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TOWARDS A SOCIO-MATERIAL APPROACH TO REDUCING THE WATER DEMAND OF CLEANLINESS

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Abstract

In the UK, water supplies are under pressure from climate, population, and lifestyle change, and showering is the largest component of domestic water consumption. Students are high water-users, in part due to pressure to conform to high standards of cleanliness and body-image to be accepted into new social groups away from the family home. Spatial transience means that their everyday routines are dynamic, and habits are shaped by their changing socio-material context. This thesis makes a three-fold contribution to knowledge and substantive water conservation practice – theoretical, methodological, and empirical in a real-world setting. The research focused on practical shower water-saving measures targeted at first year university students living in campus accommodation at the University of the West of England, Bristol, UK. A programme of both conventional showering demand reduction and novel social practice theory-based interventions were designed and evaluated, framed using the Scottish Government Individual-Social-Material model. A mixed-methods approach was developed to test the efficacy of measures and provide end-user insights to interpret changes in volumetric water consumption. An exploratory or baseline phase followed by two intensive waves of fieldwork, spread across two academic years with different student cohorts were delivered. Household meter and logged shower fixture volumetric consumption was assessed to confirm typical water-use patterns at different scales. Personal-use questionnaire responses were analysed to classify student showering styles. Volumetric findings were validated and interpreted by combining with shower diary and focus group insights. Theoretical, methodological, and empirical contributions were discussed and recommendations for future water efficiency strategies and further research were proposed.

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Acknowledgments

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Thank you all, x.

[1] I do not drink coffee!

Chapter 1 Introduction

This chapter introduces the policy context within which this research sits; highlights the urgent need to reduce water demand; justifies the focus of enquiry into the showering routines of students (the why, what, where and who); and explains how a socio-material approach might be more effective for delivering real-world interventions, rather than relying on individual choice to enact change. The research questions this study addresses are introduced; the value this research brings are stated; and the structure of the thesis is outlined.

1.1 Water demand management

1.1.1 Water is life

Water is one of the essential ingredients for life on earth. We cannot live without it. We can only survive for about three minutes without oxygen, three hours without shelter, just three days *without water* and approximately three weeks without food[2] (Staddon, 2010a). Water is a building block for our bodies which are comprised more than 50% water by weight. Water is so fundamental to life as we know it that the search for water is central to interplanetary exploration[3]. Back on earth it remains the case that more than a billion people lack reliable access to drinking water. *Ensuring availability and sustainable management of clean water and sanitation for all* is goal six of the United Nations Sustainable Development Goals (UN, 2022). Everyone needs *sufficient*; *safe*; *acceptable*; *accessible* and *affordable* water supplies (UN, 2014).

Water is one of the body's physiological primary needs for physical survival and bodily comfort, situated as a foundation of human existence at the base of Maslow's Hierarchy of Needs pyramid (Maslow, 1943) – see Figure 1-1. Water is essential for *homeostasis* – maintenance of steady state internal, physical, and chemical conditions for optimal functioning of living systems[4]. Along with *drinking* water, it is also essential in the provision of food and public health needs, including personal hygiene and sanitation. The World Health Organisation recommends that between *50 and 100* litres of water per

[2] This hierarchy underplays the importance of water: air gets contaminated but is *never* withheld; whereas water *often* is.
[3] Up to a fifth of Mars might once been covered by water (Choi, 2016).
[4] It is a gross understatement to say that water is '*only*' about hydration – water is also implicated in all metabolic processes including oxygen transfer through respiration, pH management and waste removal (Kamler, 2004).

person per day (l/p/d) are needed to meet basic human needs (UN, 2014), and even in emergency situations, such as natural disaster or social and political disorder, the office of the United Nations High Commissioner for Refugees suggests that at least 15 l/p/d should be provided in the immediate aftermath, rising to at least 20 l/p/d within two years post emergency (UNHCR, 2020).

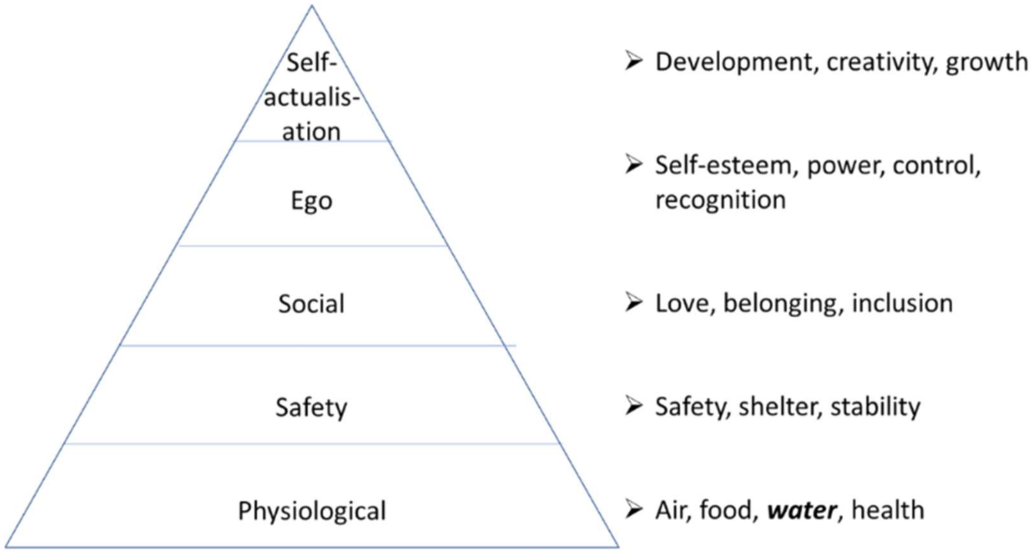


Figure 1-1 Hierarchy of Needs (adapted from Maslow, 1943)

And yet, despite water being so important, in the developed world we undervalue it, take it for granted, and pour vast amounts of it down the proverbial drain without a second thought. After a century of progressive engineering and government regulation water systems across most of Europe and North America are so effective and efficient that they have become largely invisible (Staddon and Healy; Staddon, 2010a). The *paradox of value* (or diamond-water paradox) helps to explain the difference between *use value* and *exchange value* (Smith, 1890). Whilst diamonds have little use, they are expensive because they are rare and in short supply worldwide. Water is critically vital but is relatively – some might say ridiculously -- cheap because it is apparently abundant, at least in some world regions. But context matters – ask a person dying of thirst which is most valuable, and you get a different answer! More than two centuries ago, Benjamin Franklin famously quipped that "*when the well is dry, we know the worth of water*" (Franklin, 1791) and it is thought that half a century later the American author Mark Twain, said "*whiskey is for drinking, water is for fighting over*"[5].

Over two centuries of industrialisation and urbanisation have driven the organisation, processing, and transport of water to growing and diversifying communities of users

[5] although this cannot be substantiated (Brelsford, 2014).

through a largely invisible collection, distribution, and treatment system. Once supplied and used, wastewater must be collected via a different, largely unseen, pipe network for treatment and return to the natural environment. Whilst critical to modern society, water is often undervalued and invisible in its path from rain cloud to human user and back to the natural environment (Staddon and Healy).

This would not matter too much if water were indeed ubiquitous, as air is (whatever its quality), but just three percent of all the water on earth is freshwater that is potentially available for ingestion by humans. The rest is saline, frozen, or vapour and therefore unusable without expensive, energy-intensive treatment. More than half of global freshwater is locked in rapidly melting polar and high mountain glaciers and ice caps. Just 0.5% of all water on earth is available for immediate use and is unevenly distributed both spatially and temporally across the seasons (Shiklomanov and Rodda, 2003). Even regions with relative water abundance such as the UK, can experience extremes of both flood and drought, sometimes in rapid succession, particularly in groundwater supplied regions (Staddon, 2010a). This variability is likely to become more marked as weather patterns are impacted by our changing climate. Thus, abundance and deficit of water often co-exist spatially and temporally.

Experts have been warning of water scarcity for years. The United Nations estimate that more than 3 billion people are affected by water shortages and warns of the consequences of failing to save water and tackle the climate crisis (Harvey, 2020). In early 2018, Cape Town was the first major city in modern times to face the risk of running out of water and faced extreme measures to ration water. However, a quarter of the world's major cities are water stressed - a situation in which available water is insufficient to meet the needs of the population. This threat is not limited to faraway megacities located in warmer climates. Surprisingly, London is listed in the top ten of cities most likely to run out of water (BBC, 2018). Indeed, in March 2019, Sir James Bevan, Chief Executive of the Environment Agency, delivered his "*jaws of death"* keynote speech at the annual Waterwise conference (Bevan, 2019). He captured the attention of the media with his apocalyptic warning that England could *run out of water* within 25 years, without radical action[6] to reduce water consumption to address the worsening supply-demand imbalance. In a more recent speech, Bevan highlighted that water quantity (not quality) is the biggest threat to our environment, economy, and lifestyle – "*while good water*

[6] He reiterated his warning at the Royal Society Conference in October 2021 (Bevan, 2021).

quality is essential, the right water quantity is existential", and he described water as the "*new gold*" (Bevan, 2022).

1.1.2 Twin-track approach to supply/demand balance in England

Systems for the organisation, financing and regulation of public water supplies vary internationally. In many countries, water supply is a public sector service, whilst in England and Wales the industry was largely transferred to a privatised model in 1989. The industry comprises ten regional water and wastewater service companies and a (continually shifting) number of smaller water-only suppliers and retailers. Water bills in England and Wales, based on a 'cost plus' pricing model[7], are paid directly by customers, whilst elsewhere it is often funded through national or local taxation. Historically, domestic water charges were made as a fixed charge based on the size or '*rateable value*' of homes whether rented or owned, rather than the metered volume used. Whilst water meter penetration has increased significantly during the last ten years, only around half of households in England are charged for the volume that they use. Devolution also means that there is a diversity in governance, political ideologies, institutional arrangements, and cultures, across the constituent nations in the UK, which determine different water conservation approaches.

Managing water demand in England has become a policy focus in the last twenty years. This is because of:

- *increasing demand* arising from population growth and lifestyle change;
- *reduced supply* due to extreme in weather events causing water shortages;
- reformed water resource abstraction regulations intended to protect environmental water for wildlife; and,
- a move away from purely supply-side approaches towards supply-demand *balance*, (stemming from agreements made at the United Nations Rio Earth Summit in 1992).

Historically, the UK water sector has operated on a *predict* and *provide* approach to keeping up with growing consumer demand, starting with the establishment of truly modern water services companies in the mid-19th century (Staddon and Healy). Building new supplies was historically incentivised by the Office for Water Services (the financial

[7] Based on actual costs, without cross-subsidy.

regulator, known as Ofwat), as capital schemes give reliable returns on investment for shareholders, and large infrastructure programmes are effective job-retention policies during economic downturns, for example the early 1990s recession that coincided with water privatisation in England and Wales. This ‘build-it’ or ‘pouring concrete’ mentality meant that the industry has been predominantly staffed by engineers who saw managing the supply-demand balance in predominantly physical infrastructure terms. More recently attitudes have shifted responsibility away from solely supply-side operations by water supply companies, towards supply-demand balance, in which demand-side approaches are targeted at consumers. The Water Industry Act 1991 placed a statutory duty upon the privatised undertakers to *promote the efficient use* of water, and this obligation has been progressively strengthened since.

The Water Summit in 1997, called by the then new Labour government in response to the impacts of the 1995 drought in Yorkshire, was a watershed moment that paved the way to reform abstraction licencing via the Water Act 2003 and led to a more balanced *twin-track* strategy for managing *demand* as well as *supply*.

A large area of England has been identified as seriously water stressed (Environment Agency, 2021). This means that demand by household consumers, businesses, and the natural environment (to sustain wildlife), outstrip the available supply, particularly at times of low rainfall. With predictions of greater variability in rainfall patterns and water availability due to our increasingly volatile climate, droughts and water shortages are expected to increase in frequency and severity, with hotter, drier summers, particularly in the southern and eastern regions. Figure 1-2 shows the levels of water stress in England, broken down by water supply company. Only the northern regions (Northumbria, Yorkshire, and the northwest) and western fringes (Devon and Cornwall, Bristol, and pockets along the Welsh border) with lower populations and comparatively more rainfall, are classed as not seriously stressed.

Official estimates indicate that 56.6 million people live in England (67 million in the UK as a whole) with almost one-third of England’s population in the urban and suburban southeast, and nine million in London alone (Office of National Statistics, 2021). England is the most densely populated major country in Europe, with 434 people per square kilometre. However, this is unevenly distributed, with 5,727 people per square kilometre living in London, compared 237 people per square kilometre in the southwest. Unfortunately, this means that most people are living where there are the least abundant naturally available water resources, particularly in the east and southeast of the country.

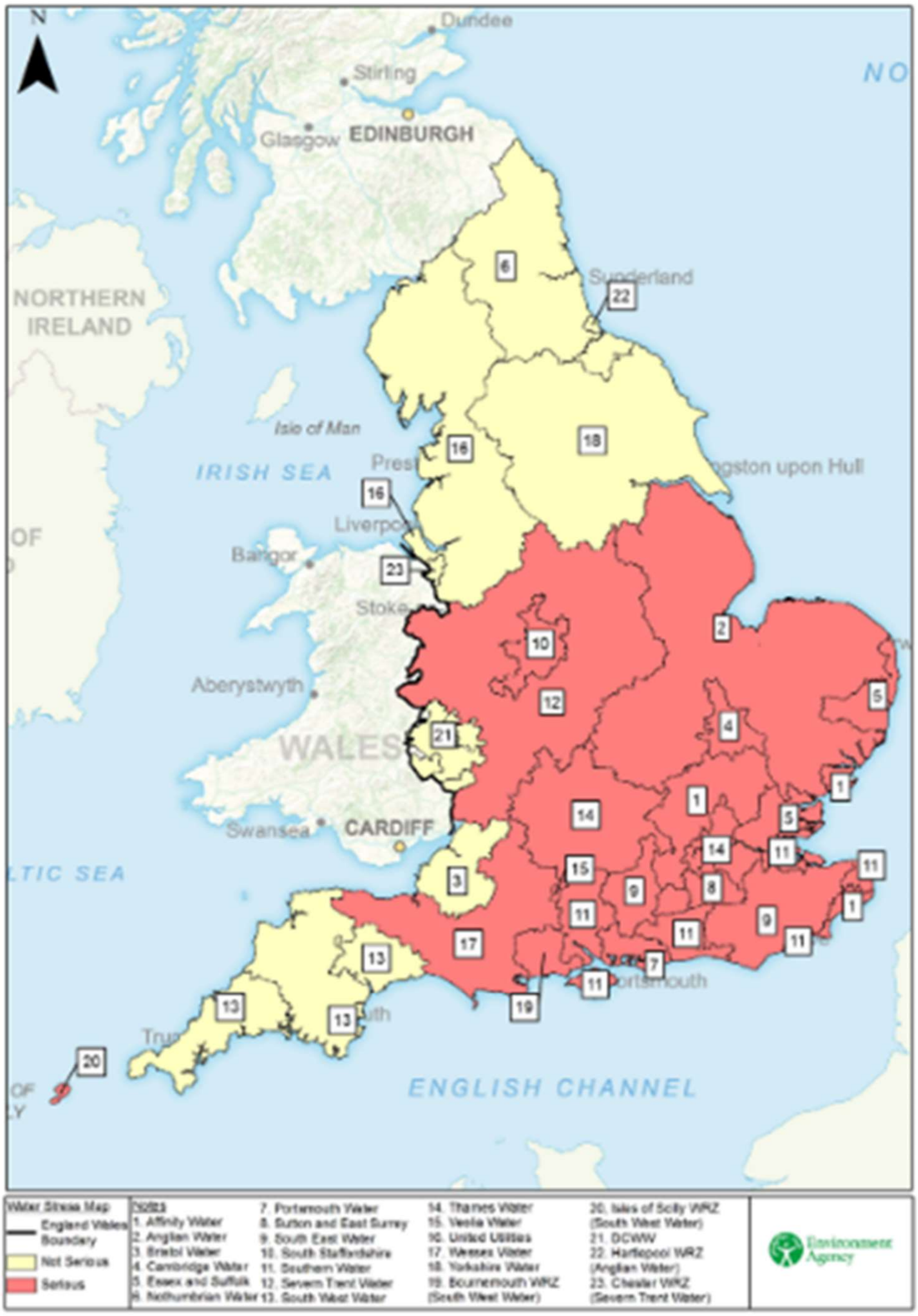
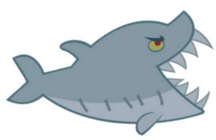


Figure 1-2 Water stress in England (Environment Agency, 2021, p.8)

Note that the area served by Bristol Water is not classified as water stressed. The latest water resources management plan (WRMP19 – Bristol Water, 2019) predicts that whilst the region’s population is expected to increase by a quarter (from 1.2 million to 1.5 million) in the next twenty-five years (to 2045) a comprehensive programme of demand management through: leakage reduction (by 15%); increased meter penetration (from 66% to 87%); and customer water efficiency measures (to drive consumption down from 141.6 l/p/d to 129.4 l/p/d), will be sufficient to maintain reliable and secure supplies for the growing customer base, even during severe (one in 200 year) droughts, and no new resources will be required during the next twenty-five years.

Added to an uneven spatially distributed population and climatic pressures, heightened competition for land means there is limited space to collect and store the water that falls from the sky (i.e., build reservoirs), and the storage capacity for some UK water companies can be as little as 12-18 months' supply (Bulmer, 2017; Thames Water, 2012). For example, the two dry winters preceding 2012 were responsible for drought and serious water shortages in the east and south of the England in the first half of that year. Figure 1-3 illustrates the supply-demand deficit forecast by Thames Water for London over the century for a dry year (Thames Water, 2020).



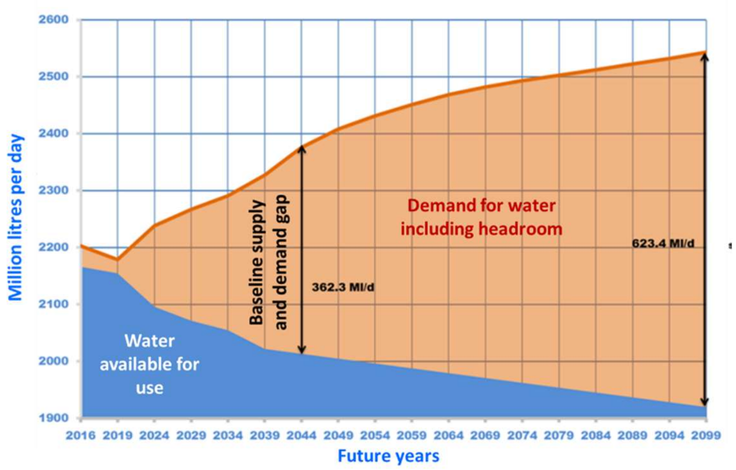


Figure 1-3 Baseline London supply demand summary (Mld), dry year (Thames Water, 2020, p.4)

In his *"jaws of death"* speech, Bevan (2019) described how as demand rises (due to population growth) and supplies reduce (due to the impacts of climate change and environmental permitting), where the two lines cross is known by some as the *jaws of death* – the point at which we will not have enough water to meet our needs. Bevan outlined the action being taken by the government, environmental regulator (Environment Agency), water companies and other non-governmental organisations, but warned that we must all change our *attitudes* and *behaviours* related to wasting water, so it becomes as socially unacceptable as dumping plastic bags into the sea. In other words, Bevan argues that the "*jaws of death*" can only be truly addressed through fundamental changes in how users think about water, and other environmental resources. This is, in his view, an existential crisis.

In England, privatised water companies collect, treat, and deliver approximately 14 billion litres of potable water into public supply each day (Environment Agency, 2020). More than half (55%) is consumed in households, with the rest divided between non-domestic (industrial and business) users (21%) and water lost from infrastructure through leaking pipes and plumbing systems (21%) (see Figure 1-4). A small amount (3%) is used for other uses such as firefighting. A further 1,000 million litres are abstracted directly for industry, energy generation and agriculture, although this varies significantly by season and region. However, internationally, demand from different sectors varies across the globe. The dominance of demand for domestic supplies in England reflects the low demand for irrigation in our temperate climate and a diminished manufacturing base, within our globalised supply chain. It signals the importance of downstream or demand-side focused water efficiency mitigation on *household* consumption (the focus of this thesis), in parallel with upstream or supply-side regulatory levers to squeeze down leakage[8] in the distribution network.

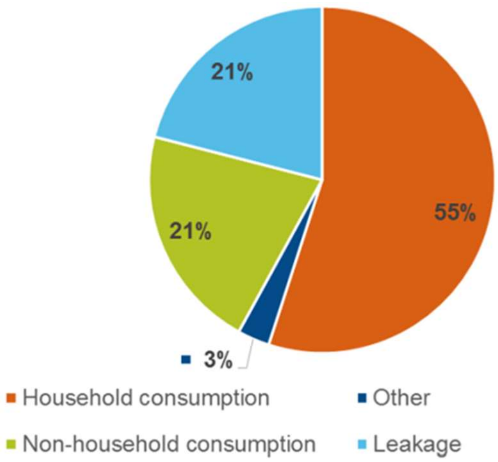


Figure 1-4 Public water supply in England, 2018-19 (Environment Agency, 2020, p.21)

The National Framework for Water Resources (Environment Agency, 2020) highlights the challenges of increasing drought resilience and enhancing environmental protection whilst maintaining supplies into the future in the face of population growth and climate change. The strategy drives stakeholders to work together on a regional scale to plan for pressures that are contributing to the potential additional national water need of 3,435 million litres per day by 2050 (see Figure 1-5), representing a 23% deficit. Half of the supply deficit (1,765 Mld) is in the southeast region.

[8] With more extensive metering in recent years, water suppliers are finding that a significant proportion (up to a quarter) of these network losses are from customer-side plumbing (supply pipes and internal plumbing, downstream of the company stop-tap located on the property boundary), for which the suppliers have no jurisdiction to fix (CIWEM, 2021).

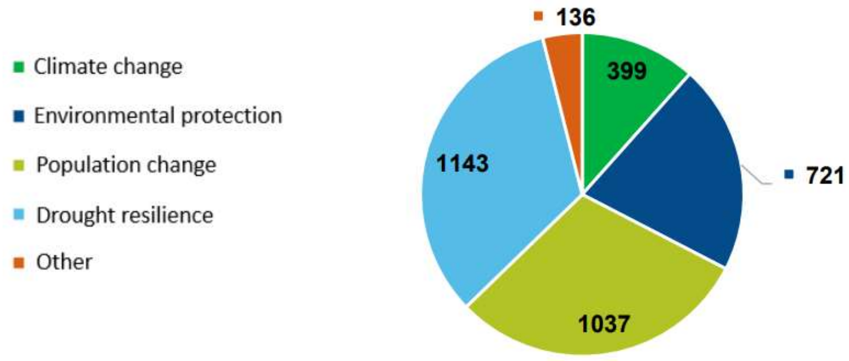


Figure 1-5 Pressures on public water supply contributing to potential additional water need by 2050 (Environment Agency, 2020, p.22)

1.1.3 Climate mitigation and the path to zero carbon

The impacts of climate change manifest themselves throughout the water cycle, and water demand management is an *adaptation* strategy to be more resilient in a future of unreliable and unpredictable water availability. However, reducing domestic water consumption is also an important *mitigation* step towards reducing further climate breakdown on the path to a low or zero carbon future. It is common for water managers to think in terms of litres or megalitres of consumption per day, but it is useful to remember that water use can also be denominated in kilogrammes or tonnes of carbon produced to deliver the services we rely on (for example, drinking water, sanitation, etc.) to be available at the right time and place.

Turning this on its head, water management could be a useful visualisation tool for carbon managers, as the physical presence of water is more tangible than carbon which cannot be seen. Water efficiency is often relegated to a lower priority compared with energy efficiency, particularly with the current high cost of energy, perceived water abundance and its scope 3 emissions[9] status (relegating it to the water supply sector's responsibility within the supply chain). However, water demand is intrinsically and directly linked to energy use through hot water consumption, which also contributes to scope 1 (or 2) emissions.

Water is a heavy resource to move around the underground pipe network. The production and supply of potable water; and treatment and disposal of wastewater produces over 5

[9] Scope 1 emissions originate directly from business processes such as boilers and vehicles, whilst scope 2 emissions arise indirectly through demand for electricity from the grid. Scope 3 emissions include all greenhouse gases that stem from upstream and downstream value chain, via procurement, commissioning and disposal (and usually accounts for significantly more carbon than scope 1 and 2 emissions). Embedded carbon in water supply and wastewater disposal sits within scope 3 as it is produced elsewhere by a third-party water supplier.

million tonnes of greenhouse gases (2005/06), representing 0.8% of annual UK emissions (Defra, 2008a). However, a further 35 million tonnes of greenhouse gases are generated through *heating* water in the home (for personal and household washing, cooking, and cleaning), representing 16% of total household energy use). Greenhouse gas emissions arising from the total combined water '*supply – use – disposal'* envelope represents more than 5% of total UK greenhouse gas emissions. Therefore, reductions in domestic and non-household water use deliver reduced energy consumption and related carbon emissions. This will become increasingly urgent if we are to meet UK and international climate commitments and make a valuable contribution to helping offset energy bills, made more urgent by the current cost-of-living crisis. Thus, managing water is also linked to energy efficiency and is important with respect to meeting carbon reduction commitments.

Water suppliers have recently published carbon plans to set out how they aim to decarbonise their operations. For instance, Bristol Water, as a water only supply company, has set out four pathways to reach zero carbon by 2030, including through reduced leakage and customer water efficiency programmes as well as switching to zero carbon sources of energy (Bristol Water, 2021). Meanwhile, Wessex Water, a regional water and wastewater undertaker, has included plans to increase renewable energy generation through their operations, such as capturing biogas from anaerobic digestion (part of the wastewater treatment process) and increased wind and solar power on their operational sites (Wessex Water, 2021).

1.1.4 Per capita consumption

Water demand policymakers commonly use *per capita consumption* (PCC), estimated in litres per person per day (l/p/d), as a key measure of domestic water use. Latest reports indicate that the estimated average PCC for England and Wales is 145 l/p/d, with metered customers averaging 139 l/p/d and unmetered households consuming 32% more, or about 183 l/p/d (Water UK, 2022). However, only about half of domestic properties in England and Wales are currently metered although this number is increasing, with extensive regional metering programmes in some areas over the last ten years (Water UK, 2019).

International comparisons of water consumption (International Water Association, 2016) typically show the UK to be an average performer within the European context (Figure 1-6), but a very conservative performer compared with other industrial economies such as the US and Canada. By comparison, Denmark and Belgium reported PCC values of around

100 l/p/d. However, international comparisons can be problematic due to differences in the way statistics are calculated and reported.

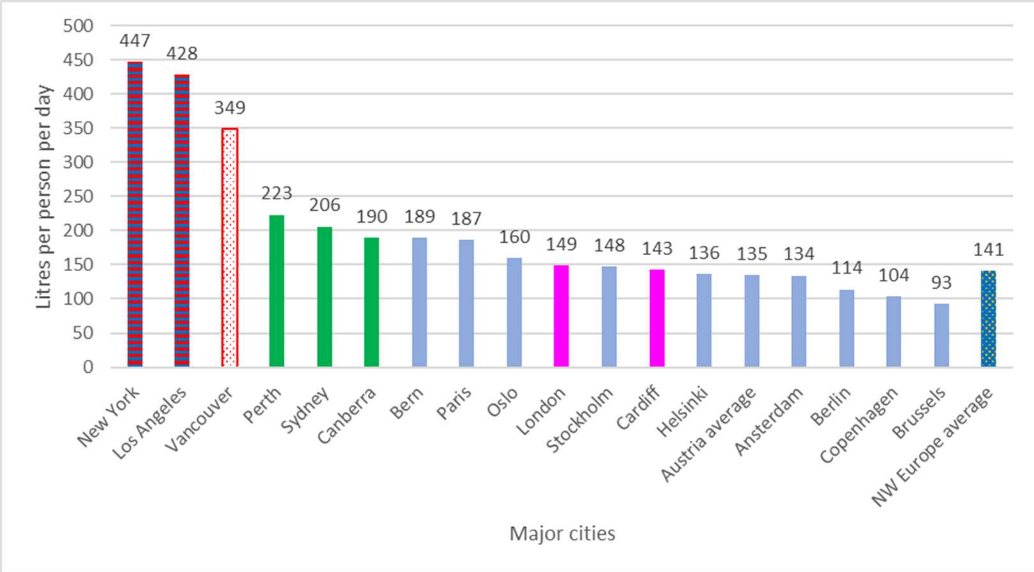


Figure 1-6 Water consumption for households (based on figures from IWA, 2016)

In the first decade of the 21st century, the UK government set out to reduce average PCC[10] in England by 2030 to 130 or even 120 l/p/d, through a combination of direct and indirect drivers including household behaviour change; fixture retrofit programmes; increased metering; and tighter Building Regulations[11] (Defra, 2008a). From 2010, new regulations made water suppliers responsible for demand management by setting modest water saving targets based on one litre per property served, with water stressed areas required to meet enhanced obligations. Savings were reported on the distribution and installation of a range of water saving devices, such as cistern displacement devices for WCs, low flow showerheads and tap fittings, that were assigned a predetermined *assumed* (not measured) saving value. Thus, provided a given water company distributed a large enough number of water-saving kits, it could report an assumed level of water savings at or above its water saving target to meet its regulatory obligation. Little of this was based on assessed or *measured* household savings.

Since its Future Water report (Defra, 2008a), the UK government had made little progress towards a measurable reduction until very recently, with the publication of the

[10] This quantified ambition was rolled back by the next administration to a more arbitrary *reduction* through a combination of water efficiency and leakage control measures in the Government's 25-year environment plan (Defra, 2018a).

[11] In England and Wales Building Regulations (HM Government, 2016) are nationally mandated standards for buildings, including water, gas, and electricity fittings as well as structural and groundworks standards. They are periodically updated, and the current domestic water related regulations can be found in HM Government, 2016.

Environment Agency's National Framework for Water Resources, which has introduced a PCC target of 110 l/p/d (Environment Agency, 2020; Defra, 2019). With population growth set to increase total demand whilst climate change renders existing supplies more vulnerable, there is concern that even a c.29% reduction in PCC to 110 l/p/d, on average by 2045, might be insufficient to achieve a positive water balance. Some water utilities have pledged to reduce water consumption more drastically. For example, Southern Water, which serves the central south coast of England, including Hampshire, West Sussex and the Isle of Wight has committed to achieving a 100 l/p/d target by 2040 (Southern Water, 2019). The COVID-19 pandemic complicates matters further because more working from home and fewer overseas holidays meant that total *domestic* consumption increased (by 17%) even though water consuming processes did not necessarily change, with less consumption incurred by businesses or beyond the UK (Menneer *et al.,* 2021).

1.2 Water-using fixtures

An important challenge in trying to intervene in individual or household water demand is that the process of aggregating and averaging ignores diversity in the range and differences in everyday water-using routines. This gets in the way of understanding complex variations in demand at the individual or personal, and at household scale. Also, there are limited data on *how* people in the UK use water. Micro-component studies measure flow from different water-using fixtures and appliances and reveal a great variety in individual household patterns of consumption (UKWIR, 2016 and 2014). These patterns are even more difficult to measure when almost two-thirds of water consumption by individuals occurs in private behind a locked bathroom door. Household-level (site) variations are illustrated in Figure 1-7.

The ring diagram summarises the aggregated and averaged consumption for each type of water fixture or micro-component, whilst the bar chart illustrates the relative demand of each micro-component (or fixture type - see key for colour codes) ranked by total consumption (Y axis) for individual households (or sites, along the X axis).

Currently, it is estimated that personal washing (showering and bathing combined) typically accounts for around 43% of England's household water use (Environment Agency, 2020). Showering is the largest and growing component, having overtaken WC flushing (see Figure 1-8).

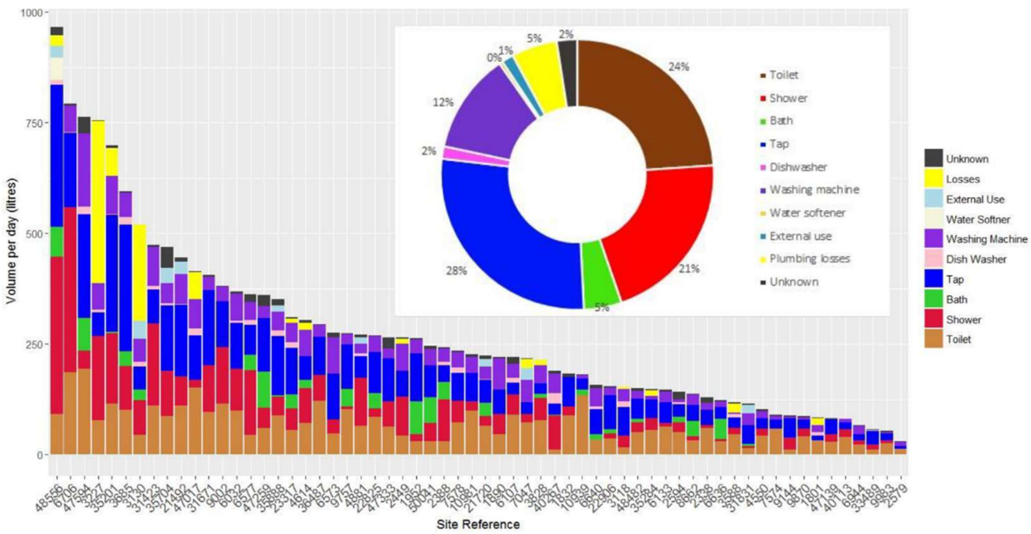


Figure 1-7 Household consumption and micro-component split (UKWIR, 2016, pp. 15-16)

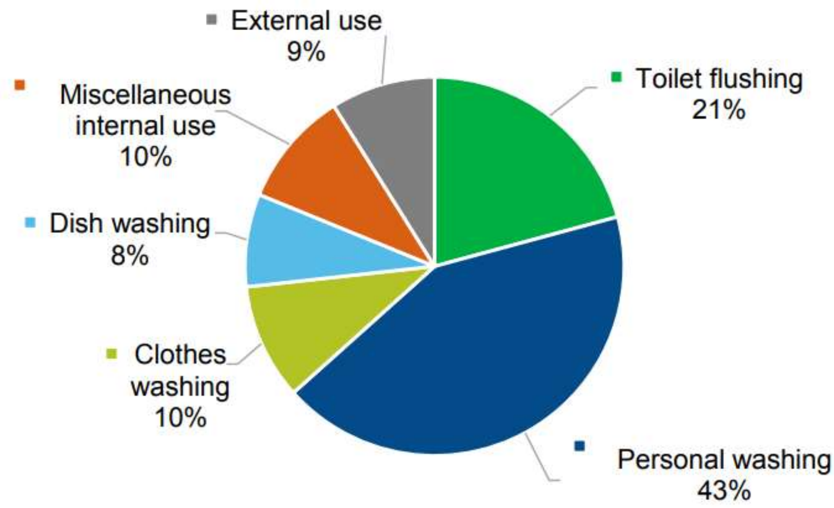


Figure 1-8 Domestic water consumption by use (Environment Agency, 2020, p.69)

Showering is a routine activity that has grown rapidly in the last few decades, taking over from immersive bathing as the principal method for cleaning our bodies (Shove and Walker, 2010; Quitzau and Røpke, 2009; Shove, 2003a). Our practices have evolved from only periodic immersive bathing to regular (often daily) showering as the usual way to keep our bodies clean (Staddon and Healy; Ward, 2019). During this time, there has been a rapid growth in the availability, diversity, and desirability of showering fixtures (from mixer showers over the bath and en suite bathrooms, to wet rooms and power showers). This has been coupled with a parallel evolution in shared understandings of what showering means and how it is done, from functional cleaning to a form of relaxation or status.

Whilst showers have overtaken toilets as the most water consumptive fixture, there is growing concern that modern toilet cisterns are prone to failing, resulting in intermittent or continuous flushing and considerable wastage (i.e., 'running toilets', see also Ricardo Energy & Environment, 2015). High rates of leakage are generally associated with faulty fill valves, faulty dual flush mechanisms, and seal degradation. These failings are estimated to affect around 4% of all WCs and contribute up to 4.6% of PCC, at rates of 215 litres per toilet per day, on average (up to 400 litres per day). These leaks can go undetected and unresolved as the water leaks to the drain, often silently.

Shower water consumption is a function of frequency, duration, and the flow rate of the fixture (Hussein, Memon and Savic, 2016). Showering practices have increased in both frequency and duration, whilst modern pumped or power showers (delivering up to 20 litres per minute) can easily use more water than a single bath (80 litres), depending on the duration of the shower (average shower time is 7.5 minutes, Energy Saving Trust, 2013). This renders the commonly understood advice of taking a *shower instead of a bath* to save water seem outdated and can result in unintended consequences. A generation ago, it was standard practice to take a weekly (Sunday evening) bath. Now it is standard to have a daily (or even more frequent) shower. Paired with increased frequency in laundry use, and the availability of cheap clothing (*fast fashion)*, changes in unwritten social expectations of personal hygiene and cleanliness have contributed to ever increasing water demand per person. Thames Water reports an increase of almost a third in daily personal use over the last 30 years, due to changing lifestyles and lower occupancy household configurations (Thames Water, 2016).

The diversity in household water use by micro-component studies is shaped by access to hard infrastructure within a house. For example, the plumbing arrangement and type of boiler or source of hot water; the number and types of fixtures (taps, baths, showers, WCs) and bathrooms; and water-using appliances (washing machines and dishwashers). Diversity in the material aspects of water provision can be controlled for by situating research within a standardised setting such as university accommodation or other communal living spaces, where the infrastructure configuration and fixture performance is uniform and well understood, and where the resident population resets annually, allowing for repeatable experiments. Insights gathered from end-users within such a setting can then be isolated and explored, allowing for the findings to be translated to the wider population and housing stock. The uptake of modern water fixtures has made showering and laundry activities possible, easier, and more convenient. A bit like road building – you cannot drive a car if there are no roads but build new roads that are accessible and take you where you want to go, and they fill with increased traffic. Meeting current demand fuels increased demand in the future.

1.3 Key transitions and life paths

There is much anecdotal and some empirical evidence that teenagers and young adults are high consumers of water (Hassell, 2016; Staddon, Toher and **Simpson***,* 2016; Vewin, 2015; Walker and Zygmunt, 2009; Gram-Hanssen, 2007). However, the 18-24 years segment of the population are perhaps harder to reach via traditional research methods. Energy and water utility companies traditionally rely upon the price signals and information contained within bills as their main customer engagement tool, but children and young adults are much less likely to ever have sight of these communications, let alone take decisive and conscious action in response to information contained in a utility bill. And whilst the current generation (*gen Z*)[12] have grown up with sustainability on the education syllabus, they may not make the link between their individual and everyday showering regime with a drain on the planet's water (and energy) resources, as such everyday routines are normalised and the accepted standard. For this reason, the water utilities in England and Wales have education teams that provide (albeit limited) outreach services to schools in their regions to support the curriculum, raise awareness and promote the message to value and conserve water.

Whilst there is generally an aging population across the country, London is the home to a larger proportion of younger people, with a median age of 35.8 years and 67.2% of working age (16-64 years) compared with 40.2 years, on average, and 62.3% of working age for England (Office of National Statistics, 2021). This means that, as previously noted, there are proportionally more *younger* people living in the densely populated southeast of England where there are significant pressures on water availability, and therefore, it is particularly important to consider the water using routines of the younger segment of the population when designing water efficiency programmes.

College and university students are at the point of a significant life stage transition, maturing from children into independent adults, gaining autonomy and self-determination away from the family home for the first time. Parents influence and regulate household routines of family members, but as children transcend adolescence

[12] Generation Z, born between late 1990s – early 2010s. Grown up with access to the internet and mobile phones, digitally literate, expect unlimited access to services (24/7).

through their teenage years into adulthood, individual motivations and peer pressure have an increasing impact on modifying or re-enforcing daily habits which, once they take hold, can endure for decades (Gram-Hanssen, 2007[13]).

Moreover, modern popular culture is fixated on body image and young adults are certainly more driven by shifts in their hormones to meet potential life-partners, and these factors are likely to be important determinants of showering routines and associated personal hygiene patterns. The daily shower is simply understood to be the right and proper way that things are done, and part of becoming a responsible but free-spirited adult.

This phase of higher consumption may reduce following graduation and through their twenties, once they have established work-routines with reduced leisure time, settle with a life-partner, and have families of their own, and adopt the patterns of older generations. Alternatively, the embodied routines that are established during this formative life stage could continue into later life, suggesting that lower demand observed in older generations, who grew up in a different era with diverse expectations and conduct standards, may be replaced by more consumptive lifestyles. Approaches that were successful for the *last* generation may not be adopted by the *next* generation of water users (Browne *et al*., 2013b; 2013c).

As well as temporal transience, students are especially spatially transient, regularly moving between short-term rented accommodation, fixed-term tenancies and jobs, interspersed with periodic returns to the family home during the holiday periods and between academic years. However, with rising house prices, reliance on rented housing is stretching well beyond early careers, leading to a perpetuation of spatial transience. Such points of transition provide important opportunities to modify, shape and disrupt everyday routines and habits.

At a basic level, the opportunity for participating in different (personal washing) practices is governed by age, gender, and social class. These bundle together to create characteristic resource use habits that are discernible through research. Bourdieu's (1977) *habitus* conveys the routinised ingrained habits or sub-conscious nature of everyday life and bridges between the cumulative effects of past experiences, resources and tastes, and the character of future-oriented aspirations. *Habitus* mediates between the

[13] This is why, for example, banks are keen to offer students inducements and benefits to take out accounts, as once accounts are set up, they become habitual with all the attendant related business that accrues.

influences of both social structures and individual intentions on how things are done through shared rules, tacit knowledge, and embodied memory (Gregory and Johnston, 2009). The daily and life paths of individuals are intertwined with collective and policy structures through their different identities and roles such as student, employee, child, or parent. The rules of family life and the systems of provision influence the distribution and circulation of materials, competence, and meanings of what are normal and acceptable ways of doing things. And everyday disturbances of routines, such as the introduction of water restrictions, illness, a new household member, a new technology or (of significance to students) moving to a new home, present opportunities to modify consumptive activities (Strengers, 2011).

1.4 Theoretical framework

Conventional approaches to water demand reduction are grounded in rational choice via price signals through metering, educational information in customer bills and other communications, focused upon individual decision makers. There is a logical assumption that customers in receipt of metered bills make a cost-benefit assessment and use less water than unmetered households, because it is presumed that they will make the link between water used and the financial cost, and therefore, they will be motivated to moderate their consumption to save money. But this widely shared assumption does not ring true, as actual measured consumption is often obscured from end-user sight, due to:

- **Inaccessible meters**[14] - locked away behind a cover or in the pavement outside, making it effortful and inconvenient for consumers to be aware of their routine water use with any precision;
- **Infrequent meter reads**[4] - actual (or read) metered bills (as opposed to estimated bills) are infrequently posted (and smart meters, first rolled out with energy have proven that the relations between data and resource use are complex indeed);
- **Direct debit payments** - smooth automatic monthly payments evenly across the year, render any diurnal, weekly and seasonal fluctuations (e.g., garden watering) less visible, and can even normalise unsustainable resource use patterns; and,

[14] Programmes to roll out of Automatic Meter Reading or smart water meters (connected to user apps or portals) in the south and east of England, will help to overcome meter accessibility and meter-read frequency, making day-to-day consumption and cost more visible to bill payers, but these measures fall short of directly *linking* consumption to financial cost at the point of use; or widening the reach of information to *all* household members.

- **Single named bill payers** - accounts are registered to a single named bill payer within a property, such that most household members have little visibility of the costs (if lumped in with other household bills), let alone their own personal water use.

Added to this, research suggests that the price elasticity of water demand is relatively low, (Lu, Deller and Hviid, 2019; Walker, 2009), although with the current cost-of-living crisis, affordability issues are increasing for some segments of the population. Relative to other household bills, such as energy, council tax, rent or mortgage, and food, water is cheap. Average water and sewerage bills are currently around £400 per year (Water UK, 2020). In addition, the Water Industry Act 1999 made it illegal for domestic water supplies to be restricted or disconnected for non-payment of bills on public health grounds. The low marginal cost of water means that social and cultural forces, such as fashion or habit, have a greater impact on consumption than price signals or information, however fine grained. These factors combine to limit the efficacy of water bills compared with other competing financial obligations, and consumers who fall into debt are advised to prioritise payment to other creditors first.

Transformational change is necessary to address a range of urgent societal challenges including the obesity epidemic, climate, and ecological emergency and even the COVID-19 pandemic. Changes to society's underpinning material structures, such as infrastructure and technologies are vital to driving societal change, but their success depends upon the uptake and adoption by end-users. For example, an affordable and integrated public transport service will fail to reduce traffic congestion, carbon emissions and air pollution if end-users do not use the service and continue to travel in private motor cars. These are the actions of individuals and groups of people. Therefore, it is important that policymakers and demand managers understand how and why people *act* the way they do if they are going to successfully design effective interventions.

Many theoretical approaches to behaviour change originate from the health and marketing arenas (and are rooted in psychology), although their application has evolved to addressing environmental concerns in recent years. Broadly speaking, until recently most approaches have focused on changing individual behaviours through rational appeals such as information campaigns or pricing. The implicit view here is that societal goals can be met by getting enough rational actors to change their actions within the target domains (e.g., obesity, recycling, etc.). Whilst some ideas can be translated from health to the environmental sustainability field, the relative balance between *individual* and *collective* impacts, and short- and long-term gains are different and may help to explain some of the challenges faced in reducing unsustainable resource consumption for the common good, in situations where there is no immediate tangible concern or only limited benefit to the individual, unlike with personal health outcomes. For example, a health programme designed to encourage individuals to eat healthier foods can point to short-term, direct, and measurable personal wellbeing benefits, whereas a similar campaign to encourage individuals to recycle more can point only to societal gains (with indirect and longer-term benefits).

In the last decade Government policy has focused on creating behavioural 'nudges' by resetting subconscious (psychological) cues (Institute for Government, 2009; Thaler and Sunstein, 2008) rather than simply providing information or price signals and expecting individuals to make rational (cost-benefit) choices. However, these approaches remain focused on individual behaviours, within the context of wider political, economic, social, technical, environmental, and legal systems and structures. Placing responsibility on the individual to act can be viewed as blaming the end-user (and failings to recognise shared and distributed responsibilities across a range of actors, organisations, and scales), although such reductionist philosophies remain popular within our free choice neoliberal western society.

Ordinary human actions are inherently bound to powerful social and material structures that can work in opposition to individual autonomy or agency, and the creation and reproduction of social activities is shaped by both structure *and* agency without giving primacy to either notion (Giddens, 1984). Theories of *social practice* (SPT) present an alternative (sociological) approach by reframing problematic individual actions, to viewing them as integral to a *collective* or cultural practice and presents an opportunity to rethink mitigations. A practice is a routine or habitual (sub-conscious) way things are done and removes the focus on the individual as the unit of enquiry. Instead, the practice is the entity or thing of focus, and the individual is relegated to the performer of the practice. Reckwitz (2002) proffers that social practices comprise several interconnected elements including forms of bodily and mental activities, things and their use, and background knowledge (understanding, know-how, emotional state, and motivations). A simplified three-elements model[15] (Shove, Pantzar and Watson, 2012), comprising *material*, *meaning*, and *competence*, is shown in Figure 1-9.

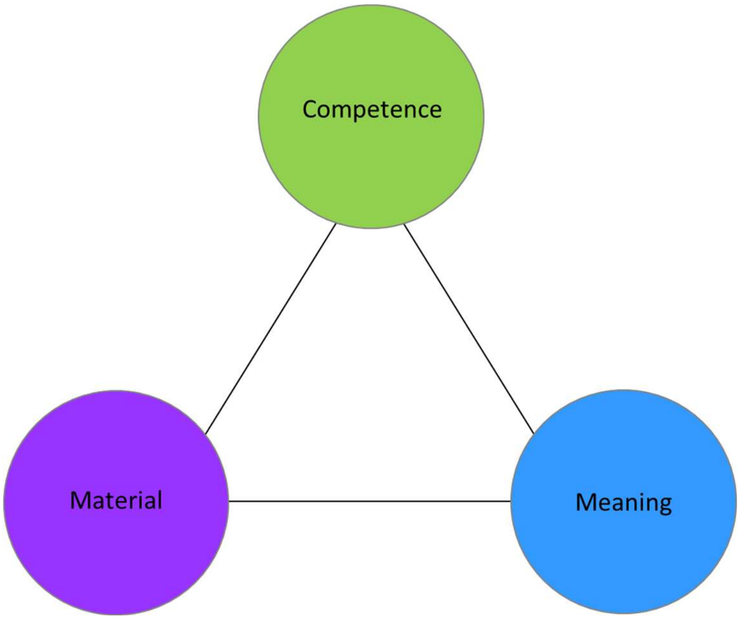


Figure 1-9 Practice – how THINGS are done (adapted from Shove, Pantzar and Watson, 2012, p.29)

SPT recognises that everyday human routines are arrangements of interconnected elements including materials, competences and meanings that define, reproduce, and transform normal ways of life (Shove, Pantzar and Watson, 2012). Understanding how practices are stabilised or modified may give an insight and basis for intervening to create more sustainable patterns of resource (in this case water) consumption. Showering or the more specific acts of hair washing or shaving (showering sub-processes or micro-practices), are part of broader everyday rhythms like morning rituals, exercising or going to the gym, going out for leisure or as part of a bedtime routine.

Whilst SPT is popular in academic circles, it can be criticised as being too theoretical and not practical for those tasked with reducing consumptive patterns in daily life. It has been applied retrospectively to demonstrate and explain the historical evolution in how things are done, with socially shared understandings that are locked-in by cultural and material structures. Past intervention programmes have been evaluated using SPT (for example, the London congestion charging (Shove, 2014) and the Japanese Cool Biz programme to reduce electricity consumption from air conditioning (Shove, 2014; Strengers, 2011). However, demand managers who are constrained by limited external resources and

[15] The three elements have been coloured to help with comparison with the ISM model that follows.

personal competence, have struggled to apply SPT in the design and delivery of planned programmes of mitigation measures.

The Individual-Social-Material (ISM) model (Darnton and Evans, 2013 - see Figure 1-10), was the product of a systematic review and synthesis of numerous behaviour and social change theories prepared for the Scottish Government (Darnton, 2008). It was designed as a practical conceptual framework that summarises complex theory, making it accessible to policymakers and specialist staff who may not be skilled in the social sciences. It comprises ten steps for co-designing behaviour change programmes, from identifying a specific problem or process to target, through to acting and evaluating success.

Figure 1-10 Individual-Social-Material model (Darnton and Evans, 2013, p.3)

ISM has been embedded within Scottish low carbon and climate change programmes. It is underpinned by many theories, including both individual behaviour change (IBC) and SPT, and helps demand mangers to co-design and evaluate intervention programmes. However, it has had limited application south of the Scottish border or within the water sector[16].

[16] ISM was used in the rapid evidence assessment report on water efficiency and behaviour change (Defra, 2018b), although this report was published after the data collection phase of this research was embarked upon.

The ISM model is *not* a SPT tool *per se*, but it can help to focus on the constituent elements, the interconnections of a specified action, and the linkages between bundles of practices. There are direct associations between the two models, for example, the materials element in SPT (shaded purple in the adapted representation in Figure 1-9) maps directly onto the material domain of the ISM model, whilst the meanings element (blue) links with the social realm (meanings and tastes factors) in ISM. Whilst it is relegated from the elements of SPT, the individual is still the performer of the practice (and without the performance the practice would not exist). The individual embodies (or not) the necessary competences to perform the procedures. This know-how is socially learnt, through norms, institutions, networks, and roles.

The ISM model has been criticised for starting with the individual (with the 'ISM' name and by putting the individual in the centre of the graphic) and using the term *behaviour* throughout to describe visible human actions. Behaviour is an individualistic term, reflective of its psychological origins, whereas SPT uses the collective terms *routines* or *patterns*). But ISM does allow for wider social and cultural elements to be considered and given equal focus alongside material and individual factors. These issues and challenges are discussed further in the next chapter.

1.5 Research focus

This chapter has set out the policy context within which this research thesis sits. The urgent need to reduce water consumption in England (the *why* and the *where*) has been highlighted and the specific focus on the showering routines (*what*) of a high-consuming but low-engaged segment of the consumer-base - students (*who*), has been justified. The dominance of individualistic rational choice approaches to demand management, despite being weak or ineffective, was highlighted. The research presented here used a theoretical framework (*how*) based upon a combination of SPT and the ISM toolkit and mixed-methods approach, to move beyond the individual to assess whether strong *social* forces can be capitalised upon to produce an effective *socio-material* approach to delivering real-world water efficiency programmes that might be more effective than conventional rational choice methods.

The aims of this research were:

- *To explore and understand how and why UWE students 'do' showering, and to classify their showering routines;*

- *To design, pilot and deliver a mixed-methods research project focusing on showering (as a significant contributor to water use); and,*
- *To evaluate both the efficacy (through volumetric measurement) and user-acceptability of real-world water conservation interventions to inform future domestic water efficiency programmes.*

The research objectives and questions to meet these research aims are set out in Table 1-1, along with a summary of the methods (detailed in in Chapter 3) that were used to address the research questions.

Table 1-1 Research objectives, questions and methods used

Objectives	Research questions	Methods
1. To assess the *extent* and efficacy of *behaviour*[17] change approaches used to reduce (household) showering[18] water demand in England[19];	1.1 To what extent are current household water demand reduction programmes in England informed by *behaviour*[7] change theories? 1.2 Are there any examples from other areas of sustainable resource consumption that have potential for helping water demand management? 1.3 How is the evidence spread across the contexts of **Individual**, **Social** and **Material**? 1.4 What are the features of successful resource demand reduction strategies?	• Extensive and systematic review of academic and grey literature (see Chapter 2)
2. To establish the baseline water consumption by students in UWE managed campus accommodation;	2.1 How do the university accommodation water fixtures perform? 2.2 How much water do resident students consume? 2.3 Is it feasible to measure the shower micro-component in a large student house?	• Water fixtures audits • Analysis of historic metered water data for UWE student accommodation • Test compatibility of loggers with university BMS and sensitivity of segmentation software

[17] *Behaviour* in this context is a term that covers observable human actions and includes how *things are done* – the routinised *practices* of everyday life
[18] This thesis has a particular focus on showering, but this is set within wider household water consumption
[19] Whilst the literature review covers water efficiency research findings across the globe, this thesis is focused upon England as water management policy and governance varies across countries and even between the devolved nations of the UK

3. To understand and classify the showering routines of the UWE student population to identify groups that share similar showering patterns	3.1 Can the target population be categorised into distinct showering practice groups? 3.2 What are the features of these groups?	• Expansive survey of student population (questionnaire Q/0), followed by cluster analysis of end-user showering pattern typology
4. To design, pilot, deliver and evaluate components (factors[20] and processes[21]) of a real-world intervention strategy covering multiple levels and contexts.	4.1 Can volumetric and end-user insights be collected and evaluated in combination despite different philosophical foundations? 4.2 How can ISM/SPT derived interventions be operationalised in a real-world application? 4.3 Does a SPT approach help to identify factors that would be overlooked from a conventional individualistic perspective? 4.4 Can some factors be harnessed to alter the current trajectory of showering demand? 4.5 What are the benefits and limitations of using the ISM model to design and evaluate showering water demand reduction strategies?	• Measure changes in water consumption at household (meter) and shower fixture (logger) scales • Gather expert/upstream stakeholder insights via ISM workshop on real-world application • Collect user-experience data on showering routines via questionnaires, diaries, focus groups

[20] *Factor* is an ISM term, whilst *element* is the equivalent from SPT
[21] Processes are the links or relationships between elements or factors

It is intended that the findings presented in this thesis can be used to inform not only future household water efficiency programmes, but also the combination of approaches used can translate to other resource consumption mitigation action plans to transform responses to the climate and ecological emergencies and other pressing societal problems.

This chapter has introduced the policy context for this research and outlined the drivers behind the enquiry to demonstrate the value of the findings in helping to secure sustainable water supplies in England into the future. In the next chapter (Chapter 2), relevant academic and grey literature on water demand management, resource efficiency and behaviour change are reviewed (objective 1, research questions RQ1.1 to RQ1.4), and alternative approaches to intervening in everyday consumptive processes are debated; to show how the theoretical framework for this research was established; and, to demonstrate the gap in theoretical, methodological and empirical knowledge that this study has contributed to .

This leads on to the methodology chapter (Chapter 3) which sets out the philosophical foundations for this research and justifies the mixed-methods approach adopted. It includes a description of the experimental design; the configuration of the *living laboratory* (campus student accommodation at the University of the West of England); and the demographic characteristics of the research participants (student residents). The chapter describes the basis for, and design of, two suites of water saving interventions that were tested via two field trials (Wave 1 pilot and Wave 2) during 2018, divided into conventional and practise-based measures. Data collection at different scales of resolution (at household, bed, and shower fixture level), and quantitative analysis of volumetric water consumption data is described (objective 2). This is complimented with an outline of how end-user insights were collected and evaluated (objective 3), using both quantitative and qualitative methods, including abductive thematic analysis. The ISM model was used to structure the evaluation of the effectiveness of the field trials from the end-users' perspectives and identify opportunities for future intervention.

The main research findings are presented in the following three chapters. Chapter 4 sets the historic or baseline (or Wave 0) water consumption level (objective 2, RQ2.1 to RQ 2.3) by students living in the university accommodation, prior to the implementation of the packages of water saving interventions. It also classifies how UWE students '*do'* showering (objective 3, RQ3.1 and RQ 3.2), by summarising the results of the expansive Q/0 questionnaire deployed across the student body and characterises features of the major or '*UWE standard'* style of student showering, established via a cluster analysis of different dimensions of showering.

Chapter 5 summarises the volumetric and end-user insights from the Wave 1 field trial, undertaken in the spring of 2018, to pilot the feasibility of combining a mix of different data collection techniques and intervening in a real-world environment (objective 4, RQ4.1 and RQ4.2). The Wave 1 tested a range of conventional *individualistic* water saving interventions, including:

- information posters;
- simple (sand) shower timers;
- Amphiro smart shower devices; and,
- face-to-face engagement (via a focus group).

The quantitative results are compared with the Wave 0 baseline results (in Chapter 4) to assess whether any of the mitigation measures delivered measurable water savings (RQ4.4), and the frequency and coverage of ISM factors across the five focus group discussions are assessed (RQ4.5).

Chapter 6 presents the volumetric and end-user results from the Wave 2 field trial that was run in the autumn 2018, for a new cohort of student residents, using novel *practice-based* interventions that targeted the '*UWE standard*' style of showering. (Objective 4, RQ 4.2 to RQ 4.5). The water saving measures rode on the coat tails of the 'Blue Planet' effect[22] and the prevailing public concern for single-use plastics. Participants were:

- invited to: *'go green'* and substitute their usual plastic-bottled shower products in exchange for an unpackaged solid shampoo bar; and,
- challenged to reduce shower frequency ('*go gold'*) by using dry shampoo as an alternative to daily hair washing, supported with guidance on alternative 'between-wash' hair shampoo hair styles.

The impact of the interventions is assessed in terms of changes to measured water consumption; the dimensions of showering are compared with the Wave 0 and Wave 1 findings; whilst the spread of ISM factors during the two focus group discussions are analysed.

[22] Sir David Attenborough raised concern over plastic pollution via his *Blue Planet* TV series and the term '*single-use'* was the 2018 word of the year., added to the English Dictionary (Flood, 2018)

Chapter 7 reflects upon the results from the different phases of the research and discusses prominent and emergent themes from the qualitative analysis of the focus group transcripts, in relation to the ISM domains and factors and other ideas that developed from the discussions that were not fully captured or omitted by the ISM model. It also presents the conclusions, limitations, and recommendations for future research and the possible features of successful communal establishment water efficiency programmes. A large amount of primary end-user data was collected for this research, including via four questionnaires (*n=220* responses), two rounds of diaries (*n=47* diarists) and eight focus groups (*n=41* participants). Not all the results are presented or summarised in Chapters 4-6, particularly if they were judged to be repeats of previous rounds. Instead, responses to recurring rounds of the questionnaire were used to validate and confirm the findings of the first (Q/0) survey and only exceptions are highlighted. However, the full results are tabulated in the supporting appendix (Appendix C), for comparison.

Chapter 2 Literature Review

Having set out the policy context within which this thesis sits (the *why*, *what*, *where* and *who*), this chapter reviews the academic and grey literature to meet objective 1 and associated research questions RQ1.1 to RQ1.4:

Objective1. To assess the extent and efficacy of behaviour change approaches used to reduce (household) showering water demand in England.

RQ1.1 To what extent are current household water demand reduction programmes in England informed by behaviour change theories?

RQ1.2 Are there any examples from other areas of sustainable resource consumption that have potential for helping water demand management?

RQ1.3 How is the evidence spread across the contexts of ***Individual, Social*** *and* ***Material****?*

RQ1.4 What are the features of successful resource demand reduction strategies?

2.1 Behaviour change or cultural change?

It is recognised that the technical solutions (termed *hard* measures) favoured by the water companies cannot meet the forecast water supply/demand deficit alone. Hard measures include installation of fixtures and fittings that physically reduce the flow of water, e.g., the installation of low flush toilets or flow regulated showerheads (Staddon, Toher and **Simpson***,* 2016). It is increasingly accepted that *soft* human behavioural-based interventions are at least as important for reducing water demand (Waterwise, 2017a; Wymer *et al*., 2014), as they determine how consumers adopt new technologies and engage with the infrastructure that delivers water within our homes. Humans are complex beings, and to understand why people act the way they do in modern life, we need to understand the social context that shapes the "*way things are done"* (Chatterton, 2011, p.29).

Behaviour change approaches are broadly drawn from the fields of psychology, economics and sociology, and each discipline carries its own language, culture, and perspective. Indeed, *behaviour* is a psychological term, and refers to the way in which individuals act or conduct themself, especially towards others. However, it is a term that is often used (or mis-used) interchangeably to describe *collective* human actions. Different theories offer different explanations of what happens and focus on different aspects of the issue of concern. None of them provide the complete view and it is unlikely that complex problems can be solved via a single approach. People are all different with unique perspectives, skills and motives, and there is great variation in their patterns of water consumption. Water demand managers and policymakers are often drawn from a range of technical disciplines, and they develop interventions by selecting and blending approaches from three broad theoretical categories, grounded in social psychology, behavioural economics, and SPT.

Social psychology and behavioural economics form the basis for conventional IBC models that are rooted in public health and safety and focus on the individual; someone who responds both deliberatively and automatically to stimuli that drive how they act. Examples of this type of approach include '*smoking kills'* tobacco cessation messaging, '*when stroke strikes, act fast*', pension autoenrollment, organ doner opt-out and Public Health England's '*change 4 life'* social marketing campaign to tackle the causes of obesity.

Complementary to these traditional individualistic approaches, there is emerging interest in how a sociological approach can help with understanding what drives frequent and routine consumption of resources and how these patterns do and might change. SPT focuses on the socio-material elements that shape the actions of performers of activities and represents a shift in perspective by removing the individual as the focus of enquiry. Examples of this approach are more limited than individualist framing, but include London congestion charging (Shove, 2014) and *'Cool Biz'* (Shove, 2014; Strengers, 2011), a Japanese initiative to reduce office electricity consumption by limiting the use of air conditioning.

These represent two-ways of looking at the same issue – the first puts the individual actor in the centre, whilst the second focuses on the *activity*, within its socio-material context. These approaches are reviewed in the following sections.

2.2 Individualist approaches to behaviour change

2.2.1 Socio-psychological models

Government has been influencing its citizens' behaviour since at least the second world war to achieve health and safety goals and more recently to address environmental concerns and other public policy challenges. During the war, messages appealed to the *national* spirit and encouraged action for the *public* good rather than individual *self*-

interest (i.e., there was a *social*[23] influence acting upon the actions of individuals). Examples included '*your country needs you*', '*careless talk costs lives*', and '*dig for victory*' (see Figure 2-1). In 1946 the Central Office of Information was formed. Campaigns have historically provided information to educate citizens to make logical choices, backed up with legislative prohibition or financial (dis)incentives designed to steer people to adopt the desired actions, although there is evidence that people tend not to respond well purely to price (Chatterton, 2011).

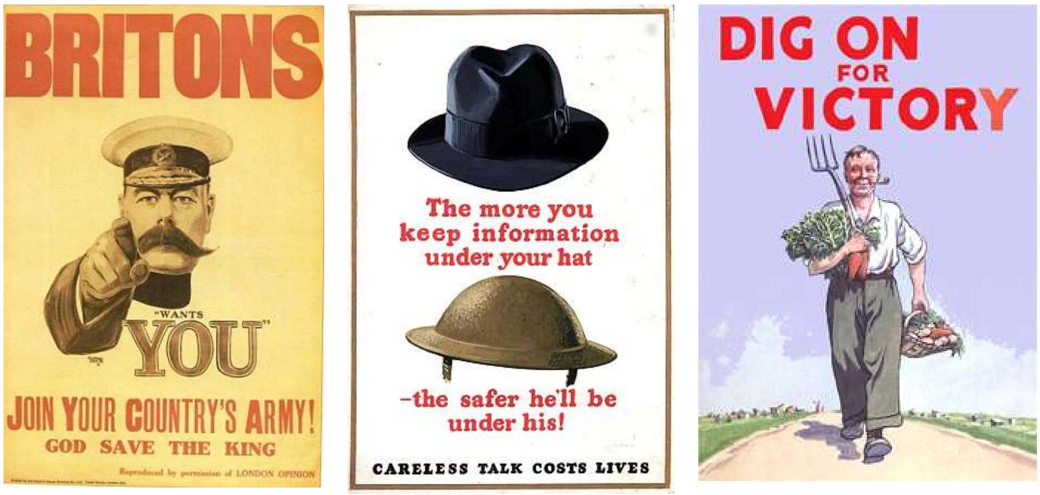


Figure 2-1 Examples of wartime information campaigns

Psychological models represent different aspects of human decision-making processes. They assume that consumption can be affected by *stimulus-response* mechanisms, and by engaging attention or rational thought processes (Chatterton, 2011). To a degree, humans are agents of our own destiny, but our choices and actions are shaped by the *external* world. The individualist models currently prevalent in environmental policy originate mainly from health whereby efforts are made to *persuade* (stimulus) individuals to *adopt* (response) healthy lifestyles, such as balanced diets, weight management, increased exercise, smoking cessation, and reduced alcohol consumption. These influential models, sometimes referred to in the literature as ABC models, for Attitude, Behaviour, Choice/Context/Constraint, (Chatterton, 2011), focus on the provision of information (stimuli) to engage attention, influence attitudes, persuade individuals to change (respond) their behaviour and to make rational choices based on individual value-judgements. They assume that individual actors will respond to salient or relevant information by adopting lower consumptive routines (or healthier lifestyles). Financial

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[23] This section of the literature review focuses on the evolution of individualist or psychologically framed models, and tracks the increasing recognition that the external context, and ideas that are rooted within sociology, have important influences on how things are done.

savings (or better health) will give individuals the motivation to act, whilst wider *society* benefits from reduced demand on natural resources (or public health services for preventable conditions). This section tracks the evolution of psychological models and charts the rise in emphasis of the need to consider *external social* influences on individual behaviour and the role of subconscious routines or habits in our actions.

The ***health belief model*** was developed by social psychologists from the US health service in the 1950s and assumes that behaviour is the result of a set of core beliefs, perceived benefits of and barriers to action, and that self-efficacy explains engagement in healthy behaviour (see Figure 2-2). The HBM assumes that individuals consciously process information to make rational decisions but largely ignores *social* contexts (other than 'cues to action') and emotional factors (Ogden, 2007).

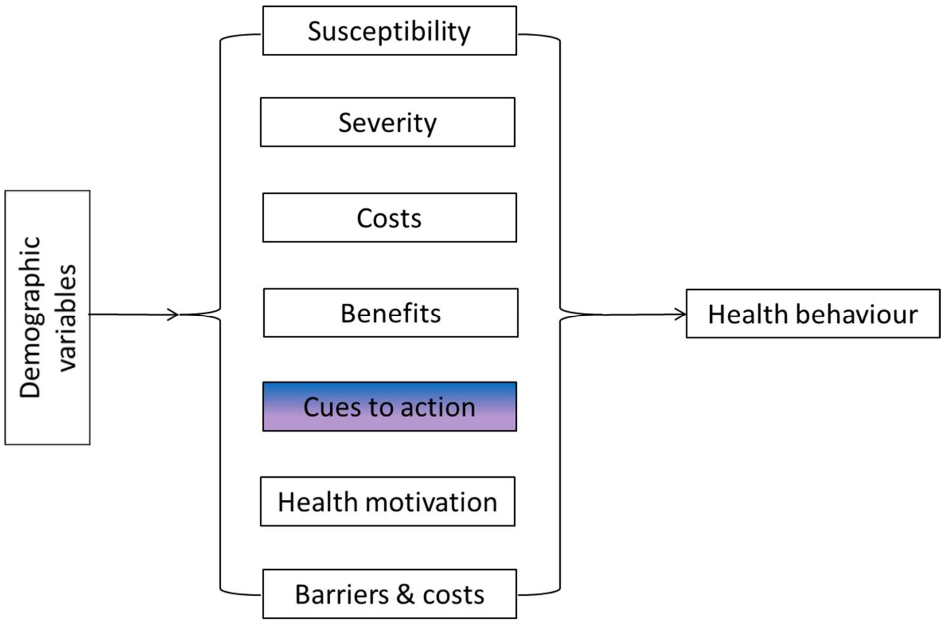

Figure 2-2 Health belief model (based on Rosenstock, 1966 in Ogden, 2007, p.25)

Central to most psychological models are *attitudes* or preferences toward a behaviour (or object) and is a deliberative calculation which balances our generic beliefs (or worldview) and the innate value we attach to those beliefs, and generally aligns with economic rational choice (Darnton, 2008). Most psychological models are intention-based and as models have evolved over time, additional elements to explain outcomes have been included that diminish the central primacy of attitudes in determining behaviour, such as norms and agency. The role of intrinsic values in driving pro-social or pro-environmental behaviours is further discussed below.

Ajzen and Fishbein (1980) observed that it is common for people not to act in-line with their stated intentions (or when they are armed with relevant information to make informed choices). This is known as the 'value-action gap' (or *information*-action gap). For example, people may express pro-environmental intentions, but then fail to act in line with these attitudes (Chatterton, 2016). The ***theory of reasoned action*** (Ajzen and Fishbein, 1980) extended the individual HBM to address the value-action gap by setting internal attitudes within the social context of subjective norms, or beliefs about what others think and their internal motivation (including previous experience) to fit in with other people (see Figure 2-3).

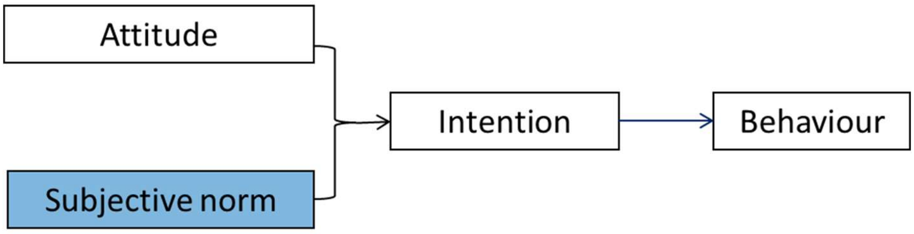

Figure 2-3 Theory of reasoned action (based on Ajzen and Fishbein, 1980, p.100)

Social norms refer to the beliefs that an individual has about what the majority of other people-like-them do or think and can strongly influence behaviour. Norms act as a guide to how we *should* behave and how we *expect* others to behave. Cialdini makes a distinction between *descriptive* norms, based on what *is* done by the majority, and *injunctive* norms, that specify what *ought* to be done – tacit rules on appropriate conduct (Cialdini, 2008). Schwartz *et al.* (2016) also highlight *personal* norms, based on internalised sense of moral responsibility to help others.

The ***theory of planned behaviour*** (Ajzen, 1991) shown in Figure 2-4, expands the TRA model to include barriers determined by both internal and external factors (perceived behavioural control or 'efficacy'), including perceived constraints (such as lack of time, money, skills, or the co-operation of others). The TPB highlights a particular aspect of agency or an individual's self-efficacy, that is their sense of control or ability to act, and their belief that the action will result in the expected outcome. Agency determines whether someone will attempt a behaviour and how much effort they will put in (Darnton, 2008). However, the TPB provides no process for assessing the impact of external conditions on behaviour other than as perceived by the individual, placing responsibility for behavioural control on the individual's state of mind (Chatterton, 2016).

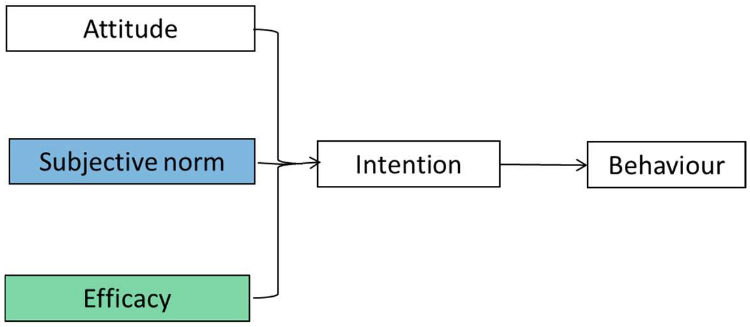

Figure 2-4 Theory of planned behaviour (based on Ajzen, 1991, p.182)

The ***theory of interpersonal behaviour*** (Triandis, 1977) shares the same strong individual and internal psychological focus on rational decision-making as the TRA and TPB, by including attitudinal and social influencing factors (see Figure 2-5). However, the TIB model was expanded to include wider contextualised processes. Within '*social factors*', the TIB brings in the idea that behavioural intention is influenced by the individual's identity or role by *reference to* others within a social group, and how they see themselves privately, publicly, and collectively, and this is subject to ongoing negotiation (Jackson, 2005).

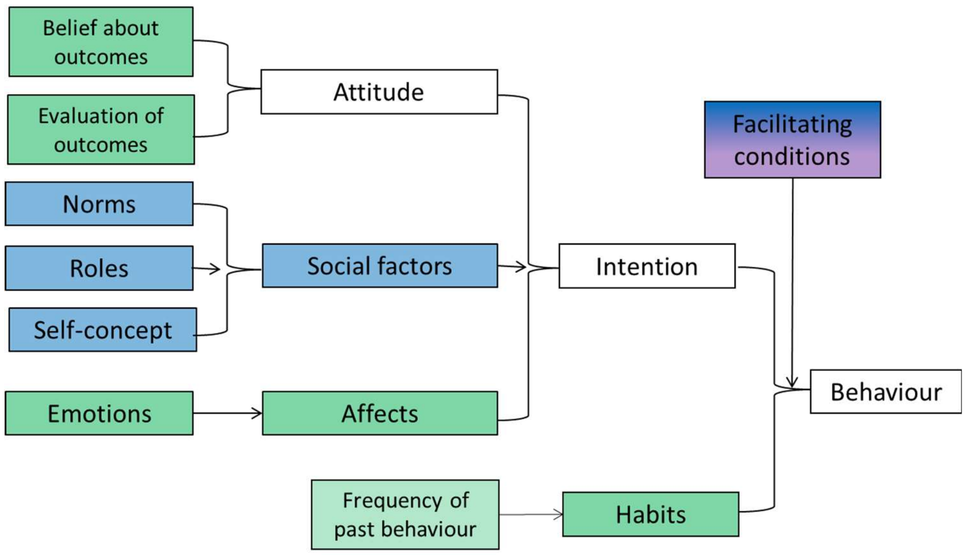

Figure 2-5 Triandis' Theory of interpersonal behaviour (based on Jackson, 2005, p.95)

As well as deliberative cognition of attitudes, the TIB also acknowledges that emotional states, including mood and values, are important in sub-consciously driving patterns of behaviour (Chatterton, 2011). The explicit inclusion of affect in the TIB is notable, as most psychological models implicitly include emotion within other factors (Darnton, 2008).

Whilst the TPB positions beliefs as the underlying foundation of behaviour, the TIB allows for less deliberative behaviours and identifies the significance of habits and routine in determining behavioural tendencies directly (Darnton, 2008). Habits bypass the conscious and sub-conscious pathway of intention formation, and are routine automatic behaviours driven by unconscious repetition within a stable context (Chatterton, 2011). Their inclusion in the TIB acknowledges that people frequently "*do things without having a clearly formed intention to act in that way*" (Chatterton, 2016, p.37). Stern (2000) describes habit as an individual's "*standard operating procedure"*. This is important, as problematic behaviours can become an issue if they are repeated, or when previously unproblematic behaviours (e.g., driving, or in the context of this thesis, frequent or lengthy showering) come to be seen as problematic (Chatterton, 2016). Habits are an important feature in both behavioural economics and SPT, which are discussed below (sections 2.2.2 and 2.3.1, respectively).

The TPB identifies internal control as a constraint to decision-making, whilst the TIB extends this to also include external controls within the term facilitating conditions, covering both external or environmental determinants that shape the observable behavioural outcome, as well as individual competences or resources and their perception of them. These contextual factors are those beyond an individual's control (Stern, 2000), and are often omitted from most psychological models as they are more concerned with the influencing factors that are situated within the individual's psyche (Darnton, 2008). Instead, most models account for context by incorporating them within agency.

