Wang, H. (2013). Dispersion and risk assessment of bacterial aerosols emitted from rotating-brush aerator during summer in a wastewater treatment plant of Xi'an, China. *Aerosol and air quality research*, *13*(6), 1807-1814.9 Microsoft Word - 18_AAQR-12-09-OA-0245_
19. Liu, Y., Deng, G., Liu, H., Chen, P., Pan, Y., Chen, L., ... & Zhang, G. (2024). Seasonal variations of airborne microbial diversity in waste transfer stations and preventive effect on Streptococcus pneumoniae induced pulmonary inflammation. *Science of The Total Environment*, *912*, 168888.
20. Seasonal variations of airborne microbial diversity in waste transfer stations and preventive effect on Streptococcus pneumoniae induced pulmonary inflammation - ScienceDirect Abstract Only
21. Lü, F., Wang, W., Hu, T., Duan, H., Shao, L., Zhang, H., & He, P. (2022). Release of airborne antibiotic resistance genes from municipal solid waste transfer stations. *Sustainable Environment Research*, *32*(1), 28.
22. Release of airborne antibiotic resistance genes from municipal solid waste transfer stations (springer.com)

23. Ma, J., Han, Y., Li, L., & Liu, J. (2023). Distribution characteristics and potential risks of bacterial aerosol in waste transfer station. *Journal of Environmental Management*, *326*, 116599.

24. Distribution characteristics and potential risks of bacterial aerosol in waste transfer station - ScienceDirect Abstract Only

25. Madsen, A. M., Frederiksen, M. W., Kurdi, I. M., Sommer, S., Flensmark, E., & Tendal, K. (2019). Expanded cardboard waste sorting and occupational exposure to microbial species. *Waste Management*, *87*, 345-356.

26. Expanded cardboard waste sorting and occupational exposure to microbial species (sciencedirectassets.com)

27. Madsen, A. M., Raulf, M., Duquenne, P., Graff, P., Cyprowski, M., Beswick, A., ... & Crook, B. (2021). Review of biological risks associated with the collection of municipal wastes. *Science of the Total Environment*, *791*, 148287.

28. Review of biological risks associated with the collection of municipal wastes (sciencedirectassets.com)

29. Małecka-Adamowicz, M., Kubera, Ł., Donderski, W., Kolet, K., 2017. Microbial air contamination on the premises of the sewage treatment plant in Bydgoszcz (Poland) and antibiotic resistance of Staphylococcus spp. Archives of Environmental Protection 43, 58– 65. https://doi.org/10.1515/aep-2017-0040

30. Ncube F, Ncube EJ, Voyi K. A systematic critical review of epidemiological studies on public health concerns of municipal solid waste handling. Perspectives in Public Health. 2017;137(2):102-108. doi:10.1177/1757913916639077 A systematic critical review of epidemiological studies on public health concerns of municipal solid waste handling - France Ncube, Esper Jacobeth Ncube, Kuku Voyi, 2017 (sagepub.com) Abstract Only

31. Nhu Nguyen, T. M., Ilef, D., Jarraud, S., Rouil, L., Campese, C., Che, D., ... & Desenclos, J. C. (2006). A community-wide outbreak of legionnaires disease linked to industrial cooling towers—how far can contaminated aerosols spread?. *The Journal of infectious diseases*, *193*(1), 102-111.Community-Wide Outbreak of Legionnaires Disease Linked to Industrial Cooling Towers—How Far Can Contaminated Aerosols Spread? | The Journal of Infectious Diseases | Oxford Academic (oup.com)

32. Poulsen, O. M., Breum, N. O., Ebbehøj, N., Hansen, Å. M., Ivens, U. I., van Lelieveld, D., ... & Wilkins, K. C. (1995). Sorting and recycling of domestic waste. Review of occupational health problems and their possible causes. *Science of the total environment*, *168*(1), 33-56.

33. Sorting_and_recycling_of_domestic_waste.20161218-7140-1qfw0bz-libre.pdf (d1wqtxts1xzle7.cloudfront.net)

34. Scottish Government Part 2 Code of Practice on Control of Odour Nuisance from Waste Water Treatment Works - Assessment and control of odour nuisance from waste water treatment: code of practice - gov.scot (www.gov.scot) -untitled (www.gov.scot)

35. Paolo Stellacci, Lorenzo Liberti, Michele Notarnicola, Charles N. Haas (2010)

36. Hygienic sustainability of site location of wastewater treatment plants: A case study. II. Estimating airborne biological hazard, Desalination, Volume 253, 106-111,

37. https://doi.org/10.1016/j.desal.2009.11.024

38. Van Leuken, J. P. G., Swart, A. N., Havelaar, A. H., Van Pul, A., Van der Hoek, W., & Heederik, D. (2016). Atmospheric dispersion modelling of bioaerosols that are pathogenic to humans and livestock–A review to inform risk assessment studies. *Microbial Risk Analysis*, *1*, 19-39.

39. Atmospheric dispersion modelling of bioaerosols that are pathogenic to humans and livestock - A review to inform risk assessment studies (sciencedirectassets.c

Glossary

ARG- antibiotic resistance genes

NSGH – New South Glasgow Hospital

SGH – Southern General Hospital

SRF – Shieldhall Recycling Facility

SWWTW – Shieldhall Waste Water Treatment Facility

WHF – Waste Handling Facilities

WWTW- Waste Water Treatment Works


SCOTTISH
HOSPITALS
INQUIRY

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REVIEW BY NHSGGC

OF

REPORT OF ALLAN BENNETT IN CONNECTION WITH SITE CHOICE

DATED 17 DECEMBER 2024

1. A report by Allan Bennet entitled *"Impact and Infection Risk of QEUH and RHC site choice* dated 17 December 2024 (the "Report") has been disclosed to Inquiry core participants. This document contains NHSGGC's response to the Report.

2. The limitations of the Report detailed at section 3 are noted. Limitations of available studies are acknowledged at paragraph 9.4. It is also noted that the author states he has no expertise in connection with vermin risk. The Report must be viewed in that context.

3. In section 11, the author suggests that proximity to Shieldhall water treatment plant and Shieldhall recycling centre was the reason for selecting mechanical ventilation for the QEUH/RHC. He also hypothesises that, if an alternative site was chosen, there may have been natural ventilation. It is submitted that these are matters for the evidence of witnesses involved in site selection, design and build. No conclusions can be reached without hearing evidence from those witnesses. Site selection requires a balance to be struck. Considerations include accessibility for patients and proximity to and the co-location of services. This is acknowledged in the Report. Evidence requires to be heard on these issues.

4. Subject to the above comments, NHSGGC considers that the Report is balanced. It reaches the reasoned conclusion that an infection risk arising from Shieldhall water treatment plant or Shieldhall recycling centre is very unlikely. NHSGGC agrees with this conclusion.

14 February 2025

SCOTTISH HOSPITALS INQUIRY

Bundle of documents for Oral hearings commencing from 13 May 2025 in relation to the Queen Elizabeth University Hospital and the Royal Hospital for Children, Glasgow

Bundle 39 - Impact and Infection Risk of QEUH and RHC site choice by Allan Bennett