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# Determining the pathways of virus transport through a sandstone aquifer

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Due to increased water demand in cities, reuse of urban waste-water has been seen as a potentially viable management option. However, urban waste-water will often contain viruses, including human, other mammalian or avian. Use of waste-water in, for example, artificial recharge therefore requires that a risk assessment of virus hazard be undertaken. Studies in different countries have shown the presence of viable human viruses in groundwater, indicating that they can remain active following passage across the soil. In urban red-bed sandstone aquifers from the UK, which are predominantly matrix flow systems, other studies using evidence from well and piezometer monitoring have shown that viable human viruses can be transported to depths of at least 40 m. The main objective of this study is to find the lateral pathways of the viruses through this sandstone system. This is being attempted by undertaking detailed borehole-to-borehole tracer tests at a site where lateral migration was shown to occur in a previous study. The tests will use bacteriophages as surrogates for human viruses together with fluorescein as an unreactive tracer. A range of somatic phages (PRD1, ΦX174, H40/1) and a male-specific ($F^+$) phage (MS2) will be used. They will be injected in one borehole and recovered in a second, 7 m distant. The intake of the main pump will be located in the cased section at the top of the recovery well, and sampling pumps will be used to sample virus and fluorescein concentrations at five different depths. The up-hole flow rate at the sampling depths will be measured by an impeller device, allowing the variation in phage influx with depth to be calculated. Samples

will be pumped through a fluorimeter and a set of virus filter traps at the surface. The virus filter traps will be eluted using a mixture of beef extract and glycine, and the eluate analyzed using the double agar layer method and epifluorescence microscopy. The pathways identified will then be investigated with targeted tracer tests. In addition, laboratory column experiments will be undertaken once the virus-permeable units are identified in order to determine the transport mechanisms.