The role of values and identity are important factors in determining appropriate behavioural responses, whether by conforming to social norms or by deliberately trying to stand out as different. Humans are social creatures who strive for autonomy whilst maintaining close relationships with others. Through life, the influences of family and peers on autonomy and relatedness change and different cultures place different values on the development of autonomy and relatedness. Western cultures tend to embrace individualistic orientations, in keeping with neoliberal ideology, whilst social relatedness may be more strongly favoured amongst the non-Western population (Zhao and Chen, 2015; Triandis, 1995).

Values and frames can help to explore the influence of social factors and the value-action gap. The Common Cause (commoncause.org.uk), a not-for-profit social enterprise that supports the local community to support food growth was set up in 1991 in West Sussex. It champions the need to engage with people's intrinsic pro-social or pro-environmental values to tackle societal problems, including mitigating for climate change or tackling biodiversity loss (Crompton, 2010). Whilst co-operating to tackle these 'bigger-than-self' problems may not be in an individual's self-interest, values-based approaches can draw upon people's compassion and sense of community to act responsibly and 'do the right thing' and override competing extrinsic values that drive individuals to seek praise, reward, and power to boost status or ego. However, values are not the only determining factor, and social norms, facilitating conditions and habits, as described previously, are also important (Chatterton, 2011).

2.2.2 Behavioural economics

In combination with legislation to control or prevent certain activities, policymakers have used economics to steer behaviour through pricing. Standard economic (or rational choice) theory assumes that individuals will make rational decisions to maximise their own self-interest (or *utility*) and these choices are based on the relative balance of costs and benefits. Most socio-psychological models align with standard economic theory with behaviour viewed as the expected outcome of a deliberative and linear decision-making process. However, evidence indicates that people do not always act rationally or consistently because their attitudes, emotional state, and the social influences on their intention impact upon their decision-making processes. The application of psychology to explore departures from economic rationality is termed *Behavioural Economics and* has become popular in the last decade.

Nudge theory (Thaler and Sunstein, 2008) proposes that many previous attempts to change behaviour have failed because they have attempted change people's minds simply by raising awareness or appealing to some rational argument (for example, '*saving water is a good thing to do*'). However, the theory goes that human emotional or primitive brains take over many of their habitual decisions and routines in the pursuit of pleasure or an easy life, constantly sabotaging the efforts aimed at the rational mind (Dolan and Galizzi, 2015; Kahneman, 2012; Peters, 2012). Rather than making deliberative assessments of all options, our brains are hardwired to make mental short-cuts, termed *heuristics*, that have evolved to benefit us. However, systematic heuristic biases often result in less optimal decisions. One of the most common of these heuristic biases, very relevant here, is that changing water use habits is often harder than habit continuation even when actors know that change will be beneficial.

The reflective part of the brain makes careful, considered, and rational judgements, whilst the automatic system allows for a wide range of sub-conscious processes to quickly respond to external conditions or to follow routine patterns with minimal mental processing, often simultaneously doing other multiple things. However, the result of these sub-conscious processes may not always be ideal (Chatterton, 2011). This fits well with the TIB model in which habits are automatic and repeated. Behavioural economics focuses on the point of decision-making and can ignore factors that represent 'identity' which are better represented as social factors within the TIB model (Chatterton, 2011).

2.2.3 Social marketing

The National Centre for Social Marketing defines *social marketing* as 'a process for delivering behaviour change for the public good'. It is a tool that was popular during the Blair government at the start of the millennium and is used when education is not working, and regulation is not viable (Rothschild, 1999). It assumes that there is a gap between the desired pro-social behaviour and a citizen's self-interest and that this gap can be filled by an intervention that shifts the balance towards the desired action along the education/law continuum (Tapp and Rundle-Thiele, 2016).

Its theoretical background stems from psychological models, combined with other interdisciplinary ideas. Social marketing programmes usually comprise a package of measures that incentivise individuals to alter problem behaviours through support, networks, feedback, and rewards. It is much more than a communications or advertising package (Tapp and Rundle-Thiele, 2016). However, there is often a lack of integration or connectedness between different behaviour change fields which can result in narrow operating structures. Social marketing does not have to be limited to cognitive rational choice models and can be used to create social change within communities; create or break habits; or affect social norms. It can work on both downstream end-users but also in a strategic upstream direction to change policy.

A typical social marketing programme starts with research to understand the problem, collected via self-report methods (Rundle-Thiele *et al*., 2013). To ensure maximum efficiency with limited resources, the target audience is segmented or spilt into groups that share similar characteristics, such as demographic, geographic, or behavioural factors and assumes the segments share similar motivations (Andreasen, 2002). And a vital ingredient for success is a focus on service satisfaction, akin to commercial advertising (Tapp and Rundle-Thiele, 2016).

2.2.4 Examples from the water conservation context

A review of the literature reveals only a very limited number of studies in which psychological IBC theories have been explicitly applied to water demand management interventions, and mostly from regions of the world that are more obviously water stressed. However, to supplement these limited examples there are further cases in which academic research has examined the broader component psychological factors of the theoretical models of IBC, including attitudes, values, intention, norms, and habits.

Lam (1999) tested predictions of intentions to conserve water by 244 government staff in Taiwan via a questionnaire that covered the four components of the TPB model (attitudes, norms, control, and intention) supplemented with potentially conflicting or opposing variables of perceived *moral obligations* (civic duty to conserve limited water resources in the public interest) and perceived *water rights* (self-interest in personal comfort and convenience). The research indicated that whilst the model was effective in predicting intention to save water by altering routines (soft measures), it was less effective in predicting intention to fit devices (hard measures). However, this was a study into theoretical intentions and actual real-world savings were not tested.

A study of 462 participants (Marandu, Moeti and Haika, 2010) tested the TRA model to predict water conservation behaviours in Botswana. Whilst both antecedent constructs (attitudes and norms) were statistically influential contributors to water use, and individual perspectives were more powerful than shared social rules linked to water saving actions, the study concluded that these two variables did not fully explain actions and that water conservation is influenced by a host of other factors.

Morowatisharifabad, Momayyezi and Ghaneian (2012) built upon this study by comparing the efficacy of the HBM and TRA models to predict water saving behaviours among 200 households in Iran. Questionnaires via face-to-face interviews assessed the frequency of a mix of sixteen individual water saving actions (soft measures) and eleven listed *household* infrastructure maintenance and fittings (hard measures). Questions were formulated to explore each component of the two models. The research indicated that perceived barriers (HBM) were a strong determinant for preventing water saving behaviour, followed by individual attitude (TRA). The more complex HBM was reported to be more effective in predicting water saving actions and could explain 21% of variance although perceived benefits and severity were not statistically significant. In comparison, the simpler TRA model only accounted for 8.4% of variations in water saving actions (attitudes and norms).

A 354 online survey response study in Romania (Untaru *et al.*, 2016) explored the predictors of individual intention to water saving in hotels. The research used an extended TRA model that included environmental concern and water conservation activities in everyday life determinants, and found that attitudes, norms, and water conservation activities were influential. However, whilst environmental concern had a positive impact on attitudes and water conservation activities, it did not have a significant influence on changing norms.

A recent large UK survey of 1,196 households examined the relative contribution of psychosocial determinants of water conservation (Russell and Knoeri, 2019). The research found that attitudes, norms, and habits are important in controlling motivations to save water and that habits were the single most important predictor of intentions. The study concluded that changing ingrained and repeated patterns of behaviour is a vital component of effectively managing domestic water demand and suggested that discretionary or non-essential water use could be targeted by both upstream and downstream interventions. Upstream measures focus on changing the context or structural conditions before use occurs by changing norms and might include programmes that seek public commitment or set collective or community-based water saving goals, such as in schools (Walton and Hume, 2011). Whereas downstream mitigation includes providing information at decision points that may be vulnerable to change, such as information for house movers or by suppliers of renovation services including DIY stores and trades people.

In their Australian study, Jorgensen *et al*., (2013) revealed the inconsistency of combining individualised intention models with household-level consumption data used to measure outcomes, but did report that habit strength, past practices and perceived behavioural control could predict intention to conserve water. The difficulty with measuring behaviour rather than self-reported intention is also raised by Trumbo and O'Keefe (2005). They applied the TRA model to telephone survey data collected in Nevada, to measure the impact of information provision on attitudes and norms. Not surprisingly, they concluded that the actions of individuals who hold pro-environmental values are reinforced by the provision of information as they are more likely to seek and act upon water conservation messaging compared with segments that have different values. The study suggested that an intermediate step in changing water consuming behaviours in those with only low level or latent water saving intentions is to engage with the intermediary step of information seeking to boost intention.

Research has attempted to predict actual water demand using attitudes toward water conservation and use, with mixed success. Aitken *et al.,* (1994) concluded that their non-significant results add to a body of evidence that does not support the link between attitudes and behaviour.

From a review of eight theoretical behavioural models, Dreibelbis *et al*., (2013) developed a framework for designing and evaluation of behaviour change interventions for water, sanitation, and hygiene (WASH) projects. They concluded that existing models under-appreciated the role of technology in influencing behaviour outcomes, instead focusing on individual-level behavioural determinants and largely ignored the role of the physical and natural environment.

Walker and Zygmunt (for Waterwise, 2009) reviewed the water (and energy) implications of bathing and showering behaviours and technologies in the UK. They adopted Kurz's (2002) model of behaviour-technology interactions (reproduced in Figure 2-6), which aims to extend beyond simple technocratic approaches to managing resource consumption using choice theory (rooted in conventional economics). Different psychological factors that influence behaviours were identified, including the *affordances* of objects (perceived potential use); how individuals are differently *attuned* to various types of affordances; and the *effectivities* (skills) that allow people to make use of the object's affordances.

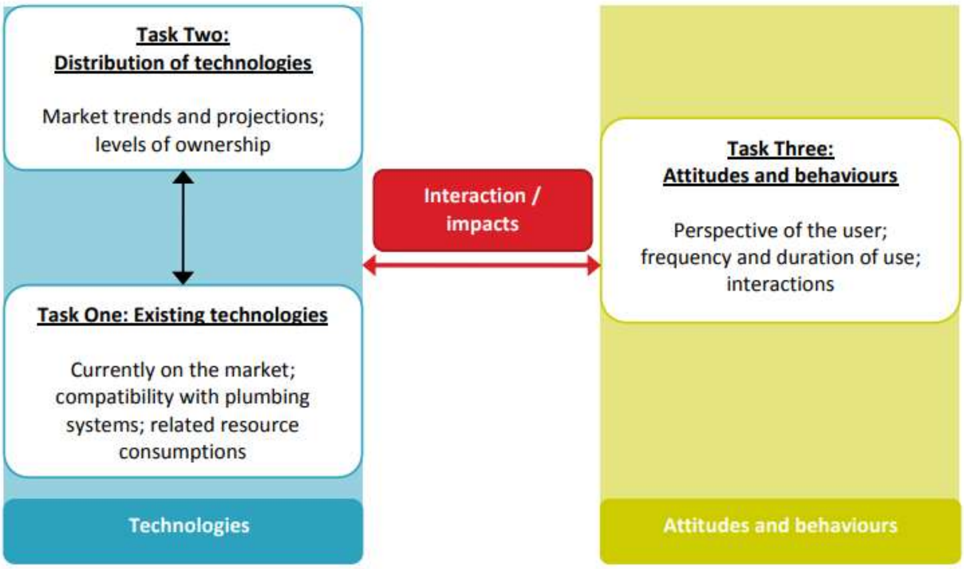

Figure 2-6 Behaviour-technology interactions and task division (reproduced from Walker and Zygmunt, 2009, p.6, based on Kurz, 2002)

The conceptual model includes psychological ideas of limited rationality, rebound and prior conditions, and the need to consider everyday interaction between the individual and their social context. Walker and Zygmunt's review is rooted in individual agency and pushes for more evidence on the drivers of behaviour in terms of shower duration and frequency. There is limited data on the impact of demographics, technologies and temporal variables on shower duration and frequency. They note that awareness of water scarcity is much lower than public knowledge of climate change, energy and waste, and there is low awareness of the interaction between water and energy.

PCC presents some key challenges in understanding and intervening in the dynamics of daily water-using routines (ESRC, 2011). PCC is only an *estimate* and can be *calculated* in two ways (Holden, 2014):

- from a top-down mass balance approach, based on the *measured* water volume (the *direct input*, or DI, of water leaving water treatment/entering the mains network and passing through District Metered Area (DMA) bulk meters, less an allowance for network losses due to leakage, and metered consumption by non-household connections) supplied to *all* domestic properties divided by the *estimated* population served (based on census. electoral roll and socio-economic data); or,
- from a bottom-up approach *extrapolated* from panel studies of *metered* households, for which water companies hold more reliable occupancy data, including socio-economic class (Edwards and Martin*,* 1995). However, householders are likely to be aware that they are part of the reference study and as a result may use water differently than the wider pool of consumers, even if unintended. Added to this, their properties are not likely to be representative of the residential population as a whole.

Metering roll-out is expanding the proportion of the *measured* component within PCC calculations, giving rise to more reliable estimates of *household* consumption (PHC), and the volume and location of leaks from water company owned assets and customer-side losses from domestic plumbing systems. However, without accurate knowledge of the occupancy of individual domestic properties, PCC remains dependent upon *estimates* that are *extrapolated* from population data derived from census figures gathered only every ten years. Despite these challenges, policymakers remain fixated on driving down PCC.

For 2020-21, the reported average PCC for unmetered customers across England and Wales was 183 l/p/d, whilst the customers that pay for their water by volume flowing through a meter apparently used a quarter less, at 139 l/p/d, on average (Water UK, 2022). However, the difference between a *measured* volume (aggregated metered consumption) and a *guess*, based on several distributed non-metered assumptions and estimates is not necessarily a *saving*, as there are too many confounding variables. For example, the roll-out of regional metering programmes has revealed that leakage has been underestimated in the past (Staddon, 2008).

A further problem with relying on PCC is that it represents an *underestimate* of **total** personal consumption (individual daily water allocation or *budget*). PCC excludes regular daytime personal water use to meet health and welfare needs (WC-flushing; hand washing; food preparation and drinks) accessed in non-household premises, such as places of work, education, and leisure venues, by those individuals whose lives take them away from the home, i.e., most of the school- and working-age population. This outsourced daytime personal use accounts for at least a further 16–28 l/p/d (c.10-20%) based on typical and excessive use benchmarks for offices (CIRIA, 2006).

During the initial COVID-19 lockdown across the UK in spring 2020, the UK government instructed its citizens to work remotely (online or by telephone) from home if they could; schools and university campuses were closed; and most leisure time was spent at home, except for permitted limited daily outdoor exercise. Water companies reported that non-household consumption was halved, as industry and businesses shut down or reduced on-site output, whilst domestic consumption increased by approximately 20% (Abu-Baker, Williams, and Hallett, 2021; Menneer *et al.,* 2021, Staddon and Bulmer, 2020). Indeed, the reported PCC figures for 2020/21 increased from 142 l/p/d the previous year, on average, to 145 l/p/d (with metered consumption up from 129 to 139 l/p/d and unmetered use *estimated* to be up from 171 to 183 l/p/d (Water UK, 2021 and 2022). This increase cannot be solely attributed to increased handwashing or other COVID-19 risk mitigations (Staddon *et al*., 2020), but a function of people spending more or most of their time at home. Some of this displaced non-household consumption may become *permanent* domestic demand, reflecting long-term closure of city-centre offices and the hospitality and retail supply chain that services city-centre workers, with home working becoming normalised; and more time spent at home due to the squeeze on disposable incomes with rising inflation and household bills.

Yet, despite these flaws, PCC is embedded within water company regulatory reporting to Ofwat and informs the basic mandatory minimum standards for new-build house developments within the Building Regulations (HM Government, 2016). In 2019, measures to reduce personal water use were consulted upon (Defra, 2019), and explored views on reducing the current design minimum PCC standard for new-build of 125 l/p/d, and an optional tighter standard of 110 l/p/d in water-stressed local authority areas. But this is unlikely to have any impact on water stress and availability, as it only potentially impacts on new build, and has no impact on the existing, older housing stock.

Meanwhile, following on from their universal metering programme of 2010-15, the regional water supply company Southern Water have adopted an ambitious PCC target of 100 l/p/d by 2040 across *all* housing stock (Southern Water, 2020 and 2019), down from a currently reported PCC of 132 l/p/d, (Water UK, 2022), and not just for new housing. International evidence suggests that 85-100 l/p/d is an achievable range if alternative water sources are used to augment potable water supplies, such as using greywater from baths, or rainwater to flush WCs (Chenoweth *et al*., 2016).

There is only weak evidence that the price elasticity of demand has an impact on domestic water demand (Staddon, 2010a; Bagozzi and Burnkrant, 1979). Despite this, metering represents a key government strategy for reducing domestic water consumption. Potential savings of 10-15% are often cited (Defra, 2008a) as justification for metering roll-out. However, these consumption reduction claims can be traced back to the national metering trials that were conducted around the time of sector privatisation (1989-1993) at a dozen sites around the UK, including on the Isle of Wight (Gadbury and Hall, 1989). The aim of the trials was to understand the practicalities of large-scale adoption of household metering rather than to demonstrate a demand reduction effect from the installation of meters. Most of the field sites were not socio-demographically representative of the wider UK population. Whilst the trials reported an 11% reduction in water consumption, 40% of this was due to enhanced leak detection and repair and had little to do with any change in average household demand, and any reductions were likely to diminish after a short time as consumers became accustomed to the meter.

However, the significant contribution to demand reduction from leakage control is largely ignored. Leakage reduction is expensive and water suppliers seek to achieve a balance between the cost of leakage reduction and benefits. The Economic Level of Leakage (ELL) is reached when the direct cost of finding and fixing leaks rises to match the marginal cost of creating new water supplies. However, following the Deputy Prime Minister’s Water Summit in 1997, company specific Sustainable ELL (SELL) targets were introduced to take greater account of other non-economic factors including social and environmental considerations (CIWEM, 2021) and by including these wider indirect costs made it more cost effective to drive leakage down further than by direct economic costs alone. This has reduced the opportunity to secure significant water savings from metering alone.

During the period 2010-15, Southern Water installed nearly half a million water meters (Ornaghi and Tonin, 2015). The universal metering programme increased meter penetration from 40% to more than 90% of households across the region. Preliminary analysis reported a 16.5% reduction in household consumption. The majority (12.5%) of this reduction occurred immediately after meter installation in anticipation of the move to metered bills, but consumption continued to drop in the following 18 months before stabilising. The researchers concluded that the accompanying information campaign had little direct impact on consumption. This was assessed by analysing consumption of previously metered homes that were not subject to any changes in pricing structure, but still received information from Southern Water (in the form of leaflets, street signage, and mobile customer information points).

The role of personalised normative feedback in reducing water consumption was tested in a small study comprising 301 households in San Diego. (Schultz *et al.,* 2014). Certain behaviours were labelled as socially undesirable, irrespective of widespread prevalence. The research showed that subtle cues were particularly effective for altering the water using behaviour of less engaged individuals with low levels of moral obligation to water conservation. The study also highlighted the importance of including indicators of socially desirable actions (injunctive norms) to avoid influencing the actions of those consumers currently doing better than average, modifying their consumption towards the 'magnetic middle'.

In a longitudinal study of 100,000 households in Atlanta, a gentle nudge was shown to deliver modest savings of 5% during a drought campaign (Bernedo, Ferraro and Price, 2014). Personalised letters and social norm messaging were used to drive behavioural adjustments. The effect of the campaign diminished by about half after a year, although a statistically significant impact was still found up to 6 years later. Analyses indicated longer-lived adjustments to individual water using habits rather than simply a shift to more efficient appliances. This research showed that consumers are unlikely to act to save water unless there is a tangible reason in the face of water restrictions and drought conditions, and following the crisis there is a considerable bounce-back effect to pre-crisis conditions.

2.2.5 Critique of individualist models

The evolutionary path of the psychological models described in section 2.2.1 to 2.2.3 demonstrates an increasing emphasis on external material and social factors that set determining conditions and shape the individual actions of rational people (Spotswood, 2016). Individualistic approaches remain popular with policymakers as evidenced by key policy documents such as *Changing behaviour through policy making* (Defra, 2005), *A framework for pro-environmental behaviours* (Defra, 2008b), and *Mindspace: influencing behaviour through public policy* (Institute for Government, 2009, see section 2.4). These models have tended to dominate policy thinking and they represent an advance on simple provision of information and economic instruments. Individual models of behaviour are intuitive and easy to understand by non-social scientists, they fit within limited budgets and clearly individuals do play some role in deciding upon or choosing their behaviour (Morris *et al*., 2012). However, there are several shortfalls in using psychological models to understand and alter behaviour in terms of sustainable consumption. These will be considered in turn.

The term *behaviour* is used to describe a wide range of human activity, but it fails to recognise different types of action. The models reduce modes of conduct to the outcome of mental processes by focusing on the internal workings of individuals and excluding, to varying degrees, external conditions. Several studies have found the link between pro-environmental attitudes and measured conservation behaviours to be weak (Miller and Buys, 2008; Bagozzi and Burnkrant, 1979), and it is recognised that models focused on individual decision-making often fail to address wider socio-cultural factors that can provide a strong headwind working against individual behavioural interventions. Whilst some individuals may express positive attitudes in relation to water conservation, they may fail to act in accordance with their stated beliefs due to wider social and material constraints.

A second criticism of conventional IBC approaches developed from psychological models, is that the individual is the key focus of enquiry, often to the exclusion of external factors. This perspective fits well with modern neoliberal ideologies of freedom of choice, free markets, and light-touch regulation. However, this tends to simply put the blame for problems on individuals and not the state. It fails to acknowledge the complex dynamics with wider external determinants in operation and social injustices, as new responsibilities disproportionally weigh on struggling population segments who have fewer resources, and distracts attention from suppliers (Horne, Dorignon and Middha, 2022).

Several of the psychological models described above include the idea of *barriers* or obstacles, from internal attitudes to action. This idea assumes individuals make a rational decision to act responsibly. Although the TIB model includes the concept of facilitating conditions, this somewhat simplifies the complexity of external factors that impact across the entire process, affecting internal attitudes, beliefs, and perceptions. Often, it is not a case of barriers to action but that contextual factors are driving people to act in opposition to the desired way (Chatterton, 2016).

The controlling impact of *facilitating conditions* is over-simplistic and underplays the social and material factors and even self-efficacy that help or hinder an individual from acting upon their intentions and habits. Indeed, these factors are likely to influence intention formation, rather than simply being a barrier or enabler once decisions have been made.

These models tend to assume that baseline conditions are static. They ignore that there is a headwind of *ongoing change*, constantly occurring in the external context. In these models, social context is overly simplified, conceived as an added extra that influences psychological processing. These models fail to recognise the scope and speed to which the contextual landscape is changing. For example, the rapid uptake of smartphone technology over the last decade. There are many factors across different *scales* that influence decisions and ignoring this results in an overestimate of the degree of fixity in behaviour (Chatterton, 2016).

Few social marketing interventions document a clear theoretical basis, and there is a lack of robust evidence recording, often relying upon limited self-reported observations, and minimal published learnings from failed applications. It is criticised for delivering only short-term change and is expensive and difficult to justify (Tapp and Rundle-Thiele, 2016). Social marketing has fallen out of favour in recent years, following the economic crash in 2008 and more recent interest in behavioural economics which have promised large and sustained shifts in behaviours for smaller financial outlay. Social marketing also has a strong focus on its downstream audience, often seen to be blaming individuals (Evans, 2011), and often fails to deal with organisational barriers in the upstream perspective.

2.3 Socio-material approaches

2.3.1 Theories of social practice

Critics of conventional IBC approaches have voiced the need to move away from initiatives rooted in assumptions about the rationality of consumers as they do not appear to help people make long-term sustainable changes to everyday routines (Shove 2014, 2011 and 2010; Shove and Walker, 2010), and effectively blame individuals for being trapped in a pattern of consumption that is created by wider social and material contexts (Evans, 2011;

Shove, 2011 and 2010). Strengers (2011) highlighted current institutional arrangements mean that the provision of supply by water companies and consumer demand are divided, and result in demand being taken for granted. She predicts that current demand management programmes are unlikely to create long-term water conservation, against a backdrop of intensifying resource consuming practices.

Whilst the dominant discussion in policy circles is grounded in the traditions of economics and psychology, as already described, practice-based models concentrate on resource-using activities (such as showering or laundry) as social practices and relegate the role of the individual to that of performer of the practice within a social context (Shove, 2014, 2011 and 2010; Shove and Walker, 2010). This concept introduces the twin ideas that practices are both *entities* and *performances* (Quitzau and Røpke, 2009). Practice as *entity* (the thing) is the focus or unit of study, whilst practice as *performance* represents the observable action by the individual. Practices are recognisable, stable, and reproducible patterns of action.

Theories of social practice are not new, and stem from the complex social ideas of Bourdieu, Giddens, Foucault, and others, synthesized by Reckwitz (2002). Practice theory presents an alternative, more holistic approach to *behaviour* change (or a cultural shift in how *things* are done) and offers a revolutionary alternative perspective (Spotswood, 2016), by asking new questions, working with new units and methods of enquiry, and reframing interventions by targeting the social organisation of the activity or practice (e.g., showering), and away from tackling individual actions or performances.

The aggregation of many separate human actions creates visible patterns of activity that are regularly and routinely reproduced. When viewed from this perspective it is possible to see that human action has the capacity to shape social structures or meanings, whilst concurrently social structures can influence or constrain human activity. This is the foundation of Gidden's meta-level Structuration theory (Giddens, 1984, see Figure 2-7) in which the production and reproduction of social life is an ongoing process and does not give primacy to either agency (intentions, meanings, and actions) *or* structure (logics, limitations, and systems). Structuration is only present in moments of social interaction at the intersection between the repetitive conduct of human subjects and social structures. It requires the antecedent conditions of skilled accomplishment (*reflexivity*); *recursiveness* in which structure is both the medium and the outcome of the practices; and *regionalisation* – the dependence on interactions with others in time and/or space (Gregory and Johnston, 2009).

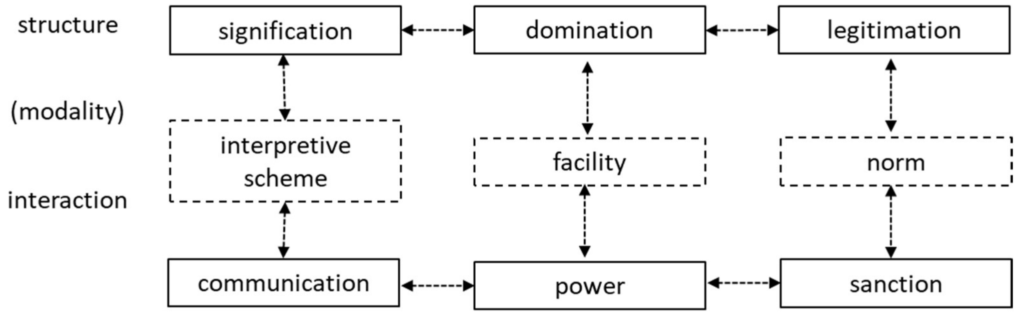

Figure 2-7 Structuration theory (Giddens, 1984, p.29)

Looking at *behaviour* at the social level moves the analysis away from the moment of decision and uncovers the social, material, and past individual experiences that have the capacity to set the conditions for the future reproduction of activities (Chatterton, 2011). The relationship between individual agency and social structure is reflective or recursive, each influencing the other (Spotswood, 2016).

Sociological perspectives suggest that rather than directly using water, we perform a range of routine activities that result in the consumption of resources as a by-product of actions, such as washing our bodies, laundering our clothes, cooking, and cleaning. Each different resource-using activity is discrete and requires targeting to change the routine action (Chatterton, 2011). Practices are cultural entities with socially shared elements including materials, competence, and meanings (see Figure 2-8) – alternatively referred to as '*stuff*, *skills* and *images*' (Kuijer, 2014). Practice theory seeks to intervene in the conditions or constituent elements that shape everyday routines rather than the actual action itself.

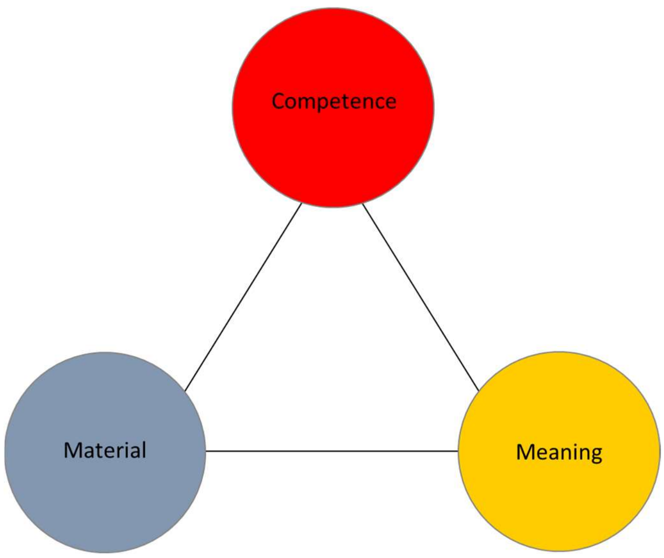

Figure 2-8 Three elements model of social practice (adapted from Shove, Pantzar and Watson, 2012, p.29)

The meanings of practices are shaped by cultural expectations, such as unwritten rules or social standards, (for example, what it is to be clean), and are influenced by other practices, attitudes, and beliefs, embedded within bundles of related activities such as getting up in the morning, exercising or getting ready for an evening of socialising. Practices are comprised of bundles of micro-practices or mini processes, for example – hair washing or shaving. Each constituent part is dynamic, and it is the ever-changing elements and their interactions that present opportunities to intervene to promote more sustainable practices.

Kuijer (2014) proposed an adjustment to the simplistic three elements (or *balls*) with a more detailed or sophisticated representation in which the elements comprise of groupings or '*constellations'* of elements visualised as bubbles, connected with a '*multitude of links*'. This alternative representation helps to distinguish between practice as *entity* or as *performance*, in which a single performance is a partial manifestation of the entity, and performances can integrate different groups of elements whilst the entity can contain many varieties or styles of performances. The bubbles representation helps to illustrate how, for example, different shower events (performances) can have different meanings that trigger them, such as waking up and getting ready for the fresh day ahead; getting clean or warm; or, relaxing after a busy day or participating in sport. The meanings element (or bubbles) may be dependent upon antecedent conditions or the sequential order of bundles of performed practices. Alternatively, different shower events performed by the same person may utilise a variety of objects, such as hair conditioning products or razor, or showers may be performed in locations with different fixtures or infrastructure – at home or outsourced to work or the gym.

Everyday disturbances or 'crises'[24] of routines in which the breaking and shifting (reconfiguration) of structures occur (Reckwitz, 2002), such as the introduction of water restrictions, illness, a new household member, a new technology or fixture, even a new object, present opportunities to modify consumptive activities (Strengers, 2011). '*New'* elements mean new to the standard practice (entity), not a new invention, but used, substituted or integrated in an alternative, unfamiliar or novel way (Kuijer, 2014). This is particularly pertinent with working with the target group in this research, in which students are transient, and frequently moving into new homes.

[24] Alternatively referred to as '*contingent events'* (Schatzki, Cetina and Savigny 2001, p.53) or '*disruptive moments'* (Shove, Pantzar and Watson,2012)

At a basic level, the opportunity for participating in different practices is determined by age, gender, and social class. Bourdieu's (1977) *habitus* bridges between the cumulative effects of past experiences, resources and tastes, and the character of future-oriented aspirations. The daily and life paths of individuals are intertwined with collective and policy structures through their different identities (such as gender, nationality, cultural) and roles, such as employee or parent. The rules of family life and the systems of provision demonstrate that state actors influence the distribution and circulation of materials, competences, and meanings of what are normal and acceptable ways of living, and governments have a role in both developing and disrupting the links in the dynamic systems of daily existence.

The term *practice* links with socio-material approaches, and reflects a pursuit of shared goals, such as the social expectations of cleanliness (Shove, 2003a), in which consumer choice is determined by the material or environmental context. Hargreaves (2011) refers to practice as a comprehensive account of individual behaviour and proposes that it offers an holistic perspective on *behaviour* change mechanisms including the impacts of social relations and norms. A SPT perspective may explain *how* and *why* things are done in everyday life, and *how* practices emerge, change, and disappear through time and space. Practices are entities that depend on the integration and interaction of materials, competences, and meanings (stuff, skills and images). And crucially, practices recruit actors or carriers who loyally perform routinised activities (Shove, 2009a; Hand, Shove and Southerton, 2005). Without the performers of practice, the practices themselves would fall out of use and disappear, suggesting that the individual actor remains vital, but is no *more* essential than the socio-material context.

2.3.2 Examples from the environmental sustainability context

Practice theory is very conceptual and there is limited empirical evidence of it being used to develop practical real-world interventions (Warde, 2005). It has yet to be applied systematically to the management and planning of water demand mitigation. Indeed, most examples of successful interventions (from other sectors including energy and health) cited in the literature depend upon a retrospective application of practice theory onto previous initiatives such as *Cool Biz* (Shove, 2014; Strengers, 2011), *Environmental Champions* (Hargreaves, 2011), London congestion charging (Shove, 2014), *Oklahoma City on a diet* and *La Maneurs* local food restaurant and shop (Sahakian and Wilhite, 2014). Alternatively, there are examples in the literature in which more sustainable futures are imagined, to give designers, policymakers and practitioners a new perspective on possible futures (Kuijer, 2017; Davies and Doyle, 2015).

However, interest in SPT has gathered momentum recently. The work of Elizabeth Shove and those working with or influenced by her, dominates the current discourse on practice theory, and she often cites the routines, habits, and practices of *showering* specifically, alongside doing the laundry, to illustrate her ideas of service in the reproduction of cleanliness (the physical removal of noticeable dirt and invisible microbes) and freshness (deodorised or perfumed), together with references to room temperature comfort and convenience food (Hand, Shove and Southerton, 2005; Shove, 2003a and 2003b). The constituent elements of showering operate together by combining with rationales of social status, body, pleasure or duty, and expediency (see Figure 2-9). Shove conceptualises systems of laundering as an assemblage of cogs that represent clothing stocks, textile materials, detergents, machine design, rationales for laundry (such as disinfection and deodorisation) and the way that laundry is done, that each turn independently (Shove 2003a).

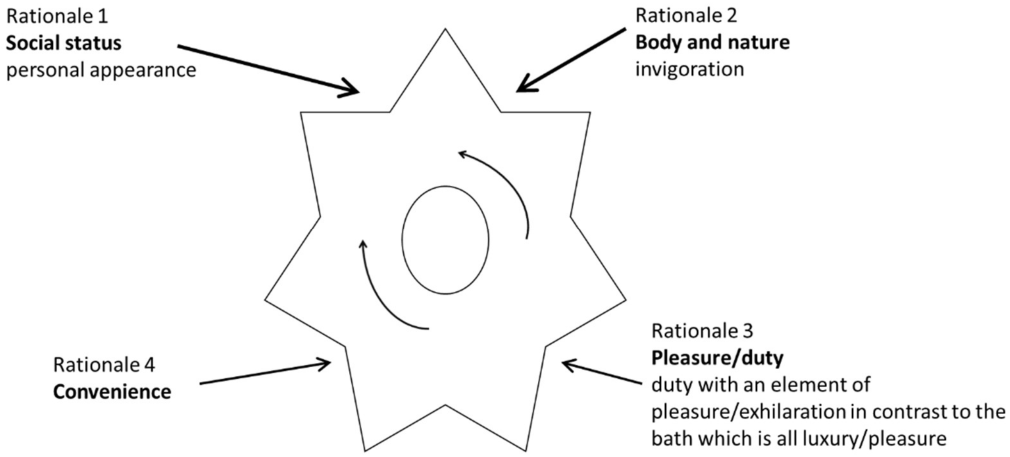

Figure 2-9 Pinning power showering in place (based on Shove, 2003a, p.408)

The *London on Tap* campaign was launched in 2007 by the Mayor of London in partnership with Thames Water, to promote consumption of tap water as a cheaper, safe, and quality alternative and to combat the environmental impacts of bottled water (Sahakian and Wilhite, 2014; Staddon and Fox, 2011). The campaign focused on the practice of ordering bottled water in upmarket restaurants, as research had shown that UK consumers were anxious about asking for tap water when dining out. Whilst the campaign was not designed from a SPT perspective, the success of London on Tap was from intervening in the meanings element by making it socially acceptable to order tap water and bringing an unspoken rule into public debate.

In their international review of behaviour change initiatives, Southerton, McMeekin and Evans (2011), evaluated a community-based social marketing campaign run by Durham Water in Ontario, that aimed to reduce summer peak water demand from garden watering (McKenzie-Mohr, 2000). The campaign showed significant water-savings among consumers that were targeted with multiple mechanisms including: pro-active and personalised face-to-face engagement (competences); community pledges (meanings); and, gauges and signs (materials), compared with consumers who simply received conventional 'passive' informational (rational choice) brochures.

The Consensus (Consumption, Environment and Sustainability) programme used SPT and collaborative research methods to explore trends and evaluate solutions for sustainable household consumption in Ireland (Davies and Doyle, 2015). One work stream focused on household water demand from personal washing practices. A process of *participatory practice-oriented* back-casting was applied to the collaborative design of three future scenarios for sustainable washing, in which regulation, cultural adaptation and technology had varying degrees of emphasis (termed 'water control', 'aqua adapt', and 'de-waterise'). Each scenario comprised ideas for new technologies, skills, norms, and expectations that together could transform the performance of personal washing. The scenarios showed people adapting their washing routines according to natural weather patterns, using waterless gels and live feedback at point-of-use consumption. Action plans covering education, policy and technical measures were co-designed, that could collectively transform washing practices.

Recognising practices as a unit of *design*, Kuijer, De Jong and Van Eijk, 2013) enlisted the help of a group of trained improvisation actors to re-imagine a less water-intensive approach to bathing, by combining bodily performance, crises of routine and a variety of performances in a living lab experiment. The research participants were tasked with creating pleasurable novel approaches to personal washing in a dry space, without a continuous "*flow of warm water going down the drain still warm and practically clean*" (Kuijer, 2017, p.67), with access to a variety of objects and imaginary water. A rich narrative of possible future bathing emerged, through a process of seated and standing *splashing* within a heated cubicle. The process of design shifted from supply-side to the performers and it bridged the gap between what people *think* they might do and what *actually* works.

The Sustainable Practices Research Group at University of Manchester researched the everyday use of water alongside the potential drivers of demand in the context of social/cultural, infrastructural and climate changes in the UK. Browne *et al*. (2014) focused on spatially distributed everyday practices of domestic water use, such as washing/bathing/showering, laundry, toilets, cleaning, drinking and cooking, gardening, and car washing. Diversity of practices was explored to classify water use based on styles of practice rather than conventional socio-demographic groupings, through a cluster analysis based on a range of variables, and whether patterns of consumption change with life-course and across the generations.

The showering classification comprised six main types or styles of personal washing, based on frequency, diversity (variation in shower duration or bath fill level), technology (bath or shower) and outsourcing (for example, at the gym or workplace). The resulting washing types were termed:

- simple daily showering (39% of research participants);
- out and about washing (16%);
- attentive cleaning (15%);
- low frequency showering (12%);
- low frequency bathing (12%); and,
- high frequency bathing (11%).

Whilst not the largest segment, the attentive cleaning style represented the most resource consumptive way of washing, as summarised below:

> *Attentive cleaning*
>
> A style of high frequency (at least daily) style of showering, usually at home (not outsourced to the gym), in which great importance is given to personal grooming backed by other aspects of personal care and is supported by good access to quality shower fixture(s). A showering practice adopted for a diversity of reasons including freshening up, waking up or relaxation, but not necessarily to get clean. Recruits are more likely to be female, but both genders tend to wet shave, including armpits and legs, and with male members following a modern, 'metrosexual'[25] lifestyle. Members probably do not pay for water via a meter (Browne *et al.,* 2013b).

[25] The term *metro-sexual* refers to an urban (or *metro*politan) hetero*sexual* male, particularly living in a western, post-industrial capitalist culture, who is meticulous with his personal appearance through fastidious personal grooming, the consumption of fashionable clothing and beauty products, that may also spill over into time and money spent on their home (Collins English Dictionary, 2021).

Hoolohan's research (2016a) recommended that technologies of water supply and demand should be *re-designed* with substituted material elements to improve the availability or access to alternatives, and in so doing to alter the expectations (meanings) of users to popularise and encourage take-up. She also proposed that consumers should be reconnected or *re-attuned* with the natural water environment through signage and messaging to make water saving more salient, and that water-using practices should be *re-located* from household to community scale, for example, to facilitate more efficient collective laundering of work- wear. However, this was a theoretical study and did not test real-world water saving potential.

Interventions to reduce the resource intensity of garment maintenance (in Melbourne, Australia) were explored by Jack (2013). Thirty-one participants (aged 18-56 years) were recruited and given a new pair of jeans. They were asked to wear the jeans for an extended period of time (at least five days per week for three months) without using any water, energy or chemicals to launder them. They shared experiences and supported each other through the highs and lows of the experiment via a Facebook group. Insights were gathered to understand how individual actions were shaped by collective conventions. The participants' experience suggested that shifts to tacit social rules or shared understandings and 'normal' ways of doing may be more effective than challenging individual behaviours in increasing *acceptance* of low wash approaches. It was through a heightened sensitivity to social influences that participants became aware of an invisible script and community censorship that shape their standard garment maintenance practices.

With so few examples of practice theory application to the water sector, one is drawn to look at the energy sector and other service provisioning. There are many parallels and linkages between energy and water demand, although water is often forgotten due to its comparatively low financial cost, and fewer regulatory drivers and stakeholders. The Residential Energy Conservation Ordinance (RECO) is a legal mandate for residential buildings in Berkley, California, to meet energy and water efficiency standards (maximum tap and shower flow rates and WC flush volumes) when properties are sold or extensively renovated (i.e., at moments of transition). The scheme changes the environmental performance of buildings to conserve both energy and water and demonstrates how intervening in the material infrastructure can reduce resource use without directly changing individual behaviours. (Evans, McMeekin and Southerton, 2012; and Southerton, McMeekin and Evans, 2011).

Demand for space heating has increased markedly in the UK over the last century, despite policy measures and energy-efficient technologies designed to curb use. Kuijer and Watson (2017) explain that the spread of heating demand through space (rooms in the home) and time is due to the co-evolution of housing circumstances, heating provision and changes in everyday practice. Changes in social housing design in the last century favoured the spatial separation of domestic functions with more privacy, better hygiene and higher education. For example, the 2-up/2-down (two bedrooms, a living room and a scullery[26]) housing model meant that 'dirty' work and cooking were separated from living quarters and the central dual-function coal-fired range (cooker and stove) was replaced with a single purpose living room heater and a gas cooker in the scullery. In parallel, changes to infrastructures of provision (water, gas and electricity) and technologies enabled the spread of space heating and of domestic activities throughout the home. The introduction of the television into the home had a critical role in shaping how rooms were used and helped to redefine the living room. As a sedentary activity, television watching became a significant driver for heating demand. Changing patterns of family life, with increasing inactivity and declining outdoor play, link trends in housing design and technology, and collective standards of good parenting to domestic energy demand.

Laakso *et al.* (2021) used practice-based interventions to reduce indoor temperatures by an average of 1^{o}C. The study focused on what 'heating is for' rather than the process of heating, and participants from 113 households in Denmark, Finland and Hungary tried to reduce their indoor temperature to 18^{o}C throughout November 2018. The results showed that changes in skills and socially shared expectations of comfort were needed. The participants became more aware of their own practices and constituent elements and learned how to challenge them.

Australian research explored how pop-up food stalls can reshape eating practices by challenging fixed infrastructure and create more flexible and sustainable approaches to urban food provisioning by disrupting and challenging temporal and spatial norms that govern standard food outlets and taken-for-granted food practices (Middha and Lewis, 2022; Middha *et al.,* 2021). The altered material landscape of mobile food outlets created opportunities to shift the meanings element of eating practice toward a more ethical ethos, with access to affordable, healthy and seasonal food and reduced energy use. The

[26] Where '*wet'* activities such as washing up, food preparation, personal washing and laundry took place

research demonstrated the potential to intervene in normalised consumption to shift it to be more sustainable and socially connected.

Temporal distribution of hot water use and showering performances in particular are likely to become increasingly important with increasing reliance on intermittent renewable energy production to meet sustainability targets (Gram-Hanssen *et al*., 2019). This Danish research into the sequencing of showering within bundles of everyday social practices within 134 households, revealed three distinct clusters of hot water time-of-use. The largest cluster (termed 'higher morning peak', n=53, 40%) showed a tendency to shower in the morning with a marked 6am spike and moderate 6pm peak. However, the second largest cluster ('Levelled', n=47, 35%) showed a more even and elevated temporal distribution throughout the day bookended with peaks (at 6am and 7pm) of similar magnitude. The third cluster ('higher evening peak', n=34, 25%) tended to shower in the evening (with a 5pm peak). The research showed that the time of showering is closed tied up with other household practices, that socio-demographics influence ordering, and the meanings of showering may vary.

2.3.3 Critique of sociological approaches

In her somewhat novel paper, presented as a fictitious conversation between a social scientist and a policymaker, Shove (2014) made an important contribution to an ongoing antagonistic, even provocative, debate between policymakers and some inter-disciplinary academics (focused on individualist approaches) on one hand, and with Shove and other proponents of practise-based approaches on the other (that prioritise the importance of wider social structures). Shove's seminal thesis builds upon an extraordinary lecture (Shove, 2009b), and subsequent paper 'Beyond the ABC…' (Shove, 2010) in which she criticised the government for restricting contemporary environmental policy to the use of individualist-focused models. She terms these approaches 'Attitude, Behaviour, Choice' models (substituting the 'context' from Stern's original ABC model, Stern 2000) and argues that policymakers were failing to embrace the alternative insights that social science brings to the sustainability policy agenda. Shove argues that the problem of changing consumer behaviour needs to be reframed to focus on how resource-consumptive routines develop, evolve, and disappear in everyday life, in which consumption is the outcome of routinised practices rather than purely rational decision making (Warde, 2005). From this perspective, Shove claims that social science thinking has the potential to facilitate a revolutionary leap to transform human consumption in daily life towards sustainable levels and help meet stringent carbon emission targets needed to mitigate for the worst impacts of climate breakdown.

Despite Shove's challenging stance and her strong focus on wider social and political determinants (almost to the exclusion of the individual), contemporary research is grappling with practice-based collective approaches to tackle environmental sustainability concerns including water demand management, by making practice theory practical (Hargreaves, 2011). Theories of social practice help to analyse, critique, and explain resource-consumptive patterns of everyday life, and can offer some *indirect* approaches and useful insights for planning intervention programmes. However, demand managers (often non-social scientists), constrained by organisational structures and limited financial budgets, remain sceptical in the applicability of such academic and abstract methodologies to real-world concerns, leaving them to say "so what". Success may require wholesale institutional and policy change that may not be achievable within current governance arrangements and financially constrained budgets and may need to be a long-term endeavour. Indeed, Hampton and Adams (2018) acknowledge that the existing policy framework is likely to need a fundamental overhaul if SPT is going to realise its full potential and transform policy development.

Shove describes practices as having lives of their own. Interventions can be unstable and as *unpredictable* as the practices themselves due to ongoing reproduction and transformation. Practice theory gives no guarantees and there is a risk of unintended consequences or rebound effects (Hertwich, 2005). To be successful in changing consumption, policymakers may need to redefine the agendas and priorities of their colleagues across functional silos by undertaking cross-sector analysis of how policy influences the routines of daily life and patterns of consumption and to measure trends in different practices (Shove, 2014).

There is an ongoing debate on the role of social science in government policy, and an apparent stand-off between advocates of SPT and those who favour behavioural economics. Hampton and Adams (2018) interviewed a small group of government social researchers working on energy policy and familiar with both behavioural economics and SPT. A lack of applicable evidence was cited as a reason that SPT has struggled to gain traction and has remained peripheral in government policy making to-date. If SPT is to make a greater contribution to policy development, it needs to overcome perceptions of theoretical complexity and break through the current positivist framework of evidence-based policy, founded on *quantitative* research.

An important observation, from the perspective of a researcher that heralds from the positivist or scientific paradigm, is that the majority of SPT research favours qualitative methods and experiential self-reporting to understand underlying mechanisms, but this is rarely supported with empirical evidence of measurable impact in terms of resource use. Indeed, Browne *et al*., (2015) and Browne, Medd and Anderson (2013) highlight the need to expand the range of methods used in SPT research. This is built upon in Chapter 3 in terms of the choice of approaches use in this mixed-methods research and makes methodological and empirical contributions towards this knowledge gap .

2.4 Integrated tools and frameworks

The previous two sections (2.2 and 2.3) have sought to illustrate the current state of knowledge and theoretical concepts around behaviour and social change. Individual approaches, favoured by neoliberal policy, stem from the disciplines of psychology and behavioural economics, and assume that behaviour change is a matter of individual *choice*, set within a social context that can help or hinder individual action. In contrast, *collective* approaches, rooted in sociology and supported by theories of practice, emphasise that activities have mechanisms that are *separate* from individual performers, and imply that change happens when the constituent elements (its materials, competences, and meanings) are altered during the *performance* or reproduction of a practice. Each discipline offers a different perspective on human activity and the role of the individual.

Reversing the upward trend in domestic water consumption is complex and likely to require a package of interventions across different scales. It is unlikely that there is a single ‘silver bullet’ or winning discipline. Instead, policymakers and demand managers will need to work in a pluralistic fashion utilising a range of models. It can be overwhelming for demand managers and sustainability practitioners to translate and apply the vast array of theories that stem from outside their disciplines into practice, due to the complex nature of human action within the wider socio-material context.

In the last decade there have been several reviews that have synthesised the plethora of behaviour or cultural change theories (Southerton, McMeekin and Evans, 2011; Darnton, 2008). Frameworks take theoretical concepts and distil them into tools that can be applied. Whilst some of the nuance may be lost, these tools present practical approaches for applying theory to problems of concern. This section summarises six frameworks and links them back to the theoretical approaches outlined above.

2.4.1 Integrated quadrant model

The *All Quadrants All Levels* (AQAL) or *integrated quadrant* model (Wilber, 2006) reflects interactions of psychology, behaviour, culture, and systems (see Figure 2-10). Brown (2007) applied this framework to compare several mainstream sustainability books and demonstrated a strong bias toward the external/collective 'systems' quadrant (lower right), in most best-selling sustainability texts, suggesting a propensity for this literature to blame *systems* for environmental degradation, and take responsibility away from the individual. This illustrates the dualism in social-psychological models, tending to focus on either the individual *or* wider socio-cultural drivers, but often falling short in addressing all perspectives.

	INTERIOR	**EXTERIOR**
INDIVIDUAL	PSYCHOLOGY *"What I experience"* "I", subjective realities, e.g., self and consciousness, states of mind, psychological development, mental models, emotions, will.	BEHAVIOUR *"What I do"* "It", objective realities, e.g., brain and organism, visible biological feature, degrees of activation of the various bodily systems.
COLLECTIVE	CULTURE *"What we experience"* "We", intersubjective realities, e.g., shared values, culture and worldview, webs of culture, communication, relationships, norms boundaries, customs.	SYSTEMS *"What we do"* "Its", interobjective realities, e.g., social systems and environment, visible societal structures, economic systems, political orders, natural resource management.

Figure 2-10 AQAL/Integrated quadrant model (based on Wilber, 2006)

2.4.2 Defra 4 Es model

The Defra *4 Es* model (Figure 2-11) emerged from individual-focused research (by Jackson, 2005) on consumption. The framework advocates a combination of:

- *enabling* to remove barriers and build capacity;
- *encouraging* to motivate and incentivise change, or discourage unwanted action, using nudging, social norms, and social marketing;
- *engaging* to get people active and involved; and
- *exemplifying* or leading by example.

The model also identifies that where a behaviour is entrenched or habitual, there is a role for policymakers to *catalyse* people to behave differently. Whilst interventions derived from this model are focused on changing individual behaviour, it also introduces other routes to change such as *community* action and leadership which impact on the social contexts in which individual choices are made. However, it ignores opportunities for critical reflection on the impact of wider social forces that impact on the decision-making context (Morris *et al.*, 2012).

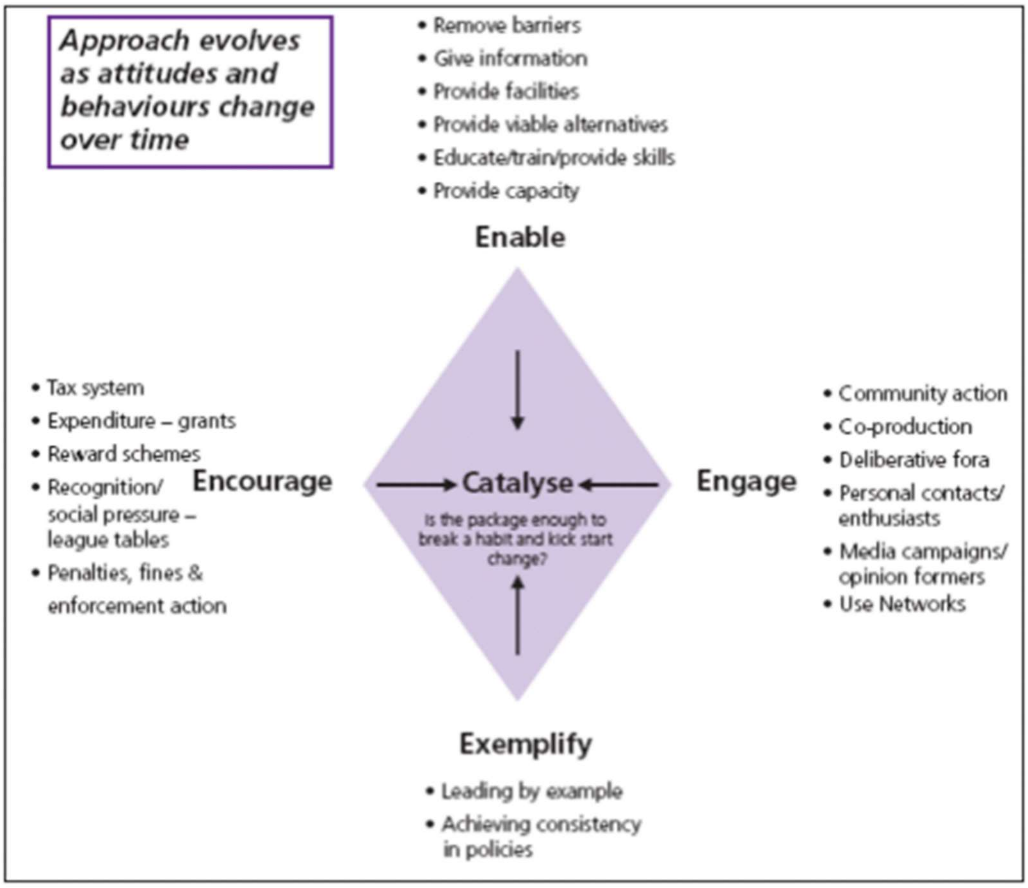

Figure 2-11 Defra 4 Es model (Defra, 2008b, p.53)

2.4.3 MINDSPACE

Behavioural economics promises significantly improved outcomes for some important societal problems, at a lower cost than simple psychological measures alone. The idea of giving a gentle prod was very popular with both David Cameron and Barak Obama and led to the establishment of the UK government's Behavioural Insights team in 2010. The *Mindspace* policy-making checklist (Institute for government, 2009) draws upon behavioural economics to identify key non-coercive influences on behaviour (Table 2-1).

It is strongly focused on individual decision-making processes but supports the notion of changing the context (or choice architecture) of routine decisions (Thaler and Sunstein, 2008), and resetting subconscious cues by providing prompts. Despite its recognition of the significance of how communications are delivered and by whom, Mindspace generally fails to properly engage with wider social, political and economics determinants of human action.

Table 2-1 MINDSPACE checklist (Institute for Government, 2009)

Messenger	We are heavily influence by who communicates information
Incentives	Our responses to incentives are shaped by predictable mental shortcuts such as strongly avoiding losses
Norms	We are strongly influenced by what others do
Defaults	We 'go with the flow' of pre-set options
Salience	Our attention is drawn to what is novel and seems relevant to us
Priming	Our acts are often influenced by sub-conscious cues
Affect	Our emotional associations can powerfully shape our actions
Commitments	We seek to be consistent with our public promises, and reciprocate acts
Ego	We act in ways that make us feel better about ourselves

2.4.4 Four dimensions of behaviour

Chatterton and Wilson (2014) identified the characteristics of different types of behaviour to help sustainability specialists both understand behaviour, and design successful change programmes. In the *four dimensions of behaviour* (see Figure 2-12), it is argued that approaches need to be selected to match who is the focus (*actor*), the factors that shape the behaviour (*domain*), longevity or how *durable* it is over time, and how the behaviour interacts with other behaviours (*scope*). From this perspective, the psychological models described above tend to operate in the cells to the left, focused on individuals, psychological processes, and one-off, discrete actions. However, to achieve universal or population-scale lasting transformative lifestyle or cultural change, interventions need to focus on mechanisms that affect the levels to the right of the framework.

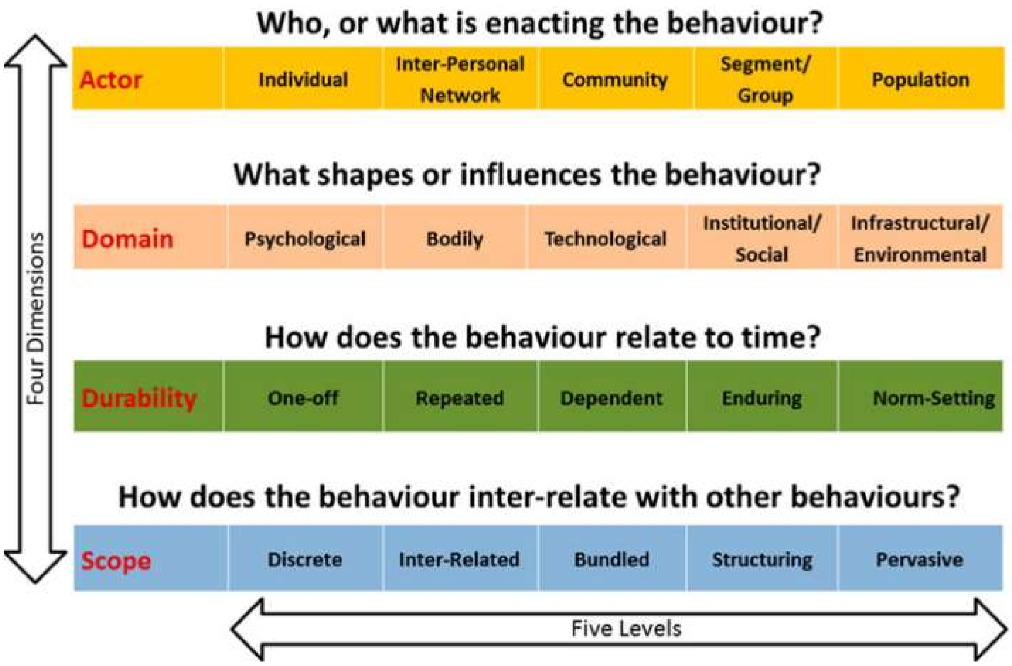

Figure 2-12 Four dimensions of behaviour (Chatterton and Wilson, 2014, p.46)

2.3.5 Individual-Social-Material (ISM) toolkit

Following extensive reviews of more than sixty models (Darnton, 2008) and thirty case studies (Southerton, McMeekin and Evans, 2011), the *ISM toolkit* for environmental sustainability policymakers and demand managers was developed (Darnton and Evans, 2013), with the aim of influencing peoples' behaviours to reduce carbon emissions. The ISM toolkit is grounded in theory (drawn from *all* three dominant disciplines) and incorporates the most pertinent factors and influences from a myriad of models to help tackle complex policy problems. The model comprises 18 factors spread across three contexts of individual, social and material, as illustrated in Figure 2-13. The User Guide (Darnton and Horne, 2013) presents the model in an accessible format to facilitate both the design and evaluation of interventions by non-experts with little theoretical knowledge, across a ten-step process.

ISM has been adopted as a policy framework in Scotland for low carbon programmes and has been applied elsewhere to tackle a range of specific environmental and health concerns. For example, it has been used to identify several interlinked factors and to design interventions to facilitate a step change in the uptake of electric vehicles by consumers. In the health arena, the Scottish strategy for preventing and reducing alcohol-related harm comprises more than 40 measures developed using the ISM model, spanning all three contexts. It has also been used to evaluate the success of kerbside recycling over the last 10-15 years, demonstrating that it has become the social norm because of many actions by different actors across a range of factors (all examples from Darnton and Horne, 2013).

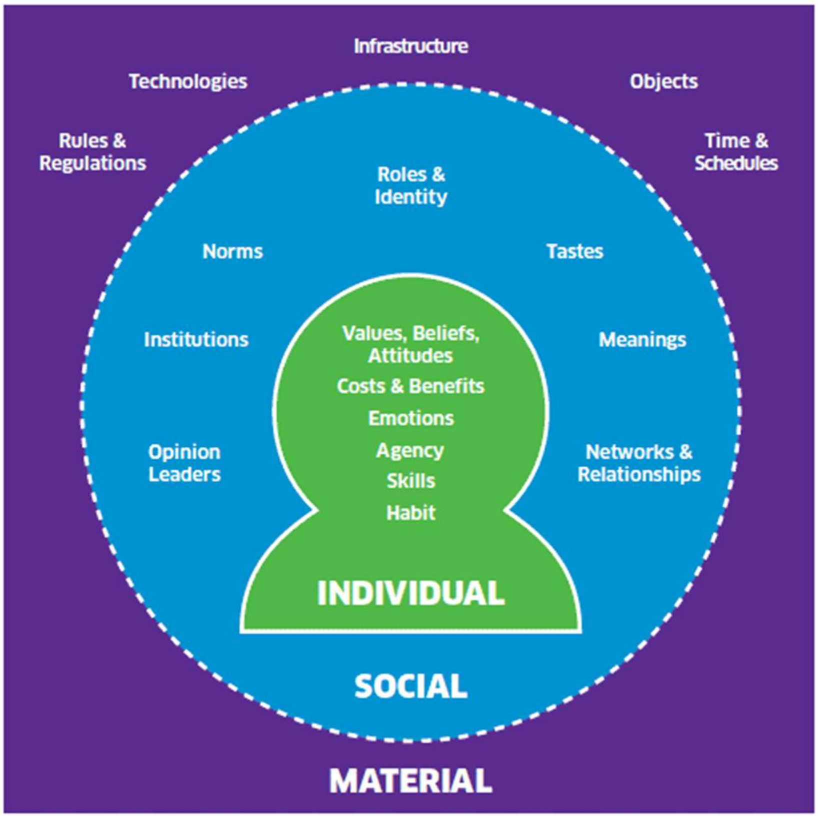

Figure 2-13 Individual-Social-Material (ISM) toolkit (Darnton and Evans, 2013, p.3)

The ISM toolkit offers a pragmatic arrangement of diverse approaches for sustainability practitioners grappling with complex social problems in the here and now. It does not try to unify theories, and acknowledges that whilst disciplines span the individual, social and material contexts, they do not map neatly across. The ISM model claims to offer no hierarchy in the factors and aims to uncover new insights to maximise impacts from interventions. Different emphasis can be placed on the different contexts, for example, to highlight social factors if previous work has been led by infrastructure or technological solutions for example, or by contrast, the material might be emphasised if workshop participants are more inclined to focus on 'communication-based' solutions. However, Darnton (2017) does recognise that it has some limitations, particularly gender differences and geographical distance.

2.4.6 Change Points

The Change Points toolkit (Hoolohan and Browne, 2018) – published after this research was planned and started, has been developed to help design practice-based interventions to tackle locked-in unsustainable resource consumption. It comprises six steps from identifying the problem, through collaborative investigation and expansive mapping, to reframing and planning action (see Table 2-3). Conceptually, these steps reflect a similar approach to and can be broadly mapped across to those in the ISM toolkit. Having noted that ISM remains rooted to influencing *behaviours* (an individual or psychological term), Change Points also refers to *individual behaviours* and what *people* do (rather than exclusively a sociological perspective of how *things* are done).

Like practice theory, the Change Points process emphasises a shift away from *individuals* (customers, consumers, users) and toward the need to focus on cultural, political, and technological elements that shape everyday activity. These broadly (but not exclusively) map across to the social and material factors in ISM, as illustrated in Table 2-2. Change Points includes spatial factor patterns which are perhaps a significant omission in the ISM tool (and acknowledged by Darnton (2017) in ISM's limitation regarding geographical distance). The ISM approach recommends having a mix of people in the room (step 2) and suggests ten is a workable number, whilst Change Points recommends groups of half this size, with between 3-5 participants, to allow everyone to contribute. For larger groups Change Points recommends splitting into sub-groups. Both toolkits have tended to target *upstream* participation – policy experts and practitioners professionals rather than end-users, although the research presented in this thesis extensively relied upon the input and participation of end-users, as they were best placed to fully understand the showering routines of the subjects being investigated.

Change Points recommends spending at least a full day to explore a challenge; embrace complexity and identify the connections, interactions with bundled activities, and (antecedent/post) sequences; recognise diversity and distributed responsibilities for actions; examine options for intervention, design a selection of intervention programmes, and the necessary steps to implement new thinking. There are no time recommendations for the ISM toolkit. However, in practice a balance needs to be struck between allowing enough time to fully explore the specific issues of concern and to design potential solution options with securing sufficient commitment from busy stakeholders.

The ISM and Change Points processes are listed in Table 2-3 to illustrate how the two approaches compare. The ISM toolkit was formulated to *design* interventions (plan, prototype, pilot) and to provide a framework to *evaluate* new or existing interventions by capturing a breadth of contextual factors. Whilst evaluation is not explicitly built into the ISM ten-step process, it is included in the User Guide (Darnton and Horne, 2013) as an add-on, and experts are advised to test out new approaches to learn lessons before full operational deployment. The ISM framework helps record the breadth of contextual factors and when combined with evidence, supports the identification of the most pertinent issues. In contrast, evaluation is explicitly built into the final procedural (plan) exercise in the Change Points toolkit, in which workshop contributors are invited to consider how they will monitor change and spot any warning signs that the intervention is not working.

Table 2-2 ISM factors mapped to Change Points elements

ISM Grounded in a multitude of theories but none in particular		**Change Points** Based on social practice theory
Individual • *Values, beliefs, attitudes* • *Costs & benefits* • *Emotions* • *Agency* • *Skills* • *Habit*	→ *Map across to*	Intentionally absent from Change Points. Social practice discourages putting the consumer as the key change agent. Instead, the importance of *diversity* over focusing on an 'average' individual is raised. (Traditional segmentation on socio-economic/attitudes is not a good predictor of how/why things are done the way they are.).
Social • *Norms* • *Meanings* • *Tastes* • *Opinion leaders* • *Networks & relationships* • *Roles & identity*	→	*Cultural* elements
• *Institutions*	*Map across to*	*Political* elements (see also *Rules & regulations* below)
Material: • *Infrastructure* • *Objects* • *Technologies*	→	*Technological* elements
• *Rules & regulations*		*Political* elements (see also *Institutions* above)
• *Times & schedules*		*Temporal rhythms*
Absent from ISM		*Spatial patterns*

In summary, the two toolkits have similar aims and are likely to result in similar outputs provided the facilitator guides the participants to focus on practices or problem routines rather than prioritising individual behaviours.

Table 2-3 ISM steps and Change Points exercises

ISM steps	Change Points exercises
1.Target behaviour 2.Good mix of people 3.Introduce ISM tool	(IDENTIFY) 1.Problem solving
4.Existing context	(INVESTIGATE) 2.Change Points 3.Diveristy
5.ISM behaviour mapping 6.Cover all ISM factors 7.Immediate observations 8.Policy mapping	(EXPAND) 4.Influence mapping
9.Identify gaps and ideas	(CREATE) 5.Reframing
10.Take action	(PLAN) 6.Ideas into action

2.5 Summary

There is no single behaviour change discipline but instead ideas stem from a multitude of perspectives and schools of thought. However, tracking the evolution of theories reveals a twin track progression along two distinct academic paradigms:

- Psychology - the study of the internal workings or the mind; and,
- Sociology - the study of the structures and functioning of society.

This parallel development from two schools of thought is summarised in Figure 2-14.As explained at the start of this chapter, wartime information campaigns focused on the national spirit and common good (a sociological approach), but the post-war years gave attention toward health education from a psychological view, albeit with a growing acknowledgement through the 1970s and 80s, that individuals do not act in isolation from their social context (shown in the upper half of the diagram). The individual perspective was further supported by Thatcherism and the neoliberal politics that it spurned, in which nationally owned infrastructure was privatised and the welfare state was drastically reduced. Indeed, Thatcher famously declared that there was "*no such thing as society*" (Thatcher, 1987).

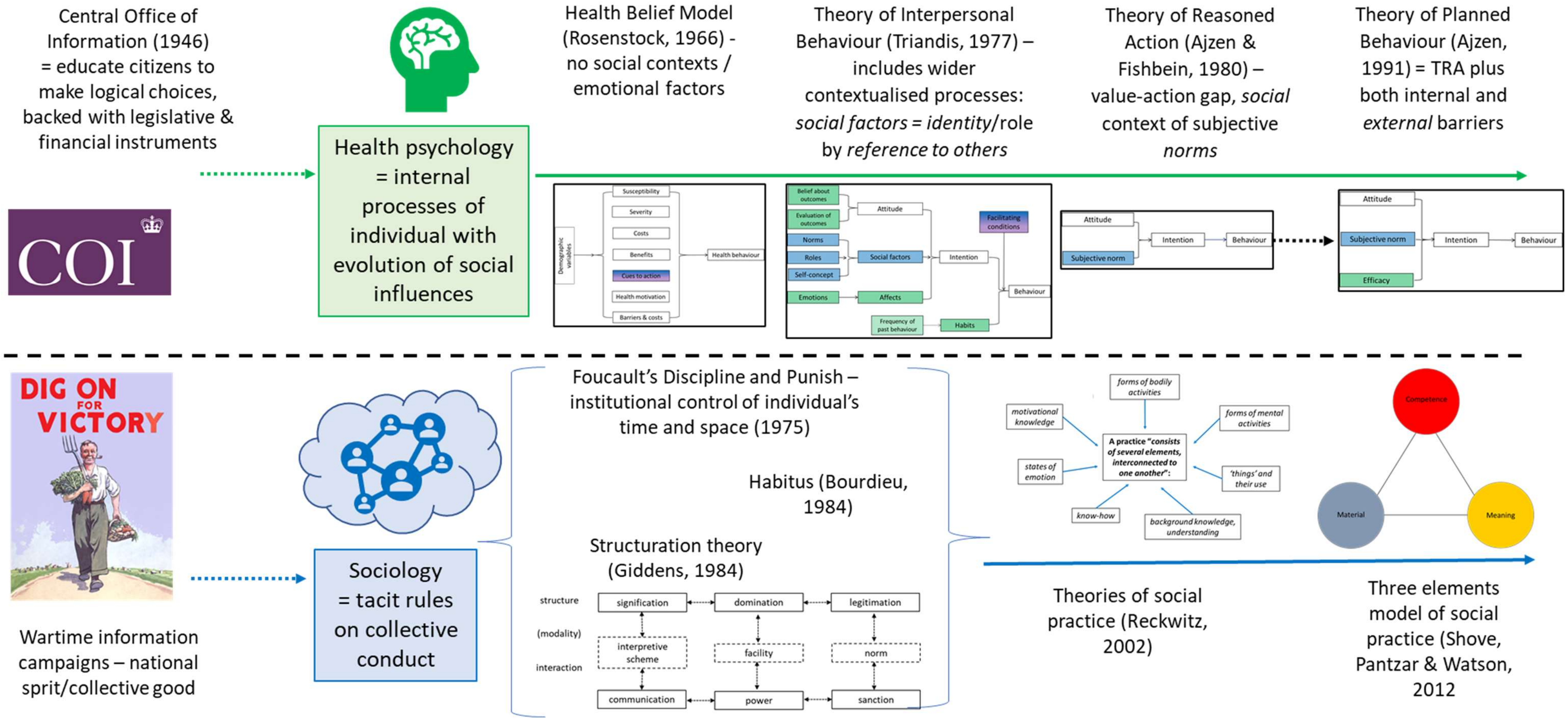

Figure 2-14   Parallel timelines of theoretical developments

Meanwhile, during the Thatcher years, and in response to the dominant discourse grounded in individual responsibility, influential social scientists were developing sociological theories to represent how society operates, although these disparate ideas were not brought together into a single coherent model until the new millennium. The parallel evolution of theory has since been brought together in the last decade by policy makers and practitioners tasked with tackling locked-in unsustainable systems consumption to conserve limited resources. Professionals working in this space have grappled with the challenge of turning the raft of abstract theories into practical applications in the real world.

This review of the available academic and grey literature across the disparate field of *behaviour* change set out *to assess the extent and efficacy of behaviour change approaches used to reduce (household) showering water demand in England* (Objective 1). Very few limited examples of theory-based (or theory-light) intervention programmes aimed at unsustainable resource consumption and specifically water demand management were identified (RQ1.1). Current household water efficiency programmes are rarely grounded in theory, and those that are, tend to stem from the logical or individualist rational choice paradigm that lends itself to working with limited budgets and the scientific grounding of the professionals who are tasked with delivering transformational change in this realm.

Many experts and policymakers working in the field of water demand management (are white and male and) herald from the engineering and scientific community who are trained to rely upon measurable evidence and security of effect. There appears to be a disconnect between the translation of academic or theoretical concepts into measures that can be practically deployed or operationalised by professionals working in the real world. Chatterton and Wilson (2014) argue that policymakers pragmatically select options that 'work' from a selection of available strategies, and Whitmarsh, O'Neil and Lorenzoni (2011) explain that whilst psychologists focus on individuals (within a social and physical context), sociologists focus on the context (and how individuals reflect that context). Psychologists may be overly individualistic and overlook the role of the socio-material context, whilst sociologists tend to focus more on wider determinants, to the exclusion of the role of the individual.

Much thinking in the last seventy years, since WW2, has focused on persuading individuals to change their actions, relying on rational choice theories from psychology and economics. Current policy in England tends to focus on drivers and barriers, described by

Shove (2010) as the ‘ABC’ or Attitude-Behaviour-Choice paradigm. However, addressing the challenge of sustainable resource consumption is a complex problem and it is unlikely that it can be resolved easily with any single theory. There are multiple layers at different scales contributing to the issue, ranging from individual actions to powerful shifts in social forces and the material landscape. Therefore, the solution is likely to need multi-disciplinary approaches rather than relying upon a single perspective. Different disciplines have a diversity of strengths and weaknesses and can make distinct contributions to the same problem.

By bringing disciplines together, different routes to intervention may be identified. However, it needs to be recognised that combining disciplines in this way presents tensions at theoretical level and challenges epistemological paradigms. The language and labels used by different disciplines, such as factors, influences and elements are not equal, and the terms *behaviour* and *practice* have different disciplinary understandings and are not inter-changeable.

SPT, from sociology, offers a different perspective for tackling unsustainable resource consumption and focuses on the social and material structures that create and sustain everyday routines through bundles of shared understandings, socially learned competences and hard infrastructures. Meanwhile the ISM toolkit, produced for the Scottish Low Carbon Programme (used to design and evaluate measures to improve the uptake of electric vehicles and adoption of kerb-side recycling schemes), offers a multidisciplinary model for addressing unsustainable resource use with potential to be successfully applied to target high shower water use by students (RQ1.2). Whilst ISM starts with the individual (in its name and in the centre of the diagram – Figure 2-13), it is theoretically grounded and in combination with SPT, the ISM framework provides a viable starting point from which *to design, pilot, deliver and evaluate components of a real-world intervention strategy covering multiple levels and contexts* (Objective 4).

The literature review identified only a limited application of the ISM model in England. For example, the National Union of Students applied the ISM approach to tackling excessive pre-drinking (‘*prinking’*) to reduce binge drinking of alcohol, to promote responsible consumption by mitigating against direct safety risks and longer-term health implications. The NUS have also used ISM to identify measures to promote the uptake of safe cycling by students and staff to reduce university scope 3 carbon emissions arising from commuting.

There was only one example in which ISM has been used within the water conservation sector (a rapid evidence assessment of water efficiency and behaviour change for Defra, 2018b). The report came after this study was scoped and initiated. Water supplies in Scotland are not under the same level of stress that parts of the south-east of England are due to the combined pressures of population growth and climate impacts and water governance is different in each of the developed nations. Therefore, water efficiency in Scotland does not have the same level of urgency or regulatory pressures as in England and is not a key focus for the Scottish Low Carbon Programme. Waterwise, the leading authority on water efficiency, prepared a draft handbook on behaviour change to support its UK strategy (Waterwise, 2017a and 2017b). Whilst it included sociological approaches and frameworks and had a section on SPT (drafted by Browne, Hoolohan and Sharp, the leading academics in this field) the ISM toolkit did not feature. It is this gap in the literature that this thesis seeks to fill.

By combining the two approaches (ISM and SPT) and focusing on bundles of activity (or micro-practices) that are routinely undertaken under the running flow of the shower, the relative balance between the individual, social and material domains could be balanced to relegate the role of the individual to that of the performer, the *doer*, such that interventions might be designed to target the socially shared understandings and expectations and the physical environment or fittings in which they occur (RQ1.3 and RQ1.4).

This multi-level approach may be criticised by purists as being incompatible, as the different behaviour and social change ideas on which the framework is based, originate from inherently different paradigms. However, the approach represents a pragmatic way to translate valuable insights that different disciplines can bring to professionals who are currently grappling with the challenge of finding practical ways that work for reducing water demand (Chatterton and Wilson, 2014; Whitmarsh, O'Neill and Lorenzoni, 2011). Success is unlikely to come from a single approach or intervention, and the inclusion of multiple factors within the social and material contexts demonstrates how action on multiple levels by many actors is needed to create inclusive and lasting change. Indeed, one of the strengths of the ISM model is that it forces specialist staff to consider all three domains and corrects for the tendency to reach for single models to address complex problems.

This research sets out to use the ISM toolkit as a framework to design *and* evaluate practical mitigation programmes in the real-world to reduce the water demand of showering in the resident student population at UWE. The first field trial (Wave 1) tested and evaluated a series of conventional individualist interventions of the type that are typically deployed by water suppliers in England, whilst the second trial (Wave 2) used ISM to design *and* evaluate a set of SPT-based solutions targeted at a population segment that have a tendency to adopt a leisurely, high frequency '*attentive'* style of showering (inspired by the work of Browne *et al.,* 2013b) as their standard *modus operandi*, by riding on the *social* phenomenon of increased awareness and public concern for the impact of single-use plastics (objects) – the David Attenborough '*Blue Planet'* effect.

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Chapter 3 Methodology

This chapter sets out the step-by-step development, reasoning, and reflections behind the mixed-methods (quantitative and qualitative) adopted in this study and demonstrates the validity of the approach. Firstly, the epistemological foundations, and the researcher's own affiliations and position are stated. This is followed by descriptions of the material and social contexts (the *where* and the *who*) within which the research was located. The ethical considerations and socio-demographic characteristics of the resident population from which the research subjects were recruited are presented, and the physical building infrastructure and water fixture performance is described.

Having set the context, the experimental design (the *how*) is set out in terms of the different phases of data collection fieldwork and the water saving interventions that were deployed (the *what*). This included an initial exploratory phase (Wave 0) in which baseline infrastructure performance was assessed and student showering routines were explored, followed by the development and delivery of two intensive periods of intervention-based fieldwork (Wave 1 and Wave 2). The Wave 1 field trial piloted the feasibility of combining all the selected research methods to test the efficacy or material impact of conventional water efficiency interventions in a real-world setting, whilst the Wave 2 trial adopted a refined approach to test the potential of a novel practice-based intervention to deliver measurable reductions in water use, following an adjusted experimental design to overcome some practical limitations experienced in the pilot trial. The chapter finishes with an outline of the analytical methods used to understand and *classify* student showering routines and to assess the *efficacy* of the water saving mitigation measures and includes a discussion on the justifications for choosing each method as opposed to alternative options to demonstrate the validity of the approach.

3.1 Epistemological foundations and researcher positionality

Historically, the water sector in England has been monopolised by the engineering and physical science disciplines (and dominated by white male professionals). Operational performance is managed and monitored via a heavily *quantitative* regulatory burden, although some of those controls try to quantify human activity. With the introduction of statutory water saving targets in 2010 (Water Briefing, 2008), the water suppliers were forced into trying to change the water-using behaviours of their customers, without necessarily having staff with the appropriate skills or competences to operate within this space. The focus on quantitative performance measures perpetuates the authority of hard science within the industry.

Historically, the only interaction that a water company had with its customers was through billing enquiries or operational events, neither of which are extensive nor positive engagements. Only 5% of Wessex Water's 2.9 million customers had any direct contact with the business in the last 5 years (Skellett, 2023). Efforts to reduce water demand to protect future supplies is dominated by combinations of technical solutions that reduce flow at the point-of-use, price signals through metered bills and information campaigns framed around reducing bills, environmental or social good to persuade consumers to act rationally. And success is often solely measured in terms of PCC reduction which (as described in Chapter 2, section 2.2.4) is a flawed and compromised representation of reality, as it is only an *estimate* (Holden, 2014), calculated as the *measured* water volume supplied to domestic properties divided by the *estimated* population served, or based on *extrapolation* from panel studies of metered households for which water companies hold more reliable occupancy data (Edwards and Martin, 1995), and ignores consumption away from the household during employment, education and leisure activities. Therefore, conventional water management traditionally heralds from the positivist or scientific method, predicated upon empirical evidence and objective measurement, and can be thought of as *masculine* or *patriarchal* in nature.

There are many everyday examples where dominant scientific rhetoric gives a convincing veneer of credence or illusion of accuracy, but quantitative metrics are often only indicators of reality, not precise or accurate. Not everything in life is feasibly measurable and sometimes metrics are only representative of a snapshot in time. For example, food manufacturers are given significant latitude (of up to 20%) in the calorie figures quoted on packaging, and fitness trackers have been criticised for not being accurate, providing only an indication of step count (Walsh, 2017). The widely used body mass index is discredited as a reliable measure of a person's health, although its use continues. Many will recognise that the salary that an employee earns is not a reliable or objective measure of their competence and achievements.

However, it is not possible to remove the human from the *interpretation* of research and there can be no knowledge without a *knower* (Feyerabend, 2011). This challenge discredits purely positivist views of the world and has led to an increasingly diverse and methodologically pluralistic contemporary research landscape, in which mixed-methods, both quantitative and qualitative, are used to try to get to the truth (Buchanan and

Bryman, 2007; Cameron and Miller, 2007). Constructivism sits at the opposite end of the epistemological spectrum from positivism, where the social context determines the reality that people know and create within their own minds (Gregory and Johnston, 2009). From this opposing perspective, the search for experiential meaning is subjectively interpreted, sensitive and *feminine* and comprises socially imagined stories or narratives formed inductively by inferring generalisations from emerging patterns.

Within the middle ground between the extremes of positivism and constructivism sits the realist perspective (Sayer, 2000). Whilst empirical approaches rely on *deductive* reasoning to *test* theories, and constructivist approaches use *inductive* reasoning to *derive* theories, a realist approach *recursively* develops theory derived from both evidence *and* expertise, termed *abductive* reasoning, and tests the hypotheses to determine causal explanations (Lewis-Beck, Bryman and Liao, 2003). From this perspective, the mechanisms of causation become important in revealing *how,* for *whom*, *why* and *when* things happen in the messy social world that cannot be answered by empirical science alone. Rather than simple aggregation, realism relies on a process of triangulation to assemble and arrange diverse evidence, including context and mechanisms gathered through a range of complimentary methods, to *infer* the most *likely* (but not certain) causation to evaluate intervention outcomes. Thus, a realist perspective gathers evidence from both positivist and constructivist perspectives and attempts to reconcile the two approaches to find the truth.

The researcher's starting point for this thesis was guided by her disciplinary and professional background, and also her family[27] upbringing and cultural roots (white British, early generation X[28]) that have influenced and defined her own identity and embedded ways of thinking. She completed her undergraduate combined *science* (majoring in environmental *science*) degree in the late 1980s, located in a dichotomous world of two departments, bridging the disciplines of biology and geography. She followed a Bachelor of *Science* (rather than a Bachelor of Arts) pathway, and always considered herself until recently, as a *scientist*, albeit not hard science (based on mathematics and physics), but a *softer* applied natural scientist. For this PhD, the researcher was based within the department of Geography and Environmental

[27] Father, brother, husband, and father-in-law are all engineers of various types and whilst the researcher enjoyed the arts as a girl, she was guided to pursue scientific interests with the promise of more secure employment prospects.
[28] Generation X, born between mid 1960s – 1980. Also known as 'Thatcher's children', latchkey kids or the MTV generation. Grew up during a period of social change and unrest.

Management at UWE. Geography is a discipline of two halves. Physical geography is about understanding the features and processes of the natural world, whilst human geography explores human activities and their interactions with the environment (and is what makes the discipline a humanity).

The researcher has spent her career working as a scientist within the heavily regulated privatised water sector in England and Wales, starting in technical roles working in multi-disciplinary teams comprised of engineers, hydrologists, scientists, and statisticians aiming to meet a raft of quantitative key performance indicators. Her previous job roles have included *scientist*, *engineer,* and *analyst* in their titles, along with planner, adviser, and consultant. Her portfolio career does not situate her neatly in a single professional box, and at times has served a degree of identity confusion, although this is a strength as it demonstrates flexibility. For most of her career her outlook has been firmly located within a scientific or positivist silo, as the product of academic, professional, and social conditioning. In the last decade, her career has migrated away from technical consultancy into the realm of community engagement and stakeholder partnerships that depend upon softer, more feminine interpersonal communication and diplomacy skills, with the objective of reducing water demand, in the Water Efficiency team at Thames Water.

Working more closely with customers and communities was also a new direction for the water utilities. Increasingly, the economic regulator (Ofwat) has forced the water companies to climb Arnstein's ladder (1969) by increasing public engagement and improving customer service. Indeed, there is a growing realisation that innovation in the sector to meet the competing challenges of adapting to extreme weather events and achieving net zero carbon whilst keeping customer bills affordable, is dependent upon increasing customer participation, through increased awareness and demand-side action to reduce water use, prevent sewer blockages and manage rainfall where is lands by diverting it away from the combined sewer system (Corporate Culture, 2017).

Since the privatisation of the water utilities in England and Wales in 1989, the sector has broadened its outlook from simple *economic* determinants, to consider the needs of the *environment* with the implementation of significant programmes of investment through the 1990s and early 2000s to comply with a raft of European environmental legislation. However, more recently, *social* aspects have come into increasing focus, confirmed by the statutory requirement for public participation in the EU Water Framework Directive (2000).

Whilst the assessment of infrastructure performance by analysis of household and water-fixture scale volumetric data to test intervention efficacy for this PhD is rooted in the scientific method, the exploration of the patterns, meanings and socially shared rules of showering routines has necessitated a foray into the uncomfortably messy and less predictable social realm, through a mix of both quantitative and qualitative approaches to gather end-user insights. This blending of techniques sets this research within the realm of *pragmatic realism*. It has required the researcher to use new vocabulary to triangulate the results of different enquiry approaches and translate the findings gleaned from the social world into a language that the water industry audience can understand. Suppression of disciplinary and professional heritage has allowed for a latent social scientist to emerge, supported by natural empathy, emotional intelligence, and pluralistic adaptability.

As stated in Chapter 1, this research set out to better *understand* the showering routines of students and the *efficacy* of water conservation measures to inform future domestic water efficiency programmes. The first component explored the *social* patterns of personal cleanliness and *how* showering is done: the socially learned skills; shared understandings, rules, and meanings; and tacit negotiations for use of the shared bathroom space. The research investigated the role of materials, skills and meanings and their interrelationships in shaping showering routines. Human participation was essential to exploring the research problem – without human actors, there would be zero water demand to measure. Conversely, reducing human decisions about water use to only volumetric data flattens out more complex realities related to water's role in social life. However, social science is intrinsically messy and unpredictable.

The testing of water efficiency approaches was *technical* or scientific, and aimed to assess infrastructure performance through the collection of volumetric measures of water use at the household-scale and point-of-use shower fixture, to test the effectiveness, feasibility, and scalability of shower demand interventions to inform future water saving strategies.

With the intention to translate the research findings into real-world interventions, the social and material aspects dictated the need to adopt a range of research methods, qualitative and quantitative, subjective, and objective, to converge and triangulate findings to improve understanding of the problem and potential solutions. It therefore pointed to a recursive or abductive mixed-methods approach (Sayer, 2000). Qualitative inquiry to derive ideas was combined with quantitative approaches to test theories, with a careful choice of language to translate and convey the findings gleaned from the social world into terms that the water supply sector audience can understand.

3.2 Living lab – physical setting

The SPT literature point to the value of living laboratory settings for researching the design and efficacy of interventions, by embedding practices within their socio-material contexts. For example, Kuijer, De Jong and Van Eijk (2013) point out that simply isolating practices from their everyday context risks missing important links to other practices that are spread in time and space. However, by studying practices within a standardised setting, such as the opportunity presented by situating research within student accommodation, variations in the material infrastructure can be controlled for. University accommodation also presents the advantage of having the resident population re-set annually.

3.2.1 Student accommodation and water supply configuration

The University of the West of England's (UWE) main Frenchay campus in north Bristol has a current residential capacity of nearly 3,000[29] beds, housed across two developments within the estate, built at different times to varying specifications and with diverse models of student life in mind. The site is classed as an *exceptional night user* (ENU919) by Bristol Water, whilst the university has energy, water, and carbon reduction targets for the estate (UWE, 2021; UWE, 2020; and Universities UK, 2019[30]). UWE and Bristol Water have been jointly researching the water infrastructure performance and consumption patterns of the Student Village (built in 2005 and located on the northern edge of the campus) since 2012 (Staddon, Toher and **Simpson**[31], 2016, see Appendix F). Advantages of using student accommodation as a laboratory to research resource demand management include:

- the site is easily accessible with standardised buildings and plumbing systems and managed by the UWE Estates department;
- the resident population is well understood as the accommodation is exclusively for UWE students and managed by UWE Accommodation Services, and occupant records are available;

[29] The oldest development of around 500 beds in two-story houses, Carroll Court, dating back to the 1980s was demolished in 2021 and the land is being redeveloped into new student accommodation.
[30] Universities are required to "*encourage residents and staff to be environmentally responsible in their consumption of energy and water*".
[31] **Simpson** was co-author, see Appendix F

- the occupants effectively renew annually as it generally houses first year students only, allowing for repeatable experiments at a scale that supports generalisation;
- several cycles of infrastructure performance and consumption patterns of successive student cohorts are now available; and,
- it is possible to develop a research design based on the repeatable trials at a reasonable scale.

The first year of the Bristol Water/UWE collaboration (in advance of the PhD research reported here) was spent identifying infrastructure improvements, overcoming technical difficulties, and fixing leaks. By May 2014, a network of Automatic Meter Reading (AMR) technology was installed, fully commissioned, and linked to the Building Management System (BMS) to measure water, gas, and electricity use at 30-minute intervals. With one meter per block, this represents a resolution of between 66 to 84 beds and is equivalent in scale to a small residential street.

The 1,932-bed Student Village development comprises 24 blocks of flats arranged around four courtyards, as illustrated in Figure 3-1. The UWE Centre for Sport is located next to the Student Village, on the northern boundary of the site (just off the top of the plan). Each block is comprised of paired flats with five or six single occupancy en suite study bedrooms, accommodated across six or seven floors either side of the staircase and lift shaft. Accommodation fees across the estate are charged inclusive of all water and energy and the BMS data is used for operations and maintenance, not for energy or water billing, although there have been initiatives to reduce energy and water consumption via targeted university halls *information campaigns* supported by the Students' Union, in which metered consumption was published in hall league tables.

The externally contracted '*Reduce the Juice'* campaign ran for two academic years from 2016-18 and recruited 'Sustainability Engagement and Action Leaders' (SEALS) to support a social media campaign. Students living in university accommodation were challenged to reduce energy and water use and improve recycling rates, with inter-house/block and inter-university challenges and month-long 'sprints', competing for prizes. From autumn 2018, UWE opted for an internally staffed resource efficiency drive in partnership with the Students' Union, to meet its Universities UK Code of Practice (2019) energy and water efficiency obligations.

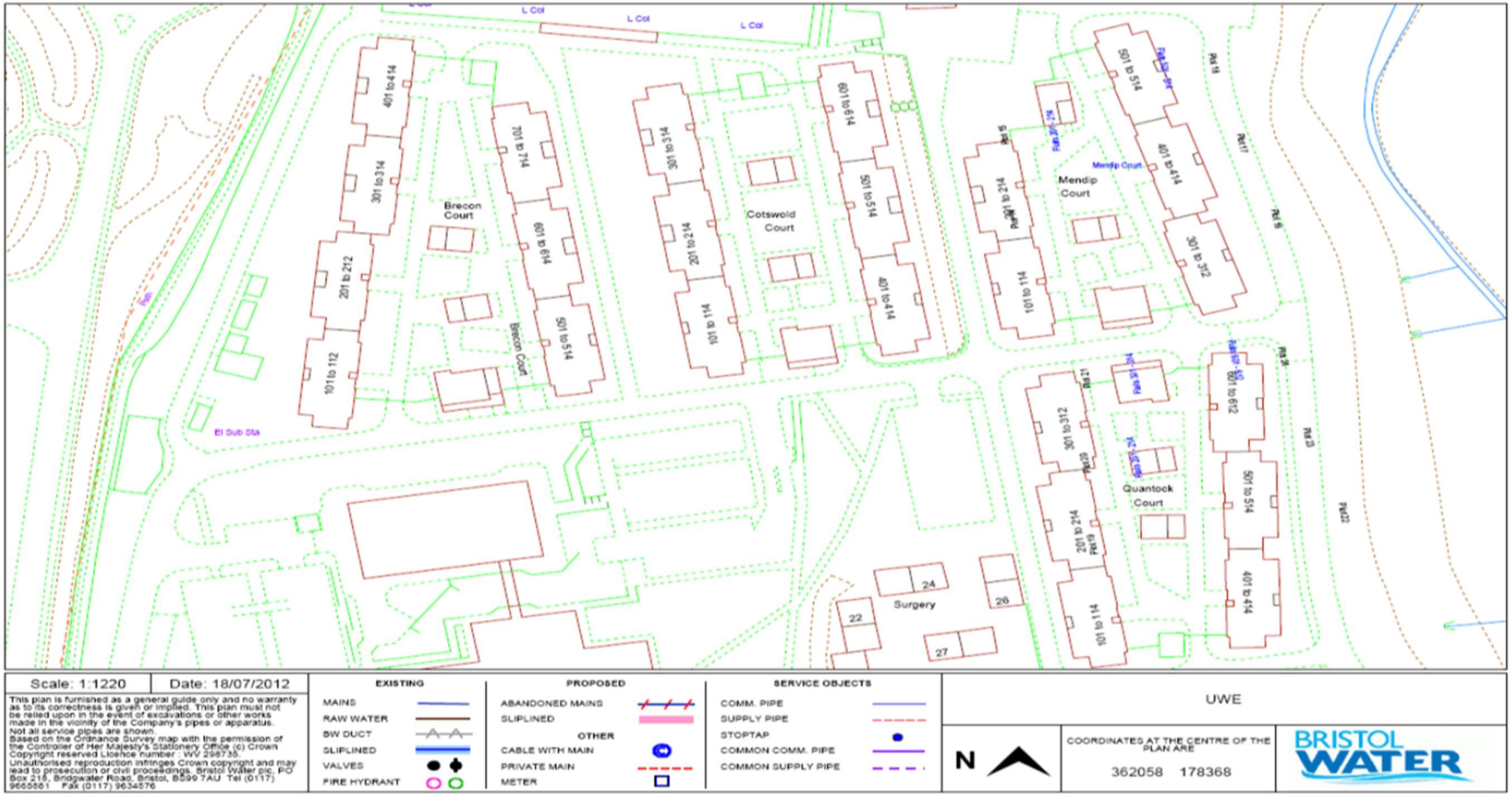


Figure 3-1 Plan of Student Village, Frenchay campus, University of the West of England, Bristol (Source: Bristol Water)

In the first experimental cycle (2014/15), several incremental water efficiency interventions were assessed, including wash-hand basin tap flow-restrictors, low flow shower heads, and shower timers. Analysis indicated that the tap restrictors delivered water savings, but there were only marginal measurable demand reductions from showerheads or timers. However, further analysis suggested that socio-demographic factors (gender and nationality) had a confounding effect on water consumption, over and above the implementation of hard and soft measures (Staddon, Toher and **Simpson**, 2016).

The research described in this PhD thesis built upon the early investigations and water consumption data from the Student Village were analysed to provide baseline infrastructure performance levels (Wave 0, see Chapter 4). However, for reasons of granularity and scale, primary data collection and intervention delivery (Wave 1 and Wave 2) were focused on a group of a dozen modern townhouses within the smaller Wallscourt Park phase 1 (WCP1).

The 404-bed low-rise WCP1 development was built in 2014[32] on the western side of the campus. Two-thirds of the 37 WCP1 townhouses have four-stories, with bedrooms on the top three floors. There are four bedrooms per floor, accommodating twelve students. There are also a dozen smaller three-story townhouses, accommodating either eight or ten beds arranged around a central courtyard. The ground floor in each house has a shared cloakroom with a dual-flush WC and a wash-hand basin fitted with a flow regulated mixer tap (5 l/min) and a communal kitchen-diner with two sinks supplied by unregulated/high-flow mixer taps (that deliver at least 12 l/min).

Whilst electricity, gas and water are recorded for each block of flats in the Student Village (at a course resolution of 66-84 beds per meter), the townhouses in WCP1 are separately metered via AMR linked to the BMS, with a finer granularity of just eight to twelve beds per meter. These smaller houses were the focus of the research documented in this thesis, as they were more comparable with typical domestic dwellings in the wider population with greater validity to scaling-up the findings. And pragmatically it was easier to engage with these smaller households.

[32] WCP1 is part of an extended mixed development that was completed in 2016 with a total of 965 beds. Phase 2 comprises low-rise flats that are supplied by a centralised hot water system and for this reason is not metered at a house or flat scale, and therefore did not form part of this PhD project.

The total design occupancy for the twelve-house study site is 104 persons, and in each house the hot water outlets (taps and showers only, there are no baths) are supplied by a 300-litre hot water storage gas-fired calorifier, with back-up electrical immersion heater. The photograph of the exterior of the development showing eight of the houses from the rear aspect (houses E to L) is shown in Figure 3-2 and a plan of the study site is illustrated in Figure 3-3.

Figure 3-2 Exterior of university housing development – from rear of houses H and I (Source: author)

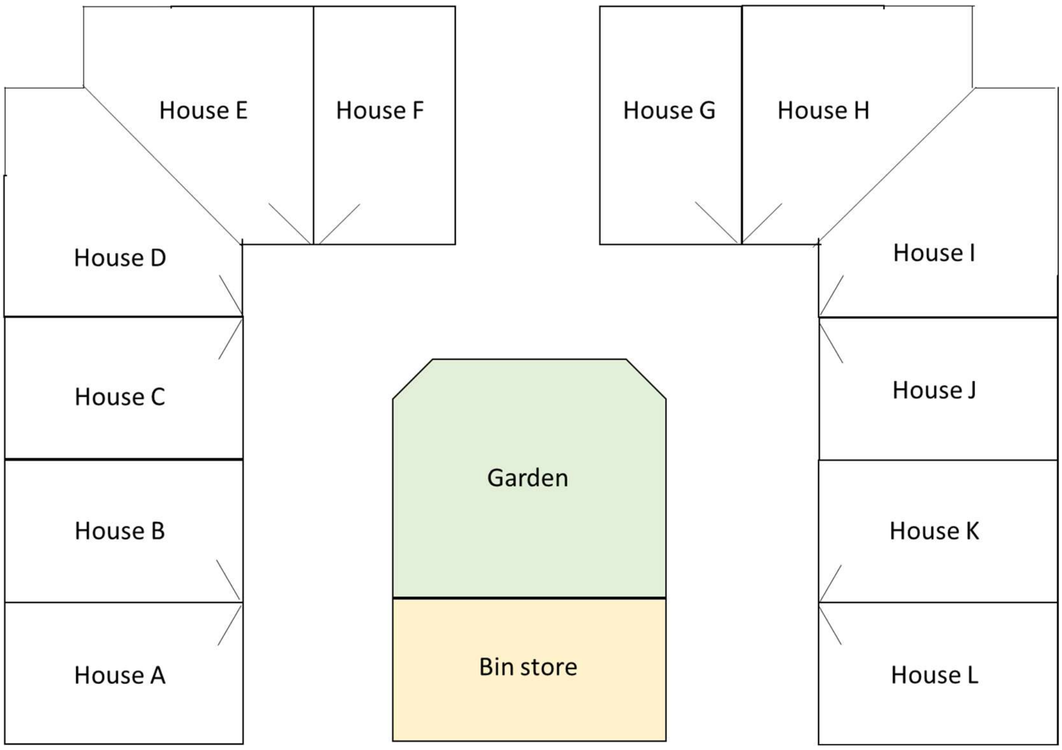


Figure 3-3 Plan of study site – not to scale (Source: author)

Eight of the twelve study houses (A, B, C, F, G, J, K and L) comprise eight single-bed rooms with four shared WC/shower rooms arranged across the two upper floors (four bedrooms and two WC/shower rooms on each floor). The four larger corner-aspect houses (D, E, H, and I) have the capacity to house ten occupants, with one twin/shared bedroom, three single occupancy bedrooms and two shared WC/shower rooms on each of the top two floors. The layout of the first-floor elevation for six of the houses (A to F) is shown in Figure 3-4, annotated to show the pairs of internal facing shower rooms each side of the service cupboards (housing boilers and plumbing) on each landing. Plans for the top two floors for both halves of the study site (houses A to F and G to L) are shown in Appendix A.1.

3.2.2 Water fixtures

The shower rooms have a large separate shower enclosure and are fitted with water-efficient showerheads[33] (manufactured by Ideal Standard or Rada, rated at 8 l/min), controlled by a thermostat (see Figure 3-5 to Figure 3-7), a wash-hand basin with flow-regulated mixer tap (5 l/min) and a dual-flush (pneumatic, 6/4 litre) WC. Laundry facilities are provided centrally for residents in a separate building within the estate and were outside the scope of this research project. There was no outside water-use such as gardening or car-washing that needed to be accounted for.

To gain familiarity of the accommodation and to directly measure the performance of the existing water infrastructure performance, a water fixtures audit of WCP1 was undertaken in August 2017. A sample of five houses (representing 13% of the WCP1 estate) was selected at random across the development and all water fixtures within each house were audited. Manual flow measurements were initially made using specialist flow cups, but the bubbles from the aerated flow made it impossible to accurately read the flow rate scale. Instead, flow measurements were recorded by placing a measuring jug under the full flow for five seconds (and then multiplied by 12 to calculate a litres per minute flow rate). Audit results are summarised in Table 3-1.

[33] Showerheads are routinely exchanged on a quarterly basis as part of the university's *Legionella* risk mitigation programme.

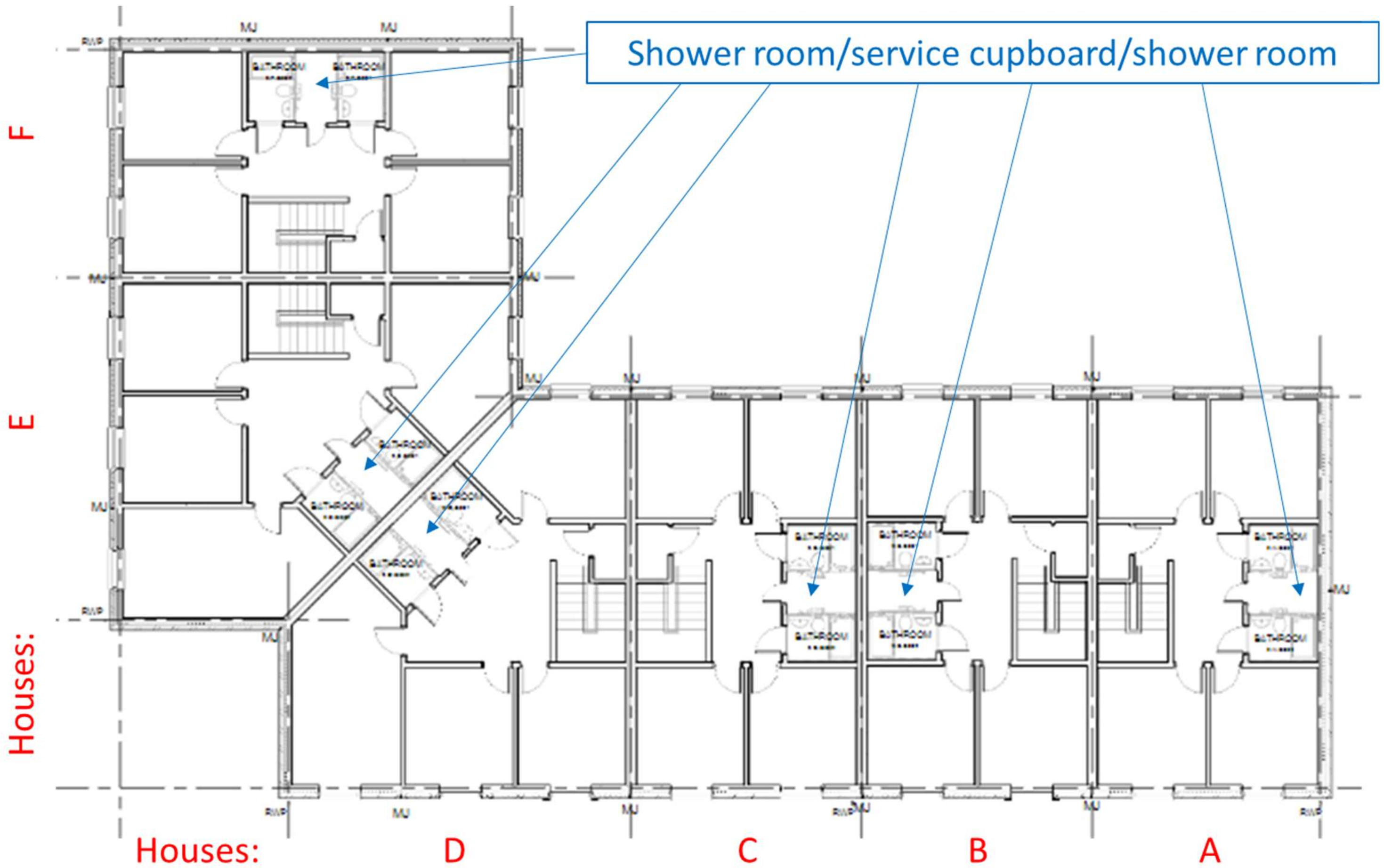


Figure 3-4 Plan of layout for houses A to F, first floor bedrooms and shower rooms (source: UWE)

Figure 3-5 Shower/WC room (Source: author)

Ideal Standard

Rada

Figure 3-6 Water efficient showerheads (Source: author)

Figure 3-7 Shower thermostatic control (Source: author)

Table 3-1 Audit findings, August 2017

House	**Kitchen taps** *(litres/min)*	**Wash-hand basin taps** *(litres/min, with regulator inserts)*	**Showers** *(litres/min, with showerhead)*
	x2 per house, ground floor kitchen	*X7* (0r x5) per house, ground floor cloakroom, and each shower room on upper floors*	*X6* (or x4) per house (1 per shower room)*
X*	Leaking tap, flow too high to measure	4.2	9.0
Y*	Dripping tap, flow range 3.4 l/m (hot) to 14 l/m (cold)	4.6	7.5
Z*	Dripping tap, flow range 6 l/m (hot) to 11.4 l/m (cold)	4.7	6.6
B	Flow rate too high to measure	5.1	8.0
G	Dripping taps, flow too high to measure	7.2	7.7
**Houses X, Y and Z were within the 404-bed WCP1 (2014) development, but were larger 12-bed, 4 story townhouses and not part of the intensive field investigations presented for this research*			

The audit showed that despite standardised modern fixtures in the new build development (three years old), there were variations in the performance of the infrastructure across the houses. This may be due to slightly different configurations of the plumbing supplying each fixture, such as, the positioning of pipe joints, or even the work style of different plumbers, or fixture changes following maintenance. There was a non-standard (high flow, unregulated) wash-hand basin tap in house G. The findings were shared with the Estates department so that any defects could be rectified prior to the study commencing.

Whilst WCs were not the primary focus of this thesis, they do contribute to total measured consumption. The extent of leaking cisterns were assessed, by listening and looking for signs of rippling of the water in the bowl. Blue tissue was put on the side of the bowl above the water line, to see if it absorbed water (and changed to a darker blue). The results are summarised in Appendix A.2. There was evidence that two of the 31 WCs in the five audited WCP1 houses were leaky. One had a possible dribble down the back of the bowl (with potential to deteriorate into a more consumptive leak), whilst the other was clearly flowing continuously. In addition, five WCs had faults with the dual flush mechanism, with either the full or half flush not functioning properly, which could drive users to double-flush or always select the full flush option.

3.3 Resident population

3.3.1 Social context

Water is not generally consumed without a consumer[34] (there is no practice without a performer). To understand how, why, and when water is used within households and to evaluate the user-acceptability of water saving solutions, student residents were asked to complete online questionnaires, keep personal shower diaries and attend focus groups. The planned research clearly involved humans both as the focus of the research (and their showering routines – a potentially sensitive and private matter) and as instruments of data provision and intervention (Browne *et al*., 2015). Therefore, the research was subject to university ethical approval.

Full Research Ethics approval was granted by the UWE Bristol Research Ethics Committee in May 2017 (Reference No. UREC16-17.02.09). All participants were required to give written informed consent to use their data for the research. Copies of the participant information and consent sheets are included in Appendix A.3. Ethical review

[34] Except for leaks, the reporting of which relies upon human action.

considerations included plans for the standard practice of compensating participants for their time and commitment with £20 shopping vouchers, depending on their level of input. Participants who actively took part in the interventions and kept shower diaries were compensated with a voucher, whilst for data collection activities that required less time commitment (questionnaires and focus groups) participant names were entered into prize draws to win vouchers. Participants were recruited through a mix of convenience, snowball and quota (non-probability) sampling (Burton, 2000) during student facing events, including the annual Freshers' Fair for new students, leaflet drops, door-knocking, referrals and via other student-facing channels.

Summary demographic information for the occupants of the study houses was obtained from UWE Accommodation Services, spanning two academic years (2017-18 and 2018-19) to cover the periods of the field trials. Most of the resident population of the WCP1 development reset between the two intensive field trials. This data is summarised in Table 3-2 and Table 3-3.

Table 3-2 Occupant demographics – Wave 1, spring 2018

House (design occupancy)	**Gender** female:male (void)	**UWE Centre for Sport membership**	**Age** (18-22, 23+)	**Nationality** (UK, Europe, Non-Europe – Africa/Asia)
A (8)	8:0 (0)	5	3, 5	1, 0, 7
B (8)	4:4 (0)	2	8, 0	7, 0, 1
C (8)	8:0 (0)	4	7, 1	0, 0, 8
D (10)	5:5 (0)	2	6, 4	5, 0, 5
E (10)	5:3 (2)	4	7, 1	6, 0, 2
F (8)	8:0 (0)	2	8, 0	5, 2, 1
G (8)	4:4 (0)	2	8, 0	5, 2, 1
H (10)	3:7 (0)	4	9, 1	8, 2, 0
I (10)	4:6 (0)	7	9, 1	8, 2, 0
J (8)	4:4 (0)	3	7, 1	7, 1, 0
K (8)	4:4 (0)	3	8, 0	8, 0, 0
L[35] (8)	3:2 (3)	0	4, 1	4, 0, 1
Total	**60:39 (5)**	**38**	**84, 15**	**64, 9, 26**
As of 27 March 2018				

[35] House L is not routinely let to students and intentionally kept void. It is retained as a show house for prospective students at open days and as temporary accommodation for emergencies (e.g., flood, fire, or for student wellbeing). Thus, in the latter part of 2017/18 academic year (Wave 1) house L was partially occupied (Table 3-2) whilst at the start of the following academic year 2018/19 (Wave 2) it was empty (Table 3-3).

For the academic year 2017/18, *actual* occupancy was 95.2% of design occupancy (99 let beds out of 104-maximum capacity, with five void beds between houses E and L), whilst it was 92.3% (96 of 104 beds, with all eight void beds in house L) the following year, 2018/19. *Actual* occupancy is likely to have fluctuated above and below the snapshot of *official* rented levels, further confounded by informal visits by houseguests, or tenants staying elsewhere.

Table 3-3 Occupant demographics – Wave 2, autumn 2018

House (design occupancy)	**Gender** female:male (void)	**UWE Centre for Sport membership**	**Age** (18-22, 23+)	**Nationality** (UK, Europe, Non-Europe – Africa/Asia)
A (8)	4:4 (0)	4	6, 2	1, 1, 6
B (8)	4:4 (0)	2	8, 0	0, 2, 6
C (8)	0:8 (0)	2	8, 0	0, 1, 7
D (10)	4:6 (0)	8	10, 0	0, 0, 10
E (10)	5:5 (0)	3	7, 3	6. 0. 4
F (8)	4:4 (0)	2	6, 2	5, 0, 3
G (8)	4:4 (0)	3	8, 0	8, 0, 0
H (10)	6:4 (0)	4	9, 1	8, 2, 0
I (10)	3:7 (0)	4	10, 0	8, 0, 2
J (8)	4:4 (0)	2	8, 0	8, 0, 0
K (8)	4:4 (0)	5	8, 0	7, 0, 1
L[20] (8)	0:0 (8)	0	0, 0	0, 0, 0
Total	**42:54 (8)**	**39**	**88, 8**	**51, 6, 39**
As of 03 October 2018				

Comparing the data across the two academic years, the gender split was significantly different, with more females than male in the spring 2018 (61% female), and more males than female (44% female, but a closer balance) in the autumn. Gym membership and age splits were similar for both periods, but the nationality of residents was also significantly different, with fewer UK and more non-European students in the autumn.

3.3.2 Sampling strategy

A recruitment target of 25 student participants was set for the Wave 1 and Wave 2 trials. This was judged to be an appropriate sample size, representing a quarter of the resident population and a manageable number for the researcher to co-ordinate, analyse and triangulate results across the multiple end-user outputs, within the limited financial and time resources of a PhD (Burton, 2000). The recruitment target was exceeded for Wave 1 (with 26 diary participants and 34 unique participants across the range of end-user collection instruments, although only nine students went on to complete all three instruments). Whilst the 25-recruitment target was not quite achieved for the Wave 2 trial, a slightly modified research design meant that there was better retention across all instruments. All 23 responded to the Q/2A survey, 22 returned the follow-on (Q/2B) questionnaire, 21 completed diaries, and eleven participated in the two focus groups.

Participant socio-demographics were compared with the wider population data (Table 3-2 and Table 3-3) as a conventional check for validity. However, it was more important that the showering styles of the participants reflected those of the wider student population. This was assessed by comparing the showering dimensions (duration, frequency, location and number of products) favoured by the Wave 1 and Wave 2 participants, with the results of a cluster analysis of the baseline survey (Q/0) responses which identified showering types for the student body (see section 3.6.1 *Questionnaires*).

3.4 Interventions

Chapter 2 showed that there is limited empirical research on practical water demand measures and this research set out to contribute to the literature gap on interventions. Intervening in practices can be distinguished between types and scale of ambition. Spurling and McMeekin (2015) describe zooming-in to intervene at the element level to *recraft* practices to reduce the resource intensity of existing practices and zooming-out to look at the role of multiple or bundles of practices by *substituting* and changing how practices *interlock* with other practices.

This framing suggests opportunities to reduce the demand for showering are overlooked by conventional policy interventions as the 'need' or 'want' for a daily shower is accepted as a non-negotiable requirement. Instead, mitigation schemes tend to focus on changing elements through (often one-off) technical fixes, such as installing low flow shower heads. Shower water demand is the product of flow rate, duration and frequency, but intervening in these dimensions requires different types of mitigations.

Changing flow rates represents the simplest solution, through fitting flow regulated fixtures to alter a material element to *recraft* showering practice and has the potential to deliver savings of a few litres per minute. In the university accommodation context, all water fixtures were already standardised and water efficient. Duration requires ongoing intervention and is dependent on repeated performance and can be supported by real-time feedback from shower timers. Shorter showers may shave a minute or two from each shower, equivalent to perhaps 10-15 litres per shower. The opportunity to alter shower frequency is more challenging for conventional policy interventions as it requires a renegotiation of the accepted daily norm. Spurling and McMeekin's (2015) framing points to the need to explore the patterns of daily life and to understand how work (education) and leisure is organised. However, intervening in shower frequency carries the potential for the greatest impact, but is considered to be beyond the reach of water managers tasked with reducing demand, particularly as they do not wish to tell customers what to do and dictate how to live their lives.

One of the stated aims of this research was to evaluate the efficacy and acceptability of real-world water conservation interventions to inform future domestic water efficiency programmes. Interventions were tested in two waves of fieldwork. Wave 1, in spring 2018, formed a pilot to test the operational deployment of a mix of primary data collection methods in combination within the real-world setting of the university residential accommodation, to confirm the practicalities of the experimental design using. As this was a proof of concept, the trial tested a range of *conventional* water saving measures of the type that are currently favoured by English water companies, based on IBC approaches, with or without supporting technology. The experimental design was modified for Wave 2, in autumn 2018, reflecting on the experience of the Wave 1 trial, and tested a package of SPT-inspired interventions.

Access was granted to the modern, standardised built environment of the university residential accommodation to deliver a mix of shower-water saving interventions (Research Objective 4) in a real-world setting (RQ4.2).

3.4.1 Wave 1

The Wave 1 field trial piloted the feasibility of combining research methods to test the efficacy of conventional water efficiency interventions in a real-world setting. Most conventional water efficiency interventions are framed around individual choice and provide information with the expectation that cost-benefit evaluations or environmentally focused values will drive preferred behavioural outcomes (Defra, 2018b; Waterwise, 2015; Ofwat, 2011; Environment Agency, 2009). Interventions were allocated to pairs of houses, as summarised in Table 3-4, along with their theoretical mechanism (ISM context).

Laminated posters, created by Bristol Water and designed to prompt emotional reactions, were put up in communal spaces in houses C and D, principally on the back of the door of every shower room (with separate designs for each house), with more generic posters in the downstairs cloakrooms (on the back of the door) and on the kitchen-diner noticeboards. Images of the posters are shown in Figure 3-8, and in larger format in Appendix A.4.1. Simple 4-minute sand timers, supplied by Bristol Water were distributed to all residents in houses E and F to passively target shower durations, and Amphiro a1 smart shower meters (purchased from Amazon) were fitted to every shower in houses G and H (see Figure 3-9) in a more engaging focus on shower durations.

Table 3-4 Wave 1 (pilot study) – conventional water efficiency interventions

Houses	Intervention	Type/ISM context	Location
A/B	Control – no intervention	N/A	N/A
C/D	Posters from Bristol Water	Classic behavioural (passive) - Individual	Shower room door x8
E/F	4-minute shower timers, supplied by Bristol Water	Behavioural with enabling technology - Individual/Material	Given to all residents x18
G/H	Amphiro a1 smart shower meters	Behavioural with enabling technology - Individual/Material	Installed on all showers x8
I/J	Face-to-face engagement	Collective behavioural - Individual/Social	Communal dining area in house J (4 participants)

The Amphiro a1 is a commercially available smart meter with an in-shower user display that shows water, and energy consumption at the point-of-use. It is simple to install and fits between the showerhead and shower hose without any special tools or plumbing knowledge. The display is powered by hydro-electric energy generated by the water flow through the device and displays the water temperature and total volume used in real-time alongside a dynamic graphic of a polar bear on a melting iceberg to both directly and emotively link the impact of shower energy consumption to climate breakdown in an attempt to reduce shower durations. At the end of a shower event the energy use (in Watt-hours/kilowatt-hours) and energy efficiency class are displayed, along with an efficiency code (that allows users to track their average shower consumption over time via an online portal, although this functionality was not used in this research to preserve participant privacy).

The face-to-face engagement was delivered half-way through the intervention/diary fortnight (on 28 February) and took the form of a focus group (FG1). See section 3.5.2 for further details of the focus groups.

House C, back of shower room door x4 (A4 size)

House D, back of shower room door x4 (A4 size)

Back of downstairs cloakroom door – 1 per house (A4 size)

Kitchen-diner noticeboard – 1 per house (A3 size)

Figure 3-4 Images of posters – houses C and D, Wave 1 (Source: Bristol Water)

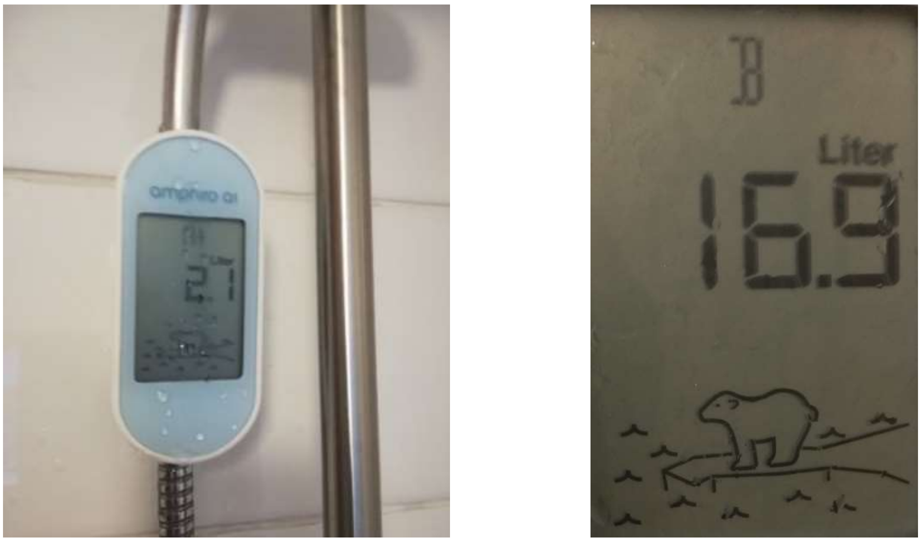


Figure 3-5 Amphiro a1 smart shower meter, with close-up of polar bear graphic display (Source: author)

3.4.2 Wave 2

The second field trial adopted an adjusted experimental design to overcome some practical limitations the Wave 1 trial. For Wave 2, in autumn 2018 (with a new cohort of student residents) a *novel*, *practice-based* intervention was tested. Analysis of an expansive context setting questionnaire (Q/0 in autumn 2017, see Chapter 4) revealed that hair washing was a key in-shower activity and that the dominant style of showering by the students (termed the '*UWE standard*') shared similar characteristics to a showering type described as '*attentive cleaning'* by Browne *et al.,* (2013b).

It was challenging to design a SPT-based intervention as it needed to be practical, make sense to the resident population and be attainable within the limited personal (skills, time) and external (financial, access to study site) resources available to the researcher, within the constraints of a time-limited PhD study. The researcher turned to the changing socio-material landscape to formulate a pair of mitigation measures by tapping into the '*Blue-Planet'* effect and the associated strong public concern about single-use plastics. Evolving social opinions were seized upon as a meaningful vehicle to reduce water demand as an indirect consequence of targeting plastic-bottled shampoo products. The researcher recognised that there was little prospect as a lone agent that she could create the necessary cultural change among the student residents to deliver a practice-based solution with any potential of achieving the desired water-saving results. The intervention rode on the coat tails of a powerful social force and was designed to test initiatives to disrupt dominant *haircare* micro-processes. The intervention comprised two incremental parts, each designed to act upon a different dimension of showering – duration and frequency.

> ***'Go green'*** – students were challenged to avoid using all of their plastic bottled shower products for two weeks by substituting with an alternative unpackaged solid shampoo bar for all their ablutions (akin to a plastic bottle amnesty although participants were not asked to hand over their personal products). The aim was to reduce the number of products used in the showering process that might determine the procedural steps, and to indirectly reduce shower *duration*.
>
> ***'Go gold'*** – students were asked to reduce their shower frequency for two weeks by skipping showers and were provided with an alternative aerosol canned dry shampoo product for between-shower haircare instead, supplemented with

advice on between-wash hair styles and low/no poo[36] lifestyles. The aim was to disrupt shower *frequency*.

The intervention had similarities to of practice-based interventions in the literature in terms of stopping the use of material resources (plastic bottles or shower entire events). For example, the participants in Kuijer's (2017) 'Splashing' research were not allowed to use continually flowing water, whilst Jack's (2013) laundry intervention, the end-users were instructed not to use water, energy or chemicals to clean their jeans. Using Spurling and McMeekin's (2015) framing, the shampoo bar represented a *recrafting* of a resource-intensive practice for a more sustainable alternative, whilst the dry shampoo solution was an attempt to *substitute* showering by providing an alternative means for hair maintenance.

Dry shampoo is a relic from the past which has seen a resurgence in popularity in the last decade or so (McGarry, 2008), and is favoured by festival-goers who are limited in their access to showering facilities (Hitchings, Browne and Jack, 2018). The starch-based powder absorbs grease, dirt and sweat which is then brushed or combed out and it adds a fragrance to help mask perceived odours. The recent resurgence in dry shampoo use is likely to be driven by time saving convenience rather than for resource saving motivations (Hielscher, Fisher and Cooper, 2009).

The package of interventions was dependent on recruiting participants living within the study site who were willing to try a new approach to showering. Therefore, the precise location of the intervention was not pre-determined but dictated by the recruitment of willing participants. This may have resulted in some *opt-in bias*, with perhaps more sustainability-minded students participating (Staddon and Genchev, 2013), although the intervention was designed to appeal to a wide audience and in particular to those students who placed importance on personal grooming *('attentive cleaning'* types).

Being mindful of personal preferences and tastes*,* consideration was given to provide the volunteers with product leading brands for the trial. A stall was set up in the courtyard of the study site, outside empty house L (to avoid causing nuisance to residents) on 10 October 2018 in the run up to that two-week trial, to gather market intelligence on

[36] Conventional *shampoo* products contain sulphates which lather up to remove dirt and grease and are often used with *conditioners,* designed to replace the natural oils that the shampoo strips out. *Low poo* refers to a shampoo which is free from sulphates but is often intended for use with a conditioner. *No poo* means washing hair without any shampoo – this could be *water only* or using baking soda or apple cider vinegar.

students' preferences on a selection of solid shampoo bars and dry shampoo options (see Figure 3-10).

Figure 3-6 Market research and recruitment stall, 10 October 2018 (Source: author)

Houses surrounding the courtyard were leafleted and the stall was promoted via the 'UWE Green Team' and 'UWE Big Green Week' social media channels. Residents and passers-by were invited to vote for their favourite solid shampoo bar from a choice of six (five products from the market leader Lush, and one lower priced ethical product - Friendly Soap, on sale in the Student Union shop), by ranking their first three choices and least favourite. Preference was largely based upon smell and lathering potential of the products using hand bowls of (regularly refreshed) warm water, alongside product information. It was not practical to test performance as hair care products at the stall. Ingredient information sheets (see Appendix A.4.2) were available to mitigate for any risk of skin allergies. Students were also invited to vote for their favourite smelling (market leader Baptiste) dry shampoo from a choice of two. The preferences are summarised in Table 3-5.

The *avocado* co-wash[37] was the clear favourite, with mixed results for all the other shampoo bars. The *fruity* dry shampoo was the most popular dry shampoo product. For the trial, the preferred products were provided to each volunteer participant, and enough unpackaged shampoo bars (with storage tins) and dry shampoo cans were purchased to distribute to another ten trial participants.

[37] *Co-washing* means using a conditioner to clean and condition hair in a single application.

Table 3-5 Market research findings, 10 October 2018

Product	**1st choice**	**2nd choice**	**3rd choice**	**Least preferred**
Solid shampoo bar				
Avocado *(co-wash)*	9	1	2	1
Black pepper and vanilla *('Monsters and Aliens' multipurpose 'Fun' putty)*	2	1	2	2
Coconut (*'Trichomania')*	2	1	4	4
Jasmin *('Godiva')*	0	2	3	1
Seaweed, sea salt and lemon *('Seanik')*	1	5	0	4
Lavender and geranium *(Friendly Soap from SU shop)*	1	4	1	1
Dry shampoo				
Classic *('Original')*	5			
Fruity *('Tropical')*	9			

Sixteen volunteers (eight females, eight males) were recruited to take part in the trial. They were residents from five of the twelve houses within the study site. These five houses were targeted in a second phase of recruitment via leafleting, door knocking and housemate referrals. The final tally of 23 volunteers (target of 25), representing 55% of the residents in these houses, is shown in Table 3-6.

Table 3-6 Summary of Wave 2 participants

House	**Occupancy**	**Female**	**Male**
F	8	4	2
G	8	4	3
H	10	1	1
J	8	2	3
K	8	1	2
Total	**42**	**12**	**11**

Residents from houses F and G were particularly keen to take part in the trial with six and seven volunteers, respectively (out of eight residents) willing to take part. There was also a good gender balance, which reflected the 52:48% female to male ratio of the intervention houses population, suggesting that both genders were sufficiently interested in haircare and/or sustainable or ethical consumption, and could identify with an *'attentive cleaning'* style of showering.

At the start of the trial, the participants were supplied with:

- Participant information sheet and two copies of the participant consent sheet (counter signed by the researcher - one copy retained by the participant, the other securely stored by the researcher, as per ethical approval and data protection requirements);

- A shower diary template (see Figure 3-13);
- *'Go green'* - a solid shampoo bar (from a choice of six) in a small storage tin and list of the relevant product ingredients/user directions, taken from the bulk purchase packaging/manufacturer's website (in lieu of product packaging, to mitigate for any risk of allergies);
- *'Go gold'* - an aerosol can of dry shampoo (from a choice of two), a few elastic hair bands (for those with longer hair only) and a booklet of suggested between-wash hair styles and '*low/no poo'* advice, created by the researcher.

3.5 Experimental design and primary data collection

The fieldwork spanned two academic years (2017/18 and 2018/19). A timeline of primary data collection is listed in Table 3-7, and key academic dates are included in Appendix A.5.

Table 3-7 Timeline of data collection activities

Month	Day	Activity or event	Where/Who	Phase
2017				
May	12	Full ethical approval granted		
Jun-Sep		*Student summer vacation*		
Aug	10	Fixtures audit	Houses X Y Z B G	Wave 0 - baseline/ exploratory
Sep	25	➢ *Start of teaching block*		
Oct	16-31	Questionnaire Q/0	University-wide	
Nov	15	➢ Start Siloette logger test	House A	
Dec	04	X End Siloette logger test	House A	
	08	X *End of teaching block*		
	27	➢ Install x10 Siloette loggers	House A – J	
2018				
Jan	22	➢ *Start of teaching block*		Wave 1 –conventional interventions (downstream focus)
		➢ Start PRE-INTERVENTION		
Feb	13	X End PRE-INTERVENTION		
	14	➢ Install x8 Amphiros	Houses F & G	
	14-20	RECRUITMENT	Houses A – J	
	21	➢ Start INTERVENTION	Houses A – J, X	
		➢ Start Diaries (D1)	Houses A – J, X	
	28	➢ Focus group (FG1) – f-2-f intervention for houses I/J	House J	
Mar	06-21	Questionnaire Q/1 live	Wave 1 participants	
	07	X End INTERVENTION		
		X Collect Diaries	Houses A – J, X	
		Focus group (FG3)	House H	
	08-13	POST-INTERVENTION		
	14	*No water event*		
		Focus groups (FG3 & FG4)	Houses D & F	

Continued overleaf...

	21 25 26 27 28	Focus group (FG5) *Clocks forward 1 hr to BST* ➢ *Start of Easter vacation* WCP1 demographic data applies X Remove x10 Siloette Loggers X Remove x8 Amphiros	House B (& Skype) WCP1 Houses A – J Houses F & G	
Apr-May		*Student assessment (exams)*		
May	30	Focus group (FG6) - stakeholders	Evaluation, reflection, and design with upstream actors	
Jun-Sep		*Student summer vacation*		
Sep	15 24 30	➢ *Students arrive* ➢ *Start of teaching block* ➢ Start PRE-INTERVENTION *Late arrival to accommodation*	 House A	Wave 2 – novel practice-based interventions (downstream focus)
Oct	02 03 04 08 10 25 27 29	*Late arrivals to accommodation* *Late arrivals to accommodation (maximum occupancy reached)* WCP1 demographic data applies ➢ Start RECRUITMENT ➢ Install x8 Amphiros Market research stall ➢ Install x8 sub-meters & x8 Siloette loggers *Clocks back 1 hr to GMT* ➢ Launch Questionnaire Q/2A	House D Houses G H WCP1 Houses A – L Houses G & J Outside house L Houses G & J Wave 2 participants	
Nov	06 07-21 19 21 22 28	X End RECRUITMENT INTERVENTIONS and Diaries X End Questionnaire Q/2A X Collect Diaries ➢ Launch Questionnaire Q/2B ➢ Start POST-INTERVENTION Focus groups (FG7 & FG8)	 Houses F G H J K Wave 2 participants Wave 2 participants Houses G & F	
Dec	2 7 10	X End POST-INTERVENTION X *End of teaching block* X End Questionnaire Q/2B X Remove x8 loggers/Amphiros	Houses F G H J K Wave 2 participants Houses G & J	

3.5.1 Volumetric measurement

Most studies into socio-material approaches to intervention adopt qualitative methods to gather evidence. However, it was important for this PhD research to gather empirical data through quantitative methods to mesure the impact of interventions on shower water use, in order to translate the findings to professionals that are tasked with managing water demand. Indeed, Browne *et al*., (2015) and Browne, Medd and Anderson (2013) advocate for an expansion of methods to include quantitative assessments in social practice research.

Due to technical challenges with using PCC as a measure, the research reported in this thesis also used other indicators that are arguably more empirically sound or at least complementary. For instance, *per bed* consumption, in which the building *design* occupancy (where the number of beds in a house or flat is known, if not the exact number of occupants, which may change through time) was calculated. This measure tended to slightly underestimate *actual* PCC, as the university accommodation typically operates at 97-99% of maximum bed capacity. However, PCC, based upon *rented* occupancy was also used, with the caveat that the rented occupancy figures represent a snapshot view at a single point in time during the research, and the *actual* occupancy may have fluctuated either side of *rented* bed levels.

Baseline volumetric datasets from the university's AMR water meters were sourced from the Facilities department. It comprised half-hourly water consumption data covering both the Student Village (24 blocks of flats) and WCP1 development (37 townhouses). Student Village data was initially provided for the planning year 2016/17. Having switched attention to the smaller WCP1 houses, data for the two academic years 2017-18 and 2018-19, covering the operational period of the research was downloaded from the BMS.

To supplement the 30-minute meter data and to monitor student water-use patterns, high-resolution *Siloette* event loggers (on loan from Artesia Consulting Limited) were used to collect event data to determine the frequency, volume, and duration of different micro-components (particularly showers). The Siloette devices capture water use at sub one-second temporal resolution, with a pulse for every 500ml through the meter. They have large memory capacity and long battery life (up to two years), minimal set-up requirements and are small enough to sit within the meter box. The units were connected to the pulsed output of the household meters via splitter cables that were designed to maintain the integrity of the telemetry signal to the BMS as well allowing the loggers to capture the second-by-second flow timeseries, in parallel. Figure 3-11 shows a logger attached to a household meter via a splitter cable.

Prior to the Wave 1 pilot field trial, a single logger was connected to the household meter for house A for 20 days (15 November to 04 December 2017) to check that it would record the micro-components at the water fixture scale and confirm that it was feasible to capture individual shower events. The results of this test are reported in Chapter 4.Loggers were installed on ten household meters across the study site (houses A to J, from late December 2017 to March 2018), ready to capture shower events for the Wave 1 field trial. However, post-trial analysis showed that nine of the ten loggers failed to record data. A single logger, connected to the house G meter captured timeseries data. However, it was later discovered that the successful event monitoring had disrupted the

AMR data for that meter for the duration that the logger was *in situ,* due to interference with the BMS telemetry. This also explained the loss of AMR data for house A during the initial 20-day test. The splitter cables did not operate as expected and failed to send pulses to the loggers. This was not detected during the Wave 0 test because the pulse data for that test was successfully collected. The splitter cables did not allow both measures to be collected in parallel, only permitting one type of measurement (BMS *or* logger pulse data), with the BMS taking priority in most cases.

Figure 3-7 Siloette logger (black box) attached to AMR meter via white splitter cable (Source: author)

Therefore, for the Wave 2 field trial, the experimental design was modified. Additional sub-meters were installed directly to the cold-water[38] pipe supplying each shower in two houses (G and J, four showers per house), to bypass the pulse-splitter problem. These sub-meters were situated in the service cupboards on each floor housing the hot water boiler and plumbing system (not user accessible). Houses G and J were selected based on the balanced gender demographics of the occupants (see Table 3-3), prior to participant recruitment. Following a couple of abortive attempts (due to incompatible or non-standard pipework), the sub-meters were successfully installed on the cold-water feeds to eight showers on 25 October 2018. Loggers were connected directly to each of the eight new sub-meters (see Figure 3-12).

[38] It is not feasible to reliably meter hot water supplies.

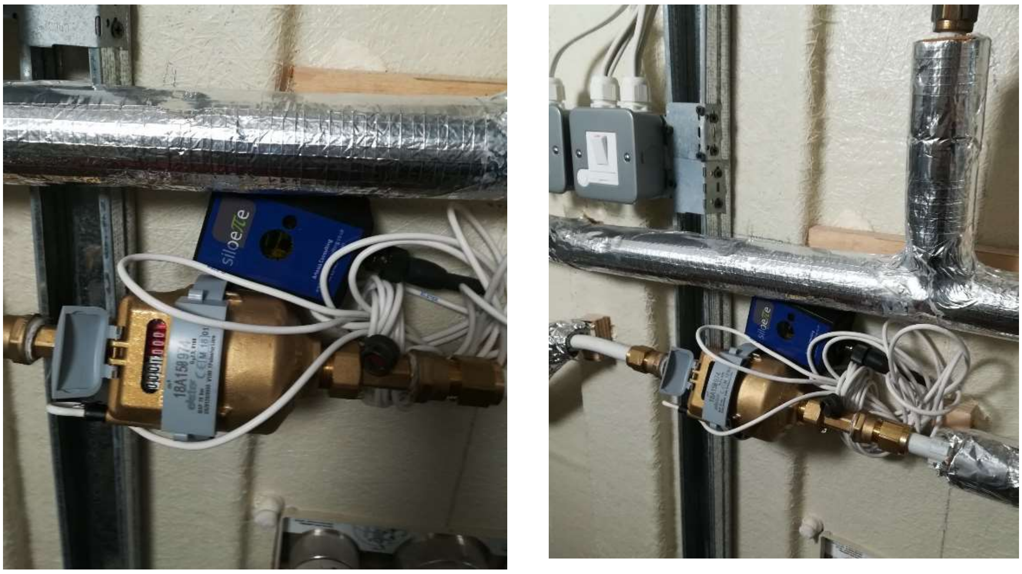


Figure 3-8 Logger connected to shower cold-feed sub-meter in service cupboard (Source: author)

To compensate for not being able to capture total shower use (hot and cold water) user-facing Amphiro a1 basic smart shower meters were also installed (01 October 2018) on the shower hoses inside each of the eight sub-metered shower cubicles in houses G and J. Flow tests using the Amphiro devices (and manually with a measuring jug) were taken to measure the total combined hot and cold-water consumption by each of the shower fixtures, so that a multiplying factor could be calculated using the Siloette measured cold-water shower events to *estimate* total shower water demand. The flow test results are summarised in Table 3-8.

The Siloette loggers were disconnected and removed from the household meters (Wave 1) on 28 March 2018 and from the cold-water shower feeds (Wave 2, along with the Amphiro devices) on 10 December 2018. The loggers were taken to Artesia Consulting to download event data in preparation for data processing including event segmentation using bespoke software.

Table 3-8 Flow test results

	Siloette logger			**Sub-meter**	**Amphiro**		**Manual**	**Estimate**
	Cold only				*Mix of hot & cold*			*Hot:cold*
House/floor/ shower room	Logged duration[1] *(digital mins)*	Logged volume[2] *(litres)*	*Calculated mean flow (litres/min)*	Manually read volume *(litres)*	Measured volume *(litres)*	*Calculated flow (litres/min) [Amphiro volume/ logger duration]*	*Estimated flow (litres/min) [volume in 5 seconds*12]*	*Calculated ratio % [logger:Amphiro]*
G/1/B001	5.00	20.5	*4.1*	21	48.2[5]	*9.6[5]*	*6.0*	*[57.5:42.5]*
Repeated 10/12/18	2.00	8.5	*4.3*	N/A	13.9	*7.0*	*5.4*	*38.8:61.2*
G/1/B002	4.83	30.5	*6.3*	31	27.1[4]	*5.6[4]*	*5.5*	*N/A[4]*
G/2/B001	4.78	14.5	*3.0*	14	23.4	*4.9*	*4.8*	*38.0:62.0*
G/2/B002	4.75	12.5	*2.6*	3[3]	26.9	*5.7*	*4.8*	*53.5:46.5*
							Mean for house G	***43.5:56.5[7]***
J/1/B001	4.77	17.5	*3.7*	17	27.9	*5.9*	*6.4*	*37.3:62.7*
J/1/B002	4.82	25.5[6]	*5.3[6]*	26[6]	33.5[6]	*7.0[6]*	*6.2*	*23.9:76.1[6]*
J/2/B001	4.78	17.5	*3.7*	18	26.3	*5.5*	*4.8*	*33.5:66.5*
J/2/B002	4.83	16.5	*3.4*	17	25.7	*5.3*	*5.3*	*35.8:64.2*
							Mean for house J	***32.6:67.4***
							Weighted mean across both houses	***38.0:62.0[8]***

[1]Majority of 5-minute flow tests were slightly under 5 minutes due to manual timing
[2]Logged volume with 0.5 litres manually added due to premature truncation of shower events during data processing stage (see section 3.6.1e)
[3]Sub-meter volume appears erroneous when compared with logged volume, all other sites match well (within 0.5 litres)
[4]Low Amphiro reading because shower was run at cold temperature (in error) rather than the standard 40^{o}C setting
[5]Unexpected high Amphiro reading, repeated 2-minute test on 10/12/18 is closer to other fixtures
[6]Shower in J/1/B002 delivered higher flow than other fixtures in study, with larger hot:cold water ratio
[7]Based on three readings [ignore G/1/B002 reading on 25/10/18]
[8]Weighted mean (of two house means)

3.5.2 End-user insights

Questionnaires

Social science inquiry usually points to the adoption of qualitative methods aimed at gaining detailed insights into the phenomena under investigation. Deviating from this standard research practice, Browne, Medd and Anderson (2013) point to a need to adopt quantitative approaches in order to scale up understandings using large scale household datasets to population level. Indeed, Browne *et al.* (2015) advocate for '*expanding the range of methods used to actualise theories of practice*' (p.179).

The questionnaire was selected as a suitable research instrument to rapidly collect a mix of both quantitative (closed and pre-coded multiple-choice) and qualitative (open-ended) responses within a standardised structure to start exploring the shower routines of the student body (Burton, 2000). Four rounds of questionnaire surveys were implemented across the field trials hosted on the Bristol Online Surveys platform.

The aim of the Q/0 questionnaire, launched in October 2017, was to inform the intensive field trials (Wave 1 and Wave 2) that followed. It was promoted across the approximately 30,000 UWE student population, via student facing events (Freshers' Fair, volunteering fair, emails sent by supportive geography department lecturers to students on their courses, adverts on the student facing 'Browzer' website, and via a targeted leaflet drop to campus accommodation), using a mix of (non-probability) convenience (availability), snowball (referral/word-of-mouth) and quota (proportionate) sampling approaches (Burton, 2000). Whilst the study research was specifically interested in the showering routines of students living in university halls, it was not practical to target the Q/0 survey solely at campus residents. Therefore, students were asked where they lived during term-time, so that responses could be screened according to housing status:

Q/0-q31. Where is your UWE term-time accommodation?

The Q/0 questionnaire comprised 49 (predominantly but not exclusively closed) questions and explored student environmental attitudes and actions including water awareness; showering routines; other water-using processes; and supplementary socio-demographic information. Participation was encouraged with the offer of a prize draw to win one of twenty shopping vouchers. The responses formed a baseline evaluation of how students '*do*' showering (Wave 0) and attributes for input into a cluster analysis to develop a showering style typology. Subsequent rounds of the survey (Q/1 and Q/2A, for the Wave 1 and Wave 2 trials) were benchmarked against this initial survey.

The second questionnaire (Q/1) was emailed directly to all Wave 1 diary and focus group participants, in March 2018. Participants were also encouraged to circulate the questionnaire link to their housemates. The questionnaire was based on the first Q/0 questionnaire, with a few adjustments to clean up typographical and survey routing errors. It comprised 44 questions and aimed to supplement and validate the Q/0 questionnaire responses. Participation was encouraged with the offer of a chance to win a shopping voucher.

For the Wave 2 trial, the survey was split into two, with the first questionnaire (Q/2A) a repeat of the Q/1 questionnaire comprising 53 questions, and further explored specific in-shower and hair washing routines including preferred flow rate and temperature; procedural steps; product brands; amount of product used; hair length and type; whether family or peers influence showering routines, and preferred evaluation method (of focus group or interview). The Q/2A survey was emailed to all 23 participants at the start of the trial. Completion of the Wave 2 surveys was tied to full participation in the trial and recording diaries. No specific incentive was offered for just completing the questionnaires.

The purpose of the final questionnaire (Q/2B) was to evaluate the Wave 2 trial. It comprised 19 (multi-part) questions, with an even mix of pre-coded closed and open qualitative questions and provided a deeper dive into the reasons behind responses, with rich qualitative insights. Prior to setting a question about recycling empty plastic bottles (question 2, Q/2B), the researcher confirmed that collection facilities were available on site within the WCP1 waste compound. Unfortunately, there were no suitable receptacles for collecting empty aerosol cans on campus (categorised as hazardous waste due to high pressure propellant gases), and no advice was available for safe and responsible disposal. This highlighted a gap in the university's waste disposal provision. Therefore, an equivalent question on recycling empty aerosol cans was omitted.

Participants were asked their opinions on the alternative haircare products; if they managed to '*go green'* and use just the shampoo bar; and whether they were able to '*go gold'* and skip some showers (and use the dry shampoo instead). Insights were gathered on any perceived changes to the dimensions of showering practice, including duration, flow rate, and frequency. Participants were also asked if they would be adopting the modified showering regime in the future and their reasons for this. The Q/2B questionnaire was circulated to all 23 participants taking part in the trial *after* the intervention period ended on 21 March 2018. No additional incentive was offered.

Manufacturer instructions

The responses to a set of questions in the Q/2A survey about shampoo brands and information labels (question 15), led to some supplementary research on manufacturers' directions for use labels on a snapshot of different branded shampoos and conditioner products. The labels on a selection of products on high street shelves, including the brand leaders were photographed. Data from the labels were tabulated, categorised by price point from budget to top end, and the instructions were reviewed to see if manufacturer advice might influence shower duration or frequency. The findings provided supplementary insights to the Wave 2 questionnaire results and helped with interpretation. They are presented in Appendix E and summarised in Chapter 6.

Diaries

Diaries are a self-reporting approach for gathering insights of a more deeply experiential or thought-out nature (Lavrakas, 2012; Alaszewski, 2006). Given the private nature of the research topic, it was not practical or appropriate to undertake an ethnographic approach to observing showering routines. Instead, user-diaries were used as a proxy for direct observation and principally gathered quantitative feedback so that participant data could be compared with logged shower events, supplemented with contextual data on in-shower activities and product use, and in-the-moment thoughts and emotions around showering. The empirical data collected through the diaries contributes to the understanding or how students 'do' showering, and the dimensions of their showering routines, for comparison with limited evidence in the literature on the showering patterns of the wider population (Energy Saving Trust, 2013; Walker and Zygmunt, 2009).

For the Wave 1 pilot, students living in houses A-J were recruited to keep shower diaries for a two-week period (21 February to 07 March 2018, inclusive). A simple paper template was provided, with one page per week, to record the date, time, duration, and location (either shower room reference or off-site such as at a gym or a friend's house) of each shower event. Residents of houses G and H were asked to record the volume of water consumed for each shower from the Amphiro user display. Participants were also asked to note any thoughts or emotions immediately before, during or after each shower, the types of products used, and in-shower activities from a pre-set coded list. An example of the diary template is shown in Figure 3-13.

Participant initials & house number: Shower diary template Date:

Week 1 *(date)*	**Time of day**	**Duration** *(mins)*	**Shower room**	**Litres/kWh used** *(displayed by Amphiro)*	**Thoughts or emotions** *(feel free to elaborate overleaf)*	**Products used** *(see codes below)*	**In-shower activities** *(see codes below)*
07/11/18	*7.45 am* *8.30 pm*	*5* *8*	*A/B C/D* *or B/C/D*	*40.5 litres/1.8 kWh* *64.7 l/2.3 kWh*	*Eg. changes to routine, drivers for showering*	*SB* *S C G O (soap)*	*S1* *S1 C WB WF Sv O (singing)*
Notes or comments *(Did you stay away overnight? Or shower elsewhere?)*						*SB = solid shampoo bar* *DS = dry shampoo* *S = liquid shampoo* *C = conditioner* *G = shower gel* *O = other (specify)* *M = shaving mousse or gel* *E = exfoliator or scrub* *F = face pack* *T = tooth paste*	*S1 = shampoo once* *S2 = shampoo twice* *C = condition hair* *WB = wash body* *WF = wash face* *E = exfoliate* *Sv = Shave* *T = brush teeth* *F = Face pack,* *O = other(specify)*

Figure 3-9 Shower diary template – Amphiro version (Source: author)

A total of 26 diaries were completed in Wave 1, and all diarists were compensated for their time and commitment with a shopping voucher on completion and collection of the diaries. For the Wave 2 trial, the 23 participants that had volunteered to take part in trial were asked to keep shower diaries for two-weeks (07 to 21 November 2018). Again, volunteers were compensated for their contributions with shopping vouchers. Completion of the two Wave 2 questionnaires was tied to keeping diaries and using the alternative hair care products as a complete package, to boost take-up. The Wave 1 template(s) were used for the Wave 2 trial. Two participants dropped out of the Wave 2 trial and did not complete and return their diaries, but all other participants received a shopping voucher. The diary participants are listed in Table 3-9.

Table 3-9 Diary participants by house and gender

House	Wave 1 (spring 2018)	Wave 2 (autumn 2018)
Q	1F, 2F, 3F	
A	4F	
B	5F[1], 6M	
C	7F	
D	9M, 10F, 11F	
E	14F, 15F	43M, 44F, 45M, 46F, 47F, 48F
F	16F, 17F, 18F	49F[1], 50F, 51M, 52M, 53F, 54F, 55M
G	20F, 21F	56F, (57M)
H	22F, 24M, 26M, 27F, 28M	
I	29F, 30F	58M, 59F,60F, (61M), 62M
J	33M, 34M	63F, 64M, 65M
K		
L		
Total [ratio]	**18 female, 7 male** [72 : 28]	**12 female, 9 male** [57 : 43] *(+2 male not completed)*
[1]5F and 49F same student		

Full engagement in Wave 2 trial was more gender balanced than for Wave 1, with a ratio of 57% female to 43% male completing and returning the Wave 2 diaries, compared with 72% to 28% for Wave 1. When reviewed against the resident populations (see Table 3-2 and Table 3-3), it was apparent that there was a tendency to recruit and retain higher female participation, across both field trials when compared with the gender ratios of the resident population.

Focus groups

Focus groups and semi-structured interviews are similar approaches for gathering views and experiences (Burton, 2000; Davies and Dwyer, 2007; Hopkins, 2007). At the outset, it was undecided whether to use focus groups or interviews to elicit qualitative insights on student showering routines and to evaluate interventions. Focus groups are a social event that create discussion between the participants who may be less forthcoming in an interview situation. With the sensitive nature of exploring private showering routines, the open discussion and possible humour among peers (housemates) within a focus group setting had the potential to unlock valuable contributions (Browne, 2016), compared with one-to-one semi-structured interviews with the facilitator.

The gendered nature of showering was also a consideration, and discussions were less likely to be constrained or influenced by the gender of the facilitator in a mixed gender group, compared with an interview with participants of the opposite sex. It was easier to schedule a set of catered focus groups rather than trying to schedule individual interviews, and more views could be gathered within the limited time available. However, to inform the final decision on which evaluation instrument to employ, in a somewhat innovative approach, students were asked their preference. At the market research stall on 10 October 2018, eight (57%) students voted for focus groups whilst six (43%) selected the interview option as their favoured evaluation method. This was followed up in the Q/2A questionnaire:

Q/2A-q53. What is your preferred evaluation method?

Twelve students (52%) indicated they were willing to participate in a catered focus group on a Wednesday afternoon, as they liked the interactive and co-operative nature, despite the potential to disclose intimately private information about what goes on behind the locked shower room door:

"Would like interaction"

"Easier to talk in a group"

In comparison, eight students (35%) chose the web-based interview option, due to the flexibility of timing, accessibility and the privacy offered by a tailored one-to-one approach. Three students were not willing to take part in either method as they were too busy or not interested:

"i dont [sic] *want to share my shower habits with a lot of people"*

Therefore, focus groups was selected as the favoured evaluation tool. For the Wave 1 pilot, five focus groups with a total of 22 participants were run on four consecutive Wednesday afternoons (28 February, 7 March, two focus groups on 14 March and, final one on 21 March), with one per pair of houses in the same intervention group. All residents of the paired houses were invited via letter from the researcher addressed for the attention of all housemates and via word-of-mouth by the diarists. Participants were invited to a focus group (lasting up to two hours). Those unable to attend their paired house focus group, were invited to attend the final focus group on 21 March 2018 instead (although none accepted that invitation). Engagement declined through the post-trial evaluation period, due to competing pressures and academic deadlines as the term progressed.

Participants were obliged to give written informed consent (in line with the research ethics approval), and confidentiality ground rules were agreed at the outset of each session. The focus group conversations were captured via audio recording for later transcription. The focus group themes included the reasons for saving water, tools available to water companies, and discussion around the individual, social and material factors that shape showering frequency, duration, flow rate or in-shower practices. The ISM model was used to frame the discussion to evaluate the trial and co-design alternative interventions. Flashcards with each of the 18 ISM factor descriptors were used to prompt and steer discussions. Notes of the discussion were made by the participants and facilitator on flip chart paper, in different colours relating to the three domains of individual, social and material. Participation was encouraged by entry into a shopping voucher raffle.

Following the series of downstream facing Wave 1 focus groups (FG1 to FG5), working directly with end-users, an interim (between field trials) workshop (FG6) with eight stakeholders and specialists (30 May 2018) was convened to review and evaluate the Wave 1 findings, and explore and co-design alternative practice-based interventions, targeting *'attentive cleaning'* types. Key UWE staff from relevant departments (Estates, Facilities, Accommodation, academic) and interested students (from the Students' Union sustainability committee) were invited to participate in the two-hour focus group. Initial findings from the baseline Q/0 questionnaire and the Wave 1 trial were presented, and the ISM model was introduced. The stakeholders were asked for their views and ideas for possible alternative interventions for the Wave 2 trial. The 18 ISM factor flashcards were used to prompt and steer the discussion.

The focus group approach was slimmed down for the Wave 2 trial, in the light of the Wave 1 experience. Two catered focus groups were run in sequence (on 28 November) in the communal dining room in two of the participating houses (house F at 2pm and house E at 4pm), with a mix of trial participants invited (11 participants in total). Participation was limited to active trial participants only (diarists from houses F, G, J and K) and was not extended to non-participating housemates or other houses. The practice-based (haircare products) interventions were evaluated using the ISM model structure. As before, participants were entered into a shopping voucher prize draw.

3.6 Data analysis

3.6.1 Quantitative and statistical analysis

AMR metered consumption

The meter data were checked for anomalies and confirmed minor data loss:

- leaks – evident with very high consumption and 24-hour periods in which the minimum did not reach zero (night line monitoring);
- repeated 30-minute values across multiple time steps and across the estate (indicative of the BMS going off-line);
- impact of seasonal time changes: 25 March 2018 (1 hour forward) and 27 October 2018 (1 hour back).

The 30-minute timestep resolution, with 48 half-hourly readings per day, allows for the diurnal flow pattern of water through the meter to be recorded. However, the daily pattern was too variable to identify any meaningful patterns in use. The 48 half-hourly readings were aggregated into daily totals per meter (Student Village block or WCP1 house). *Household*, per *bed* (based upon design occupancy/maximum capacity) and per *capita* daily consumption (based on rented occupancy data provided by UWE Accommodation Services, see Table 3-2 and Table 3-3) were calculated.

Coding written (by summer intern students[39] from the university statistics department) in the open-source statistical package 'R' was used to generate several different visualisation plots, including average daily diurnal flow profiles, daily water usage per block/house plots and per *bed*[40] water consumption. The R-based visualiser was written to allow for the three consumption classifications to be varied and allowed modelling of what consumption might look like with different definitions of high, mid, and low consumption. Three performance zones were plotted: high or *excessive* (in red); middle (pale yellow); and low or *excellent* (blue) usage quartiles, as illustrated and annotated in Figure 3-14.

[39] M. Poffley in 2019 and L. Marchione in 2020

[40] Design occupancy was a convenient fixed denominator, made calculations simpler and was hard-wired into the code, although was likely to underestimate the true reality, due to underoccupancy.

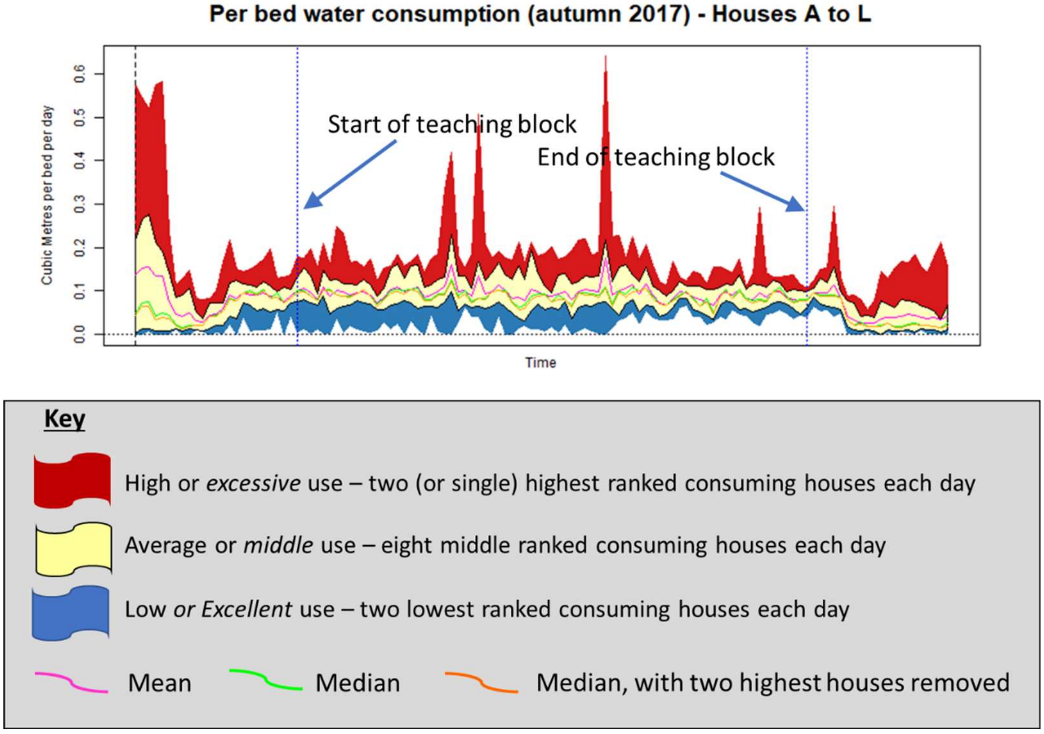


Figure 3-10 Annotated illustration of visualiser output

The mean and median were also plotted. The *excellent* zone represents the best performing two blocks/houses on any day. This was not necessarily the *same* two blocks/houses every day, although there was a tendency for the same few to be present. Most blocks/houses were represented in the middle zone, with plots of the mean and median use. Removal of the highest or worst performing block(s)/house(s) revealed the typical pattern of daily consumption through time.

To test for consistency, analysis of variance (ANOVA) tests of daily per *bed* consumption (total water used per block/house divided by *design* occupancy) to find statistical differences between different time periods for each block or house, including days of the week and across the different phases of the trials. As standard or parametric ANOVA tests require the data be normally distributed, consumption data were tested for normality using two standard tests in the SPSS statistics package – the one-sample Kolmogorov-Smirnov and Shapiro-Wilk tests (Geert van den Berg, 2022). These tests confirmed *null* results, due to the variability or 'messiness' of the data and indicated that the consumption data were not normally distributed. The SPSS outputs for these tests are summarised in the Appendix B.1.

As the datasets were found to not have normal distributions, non-parametric one-way ANOVA tests, using Kruskal-Wallis and Tukey HSD (Honestly Significant Difference), were run (by M. Poffley[41]) to test for statistical differences. The Kruskal-Wallis test uses ranking to overcome skewing by outliers (Geert van den Berg, 2022). If significance was confirmed, then the Dunn's test (with Benjamini-Hochberg correction) was applied to allow for repeating values. These tests were performed in R and the outputs are listed in the Appendix B.2. The results showed no significant difference in water use between the different days of the week and confirmed that it was valid to compare consumption data between days and between annual cycles. For twenty of the twenty-one Student Village blocks assessed, there were no statistically significant differences found after correcting for multiple comparisons.

Volumetric consumption was analysed at different spatial scales, from development (Student Village and WCP1) to separate block or house were explored and using different occupancy estimates. Rental figures only represented a snapshot and may not have captured fluctuations through time. Using *actual* occupancy to calculate PCC would be the ideal, but it is complicated to collect and calculate. Collection would entail some form of draconian surveillance that would be challenging to get ethical approval, even if participants were prepared to give informed consent. Consumption was also divided into a range of temporal phases from academic years and teaching terms to shorter fieldwork stages, including participant recruitment, pre-, interventions and post- trial periods (as summarised in Table 3-10).

A Spearman's rank correlation coefficient was calculated for the 2017/18 PCC for each of nine[42] study houses to assess whether relative household consumption levels were consistent for each house between the two terms (with the same residents, for which term 1 represented Wave 0 or no intervention, and term 2 coincided with the Wave 1 trial). The details of this calculation are presented in Appendix B.3. The resulting coefficient was 0.72, indicating a moderate correlation between the two sets of consumption data. This suggests that consumption levels were broadly comparable between the two teaching periods for each house, allowing for the noisiness of the data previously noted. It was not appropriate to do a similar test on the consumption data for each house between term 2 of 2017/18 (Wave 1) and term 1 of the following academic

[41] a summer intern student from the university statistics department.
[42] House A was excluded due to missing BMS data in term 1, whilst House G was excluded due to missing BMS data in term 2 because of logger interference. House L was excluded due to unknown and varying occupancy levels

year (Wave 2), due to the change in resident population and the different water-saving interventions deployed during the trials.

Table 3-10 Wave 1 and Wave 2 fieldwork phases

	Wave 1 – conventional (pilot)		**Wave 2 – practice-based**	
	Dates	*No. days*	*Dates*	*No. days*
0.Pre-trial (recruitment/ installation)	22 Jan to 13 Feb 2018	23	04 to 26 Oct 2018	22
1.Pre-intervention	14 to 20 Feb 2018	7	26 Oct to 06 Nov 2018	12
2.Interventions deployed	21 Feb to 07 Mar 2018	15	07 to 21 Nov 2018	15
3.Post-intervention	08 to 13[1]Mar 2018	6	22 Nov to 07 Dec 2018	16
Removal of Siloette loggers and Amphiros	26 Mar 2018	-	10 Dec 2018	-
Total	**22 Jan to 13 Mar 2018**	**51**	**04 Oct to 07 Dec 2018**	**65**

[1] Post-trial ended prematurely due to major mains burst /no water event across a large portion of the campus
[2] 24 September 2018 was first day of teaching, but some occupants did not arrive until term had started. Final arrivals on 03 October 2018

Siloette loggers

The loggers were downloaded at the office of Artesia Consulting, and specialist Siloette software was used to create high-resolution flow traces of the flow through each household meter. The initial 20-day test logger (15 November to 04 December 2017) was analysed by an Artesia Consulting staff member. All subsequent data processing and analyses was completed by the researcher under supervision.

As the standard fixtures operate within known ranges of flow and duration patterns (for example, WC refills), the loggers allow water consumption measurements to be disaggregated into micro-component uses with pattern-recognising software; a process called *event segmentation*. Each type of water-using event (based on fixture) was identified by its characteristic combination of duration, volume, and flow rate. Bespoke Siloette software used pattern-recognition algorithms to disaggregate and quantify the separate micro-component events and provide summary profile information. However, the processing requires some manual processing based on user judgement to allocate events to component type. Therefore, the process was not entirely automated within the software, and was dependent upon subjective judgement on the part of the analyst. As this research was solely focused on shower water use, other components of water use were ignored.

The data processing comprised the following steps:

a) Confirmation of time zone

The event time stamps were determined by the time zone on the PC when the loggers were set-up. For the house A test (November 2017) and Wave 1 (spring 2018) the loggers operated in Greenwich Mean Time (GMT). However, whilst the Wave 2 intervention (autumn 2018) took place in the GMT period, the loggers were initially set-up in September 2018, which corresponded with British Summer Time (BST). Therefore, all logged shower events from 27 October 2018, had their timestamps adjusted back one hour so that they could be directly compared with other datasets (metered consumption, diary records, etc.)

b) Visual identification of events

The plotted timeseries was reviewed visually to identify events with flow profiles (duration, flow rate and volume) typical of showers. Other events were ignored. For the Wave 2 data, virtually all events were marked as showers as no other fixtures were supplied via the sub-meters, except a few small and temporally remote events that were not representative of showers. Whilst these could only be shower fixture use, it was assumed that they did not represent personal showering and were dismissed as unknown activities, such as cleaning the cubicle or perhaps muddy shoes.

c) Confirmation of component allocation

The detailed characteristics (duration, flow, and volume summary statistics) of each event were checked to confirm event allocation.

d) Separation of multi-layered events (Wave 1 only)

The timeseries plot was manually edited by separating parallel multi-layered events in time (for example, when two showers coincided or when a shower and another use event overlapped), by using the cleave tool (by eye) within the software to split the events. This step was much simpler for Wave 2 as there were no overlapping events.

e) Reposition of event end marker

The end marker for each shower event (automatically assigned by the pattern recognition software) was manually moved back by one timestep, as it was apparent that the shower fixtures tended to dribble on for some considerable time (hours) after a shower event had finished, thus distorting the shower duration statistics. By sacrificing the last 500ml (allocated to an 'ignore me' component), it was possible to generate a more representative record of shower event durations (a key focus of the Wave 2 intervention). Final shower volumes were adjusted by the manual addition of 500ml to compensate for this end marker repositioning.

Figure 3-15 shows a timeseries flow plot, with pulse data between 17:00 and 21:30 on an arbitrary day, whilst Figure 3-16 shows an example of the flow trace (Wave 1, House A, test period) with the timeseries flow data presented in three horizontal channels. The blue flow trace in the lower channel shows the entire flow record for the period of installation (20 days, 15 November to 04 December 2017, inclusive), including periods of zero flow. The events shown in the centre channel, with red blocks representing showers, are temporally compressed to remove periods with zero flow. Immediately below the red blocks are green start and red stop markers for each event. For parallel multi-layered events, the separation process assigned the other events (either non-showers or second showers) to the top channel.

As the loggers in Wave 2 were fitted directly to the cold-water feeds to each of the shower fixtures, it was necessary to allow for the hot-water component to estimate the *total* water used. When the loggers were installed (on 25 October), each shower was run on the standard 40^{o}C temperature setting with a quarter turn of the flow control for five minutes. This allowed for the *cold*-water volume to be identified in the logged pulse time series. At the end of the five-minute flow test, the total volume was noted from the Amphiro display, representing the mixed hot *and* cold-water volume. This allowed for fixture level hot to cold water ratios to be calculated for each shower. In addition, a manual flow check was made with a measuring jug (held under the flow for five seconds and converted to a flow rate per minute), to verify the Amphiro estimates.

Daily total water and shower volumes for each house were ranked to assess whether shower use changed through the course of the trial by checking the number of pre- and post-intervention phase days ranked above the median consumption level.

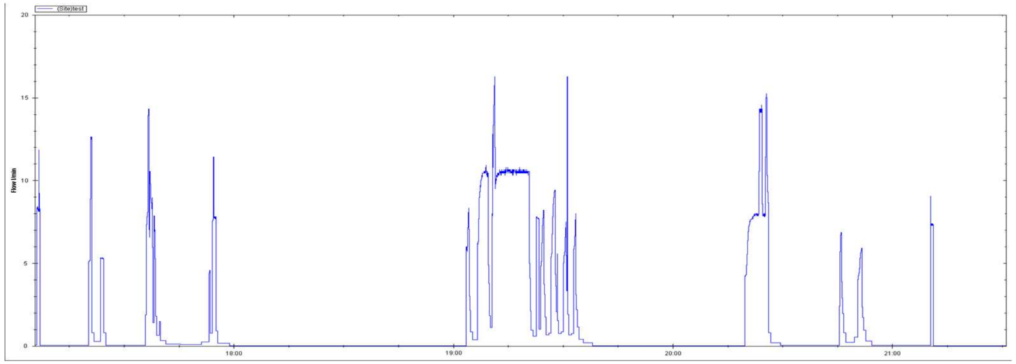


Figure 3-11   Sample Siloette pulse data showing water-using event time series, 17:00 to 21:30 hrs (Source: Rogerson and Spey, 2018)

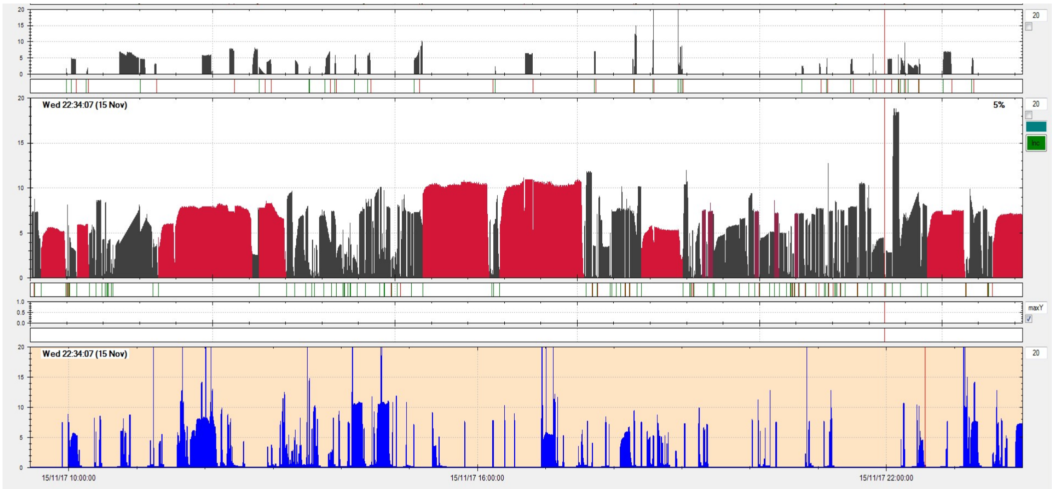


Figure 3-12   Screen shot of Siloette user-interface interface for 20-day test flow trace with shower components (in red) (Source: Rogerson and Spey, 2018)

Questionnaires

Research ethics protocols for voluntary participation and informed consent were designed to screen out participation by vulnerable groups:

> *Q/0-q1. I have read the terms and conditions, agree to ALL of the above statements (1-6) and I wish to take part in the survey.*

However, in response to a supplementary question on age (question 39 asked *What is your age (in years)?*), it became apparent that two participants were (unexpectedly) under the age of 18 putting these respondents into a vulnerable group. Research involving children under 18 requires additional safeguarding training and Disclosure and Barring Service criminal records checks, and as ethical approval was neither sought by nor granted for research with this vulnerable group, these responses were screened out of the subsequent analysis, and formed no further part in this research.

Summary statistics for the four rounds of questionnaire data were tabulated and plotted. Responses to the first survey (Q/0) were divided by accommodation type so that findings for students living on campus (where the university Accommodation Services control the lettings, and the water fixtures are of a known and standard specification) could be compared with those living off-site (where the configuration of bathroom facilities were varied and unknown). The response from students living on campus were directly relevant to the experimental design and helped to set the context for the research that followed. Responses classed as living on campus included a few who were living in university-controlled accommodation on a smaller campus, whilst those living off-site, included those living in private houses (rented or otherwise) and student halls provided by private landlords (for example, those in the city centre operated by Unite).

Survey data for four dimensions of showering (duration, frequency, location, and number of products) were imported into SPSS for cluster analysis. Cluster analysis is a statistical method that can help to search for patterns in data and classify things into groups with similar characteristics or attributes (Boyatzis, 1998). It is an exploratory, emergent, and inductive approach, with similarities to qualitative thematic analysis as opposed to other quantitative statistical methods, and it does not distinguish between dependent and independent variables. It can be used to try to identify (previously unknown) structures within the data, where variables help to describe the members of the group. For this research, the technique was used to identify showering patterns and to identify common ways in which showering is performed among the students.

Browne *et al*. (2013b; 2013c) used cluster analysis to understand the diversity of performance of water using practices, including personal washing (showering and bathing), and to classify quantitative questionnaire respondents (*n = 1,747*, aged 16 years to adult from south east England) into their style of performance, based on four variables: frequency; diversity; technology (bath or shower) and outsourcing (outside the home), to explore whether certain performance characteristics can be bundled together in a coherent way. Six personal washing clusters emerged from this research, although not all of them were relevant to this UWE showering study due to the absence of baths.

All Q/0 questionnaire responses (n=156) covering different shower dimensions were imported into SPSS to do hierarchical cluster analysis by case (student). The following variables were included:

- Frequency *(Q/0-q6. How often do you shower?)*
- Duration (*Q/0-q5. Approximately how many minutes do you spend in the shower (each time you shower)?*
- Outsourcing (*Q/0-q36a. If you are a member of a gym, where do you shower after sport?)*
- Number of products *(Q/0-q9. How many different personal shower products do you use during a typical shower?)*

The range of solutions (using centroid clustering and squared Euclidean distance with standardised values in the range -1 to 1) was set to between three and six clusters. This mirrored the six personal washing clusters in Browne *et al.'s* research (Browne *et al*., 2013b; 2013c). Shower frequency responses (question 6) were converted from text into a numeric scale, as summarised in Table 3-11. The results are presented in Chapter 4 (section 4.2.2).

Table 3-11 Shower frequency (Q6) conversion to numeric scale

Q6. How often do you shower?	**Times per week**
About once a week	1
Up to three times per week	3
Other (3-4; or every 2 days)	4
4-6 times per week	5
Every day	7
More than once per day	10

Diaries

The paper diary records were tabulated to calculate summary statistics on self-reported showering routines. The results for each dimension of showering were compared with the findings from the questionnaires (both the expansive or baseline Q/0 survey, and the relevant field trial survey) to confirm the shape of the emerging showering patterns.

The diaries provided a deeper level of information than the questionnaires, as dimensions were recorded for every shower event during the two-week trials, and these were used to validate the self-reported estimates for *typical* showers in the questionnaires. Whilst some data points may have been estimated (for example, duration) by some participants, there was evidence that most data points were reliable. For example, it was apparent that most diarised durations were measured rather than estimated, with timings recorded in digital minutes, or minutes and seconds, rather than rounded to the nearest minute or five minutes.

The diary template had space for participants to record their thoughts and emotions immediately before, during or after their showers. These text responses were imported into NVivo (qualitative data analysis software package), coded, and plotted in word clouds for each field trial to supplement the qualitative analysis of the focus group transcripts and associated outputs.

3.6.2 Qualitative analysis

Content and thematic are two types of qualitative analysis and the two terms are often confused and used interchangeably, as they both involve going through the data to identify patterns and themes. The key difference is that content analysis focuses on the frequency and coverage (quantitative) of code occurrence (a deductive process using a codebook with theoretical foundations), whilst thematic analysis is more concerned with inductively identifying themes and considered to represent a deeper and qualitative dive into the data (Boyatzis, 1998; and Burton, 2000).

The principal approach adopted to qualitatively analysing the focus group transcripts and associated textural outputs for this thesis was a codebook (based on the 18 ISM factors) content analysis. To supplement this, and to explore for weaknesses, limitations or omissions from the ISM framework, the researcher was also receptive to emerging themes.

Eight focus groups were run across the two trials. Audio recordings of the discussions were transcribed verbatim, and sections of speech were segmented by participant. The transcripts were imported into NVivo. Attributes based on socio-demographic information collected via the questionnaires and intervention allocations were assigned to participants, so that each section of speech could be classified accordingly., A codebook based upon the 18 ISM factors, supplemented with codes representing different showering styles (derived from the cluster analysis such as '*out and about'* and '*attentive'*) and dimensions of showering (flow, duration and frequency) was created. See Appendix D.1 for the initial codebook.

The content of each transcript was coded deductively using the codebook by highlighting sections of text within the NVivo software and allocating multiple codes to it. This process enabled segments of the transcripts to be grouped by code, so that contributions from different focus group participants about a specific factor, style or shower dimension could be gathered together for comparison and interpretation.

In addition, the transcripts were also coded inductively by creating and assigning new codes as new ideas emerged through the iterative process. These new codes represented ideas or features that were missing from or did not fit neatly within the ISM factors and helped the researcher to assess the limitations or weaknesses of the ISM framework. These emergent ideas are discussed in Chapter 7 (section 7.1.4).

Transcripts were supplemented with summaries and scans of the focus group flip-chart outputs. Qualitative (open-ended questions) responses to the questionnaires and the emotions/thoughts fields from the shower diaries were also imported into NVivo and coded.

The frequency and coverage of ISM factors were plotted to identify the spread of discussion against the 18 factors. These are presented in Chapter 5 for Wave 1 (FG1-FG5) and Chapter 6 for Wave 2 (FG7 and FG8), whilst the results of the interim upstream stakeholder workshop (FG6) are summarised in Appendix D. Emergent ideas from the inductive analysis represented potential gaps or weaknesses in the ISM approach and these are discussed in Chapter 7.

3.7 Lessons learnt

As the fieldwork progressed and challenges were overcome, practical considerations were gleaned as to how to operationalise a mixed-methods research study in a real-world setting. Insights gained from the Wave 1 trial were used to inform the subsequent steps in the research, to refine and simplify the data collection approach, and boost engagement and participation for the subsequent Wave 2 field trial.

Lessons from Wave 1 included:

- **Access to accommodation** – stakeholder liaison and management was essential to build trust with the gatekeepers. This involved many meetings with relevant parties based in the university Estates, Facilities and Accommodation Services departments to build trust and demonstrate competence over many months, whilst the research proposal was developed and planned. Although the study site was apparently accessible due to its proximity on the university campus, the researcher had to learn the rules of engagement, and who to ask for permissions and when. Access to student housing is controlled by the Accommodation Service, and seven-days' notice had to be given in advance to residents via the Estates department (for example, to put up posters for Wave 1, install Amphiro devices to showers, or to fit the sub-meters and loggers in the service cupboards for Wave 2).
- **Loggers** – only through trial and error during the Wave 1 trial did it become apparent that the pulse splitter cables used to attach the loggers to the household meters were incompatible and caused interference with the BMS signal. A workaround was found in partnership with the UWE Estates department, in which additional submeters were fitted directly to the cold-water feed to each shower so that the loggers could be installed directly at the fixture level. This had the added benefit of simplifying the data analysis as it removed most of the guess work in the event segmentation process.
- **Engagement and participation** – for the Wave 2 trial, participation in the different data collection methods was linked and receipt of shopping vouchers to compensate participants for their time and commitment was dependent upon trying out the haircare products, keeping diaries *and* completion of both questionnaires (Q/2A and Q/2B). Coupled with early engagement with participants at the market research stall, this helped to build commitment from the participants, although it is acknowledged that this may have skewed self-reported responses and produced a social desirability bias in the data.
- **Evaluation methods** – just two targeted and better attended focus groups (FG7 and FG8) with mixed household participation, were delivered on a single day for Wave 2. This resulted in higher quality discussions, less audio to transcribe and fewer outputs to analyse, compared with the Wave 1 approach. Whilst there was

support for evaluation interviews, these were not taken forward due to limited research resources despite them having the potential to provide richer and deeper personal insights into why students *do* showering in the way they do.

This chapter described a robust mixed-methods approach for designing, piloting, and evaluating domestic water efficiency interventions in university student residential accommodation. One purpose of the research was to add to the evidence base underpinning water demand management policies and practices. The researcher has demonstrated how difficult it is to design and execute a multi-methods strategy of sufficient robustness to take debate beyond overly simplistic *rational choice* models of water use. The methodology included the design and deployment of two waves of practical real-world interventions.

Chapter 4 Results – Wave 0 (baseline)

This chapter comprises two parts and responds to Objectives 2 and 3. The first section (4.1) sets out the background water consumption data for the Student Village and WCP1 campus accommodation (from 2016 and 2017), using readily available (or secondary) metered water consumption data from the university BMS. This was an exploratory phase (or Wave 0) of the research, prior to the deployment of interventions in 2018 (Wave 1 and Wave 2) and set out to meet Objective 2 and corresponding Research Questions 2.1 to 2.3:

> *Objective 2. To establish the baseline water consumption by students living in UWE managed campus accommodation*
>
> > *RQ2.1 How do the university accommodation water fixtures perform?*
> >
> > *RQ2.2 How much water do resident students consume?*
> >
> > *RQ2.3 Is it feasible to measure the shower micro-component in a large student house?*

The findings set the baseline for understanding the performance of the water infrastructure and quantified water use by students. The results of a test run of a Siloette pulse logger to measure separate shower events in an eight-bed student house are also presented here.

Primary data were also collected via an expansive questionnaire (Q/0) survey of the student population to gather insights into how students use water and more specifically the way that showering is *done*. The survey was distributed across the university student body, to address Objective 3 and its associated Research Questions, 3.1 and 3.2 (see section 4.2):

> *Objective 3. To understand the showering routines of the UWE student population to identify groups that share similar showering patterns*
>
> > *RQ3.1 Can the target population be categorised into distinct showering practice types?*
> >
> > *RQ3.2 What are the features of these types?*

The responses were explored via cluster analysis to identify the showering pattern typology. The results presented here were used to inform the design and delivery of two subsequent intervention field trials – Wave 1 and Wave 2. The results of these trials are presented in the following two chapters - Chapter 5 and Chapter 6, respectively.

Summary of Wave 0 findings

Research Objective 2 (volumetric measurement)

- Daily water consumption for WCP1 was modest, at around 100-120 l/*b*/d, and less variable than for the Student Village (c.200 l/*b*/d) *(RQ2.1);*
- There was little variance in daily consumption between different days of the week or between weekdays and weekends *(RQ2.2);*
- Calculating the key consumption indicator of PCC was problematic even for a development with standardised fixtures and apparently known levels of occupancy *(RQ2.2);*
- It was feasible to use a single logger to identify showering patterns within a large eight-bed house *(RQ2.3)*.

Research Objective 3 (showering routines)

- On average, students living *on campus* shower for longer duration (13 minutes) and more frequently (68% shower at least every day), than those living *off-site (RQ3.2);*
- Students living in the Student Village, with private en suite fixtures, shower for longer duration and more frequently, on average (13.5 minutes, 70% at least daily), compared with those using the shared shower facilities in Wallscourt Park *(RQ3.2);*
- Students living *on campus* tend to have no fixed pattern to the time of day that they shower, compared to the tendency for a morning shower by those living *off-site (RQ3.2);*
- Students generally do not *outsource* their shower to the gym, despite 40% having gym membership. Just 8.3% shower away from their rooms, dropping to 5.6% of those living *on campus (RQ3.2);*
- On average, students use three shower products to perform 3.2 in-shower micro-practices *(RQ3.2);*
- The showering routines of the UWE student community is homogenous, and 90% follow the '*UWE standard'* way of showering *(RQ3.1).*

4.1 Volumetric water consumption

4.1.1 Household and *per capita* consumption

Student Village

The average 24-hour diurnal flow profile across the Student Village for term 1 in 2016, calculated as total consumption in 30-minute time-step *per bed* (maximum design occupancy) is shown in Figure 4-1. Had the *actual* (or rented) occupancy been used, then the estimated PCC would have been slightly higher, as the student accommodation tends to operate at around c.97-99% of maximum capacity. The diurnal flow profile indicates that the students, unsurprisingly, shifted their waking hours to later in the day – and are later to rise and late to bed. The 'morning' peak was around lunch time (12-1pm, 0.414 m^3 at 1pm). This was similar to the evening rise in terms of size and shape, with a peak at 7pm (0.420 m^3), with demand high all day. The profile reflects the students spending long periods of time in their rooms or flats. Water use did not drop-off until late at night, with the lowest level recorded at 6am (0.162 m^3).

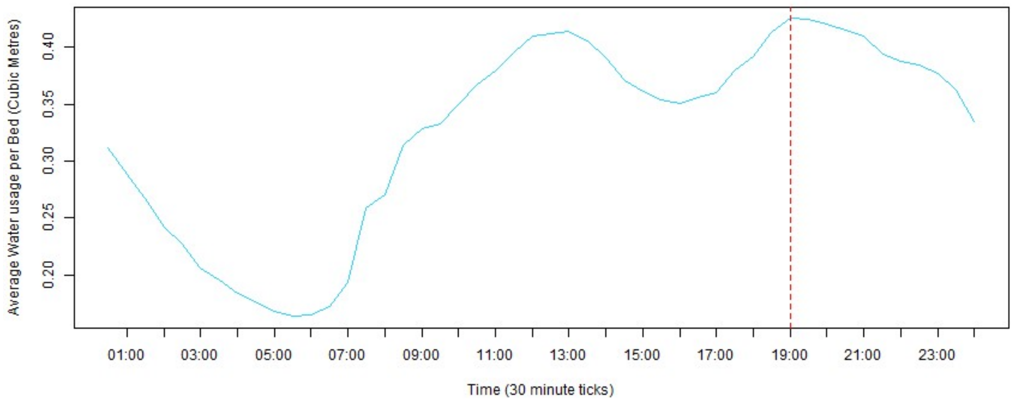


Figure 4-1 Average diurnal consumption profile (Student Village – Term 1, 26-Sep to 09-Dec 2016)

For comparison, a typical daily domestic water demand profile is shown in Figure 4-2. It illustrates that daily demand usually comprises a double peak, with a concentrated spike in the morning between the hours of c.6-9am representing water use associated with getting up and ready for the day ahead (in this example the peak demand is at around 8am), and a second lower peak in the evening, associated with a return home from a day out at work, education, or leisure. The lowest demand is usually recorded in the middle of the night, when most users are asleep, and water suppliers monitor this *nightline* as a leakage detection indicator.

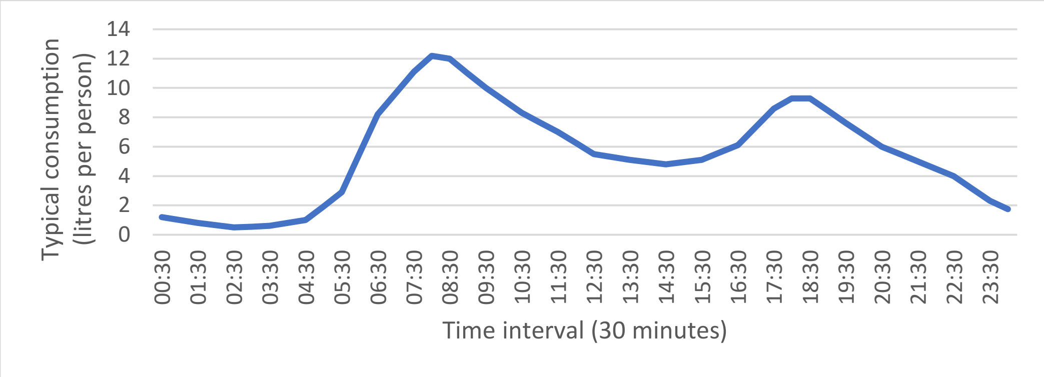


Figure 4-2 Typical domestic diurnal consumption pattern (based on Gurung et al., 2014, Figure 3)

Daily water use was plotted to for each block of flats[43] within the Student Village (2016/17). This is presented Figure 4-3 to Figure 4-8[44]. The median daily *per bed* water consumption in shown in Figure 4-3. For teaching block (or term) 1, from 26 September to 09 December 2016 the median water use was consistent but high, at around 0.2 cubic metres, m^3/*b*/d (200 l/b/d). It was more variable during the Christmas and New Year exam period before settling down again for teaching block 2 (23 January to 31 March 2017).

The next plot, in Figure 4-4, shows the daily *per bed* water use for each of the 24 blocks, and illustrates the high variation or 'noise' in the data, particularly the extremes above the median. The subsequent plots, Figure 4-5 to Figure 4-8, show the variation in water use between blocks in the same courtyard. The consumption in Figure 4-6, for blocks C1 to C6, shows the least variation, with block profiles close to the median.

The same daily water use data (from 01 September 2016 to 30 April 2017) were plotted with upper and lower consumption bounds to assist with visualisation in Figure 4-9[45]. The yellow middle zone shows the typical performance for the majority two-thirds of blocks. Consumption was surprisingly high, averaging around 200 l/*b*/d (0.2 m^3/*b*/d), compared with average domestic PCC of c.145 l/*p*/d across England and Wales (Water UK, 2022), particularly as it excludes laundry and external usage.

[43] The Student Village is a 1,932-bed development and comprises 24 blocks of flats with between 66-84 single study bedrooms with en suite shower rooms, arranged around four courtyards (labelled B, C, M and Q) – see Chapter 3 for a more detailed description and Figure 3-1 for a plan of the layout

[44] For further explanation on how the visualiser plots were configured, refer to section 3.6.1.

[45] See Figure 3-14 for an annotated illustration and key to aid interpretation.

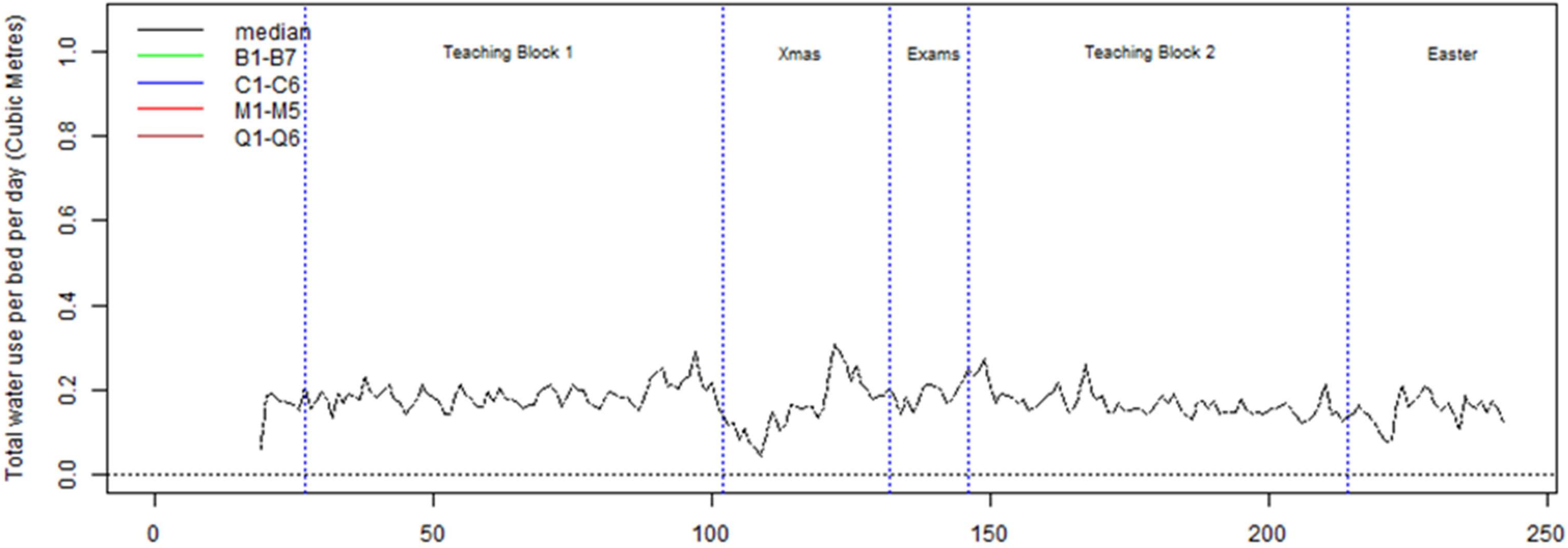


Figure 4-3 Median daily per bed water consumption for ALL blocks (n=24), 2016-17 – Student Village

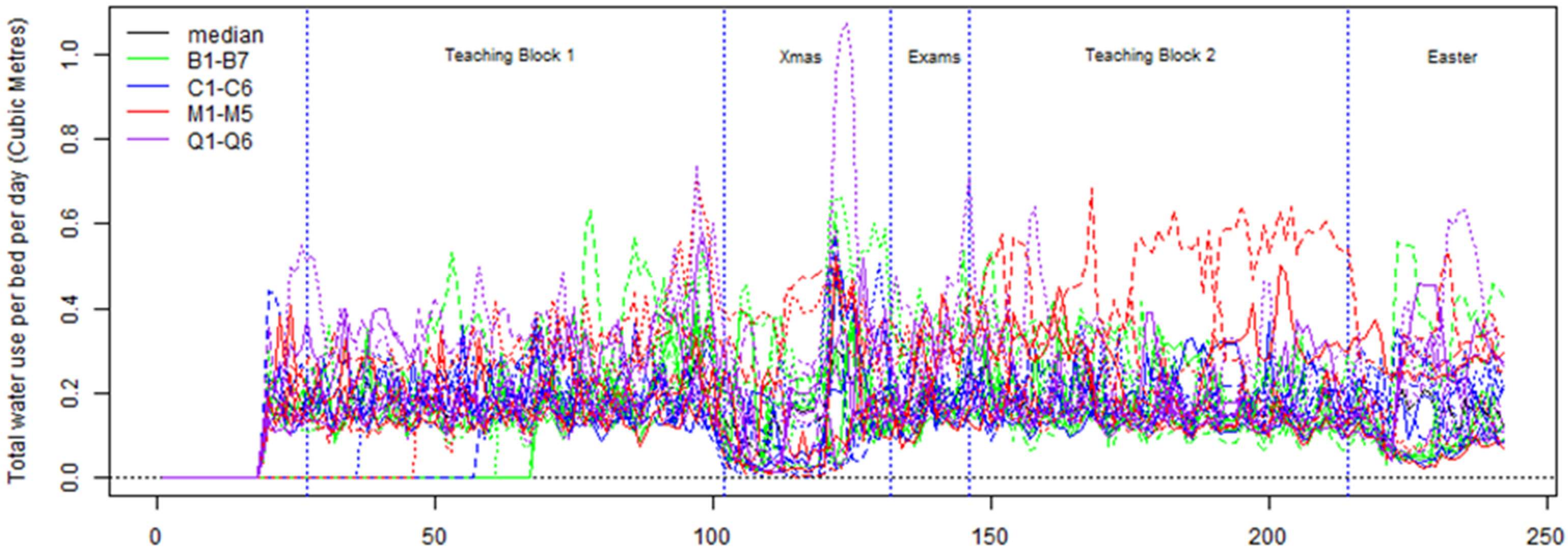


Figure 4-4 Daily per bed water consumption for EACH block (n=24), 2016-17 – Student Village

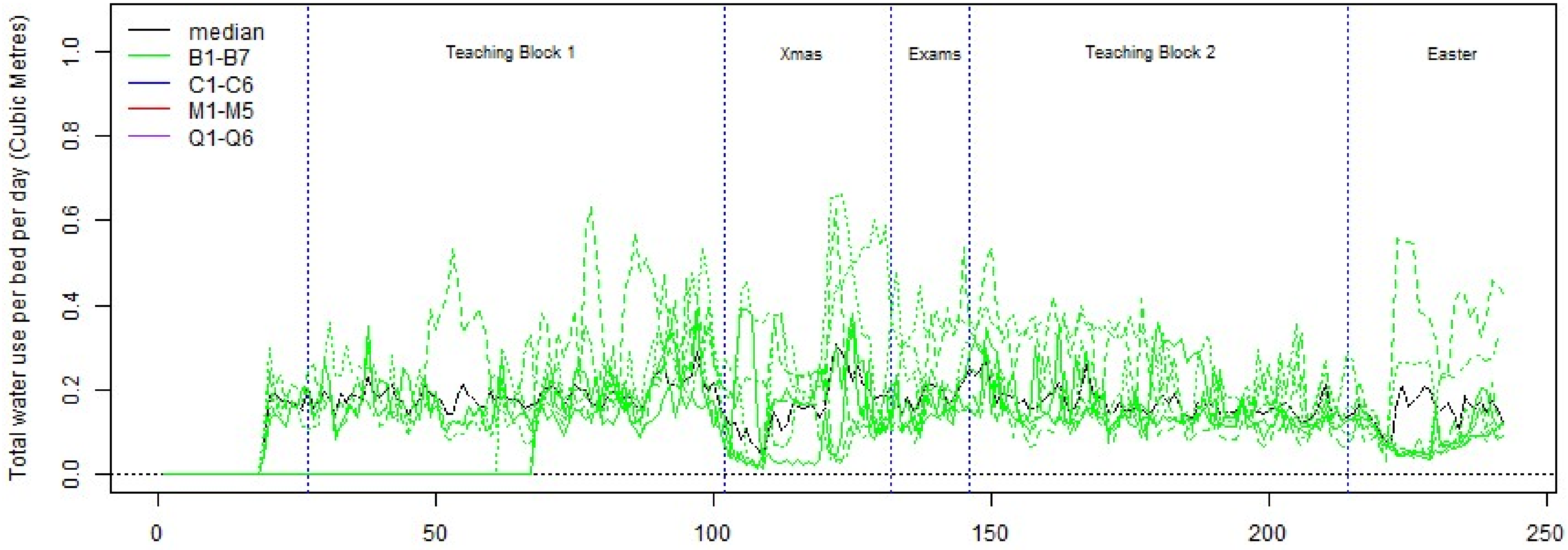


Figure 4-5 Daily per bed water consumption for blocks B1 to B7 (n=7), 2016-17 – Student Village

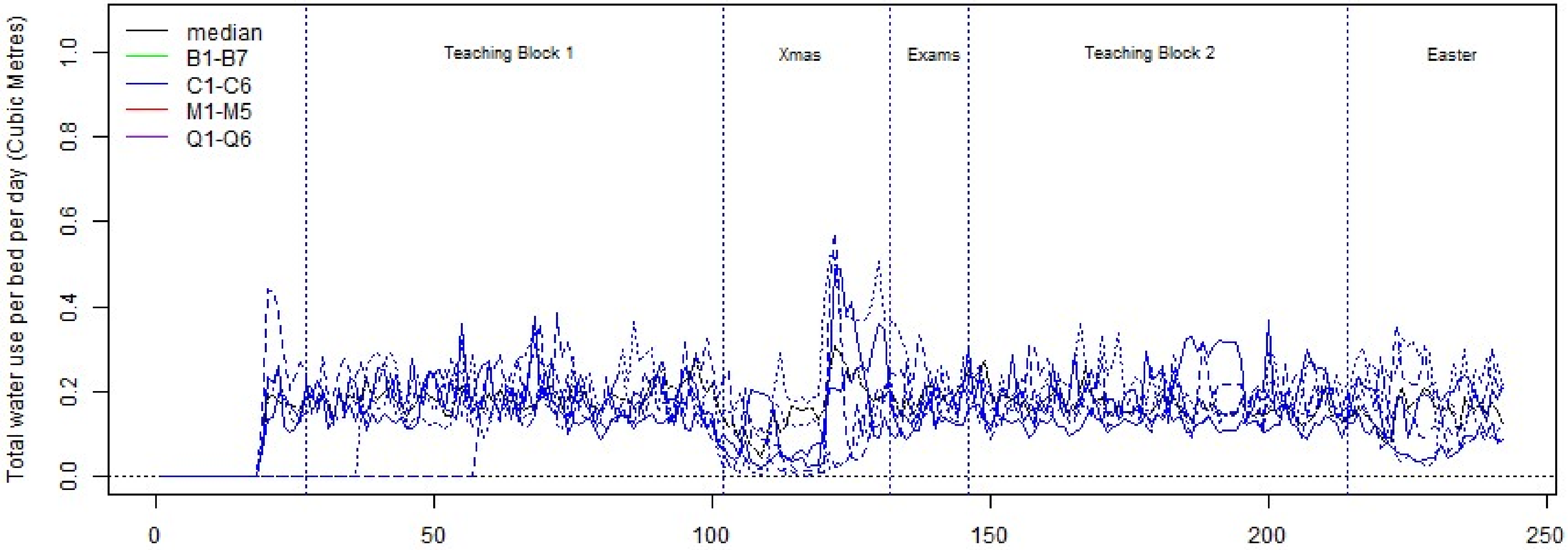


Figure 4-6 Daily per bed water consumption for blocks C1 to C6 (n=6), 2016-17 – Student Village

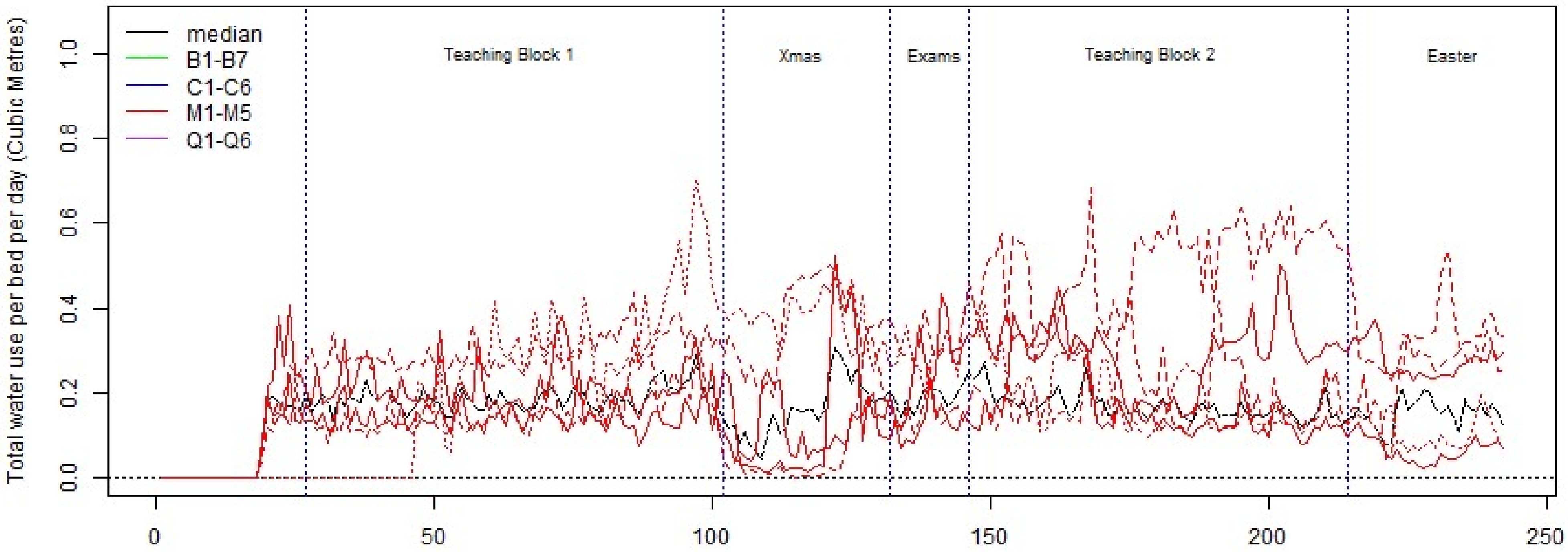


Figure 4-7 Daily per bed water consumption for blocks M1 to M5 (n=5), 2016-17 – Student Village

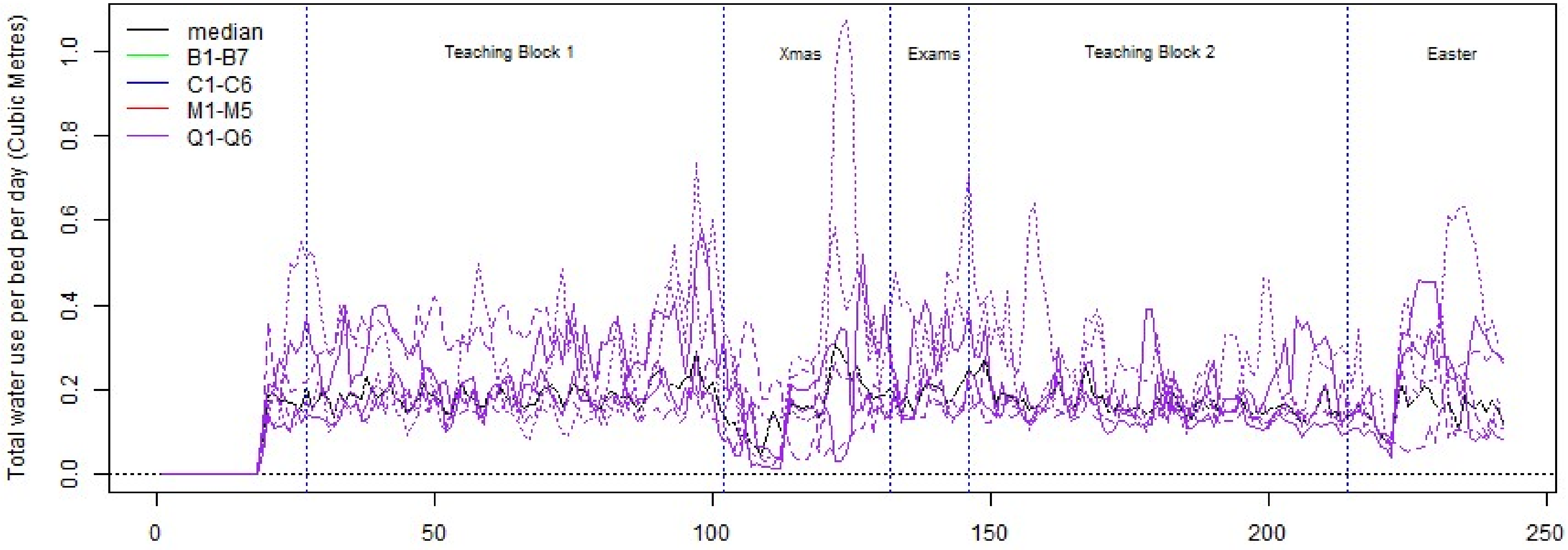
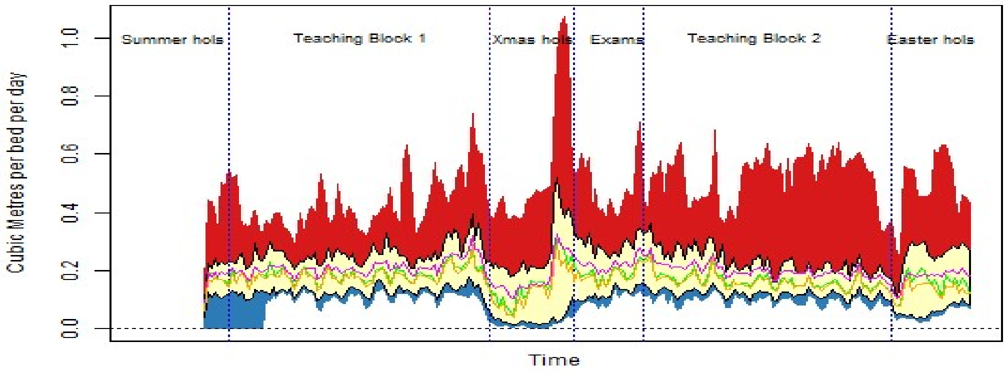
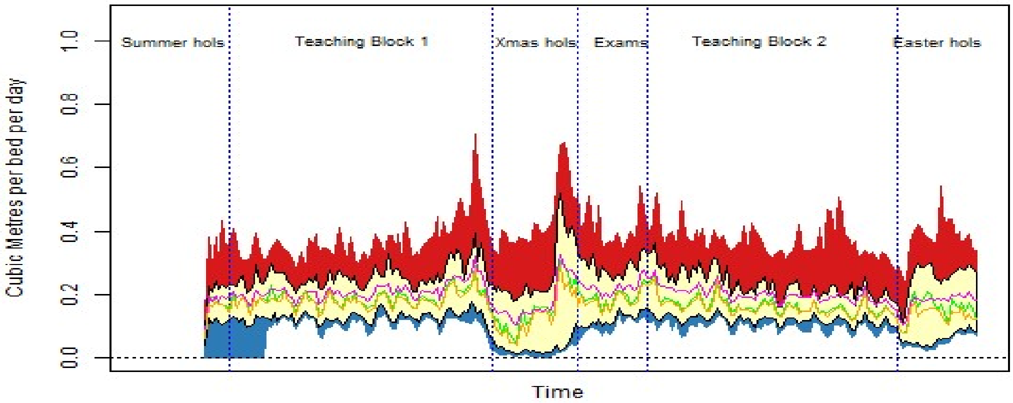


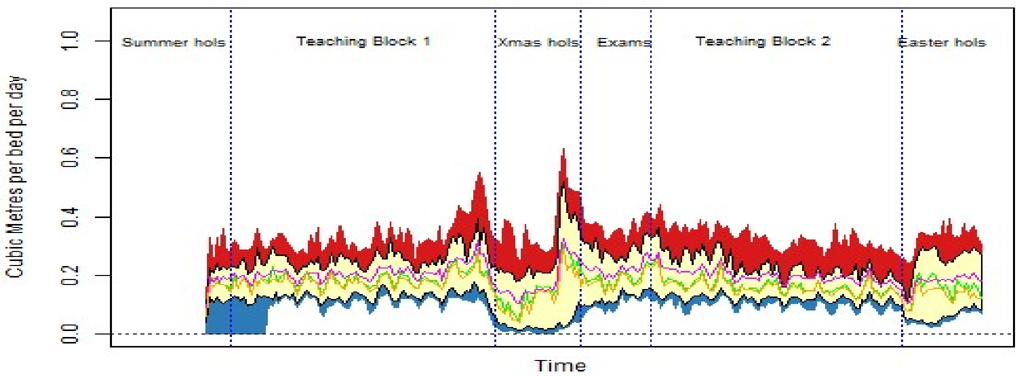
Figure 4-8 Daily per bed water consumption for blocks Q1 to Q6 (n=6), 2016-17 – Student Village



Excessive = *six* high use (top 25%); *Middle* = 16 blocks; *Excellent* = two low use blocks on any day
Mean; median; and median with top two blocks removed



Excessive = *five* high use blocks on any day (maximum use block removed)



Excessive = *four* high use blocks on any day (*two* maximum use blocks removed)

Figure 4-9 Per bed water consumption (2016-17) – Student Village

The sector tends not to consider life stage differences, nor the impact of working and living in the same spaces on consumption, although this has recently been exposed due to lifestyle changes and more home working, post-pandemic (Abu-Baker, Williams, and Hallett, 2021; Menneer *et al.,* 2021, Staddon and Bulmer, 2020). The difference between the median and median with the top (excessive) two blocks removed (green and orange lines, respectively) is small, showing that the removal of the high consuming outliers did not markedly alter the central tendency consumption.

The plots show some zero values at the start of term for five blocks (B1, B2, B7, C2 and M3) – this can be seen in blue zone at the start of the academic year, before the BMS settled. There was a rise in daily consumption towards the end of the first term (teaching block 1), with a spike during the Christmas holidays. Some flats remain occupied during holiday periods, particularly by overseas students (although data on holiday occupancy levels was not collected for this research). Even with increased residence by overseas students, this is unlikely to account for the observed increase in average consumption, especially as international students make up only 25-30% of the resident population of the Student Village in any year. The spikes in consumption during the holidays are more likely to be the result of *Legionella* risk control measures[46], and/or a high proportion of leaking or continually flushing WCs.

Wallscourt Park phase 1

The daily *per bed* water consumption for WCP1 during 2017/18, term 1 (data was not available in this form for 2016/17) are shown in Figure 4-10 to Figure 4-12. The x-axis is shown as days (and weeks) into the academic year. Figure 4-10 shows a consistent and modest (compared with the Student Village, refer to Figure 4-3) median daily water use of around 0.1 $m^3/b/d$ (100 $l/b/d$), whilst Figure 4-11 and Figure 4-12 show the 'messy' variability in water use between the houses within the development (*n=37*) and the study site specifically (houses A to L, n=12). The significant difference in average daily consumption between the Student Village (Figure 4-3) and WCP1 is most likely due to: the age and condition of the fixtures and fittings; the maintenance regime; and, the *Legionella* risk control measures.

The daily water use data for each study site house (A to L), from 01 September to 31 December 2017 are plotted in Figure 4-13, with upper and lower consumption bounds to aid visualisation[47] and show the typical pattern of consumption. Term 1 (24 September to 08 December 2017) is marked between the two vertical lines.

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[46] Water fixtures are flushed by university Facilities staff when en suite bedrooms in the Student Village, or whole houses in WCP1 are left unoccupied for a week or more.

[47] See Figure 3-14 for an annotated illustration and key to aid interpretation.

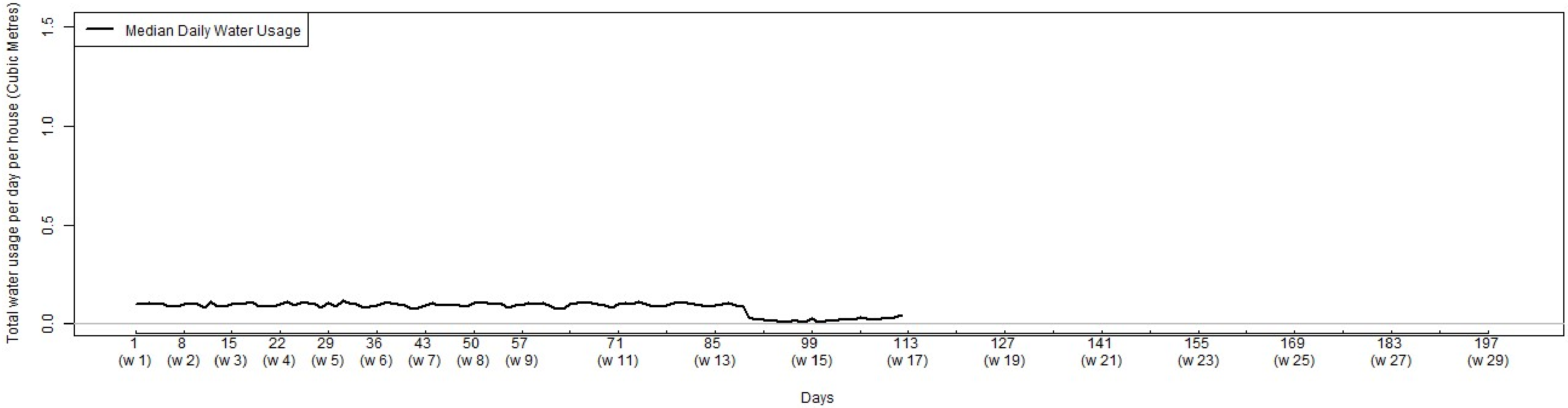


Figure 4-10 Median daily per bed water consumption for ALL houses (n=37), 2017/18 (Term 1) – WCP1

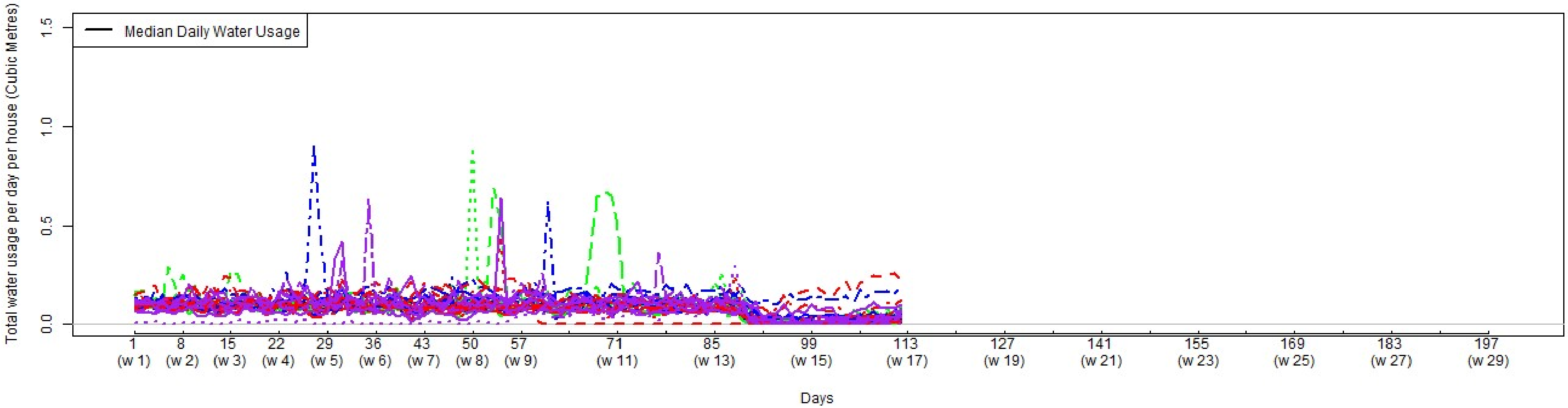


Figure 4-11 Daily per bed water consumption for EACH house (n=37), 2017//18 Term 1 – WCP1

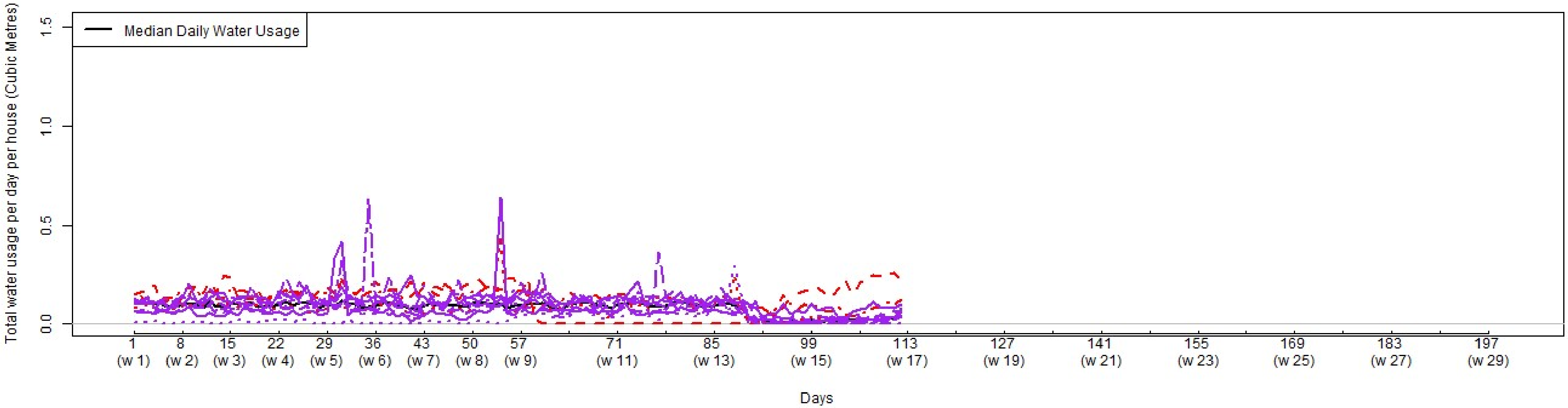
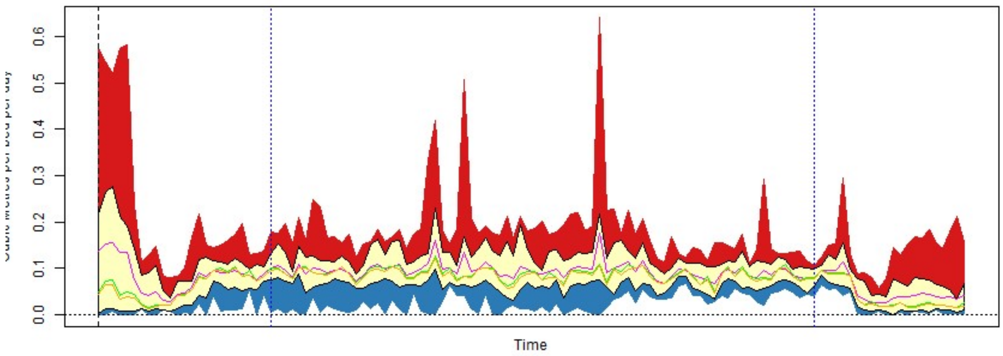
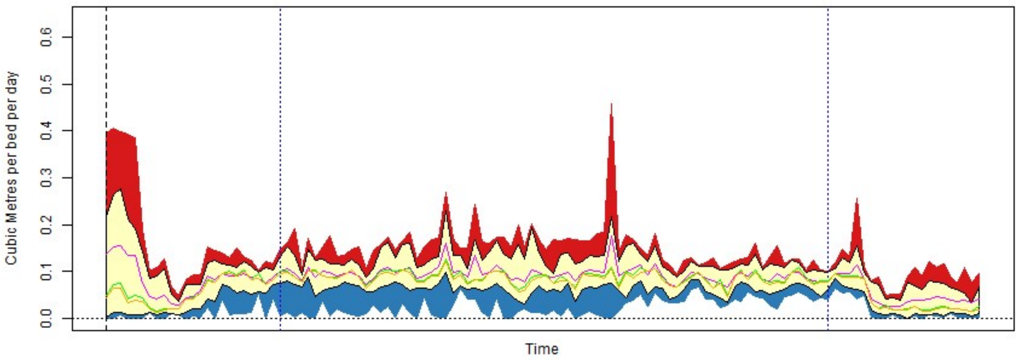


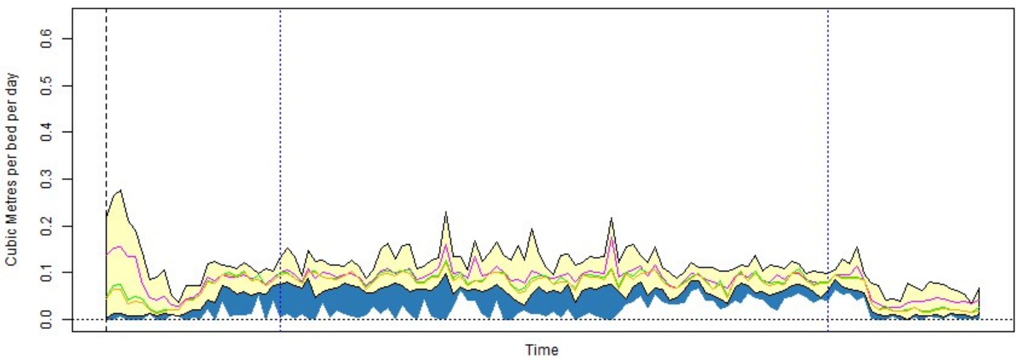
Figure 4-12   Daily per bed water consumption for EACH study site house (n=12), 2017/18 Term 1 – WCP1



Excessive = worst *two*; *Middle* = eight; *Excellent* = best two houses on any day
Mean; median; and median with top two houses removed



Excessive = worst house on any day (worst house removed)



Worst *two* houses removed

Figure 4-13 Per bed water consumption (Term 1, 01-Sep to-31-Dec 2017) – WCP1

An analysis of the tendency for each house to fall into the minimum or maximum extremes of daily *per bed* consumption is summarised Appendix B.4. The results are summarised in Table 4-1 and show that ten houses across WCP1 (including three study houses) that with the highest two daily *per bed* consumption (in the red *excessive* zone in Figure 4-13), but *never* in the lowest use (blue) zone, indicating a tendency for high consumption. Meanwhile, there were thirteen houses in the development (including three study houses) in the *excellent* low use zone, that did *not* appear in the *excessive* (red) zone, pointing towards low water use.

Table 4-1 Tendency for high and/or low consumption

2017 Term 1	Study houses A-L	Rest of WCP1	All WCP1 houses
Tendency towards excessive use[1]	3 [25%]	7 [28%]	10 [27.0%]
Tendency towards excellent use[2]	3 [25%]	10 [40%]	13 [25.1%]
Both extremes	6 [50%]	5 [20%]	11 [29.7%]
Neither extreme	0 [0%]	3 [12%]	3 [8.1%]

[1]*Excessive use for top two consuming houses per day*
[2]*Excellent use for lowest three consuming houses per day*

The low use zone was dominated by two houses. It was of no surprise that the under-occupied house L was consistently (89.5%) in the lowest two consuming houses (68 days of the 76 day-long term). However, house A appeared in both extremes of consumption, with 29 days in the top two consumption (red zone) and 24 days in the low consumption zone. The data indicate that house A was a high use house, and its appearance in the low use zone is not a reflection on its actual performance but due to an interruption in the metrology signal. The low use period coincided with the installation of the Siloette logger on 15 November 2017, which interfered with the BMS system and subsequently resulted in zero consumption recorded via the meter. House A recorded the highest or second highest use on 53.8% (28 of 52) days prior to 15 November. This is reported further in section 4.1.2 and Chapter 5.

Most households (eight of twelve) were sandwiched in the middle zone between these two extremes. Other than a spurious spike in consumption (possibly due to a leak) on 10 November 2017 (house J with daily consumption peaking at 0.64 $m^3/b/d$, and house B with 0.442 $m^3/b/d$) the spread of typical use narrows and is more consistent between houses.

The meter data across all 37 houses (labelled A-X) in the WCP1 development, and the study site specifically (houses A to L, *n=12*) were used to estimate PCC using both *design* occupancy and *rented* [48], for two academic years: preceding the research (2016/17); and, during the first wave of fieldwork (2017/18). These are summarised in Table 4-2.

[48] A snapshot of rented occupancy on a specific fixed date within the year.

Table 4-2 Estimates of historic PCC for WCP1 (l/p/d)

Periods		**2016/17**		**Term 1**	**Term 2**	**2017/18**		**Term 1**	**Term2 [Wave1]**
Dates	Houses	*Occupancy*	01-Aug to 31-Jul	26-Sep to 09-Dec	23-Jan to 31-Mar[1]	*Occupancy*	01-Aug to 31-Jul	25-Sep to 08-Dec	22-Jan to 13-Mar[2]
No. days			*365*	*75*	*68*		*365*	*75*	*51*
Design occupancy (*per bed*)	All: A-X	*404*	69.2	118.5	94.4	*404*	62.2	99.9	101.7
	Study: A-L	*104*	65.3	103.1	92.2	*104*	66.3	93.6	96.3
Rented occupancy (*per person*)	All: A-X	*395*	71.1	121.9	97.1	*394*	63.8	102.4	104.3
	Study: A-L	*98*	69.7	110.0	98.3	*99*	69.6	98.3	101.2

Rented occupancy is based on lettings on a particular date as supplied by UWE Accommodations Service and assumes the same level of occupancy throughout:
2016/17: rented occupancy -All: A-X is 97.8% (9 void); and Study: A-L is 94.2% (6 void) – lettings data supplied on 30 November 2016
[1]Figures exclude house J (due to high consumption/possible leak during Term 2: 23 January to 23 March 2017
2017/18: rented occupancy – All: A-X is 97.5% (10 void); and Study: A-L is 95.2% (5 void) – lettings data supplied on 27 March 2018
[2]Term 2 truncated from 14 March 2018 due to 'no water' event which caused seven meters across WCP1 to malfunction, including house A.

These PCC estimates indicate that the average water use was at a similar level between the two academic years, despite housing different cohorts of students. For the whole 12 months of the academic year (in the darker blue column), consumption ranged between 65.3 l/*b*/d and 71.1 l/*p*/d in 2016/17, depending upon whether *design* or *rented* occupancy was used as the denominator in the calculations, and looking across the whole 37-house development or the 12-house study site. The following year (dark green column), ranged between 62.5 l/b/d and 71.9 l/p/d.

However, it must be acknowledged that these consumption values are low, due to the inclusion of *void* periods (e.g., summer, Christmas, and Easter vacations) within the year. It is more representative to estimate consumption based upon periods of *maximum* occupancy, during the teaching periods (term 1 and term 2 in the lighter coloured shaded columns), when almost full (c.98%) occupancy can be assumed. These values ranged from 92.2 l/*b*/d to 121.9 l/*p*/d in 2016/17, with slightly less variability for the 2017/18 academic year, from 93.6 l/*b*/d to 104.3 l/*p*/d.

The calculated PCC values in Table 4-2 are a best *estimate* of the actual *per capita* usage, calculated using *measured* water consumption through the meters and *estimated* occupancy, as the occupancy data represent a snapshot in time. Even the lower estimates based on *design* occupancy cannot be assumed to be the minimum PCC, as many students will have had visitors, and some may have had longer term or more regular house guests for overnight stays.

4.1.2 Shower fixture micro-component events

The single logger connected to the meter for house A for 20 days (15 November to 04 December 2017) to test the feasibility of recording separate shower events or micro-components (RQ2.3) captured 160 shower events, along with an additional 4,000 other water-using events. A summary of general household water use patterns is shown in Table 4-3.

Table 4-3 Average daily water consumption (house A)

Variable	**Median consumption (litres per day)**		**Mean consumption (litres per day)**	
	Household	*Per capita**	*Household*	*Per capita**
Weekday *(n=12)*	1,689.5	211.2	1,439.2	179.9
Weekend *(n=6)*	1,690.3	211.3	1,608.5	201.1
All days *(n=18)*	1,689.5	211.2	1,495.6	187.0
**PCC based on design occupancy of 8*				

Assuming full design occupancy of eight residents, average PCC was *high* at around 200 l/*b*/d. This is substantially higher than the estimated *average* PCC values reported for WCP1 in Table 4-2, although within the expected range. It is similar to the background level reported for the Student Village during 2016-17 (see Figure 4-4), although represents only a limited period (20 days) and this high consumption cannot be explained by *Legionella* flushing or leaking WCs. Analysis of the tendency for each house to fall into the extremes of daily consumption (Appendix B.4) showed that house A was consistently a high consumer, placed in the top three (of 37 houses) for 36.9 % of the time (despite also recording zero flow due to (test) logger interference for 31.6% of the time).

Total daily consumption for the logged site was plotted through time (Figure 4-14). The shading of the bars differentiates weekdays (darker) and the weekends (lighter shading). Partial days are marked with green boxes, where there were gaps in the time series: on installation on 15 November; removal on 04 December; and an unexplained period of missing data during the middle week (from 21 to 24 November).

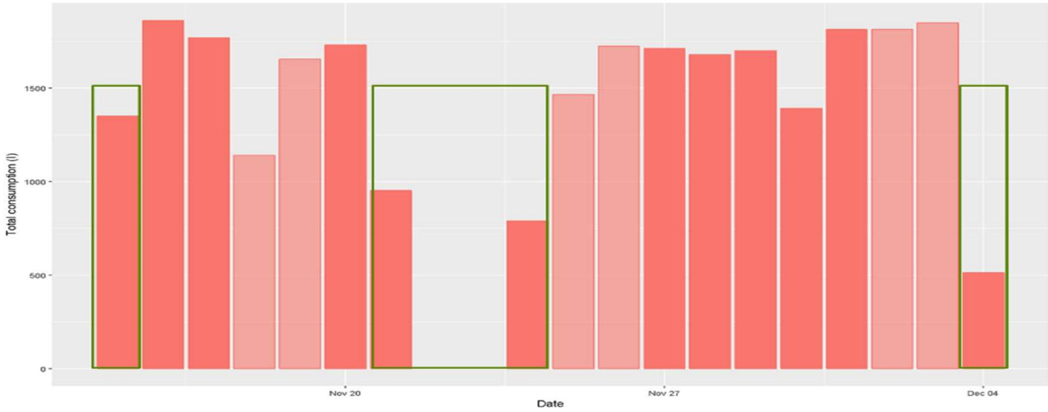


Figure 4-14 Daily consumption through time (Source: Rogerson and Spey, 2018)

The boxplots in Figure 4-15 show the range, median, and spread of the total consumption for the weekdays (in pink on the left) and weekends (blue, on the right). There were three weekends during the test period (six days) compared with twelve weekdays (but only eight fully captured and four partially captured days). There was no difference in median consumption for weekdays (1,689 litres per day) and weekends (1,690 l/d) supporting the findings of the ANOVA on the Student Village water consumption data that concluded there was no significant difference between different days of the week. However, the spread or variation on weekdays was much greater, with daily consumption ranging between c.500 litres and c.2000 litres on any one day.

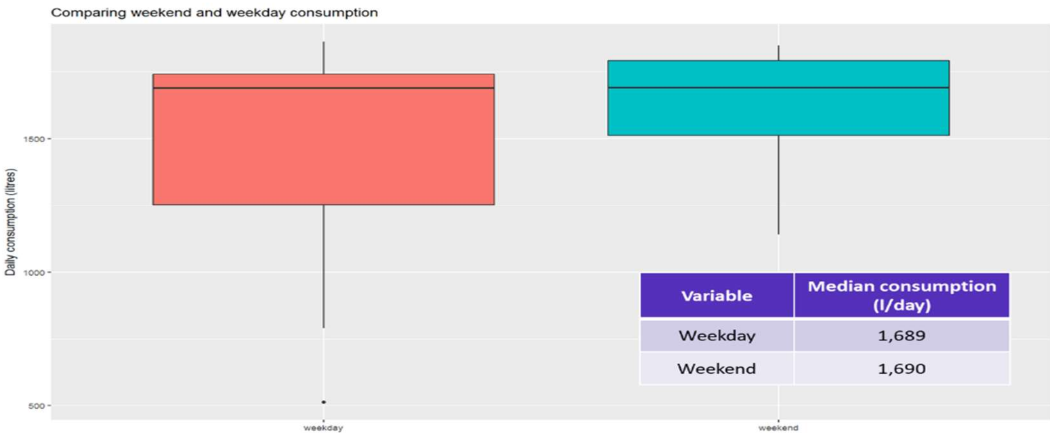


Figure 4-15 Comparison of weekday vs. weekend total consumption (Source: Rogerson and Spey, 2018)

Figure 4-16 presents the time series flow data in three horizontal channels, segmented into separate shower and none-shower water-using events. The blue plot in the lower channel shows the entire water-use record for the test period (20 elapsed days, 15 November to 04 December 2017, inclusive), including periods of zero flow.

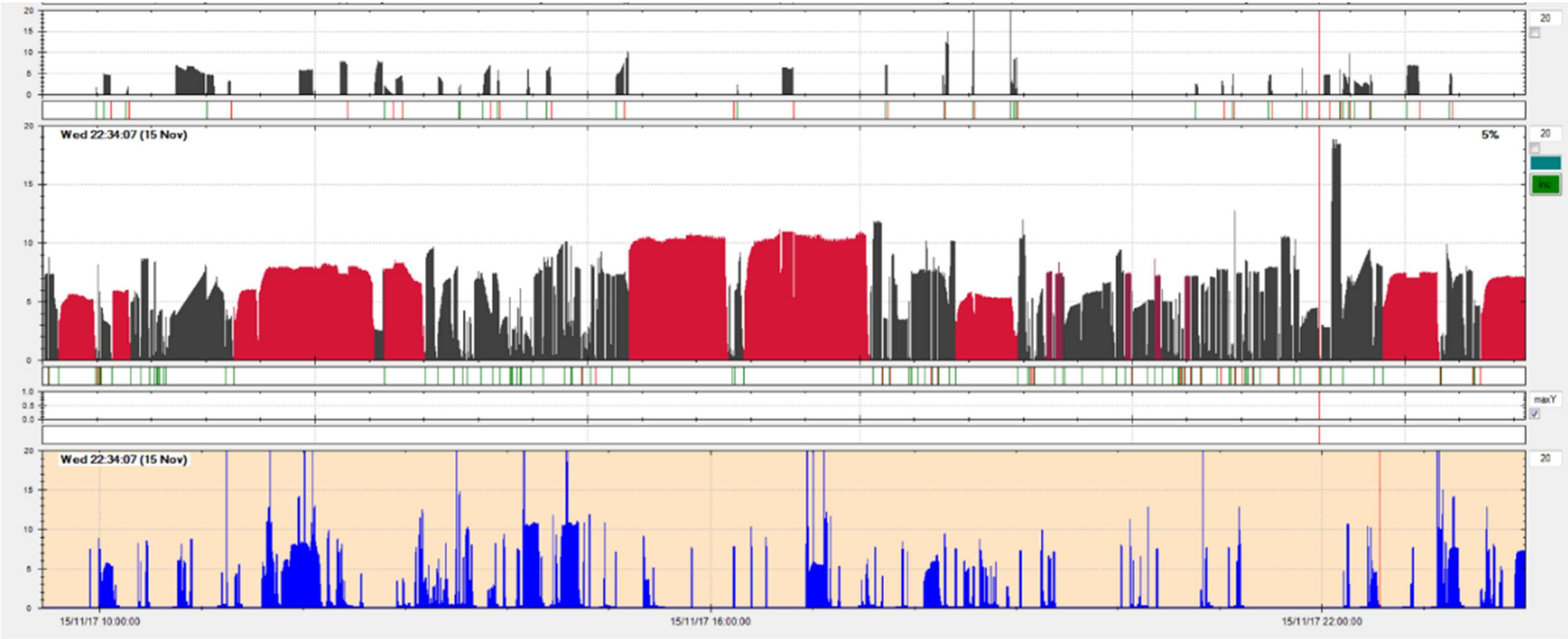


Figure 4-16 Screen shot of Siloette user interface showing part (15-Nov-2017) of the flow test trace with shower components (in red) (Source: Rogerson and Spey, 2018)

The separate water-using events are shown in the central channel, with red blocks representing showers. These are temporally compressed to remove periods with zero flow, with start (green) and stop (red) markers beneath the event blocks.

Where there were parallel or multi-layered events, a manual separation process assigned the other events (all 'non-showers' in this example) to the top channel (refer to section 3.6.1). The overlapping events in the eight-bed house made micro-component segmentation difficult, and the process required interpretation by the analyst (Artesia Consulting staff member), based on human judgement and experience. In this example, the overlapping events were likely to be WC flush events or tap usage elsewhere in the house, due to the shape of the flow and duration profiles.

The shower event data were analysed to calculate average shower freqency, volume and duration. These results are summarised in Table 4-4. The results indicate that for the test house (A) alost nine showers were taken each day, suggesting that at least one resident showered more than once per day, or there was a regular house guest for the duration of the test period. Each shower used 62 litres on average, depending on the day of the week, with slightly more used at the weekend, although weekend frequency and duration were lower. The volumes and durations appear to be representative and within expected limits, and provide assurance that the events identified as showers were indeed showers.

Table 4-4 Average shower frequency, volume, and duration (house A)

Variable	**Mean frequency** *(uses per day)*	**Mean volume** *(litres)*	**Average daily *household* shower consumption** *(l/h/d)*	**Average daily *per capita* shower consumption*** *(l/p/d)*	**Mean duration** *(minutes)*
Weekday	8.9	56.2	501.1	62.6	12.5
Weekend	8.8	64.8	572.4	71.6	11.6
All days	*8.9*	*62.0*	*551.2*	*68.9*	*12.2*
**Per capita shower consumption based on design occupancy of 8*					

The daily *household* shower consumption was divided by the number of residents in the house (eight) to *estimate* the average *per captia* shower consumption, which ranged from 62.6 l/*p*/d for weekdays to 71.6 l/*p*/d at weekends. This equates to between 30-36% of total water use, and is in line with the estimated personal washing (showers and baths) segment of domestic water consumption as reported in the literature (Energy Saving Trust, 2018). Finally, the average shower durations were long, at around twelve minutes.

Daily *household* consumption was ranked, to illustrate the variation in the proportion of shower use compared with total daily use. This is shown in Figure 4-17.

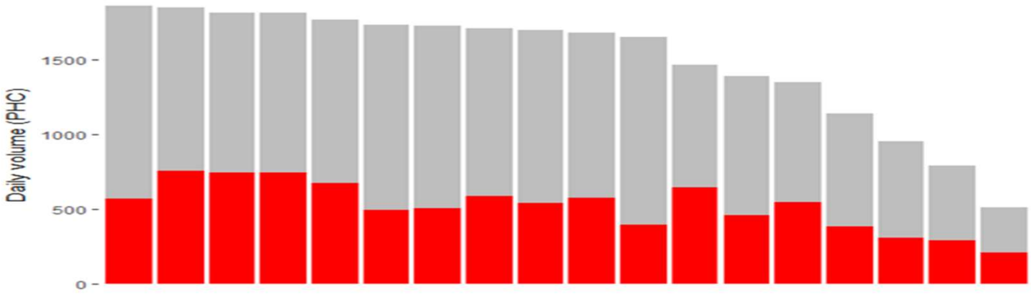


Figure 4-17 Ranked daily household consumption assigned to showers (red) and other uses (grey) (Source: Rogerson and Spey, 2018)

To explore any temporal patterns in showering routines, the 160 unique events were plotted by day of the week (shower volume and shower duration, in Figure 4-18 and Figure 4-19, respectively).

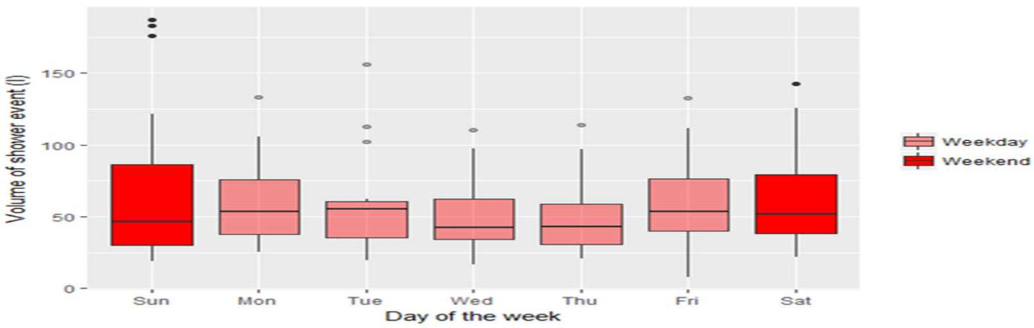


Figure 4-18 Volume of shower events by day of the week (Source: Rogerson and Spey, 2018)

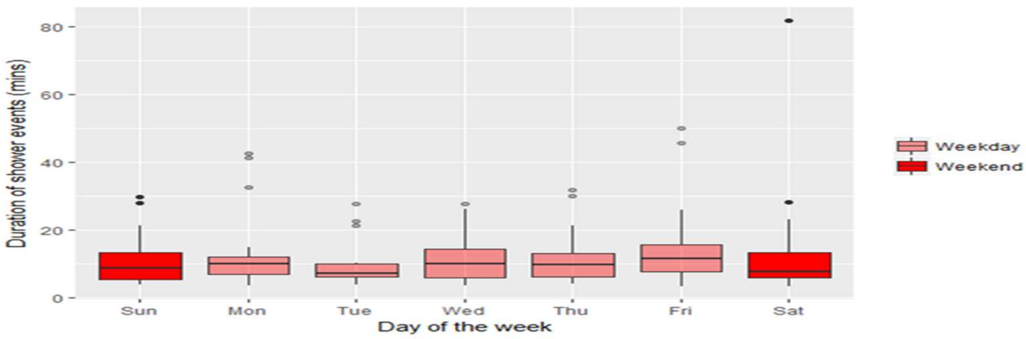


Figure 4-19 Duration of shower events by day of the week (Rogerson and Spey, 2018)

The results did not show any obvious difference between weekday and weekend shower volumes, with the data evenly spread across both types of day and similar mean values, although weekend shower volumes were more variable (wider range in volume), suggesting unsurprsingly, that the rhythm of daily life was less rigidly structured at the weekend. This is at odds with the total water use shown in the previous box plot (Figure

4-15) that indicated greater variability during the week. However, the uniformity provides further confidence that all shower events were correctly identified in the segmentation process.

Average shower volume, frequency and proportion of total consumption is plotted in Figure 4-20. The top (pink) chart confirms that the average shower volume was slightly higher at weekends (lighter shading) compared with weekdays (darker), but the average volume of just over around 62 litres per event is representative of typical or middle shower use. Whilst weekend shower events were slightly longer with a higher volume, they were a little less frequent (blue plot) and formed a lower proportion of the average weekend consumption, compared with weekdays (green plot).

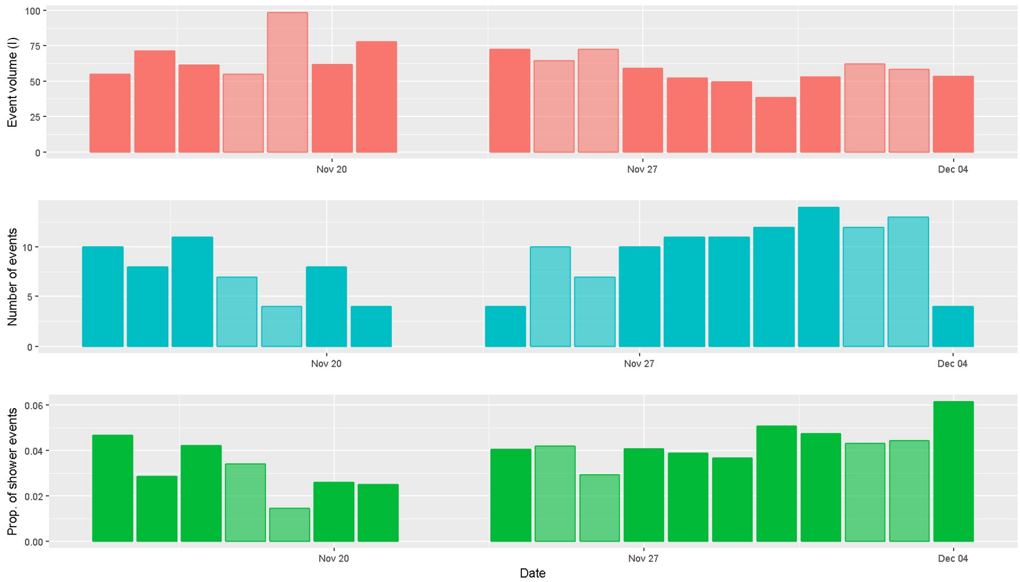


Figure 4-20 Shower volume, number, and proportion (Source: Rogerson and Spey, 2018)

The start time for each shower event was analysed. This showed that showers occurred later in the morning on weekends compared with weekdays, with no showers between 02:00 hrs and 10:30 hrs at the weekend, whilst showers started from 06:00 hrs on weekdays. There were late night showers (between midnight and 02:00hrs) on *all* days, albeit of short duration. Finally, the volume per event per day of the week was analysed (see Figure 4-21). Weekdays were more consistent, and weekends varied dependent on time of day, with leisurely afternoon showers being the most consumptive, as they were not constrained by the same times and schedules of weekdays. However, there were insufficient data to test for the statistical significance of any variations.

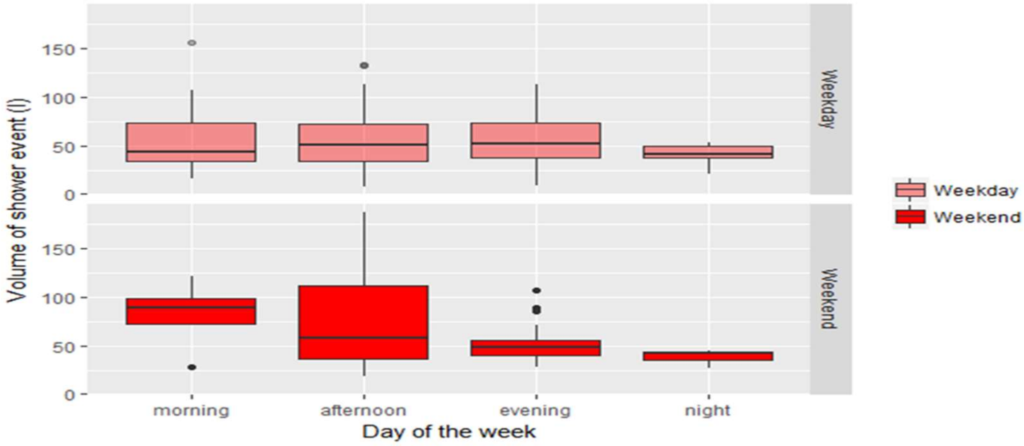


Figure 4-21 Shower volume per event (Source: Rogerson and Spey, 2018)

Whilst the test flow trace was short in time, it served as a proof of concept that it was technically feasible to identify the pattern of distinct showering events in the relatively high occupancy student houses, and that it would allow the efficacy of event and household level interventions to be tested (RQ2.3).

4.1.3 Summary of volumetric measurement findings

The first part of this chapter aimed to address Research Objective 2*, to establish the baseline water consumption by students living in UWE managed campus accommodation*. Historic meter data for two modern residential accommodation developments were reviewed and analysed to assess the performance of water fixtures (RQ2.1) and to estimate the PCC of the resident populations (RQ2.2).

The analysis showed that daily water consumption was less variable for WCP1 than the older, but larger Student Village development, and that there was no statistically significant difference in daily water use between different days of the week or between weekdays and weekends. The calculation of PCC proved to be problematic, despite the standardised infrastructure and having good knowledge about the occupancy. The estimated average consumption for WCP1 was a modest 100-120 l/*b*/d, compared with the high c.200 l/*b*/d for the Student Village.

The WCP1 development was selected for the subsequent field trials due to the availability of finer resolution meter data, with one meter for each eight- to twelve-bed house. However, as the research was focused on the *showering* segment of total water consumption, this part of the study also set out to test the feasibility of measuring the shower micro-component within large student houses (RQ2.3). Using a Siloette logger linked to the inlet water supply via the meter. The subsequent timeseries data set was successfully disaggregated into separate shower event profiles. This was a proof-of-concept pilot to investigate whether it was possible to operationalise the plan, prior to full deployment in the subsequent Wave 1 and Wave 2 field trials, across multiple houses and for an extended period of weeks and months.

4.2 End-user insights – showering routines of students

Responses to the Q/0 survey were returned by a total of 158 students. However, two returns were screened out of all further analysis as they were found to be from minors (under 18 years).

4.2.1 Descriptive statistics

The valid Q/0 questionnaire responses were summarised, described, and plotted to illustrate how UWE students *do* showering. Further details from the survey responses are tabulated and presented in Appendix C.1 for reference.

Environmental awareness and actions

The survey opened with some broad questions to gauge the level of environmental awareness and action among the respondents:

> *Q/0-q2. Do you think of yourself as being environmentally aware?*
>
> *Q/0-q3. Have you ever considered how much water you use each day?*
>
> *Q/0-q4. Do you sort and recycle your waste, including food waste? (q4.1 At home; q4.2 At UWE)*

The majority (91%) considered themselves to be environmentally aware, whilst slightly fewer (82%) had thought about the quantity of water they use. In terms of taking environmental action, 62% said that they *always* recycled their waste at home, rising to 69% *always* recycling (and just 8% reporting that they *never* recycle) at their term-time address.

Later in the survey students were asked:

> *Q/0-q18. Have you heard of any water saving campaigns or messaging at UWE?*
>
> *Q/0-q31. Where is your UWE term-time accommodation?*

The responses indicated that only 11% could recall any water saving campaigns or messaging at UWE (12%of those living *on campus* and 9% living in *off-site* private housing) and revealed a low awareness of the '*Reduce the Juice*' campaign. Of those that could recall hearing about any campaigns, only three mentioned it specifically by name and another six indicated that they had heard of it without naming it:

"A company offered free pizza to talk to students about saving energy and water, also providing us with a timer for the shower"

"Stand at freshers fair"

"Saw some posters"

"I signed up for something outside accommodation in September but I forgot what it's called. They said we would have a meeting and learn to talk to people about energy saving and they had hoodies for when we finished"

"Posters around campus"

"Facebook - UWE Freshers group"

Other responses referred to course specific information, or wider (non-UWE) messaging such as "*Toilet Day"*[49], shower timer giveaways and *"Zoo in the loo"*[50].

Showering practices

Duration

The students were asked about their typical shower duration :

> *Q/0-q5. Approximately how many minutes do you spend in the shower (each time you shower)?*

The results are presented in Figure 4-22. Values to this open question were returned in single digit integers for responses up to ten minutes duration, but beyond this, times were estimated and rounded to the nearest five or ten minutes. The mean average shower duration reported was 11.9 minutes, with median and mode values of ten minutes, and ranging from a conservative three minutes to a staggering 60 minutes. Students living *on campus* reported longer shower durations (mean of 13 minutes and median of 10 minutes) than those living *off-site* (10.6 minutes and 10 minutes respectively), on average. The results indicate that students tend to shower for between 10 to 20 minutes. This is longer than the social norm of around seven or eight minutes for the general population (Energy Saving Trust, 2013; Walker and Zygmunt, 2009).

[49] World Toilet Day is an official United Nations international observance day on 19 November to inspire action to tackle the global sanitation crisis.

[50] *Zoo in the loo* is campaign branding used by SaveWaterSaveMoney.co.uk – a business that partners with many of the UK water suppliers to distribute both free and paid for water saving devices and online water efficiency engagement services.

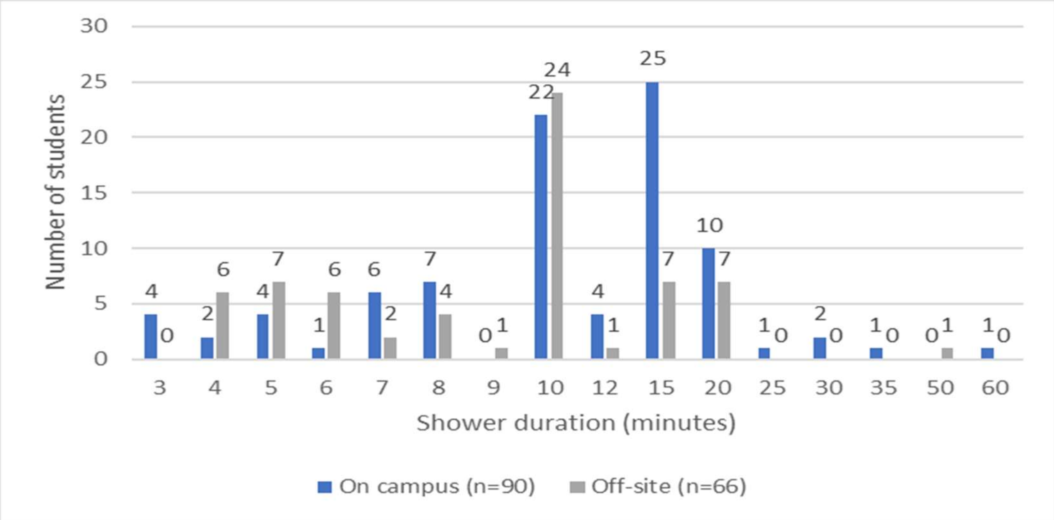


Figure 4-22 Approximately how many minutes do you spend in the shower (each time you shower)? (question 5)

The responses from *on campus* residents were split by accommodation type, between the Student Village and WCP1 (a further seven responses were returned from students living in other campus accommodation), to explore whether the private en suite showers in the Student Village had any influence over their routines. The mean duration for Student Village residents of 13.5 minutes (and a median of 12 minutes) was four per cent longer than for those living in WCP1 (with a mean duration of 13 minutes and a median of 10 minutes), suggesting that the private en suite space may have the capacity to influence longer duration showers.

Frequency

Half of all students stated that they have a shower every day (and another 8.3% shower *more than once per day*), in line with the social norm for the wider population (Energy Saving Trust, 2013; Walker and Zygmunt, 2009).

Q/0-q6. How often do you shower?

Showering frequency was higher for those living in university accommodation (67.8% shower at least daily), compared with those living in *off-site* housing (45.5%). Showering frequency split by accommodation type is shown in Figure 4-23. The *on-campus* responses were sub-divided by accommodation type to explore any differences in shower routines for those with en suite shower rooms (Student Village), compared with shared facilities in Wallscourt Park. The results showed a tendency for students living in the Student Village to shower more frequently than those with shared facilities. Almost 70% of Student Village residents reported showering at least daily shower (and zero had a weekly shower), compared with 55% of Wallscourt Park residents, 44.4% of *off-site* students and 58.3% across *all* survey responses.

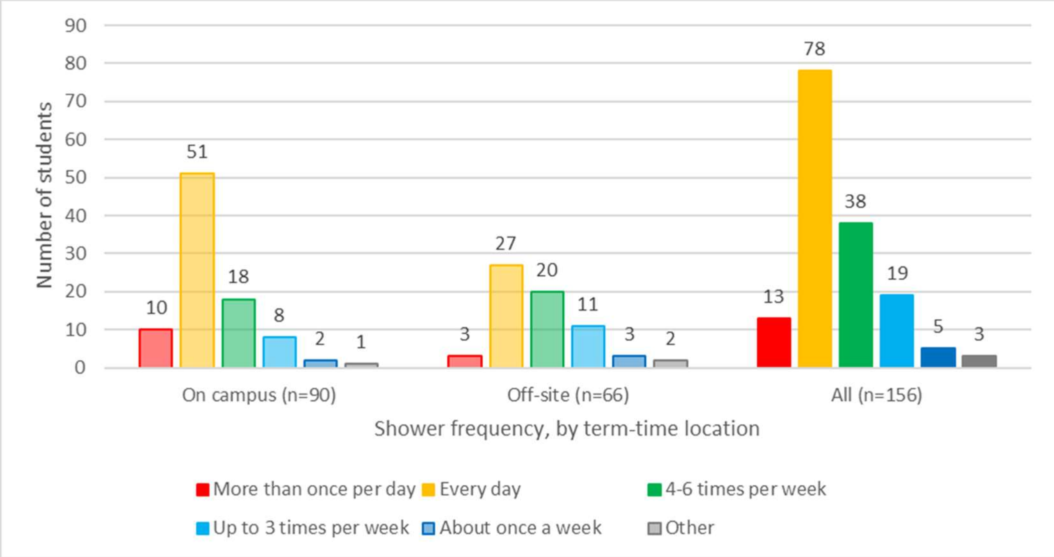


Figure 4-23 How often do you shower? (question 6)

Time of day

Students were asked whether they had a set time of the day in which they showered.

Q/0-q7. When do you shower?

The results are presented in Figure 4-24.

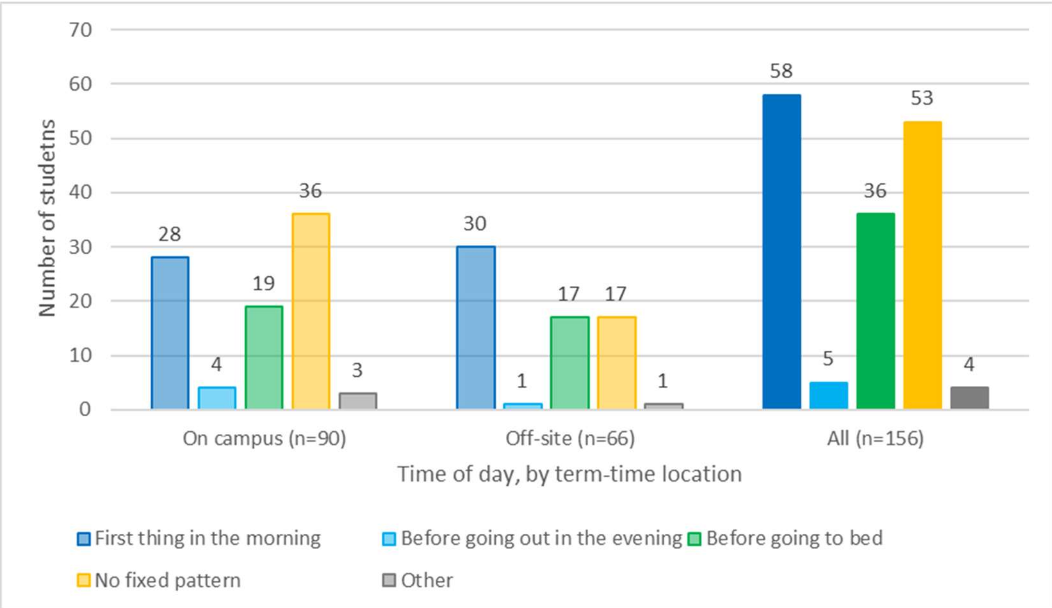


Figure 4-24 When do you shower? (question 7)

The results show that household location has the potential to alter the time of day that showering is performed. Forty per cent of *on campus* residents indicated that they had *no fixed pattern* in when they showered whilst 31% showered as part of their morning routine. Students living *off-site* were most likely (45.5%) to shower in the morning before heading out to university. This compares with 40% tending to shower in the morning and

35% showing a more even temporal pattern in Gram-Hanssen *et al*. (2019), suggesting that the observed patterns may be related to life stage.

Outsourcing

Students were asked about sports centre or gym membership and whether this influenced *where* they showered.

> *Q/0-q36. Are you a member of a gym and if so, which?*
>
> *Q/0-q36a. If you are a member of a gym, where do you shower after sport?*

Of the 156 surveyed students, 40.3% confirmed that they had a gym membership. Gym membership was more likely among campus residents, with 43.3% living *on campus* (all bar one at the university sports centre) and 36.4% living *off-site* (three quarters of these were members of an *off-site* gym) confirmed gym membership. The level of gym membership reported for campus residents was slightly lower than the Accommodation Services data that indicated just over half (51.4%) of WCP1 residents had membership at the university sports centre in 2017/18 (membership fluctuates by accommodation type and academic year). Having a gym membership does not necessarily mean that the student uses the facilities, but one can presume that the financial cost of having the membership would motivate them to use it, particularly at the start of the academic year when the Q/0 survey took place.

The vast majority (91.7%) indicated that they showered in their own bathroom. Just 13 students (8.2%) *outsourced* their showering to the gym or sports centre, *off-site* residents (eight) were more likely to *outsource* their showering compared with just five living *on campus*.

Products and in-shower activities

There is a plethora[51] of showering and haircare products on the market designed for a wide range of specific purposes (washing hair or body; shaving; facial cleansing and scrubbing; freshening up or relaxing) and to target different hair (oily, dry, damaged, dandruff) and skin (oily; dry; combination; sensitive) types. The researcher was interested to test whether the number of shower products used, or the number of in-shower processes undertaken (bundles of mini-practices performed within the shower enclosure and under running water) might determine the showering process and dictate the shower duration. The Q/0 survey asked:

---

[51] A century ago, Procter and Gamble's *Ivory* soap was marketed as being suitable *all* purposes (body, hair, laundry and dishes) (Cox, 1999).

Q/0-q9. How many different personal shower products do you use during a typical shower.

Q/0-q10. Which activities do you undertake during a typical shower? Please tick ALL that apply

The results are presented in Figure 4-25 and Figure 4-26. On average, students used three products in the shower (this was not dependent upon accommodation location), to perform 3.2 in-shower activities. Unsurprisingly, the most common activity reported was to *wash the body* (96.8% of students reported this for a typical shower). The *single application of shampoo* was the next most popular process (88.5% reported this). However, *shampooing twice* is no longer a common practice among the students (only 11% did this).

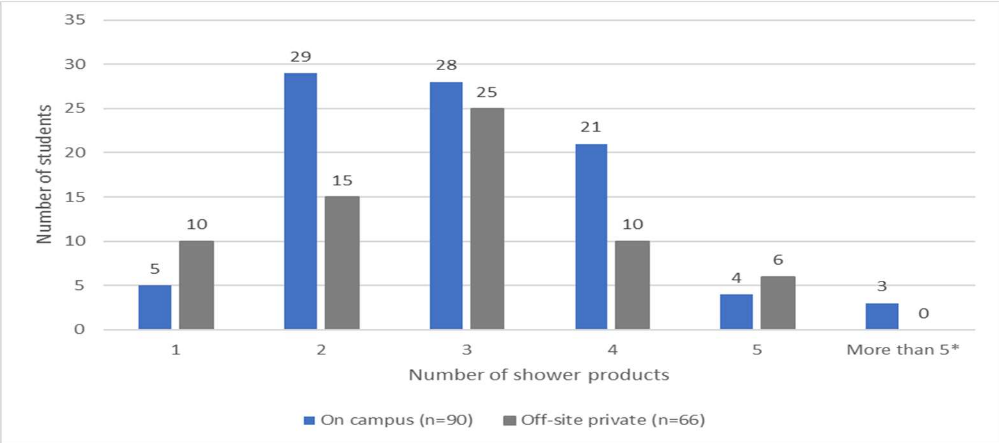


Figure 4-25 How many products do you use? (question 9)

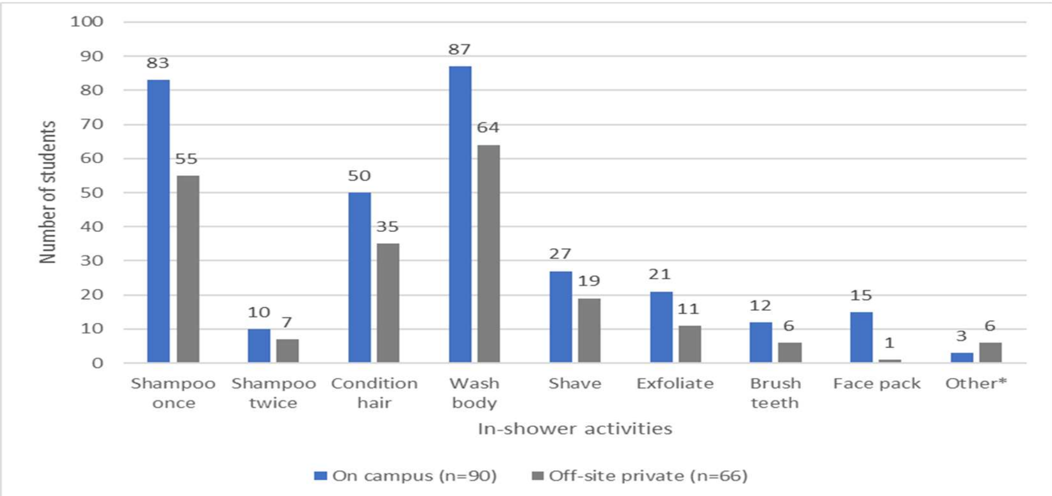


Figure 4-26 Which activities do you undertake during a typical shower? (question 10)

The first *cold* draw

Students were asked how quickly they immerse themselves under the running water when they turn the shower on.

Q/0-q8. When you first turn the shower on, do you?

The results, summarised in Figure 4-27, indicate that most students (just over two-thirds) turn the shower on and then wait a short while before getting under. However, the length of time (and wasted water) in doing this was not quantified.

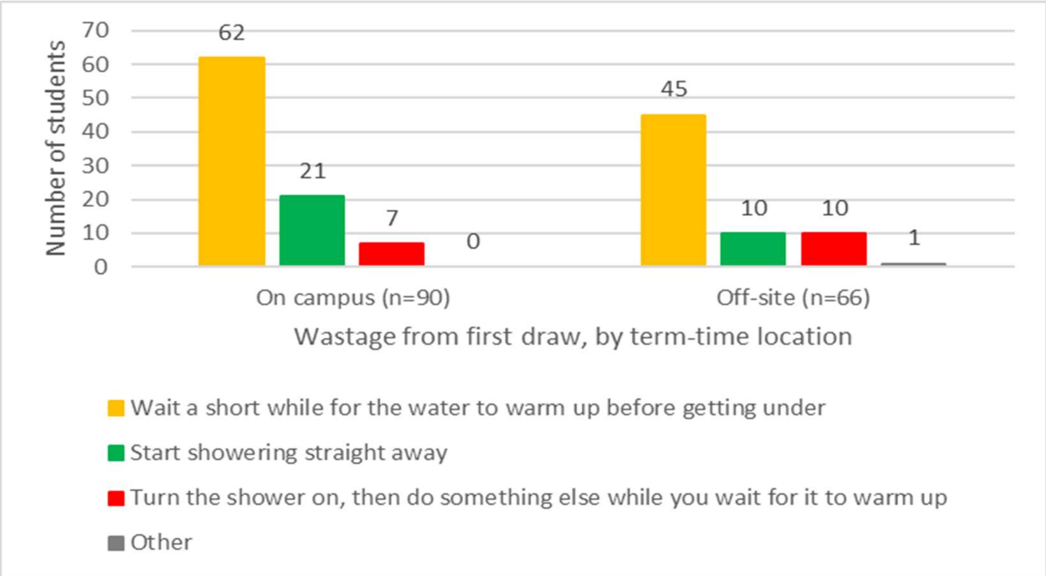


Figure 4-27 Wastage from first draw (question 8)

Other water-using practices

Laundry

Students were asked about the frequency of laundering different types of textiles.

Q/0-q11. How many loads of personal laundry do you do in an average week?

Q/0-q12. How often do you change and launder your bed sheets?

Q/0-q13. How often do you use fresh/clean towels?

Q/0-q14. How many times do you typically wear a pair of jeans before laundering them?

The results for each question are presented in Figure 4-28 to Figure 4-31. Students who tended to wash their clothes, towels, and bedding communally with others, were asked to base their answers on the number of loads of their own personal laundry (the Q/0 questionnaire did not ask if they undertook any communal laundry). The majority (59.6%) indicated that they did a single load of laundry per week, and there was little difference between housing location.

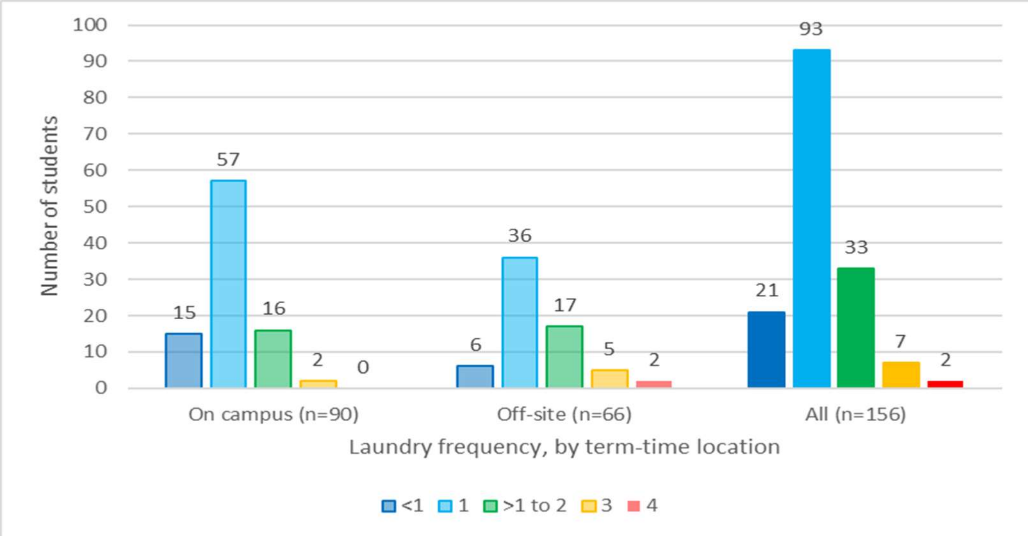


Figure 4-28 How many loads of laundry do you do in an average week? (question 11)

There was a wide range in the frequency of laundering bed sheets (Figure 4-29), from weekly to termly. The majority washed their sheets either fortnightly or monthly, although students living *on campus* tended to wait slightly longer between sheet changes than those living *off-site*.

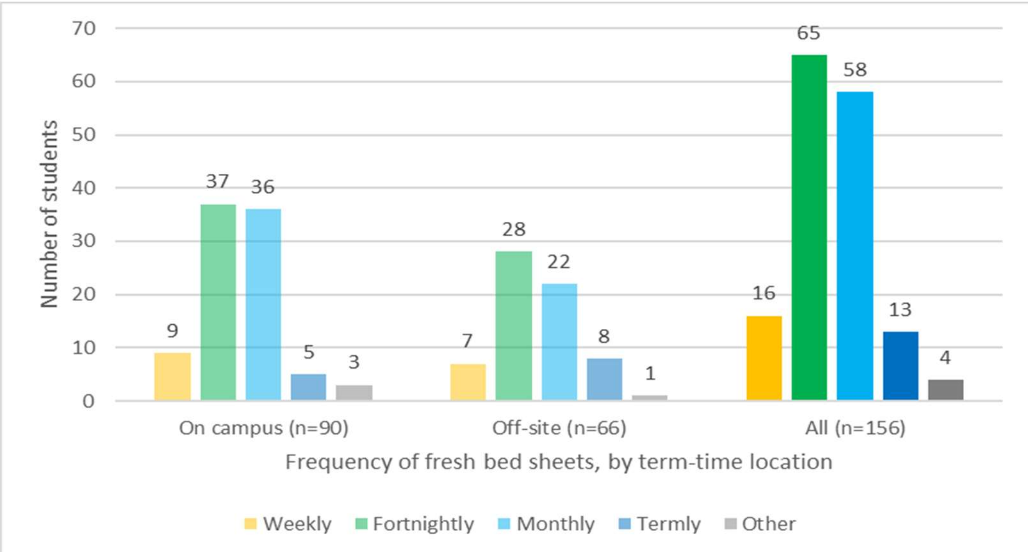


Figure 4-29 How often do you change and launder your bed sheets? (question 12)

Students changed their towels (Figure 4-30) more often than they changed their bed sheets, possibly directly linked to and a reflection of their frequent shower use. The majority stated that they use clean towels either weekly (40.4%) or fortnightly (34.6%). There was little difference in the relative pattern between students living *on campus* or *off-site*.

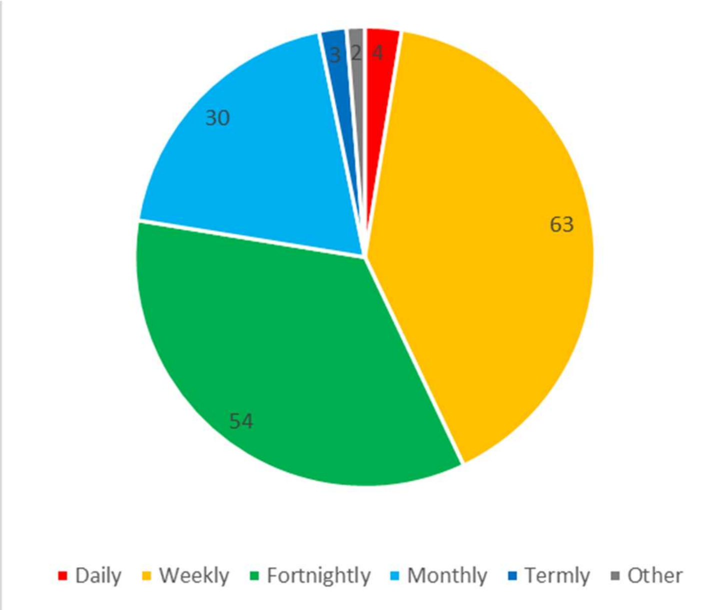


Figure 4-30   How often do you use fresh/clean towels? (question 13)

The question on jeans laundry (inspired by Jack, 2013) allowed for answers in the students' own words, as a succinct single line of text, and as such there was a mix of responses (and cannot be directly compared with Jack's findings) with a mix of frequency and triggers for laundry cited. The responses were grouped into frequency ranges, with the lowest frequency answer dictating to which group the response was allocated. The patterns of responses were similar for *on campus* and *off-site* living, and the largest grouping (43.6%) did not indicate a specific frequency, but instead opted for a subjective 'dirt' or 'smell' indicator for when their jeans were ready for washing (dirt was the reason given for 31.4% of responses in Jack, 2013). Of those that stated a frequency, the most common response (30.1% of all cases) indicated that they wear their jeans for three or four times between washes (Jack reported 45% indicated 2-3 wears). None of the UWE students reported 'habit' as a driver (compared with 51% of Jack's cohort). The results are shown in Figure 4-31.

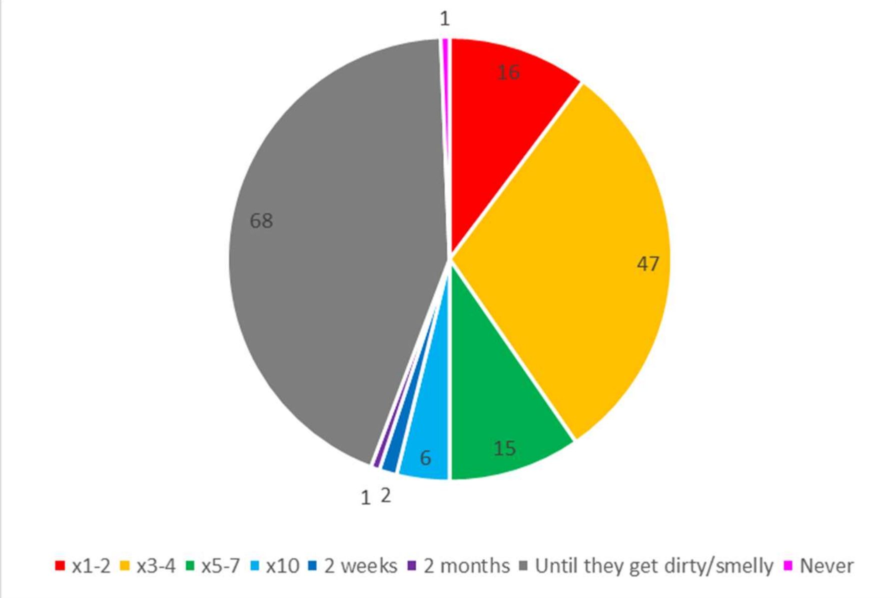


Figure 4-31 How many times do you typically wear a pair of jeans before laundering them? (question 14)

Washing-up

Washing the dishes is different from most other water using processes around the home, in that it is done in a shared space and may be shared. Students were asked the following questions about their washing-up practice:

> *Q/0-q15. How often do you wash-up your cooking pans and dirty dishes?*
>
> *Q/0-q16. Do you usually wash-up just your own dishes or do you take it in turns with your housemates to wash up communally?*
>
> *Q/0-q17. How do you usually wash-up your dishes?*

There were two quantitative and two qualitative options to question 15. The results are presented in Figure 4-32. Nearly 38% of *off-site* residents indicated a relaxed approach to washing-up by selecting the *'once per day'* low frequency option, compared with 26% of *on campus* students.

Figure 4-33 shows the level of communal washing-up (question 16). The majority (59%) of students clean solely their *own* dishes, rising to two-thirds of *on campus* residents. However, those living *off-site* were more likely to share the chore (almost 20% living *off-site* wash-up communally, with a further 32% collaborating some of the time), whereas only 4% of those living *on campus* always do this (and 29% sometimes wash-up together).

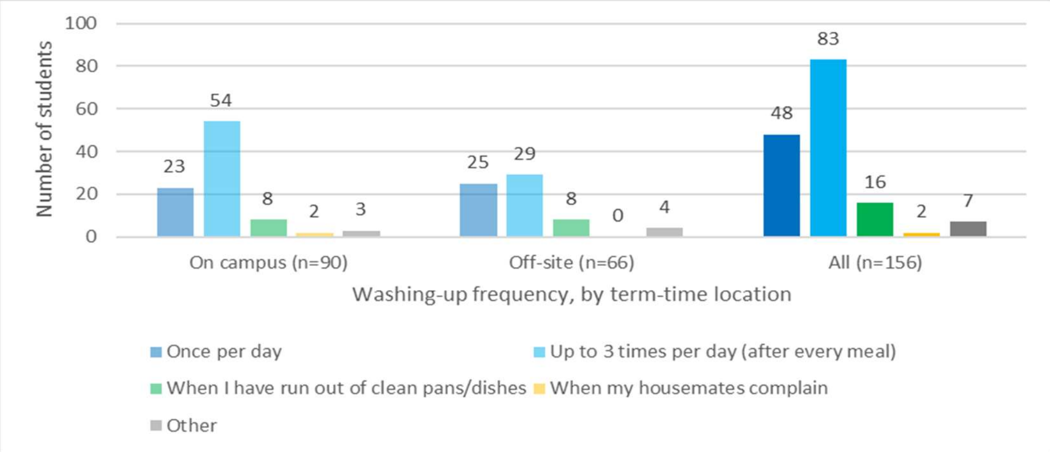


Figure 4-32 How often do you wash-up your cooking pans and dirty dishes? (question 15)

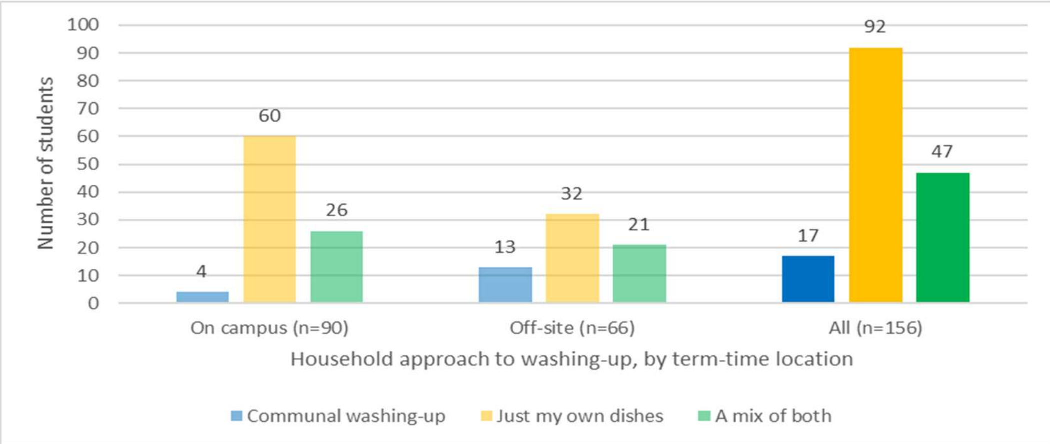


Figure 4-33 Do you usually wash-up just your own dishes or do you take it in turns with your housemates to wash-up communally? (question 16)

Nearly 48% of *campus* residents reported that they used a *bowl* to wash-up (Figure 4-34) However, the next most popular method reported was washing-up under a *running tap*, with a third of all students adopting this highly consumptive approach.

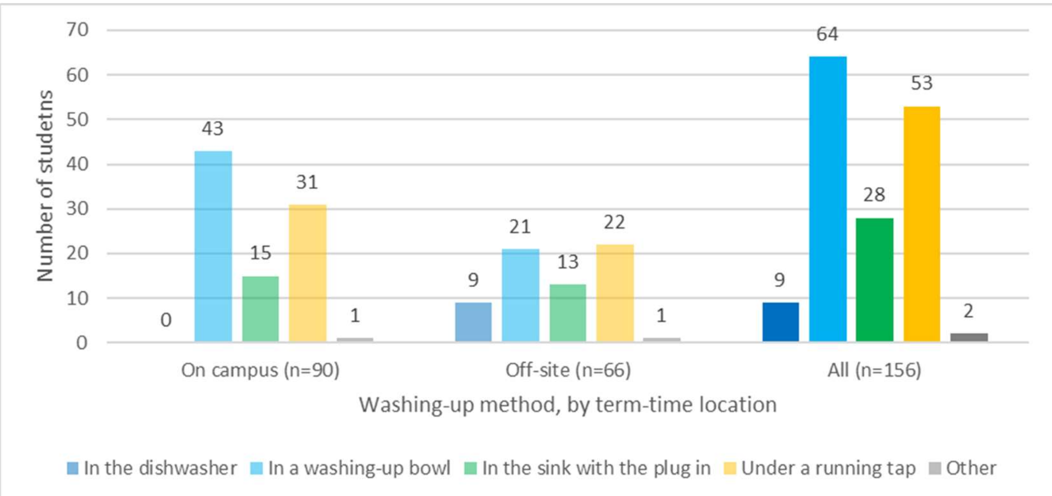


Figure 4-34 How do you usually wash-up your dishes?

A later part of the Q/0 survey enquired about life at home, and the students were asked if there was a dishwasher at home (question 28, Figure 4-35). Responses indicated that 58% have a dishwasher at home. Modern dishwashers can use as little as nine litres of water per wash for up to 14 place settings, and provided the appliance is fully loaded, can be more water efficient than washing the same dishes by hand, especially the top (A or A+++) energy rated models[52] and particularly compared with the *running tap* method.

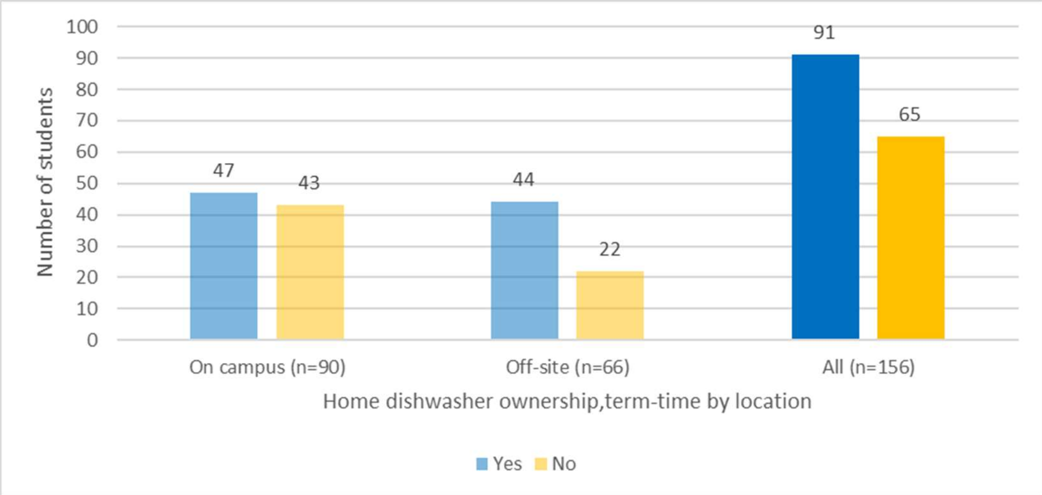


Figure 4-35 [At home] Does your family own a dishwasher? (question 28)

Meters

Economic instruments are offered as a rational stick with which to change behaviour, and therefore it is assumed that customers that pay for their consumption via metered bills will use less than those not on a meter. However, the water meters *on campus* are only used to manage the estate and are not visible to residents. The meters used for charging for consumption and accommodation fees are inclusive of utility bills. Students were asked whether their family home paid for water use via a metered bill:

> *Q/0-q29. Does your family home have a water meter (i.e., do they get a metered water bill)?*

The results are presented in Figure 4-36, split between UK students and those from overseas (question 19), in recognition of differing international water management policies.

[52] The EU energy label (Defra, 2011) gives information about the energy efficiency of an appliance, with ratings of A+++ to G. The labelling scheme aims to inform (rational) consumers to influence their buying choices and drive innovation and competition among manufacturers to produce energy efficient models. The scheme has recently been simplified and updated with ratings from A to G (Label2020, 2021). There is a long-promised water efficient labelling scheme on the horizon.

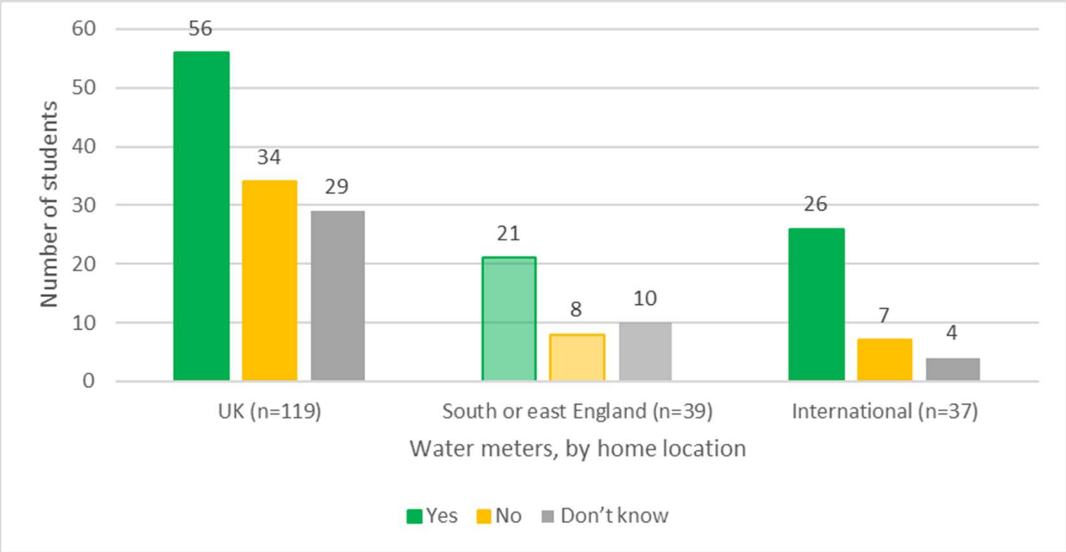


Figure 4-36 Is there a water meter at home? (question 29)

Almost half of UK students (47.1%) confirmed that their families paid for their water use via metered billing, which is broadly in line with reported meter penetration for England. This compares with 70% of international students who indicated that water at home is metered. Responses were also disaggregated for students from *south* or *east* England (from Hampshire to Kent, London, and East Anglia). This indicated that 53.8% of those from the south and east of England have a water meter at home, reflecting the roll out of universal or compulsory metering by the regional water suppliers in this water stressed region during the last decade. However, about a quarter of UK students did not know if there is a water meter at home, demonstrating that messaging via water bills does not reach all members of the household.

Water quality

Students were asked about the quality of the water at home:

> *Q/0-q30. Is the water at home: hard or soft?*

The results are shown in Figure 4-37, split by UK and overseas. The results show that 40.3% of UK students reported hard water (like Bristol water supplies which are prone to limescale build-up), whilst more than a quarter (27.7%) did not know. However, international students indicated that water at home was more likely to be soft (32.4%), although a large proportion (43.2%) lacked awareness on this.

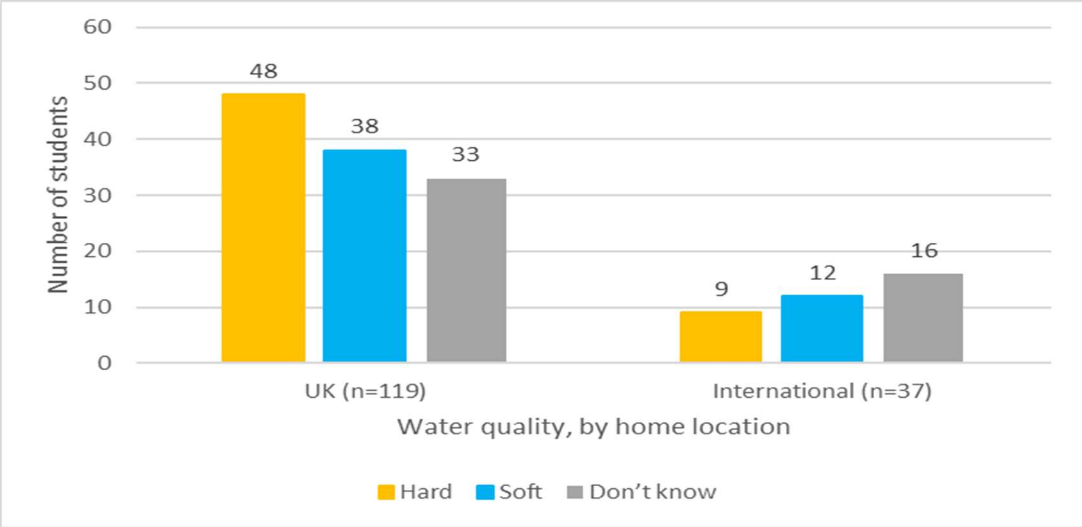


Figure 4-37 Water quality at home (question 30)

Occupancy

The difficulties in calculating *per person* water consumption even when occupancy is apparently known were highlighted in section 4.1.1. The WCP1 development (houses A to X) operated at about 97-98% occupancy, with a slightly lower occupancy (94-95% of maximum capacity) for the study site (houses A to L), due to house L being used for short term emergency accommodation only. However, these occupancy values do not determine how much of the time in a day or week, the residents are in the accommodation and using water. Students were asked how long they spend in their student flats or houses:

> *Q/0-q37. On average, how many hours (per 24 hours) do you spend in your student accommodation on weekdays, including sleep?*
>
> *Q/0-q38. Do you tend to stay at UWE at the weekend, or go away? For example: go home, stay with friends.*

The responses are summarised in Figure 4-38 (weekday occupancy) and Figure 4-39 (weekend occupancy), respectively, split by accommodation location and by UK and international students.

The results show that *off-site* students spent more time away from their houses/flats than those living *on campus* in proximity to the university and its services. This suggests that campus residents both live *and* work in their accommodation, more so than those living elsewhere, and they outsource less of their daily consumption, compared with the general population, which impacts on PCC levels. There was little difference between UK and overseas students on this measure.

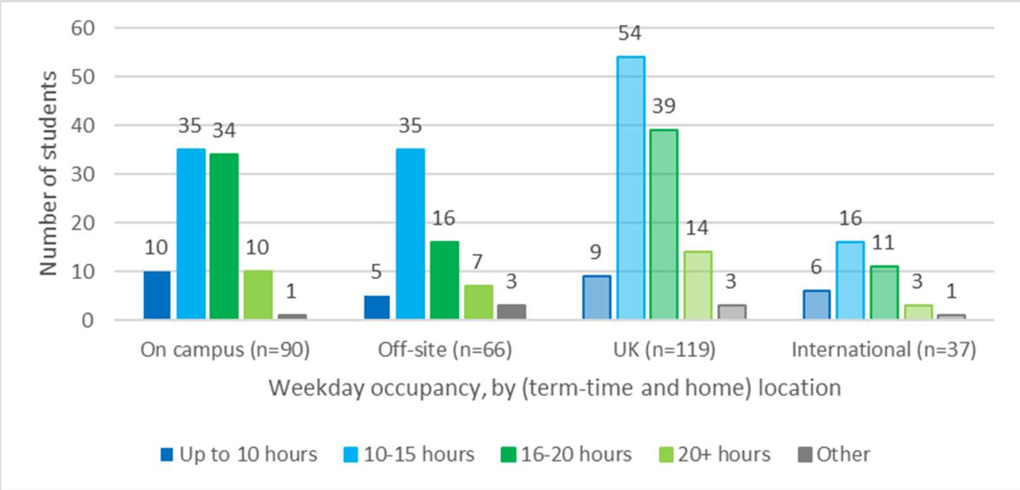


Figure 4-38 Average hours spent in house or flat during the week (question 37)

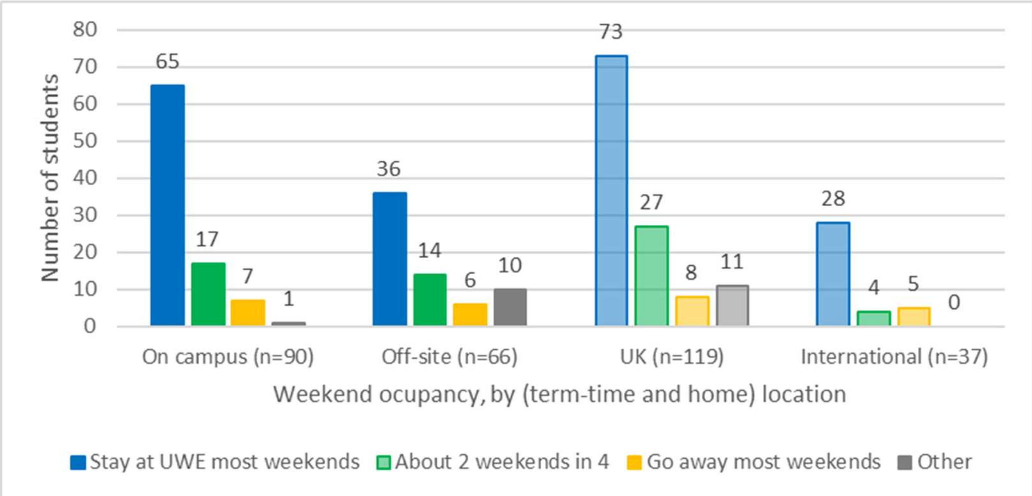


Figure 4-39 Weekend occupancy (question 38)

Supplementary questions

The questionnaire was structures to principally gather data to understand the water-using practices of UWE students, However, more conventional socio-demographic and other contextual data were collected to supplement the main questions on water use. Responses to the following questions are tabled in Appendix C1.4 and C.1.6:

Q/0-q19. Which town (or country, if you are not from the UK) is home?

Q/0-q20. Approximately in which era was your home built?

Q/0-q21. How many people normally live at your home address (excluding you)?

Q/0-q22. How many of the people living at your family home are wage-earners?

Q/0-q23. What type of dwelling best describes your home?

Q/0-q24. What tenure is your home?

Q/0-q25. How many bedrooms are there at home?

Q/0-q26. How many bathrooms/en suites/shower rooms are there at home?

Q/0-q27. What type of showers are installed at home?

Q/0-q33. What type of course are you studying?

Q/0-q34. Which Faculty are you based in?

Q/0-q40. What is your gender?

Q/0-q41. What is your marital status?

Q/0-q42. Do you have any dependents? For example: children, spouse.

Q/0-q43. What is your ethnicity?

Q/0-q44. What is your religion?

Q/0-q44b. Do you practice your religion?

Responses to question 19 on hometown or country were presented above (see Figure 4-36), in relation to metered billing at home. In summary, most campus residents surveyed were undergraduates (87%), studying courses based in the Business and Law (37%) and Environment and Technology (34%) faculties (delivered from the main Frenchay campus) with fewer responses from Health and Applied Sciences (16%) and Arts, Creative Industries and Education (10%) students (who tend to be based at other UWE campuses). All campus students surveyed indicated that they were single and had no dependents. Almost two-thirds (64%) reported their ethnicity as white, followed by 12% Chinese. Almost half (49%) declared no religion, and 29% were Christian. Just over one third (38%) stated that they (always or sometimes) practice their religion.

The results presented above (and in Appendix C.1) cover the substantive research findings from the Q/0 questionnaire. The remaining questions have not been documented in this thesis as they related the operational delivery of the fieldwork, and included consent (question 1), participation in further research activities (question 45), contact details (questions 32 and 45a-c), entry into the prize draw (questions 47-48) and how they heard about the research (question 49).

Finally, respondents were given the opportunity to give further comments:

Q/0-q46. Would you like to make any further comments about this survey or the topics of showering or water conservation?

Some students took this opportunity to give some water saving tips or recommendations for improvements to accommodation fixtures (often from an overseas perspective). For example:

> *"Water-saving devices should be fitted on the taps/faucets/showerheads."* [149M, 3rd year overseas student living on campus]
>
> *"I have the feeling that the UK is behind Germany, e.g. in our home at use we use rain water to flush the toilets. Its collected in a tank in our backyard. The water is also heated with solar energy. I also want to add that I find it important that one turns off the water in the shower while shampooing, shaving etc..."* [156F, postgraduate student from Germany living on campus]
>
> *"My shower is so low pressure that I only use it once a week after workout, it's not strong enough to wash my hair. I was* [sic] *my hair in the bath (with a jug) twice a week. It's concerns me the amount of water that myself and my housemates use by bathing often instead of showering! I have reported to UWE repairs and maintenance three times. It means it's hard for us to conserve water!"* [180F, 1st year UK (south-east) student living on site]
>
> *"Yes, I would like to offer some changes to be made in hostel accommodation facilities, in order to save more water."* [186M, 2nd year overseas student living on site]

> *"I use an eco shower head, which reduces water flow, reducing the amount of water I shower in. I use a washing machine with an eco cycle, a dishwasher with an eco cycle, and my metered water bill for my two bed home is £350 a year. I consider myself to be pretty responsible with water usage. My garden is watered from rainwater collected from the guttering. I have a soakaway in the garden, reducing water run off to the drainage system, and I believe myself to be environementally* [sic] *responsible"* [243M, postgraduate local student living at home]

4.2.2 Types of showering

The results of the hierarchical (three- to six-way) analysis, using the Q/0 questionnaire responses to shower *frequency* (question 6); *duration* (question 5); *outsourcing* (question 36a); and *number of products* (question 9) are summarised in Table 4-5, split by accommodation location.

The output indicates that most cases (survey responses) were grouped into just one dominant group, suggesting that most students shared a homogenous or standardised style of showering routine, and that there was little sensitivity in the number of clusters chosen. The three-way cluster option was selected as optimal (highlighted in yellow), as the additional (four-, five- and six-way) options did not reveal any meaningful showering types (with only between one and three members).

Table 4-5 Number of cases (responses) per cluster (round 1)

	Cluster 1	**Cluster 2**	**Cluster 3**	**Cluster 4**	**Cluster 5**	**Cluster 6**
All *(n=156)*						
3 clusters	13	141	2	N/A	N/A	N/A
4 clusters	13	139	2	2	N/A	N/A
5 clusters	13	136	2	3	2	N/A
6 clusters	11	136	2	2	3	2
On campus						
(n=90)	5	84	1	N/A	N/A	N/A
3 clusters	5	82	1	2	N/A	N/A
4 clusters	5	81	1	1	2	N/A
5 clusters	4	81	1	1	1	2
6 clusters						
Off-site *(n=66)*						
3 clusters	8	57	1	N/A	N/A	N/A
4 clusters	8	57	1	0	N/A	N/A
5 clusters	8	55	1	2	0	N/A
6 clusters	7	55	1	1	0	0

The variable dimensions for each cluster are summarised in Table 4-6; and Figure 4-40 to Figure 4-42. A descriptive cluster name or label was allocated to each style of showering. The dominant showering type (Cluster 2) contained 90.4% (141) of cases. Given this primary position, it was presumed to be typical of the '*UWE standard*' way of doing showering or *modus operandi*. Members showered slightly *less frequently* than the other two clusters (on average 5.9 times per week), but for slightly *longer* on average, compared with the '*out and about*' group (Cluster 1), in the comfort of their own bathroom.

The defining feature for Cluster 1 was *outsourcing*. This secondary cluster comprised all the cases (students) that indicated that they showered at the gym. Members of the group appeared to shower slightly more *frequently* (on average 6.6 times per week) than the majority style (Cluster 2), reflective of an active or sporty lifestyle, but took slightly *shorter showers* (averaging 9.3 minutes), than the primary group, perhaps because of the communal showering environment in which they took (some of) their showers or because they were *busy* people. Eight members lived *off-site* and five lived *on campus*. This type of showering can be described as '*out and about*'[53] (a term borrowed from Browne *et al.*, 2013b; 2013c).

[53] Whilst the descriptive labels were borrowed from Browne *et al.* (2013c; 2013d), the cluster analysis and its emergent showering typology represents an entirely original finding, unique to the UWE students.

Table 4-6 Cluster dimensions (round 1)

All *(n=156)*	**Cluster 1**	**Cluster 2**	**Cluster 3**	**All**
No. members *(n=)*	13	141	2	156
Q/0-q5. Shower duration				
Mean	9.29	11.52	55.00	11.56
Median	10	10	55	10
Minimum	4	3	50	3
Maximum	20	35	60	60
Std. deviation	5.484	5.650	7.071	7.477
Q/0-q6. Shower frequency				
Mean	6.62	5.9	8.50	6.03
Median	7	7	8.5	7
Minimum	3	1	7	1
Maximum	10	10	10	10
Std. deviation	1.609	2.033	2.121	2.019
Q/0-q36a. Outsourcing				
	☑	☒	☒	☒
Q/0-q9. Products				
Mean	2.92	2.9	4.00	2.91
Median	3	3	4	3
Minimum	1	1	4	1
Maximum	6	6	4	6
Std. deviation	1.320	1.126	0.000	1.138
Descriptive name	*'Out and about'*	*'UWE standard'*	*'Excessive'*	N/A

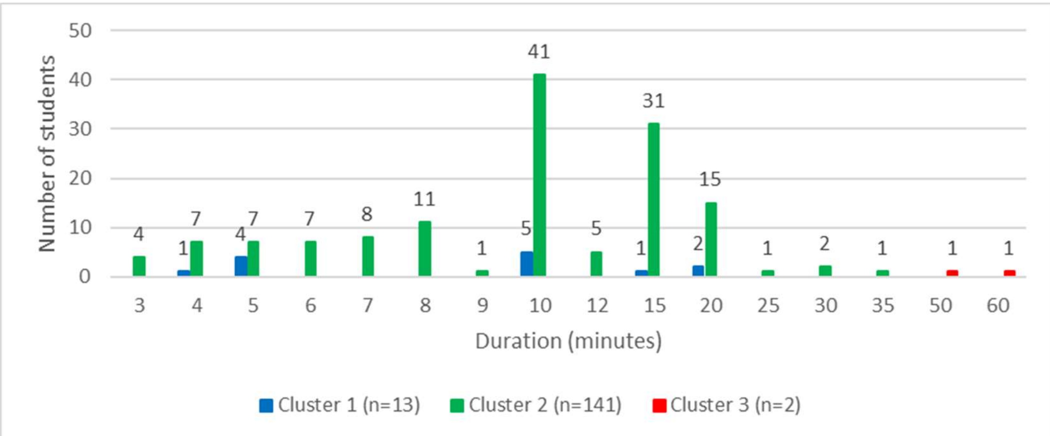


Figure 4-40 Shower duration, by cluster

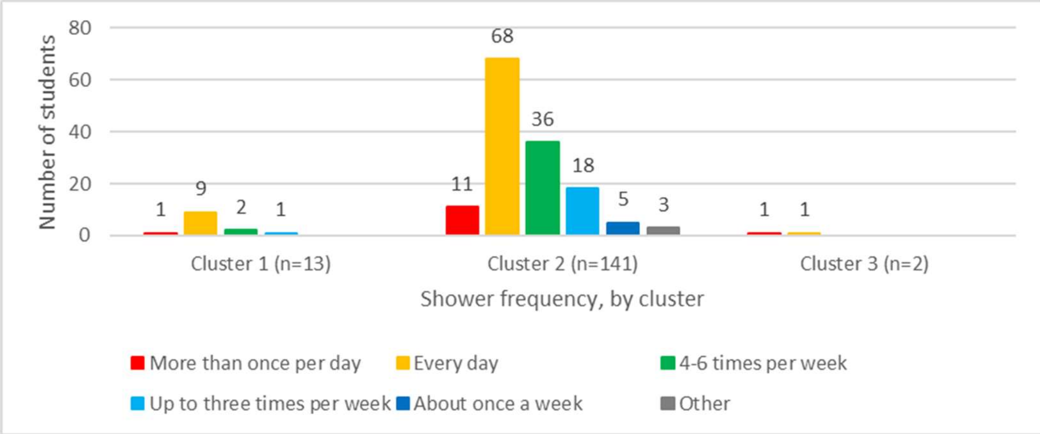


Figure 4-41 Shower frequency, by cluster

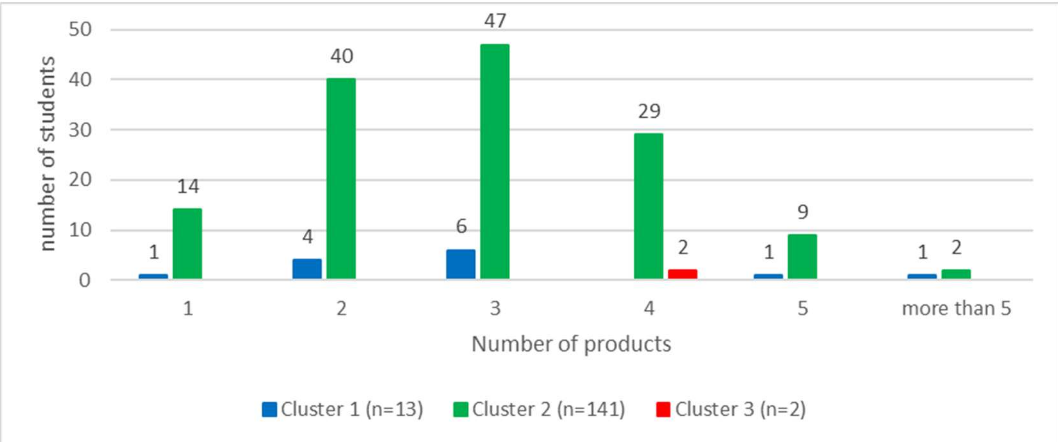


Figure 4-42 Number of products, by cluster

Cluster 3 comprised just two members, and the most obvious feature is *excessive* shower durations (50-60 minutes). Members of this group also showered more *frequently* (at least once a day) and used *more products* (4) than the rest. One lived *on campus*, whilst the other lived *off-site*, and were ascribed the value-laden label '*excessive*'. Members of this tertiary group were outliers compared with the substantive (Cluster 2) style of showering.

The volume of water used is a function of *flow* rate, event *duration* and *frequency*. Flow rate is controlled within the university accommodation with low-flow regulated water-efficient shower heads, although flow rates in *off-site* accommodation were unknown. Based on the other two variables of shower *frequency* and event *duration*, the total shower duration across the week can be calculated as a proxy for the volume of water used.

This is illustrated by the calculations below:

Cluster 1 ('*out and about*'): 9.3 mins x 6.6 times/week = 61.4 mins/week

Cluster 2 ('*UWE standard*'): 11.5 mins x 5.9 times/week = 67.9 mins/week

Cluster 3 ('*excessive*'): 55 mins x 8.5 times/week = 467.5 mins/week

The calculations indicate that the Cluster 2 style of showering was likely to use a similar volume to the *out and about* (Cluster 1) type (perhaps using marginally more water, assuming flow rates are similar between accommodation and gyms, although flow could be lower in communal gym facilities particularly those with percussion or push-button controls).

The responses to two questions on demographics were reviewed in the context of the different showering types, as a supplementary check to see if there was any sensitivity to nationality (question 19) or gender (question 40). The results are presented in Table 4-7. The nationality and gender splits between clusters (see Appendix C.2.1) mirrored the proportion in the overall sample. For example, 76.9% of *all* respondents were from the UK, and 77.3% of Cluster 2 members were domestic students, whilst 65.4% overall were female, compared with 66.0% of Cluster 2 members. This pattern was also reflected in the *on campus/off-site* dichotomy.

Table 4-7 Demographics split between clusters (question 40 and 19) (round 1)

Round 1		**Cluster 1**	**Cluster 2**	**Cluster 3**	**All**
Q/0-q19. Which town (or country, if you are not from the UK) is home?					
On campus	UK	3 [60.0%]	57 [67.9%]	0 [0.0%]	60 [66.7%]
(n=90)	Overseas	2 [40.0%]	27 [32.1%]	1 [100.0%]	30 [33.3%]
Off-site	UK	7 [87.5%]	52 [91.2%]	1 [100.0%]	60 [90.9%]
(n=66)	Overseas	1 [12.5%]	5 [8.8%]	0 [0.0%]	6 [9.1%]
All	*UK*	*10 [76.9%]*	*109 [77.3%]*	*1 [50.0%]*	*120 [76.9%]*
(n=156)	*Overseas*	*3 [23.1%]*	*32 [22.7%]*	*1 [50.0%]*	*36 [23.1%]*
Q/0-q40. What is your gender?					
On campus	Female	4 [80.0%]	56 [66.7%]	0 [0.0%]	60 [66.7%]
(n=90)	Male	1 [20.0%]	27 [32.1%]	1 [100.0%]	29 [32.2%]
	Other	0 [0.0%]	1 [1.2%]	0 [0.0%]	1 [1.1%]
Off-site	Female	4 [50.0%]	37 [64.9%]	1 [100.0%]	42 [63.6%]
(n=66)	Male	4 [50.5%]	19 [33.3%]	0 [0.0%]	23 [34.8%]
	Other	0 [0.0%]	1 [1.8%]	0 [0.0%]	1 [1.5%]
All	*Female*	*8 [61.5%]*	*93 [66.0%]*	*1 [50.0%]*	*102 [65.4%]*
(n=156)	*Male*	*5 [38.5%]*	*46 [32.6%]*	*1 [50.0%]*	*52 [33.3%]*
	Other	*0 [0.0%]*	*2 [1.4%]*	*0 [0.0%]*	*2 [1.3%]*

Whilst differences in demographic ratios were evident in the smaller clusters (1 and 3), these are unlikely to be significant, and simply a factor of small sample sizes. For example, 38.5% of Cluster 1 were male (compared with 33.3% overall, perhaps reflecting a bias for males to be more likely to be *sporty*) with 76.9% from the UK (the same proportion as *all* participants). Therefore, neither gender nor nationality had any significant bearing on membership of the clusters, and the proportion of members of each showering style shared similar nationality and gender ratios. Other socio-demographic parameters were reviewed (including era of parental home and size of family), but there was no evidence to suggest that they had any significant influence upon the style of showering adopted. This was likely to be a function of the dominance of the main '*UWE standard'* (cluster 2) type, which represented 90% of the sampled population.

Two further rounds of validation confirmed the round 1 findings that there were just three substantive showering types, representative of the research population. The results of this validation are summarised in Appendix C.2.2. Small sample sizes for the subsequent Wave 1 and Wave 2 questionnaires, precluded a repeat of the cluster analysis. Indeed, the purpose of the Wave 0 cluster analysis was to help design and targeting of subsequent interventions. However, to check that the showering typology derived in Wave 0 was representative of the subsequent cohorts of participants, descriptive statistics for four the showering dimensions (cluster attributes) were compared. These are summarised in Appendix C.2.3.

Whilst designing interventions for future shower water demand reduction strategies, it was important to be mindful of different showering styles. This was considered in more detail in Chapter 6 which covers the Wave 2 field trial.

4.2.3 Summary of end-user insights

The second part of this chapter focused on Research Objective 3, *to understand the showering routines of the UWE student population to identify groups that share similar showering patterns*. The responses to an expansive Q/0 questionnaire survey were analysed to explore how students *do* showering and other water-using practices. The data were disaggregated by accommodation location to assess differences in showering routines between students living in campus accommodation (with standardised infrastructure) compared with those living off-site (with unknown fixtures). For some dimensions, survey responses were further divided by different types of campus accommodation (and shower rooms – Wallscourt Park with shared facilities and the Student Village with private en suite spaces) and whether students were from the UK (and the water-stressed parts of south and east of England) or overseas (in relation to metered supplies and water quality at home). Slightly longer durations (4% longer than WCP residents, on average) and more frequent (70% at least daily) for students living in the Student Village (compared with 55% of WCP residents) suggest that the private en suite facilities, and the absence of any social policing by housemates wanting to gain access or monitor the actions of others, may promote more consumptive showering routines.

Cluster analysis was undertaken to categorise student showering routines into distinct styles (RQ3.1). The analysis was based upon the direct determinants of PCC: duration; frequency; and location (outsourcing to the gym); supplemented with the number of in-shower products used. These same dimensions were used to describe the features of the resulting clusters (RQ3.2).

Sensitivity tests provided verification that just three clusters could be identified, with most students (90%) conforming to a style of showering termed the '*UWE standard'* in which daily showers take ten to twelve minutes and three products are used, on average, to perform a bundle of in-shower activities, with washing the body and hair, the most common shower micro-practices. Another smaller group (8%) followed a *similar* pattern (perhaps slightly *shorter*), but they *outsourced* some of their showers to the gym - termed *'out and about'*. The final style of showering that emerged from the analysis is the '*excessive'* type, with at least *daily* and excessively *long* showers using four products, on average. However, there were only two recruits to this style of showering, so it may be regarded as an outlier. These showering types and their defining features were considered in the design of the Wave 2 field trial interventions. The results from the practice-based interventions are presented in Chapter 6.

Chapter 5 Results – Wave 1 (pilot) conventional interventions

The results presented here are from the first intensive (Wave 1) field trial that ran during the spring of 2018 (teaching block/term 2 of the academic year 2017/18). The trial set out to test the combination of essential data collection components needed to design, deliver, and evaluate (to collectively *operationalise*) a practical theory-grounded real-world water efficiency programme, within the university student accommodation, and represents the first practical steps required to address Objective 4 and Research Questions 4.1 – 4.2:

> *Objective 4 To design, pilot, deliver and evaluate components (factors[54] and processes[55]) of a real-world intervention strategy covering multiple levels and contexts.*
>
> > *RQ4.1 Can volumetric and end-user insights be collected and evaluated in combination despite different philosophical foundations?*
> >
> > *RQ4.2 How can [ISM/Social Practice Theory derived[56]] interventions be operationalised in a real-world application?*

The approaches used to answer these questions were two-fold: changes in water consumption at both household (meter) and shower fixture (logger) scales were measured; and, user-experiences were recorded through a combination of questionnaire (Q/1), diaries and focus groups (FG1-FG5). The findings were compared across the different data types in a process of triangulation to provide a level of validation and assurance that the findings reflected the true picture.

The Wave 1 trial piloted four different primary data collection instruments, supplemented with the university's BMS household water meter data. Ten Siloette data loggers were rigged up to the household water meters of ten houses in the WCP1 development, to record the volume and duration of water-using events at different fixtures (micro-components) across multiple houses for a prolonged period. The time series pulse data were processed and analysed to identify and quantify shower events. In parallel, WCP1 residents were recruited as research participants to keep shower diaries for two weeks whilst a set of water efficiency interventions were deployed. Participants were invited to complete the Q/1 online questionnaire (based on the original Q/0 survey, as described in Chapter 4) and to take part in focus groups to explore the individual, social and material

[54] Factor is an ISM term; elements is the equivalent for social practice theory
[55] Processes are the links or relationships between elements or factors
[56] Wave 1 tested conventional interventions, whilst ISM/Social Practice Theory derived interventions were tested in Wave 2 (see Chapter 6)

contexts and associated factors or elements that are bound to water-using routines in general, with a particular focus on showering. The diaries, questionnaire, and focus groups, in combination were designed to gather end-user shower routine insights to assess the impact of four shower demand reduction interventions, and to identify and co-design alternative practice-based interventions for the subsequent Wave 2 field trial (see Chapter 6).

As this was a pilot field trial to test the methodology in practice, conventional interventions of the type traditionally used by water supply companies based upon individualised rational choice were deployed. The trial set out to provide a baseline of demand reduction performance from which to compare the efficacy of the novel practice-based interventions that were later trialled in Wave 2. The Wave 1 interventions (posters; simple four-minute sand timers; Amphiro a1 smart shower fixture meters; and a face-to-face education style of engagement delivered via a focus group, FG1) were delivered to four pairs of houses, alongside four houses that received no intervention to act as controls.

The timeline for the Wave 1 trial, showing the multiple data collection activities and trial phases, across the first quarter of 2018, is summarised in Figure 5-1 (based upon Table 3-7).

Summary of Wave 1 findings

Lessons were learned as to how to operationalise a mixed-methods research approach in a real-world setting. These insights were used to inform the subsequent steps in the research including an interim stakeholder focus group (FG6) to evaluate the Wave 1 trial and to design novel, practice-based interventions (see Appendix D); and to refine and simplify the data collection approach for the subsequent Wave 2 field trial. The results from Wave 2 are presented in Chapter 6.

Some of the initial findings in this chapter were presented at the Watef Network conference in 2018 (**Simpson** *et al.*, 2018 – see Appendix F) and further developed and published (**Simpson**, Staddon, and Ward, 2019 – see Appendix F). The early results have been further expanded, developed, and interpreted here.

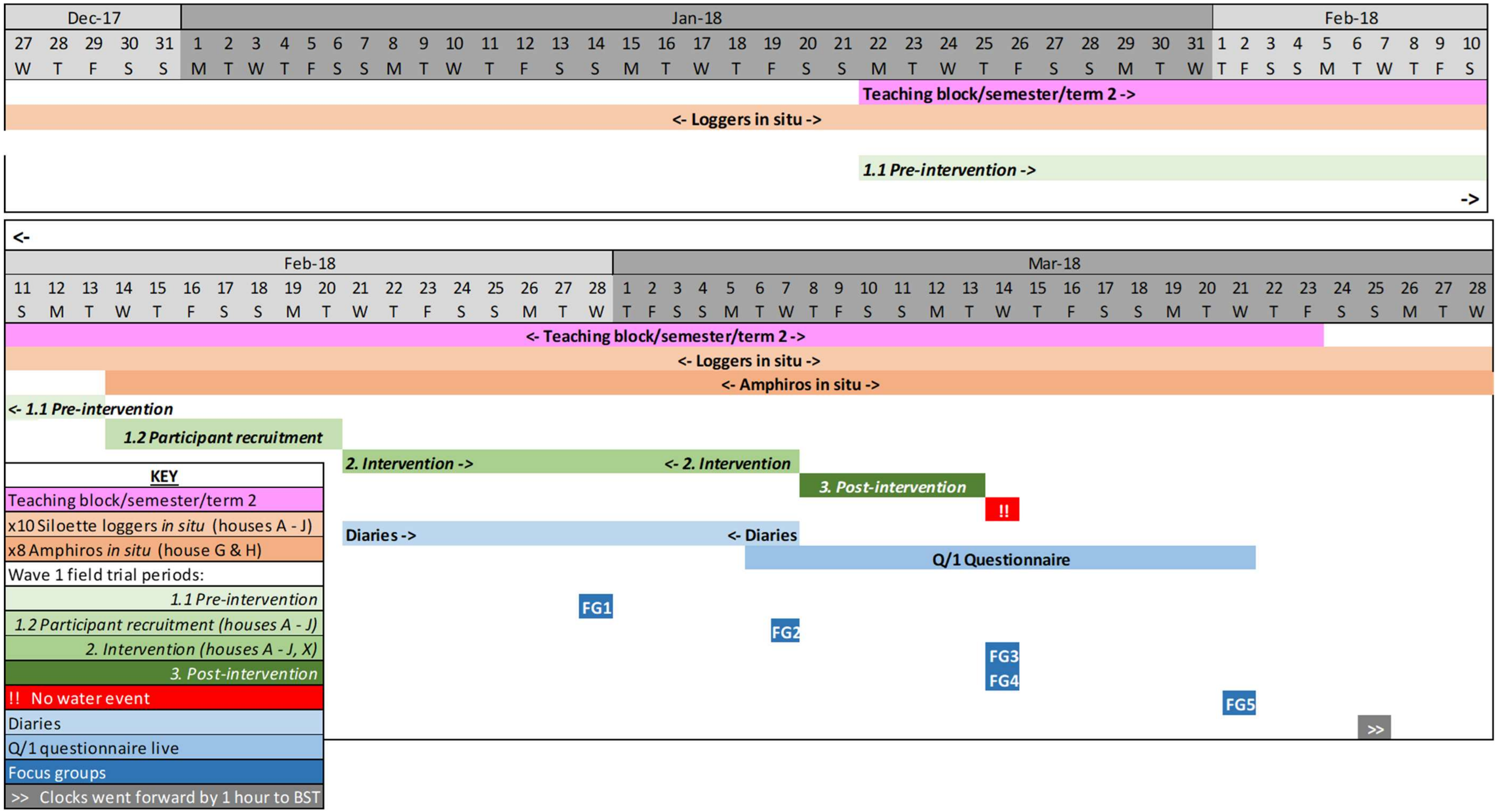


Figure 5-1 Timeline for Wave 1 field trial

Research Objective 4 (design, pilot, deliver and evaluate)

RQ4.1 (data collection and evaluation)

- Metrology is not infallible and other influences on successful measurement can be beyond the control of the researcher and need to be planned for (design and pilot);
- It was feasible, although challenging, to measure and disaggregate the dimensions of showering within a large (eight-bed) house via pulse loggers connected to the household meter, and shower routines were profiled across the multiple dimensions of frequency, duration, and volume (design and pilot);
- PCC is a flawed and unreliable measure of consumer use (evaluate);
- Students living in WCP1 used around 100 l/*p*/d during term-time, on average (evaluate);
- Consumption during the Wave 1 trial varied, from a modest 84 l/*p*/d (houses I and J) to a relatively high level of 151 l/*p*/d (houses A and B), on average (evaluate); and,
- There was a discernible, but not statistically significant reduction in consumption across the term 2 teaching period and there were also indications that the Amphiro devices may have reduced shower use (evaluate).

RQ4.2 (deploy interventions in real-world setting)

- There is little evidence that neither posters nor shower timers consistently deliver water savings (evaluate);
- There is reasonable evidence that Amphiro devices have the potential to alter shower routines and deliver measurable shower water savings across multiple dimensions (evaluate);
- The participants were receptive to engagement on their shower routines and became more aware or mindful of how they use water (evaluate);
- Morning showers were 2.6 minutes quicker than evening showers, on average (evaluate); and,
- Evaluation of a real-world water efficiency programme is complex and requires multiple approaches to get to the truth (evaluate).

5.1 Volumetric water consumption

5.1.1 Household and *per capita* consumption

Figure 5-2 to Figure 5-4 show the daily water consumption for the WCP1 development[57] during the academic year 2017/18 from 01 September to 31 May. The period covered on the left of the plot (September to December 2017) is the same as the plot in Figure 4-10 to Figure 4-12. Figure 5-2 shows consistent but modest consumption (of around 0.1 $m^3/b/d$), on average) during term time, with visible dips during student vacations (in December, coinciding with the three-week Christmas vacation and the two-week Easter vacation in late March/early April, due to lower than usual occupancy).

Water use was slightly lower during the academic assessment (exam) periods (January and May). There is an obvious dip in consumption on 14 March. This was caused by a major water mains-burst event that resulted in a large proportion (c.40%) of the campus estate, including the WCP1 development, having no water for about 30 hours (from 02:30 hours 14 March to 12:00 hours 15 March 2018), during cold and snowy weather. As a result of the burst and subsequent repair, debris was pulled through into the pipework and damaged (flatlined) seven household meters including one located at one of the trial houses (house A). This demonstrates that no metrology system is perfect and needs to be planned for in any assessment of system performance. Further instances of meter failure were also detected during the post-trial analysis and are reported in the next section (5.1.2).

Figure 5-3 shows the variability in water consumption between *all* WCP1 houses *(n=37)*, from September 2017 to May 2018, whilst Figure 5-4 plots the variability in water use for the twelve study houses, A to L. The plots illustrate the natural variability, with several spikes in consumption throughout the year and erratic extremes, with the high use more visible than the below average dips. The intensity of colour illustrates that the water consumption in separate houses track the overall median trajectory (in Figure 5-2), with a clear central tendency in usage, and the similarity between the two plots confirms that daily consumption for the twelve study houses was representative of the consumption across the whole WCP1 development.

[57] There were missing BMS data: for house A from 15 November to 18 December 2017; and for house G from late December 2017 until late March (due to interference from the Siloette pulse loggers). This is discussed further in section 5.1.2.

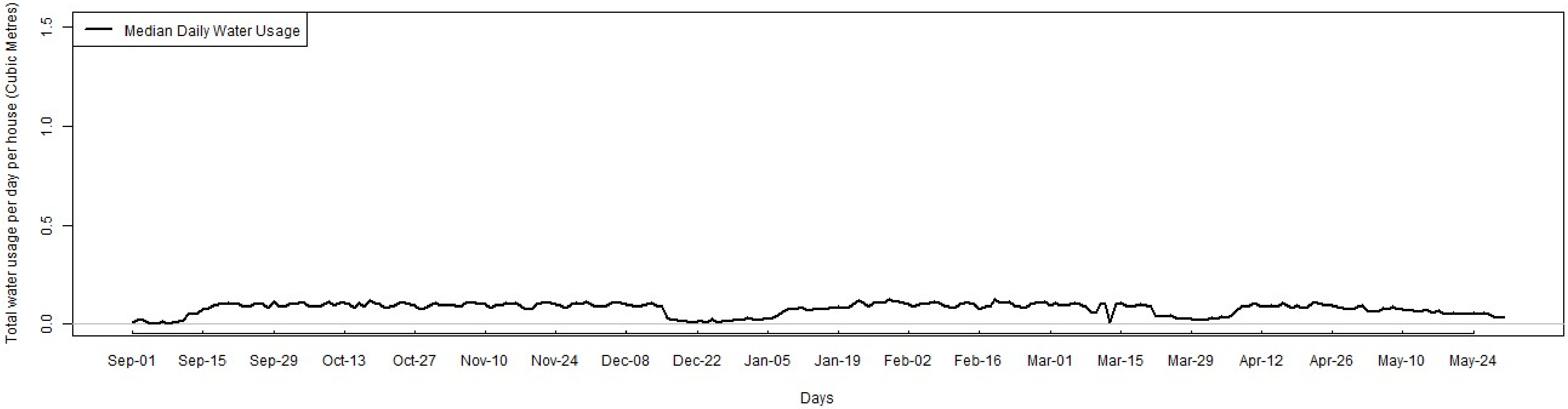


Figure 5-2 Median daily per bed water consumption for ALL houses (n=37), Sep to May 2017/18 – WCP1

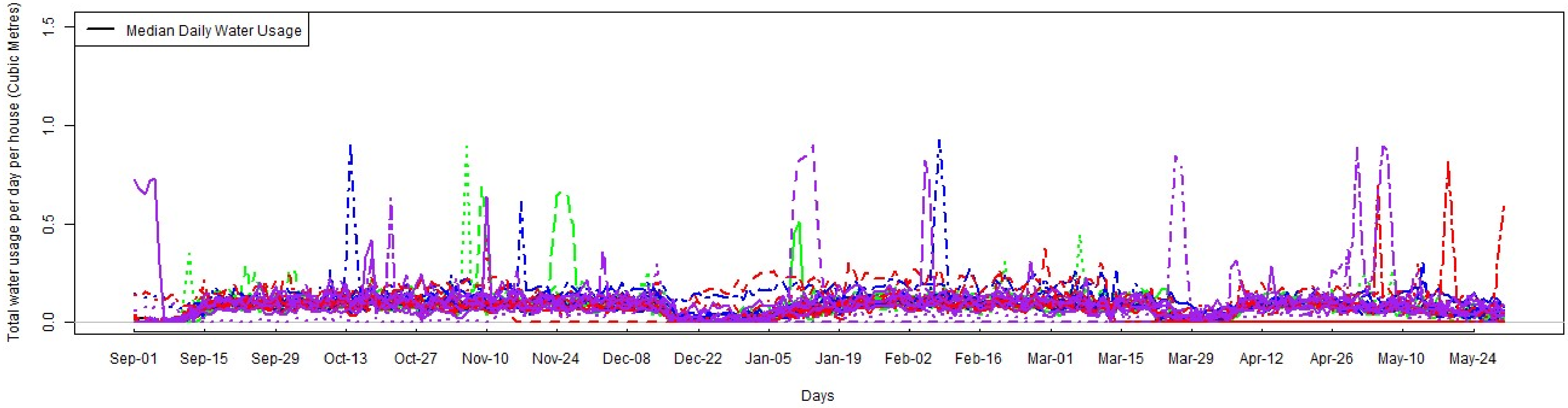


Figure 5-3 Daily per bed water consumption for EACH house (n=37), Sep to May 2017/18 – WCP1

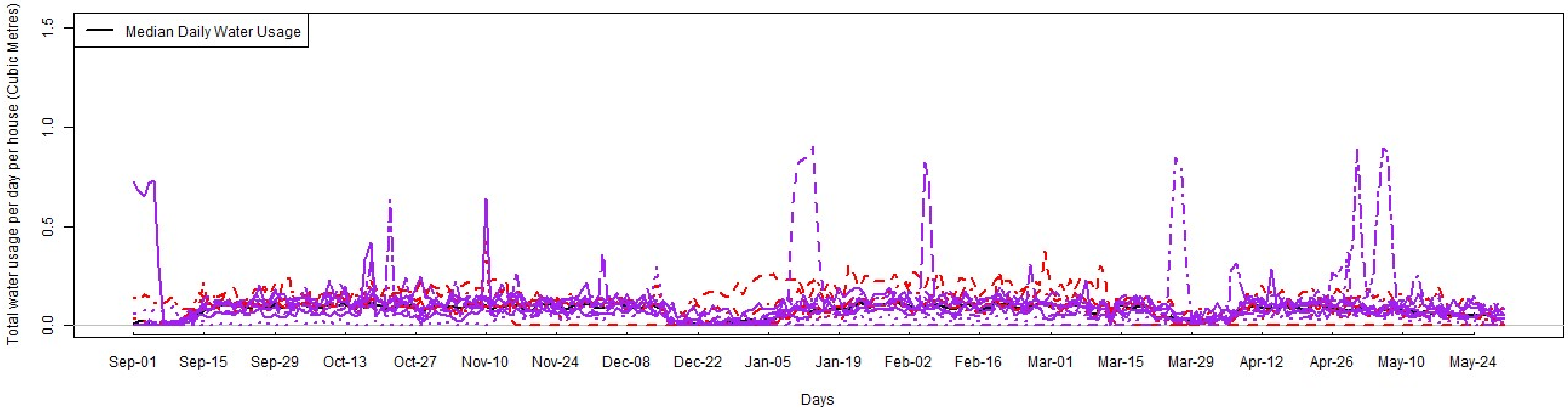
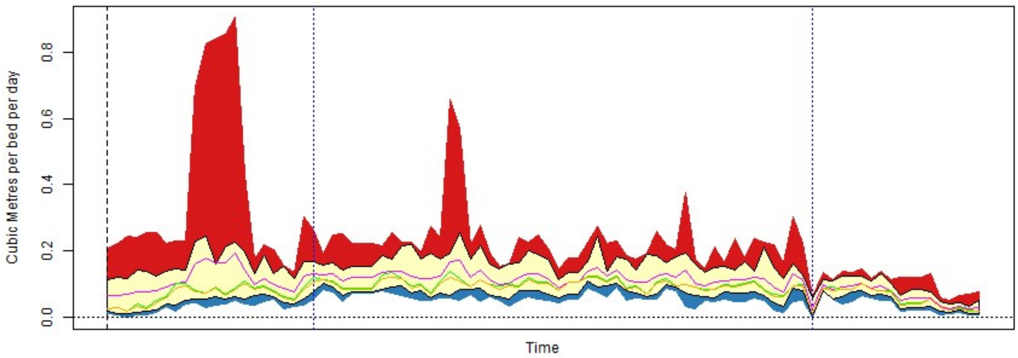
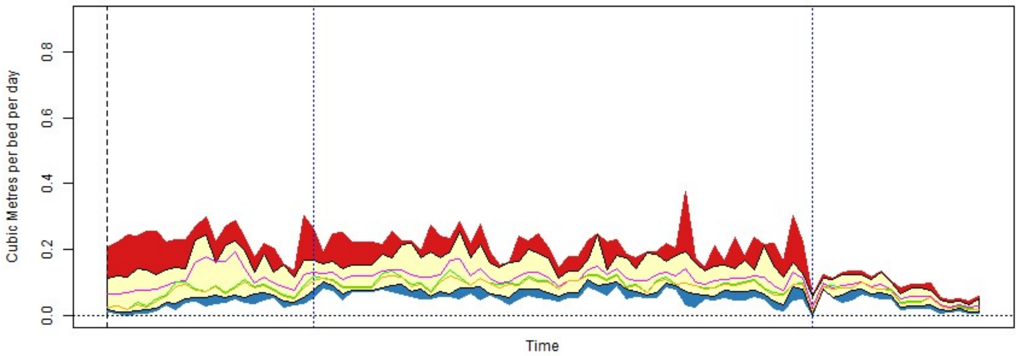


Figure 5-4 Daily per bed water consumption for EACH study site house (n=12), Sep to May 2017/18 – WCP1

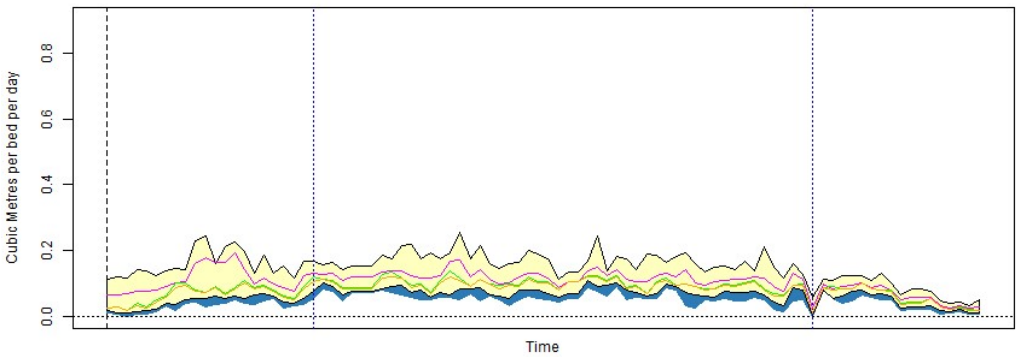
The daily water use data for each study site house (A to L), from 01 January to 31 March 2018 are plotted in Figure 5-5, with upper and lower consumption bounds to aid visualisation[58] and show the typical pattern of use. The duration of the Wave 1 trial is marked between two vertical lines, starting on 22 January when teaching block 2 started, and ended prematurely on 13 March, immediately prior to the *no water* event on 14 March.



Excessive = worst *two; Middle* = *eight*; *Excellent* = best *two* houses on any day
Mean; median and median with top two houses removed



Excessive = worst house on any day (worst house removed)



Worst *two* houses removed

Figure 5-5 Per bed water consumption (Term 2, 01-Jan to 31-Mar-2018) – WCP1 study houses A – L (n=12)

[58] See Figure 3-14 for an annotated illustration and key to aid interpretation.

The first plot shows a spike in consumption during 10-15 January (house K peaked at 0.903 $m^3/b/d$ on 14 January). This was before teaching commenced on 22 January. There was another spike on 05-06 February (0.656 $m^3/b/d$ on 05 February) at house H. The lower plots, with these outlier peaks removed, show a narrower and more consistent spread of typical use. However, it is not possible to discern any visible change in consumption that might be uniquely attributable to any of the four interventions that were deployed between 21 February and 07 March 2018. This may be because the interventions were delivered to pairs of houses with differing levels of success due to several mechanisms acting upon a mix of end-user routines, and therefore, were lost within the aggregated consumption for the eleven houses plotted here. For example, measures focused on above average users would have been more obvious and successful than targeting low consuming users with limited capacity to make savings.

PCC for the study site and the wider WCP1 development was estimated using both design (*per bed*) and rented[59] (*per person*) occupancy. These were presented in Table 4-2 and pulled across to Table 5-1 (in *grey font*), for convenience. Due to uncertainty about consumption for houses A and G due to missing BMS data arising from logger interference (see section 5.1.2), and for house L due to uncertain and varying occupancy levels, the Table 4-2 figures were reviewed to assess the impact of these three houses on total PCC. This revised analysis nudged the estimates slightly upward.

The estimations confirm that the PCC for WCP1 was just over 100 l/*b*/d across both teaching periods. There was an apparent but negligible increase in consumption during term 2 compared with terms 1, despite of the delivery of water saving interventions across the study site and supporting engagement with a sample of the resident students. This may be due to a small but unknown decrease in occupancy in term 2 compared with term 1 or other factors such as weather (e.g., colder temperatures in term 2) or activities patterns (such as different lecture timetables or other schedules).

A Spearman’s rank correlation was calculated to check for any association between the two time periods for each house. The details of this calculation are presented in Appendix B.3. The resulting coefficient was 0.72, indicative of a moderate correlation between the two sets of consumption data. This confirms that consumption levels were broadly comparable between the two teaching periods for each house (despite Wave 1 interventions).

[59] A snapshot of rented occupancy on a specific fixed date within the year

Table 5-1 PCC for WCP1 (litres per bed/person per day) – 2017/18

PCC		**2017 – Term 1 [Wave 0]** *25-Sep to 08-Dec*	**2018 – Term 2 [Wave 1][2]** *22-Jan to 13-Mar*
No. days		*75*	*51*
Design occupancy *(per bed)*	*All: A-X (from Table 4-2)*	*99.9*	*101.7*
	All: excl. houses A, G, L	101.2	102.8
	Study site: A-L (from Table 4-2)	*93.6*	*96.3*
	Study site: excl. houses A, G, L	98.0	99.8
Rented[1] occupancy *(per person)*	*All: A-X (from Table 4-2)*	*102.4*	*104.3*
	All: excl. houses A, G, L	103.1	104.7
	Study site: A-L (from Table 4-2)	*98.3*	*101.2*
	Study site: excl. houses A, G, L	100.6	102.4

[1]Rented occupancy is based on lettings on 27-Mar-2018, as supplied by UWE Accommodation Service and assumes the same level of occupancy throughout
[2]To 13-Mar-2018 only as the no water event on 14-Mar-2018 caused seven WCP1 meters to go offline, including house A
House A excluded due to missing BMS data: Term 1 from 15-Nov-2017 due to logger interference; and Term 2 from 14-Mar-2018 due to no water event
House G excluded due to missing BMS data: Term 2 due to logger interference
House L excluded due to uncertain and varying occupancy levels

The BMS water consumption data were divided into different phases of the trial:

1. Pre-intervention from 22 January to 20 February 2018;
2. Intervention from 21 February to 07 March 2018; and,
3. Post-intervention from 08 to 13 March 2018[60].

The Wave 1 BMS consumption data, divided into trial phases and grouped by paired households is summarised in Table 5-2. The missing meter data for house G were supplemented with the logger event data (see section 5.1.2 for more detail on the logger results). The average PCC consumption estimate of 108.5 l/*p*/d, was slightly higher than the 102.4 l/*p*/d estimate reported in Table 5-1. This discrepancy was due to missing BMS data in the Table 5-1 estimations (for house A in term 1, and house G in term 2), and unreliable estimates of occupancy (for house L). The PCC values in Table 5-2 include estimates for these three houses based on term 1 performance. Whereas consumption at house A was excessive and substantially higher than the other study houses, houses G and L were below average and low, respectively. In combination, the inclusion of consumption for these three houses raised average consumption overall.

[60] Post-intervention phase was disrupted for around 30 hours by the *no water* event on 14 March 2018, and the phase was prematurely truncated due to missing BMS data.

Table 5-2 PCC for different phases of Wave 1 field trial (l/p/d)

House	Whole Wave 1 22-Jan to 13-Mar	1.Pre-intervention 22-Jan to 20-Feb	2.Intervention 21-Feb to 07-Mar	3.Post-intervention 08-Mar to 13-Mar	Change in PCC Between Pre-/Post intervention	
					(litres)	(%)
No. days	*51*	*30*	*15*	*6*		
A and B	150.9	153.1	148.1	146.3	-6.8	-4.5
C and D	121.4	128.9	116.5	95.7	-33.2	-25.8
E[1] and F	118.4	125.2	111.9	100.5	-24.7	-19.8
H only	120.7	135.8	112.6	65.5	-70.3	-51.7
I and J	84.1	84.1	80.4	93.0	+8.8	+10.5
K and L[1]	61.8	61.3	65.8	54.1	-7.2	-11.7
Mean	***110.1***	***114.8***	***106.4***	***95.7***	***-19.1***	***-16.7***
G logger	*90.2*	*99.8*	*78.2*	*71.9*	*-27.9*	*-27.9*
G and H	*107.1*	*119.8*	*97.3*	*68.4*	*-51.4*	*-42.9*
Adjusted mean	***108.5***	***113.6***	***104.1***	***93.7***	***-19.8***	***-17.5***

[1]PCC calculated using rented occupancy, not design/per bed, and impacts on house E & L calculations due to void beds

Analysis shows that, for the whole study period, houses A and B (control) had substantially higher PCC (150.9 l/*p*/d, on average) than other houses in the study and across the wider estate (refer to Figure 5-2), in all phases of the trial, whilst houses I and J (face-to-face engagement) had the lowest consumption (84.1 l/*p*/d, on average) of the trial houses. Houses K and L, with the lowest consumption, were not directly included in the trial (due to insufficient loggers and, in the case of house L, low, unknown, and fluctuating occupancy), although they acted as additional no-intervention houses, supplementing the control houses A and B, and received zero engagement by the researcher and zero participation by the residents.

Changes in average PCC between the different trial phases, from pre- to post-intervention for each pair of intervention houses are plotted in Figure 5-6. Consumption reduced across most trial houses from the pre- to the post-intervention periods, including a small decrease for the control houses, A and B (and the no-intervention houses K and L). This suggests a general background trend for a slight reduction in demand across the study site as the teaching period progressed, *independent* of the interventions. The only exception was observed for houses I and J, with an increase (10.5%). However, this pair of houses started with a low PCC across (just 84 l/*p*/d) and remained low (below the mean) in the post-intervention phase. It may not have been practical to reduce already low consumption any further.

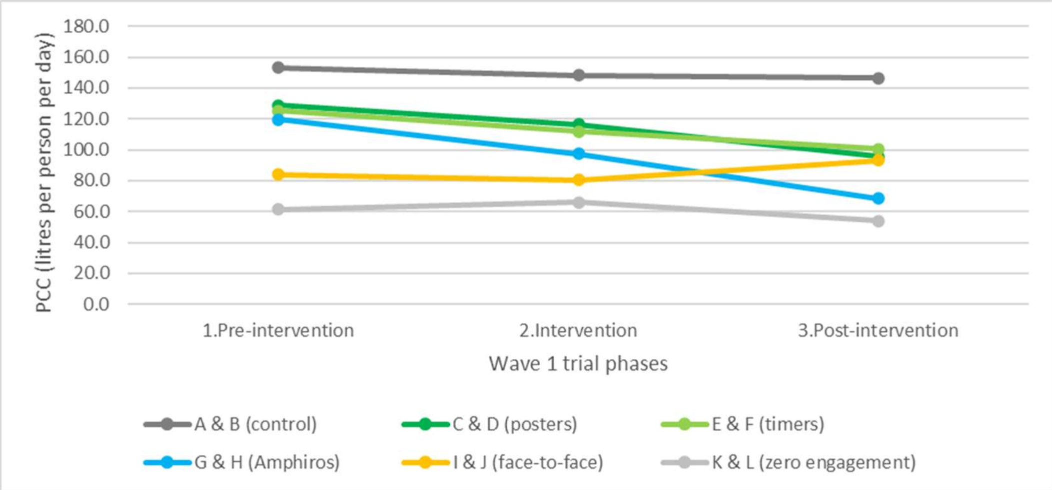


Figure 5-6 PCC for different phases of Wave 1 field trial (l/p/d)

The other four pairs of houses (A to H) started with above average consumption (at least 120 l/*p*/d), and all showed a reduction in water demand during the trial period. Allowing for the general reduction observed for the control or no-intervention houses (of around 7 l/*p*/d, or 10%), the water-saving devices (posters, timers and Amphiros) appeared to have an impact on demand reduction. Houses G and H (Amphiros) showed an impressive PCC reduction of 42.9% overall suggesting that the smart shower meters were apparently effective in reducing demand among mid to high use consumers (over and above the observable background trajectory). The presence of the posters (houses C and D) and timers (houses E and F) coincided with a modest reduction in demand, more than the small background reduction (observed in the control houses) alone would suggest.

The significance of the observed changes in consumption across the trial phases was tested with an analysis of variance using a one-way ANOVA Kruskal-Wallis test (Geert van den Berg, 2022). The outputs are listed in the Appendix B.2. The results pointed to possible significant variance in water use between the different phases of the trial for houses A, C, E and K only. Consumption at houses A and C changed in the *post*-intervention phase (3), and the *intervention* phase (2) for houses E and K.

However, these apparent changes in water use were unlikely to have been a direct result of any of the interventions or engagement activities. This is because the statistical changes were only detected for the less engaged house of each pair. None of the residents from these houses participated in any of the focus group discussions, whilst only four kept diaries and four (from two houses) completed the Q/1 survey. The timing of the supposedly significant adjustments is also relevant. The changes in consumption for house A and C coincided with the post-intervention phase, based on limited data (just six days metered consumption), rather than the intervention (and diary engagement) phase. And for house C, it did not occur when the posters were *in situ* but after they had been removed. There were no interventions in house A and only one resident participated in any of the engagement activities (diary). These observations are summarised in Table 5-3. The variance is more likely to be explained by unknown fluctuations in occupancy or other unidentified alterations in water using routines.

Table 5-3 Observations that nullify the significance of the ANOVA Kruskal-Wallis results

House	Intervention	Engagement	Phase	Observations
A	control	1x diary	3	• No intervention • No corresponding change for more engaged (2x diary, 1x Q/1, 2x focus group) paired house B
C	'share' poster	1x diary 2x Q/1	3	• Poster *in situ* during intervention phase (2) only • No corresponding change for more engaged (3x diary, 2x Q/1, 3x focus group) paired house D
E	timer	2x diary 2x Q/1	2	• No corresponding change for more engaged (3x diary, 4x Q/1, 3x focus group) paired house F
K	control	None	2	• No intervention or engagement

5.1.2 Shower fixture micro-component events

The post-trial analysis revealed that the majority of the Siloette loggers failed to record any data. Just a single logger, attached to the house G meter successfully collected timeseries pulses. On closer review, it also explained the missing BMS data for houses A and G (as noted in section 5.1.1), as the missing data was confirmed to be due to interference from the loggers when they were *in situ*, directly connected to the meters (the test run for house A, as reported in Chapter 4, and the Wave 1 trial for house G).

The timeseries pulse data for the logger attached to house G identified 263 shower events across 51 days of monitoring, from 22 January when the teaching term commenced and full occupancy was assumed, to 13 March 2018, the day prior to the *no water* event (equivalent to 32 showers per resident or 0.6 per day). The logged consumption data were analysed to calculate average household consumption, split by weekday and weekend. These are summarised in Table 5-4. The results indicate *modest* levels of consumption throughout the 51-day monitoring period, with average PCC at around 90 l/*p*/d, and weekend use was lower at about 80% of weekday use.

Table 5-4 Average daily water consumption (house G)

Variable	Median consumption (litres per day)		Mean consumption (litres per day)	
	Household	*Per capita**	*Household*	*Per capita**
Weekday *(n=37)*	739.7	92.5	788.9	98.6
Weekend *(n=14)*	587.5	73.4	613.5	76.7
All days *(n=51)*	709.5	88.7	740.7	92.6
**PCC based on design occupancy of 8*				

Total logged daily *household* consumption for house G is plotted in Figure 5-7. The bars on the left (in grey) represent the pre-intervention phase from the start of the teaching term (22 January), with the lighter shaded bars showing consumption at weekends. Reduced weekend use is visible across the Wave 1 monitoring period. The magenta bar indicates when the Amphiro devices were installed (on 14 February), whilst the subsequent week (before the main engagement/intervention phase) is shown by the red bars. The main intervention (and diary) phase is shown in green and the (limited) post-intervention phase (in which the Amphiros remained *in situ*) is shown on the right in blue.

The plot shows a drop in consumption during the fortnight *intervention* phase (green), and the following post-intervention week (before monitoring was prematurely halted on 14 March due to the *no water* event). This suggests that the smart shower devices and/or the diaries had a water saving effect. The Amphiro devices were present at the point-of-use in the showers for all residents, while the diaries were only completed by two residents, suggesting the observed water reduction was more likely to be due to the devices rather than the diary engagement. However, the act of recording diaries may have had an amplifier effect and predisposed the diarists to be mindful of water use, and to possibly rippled through to the household.

The timeseries data were disaggregated and allocated to micro-components (either shower events or other use). The 263 unique shower events were analysed to calculate average shower frequency, volume, and duration. Showering activities accounted for just over a third of total household consumption (35.7%). The analysis was split by weekday and weekend and is summarised in Table 5-5.

Table 5-5 Average shower use, by day of the week (house G)

Variable	**Mean event frequency** *(uses per day)*	**Mean event volume** *(litres)*	***Household*** **shower consumption [% of PHC]** *(l/h/d)*	***Per capita**** **shower consumption** *(l/p/d)*	**Mean event duration** *(mins)*	**Mean event flow** *(l/min)*
Weekday *(n=37)*	5.4	52.5	284.8 [36.1%]	35.6	9.3	6.2
Weekend *(n=14)*	4.4	47.4	211.6 [34.5%]	26.5	8.7	6.0
All days (n=51)	*5.2*	*51.1*	*264.7 [30.5%]*	*33.1*	*9.1*	*6.1*
**Per capita shower consumption based on design occupancy of 8*						

The results confirm that the students living in house G took fewer and shorter showers at the weekend compared with on weekdays, and they tended to shower only every other day on average (less than the daily norm), for around nine minutes per shower. This is notably lower than the self-reported average in Q/0 (Wave 0) of 12.9 minutes for those living on campus. Average shower volumes of 51.1 litres were not excessive, indicating that the low-flow water efficient shower fixtures helped to curtail consumption despite the slightly longer (than average for the general population) durations.

The same data, separated into different phases of the trial (summarised in Table 5-6) confirm a reduction in both *household* or *per capita* consumption and shower water use (volume, frequency, *and* duration) during the intervention and *post-intervention* phases. The act of installing the Amphiro devices on 14 February (part-way through the *pre-intervention* phase, between 22 January and 20 February) appeared to coincide with lower total *household* consumption (by 14.7%, from 805.9 to 687.2 l/*h*/d) and the shower component (by an impressive 36.8%, from 331.8 to 209.6 l/*h*/d). In addition, the shower frequency reduced by 23.7% (from 5.9 to 4.5) and the volume per shower reduced by 17.1% (from 56.2 to 46.6 litres per shower).

Daily *household* consumption was ranked from high to low, to explore the correlation between the shower component and total use. This is presented in Figure 5-8. High consumption is to the left, and low consumption on the right. The blue portion of the bars respresents shower use (at around 35%, on average) with water use through other fixtures shown in grey. Installation of the Amphiro devices (14 February 2018) is marked with an arrow (in pink, 14th of 51 days). The bars are labelled to show the different phases of the trial. Bars with no coloured outline represent days *prior* to any engagement/Amphiro installation (phase 1.1, before 14 February 2018, *n=23 days*). The median, day 26 is labelled.

Table 5-6 Average household consumption and shower use, by phases of trial (house G)

Variable	***Household*** **consumption** ***[per capita*** **onsumption]** *(l/h/d)*	**Mean event frequency** *(uses per day)*	**Mean event volume** *(litres)*	***Household*** **shower consumption [% of PHC]** *(lhp/d)*	***Per capita**** **shower Consumption** *(l/p/d)*	**Mean event duration** *(minutes)*
1.Pre-intervention (22-Jan to 13-Feb, *n=23*)	805.9 [100.7]	5.9	56.2	331.8 [41.2%]	41.5	9.5
Amphiro *in situ* (14-Feb to 13-Mar, *n=28*)	687.2 [85.9]	4.5	46.6	209.6 [30.5%]	30.5	8.8
2.Diaries/ intervention phase only (21-Feb to 07-Mar, *n=15*)	618.7 [77.3]	4.7	41.6	195.5 [31.1%]	31.6	8.4
2/3.Intervention and Post-intervention phase (21-Feb to 13-Mar, *n=21*)	606.4 [75.8]	4.2	45.1	189.4 [31.2%]	31.2	9.0
Change between Pre-/Post intervention	***199.5 [25.8%]***	***1.7 [28.8%]***	***11.1 [19.8%]***	***142.4 [42.9%]***	***10.3 [24.8%]***	***0.5 [5.3%]***

The variable height of the blue shower components indicates that shower use was *independent* from water used via other fixtures and other purposes. The six full days that the devices were *in situ, pre-intervention* (phase 1.2, 15 to 20 February) are outlined in red; whilst the six days that the Amphiros remained *in situ, post-* intervention (phase 3, 08 to 13 March), are outlined in turquoise. The fifteen days the diaries were recorded (*intervention* phase), by two participants are outlined in green (phase 2, 21 February to 07 March 2018) and generally match with the below median lower consumption days.

The plot shows fifteen of the 25 highest consuming days (above the 26th day median of 709.5 l/*h*/d consumption; equivalent to 88.7 l/*b*/d) correlated with the *prior* engagement time frame (phase 1.1, no coloured outline bars) and a further four high-use days fell within the *pre- intervention* period (phase 1.2), i.e., three quarters of the highest consuming days occurred during the first half of the monitoring period. Only seven *prior* engagement and two *pre-intervention (phase 1.1 and 1.2*) days (36%) had lower than average consumption (below the median, to the right of the plot). This points to lower consumption in the later stages of the trial and indicates that either the *engagement* (with two diarists) or the Amphiro *intervention* (more likely), or a combination of both, had a moderating impact on *total* household water use.

The same data in Figure 5-8 were re-ranked on daily *shower* volume rather than total household volume (see Figure 5-9). This followed a similar pattern to the daily *household* water use plotted in Figure 5-8. The analysis shows that sixteen of the *prior* engagement (69.6%) and three *pre*-intervention (57.1%, phase 1.1 and 1.2) days were in the top 25 ranked days (above the 26th day median, with 258.7 l/*h*/d; four shower events; and 33.2% of total household consumption). Meanwhile, the majority (eleven of 15, 73.3%) of the *intervention* (and diary) and five of six *post*-intervention (83.3%, phase 3) days occurred in the lower rankings. This hints that the lower shower water demand continued beyond the limited diary phase and confirms that the presence of the devices may have had a household level and continued impact on lowering shower use, including among the residents (six of eight) that did not keep diaries despite instructions on how to use the Amphiro devices only being directly shared with the diarists (on 21 February), a week *after* the Amphiros were installed. The residents were not informed that the loggers were *in situ* or that their household water use was being monitored via loggers or household meters throughout the duration of the trial. It is unfortunate that the trial was cut short prematurely by the no-water event on 14 March.

5.1.3 Summary of volumetric measurement findings

The first part of this chapter presented a face-value evaluation of the impact of interventions on water use, measured by changes to volumetric consumption. It recognised the difficulty in calculating PCC due to unknown variations in occupancy and highlighted how PCC, as usually calculated, may not be an objective or reliable measure as it is based upon estimations of the population served and is therefore, a flawed success measure. Nevertheless, section 5.1 set out to answer the question: *did the water saving interventions work* and *was a reduction in water use achieved?* (RQ4.1).

There were several practical challenges in delivering the Wave 1 trial. For example, any metrology system is imperfect and successful measurement can be beyond the control of the researcher (for example, incompatibility between the loggers and the BMS meters or the water outage and subsequent loss of data from 14 March 2018). However, despite the challenges, it was possible to measure the dimensions of showering within a large multi-occupant house, such that shower routines could be profiled.

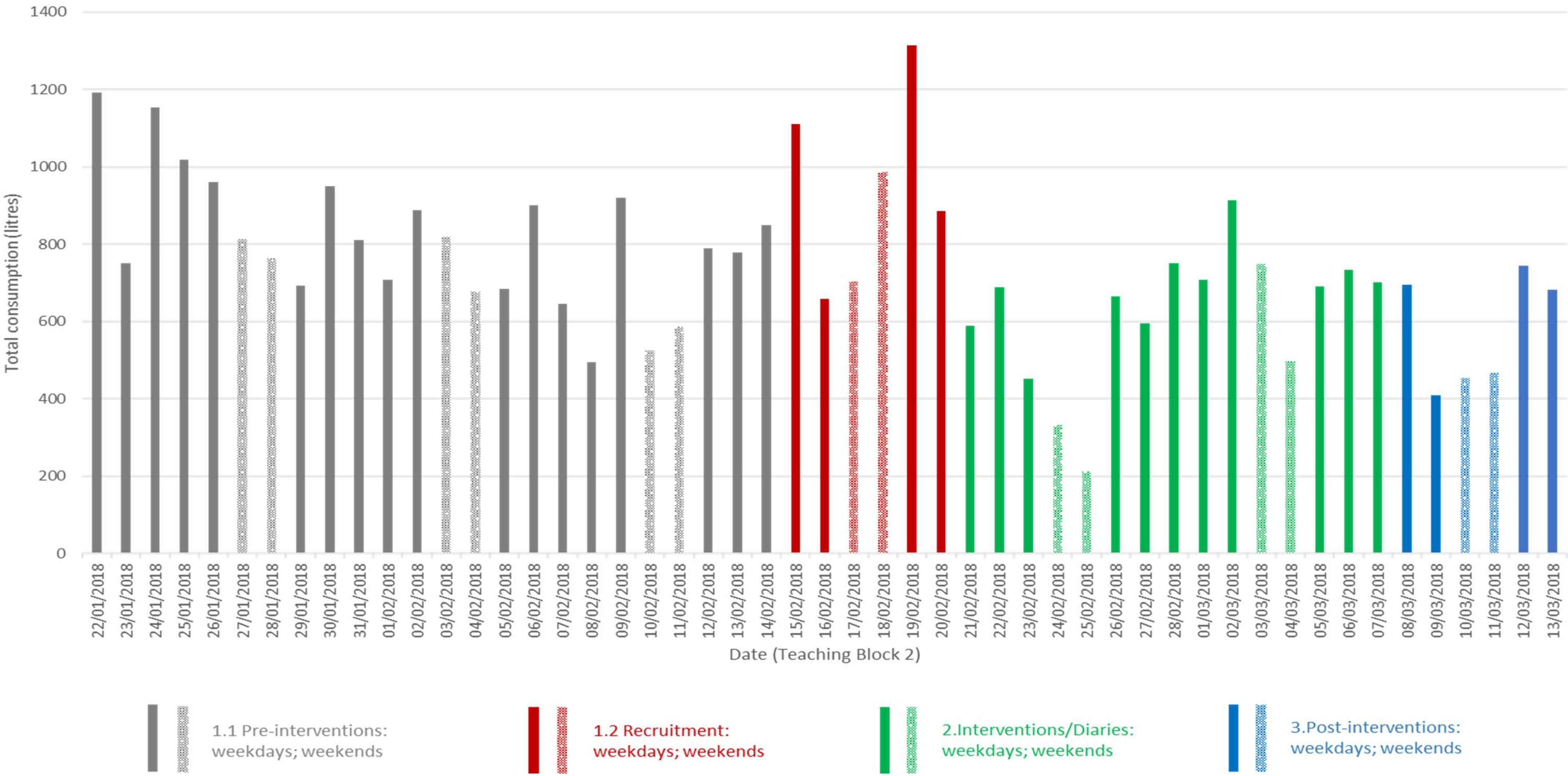


Figure 5-7 Daily consumption through time

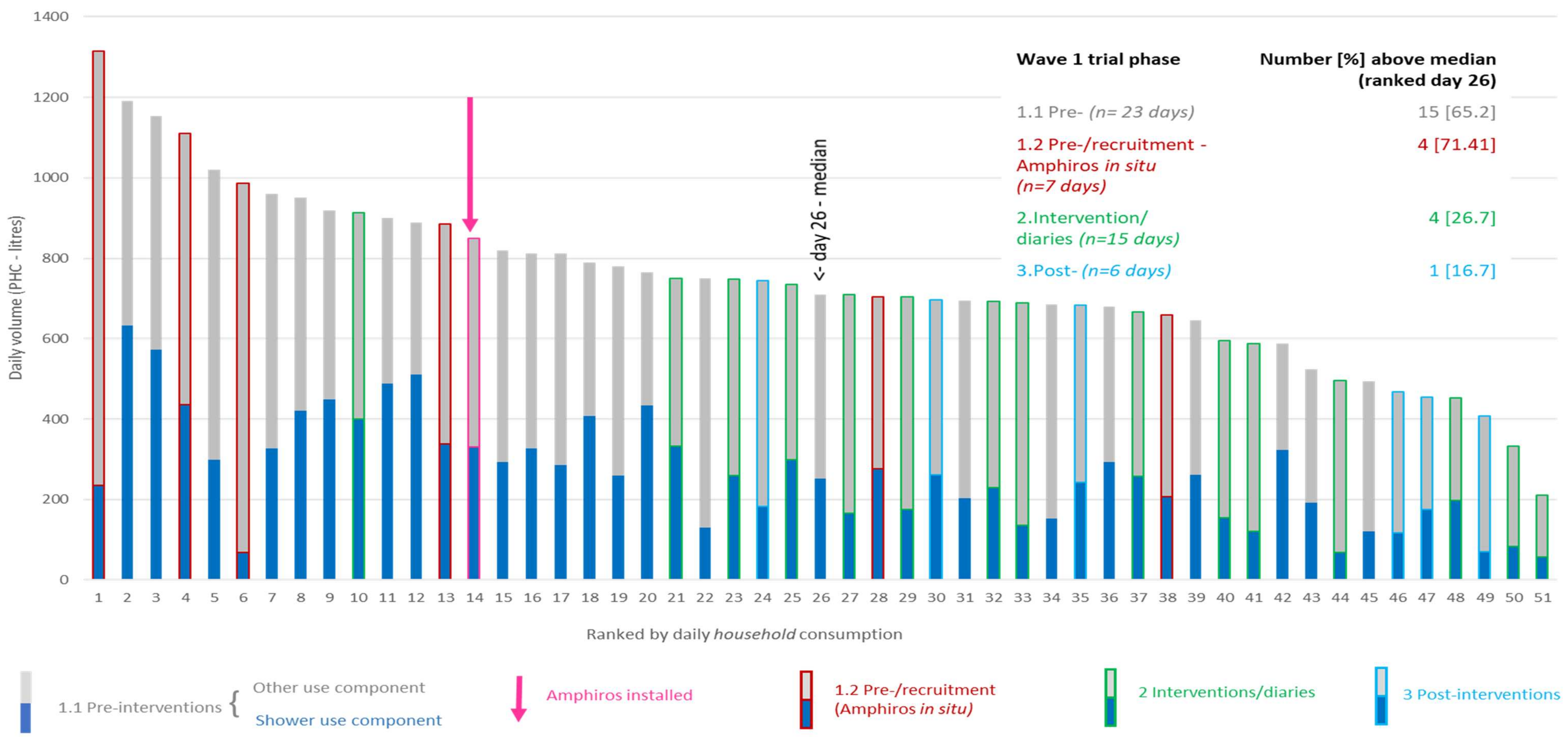


Figure 5-8 Ranked daily household consumption assigned to showers and other uses (house G)

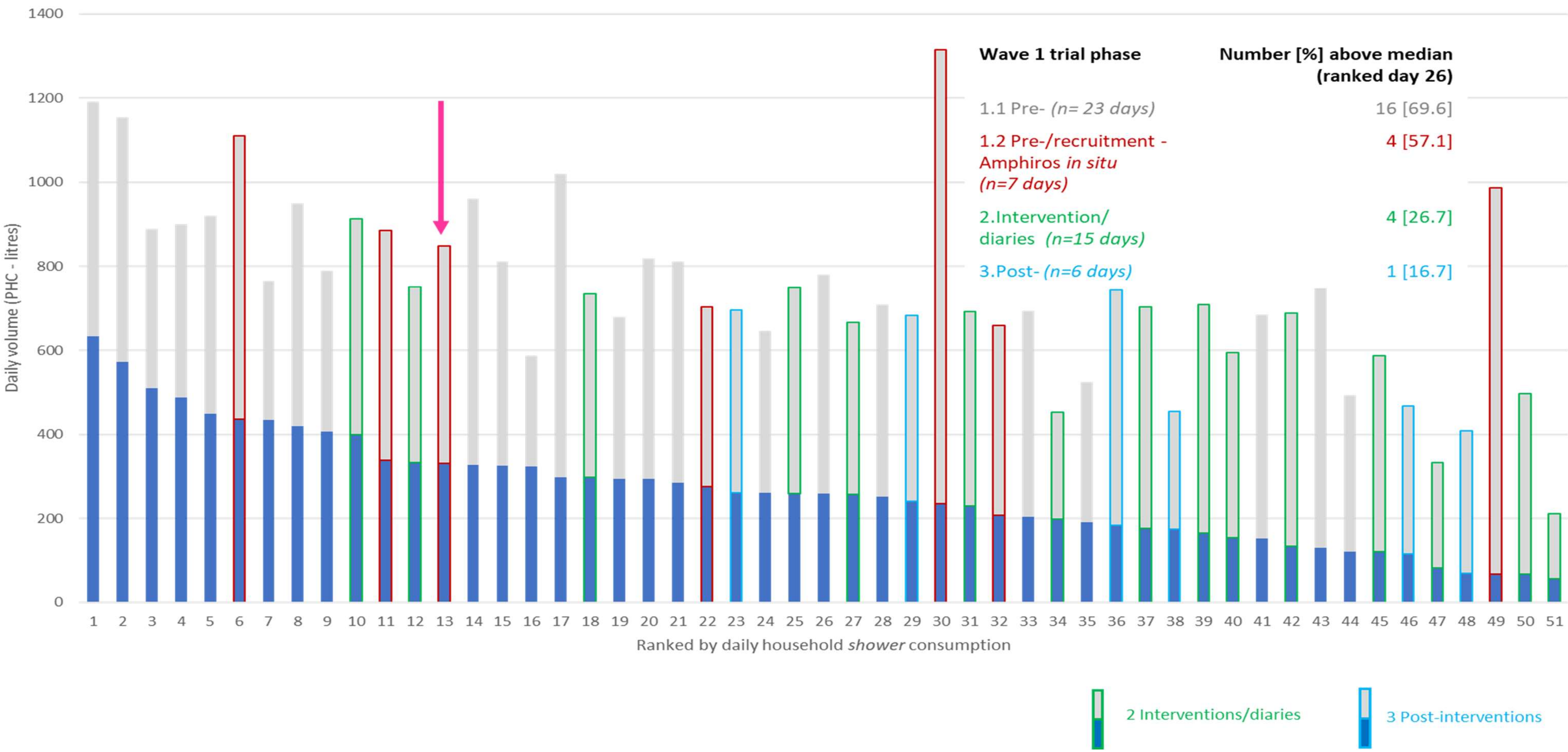


Figure 5-9 Ranked daily household consumption assigned to showers and other uses (house G)

The volumetric measurements indicated that students living in WCP1 used around 100 l/*p*/d during term-time, but consumption varied, from a modest 84 l/*p*/d (houses I and J) to a relatively high level of 151 l/*p*/d (houses A and B), on average. Whilst there was an observable reduction in consumption through the term, between the pre- and post-intervention phases, this change was not statistically significant. Morning showers were quicker than evening showers. The posters or shower timers had little impact on water use. Posters are a convenient tool and more salient than information leaflets as the message can be delivered at the point of use (i.e., in the bathroom). However, they are passive and rely on end-users receiving the message and acting logically on the information contained. The Amphiro smart shower devices appeared to deliver measurable shower water savings. The face-to-face engagement did not have any measurable effect on the pair of houses (I and J) with already low consumption (RQ4.2).

5.2 End-user insights

There were 34 unique participants across all the end-user data collection methods, representing a 34% participation rate (adjusted for five participants recruited from outside the main study site). The participants are summarised in Table 5-7.

Table 5-7 Summary of participants (split by gender)

House	Intervention	Q/1 questionnaire	Diaries	Focus groups (FG1-FG5)
Q[1]	Control	1f, 1m[2]	3f[3]	2m[4]
A	Control	0	1f	0
B	Control	1f	1f, 1m	1f, 1m
C	Poster 1	2f	1f	0
D	Poster 2	1f, 1m	2f, 1m	2f, 1m
E	Shower timers	2f	2f	0
F	Shower timers	4f	3f	3f
G	Amphiro	1f	2f	0
H	Amphiro	2f, 1m	2f, 3m	1f, 5m
I	Face-to-face	0	2f	2f
J	Face-to-face	1f, 1m	2m	1f, 3m
Total		**15f, 4m**	**19f, 7m**	**10f, 12m**

[1]site Q – outside study site (n=12), but within WCP1 (n=37)
f = female, m = male
[2]questionnaires (Q/1) = 1 male from site Q (also attended FG3)
[3]diaries = 3 females from site Q
[4]focus groups = 2 males from site Q attended FG3 (house D)

There were nine committed participants (six females and three males) that contributed to all three data collection instruments (diary, questionnaire, and focus group), representing 10% of the study population. The diary method had the highest participation rate (19 female and seven male). The researcher set out to recruit participants to keep diaries ahead of the intervention phase and early in the teaching term, whilst volunteers for the questionnaire and focus groups were recruited later, principally from the pool of diary participants. Participation waned as the teaching term progressed and students had to balance involvement with completing academic assignments.

Participation in the diaries and questionnaire were skewed towards female participation (79% of questionnaire responses and 69% of diary participants, versus 60% of study site population, Table 3-2). This may be due to recruitment bias on the part of the female researcher, or it may be evidence that females are more willing to engage in this sort of research.

5.2.1 Questionnaire Q/1

The Q/1 questionnaire was completed by nineteen participants, fifteen of whom also completed diaries. For two, the survey represented their only active participation (one from house C – posters, and one form house F – timers). Questionnaire Q/1 was principally the same as the Q/0 questionnaire (Chapter 4), with a few tweaks to correct typographical or routing errors and it was distributed to a subset of the same student cohort, i.e., during the same academic year, 2017/18.

The results from Q/1 are tabulated in Appendix C.1 for reference and comparison with Q/0 (on campus) results. The results tended to mirror the responses provided by campus residents (*n=90)* in the Q/0 survey, with some small deviations which may be explained by the smaller sample size (equivalent to 21% of the *n=90 on campus* replies to Q/0). These similarities are not reported here to save repetition. The broad similarity serves to provide a check on data validity. However, there were a few notable exceptions, and these are highlighted below.

Shower duration

In response to the question (Q/1-q5.) on shower duration, responses indicated similar shower durations compared with Q/0, with a mean of 12.9 minutes (compared with 13 minutes for Q/0) but with a longer median duration of 15 minutes (compared with 10 minutes), likely to be due to the smaller sample numbers and a tendency to give rounded estimates of duration (to the nearest five minutes) for anything over a ten-minute shower. None-the-less, the results confirm the tendency for students (84%) to shower for longer than the norm for the general population (reported at around seven to eight minutes by Energy Saving Trust, 2013; and Walker and Zygmunt, 2009).

A supplementary question asked if shower duration had changed after the trial:

Q/1-q5a. Has this changed since the trial?

Most responses (11 of 19, or 57.9%) indicated no perceived change, while five (26.3%) participants did not know. Only three students indicated a change (with two describing a *decrease* in duration), and this was captured via free text responses:

> *"I have shortened my showers" [10F, house D – "pee in the shower" posters]*
>
> *"I was more aware of the time I was spending in the shower" [18F, house F – shower timers]*
>
> *"By few more minutes less* [sic] *shower" [19F, house F – shower timers]*

Shower frequency

The choice of responses to the question (6) on shower frequency was modified slightly for Q/1, to reduce the number of respondents choosing '*Other*'. For Wave 1, the majority (15 of 19, 78.9%) confirmed that they conformed to the norm of a *daily* shower (compared with 67.8% of campus residents in Q/0), but none reported showering *more than once per day* (whilst 11.1% living on campus reported this higher frequency option in Q/0). The other four Q/1 respondents selected the '*5-6 times per week'* option.

Shower products

More shower products were reportedly used during a typical shower (question 9) in Q/1 (mean of 3.5 and median of 4) compared with Q/0 responses of three products, on average (mean and median).

Other water using processes

Laundry

Laundry frequency was reported to be slightly lower for Wave 1 participants, with just over a quarter (26%) processing fewer than one load of washing a week (i.e., fortnightly), compared with 17% of Q/0 responses, and just 5% (one participant) doing more than one load a week (compared with 20% of Q/0 participants).

Washing-up

The lower water use from laundry routines was not mirrored in the Wave 1 kitchen activities. Q/1 reported *zero* communal washing-up and only 16% of mixed (communal and individual) approaches compared with 4% and 29%, respectively in Q/0. The majority (84%) washed just their own dishes (versus 67% of Q/0 replies). This difference may be a reflection of the timing of the Q/0 and Q/1 surveys. During the autumn term, students may have been more inclined to share the chores during the early and possible anxious settling-in period, whilst making new friends in their first few weeks away from the family home. However, by the spring term, household routines would have been established (with the following year's housemates agreed and rental agreements in place), and there would have been a lesser need to share the washing-up rota to foster good relations and household harmony.

Added to this, the Wave 1 participants were much more likely to wash-up under a running tap (63% compared with 34%). None used a plug in the sink (compared with 17% in the first survey) which may reflect that the plugs had gone missing, by the time of the spring 2018 Wave 1 trial, later in the academic year.

5.2.2 Diaries

Twenty-six completed diaries were returned, representing a 26% sample of the study house population (excluding three recruits from elsewhere in WCP1 who were allocated to the control group), with a spread across the study site houses and interventions. Fifteen of the diary participants also completed the Q/1 questionnaire.

A total of 348 shower events were recorded across the two-week intervention phase (equivalent to 13.4 showers per resident or 0.9 per day). This section summarises the findings from the diaries and compares them with the questionnaire and logger results to demonstrate the level of reliability in the results.

Shower duration

The intention was that duration would be timed rather than estimated, but the results (rounded to whole integers or the nearest five minutes) indicated that there was a mix or both *estimation* and *measurement*. Twenty-one participants recorded at least some events in either decimal minutes or minutes and seconds, indicating that most event durations were indeed *measured*. Only five participants recorded all diary events in round minute integers (likely to be *estimates*). The diary events amounted to 4,020 minutes (67 hours) and had a mean event duration of 11.6 minutes and ranged from under 2 minutes up to 48 minutes. Aggregated diary durations served to estimate user-average shower durations to compare and validate the estimated *typical* shower durations collected via the questionnaires (Q/0 and Q/1), as summarised in Table 5-8. Analysis confirmed 9- to 14-minute showers to be the '*UWE standard'* for WCP1 residents (with half of users, on average and 29% of all events in this grouping), although the questionnaire datasets hinted at longer estimated durations across *all* campus accommodation.

Table 5-8 Shower duration – comparison of diary reports and questionnaire responses

Shower duration *(minutes)*	**Diaries** Wave 1 *(n=348 events)*	**Diaries** Wave 1 - by user mean *(n=26 participants)*	**Q/0** Wave 0 - on campus (as Figure 4-22) *(n=90 participants)*	**Q/1** Wave 1 *(n=19 participants)*
<3	13[3.7%]	0 [0.0%]	N/A	N/A
Short: 3-6	89 [25.6%]	6 [23.1%]	11 [12.2%]	4 [21.1%]
Norm: >6-8	40 [11.5%]	1 [3.8%]	13 [14.4%]	2 [10.5%]
'*UWE standard*': >8-14	102 [29.3%]	13 [50.0%]	26 [28.9%]	8 [42.1%]
Long: >14-20	74 [21.3%]	4 [15.4%]	45 [50%]	7 [36.8%]
Excessive: >20	30 [8.6%]	2 [7.7%]	5 [5.6%]	1 [5.2%]
Mean	*11.6*	*11.2*	*13.0*	*12.9*
Minimum	*1.8*[1]	*3.1*[3]	*3*	*3*
Maximum	*48.0*[2]	*28.6*[4]	*60*	*30*
The Wave 1 interventions coincident with the minimum and maximum event durations by event and participant were: [1]House D – 'Pee' poster; [2]House C – 'Share' poster; [3]House D – 'Pee' poster; [4]House E – shower timer				

The diarised event durations were analysed against the different interventions *in situ* for the trial, and the number of shorter- to mid-duration (under fifteen minute) showers were compared with the proportion of mid- to longer-duration (more than six minutes) events. The results are summarised in Table 5-9. The same parameters were used to summarise the Q/1 survey *estimates* of typical durations, and these are presented in Table 5-10 for comparison and verification of the findings.

The data collection methods (diaries and questionnaire) delivered similar profiles of shower durations against the different interventions, despite the small samples, giving assurance that the responses were representative. For example, the lowest duration was reported for the '*pee'* poster for both data collection tools, with means of 6.7 minutes and 5.5 minutes reported via the diaries and questionnaire, respectively. Meanwhile, the longest durations were for the '*share a shower'* poster (20.3 minutes from the diaries and 17.5 minutes from the survey). Aggregated averages across both types of posters were 11.7 (diaries, Table 5-9) and 11.5 minutes (Q/1, Table 5-10), respectively.

Table 5-9   Shower durations reported by diary participants, by intervention

Intervention (houses)	**No. diarists** *(n=26)*	**Mean duration** *(mins)*	**Range** *(mins)*	**No. short–norm showerers** *(<15 mins)*	**No. norm–long showerers** *(>6 mins)*
Control (Q, A, B)	6	14.0	5 – 30	0 [0.0%]	4 [15.4%]
Posters: (*both*)	*4*	*11.7*	2 – 48	*2 [7.7%]*	*0 [0.0%]*
'share a shower' (C)	1	20.3	5 – 48	0 [0.0%]	0 [0.0%]
'pee in the shower' (D)	3	6.7		2 [7.7%]	0 [0.0%]
Shower timers (E, F)	5	14.2	3 – 43	0 [0.0%]	3 [11.5%]
Amphiros (G, H)	7	9.2	2 – 34	2 [7.7%]	0 [0.0%]
Face-to-face (I, J)	4	8.1	3 – 20	2 [7.7%]	1 [3.8%]
All diary participants	***26***	***11.2***	**2 - 48**	***8 [30.8%]***	***8 [30.8%]***

Table 5-10   Shower durations reported in Q/1 questionnaire, by intervention

Intervention (houses)	**No. diarists** *(n=19)*	**Mean duration** *(mins)*	**Range** *(mins)*	**No. short–norm showerers** *(<15 mins)*	**No. norm–long showerers** *(>6 mins)*
Control (Q, B, no A)	3	11.7	5 – 15	1 [5.2%]	2 [10.5%]
Posters: (*both*)	4	11.5	3 – 20	*2 [10.5%]*	3 [15.8%]
'share a shower' (C)	2	17.5	15 – 20	*0 [0.0%]*	2 [10.5%]
'pee in the shower' (D)	2	5.5	3 – 8	*2 [10.5%]*	1 [5.2%]
Shower timers (E, F)	6	15.5	8 – 30	3 [15.8%]	6 [31.6%]
Amphiros (G, H)	4	12	3 – 20	2 [10.5%]	3 [15.8%]
Face-to-face (I, J)	2	12	4 – 20	1 [5.2%]	1 [5.2%]
All Q/1 responses	***19***	***12.9***	***3 - 30***	***9 [47.4%]***	***15 [78.9%]***

The durations for the poster intervention indicate that posters did not consistently deliver measurable water savings. The Q/1 survey responses appeared to *underestimate* average event durations for the control and poster houses (houses A to D and Q), whilst they *overestimated* average durations for the other houses (E to J). This led to a tendency to report (possibly overestimate) longer mean shower durations via the questionnaire (12.9 minutes) compared with the *measured* durations returned via the diaries (11.2 minutes). However, the range of measured diarised event durations were broader than the Q/1 questionnaire estimates. Whilst event data was only successfully logged for house G, the average logged duration of 9.1 minutes (Table 5-2), matched well with the average duration for the Amphiro devices (houses G and H) in the diary returns of 9.2 minutes (Table 5-9), giving further confidence that the diaries recorded reliable data.

On face-value, the focus group (FG1) engagement, attended by all four diarists plus two other housemates, appeared to be the next most successful intervention for targeting duration, with a mean of just 8.1 minutes per shower. However, the face-to-face interaction occurred halfway through the diary fortnight and there was no discernible reduction in the shower durations by any of the House I and J diary keepers in the second week following the intervention. The four house I and J diarists, fell into the two extremes of duration, with two students never recording a *long* shower (15 minutes or more), and one not recording any *short* showers (of six minutes or less). Thus, there is insufficient evidence to support a link between engagement and the observed shorter showers. The most likely explanation is that most residents of house I and J were already low duration showerers (relative to the '*UWE standard*'). This is supported by the PCC data that indicated that houses I and J already had the lowest consumption across the study site (refer to Table 5-2 and Figure 5-6).

There is some evidence that the Amphiro smart meters had an impact on reducing shower duration. The diary event data were compared with the logged events for house G to provide validation. The diaries returned a mean duration of 9.2 minutes. This compares well with the average logged event duration across the three phases of the trial of 9.1 minutes (Table 5-5). This is clearly significantly lower than the mean diary duration of 11.2 minutes across the dozen-house study site, compared with the logged house G consumption. This suggests that the small diary sample was representative of the shower routines of all house G residents.

Finally, the shower timers did not appear to have had any impact on shower duration – the very thing that they are designed to target! The mean shower duration reported for the five participants in this group (14.2 minutes) was close to the six-member control (no intervention) group (14 minutes).

Shower frequency

The diary events were aggregated into different shower frequency groupings for comparison with the questionnaire responses (Q/0 and Q/1), as shown in Table 5-11. The diary participants recorded a greater spread of actual shower events than the *recalled* estimates reported via the Wave 1 questionnaire (Q/1). The diaries recorded shower frequencies ranging from three or four times per week up to more than once per day, compared with a range of five to seven times per week in the survey. More than a third (34.6%) of diary participants recorded a frequency of more than once per day, although the daily mean (0.98 showers per day) matched the *daily* shower norm.

Table 5-11 Shower frequency – comparison of diary reports and questionnaire responses

Shower frequency	**Diaries** Wave 1 *(n=26)*	**Q/0** Wave 0 - on campus (Figure 4-23) *(n=90)*	**Q/1** Wave 1 *(n=19)*
More than once per day	9 [34.6%]	10 [11.1%]	0 [0.0%]
Every day	7 [26.9%]	51 [56.7%]	15 [78.9%]
5-6 times per week/ 4-6 times per week	7 [26.9%]	18 [20.0%]	4 [21.1%]
3-4 times per week/ Up to 3 times per week	3 [11.5%]	8 [8.9%]	0 [0.0%]
About once a week	0 [0.0%]	2 [2.2%]	0 [0.0%]
Mean per day (typical)	*0.98*	*Every day*	*Every day*
Minimum per day	*0.43*[1]	*About once a week*	*5-6 times per week*[2]
Maximum per day	*1.79*	*More than once per day*	*Every day*
[1]*0.43 equivalent to 3 times per week;* [2]*5-6 times per week = 0.71 – 0.86*			

The diary frequencies were divided between the intervention types (see Table 5-12). The lowest mean frequency by intervention confirmed that the users with the Amphiros were most likely to have the lowest frequency (with a modest mean of 0.89 showers per day), although this still represents more than six showers per week. This modest frequency may not be attributable directly to the intervention, as the Amphiro device (as well as the timers and posters) was designed act upon *duration* rather than *frequency*, although it may have had some moderating effect on frequency.

Table 5-12 Shower frequencies recorded by diary participants, by intervention

Intervention (houses)	**No. participants** *(n=26)*	**Mean frequency** *(per day)*	**Range** (min – max, per day)
Control (Q, A, B)	6 [23%]	0.98	0.50 – 1.79
Posters: (*both*)	*4 [15%]*	*1.05*	*0.79 – 1.43*
'share a shower' (C)	1 [4%]	1.43	*1.43*
'pee in the shower' (D)	3 [12%]	0.93	*0.79 – 1.00*
Shower timers (E, F)	5 [19%]	1.06	0.93 – 1.14
Amphiros (G, H)	7 [27%]	0.89	0.43 – 1.14
Face-to-face (I, J)	4 [15%]	0.96	0.71 – 1.14
Total/mean	**26**	**0.98**	**0.43 – 1.79**

The highest frequency (1.79 per day) was from a participant in the control group (house A), who recorded twenty-five showers across the two weeks (reflecting the high household consumption recorded for this house by the test logger (Chapter 4). The lowest frequency of 0.43 per day, equivalent to three times per week, was in the Amphiro intervention group (with just six showers recorded across the trial fortnight).

Volume and flow

The seven diary participants with the Amphiros (houses G and H) were asked to record the volume of water shown on the Amphiro display unit after each shower. The results, summarised in Table 5-13, were combined with the corresponding diarised duration and frequency information to compare the dimensions across the two houses.

Table 5-13 Volume and flow dimensions (Amphiros - houses G and H)

Shower dimensions	**House G**	**House H**	**Total/*average***
Number of participants	2	5	7
Measured (Amphiro) total volume (*litres*)	658	1788	2446
Total (Diary) duration (*minutes*)	190	597	787
Number of events (*diary*)	17	69	86
Mean volume per event (litres)	*38.7*	*25.9*	*28.4*
Mean duration per event (minutes)	*11.2*	*8.7*	*9.2*
Mean flow rate (litres per minute)	*3.5*	*3.0*	*3.1*

The calculations resulted in very low flow rates of between 3 and 3.5 l/min, on average, compared with logged flow rates of around 6 l/min (Table 5-5) and the water fixtures audit results (Table 3-1), with rates between 6.6 and 9 l/min, and 7.7 l/min recorded for showers in house G. This may be because the durations were over reported by the diary participants, due to *estimating* rather than measurement, or that the time following the shower, when the participants towel-dried themselves and the shower was no longer running was included in the diary records. Alternatively, the Amphiro devices may have under recorded the flow or their impellors may have moderated the flow.

Time of day

The time of day that the participants shower was analysed, by the favoured time of each participant and by event. The day was split into four six-hour blocks, this is summarised in Table 5-14. The results are similar for both participants and events, with two groupings of at least a third of participants or events in both the morning and evening periods, and up to another quarter in the afternoon. This pattern mirrors the observed diurnal peak demand in the baseline household meter data (for the Student Village) described in Chapter 4 (Figure 4-1). The mean shower duration was calculated for each six-hour time block. On average, morning showers were 2.6 minutes quicker than evening showers, although afternoon showers tended to be the shortest.

Table 5-14 Time of day

Time of day (start time)	**By participant** *(n=26)*	**By event** *(n=347)*	**Mean duration** *(minutes, n=347)*
Night (00:00 - 05:59 hrs)	1 [3.8%]	17 [4.9%]	15.5
Morning (06:00 - 11:59 hrs)	8.5 [32.7%]	123 [35.4%]	10.5
Afternoon (12:00 – 17:59 hrs)	6.5 [25.0%]	77 [22.2%]	9.9
Evening (18:00 – 11:59 hrs)	10 [38.5%]	130 [37.5%]	13.1

The event data were also analysed by intervention, as shown in Table 5-15. The results confirm the findings in the previous table, with no single time slot emerging as the most popular. The interventions are unlikely to have directly influenced the scheduling of showers.

Table 5-15 Time of day, by intervention

Time of day *(n=347)*	**Night** [%]	**Morning** [%]	**Afternoon** [%]	**Evening** [%]	**All events** [%]
Control (Q, A, B)	4 [5.1]	25 [31.6]	26 [32.9]	24 [30.4]	79 [22.8]
Posters: (*both*)	8 [14.8]	15 [27.8]	19 [35.2]	12 [22.2]	54 [15.6]
'share a shower' (C)	*8 [40.0]*	*5 [25.0]*	*2 [10.0]*	*5 [25.0]*	*20 [5.8]*
'pee in the shower' (D)	*0 [0.0]*	*10 [29.4]*	*17 [50.0]*	*7 [20.6]*	*34 [9.8]*
Shower timers (E, F)	1 [1.3]	42 [56.0]	11 [14.7]	21 [28.0]	75 [21.6]
Amphiros (G, H)	3 [3.5]	21 [24.7]	23 [27.1]	38 [44.7]	85 [24.5]
Face-to-face (I, J)	1 [1.9]	21 [38.9]	9 [16.7]	23 [42.6]	54 [15.6]

Outsourcing

Six diarists outsourced fifteen shower events in total, representing just 4.3% of all events. The results are summarised in Table 5-16. Six of the outsourced events took place during weekend visits home by three participants, whilst another student went home at the end of the trial period. One participant went away for a long weekend (Friday to Monday), and one participant recorded showers taken after swimming. These findings tend to support the previous questionnaire (Q/0) findings that the students did not shower at the gym after exercise except after swimming, when they were already wet and had a towel and change of clothes. However, there was no swimming pool on campus or operated elsewhere by the university.

Table 5-16 Outsourced showers, by intervention

Outsourced showers Intervention (houses) *participant*	**Outsourced events** [% of intervention group]	**% of ALL Events**	**When?**	**Location**
Control (Q, A, B)	5 [6.3%]	1.4%		
3F	*3 [3.8%]*	*0.9%*	*Afternoon*	*Swim pool*
6M	*2 [2.5%]*	*0.6%*	*Afternoon*	*Home*
Posters (C – '*share*') *7F*	1 [1.9%]	0.3%	*Long w'kend, morn'g/aftern'n*	*Hotel*
Shower timers (E, F)	5 [6.7%]	1.4%		
16F	*4 [5.3%]*	*1.1%*	*Weekend, morn'g/aftern'n*	*Home*
17F	*1 [1.3%]*	*0.6%*	*Weekend, morning*	*Home*
Amphiros (G, H)	0 [0.0%]	0.0%		
Face-to-face (I, J) *33M*	1 [1.9%]	0.3%	*Weekend, morning*	*Home*

Products and in-shower activities

The average number of products used, and in-shower activities undertaken by participants were aggregated by intervention type. The results are shown in Table 5-17. On average 2.6 products per shower event were used by the diary participants, this is less than the three or four products estimated in the questionnaire returns. The lower value is likely to be a feature of the natural variability of the students' personal grooming routines and the small sample size. It is unlikely to be attributable to the Wave 1 interventions, as these did not target product use. The average number of in-shower activities of 3.5 was in line with those reported in the questionnaires (Q/0 and Q/1 of 3.4 and 3.6, respectively).

Table 5-17 Products and in-shower activities, by intervention

Products/activities	**Total applications of product**	**Products per event**	**Total shower activities**	**Activities per event**
Control (Q, A, B)	215	2.7	283	3.6
Posters: (*both*)	157	2.9	178	3.3
'share a shower' (C)	65	*3.3*	68	*3.4*
'pee in the shower' (D)	92	*2.7*	110	*3.2*
Shower timers (E, F)	248	3.3	303	4.0
Amphiros (G, H)	179	2.1	287	3.3
Face-to-face (I, J)	109	2.0	179	3.3
Across all houses	***908***	***2.6***	***1230***	***3.5***

Table 5-18 shows the frequency of product application and in-shower activities by type. The most common product reported was shower gel, used in 93% of all showers, followed by shampoo for 59% of showers. These numbers were mirrored in the shower processes for which the products are designed to target, with washing the body the post common shower activity (94%), followed by face washing (83%) and shampooing hair (58%).

Table 5-18 Proportion of showers for each product and activity

Products	**Frequency of use** *(per event)*	**Activities**	**Frequency** *(per event)*
Shampoo	204 [59%]	Shampoo once	202 [58%]
Conditioner	126 [36%]	Shampoo twice	39 [11%]
Shower gel	324 [93%]	Condition hair	138 [40%]
Shaving mousse or gel	5 [1%]	Wash body	327 [94%]
Exfoliator or scrub	76 ([22%]	Wash face	290 [83%]
Face pack	40 [12%]	Exfoliate	63 [18%]
Toothpaste	75 [22%]	Shave	37 [11%]
Other (specify)[1]	58 [17%]	Brush teeth	75 [22%]
Total	**908**	Face pack	3 [1%]
[1] *"Face wash"; "Soap"; "Hair mask"*		Other (specify)[2]	56 [16%]
		Total	**1230**
		[2] *"singing"; "Listening to music, daydreaming; Listening to [7 min] motivational videos"; "singing and dancing"; "quick internal prayer/worship"; "fake tanned"; "singing (very quietly)"*	

There was an apparent disconnect between products and activities. Products can be used for multiple processes, for example, exfoliators and scrubs used for washing the body or face, and one participant reported that she used conditioner as a lubricant for wet shaving. Eleven per cent of all showers (undertaken by seven, or 27% of participants) involved a *second* application of shampoo, whilst twenty-two per cent of showers (by ten students) involved tooth brushing, an activity that conventionally is undertaken at a washbasin where it can be completed more efficiently, if done with the tap turned off. Sixteen per cent of showers involved some other form of activity that was not related to products, such as singing, dancing, listening to music or meditation, giving different meanings to showering, not just the functional purpose of getting clean, but point towards the shower as being a time and space for relaxation and even leisure.

Emotions and thoughts

Finally, whilst quantifying the day, time, duration, products, and in-shower processes on the diary template was simple and mechanistic, the participants found it more challenging to recall in their own words how they were feeling immediately before, during or after showering, and what they were thinking about in that moment, hinting at the automatic or habitual nature of the showering process. Figure 5-10 illustrates the emotions and thoughts in the diaries.

Figure 5-10 Shower puff of diary thoughts and emotions

5.2.3 Focus Groups 1-5

Twenty-two students participated in the five focus groups (FG1 – FG5), nine of whom also completed both the Q/1 questionnaire *and* diary; whilst two responded to the questionnaire but not the diary and seven recorded the diary but did not return the questionnaire. There were also four new participants who neither completed the questionnaire nor the diary. Following the gender imbalance observed for the Q/1 questionnaire and diary participants, dominated by females, the pendulum swung in the opposite direction for the focus groups with more male participants.

Only in the first focus group (FG1) on 28 February 2018 hosted by house J, did participants from the other paired house participate, despite multiple invitations via email, leaflet, and door-knocking. This workshop was also the only gender-balanced group. All four diarists, plus two other housemates took part, This was important as the focus group doubled up as the intervention itself.

The discussion meandered around due to the disparate factors from each context which interconnected and complex. The ISM model helped to reach beyond individual determinants and uncover and explore some of the wider social influences on showering routines. Whilst the participants struggled to relate some of the ISM factors to their own experiences, those from houses C/D and E/F could relate more readily to the realities of water shortages, as these focus groups took place on 14 March 2018 during the *no water* event, making the issue very tangible.

The frequency and coverage of ISM factors are shown in Figure 5-11 and Figure 5-12, respectively.

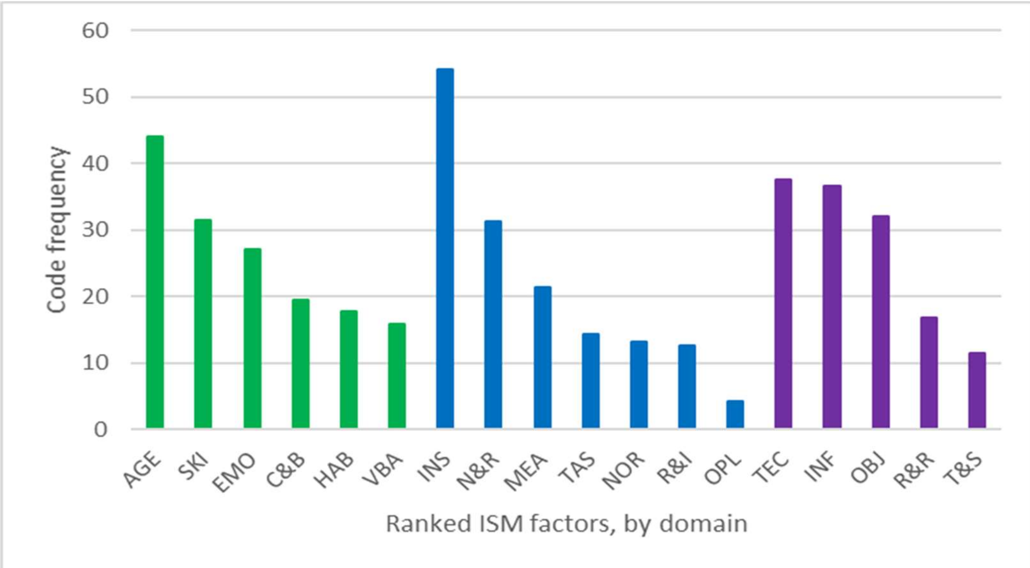


Figure 5-11 Frequency of ISM factors, as average across Wave 1 focus groups (FG1-FG5)

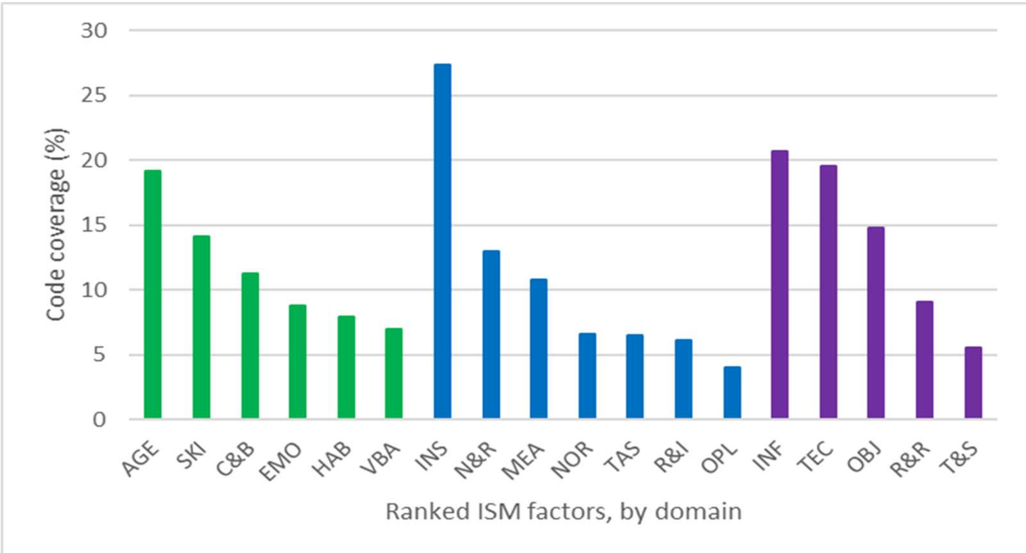


Figure 5-12 Coverage by ISM factors, as average across Wave 1 focus groups (FG1-FG5)

Comparing results across the domains, institutions (INS) was the most dominant ISM factor, across *all* contexts, followed by agency (AGE), infrastructure (INF) and objects (OBJ). The plots confirm that for the individual domain (in green), agency and skills (SKI), were the most discussed factors, with the lowest occurrence and attention given to the values-beliefs-attitudes (VBA) factor. The relative position for the other three individual context factors (emotions – EMO; costs & benefits – C&B; and habits – HAB) varied between the frequency and coverage measures.

There was a similar pattern across the social domain (blue), with institutions followed by networks & relationships (N&R) and meanings (MEA) dominating the discussion, with opinion leaders (OPL) the lowest occurrence for both measures. The other social context factors (tastes – TAS; norms – NOR; and relationships & identity – R&I) were of similar relevance during the conversations. For the material domain (purple), infrastructure and technologies (TEC) dominated the discussions, followed by objects, whilst rules & regulations (R&R) and times & schedules (T&S) featured less.

Focus group participants that had received the poster interventions, were favourable towards the *'pee in the shower'* poster, despite the potential to generate feelings of disgust, but the students thought that it simply legitimised the practice for those that already do it and therefore, would not actually realise any water savings. The '*share a shower*' poster, whilst humorous, was deemed to be impractical and had the potential for longer duration showers, especially with having to negotiate space to access products or running water within the confined cubicle space! Indeed, showering in this way was understood to change the meaning away from cleanliness.

The Amphiro devices were favourable with *all* participants (especially those from house H who had experience of using them), as the device has power (or agency) to interact with both individual values and beliefs and shared meanings (to avoid drowning the polar bear) and had the potential to set norms for performance (in terms of litres used). Several participants outside of the Amphiro group, voiced a need for (at the point of use) in-shower technology (via a waterproof visual display or audio play list), coupled with a Fitbit-type device or mobile phone app (several participants reported taking their phones into the shower room to play music despite the damp and hostile environment for treasured tech). The device also served as a topic of conversation within the household (house H), bringing in the social dimension of comparison and competition (networks & relationships). Some even considered purchasing an Amphiro for their shared private rented house for the following academic year as a way of monitoring hot water use and to make the division of water and energy bills more equitable, by clubbing together with their £20 shopping vouchers!

The ISM tool provided a set of themes to structure the focus group discussions; to analyse the outputs; and, to evaluate the water saving interventions that were tested. Whilst the ISM factors provided a codebook for deductive analysis, the process of coding also allowed for the transcripts to be inductively explored and for new ideas or related sub-factors to emerge. This allowed for weaknesses or gaps within the ISM model to be identified. These emergent ideas are discussed in Chapter 7.

5.2.4 Summary of end-user insights

The second part of this chapter evaluated the impact of interventions on water use, measured via end-user self-reports and compares these findings with the volumetric measurements reported earlier in the chapter. The findings confirmed that students tended to conform to the '*UWE standard'* style of showering, and that the interventions had little impact on saving water, although there was evidence that the Amphiro devices may have altered shower routines and delivered measurable shower savings across multiple dimensions. The Amphiros had universal application as they were connected to the shower fixture and had the potential to mediate *all* showering activities as they did not require individuals to opt-in, although the level of water saving was dependent upon the willingness of showerers to engage with the displayed imagery and quantitative messaging. In contrast, the other measures were dependent upon residents opting in, by consistently using the timers, or acting upon the poster messaging and face-to-face information.

It was also noted that morning showers were shorter (by 2.6 minutes) than evening showers, on average, and therefore, interventions that can schedule the activity to earlier in the day, such as a more limited supply of hot water restricted to the morning period, could be a promising avenue to explore.

Despite having little impact on water use, the participants were receptive to the engagement (RQ4.2) and became more aware or mindful of how they use water as a result. The evaluation of a real-world water efficiency programme is complex and requires multiple approaches to get to the truth (RQ4.1).

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Chapter 6 Results – Wave 2 practice-based interventions

This chapter presents the results of the second intensive (Wave 2) field trial that ran during the autumn of 2018 (term 1 of the academic year 2018/19). This second intensive field work trial occurred in a different academic year than Wave 1, and the student cohort was effectively reset with no direct experience of the previous interventions and allowed for repeatable science.

The Wave 2 trial set out to test novel practice-based water saving interventions, as per Objective 4, and Research Questions 4-2 to 4.5:

> *Objective 4 To design, [pilot,] deliver and evaluate components (factors[61] and processes[62]) of a real-world intervention strategy covering multiple levels and contexts.*
>
> > *RQ4.2 How can an ISM/SPT derived intervention be operationalised in a real-world application?*
> >
> > *RQ4.3 Does a SPT approach help to identify factors that would be overlooked from a conventional individualistic perspective?*
> >
> > *RQ4.4 Can some factors be harnessed to alter the current trajectory of showering demand?*
> >
> > *RQ4.5 What are the benefits and limitations of using the ISM model to design and evaluate showering water demand reduction strategies?*

These questions were answered by measuring changes in water consumption at both household (meter) and shower fixture (logger) scales and by recording user-experiences via questionnaires (Q/2A and Q/2B), diaries and focus groups (FG7-FG8). The results were triangulated across the different data types (including Wave 0 and Wave 1) to validate the findings. The focus of this chapter is to answer RQ4.2, whilst the remaining research questions (RQ4.3 to RQ4.5) are discussed in Chapter 7.

The interventions were designed using the ISM framework to reflect upon the findings of Wave 1, supported by discussions from the interim stakeholder workshop (focus group 6 in May 2018, summarised in Appendix D), to target two key dimensions of showering (duration and frequency) by capitalising upon the public attitudes and concern for single-use plastic pollution – the '*Blue Planet*' effect.

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[61] Factor is an ISM term; elements is the equivalent for SPT

[62] Processes are the links or relationships between elements or factors

The timeline for the Wave 2 trial is summarised in Figure 6-1 (based upon Table 3-7). It shows the multiple data collection activities and trial phases, spanning the last few months of 2018.

Summary of Wave 2 findings

Volumetric

- Total water consumption across the WCP1 development was modest, and similar to the previous academic year, at slightly above 100 l/*b*/d during term-time. At this macro-scale there was no visible drop in total demand attributable to interventions;
- PCC for the control (no intervention) houses increased during the trial, whereas there was a modest reduction for the five intervention houses, suggesting some measurable impact; and,
- At a household scale for houses G and J, weekend demand was *lower* than weekdays, and total demand reduced across the trial period. The interventions appeared to save water.

Shower dimensions

- At fixture scale, weekend shower event volume was *higher* than weekdays for house G (opposite to total water demand), but lower for house J (as per total demand);
- Shower volumes were more consistent compared with the messy variation of total demand and showers were estimated to be only 20-25% of total demand;
- Shower frequency was lower than the daily '*UWE standard'*, and reduced for house G during the trial suggesting good engagement with the '*go gold'* messaging;
- House J showers were short, signalling good engagement with the '*go green'* challenge;
- The 2018/19 students reported being less water aware that the 2017/18 cohort, although they reported slightly shorter showers, on average;
- 48% of participants varied the flow rate, dependent upon the task, but 35% always turned the flow up high;

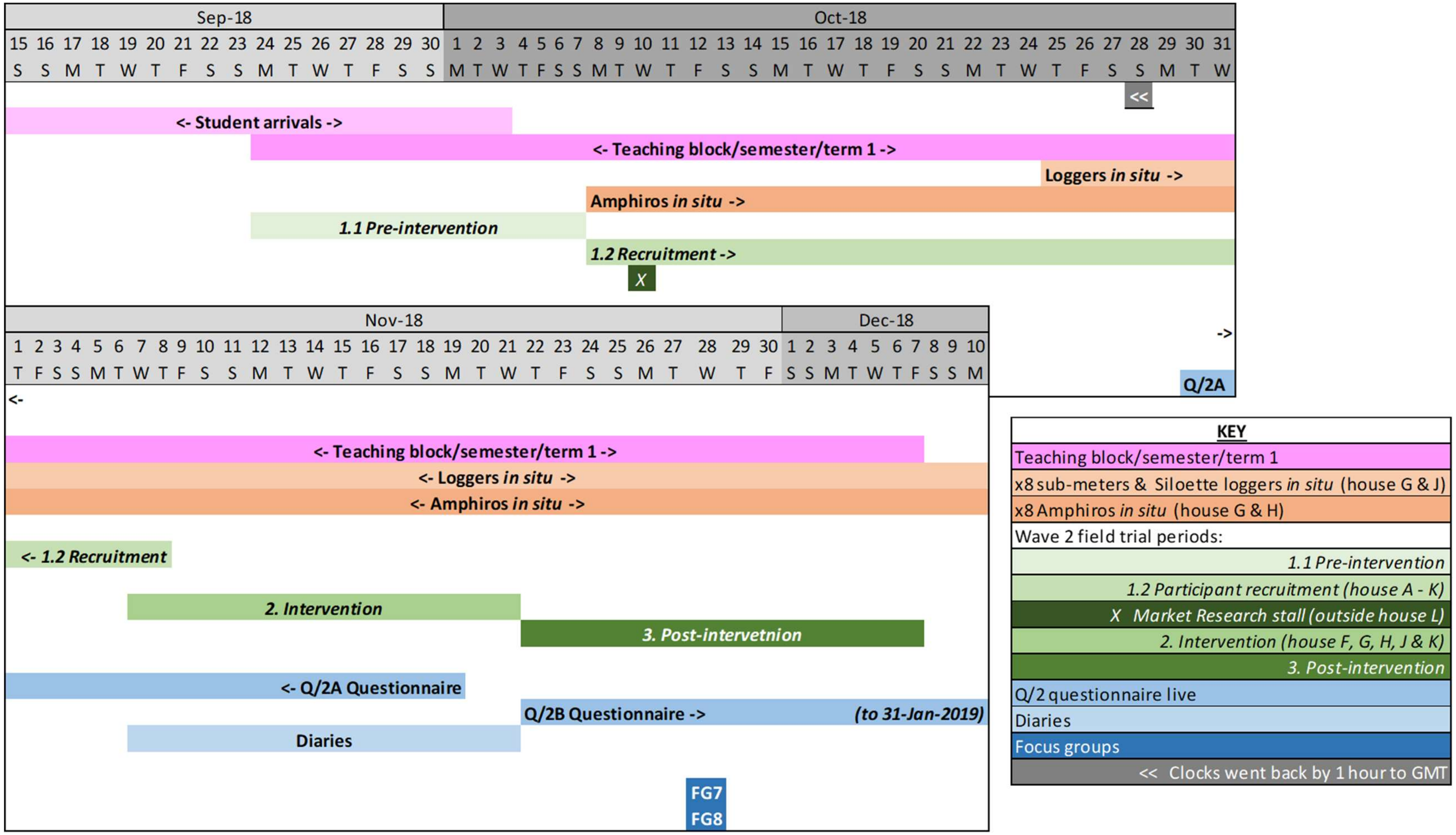


Figure 6-1 Timeline for Wave 2 field trial

- Two-thirds reported no change in shower frequency or flow rate, and were unwilling to deviate from their usual routine;
- 27% reported a reduction in shower frequency and 32% reduced the flow rate as a direct impact of the engagement;
- The Wave 2 diarists recorded significantly lower average shower durations (8.5 minutes) than the *'UWE standard'* of 11.5 minutes; and,
- More than a third of participants reported a change to their showering routine since moving to UWE, with *increased* durations and frequencies, and different times of day or locations, highlighting the transformational potential of key events and life stages.

Products and processes

- Wave 2 participants used fewer products that Wave 1, and 41% tried to give up plastic-bottled products ('*go green'*), but the initiative had to work against the 41% who said that they were loyal to their favoured shampoo brand;
- Only one-third of students read the manufacturers' instructions, but this may be a good thing for saving water as the directions on some leading products have the potential to drive higher resource consumption by users, through recommending *repeated* application or supplementing with other in-shower products that need to be *left to soak* into the hair;
- 0nly 13% of participants had tried solid shampoo before the trial;
- Hair washing is typically the first cleansing process in the shower, and two-thirds follow a standard procedure, whilst the rest vary the steps depending on whether they need to wash their hair or shave, have time constraints, or after sport;
- 77% tried to '*go green'*; and 59% were willing to try solid shampoo again;
- Two-thirds skipped some showers ('*go gold'*), but the rest raised concerns over expectations or socially shared rules on appearance; and,
- 77% tried the dry shampoo, and 41% were willing to try it again, although there was a mixed reception to the product. It had little impact upon frequency but had potential to reduce duration.

Motivation and agency

- 83% believed they have agency over their showering practice and are not influenced by external social or material factors;
- Half of participants anticipated a lasting change to shower duration and a quarter thought they would reduce shower frequency, in response to the trial;

- Two-thirds indicated that they would increase recycling rates;
- Focus groups were preferred (particularly by males) over interviews; and,
- There was good coverage of discourse across the ISM factors, with agency; skills; institutions; networks & relationships; and objects dominant themes.

6.1 Volumetric water consumption

6.1.1 Household and per capita consumption

The daily water consumption (based on *design* occupancy) for WCP1 (01 September 2018 to 31 May 2019) are plotted in Figure 6-2 to Figure 6-7. Figure 6-2 shows the median daily water use for 2018/19, whilst Figure 6-3 overlays the 2018/19 water consumption (broken line) with the previous year (solid line) for easy comparison. This confirms that water consumption across WCP1 was similar for the two academic years, particularly during the teaching blocks and the Christmas break, with average consumption at around 0.1 $m^3/b/d$ (100 l/*b*/d) during term time. There was a slight difference during the spring, with a later dip in April 2019, due to the Easter vacation compared with 2018, when Easter fell in March.

Figure 6-4 illustrates the variability in consumption between houses (*n=37)* for 2018/19, whilst Figure 6-5 shows the variability in water use for the dozen study site houses, A to L *(n=12)* for the same period. This indicates that consumption in the study houses was representative for the whole development, with a clear central tendency and some outlying spikes. Figure 6-6 and Figure 6-7 plot the household water consumption for the control group (*n=7*) and intervention houses (*n=5*), respectively, for the autumn term (01 September to 31 December 2018). The high peaks in consumption in Figure 6-7 are due to activity in houses F (dotted line: 07 to 09 October) and H (dashed line: 03 to 18 October and again 04 to 07 December 2018) respectively. These unusual peaks in demand were due to infrastructure leaks and were not representative of typical end-user demand.

The daily water-use for each study site house (01 September to 31 December 2018) are plotted with upper and lower consumptions bounds to aid visualisation[63] in Figure 6-8.

[63] See Figure 3-14 for an annotated illustration and key to aid interpretation.

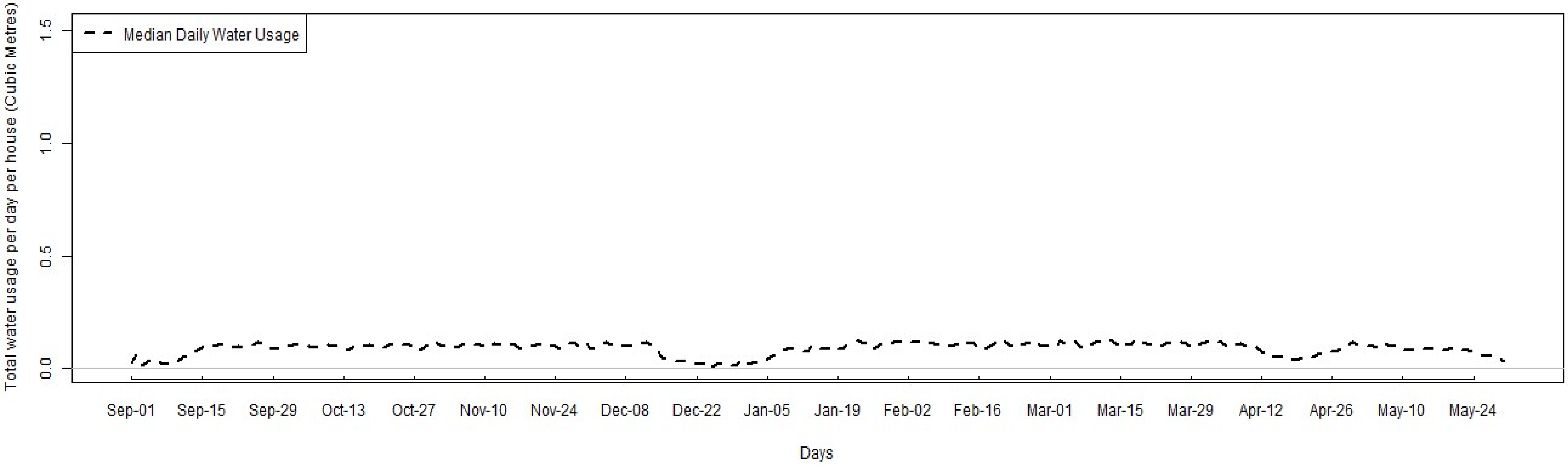


Figure 6-2   Median daily per bed water consumption for ALL houses (n=37), Sep to May 2018/19 – WCP1

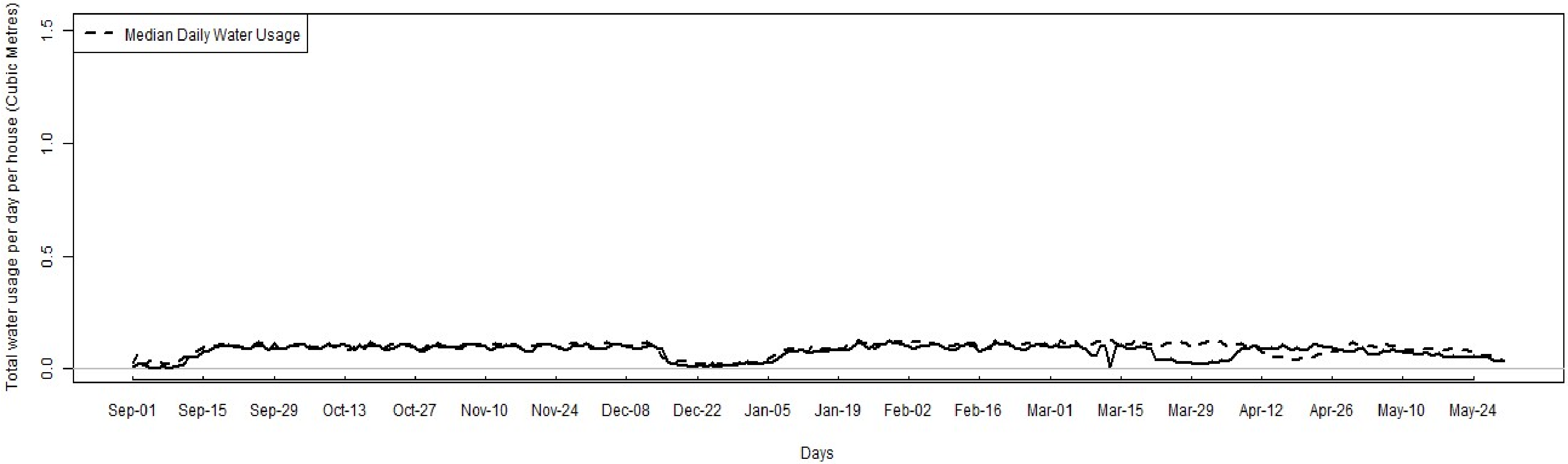


Figure 6-3 Median daily per bed water consumption for ALL houses (n=37), Sep to May 2017/18 and 2018/19 – WCP1

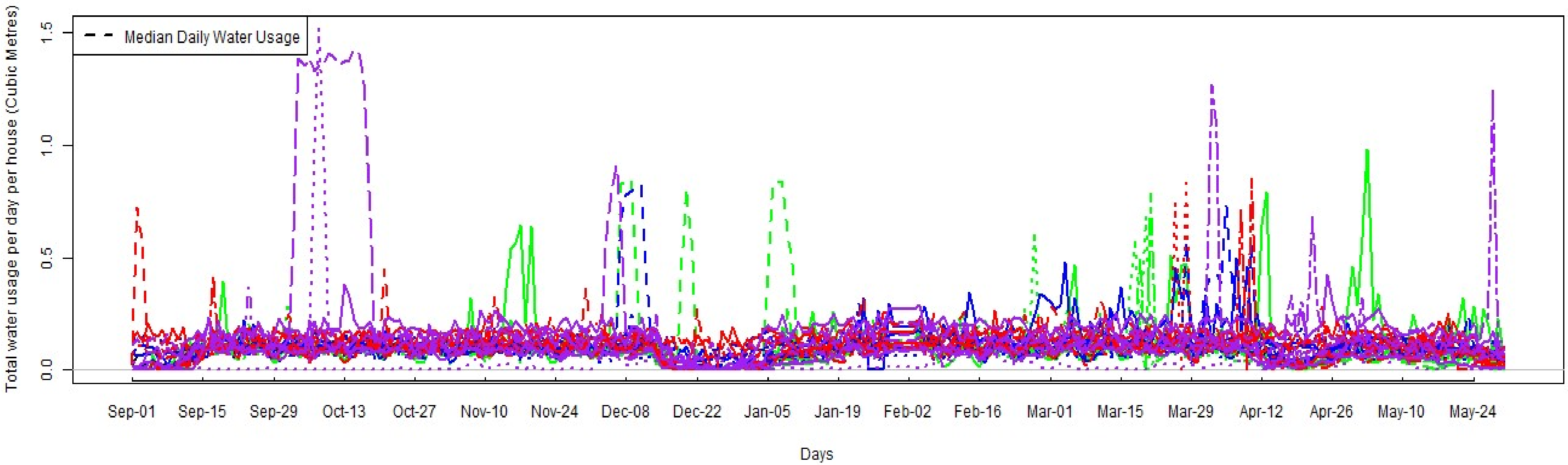


Figure 6-4 Daily per bed water consumption for EACH house (n=37), Sep to May 2018/19 – WCP1

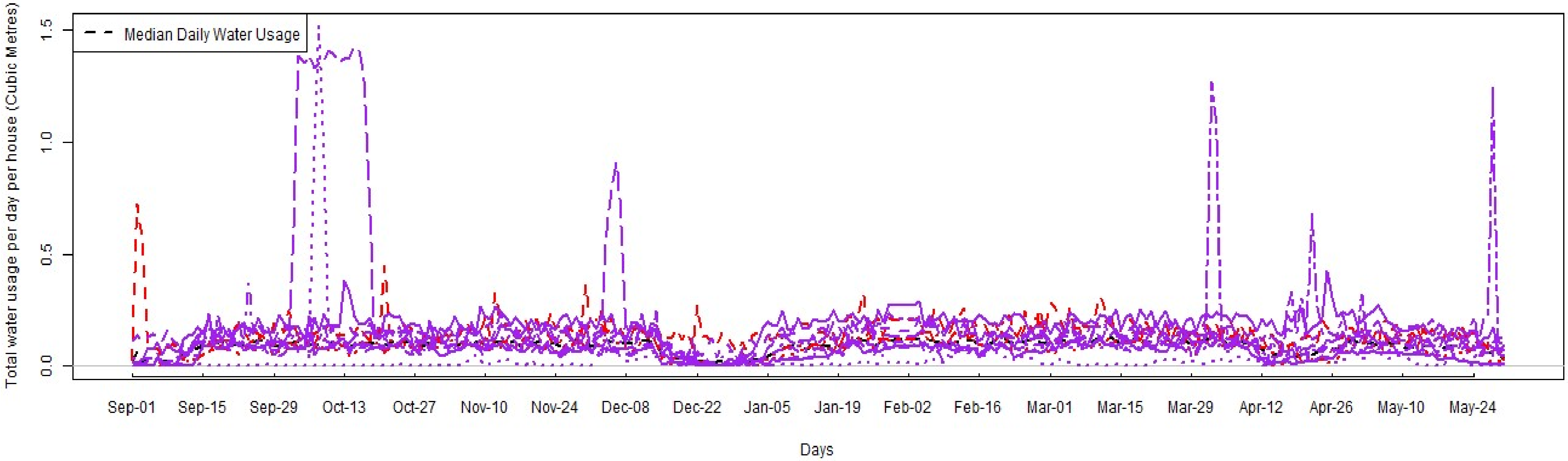


Figure 6-5 Daily per bed water consumption for EACH study site house (n=12), Sep to May 2018/19 – WCP1

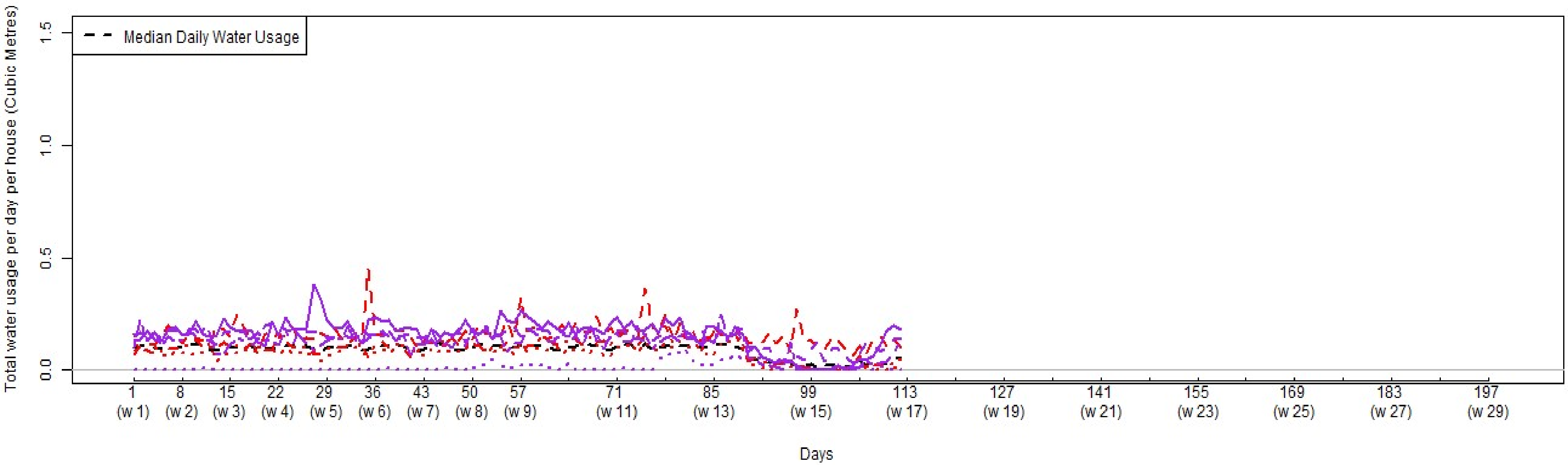


Figure 6-6 Daily per bed water consumption for CONTROL houses (A, B, C, D, E, I & L, n=7), Sep to Dec 2018 – WCP1

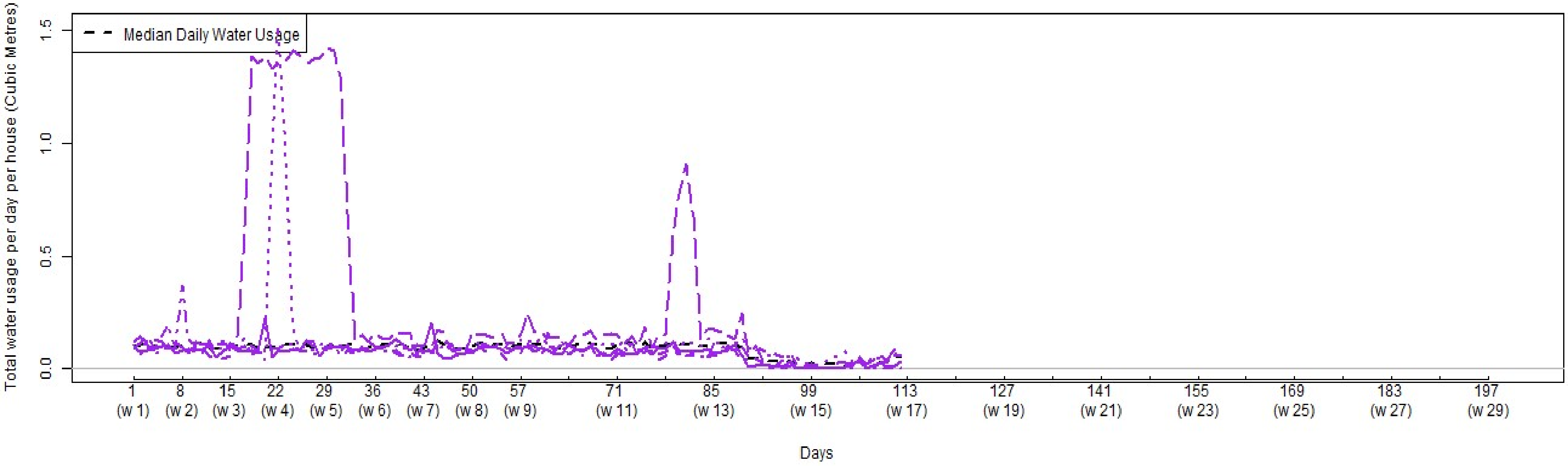
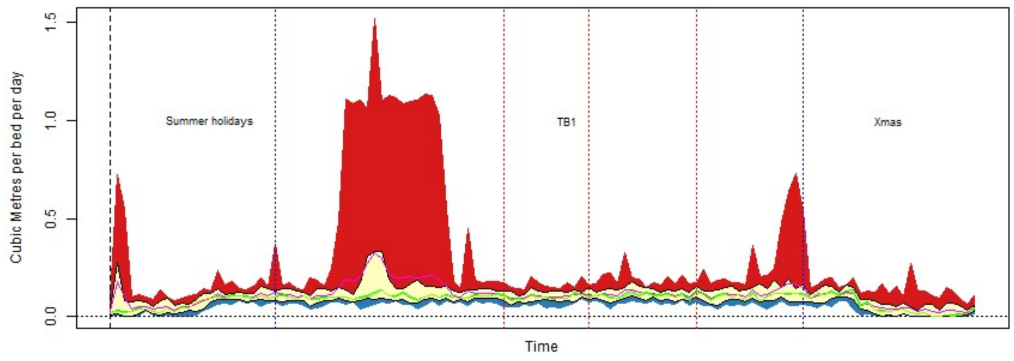
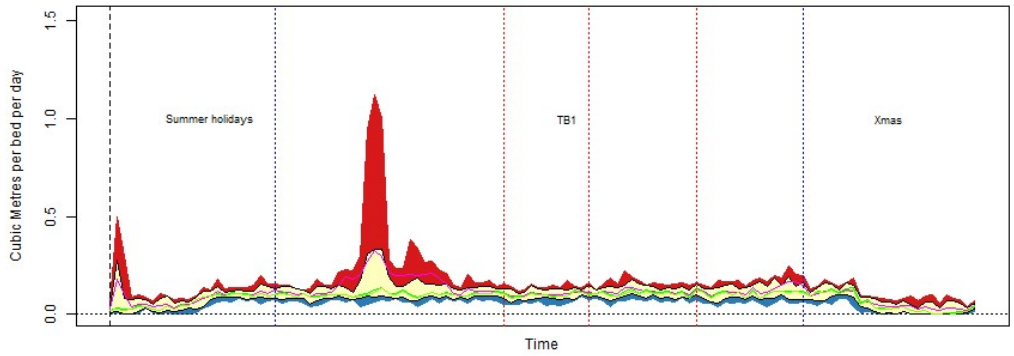


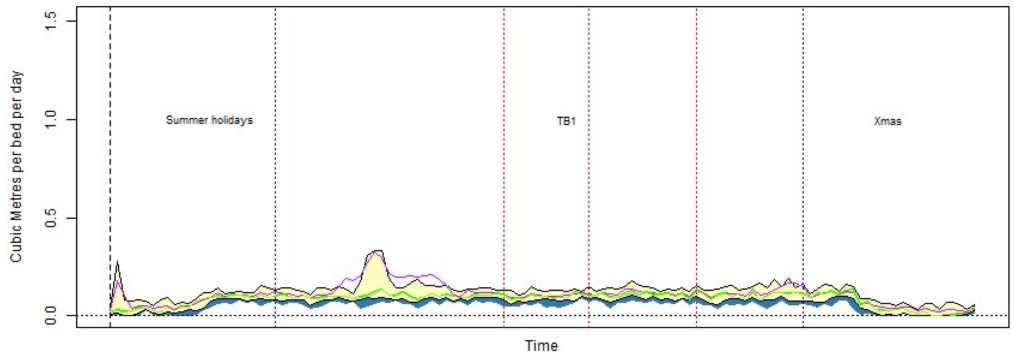
Figure 6-7 Daily per bed water consumption for INTERVENTION houses (F, G, H, J & K, n=5), Sep to Dec 2018 – WCP1



Excessive = worst *two*; *Middle* = *eight*; *Excellent* = best *two* houses on any day
Mean; median and median with top *two* houses removed



Excessive = worst house on any day (worst house removed)



Worst *two* houses removed

Figure 6-8 Per bed water consumption (Term 1, 01-Sep to 31-Dec-2018) – WCP1 study houses A – K (n=11)

There were no meaningful consumption data for house L as any occupants were temporary and unknown in number, and it was excluded from subsequent analysis. The start and end of the teaching block (or term) 1 is marked between two vertical blue lines (from 24 September to 07 December 2018), whilst the vertical red lines delineate the different phases of the trial:

0. Participant recruitment; sub-meter and logger installation: 24 September to 25 October 2018.
1. Pre-intervention: 26 October to 06 November 2018.

2. Intervention: 07 to 21 November 2018.
3. Post-intervention: 22 November to 07 December 2018.

The first two plots show an extended rise in water demand within the first phase (0 - participant recruitment and meter installation, in the first few weeks of term. Closer examination shows high demand by house H indicating a leak, that started on 03 October (0.49 m^3/b/d), averaged at 1.10 m^3/b/d for the next two weeks, through to 18 October (0.55 m^3/b/d). On 19 October, house B had the highest demand (0.178 m^3/b/d). There was also a smaller peak in demand at the end of the term, again by house H, that started on 04 December (0.48 m^3/b/d), peaked on 06 December (0.73 m^3/b/d), and ended on 07 December (0.54 m^3/b/d).

The second plot, in which the most consumptive house on each day was removed, reveals a second excessively high consumption on 08 October. This short spike was due to excessive water use in house F (1.52 m^3/b/d). For the period of the main trial (phases 1, 2, and 3), starting on 26 October there was more uniformity in demand across the study site, before consumption dropped as students headed home for the Christmas vacation. However, there is no obvious change in demand that can be attributed to the interventions that were deployed between 07 and 21 November 2018.

The household meter data for the development (excluding house L, *n=36*), and the study site (houses A to K, *n=11*) were used to calculate PCC for term 1 (autumn 2018), during which the Wave 2 trial was undertaken, and term 2 (spring 2019), representing a post-trial period, for comparison. These estimates are presented in Table 6-1, with adjustments to account for the three spurious high consumption periods, assumed to be leaks (clearly observable in Figure 6-7 and Figure 6-8).

Table 6-1 PCC for WCP1 (litres per bed/person per day) – 2018/19

	2018 – Term 1 [Wave 2] 4-Oct[1] to 7-Dec	**2019 – Term 2 Post-trial period** 21-Jan to 31-Mar
No. days	*65*	*70*
All: A-X (*n=36 houses; 396 beds; 0 void*)	107.3	117.4
Study: A-K (*n=11 houses; 96 beds; 0 void*)	112.6	119.3
Control houses: A, B, C, D, E, I *(n=6 houses; 54 beds)*	132.9	145.0
Intervention houses: F, G, H, J, K *(n= 5 houses; 42 beds)*	86.0	88.9
[1] *Assumes full occupancy - Design = rented, based on lettings and arrivals from 4-Oct-2018, as supplied by UWE Accommodation Service on 28-Sep-2018.* *Excludes house L as only temporary/unknown occupancy* *Estimates adjusted for leaks in house F (7-10 Oct) and house H (4-18 Oct and 4-7 Dec)*		

The results indicate that consumption increased in term 2 compared with term 1 by 9.4% across the development and 6% for the study houses. However, this may be a function of some beds becoming void. The study site occupants tended to use about five per cent more water than average WCP1 usage during term 1, although the gap closed during term 2. The study site PCC figures were divided into two groups (blue shading) comprising the six houses allocated to the control, and five houses with participating residents. The figures indicate that the consumption in the control group was substantially (35.3%) higher than for the intervention houses during term 1. In term 2, post-trial, there was only a modest increase in consumption for the intervention houses (3.4%) compared with the control houses (9.1%), in line with the wider development, possibly pointing to more stable occupancy levels for the study site.

Metered consumption data were analysed to assess whether the interventions made any measurable difference in total water use through the different phases of the Wave 2 trial. *PCC* figures are summarised in Table 6-2.

Table 6-2 PCC for different phases of Wave 2 field trial (l/p/d)

House		**Wave 2** 04-Oct to 07-Dec	**0.Recruitment /installation** 04 to 25-Oct	**1.Pre- intervention** 26-Oct to 06-Nov	**2.Intervention** 07 to 21-Nov	**3.Post-intervention** 22-Nov to 07-Dec	**Change in PCC** Between 1.Pre- and 3.Post intervention (litres)	(%)
No. days		*65*	*22*	*12*	*15*	*16*		
A	Control	168.1	162.4	141.2	180.0	185.0	+43.9	+31.1
B		89.7	83.8	89.6	88.8	98.6	+9.0	+10.0
C		118.4	101.7	109.6	113.2	153.0	+43.4	+39.6
D		153.9	160.2	133.6	162.9	152.0	+18.4	+13.7
E		120.3	125.0	112.6	124.2	116.1	+3.5	+3.1
I		144.7	144.0	132.9	153.3	146.7	+13.8	+10.4
Mean		***132.9***	***130.5***	***120.2***	***137.6***	***141.3***	***+21.1***	***+17.6***
F	*Interventions*	97.9[1]	90.4[1]	93.0	102.9	105.5	+12.5	+13.4
G		66.2	69.5	73.2	67.6	55.1	-18.1	-24.7
H		98.2[2]	112.3[2]	89.3	115.9	112.0[2]	+22.7	+25.4
J		86.8	94.2	86.8	84.0	79.0	-7.8	-8.9
K		82.5	87.2	81.4	90.0	69.7	-11.6	-14.3
Mean		***86.0***	***90.7***	***84.4***	***92.1***	***84.2***	***+0.2***	***+0.3***

[1]*House F – adjusted due to high consumption/possible leak 7-10 October*
[2]*House H – adjusted due to high consumption/possible leak 4-18 October and 4-7 December*

The control houses are grouped at the top of the table (blue shading) and received no intervention or engagement, and no residents participated in any of the end-user data collection. The intervention houses are grouped in the lower half of the table (green shading). Adjustments were made in the calculations for houses F (in phase 0) and H (phase 0 and phase 3) to prevent leaks distorting the underlying consumption levels.

The water consumption for *all* the *control* houses increased between the *pre*- (phase 1) and *post*-intervention (phase 3) periods as the term progressed, by an average of 17.6%. However, there was only a negligible increase (only 0.3%) in consumption by the five participating/intervention houses between the pre- and post-intervention phases overall, on average, and houses G, J and K showed a decrease. House H was the least engaged of participating houses, and just two of the ten residents started the trial (and only one completed the diary). The consumption estimates for houses F and H were mired by leaks both at the start (in phase 0) and end (phase 3) of the trial. However, the measured drop in consumption observed for houses G, J and K (from an already relatively low starting PCC) are worth highlighting and may be attributable to successful intervention and engagement.

House G was the most engaged house, with seven of the eight residents active in their participation, and recorded the most significant change in water use (25.4 % reduction), whilst house J had five participants (of eight residents) and house K had three (of eight). Despite a high level of participation (six of eight), house F showed an increase in consumption during the trial, suggesting that the intervention did not work as planned for those particular students. However, houses F and H appeared to be prone to intermittent leakage and this may have distorted the results. This also needs to be considered against the general trend for consumption to increase during the period, as demonstrated by the consumption in the control group.

The significance of the observed changes in consumption was tested with an analysis of variance. The standard Kolmogorov-Smirnov and the Shapiro-Wilk tests returned *null* for normality. Therefore, a one-way Kruskal-Wallis ANOVA (Geert van den Berg, 2022) was performed to test for significance in variation in the daily consumption between different trial phases. The outputs are listed in Appendix B.2.

The results of the ANOVA tests indicated that there was only significant variance in water use for the different phases of the trial in house A (intervention, phase 2) and house C (post-intervention, phase 3). However, as both houses were in the control group, where no interventions were delivered and no residents participated, the change in consumption cannot be attributed to the Wave 2 trial.

6.1.2 Shower fixture micro-component events

For Wave 2 both household meter data *and* fixture-level logger data were collected for two of the intervention houses. The total metered daily *household* consumption time series for teaching block 1 (24 September to 07 December) for house G is plotted in Figure 6-9 and house J in Figure 6-10.

The trial phases are colour coded. The Amphiros were fitted on 08 October are marked with a magenta arrow, during the pre-trial (phase 0 recruitment) zone in grey. The sub-meters and loggers were installed on 25 October (marked with an orange arrow). The 12-day pre-intervention phase, from 26 October is shaded in red, whilst the two-week *(n=15 days)* intervention/ diary phase is shown in green. The post-intervention phase (16 days), to the end of term 1 (07 December) is coloured blue. Weekends are marked in lighter shading. The plots indicate that consumption at weekends was generally lower than during the week, but there was no observable change in consumption between the different phases of the trial, or between the two houses.

The pulse data from the loggers on the cold feed to each shower were aggregated to calculate the total *cold* shower water use per house for the duration of Wave 2. The results are presented in Table 6-3. The data were split by weekday and weekend (shaded green), and by trial phases (in blue).

Table 6-3 Average COLD shower water consumption (houses G and J)

COLD shower water consumption - Wave 2	**Total** *(litres)*	**Household** [Total/n days] *(l/h/d)*	**Per capita*** [Household /8 residents] *(l/p/d)*
House G			
Weekday *(n=31 days)*	2321	74.9	9.4
Weekend *(n=14 days)*	883	73.5	9.2
1.Pre-intervention *(n=12 days)*	1044	87.0	10.9
2.Intervention *(n=15 days)*	1129	75.2	9.4
3.Post-intervention *(n=16 days)*	1031	64.4	8.1
All days *(n=43 days)*	**3203**	**74.5**	**9.3**
House J			
Weekday *(n=31 days)*	3376	108.9	13.6
Weekend *(n=14 days)*	1181	98.4	12.3
1.Pre-intervention *(n=12 days)*	1298	108.2	13.5
2.Intervention *(n=15 days)*	1672	111.4	13.9
3.Post-intervention *(n=16 days)*	1587	99.2	12.4
All days *(n=43 days)*	**4556**	**106.0**	**13.2**

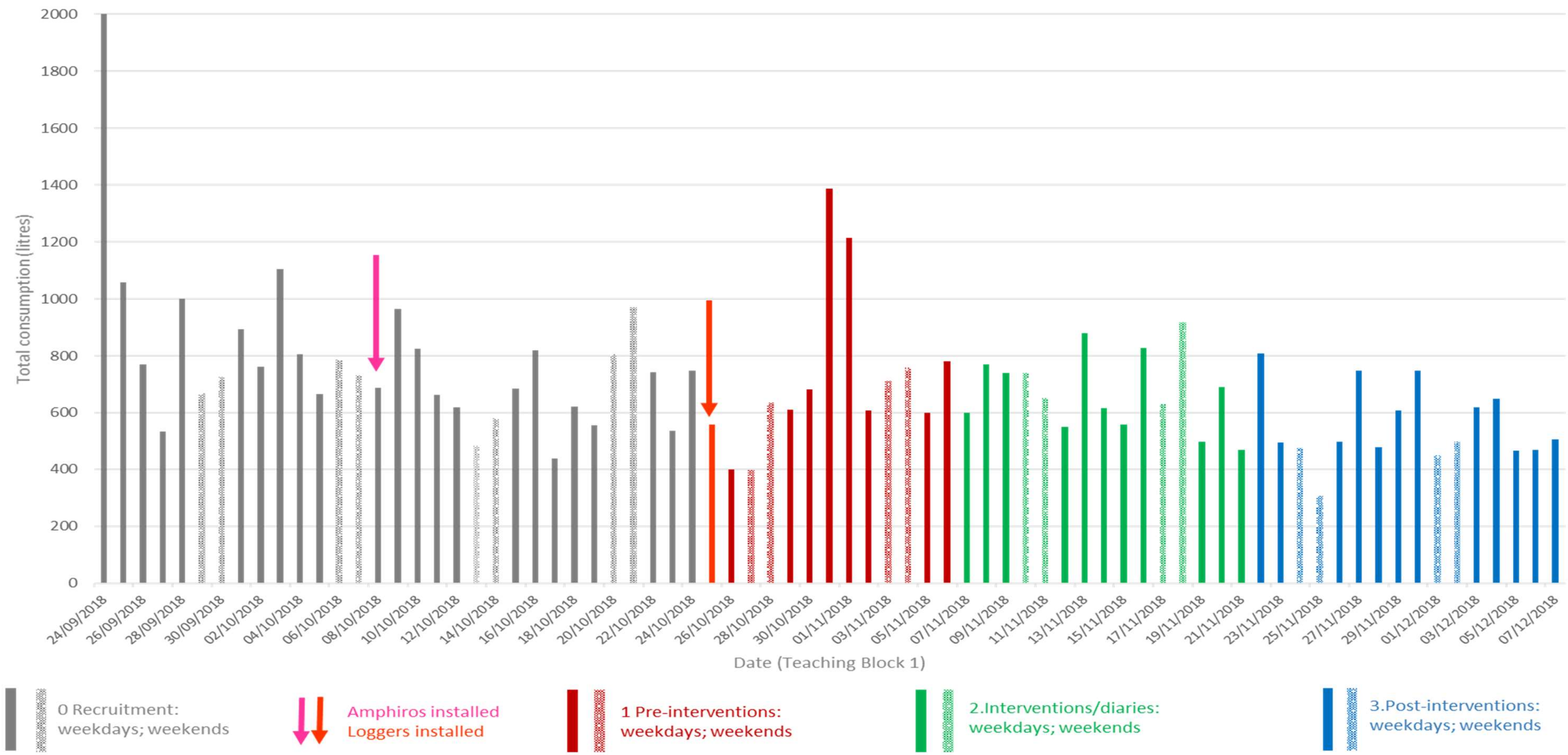


Figure 6-9 Daily household (metered) consumption - house G

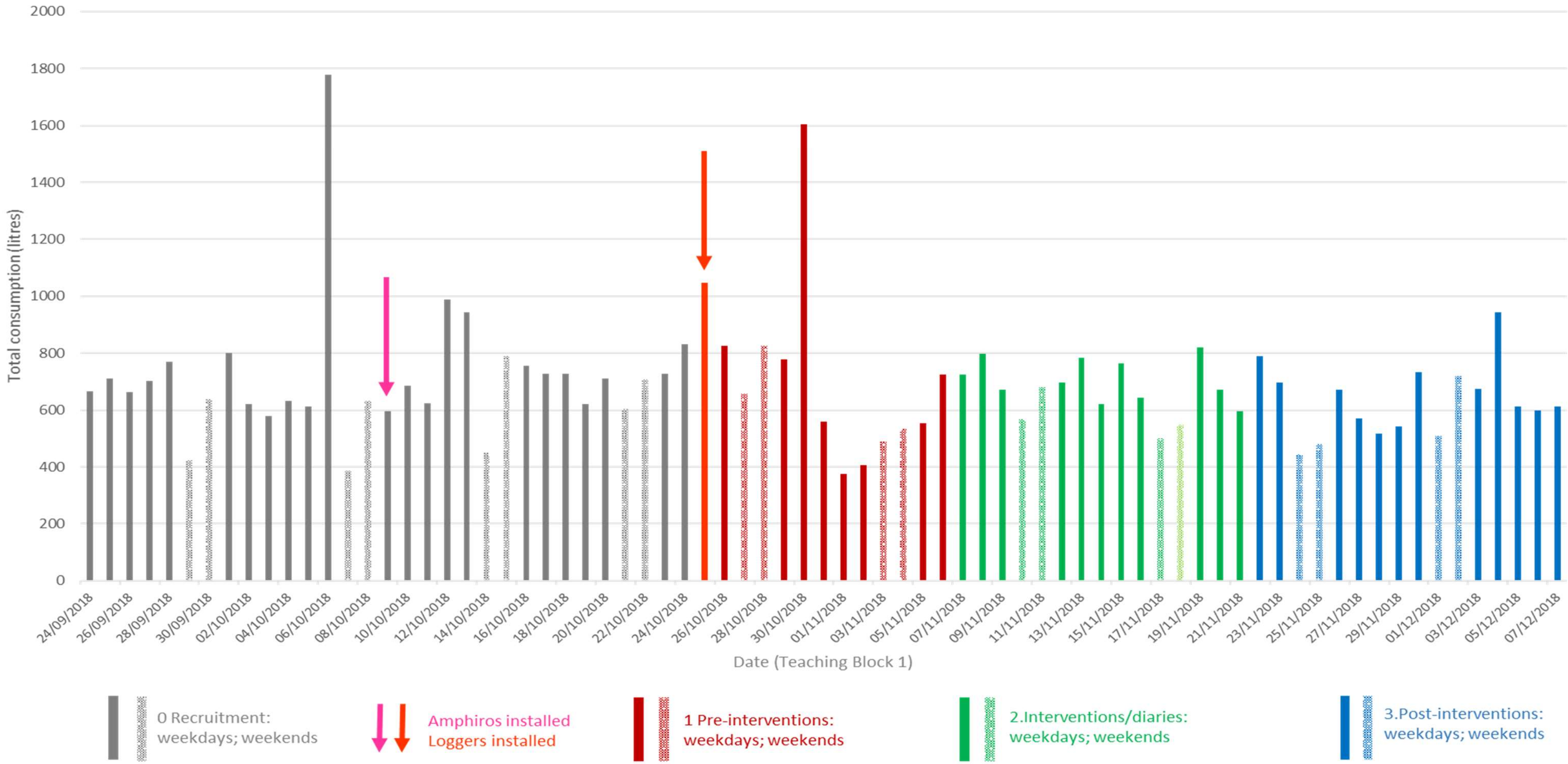


Figure 6-10 Daily household (metered) consumption - house J

Collectively the residents in house G used 29.7% less *cold* shower water than those living in house J. Cold shower water use was lower at the weekends than during the week for both houses, and consumption reduced across the trial phases in house G, in which seven of eight residents actively participated in the trial, using alternative haircare products and recorded diaries, whilst five attended focus groups. However, for house J with lower participation rate (five initially agreed to participate, but only four of eight were fully committed by returning completed diaries, and only two attended the focus groups), consumption increased slightly before dropping in the final post-intervention phase.

To estimate *total* shower water (combined *hot* and cold), the logged *cold*-water figures in Table 6-3 were combined with hot-cold ratios estimated using a combination of logger, meter, Amphiro and manual flow test data undertaken when the loggers were installed (25 October), as summarised in Table 3-7. The estimated *total* (hot and cold mixed) shower water for each house based upon fixture-level ratios, for each trial phase are presented in Table 6-4. The results indicate that overall, the total shower water consumption represented a modest 20.6% of metered PCC for house G, and 25.5% for house J.

Table 6-4 Average TOTAL shower water consumption, based upon fixture-level hot-cold ratios (houses G and J)

Estimated *total* (HOT and COLD) shower water consumption - Wave 2	**Total** *(litres)*	**Household** [Total/n days] *(l/h/d)*	**Per capita*** [Household /8 residents] *(l/p/d)*	**As % of total metered PCC**
House G: using **fixture-level** *hot-cold ratios (Table 3-8)*				
Weekday *(n=31 days)*	4089	131.9	16.5	21.2
Weekend *(n=12 days)*	1618	134.8	16.9	22.6
1.Pre-intervention *(n=12)*	1890	157.5	19.7	21.5
2.Intervention *(n=15s)*	2063	137.5	17.2	20.3
3.Post-intervention *(n=16)*	1753	109.6	13.7	19.9
All days *(n=43 days)*	**5707**	**132.7**	**16.6**	**20.6**
House J: using **fixture-level** *hot-cold ratios (Table 3-8)*				
Weekday *(n=31 days)*	5382	173.6	21.7	25.3
Weekend *(n=12 days)*	1182	156.8	19.6	27.0
1.Pre-intervention *(n=12s)*	2069	172.4	21.6	24.8
2.Intervention *(n=15)*	2665	177.7	22.2	26.4
3.Post-intervention *(n=16)*	2529	158.1	19.8	25.0
All days *(n=43 days)*	**7264**	**168.9**	**21.1**	**25.5**

For house G, there was little difference between weekday and weekend shower consumption (marginally less during the week and at odds with the total household metered consumption, Figure 6-9). The showering pattern of house J students showed higher shower consumption during the week than at weekends. Shower water consumption reduced in house G across the trial phases, with post-intervention phase consumption measured to be 69.6% of the pre-intervention phase (and a drop of 12.7% during the intervention fortnight). For house J, shower use increased slightly (by 3.1%) during the intervention phase, before reducing to 91.7% of the pre-intervention level.

As the conversion of measured *cold*-water shower consumption was based on *estimated* hot-cold ratios, sensitivity tests were completed with hot-cold ratios from different sources (house mean and weighted mean ratios) to validate the results. Sensitivity was also tested using temperature data collected elsewhere in the university estate (from Wallscourt Park phase 2 and the Student Village). The details of the sensitivity tests are provided in Appendix B.5 and summarised in Table 6-5. The results show clear similarity between the different methods of estimation and provide confidence in the validity of the findings.

Table 6-5 TOTAL per capita shower water consumption based upon different estimates of hot-cold ratio

Estimated *total* per capita shower water consumption	**House G**		**House J**	
	Per capita *(l/p/d)*	**% of total metered PCC**	**Per capita** *(l/p/d)*	**% of total metered PCC**
Fixture-level hot-cold (as per Table 6-4)	16.6	20.6	21.1	25.5
House mean: House G 43.5 : 56.5; House J 32.6 : 67.4	16.5	20.4	19.6	23.7
Weighted mean, average across houses G and J: 38.0 : 62.0	15.0	19.6	21.4	25.8
WCP phase 2 mean: 30.8 : 69.2	13.5	16.7	19.2	23.2
Student Village mean: 37.5 : 62.5 (40°C mixed)	14.9	18.5	21.2	25.6
42.9 : 57.1 (38°C mixed)	16.3	20.2	30.8	37.1

Metered daily household consumption was ranked, from high to low, to explore the correlation between the estimated shower component and the total measured daily use. This is presented in Figure 6-11 for house G, and Figure 6-12 for house J, with the blue portion of the bars representing estimated shower use (at around 20-25% of measured total consumption, on average). The bars are colour coded to show the different phases of the trial (red for the *Pre-*; green for the *Intervention/diaries;* and, blue for the *Post-intervention* phases). The median day, ranked 22nd of 43 days in total, is labelled. This corresponds with 615 l/h/d for house G (equivalent to 76.9 l/b/d) and 658 l/h/d for house J (82.3 l/b/d).

Figure 6-11 indicates that the interventions may have been successful in reducing *total* household consumption, with slightly more than half (seven of the twelve, 58.5%) *pre-intervention* days ranked above the median, to the left of the middle (22nd ranked) day on the chart, whilst only a five of 16 (31.3%) *post-intervention* days appeared above median consumption. However, this apparent success in reducing household consumption toward the end of the trial period may simply be the result of one or two residents going home early for the Christmas vacation. For house J, the relative differences between the phases (in Figure 6-12) were less pronounced, with only five of twelve (41.7%) of the *pre-intervention* days above the median. However, this may simply be because a resident was absent during the *pre-intervention* period.

The same data shown in Figure 6-11 and Figure 6-12 were re-ranked on the estimated shower component. The results are shown in Figure 6-13 and Figure 6-14 for house G and house J, respectively. Viewed this way, it was apparent that the shower volume was more constant than the inherently variable total daily household use and suggests that consumption through other fixtures (particularly taps) was more erratic. The median daily shower volume for house G was 123 litres and 152.5 litres for house J.

Finally, the frequency and duration characteristics of the logged shower events were analysed and aggregated by house. These results are summarised in Table 6-6.

Table 6-6 Average shower use (houses G and J)

Mean shower use	Mean shower frequency (uses/house/day)	Estimated mean event volume* (l/event)	Mean shower duration (min/event)
House G			
Weekday *(n=31 days)*	4.5	29.2	8.1
Weekend *(n=12 days)*	4.3	30.0	7.8
1.Pre-intervention *(n=12)*	5.3	28.8	8.0
2.Intervention *(n=15)*	4.5	29.4	7.6
3.Post-intervention *(n=16)*	3.8	30.4	8.6
All days *(n=43)*	**4.5**	**29.5**	**8.0**
House J			
Weekday *(n=31 days)*	6.6	26.3	5.4
Weekend *(n=12 days)*	5.4	29.0	6.0
1.Pre-intervention *(n=12)*	*5.6*	*30.9*	*5.9*
2.Intervention *(n=15)*	*7.0*	*25.4*	*5.1*
3.Post-intervention *(n=16)*	*6.1*	*25.8*	*5.7*
All days (*n=43*)	**6.3**	**26.9**	**5.5**
**Volume based on fixture-level hot-cold ratios*			

The residents of both houses showered less frequently than the social norm or *'UWE standard'* of a daily shower, with 4.5 showers per day in house G (equivalent to 0.56 showers/p/d, or a shower approximately every other day), and 6.3 showers per day for house J (0.79 showers/p/d). Frequency appeared to reduce during and after the trial for house G (in apparent accordance with the '*go gold'* messaging to skip showers and reduce frequency). However, frequency appeared to increase during the trial for house J. Residents in House G tended to spend around 8 minutes in the shower (close to the norm for the wider UK population - Energy Saving Trust, 2013; Walker and Zygmunt, 2009), whilst residents in house J took shorter showers, averaging around 5.5 minutes.

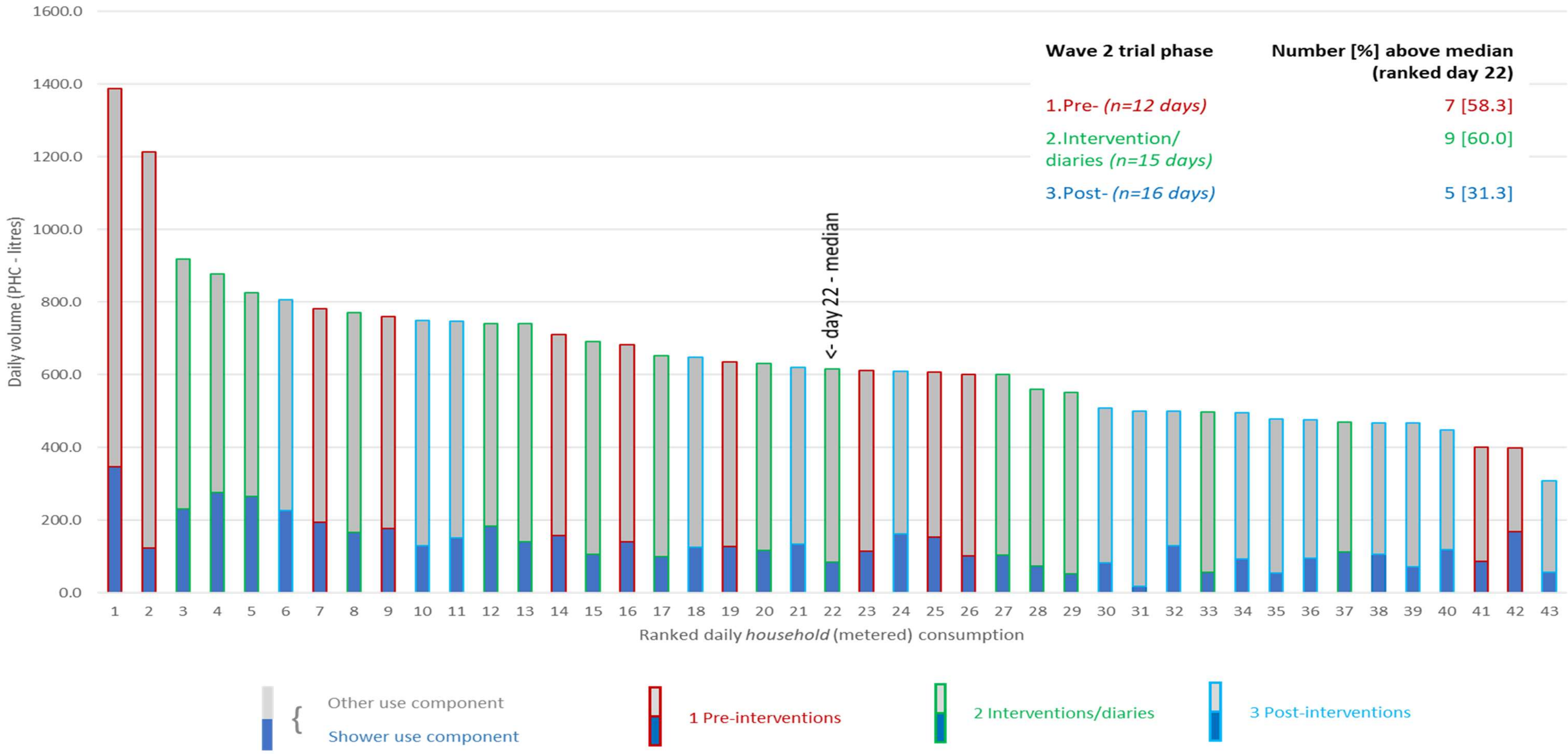


Figure 6-11 Daily household (metered) and shower consumption (estimated), ranked on PHC – house G

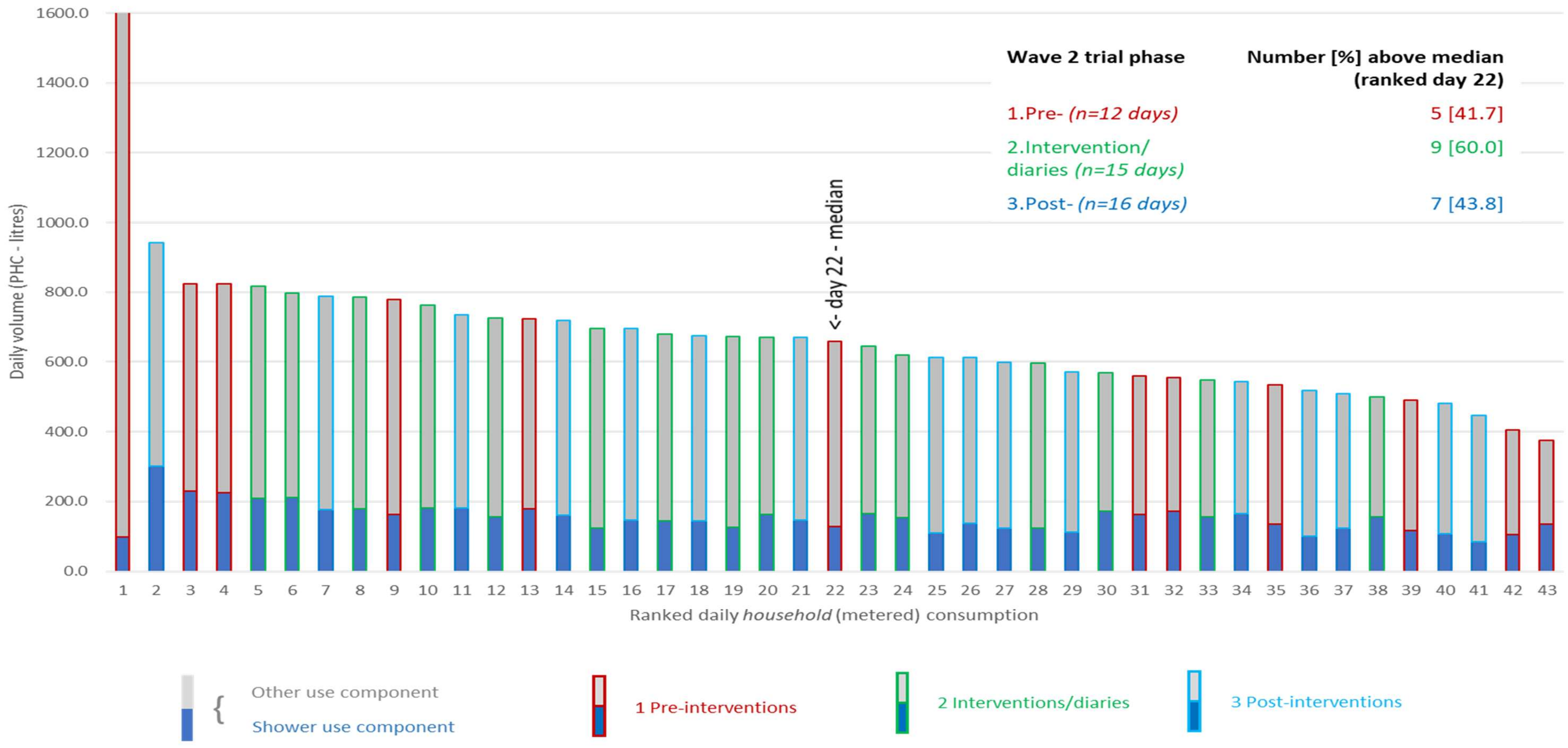


Figure 6-12 Daily household (metered) and shower consumption (estimated), ranked on PHC, ranked on PHC – house J

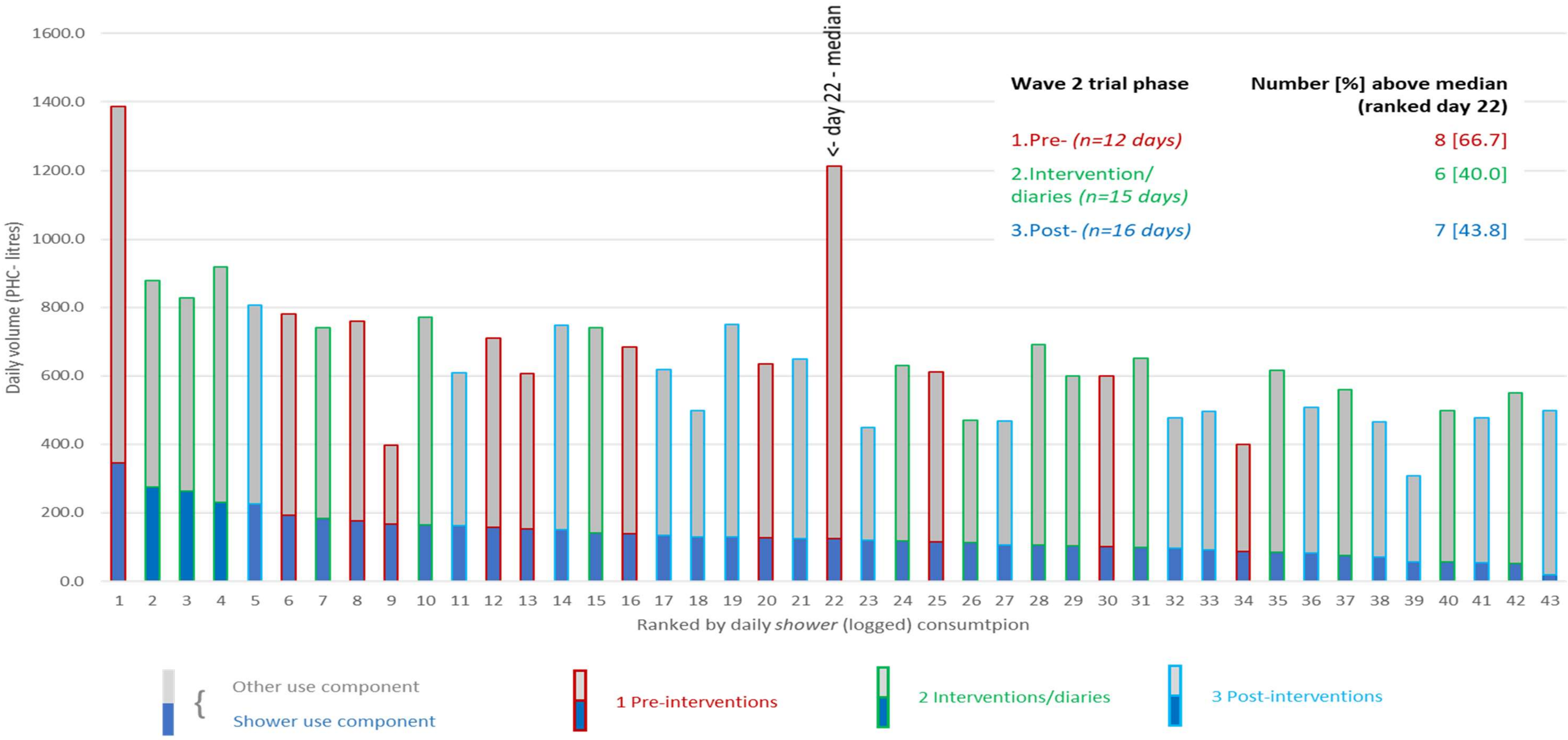


Figure 6-13 Daily household (metered) and shower consumption (estimated), ranked on shower use – house G

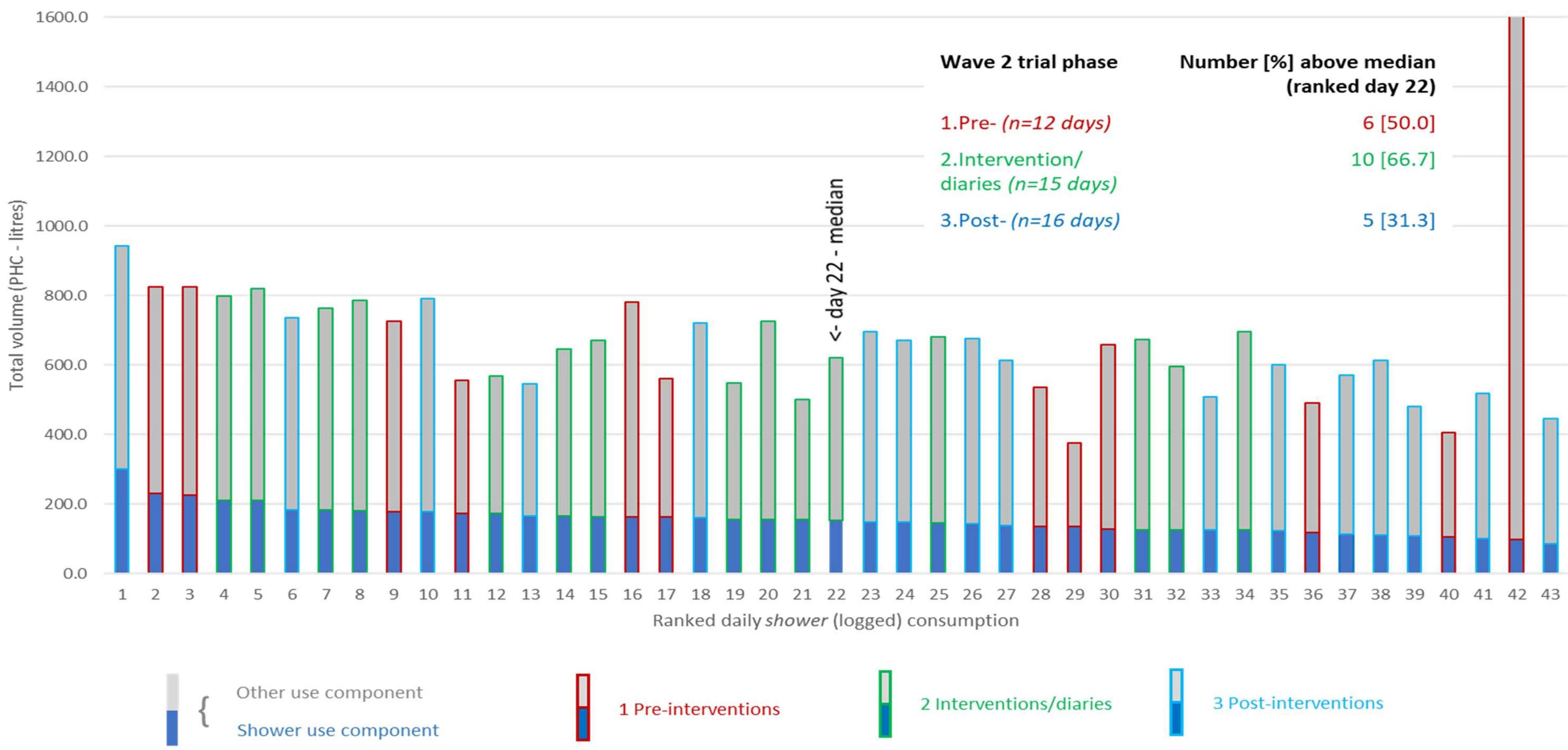


Figure 6-14 Daily household (metered) and shower consumption (estimated), ranked on shower use – house J

6.1.3 Summary of volumetric measurement findings

The volumetric analysis indicated that total water consumption across the WCP1 development was modest and broadly comparable across academic years, at slightly above 100 l/*b*/d during term-time. At this macro scale (*total* water use across the entire development), there was no visible drop in total demand attributable to the interventions. PCC for the control group of houses increased during the trial, but there was a modest reduction for the five intervention houses, indicating some measurable impact.

At a household scale, meter data indicated that total water use was lower at the weekend, compared with weekdays, and demand appeared to reduce across the trial period. There is evidence that the interventions may have reduced total water use, but this is confounded by the potential for unknown changes in occupancy.

At a fixture scale, weekday shower volumes were lower than at weekends for house G, but higher in the week for house J (in line with *total* water use). The logged pulse data indicated that shower volumes were more constant than the messy variation shown for total water use, and showers accounted for only 20-25% of total water used. The shower frequencies for both logged houses were lower than the daily shower norm, and there was a drop in shower frequency for house G as the trial progressed, suggesting that the participants engaged with the aims of the '*go gold'* messaging and skipped some showers. Average shower duration for house J was low, whilst house G was closer to the norm, suggesting that the participants from house J engaged with the *'go green'* shampoo bar challenge.

6.2 End-user insights

There were 23 participants, from five houses, that actively took part in the Wave 2 field trial, by completing questionnaires, trying the shampoo bar intervention, and recording diaries. This represents a 55% sample of the resident (42 head) population of the five intervention houses (and 24% from across the study site). A breakdown of participation is summarised in Table 6-7. The gender balance was representative of the 52:48% female to male ratio for the resident population for the five intervention houses (Table 3-3 for occupant demographics). This was an improvement in representation compared with the Wave 1 trial. Engagement was maintained through the intervention fortnight, although two male participants, from houses H and J, did not complete and return the diary, and the house J participant did not complete the second (Q/2B) questionnaire either. The consolidated format of just two focus groups, was more efficient compared with Wave 1, with eleven participants (48% of Wave 2 participants) across the two sessions.

Table 6-7 Summary of participants (split by gender)

	Questionnaires		**Diaries**	**Focus groups**	
House	**Q/2A**	**Q/2B**		**FG7** *(hosted by house G)*	**FG8** *(hosted by house F)*
F	4f, 2m	4f, 2m	4f, 2m	1f	1f, 1m
G	4f, 3m	4f, 3m	4f, 3m	2f, 2m	1m
H	1f, 1m	1f, 1m	1f	0	0
J	2f, 3m	2f, 2m	2f, 2m	0	1f, 1m
K	1f, 2m	1f, 2m	1f, 2m	0	1m
Total	**12f, 11m**	**12f, 10m**	**12f, 9m**	**3f, 2m**	**2f, 4m**
f = female, m = male					

6.2.1 Questionnaires Q/2A and Q/2B

All 23 Wave 2 participants completed and returned the Q/2A survey, whilst 22 responses were returned for the evaluation survey (Q/2B). The mostly quantitative Q/2A responses are tabulated in Appendix C.1 for reference and comparison with the results of the first two surveys (Q/0 – *on campus*, and Q/1). The Q/2A responses broadly reflected the findings from the earlier questionnaires and previous cohort of students, with some small deviations which may be due to the smaller sample size (with 23 responses, equivalent to a quarter of the *n=90* Q/0 - *on campus* results). To avoid repetition, the similarities are not itemised here. As with the Wave 1 (Q/1) results, the Q/2A responses provided a further round of data validation of the exploratory phase (Wave 0) survey (Q/0) findings. However, there were a few deviations that are highlighted below in addition to responses to new questions that focused on showering processes and hair washing in particular, that are presented here.

The second Wave 2 survey (Q/2B) comprised several open-ended qualitative questions. The results are presented here in tandem with the Q/2A results, as appropriate, following a similar structure as the previous two results chapters, by reporting on different dimensions of showering in turn. By nature, the evaluation survey results were more discussive than the first three survey results and did not allow for summarisation via tables or plots. Instead, rich insights were drawn from the survey responses, and these are evidenced by examples of the participants' own words. The significance of the findings is discussed further in the next chapter (RQ 4.5).

Environmental awareness and actions

The Wave 2 participants appeared to be slightly less water aware than the previous year's cohort. In response to the question on how much water they used (question 3, Q/2A), 57% confirmed they had considered it, compared with 77% of responses to Q/0 (and 68%

in Q/1). This lower awareness may be because the on campus '*Reduce the Juice'* resource efficiency campaign that ran over two academic years from 2016-18 had ended, and the replacement in-house campaign of inter-hall/house competitions (run in partnership between the university Energy team and the Students' Union) did not properly start until later in the 2018/19 academic year, after the Q/2A survey was live. This interpretation is supported by even lower numbers of students being able to recall any water saving campaigns or messaging (question 24, Q/2A) with only one student (4%) indicating '*yes'*, compared with 12% in October the previous year (Q/0) when some referred directly to '*Reduce the Juice'* and others recalled seeing posters and Freshers events.

In relation to recycling, the 2018/19 cohort appeared to be slightly more active than students from the previous academic year, with 74% stating that they *always* recycled at home (compared with 54% in Q/0), rising to 83% in their UWE accommodation (compared with 66% for Q/0). However, uptake was lower around the university campus with only 22% *always* using the recycling bins, and 65% *sometimes* taking this action.

To tie in with the single-use plastic focus of the interventions, the final survey (Q/2B) enquired student attitudes to plastic pollution and disposal of plastic bottles, and asked:

> *Q/2B-q2. In the first survey you were asked about recycling. Did you know that you can recycle your empty shower product plastic bottles?*
>
> *Q/2B-q3. The issue of plastic pollution is prominent in the media. Is plastic pollution of concern to you?*

The results for question 2 are summarised in Figure 6-15. Despite reporting concern about plastic pollution by 95.5% of participants (question 3), there was a lower tendency to recycle empty bathroom product bottles specifically, compared with recycling in general (as reported in the previous three questionnaire surveys). Two participants did not realise that such bottles could be recycled, and a further two reported that they did not recycle their empty product bottles when at home, whilst four did not recycle at UWE. This illustrates the '*information-action'* deficit, where environmental concern does not translate into the desired (recycling) action.

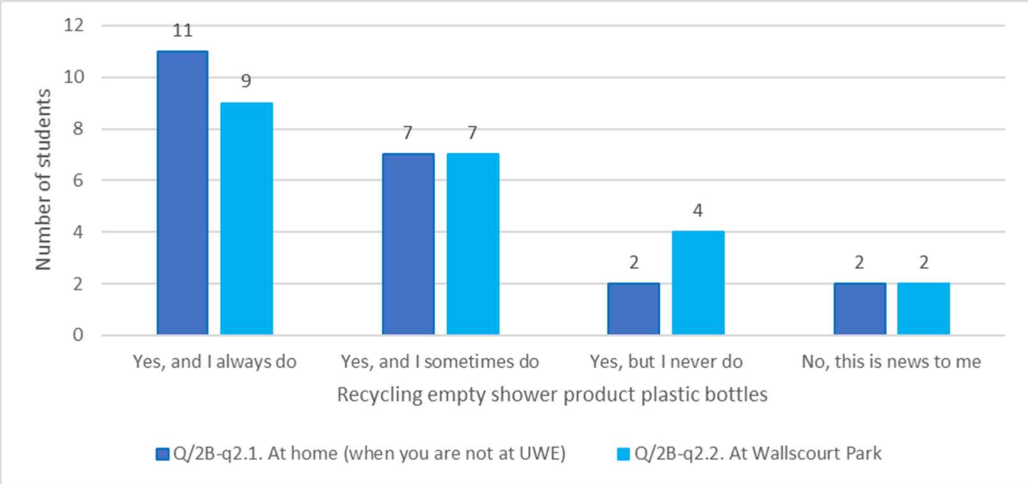


Figure 6-15 Did you know that you can recycle your empty shower product plastic bottles? (question 2, Q/2B)

Shower duration

Responses to the question on shower length (question 5, Q/2A), indicated that the Wave 2 participants showered, on average, for a shorter duration of 10.7 minutes, compared with the 2017/18 student cohort (13 minutes returned in Wave 0 and 12.9 minutes for Wave 1). When aggregated into duration categories, the *typical* shower duration was 9-14 minutes, reported by 43.5% of Wave 2 participants (similar to 42% of Wave 1 students, but shorter in duration than Wave 0 students with 50% reporting longer 15 to 20-minute showers). Nevertheless, 65% of responses reported a shower duration of ten minutes or longer, above the national average for the wider population of up to eight minutes (Energy Saving Trust, 2013; Walker and Zygmunt, 2009).

A couple of new questions about shower controls were included in Q/2A:

> *Q/2A-q9. For the duration of the shower, do you run it at…? (Quarter turn/eco-setting; Half turn/maximum flow; Varied flow?)*
>
> *Q/2A-q10. At what temperature do you run the shower at? (40 degrees C; Colder; Hotter)*

The results are summarised in Figure 6-16 and Figure 6-17. Almost half of students reported that they varied the flow while showering, suggesting that they reduce the flow rate whilst shaving or applying products, although more than a third (35%, including those that responded '*other*') opted to run the shower on the maximum flow rate for the full length of the shower. Only four students selected the lower flow *eco-setting,* a reflection on already low flow water efficient showerheads.

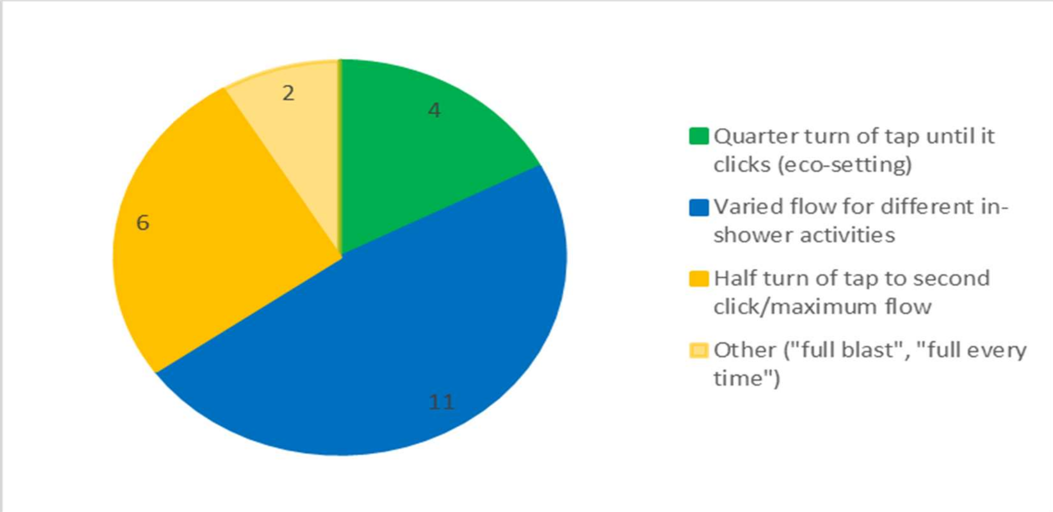


Figure 6-16 Flow control setting (question 9, Q/2A)

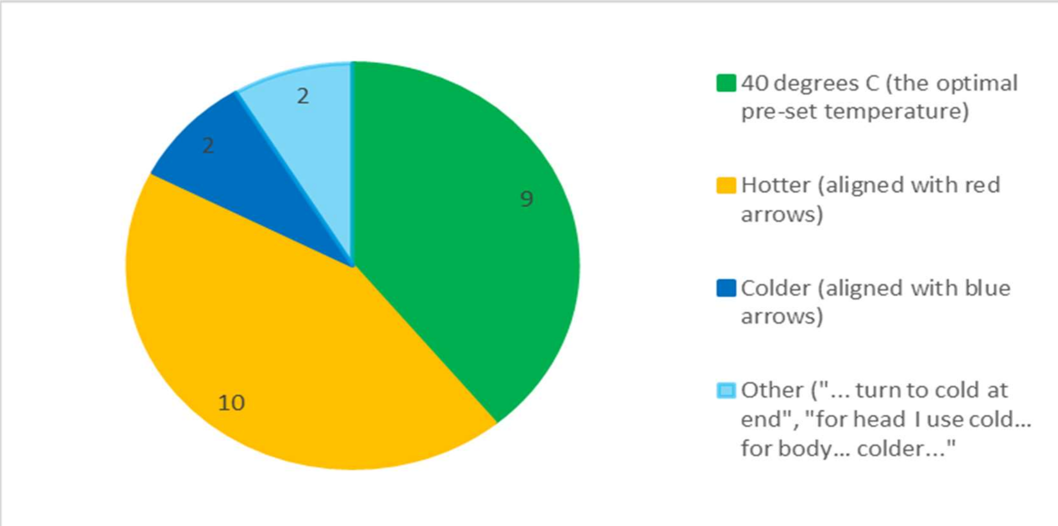


Figure 6-17 Temperature control setting (question 10, Q/2A)

The use of temperature controls was evenly split between the default 40°C setting (39%), and a hotter temperature (44%). Two students showered at cooler temperatures whilst another two reported varying the temperature depending on the activity or stage of the shower, opting to end their showers with cooler water.

The students were asked whether they had altered their shower length through the trial, and why this might be:

Q/2B-q9. During the trial, did the DURATION of your shower change?

Ten participants (45.5%) indicated no change, whilst the remaining responses were split evenly (18.2% each) between *decreased* shower time, *increased* time and *other* (in which these variations were dependent upon emotional or physical wellbeing). Of those that had reported *no change*, some said that they already took short showers (citing other peoples' shower durations as the yardstick), or were resistant to making any changes:

> *"I feel as though my showers are quite short compared to a lot of peoples."*
>
> *"I try to be quick in the shower anyway."*
>
> *"Averaged out ..., I tried to be quicker some days but was longer than usual others - depends on how im* [sic] *feeling. I have had a cold in this time and a long warm shower was nice to clear out my system. Other mornings a short cold shower to wake me up. Usually I'll have a longer shower after exercise to relax my muscles too."*

For those that said they had reduced their shower duration, they appeared to be more aware of their consumption, and wanted to *do the right thing*:

> "I was more aware of not killing the polar bear and trying to get the best grade"

The interventions appeared to have the reverse effect on duration than intended for four participants, who indicated that the shampoo bar was not suitable and was hard to use:

> *"Solid shampoo took longer to use"*
>
> *"shampoo made my hair tangled and i had no clue how to wash the shampoo from my hair so it would't* [sic] *make my hair greasy"*

Shower frequency

The spread of reported shower frequencies (question 6, Q/2A) for Wave 2 was broader than for the Wave 1 trial, ranging from 3-4 times per week (22%), up to more than once per day (13%). Only a third (35%) reported that they conformed to the daily shower norm (compared with 79% of Wave 1 and 57% of Wave 0 responses).

Participants were asked whether their shower frequency had altered in response to the trial:

Q/2B-q10. During the trial, did the FREQUENCY of your showering routine change?

Whilst almost two-thirds (64%) indicated *no change*, 27% reported that they showered *less* often. Reasons for reduced frequency indicated that the participants were more aware of their showering routine and wanted to rise to the '*go gold*' challenge of skipping some showers:

> *"Tried to go gold"*
>
> *"Skipped a few showers and tried using the dry shampoo."*
>
> *"It made me more aware"*

The majority, who stuck with their standard routine indicated a reluctance to deviate from it and cited the need to shower after exercise to remove sweat and body odour, or a desire to feel clean and fresh:

> *"I need to be clean, regardless of if I am documenting my showering habbits.* [sic]*"*
>
> *"because i exercise regularly so i shower after this and always shower in the morning to feel fresh for the day, the duration of them shortened though"*
>
> *"I prefer to shower daily to keep up body hygiene as I use the gym most days"*

Time of day

The students were asked whether they had modified *when* they showered during the trial:

Q/2B-q11. During the trial, did the TIME OF DAY that you usually shower change?

Two students (9.1%) indicated that they had modified this aspect of showering, although they did not cite the trial as being a driver for this change. The majority (19 of 22 participants, 86%) said that the interventions had not caused them to change *when* they showered. Those that previously stated that they stuck to a specific time of day, such as first thing in the morning continued to take morning showers, and those that tended to vary the time of day for their showers, continued to do so, determined by the timing of lectures:

> *"I showered before lectures and after exercise."*
>
> *"I always showered once I woke up"*
>
> *"I shower around my schedule so any changes were based on that"*

Flow rate

Participants were asked whether they varied the *flow rate* of their showers during the trial:

Q/2B-q12. During the trial, did you change the FLOW RATE of your showers?

A third of responses (7 of 22, 32%) indicated that they had *decreased* the flow, whilst the majority (15 participants, 68%), made no change. Reasons for *reducing* the flow showed that they were more *aware* of their water use (and either modified their actions to match the aims of the research or in response to the Amphiro visual display), with some turning the flow down to shave:

> *"Decreased it slightly just to see what the effect would be on the amount of water and energy used."*
>
> *"Would turn shower off completely when I shaved and didn't really use max flow ever"*

Justifications for not changing the flow indicated that some were not aware of the flow controls, or always stuck with the *default* 'eco-setting'. Some indicated that they ran the shower on maximum to try to offset the low regulated flow determined by the showerhead:

> *"I don't know how to change it."*
>
> *"Since coming up to uni I've been using the eco setting not realising it's an eco setting."*
>
> *"Water has no pressure even on the top setting"*

Products

The Wave 2 participants used fewer shower products during a typical shower than reported in the previous questionnaires (Q/0 and Q/1), with a mean of 2.8 and a median of 3, compared with 3.5 and 4 for Wave 1 (Q/1), respectively and an average of 3 (mean and median) for Wave 0 (Q/0).

> *Q/2A-q12. How many different personal shower products do you use during a typical shower?*

The survey (Q/2B) asked if the number of shower products *changed* during the trial, and why this might be:

> *Q/2B-q14. During the trial, did the number of different personal shower PRODUCTS you use during a TYPICAL shower change?*

Nine participants (41%) used fewer products – in line with the aim of the shampoo bar intervention, whilst 13 (59%) had not changed the number of products (and none increased the number of products). Reasons for using fewer products indicated that participants tried to stop using their plastic bottled products and just used the shampoo bar provided to comply with the '*go green'* challenge messaging. In so doing, some discovered that they did not need a myriad of different products:

> *"I didn't use conditioner because it was in a plastic bottle"*
>
> *"Only used the given products"*
>
> *"i found that this solid shampoo was very moisturizing and didn't need a conditioner"*
>
> *"I used the block for body and hair rather than body wash, shampoo and conditioner."*

Reasons given for not changing the number of products used included, only having a simple routine to start with; resistance to changing routine habits; or *only* substituting their usual shampoo for the bar provided (and continued to use all other products):

> *"I have a set shower routine that I tend to stick to"*
>
> *"because I don't use many products to begin with"*
>
> *"The only product I stopped using was my normal shampoo which got replaced by the shampoo bar."*

Question 15 (Q/2A) explored haircare brands; brand-loyalty; compliance with manufacturers' directions for use; and, prior experience of solid shampoo:

Q/2A-q15. Which brand(s) of in-shower haircare products do you use?

Q/2A-q15.a. Do you usually use the same brand(s)?

Q/2A-q15.a.i. Why do you buy the brands you use?

Q/2A-q15.b. Do you ever read the instructions on your in-shower products?

Q/2A-q15.c. If you use shampoo, how much product do you usually apply?

Q/2A-q15.d. Have you ever used solid shampoo before?

Figure 6-18 shows the ten leading UK (women's) shampoo brands for 2019 (Statista, 2019), plotted with the frequency of mentions in response to question 15. The results show 13 mentions (56.5% of responses) of the top six shampoos.

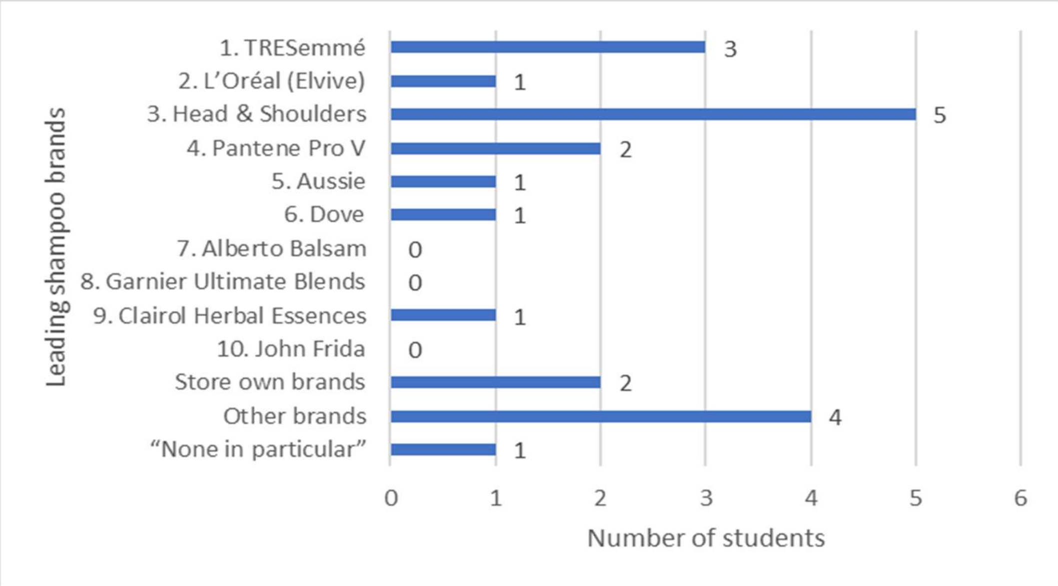


Figure 6-18 Leading women's UK shampoo brands and frequency of mentions (question 15, Q/2A)

Nine participants (41%) said they were brand loyal (not necessarily to the leading brands). Reasons included cost; effectiveness or suitability for hair type; ethical or environmental meanings and emotional connections, whilst price or special offers were the most frequent reason given for switching brands:

> *"Cheap"*
>
> *"I usually get body and face wash depending on the price but try to keep to the same brand, I always buy the same shampoo and conditioner because it's great for my hair"*
>
> *"… very cheap and do not test on animals. I also have a very sensitive scalp and it doesn't upset it…"*
>
> *"…my other half uses it and we are in a long distant relationship, so i like having his scent."*

Only a third (35%) of responses said they read the manufacturers' instructions on shower products, whilst 65% (15 out of 23) did not. This suggests that for the majority, the process of hair washing as an habitual or subconscious routine in which the necessary skills or knowledge are embodied, having been learnt during adolescence when children transition from being bathed by a parent to knowing how to and being able to shower independently.

The participants were asked to estimate how much product they applied (question 15c) by relating it to the two-dimensional diameter of a range of everyday items. The responses are summarised in Figure 6-19. The majority (56.5%) selected the £2 coin (approximately 30mm in diameter) sized option. This may indicate a response bias as it was the mid-point category in a range of suggested responses. A significant majority of participants indicated that using solid shampoo was a very new experience for them (question 15d), with twenty (87%) having *never* shampoo used bars previously, whilst two had sometimes used them, and only one student was a regular solid shampoo user.

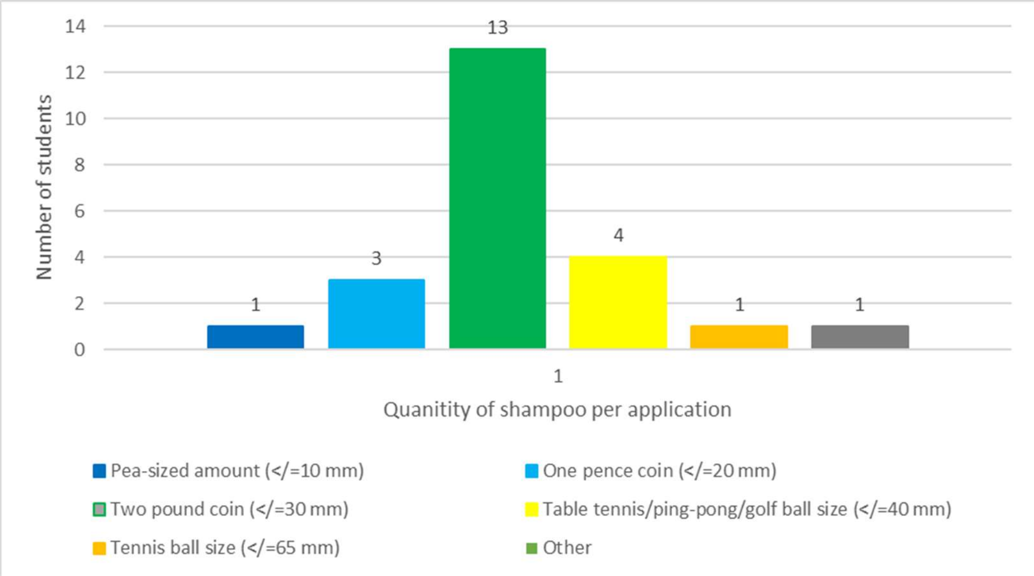


Figure 6-19 If you use shampoo, how much product do you usually apply? (question 15c, Q/2A)

Whilst only a third stated that they read the blurb, this led to a supplementary snapshot investigation into what manufacturers print on the reverse of shampoo and conditioner packaging and whether their recommended processes might drive longer *duration* or more *frequent* showers, and increased resource consumption (water, energy, product, and packaging) should users follow the steps described. The full results are presented in Appendix E and are summarised below.

For best effect, 61% of sampled products, and seven from the leading ten, recommended users follow shampooing with application of the branded conditioner, encouraging not only brand loyalty, but also increased product *consumption* and shower *duration*. Although six products (from budget to high-price point) directed the user to *repeat* the application of shampoo, none of the leading brands recommended a second application. Five brands suggested an ambiguous *quantity* of product should be used, with the budget priced bottles using meaningless qualitative terms including "*good sized dollop*" or "*good squidge*", whilst two medicated or specialist products recommended *regular* use of the shampoo, although *daily* use was not suggested.

Seventy per cent of the sampled leading shampoo brands recommended that shampooing should be followed with an application of the same brand conditioner. Three of the top seven brands directed users to leave the conditioner on, for up to 3 minutes, and a fourth product recommended *repeating* the application, all giving the potential to add to shower *duration*. Again, three products suggested an ambiguous quantity of product should be applied, using the terms "*blob"* and "*generous amount"*.

Survey data were also collected on participants' hair length, type, and condition. The results are summarised in Appendix C.1.6.

The evaluation survey (Q/2B) asked if the information on between-wash hair styles and no poo/low poo lifestyles were helpful:

> *Q/2B-q8. During the trial, you were provided with some guidance on alternative hair styles and information on no poo/low poo (shampoo). Did you find this useful?*

Just five participants (all female) used the material to try hair styles to hide grease build-up or to experiment:

> *"Putting hair up when it was getting greasy"*

Those who did not use the information explained that it was more suited to longer (or female) hair, or they were happy with their own technique:

> *"It wasn't useful as they were for longer hair and I have shorter hair."*
>
> *"I did not use it, I used my own techniques"*

In-shower activities

Question 13 enquired about the process of, and variations to the *dimensions* of showering; and, whether hair was washed every time:

> *Q/2A-q13. Please describe the TYPICAL steps you take in a shower, including the order in which you use products, from first turning the flow on, to turning it off.*
>
> *Q/2A-q13a. Do you always follow the same steps in the same order, or does your shower routine vary depending on the day, time, or context?*
>
> *Q/2A-q13b. Do you ever vary your showering routine in any of the following ways? (frequency, duration, and activities)*
>
> *Q/2A-q13c. Do you usually wash your hair when you shower?*

The *order* of typical steps described by the students were analysed. All 23 respondents mentioned washing their hair (or using shampoo and/or conditioner) and their body. The majority (16 of 23, or 70%) described washing their hair prior to washing the body (or using shower gel), and only six (26%) washed their body first. Of the twelve students that washed their face as well as their body, seven described washing their body first whilst five said they cleaned their face before their body. There was a clear tendency to wash hair before face (by 10:2). Only one student specifically mentioned shampooing twice (compared with three that responded this way to question 11 (Q/2A) on shower activities).

Five participants mentioned shaving, and for the four females, this was always after shampooing. Three students said that they turned the shower off during their shower to attend to a particular aspect of the process. One student started her shower by urinating and brushing her teeth (it transpired that she had lived in house D during the previous academic year and had been influenced by the '*pee in the shower'* posters that had been displayed for the Wave 1 trial, although she had not actively participated in the data collection activities). One student said they "*chill a bit under the shower*" and another said that they "*turn on, wait for it to warm up*", indicating water use on non-washing activities. One student noted that he considerately removed "*any hair from the plug"*.

Fourteen students followed a regular or habitual shower routine and did not deviate from the steps described, whilst nine students indicated that their routine varied and was context specific. Reasons given for varying their routines included comfort; showering after sport; being late to rise; or not needing to wash, shampoo or shave every day:

"Sometimes it's just to warm up or wash after the gym"

"Depending on whether I'm showering after exercise, then I'll just wash my body and face"

"Usually depends on how late I am getting up in the morning"

"If I'm busy, if I need to condition, if I need to shave etc"

The participants were asked which dimensions of showering they were most likely to vary (question 13b). The results, shown in Figure 6-20, indicate that that shower frequency and duration tend to vary, but that the processes within the shower were constant, suggesting an ability to speed up or slow down (to change the *duration*) depending on time available.

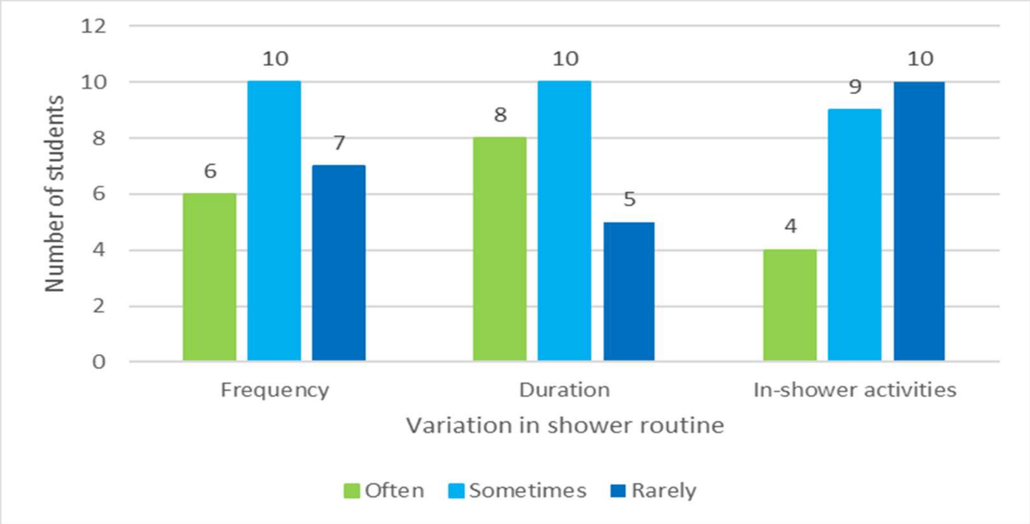


Figure 6-20 Variation of the dimensions of shower routine (question 13b, Q/2A)

The evaluation survey asked whether shower micro-processes changed during the trial:

> *Q/2B-q13. During the trial, did you change any of the ACTIVITIES you undertake during a TYPICAL shower?*

The results summarised in Figure 6-21, indicate that two-thirds (68%) of participants did not alter the number of in-shower activities, although 32% reported *fewer* by not conditioning or shaving less often and none *increased* the number of processes during a typical shower:

> *"I didn't condition as that would have involved using my plastic bottled shampoo"*
> *"I usually shave in the shower more but cut back during the trial."*

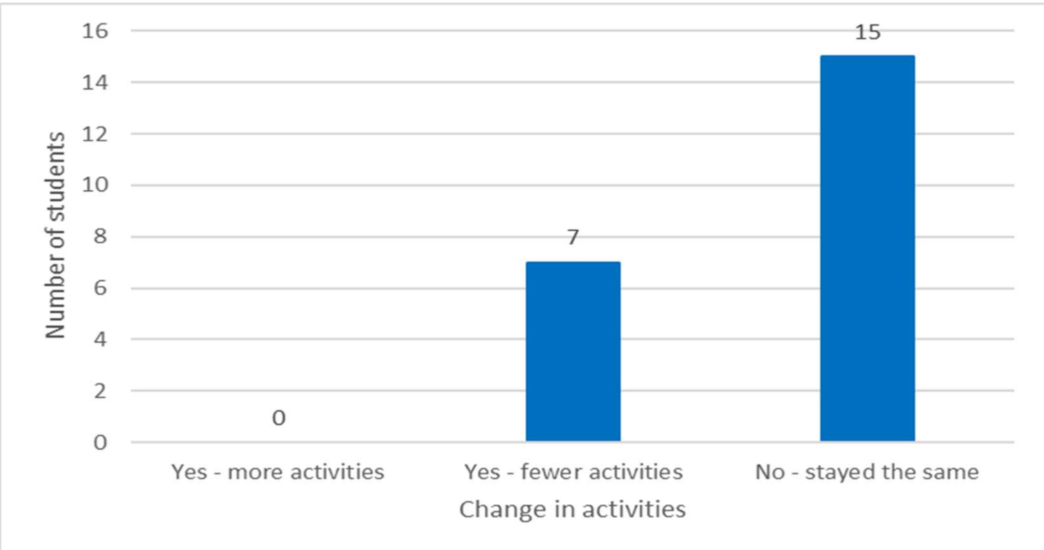


Figure 6-21 Did you change any of the activities you undertake during a typical shower? (question 13, Q/2B)

Participants were also asked which activities had the greatest impact upon the different dimensions of showering:

> *Q/2B-q13(c-e). Which in-shower activity do you think has the greatest impact on your shower:*
>
> > *q13c. DURATION (i.e., which takes the longest)?*
> >
> > *q13d. FREQUENCY (i.e., which makes you shower more often)?*
> >
> > *q13e. FLOW RATE (i.e., which makes you adjust the flow rate)?*

The findings are summarised in Figure 6-22 and confirm that the principal processes of cleaning hair and the body had the greatest impact. However, shaving had a significant bearing on shower duration and could be worth exploring for a future water saving intervention.

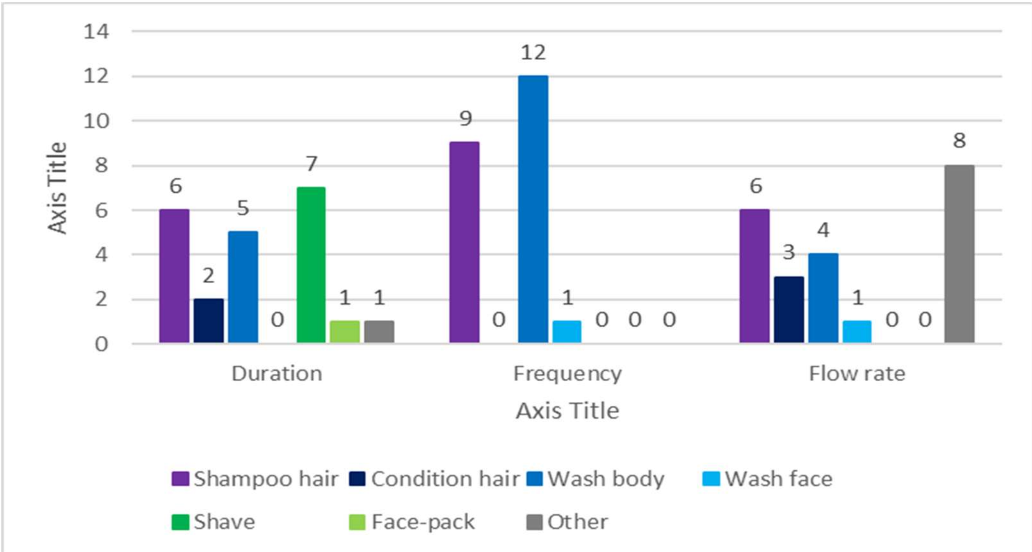


Figure 6-22 Which in-shower activity do you think has the greatest impact on your shower?

Hair washing had a significant impact on the dimensions of showering because it was one of the main processes, hair was long or thick, felt dirty or itchy, and conditioner had to be left to soak in:

> *"Main activities"*
>
> *"It takes longer to wash and rinse my hair because it's so long and thick"*
>
> *"i am in a better mood when my hair looks clean"*
>
> *"I leave it on for a minute."*

The impact of washing the body on showering dimensions was due to the time needed to wash the expanse of a tall body, the desire to feel clean and smell fresh, that it was necessary to wash after exercise, whilst shaving caused longer durations due to the need to take care not to cut the skin:

> *"I'm tall and it takes time to clean all of me."*
>
> *"I want to be clean, not smelly"*
>
> *"Clean body after exercise."*
>
> *"I'm careful and take my time when I shave"*

Interventions

'Go green'

Participants were asked about the challenge and their response to it:

> *Q/2B-q4. The trial challenged you to 'go green' and give up shower products that are packaged in plastic bottles. Did you manage to do this?*

Three-quarters of participants indicated that they accepted the *'go green'* challenge and attempted to abstain from plastic packaged shower products for the trial, with 40% doing this for all showers and a further 36% for some showers. Their motivations included ease of use or convenience and saving money, whilst others were concerned for the environment, inspired by the symbolic meanings behind the (Lush) brand and emotions triggered by the fragrance of the product. Some simply stated that they had used the unpackaged shampoo bar because that was what they had been asked to do:

> *"The solid bar worked well as a body wash"*
>
> *"I ran out of shampoo the day before the trial started so decided to try what was given to me to save shopping."*
>
> *"To reduce the amount of plastic i used"*
>
> *"I love LUSH and all their products, and I am very driven to go green and save as much of the planet as we can."*
>
> *"I ... like seaweed as it reminds me of home."*

However, reasons for not adopting the new approach included being unable to perform all their usual shower activities with the products provided, although one made a pledge to change to unpackaged products in the future:

> *"I had to shave occasionally with razors and shaving cream."*
>
> *"Gave up my shampoo but didn't feel clean after using it as a body wash..."*
>
> *"... after i finish these products i'm not going to buy them in plastic packaging"*

Some did not get on with the shampoo bar as it failed to perform in the way they had hoped or was not suitable for their specific hair type or skin condition, whilst others simply forgot about the trial, and used their usual product out of habit:

> *"No because I have to use special body wash for dry skin"*
>
> *"Some products I need and have been using for a while so I was unable to swap them out"*
>
> *"For one day I was in a rush and forgot to use the shampoo bar provided"*

Participants were asked specifically about the shampoo bar provided:

Q/2B-q5. Did you use the solid shampoo?

Q/2B-q5b. What did you think of the solid shampoo product that you were provided with?

Q/2B-q5c. How likely are you to use solid shampoo in the future?

The majority (91%, 20 of 22) of the participants used the shampoo bar, and again, referred to the relative ease (or not) of using the new product and their personal skills and expectations, whilst some compared the performance and cost of the bar with their usual bottled shampoo:

> *"… I found it difficult to use at first, but I got the hang of it, and it left my hair feeling really nice"*
>
> *"… quite easy to use"*
>
> *"… I struggled to lather it in my hair"*
>
> *"I didn't think it was as good as my normal shampoo…"*
>
> *"It has almost the same effect as of the bottled shampoo."*

Several students commented on the nice scent and strong feelings or emotions that this triggered:

> *"It smelt and felt good…"*
>
> *"I loved the smell of it, and it made my hair smell nice for a long time…"*

However, despite the positive emotional benefits, many did not find it suitable for their individual hair type, and it left their hair looking greasy or dry, pointing to difficulties in selecting the right product(s) for the trial (by both the students and researcher):

> *"… it made my hair quite dry"*
>
> *"… the shampoo didn't fit my hair type. it made them greasy no matter how much i would try to rinse it out"*

Despite the difficulties described above with learning new skills or selecting a suitable product, almost sixty per cent indicated that they would *likely* (32%) or *possibly* (27%) use a solid shampoo bar again in the future. Reasons offered confirmed that the relative ease of use (or not) and the upfront cost were influential factors:

> *"I love the convenience"*
>
> *"The extra effort required and reduced effectiveness actually lengthened my time in the shower on some occasions"*
>
> *"It is a lot more expensive…"*

Concern for the negative human impact on the planet (and even a sense of civic pride) was also a strong motivator, whilst some of the participants expressed emotional reactions (positive and negative) towards the product:

> *"I don't like packaging…"*
>
> *"i would love to minimise plastic pollution and use the shampoo as other things like shower gel, shaving gel"*
>
> *"I love the … smell of the Co-Wash"*
>
> *"Did not like my experience with this solid shampoo bar. Much prefer usual shampoo so I'll stick to that. I'll give the solid shampoo from the SU a try as it smelt good too…"*

And some resolved to take personal action in the future and to use shampoo bars again:

> *"Im* [sic] *changing to using only solid shampoos from now on, they were great"*
>
> *"I like it so might get it agin* [sic]*"*

Some commented upon its performance or efficacy compared with their regular shampoo; or the incompatibility of it with their hair type:

> *"It worked well at keeping my thick hair in check better than my actual shampoo does."*
>
> *"… I just need to find one that is better suited to my hair."*
>
> *"It wasn't better than other products I have used"*
>
> *"Made my hair greasy"*

‘Go gold’

Following on from the *‘go green’* challenge, participants were asked to extend their commitment to resource efficiency to the next level and to *‘go gold’* by skipping some showers (and use supplied dry shampoo, and/or adopt *‘between-shampoo hair styles’* supported by a handout):

> *Q/2B-q6. You were also challenged to 'go gold' by skipping some of your showers. Did you manage to do this?*

In response, almost two-thirds (64%) answered *yes*. Several revealed that they liked the permission to be lazy or the advantage this brought to their time schedules, but it was contingent on other antecedent and subsequent activities:

> *“I was too lazy to shower.”*
>
> *“I managed to do so on some days when I did not go the gym”*
>
> *“I only skipped one shower and mainly because I was running late.”*
>
> *“Yes but only on a day where I didn’t leave the house at all”*

Others skipped the occasional shower simply because they had been given the dry shampoo product and it was what they were challenged to do, whilst one expressed emotional approval towards the dry shampoo product and its performance:

> *“I skipped washing my hair every day and used dry shampoo as a replacement”*
>
> *“I loved the dry shampoo and the volume it gave my hair”*

However, there was also a reluctance to alter their usual showering routines, influenced by external factors, such as social expectations on appearance and body image; what it means to be clean and presentable; or the fact that showering is not *just* about haircare And again, the suitability of the product for their hair type was commented upon:

> *“I often have presentation classes for which I had to take shower.”*
>
> *“I shower everyday as part of my daily routine”*
>
> *“I am not going to skip showers ever, hygiene levels need to be maintained especially due to sports - bathing in my own sweat isn't so appealing to me and I enjoy not being able to smell myself.”*
>
> *“… just because I have dry shampoo doesn't mean I don't need to clean my body…”*
>
> *“the shampoo made my hair greasy. i had to take more showers than usual”*

Participants were asked if they had used the dry shampoo product and whether they would use it again:

Q/2B-q7. Did you use the dry shampoo?

Q/2B-q7b. What did you think of the dry shampoo product that you were provided with?

Q/2B-q7c. How likely are you to use dry shampoo in the future?

More than three quarters (77%) confirmed they had tried it. Their views on the dry shampoo, were somewhat mixed. Positive comments were mostly about the scent, whilst the more negative comments related to its effectiveness as an alternative to conventional shampoo products, and could, perversely encourage additional showering to rinse it out:

"Smelt very nice and worked well"

"I liked it but would be keen to try other scents"

"...but overall I would carry on using it."

"... after a few hours, It felt just as dirty again"

"... I didn't like how it got on your clothes"

"Needed a shower afterwards as it didn't feel that nice"

Despite the negative comments, 41% indicated that they were likely to use dry shampoo again, with a further 14% who might, whilst almost 46% said that they were unlikely to use it in the future. When probed for reasons for their responses, many indicated that it was unlikely to radically disrupt their standard showering practice (and therefore, was unlikely to work as an effective water-saving product). Several students pointed out that the purpose of showering is not just about haircare, but includes washing the body and freshening up after sport:

"... I'm never going to use dry shampoo unless we suddenly run out of normal shampoo."

"It doesn't clean me, after using it I still feel sweaty and dirty."

"scalp was itchy after use"

However, there were some who enjoyed using it, liked the smell, felt it could work for their lifestyles and save time:

"if i am late and have no time to wash my hair..."

"Was useful and had a good smell, saves me time before work too."

"If i needed it and i didn't have time to shower then I'd use it..."

The participants were asked if they found the handout helpful:

Q/2B-q8. During the trial, you were provided with some guidance on alternative hair styles and information on no poo/low poo (shampoo). Did you find this useful?

Only five participants (23%) answered *yes*, whilst 15 (68%) said *no*, and two did not look at it. Of the ones who found it useful, their justifications included:

> *"to find the best ways to make greasy hair look okay"*
>
> *"Putting hair up when it was getting greasy"*

However, those that did not find the handout useful said that the ideas were not suitable for males or shorter hair, or they already knew how to style it. None referenced the no poo/low poo advice:

> *"It wasnt* [sic] *useful as they were for longer hair and I have shorter hair."*
>
> *"I always wear my hair up anyway so didn't feel as though I didn't know what to do with my hair."*
>
> *"Was all aimed towards female hairstyles..."*

Motivation to change and individual agency

Prior to the trial, the Wave 2 participants were asked whether they had altered their showering routine since moving to UWE, and whether they thought they had agency over how they shower:

Q/2A-q14. Has your showering pattern changed since moving to UWE compared with life back at home?

Q/2A-q37. On reflection, who has most influence over your showering routine at UWE?

Just over a third (8 of 23, 35%) indicated that they had changed how they *do* showering. Two students said they had increased their shower *duration* as there was more access or different household rules. Two had increased the *frequency* of showering, whilst three had decreased how often they shower. One reported a switch to showering later, and another had switched away from showering at the gym:

> *"Showers are now longer as no one is waiting to use it"*
>
> *"I can shower longer. My mum isnt* [sic] *telling me off..."*
>
> *"I'm doing more exercise"*

> *"Shower later at night sometimes"*
>
> *"… I shower at home instead of gym now..."*

Overwhelmingly, 83% of participants believed that they had self-autonomy over their showering patterns and that their family or peers had no influence, while only four recognised that their routines were influenced by their family upbringing. None of the students thought that their peers had any influence.

The evaluation survey asked whether the interventions would have any lasting impact on their shower routine:

> *Q/2B-q15. As a result of the trial, will you be making any changes to your shower routine in the future? In what way?*

The results are summarised in Figure 6-23. The results varied across the different dimensions, although the majority (between half for duration, and 85% for activities) stated that the dimensions would remain unchanged and that there would be no lasting changes in their showering routine. Half the participants indicated that they would *reduce* their shower *duration*, and a quarter were motivated to *reduce frequency* (whilst two-thirds intended to *increase* their rate of *recycling* of product packaging). A third would use *fewer products* in the shower, although only 15% would undertake *fewer processes*. More than a third (38%) of students indicated that they would *reduce* the fixture *flow rate*.

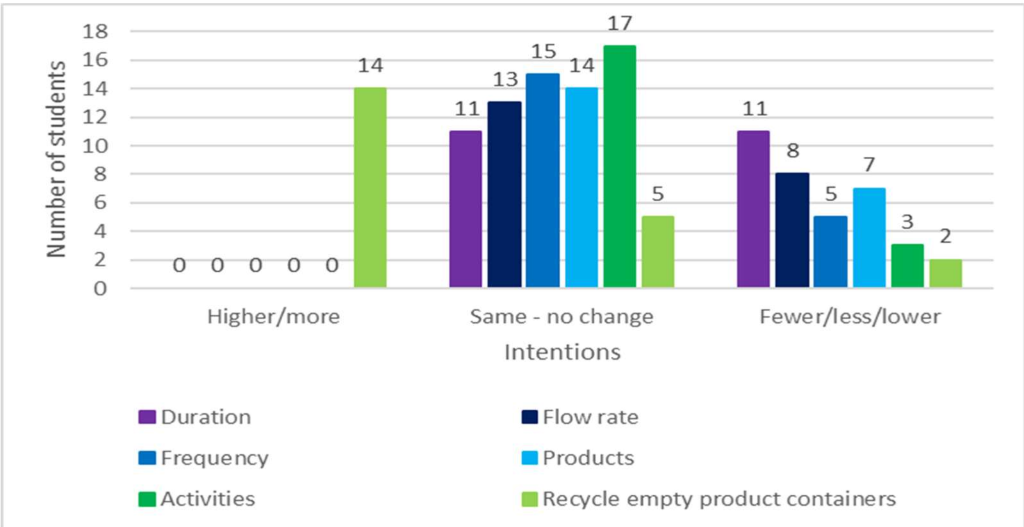


Figure 6-23 Changes to future shower routine (question 15, Q/2B)

Finally, the participants were asked:

> *Q/2B-q16. Do you have any further comments about this research or the topics of showering or water conservation*?

The students were receptive to experimenting with the showering process and positive about the need for everyone to act sustainably:

> *"Really enjoyed using new products and experimenting with my routine"*
>
> *"It was fun and would love to participate in more surveys in the future!"*
>
> *"i think everyone should try to switch to a more sustainable way of showering or at least try"*
>
> *"This experiment made me much more aware of my water consumption and I will focus on reducing this now"*

6.2.2 Diaries

A total of 21 completed diaries were returned, representing half of all residents in the five intervention houses (and 22% of the population across the eleven study houses). A total of 232 shower events were recorded during the two-week trial period. The results were validated against the Wave 2 questionnaire and event logger results, and the Wave 1 diary findings.

Shower duration

The distribution of event duration and user average durations are summarised in Table 6-8, along with the Wave 1 diary results from Table 5-3, for comparison.

Table 6-8 Shower duration – comparison of diary reports between trials

Shower duration *(minutes)*	**Diaries** Wave 2 *(n=229 events)*	**Diaries** Wave 2 - by user mean *(n=21 participants)*	**Diaries** Wave 1 (Table 5-3) *(n=348 events)*	**Diaries** Wave 1 - by user mean (Table 5-3) *(n=26 participants)*
<3	13 [5.7%]	0 [0.0%]	13[3.7%]	0 [0.0%]
Short: 3-6	86 [37.6%]	6 [28.6%]	89 [25.6%]	6 [23.1%]
Norm: >6-8	44 [19.2%]	5 [23.8%]	40 [11.5%]	1 [3.8%]
'UWE standard': >8-14	53 [23.1%]	8 [38.1%]	102 [29.3%]	13 [50.0%]
Long: >14-20	25 [10.9%]	2 [9.5%]	74 [21.3%]	4 [15.4%]
Excessive: >20	8 [3.5%]	0 [0.0%]	30 [8.6%]	2 [7.7%]
Mean	*8.5*	*8.7*	*11.6*	*11.2*
Minimum	*2.7*	*4.0*	*1.8*[1]	*3.1*[3]
Maximum	*25.0*	*18.0*	*48.0*[2]	*28.6*[4]

The diary events amounted to 1,950 minutes (32.5 hours) and had a mean event duration of 8.5 minutes, ranging from 2.7 to 25 minutes. This is significantly lower than that recorded via the Wave 1 diaries and the estimates provided in the questionnaires. The largest collection (38%) of *events* fell within the *short* duration (3-6 minutes) category, although *user means* confirmed a tendency for showers to fall into the '*UWE standard'* or norm of 9-14 minutes, on average (38%).

Shower frequency

The diary events were grouped by frequency for comparison with the questionnaire (Q/2A) responses and the Wave 1 diaries (from Table 5-10), as shown in Table 6-9.

Table 6-9 Shower frequency – comparison of diary reports between trials

Shower frequency	**Diaries** Wave 2 *(n=21)*	**Diaries** Wave 1 (Table 5-10) *(n=26)*	**Q/2A** Wave 2 *(n=23)*
More than once per day (>1)	2 [9.5%]	9 [34.6%]	3 [13.0%]
Every day (=1)	3 [14.3%]	7 [26.9%]	8 [34.8%]
5-6 times per week (=0.71-0.93)	8 [38.1%]	7 [26.9%]	6 [26.1%]
4-5 times per week (=0.57-0.71)	3 [14.3%]	0 [0.0%]	0 [0.0%]
3-4 times per week (=0.43-0.57)	3 [14.3%]	3 [11.5%]	5 [21.7%]
<3 times per week (<0.43)	2 [9.5%]	0 [0.0%]	0 [0.0%]
Mean per day (typical)	*0.81*	*0.98*	*Every day*
Minimum per day	*0.33*	*0.43*	*3-4 times/w'k*
Maximum per day	*1.54*	*1.79*	*>1/ day*

The results for the Wave 2 diaries were significantly less frequent than the standard *daily* shower routine recorded by the Wave 1 diary participants (and the pre-intervention tendency reported in the Q/2A survey). The results coalesce around *five to six times per week* with a mean of 0.8 per day, and just two students (9.5%) tended to shower *more than once per day*. Indeed, 16 of the 21 diarists (76%) showered six times or less per week, compared with 38% of Wave 1 diary keepers and 48% of Q/2A responses.

Volume and flow

Participants from houses G and J were asked to record the volume of water shown on the Amphiro display unit after each shower. These were combined with duration and frequency to calculate flow rates for comparison with the logged flow rates (in Table 6-4). This is summarised in Table 6-10. The mean flow rate for house G (3.6 l/min) was comparable to that recorded for the same house in Wave 1 (of 3.5 l/min) whilst the average for house J was higher, at 4.1 l/min. This difference could be due to the differences in fixture performance (see audit results section 3.2.2) for each house or the inherent variability of showering practice by individuals. The average event duration of 6.9 minutes was significantly lower than that observed in the Wave 1 trial (9.2 minutes).

Table 6-10 Volume and flow dimensions (Amphiro houses G and J)

Shower dimensions	House G *(n=7)*	House J *(n=4)*	Total/average
Measured (Amphiro) total volume (*litres*)	1,961	836	2,797
Total (Diary) duration (*minutes*)	544.75	204.85	749.6
Number of events (*diary*)	72	36	108
Mean volume per event (litres)	*27.2*	*23.2*	*25.9*
Mean duration per event (minutes)	*7.6*	*5.7*	*6.9*
Mean flow rate (litres per minute)	*3.6*	*4.1*	*3.7*

Time of day

The time of day that the students showered is summarised in Figure 6-24, with frequencies allocated to four six-hour blocks. The favoured time slots for Wave 2 corresponded with those reported for Wave 1 (see Table 5-12), with a morning peak and a second (slightly lower) evening peak. The mean shower duration was calculated for each six-hour time block. Morning showers (between 06:00-11:59 hrs) averaged 8.2 minutes, whilst evening showers (after 18:00 hrs) were shorter, at 7.3 minutes, on average. This is at odds with the shorter *morning* showers observed for Wave 1. Night-time showers were the most relaxed (14.6 minutes), with leisurely afternoon ablutions averaging 9.7 minutes, although showers during these time periods were less frequent.

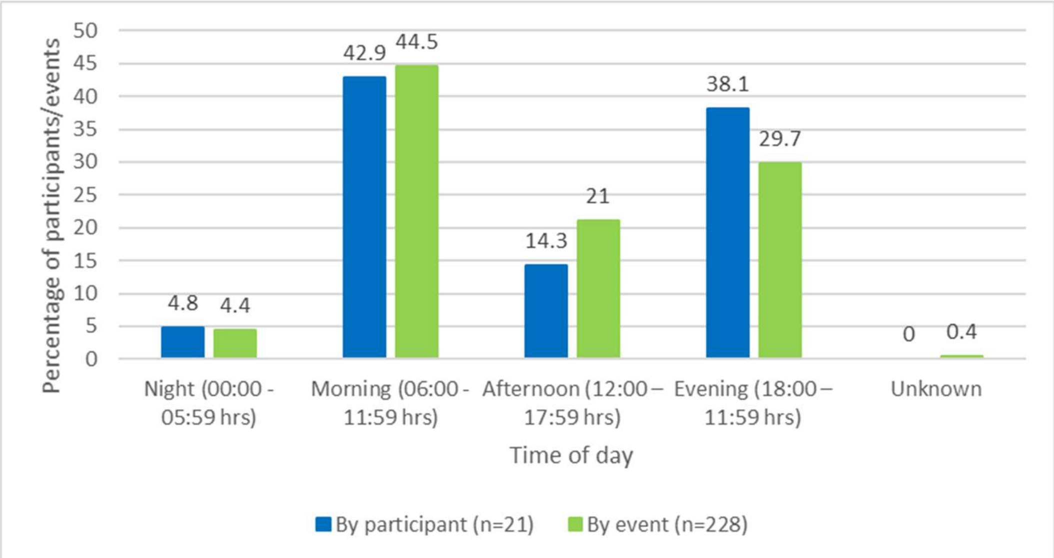


Figure 6-24 Time of day

Outsourcing

Four students reported that they had outsourced a total of eight showers, equivalent to 3.4% of all recorded events (although one student (50F) provided no further details). This supports the previous findings that the WCP1 residents did not shower at the gym. Table

6-11 summarises these outsourced showers, which took place during weekend visits home or overnight stays elsewhere. One was simply recorded as '*off site*'.

Table 6-11 Outsourced showers

Participant	Outsourced events [% of ALL events]	When?	Location
46F	2 [0.9%]	*Weekend - evening*	*Off site; away*
47F	2 [0.9%]	*Weekend - morning*	*Away*
50F	3 [1.3%]	*Wed-Fri (no other details)*	*Stayed at friends'*
63F	1 [0.4%]	*Weekend - morning*	*Home*

Products and in-shower activities

The diary participants recorded 471 applications of products, averaging 2.1 products per shower event, compared with 2.8 products per shower reported in the Q/2A survey. This suggests that the participants accepted the '*go green*' challenge and used the supplied shampoo bar to substitute for multiple different (bottled) products. Meanwhile, 674 in-shower processes across 229 showers (average 2.8 activities per shower) were performed.

The frequency of product application and in-shower activities by type are shown in Figure 6-25 and Figure 6-26.

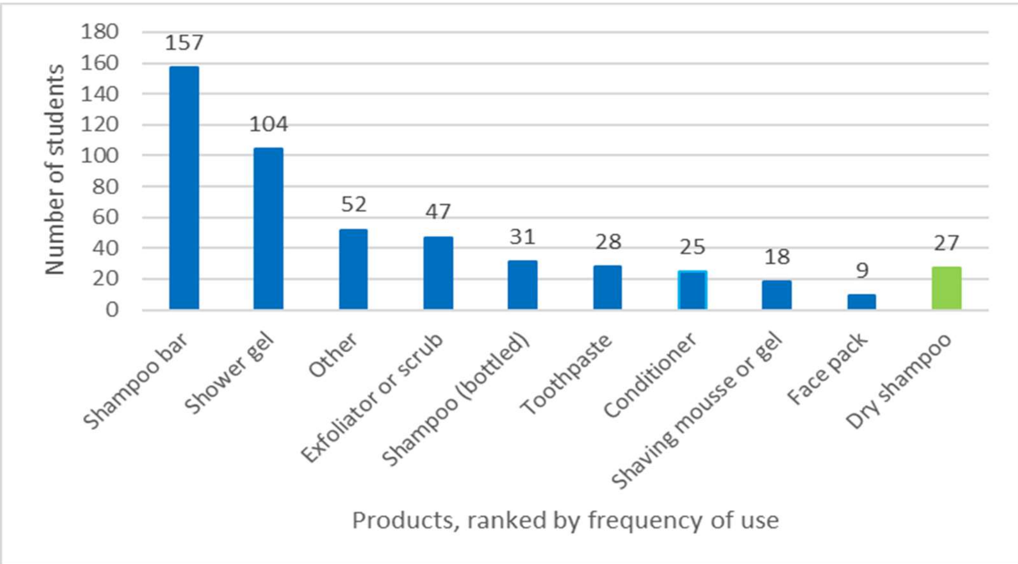


Figure 6-25 Proportion of showers for each product

The shampoo bar was used 157 times or 69% of the time, compared with just 31 applications of bottled shampoo (14% of events), and 104 uses of shower gel (45%) indicating that most participants committed to using the solid bar for the duration of the trial, as a shower gel or soap substitute for washing their bodies as well as for cleaning their hair, and helped to sever the link between using dedicated products exclusively for specific processes. The frequency of hair and body washing (66% and 95% of showers, respectively) was comparable with that recorded for the Wave 1 trial (58% and 94% respectively, Table 5-16).

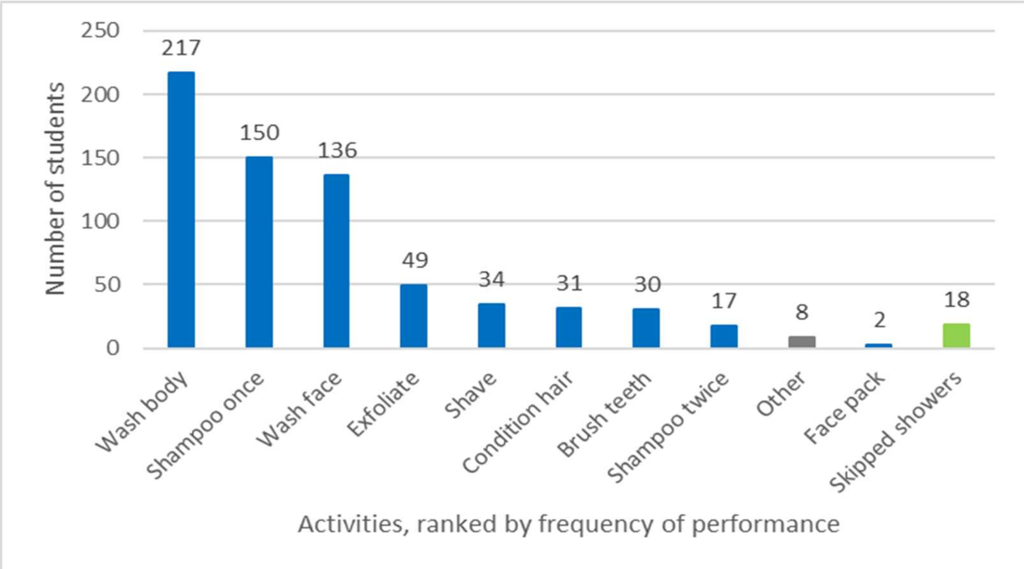


Figure 6-26 Proportion of showers for each activity

Whilst the substitution of the solid shampoo bar for other bottled products could be detected in the diary data as a route to reducing shower *duration*, the efficacy of dry shampoo as an alternative to immersive showering to reduce shower *frequency* was less obvious. Only ten students recorded that they used the dry shampoo via the diaries, with 27 applications, compared with 16 students who said they tried the dry shampoo via the questionnaire (Q/2B). This discrepancy may be because the diaries targeted the main immersive shower experience, whilst dry shampoo use was *instead* of shower events, and therefore, simply not documented.

One student recorded ten uses of dry shampoo as a substitute for seven shower events (repeated applications on three days), whilst another participant only tried the dry shampoo once to skip a shower, but recorded a further five skipped showers, despite not getting along with the dry shampoo product (due to an allergic reaction). Five students indicated that whilst they had used the dry shampoo to avoid washing their hair, they still showered on those days to wash their bodies. However, all these shower events were of a significantly shorter duration than the mean for all their showers, with an average reduction in duration of 30%, as illustrated in Table 6-12. Therefore, whilst the dry shampoo did not reduce *frequency* as planned, for these students, it did have a positive impact on water demand by reducing shower *duration*. In addition, five students recorded a reduced shower frequency by noting skipped showers (with or without dry shampoo use) in the diaries.

Table 6-12 Impact of dry shampoo use on reducing shower duration

Participant	Dry shampoo applications	Average Shower duration with dry shampoo use (minutes)	Average duration for all showers (minutes)	Dry shampoo application as proportion of all showers
46F	1	2	7.2	28%
53F	5	4.6	6.9	66%
56F	2	12.5	17.1	73%
60F	1	2.7	4.4	61%
63F	2	3.6	4.9	73%
Average	***11***	***5.4***	***7.8***	***70%***

Emotions and thoughts

As with the Wave 1 diaries, the participants struggled to record their thoughts and feelings immediately before, during and after showering. This difficulty was indicative of the subconscious or habitual nature of the showering experience and indicated that even with the diary recording task, they slipped into autopilot whilst in the moment, under the warm running water, and were less aware or mindful of their actions (or thoughts and feelings). Nonetheless, the emotions and thoughts that were recorded by students are summarised in Figure 6-27. They were similar to those from Wave 1 (Figure 5-10).

Figure 6-27 Shower puff of diary thoughts and emotions

6.2.3 Focus Groups 7 and 8

Five female and six male students participated in the two focus groups (FG7 and FG8). As witnessed in Wave 1, this represented a slight swing favouring more male participation

(54.5% male versus 45.5% female), compared with the pool of questionnaire responses (comprising 52% female students); diary participants (57% female for Q/2A); and resident population (52% female). The first Wave 2 focus group (FG7) comprised three female and two male students. One female was a resident of house F, whilst the rest were all residents of house G. The second focus group (FG8) was attended by two female and four male participants from four of the five intervention houses. There were no focus group attendees from house H, which had the lowest engagement with the trial (with just two residents who responded to the questionnaires, and one of whom completed the diary).

The coded transcripts were analysed by the frequency and the coverage of each coded ISM factor, and the results are summarised in Figure 6-28 and Figure 6-29, respectively.

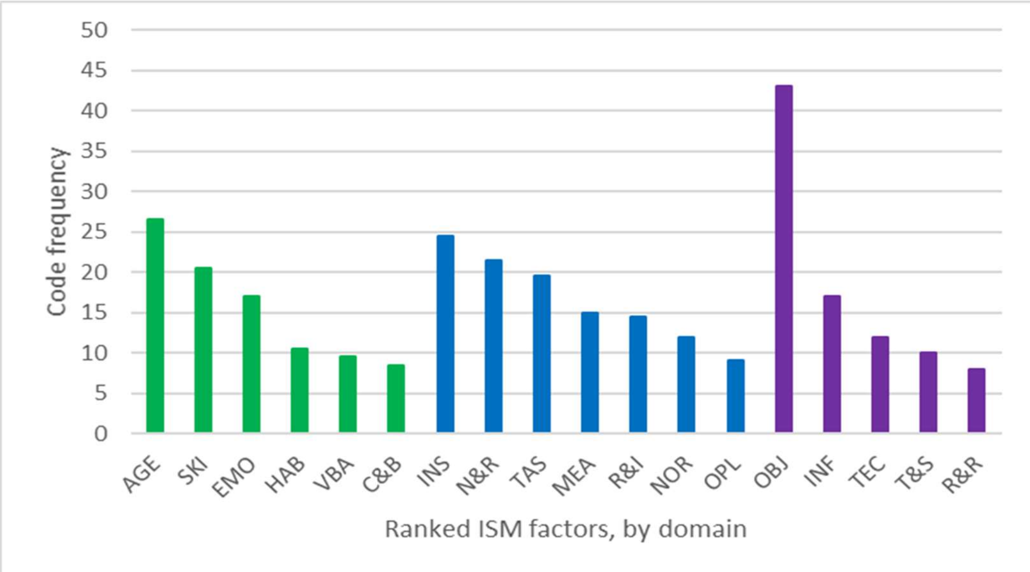


Figure 6-28 Frequency of ISM factors, as average across Wave 2 focus groups (FG7-FG8)

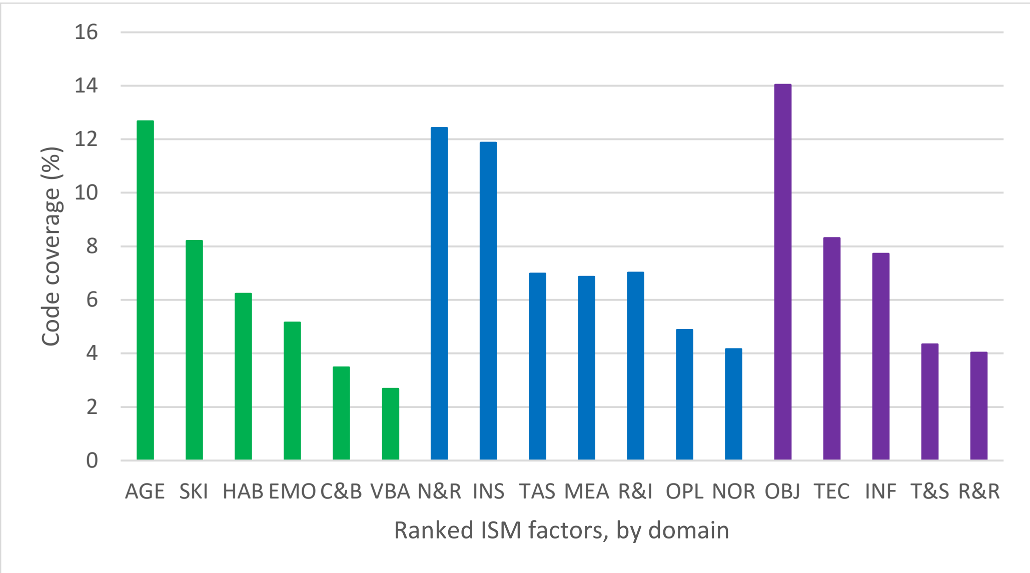


Figure 6-29 Coverage by ISM factors, as average across Wave 2 focus groups (FG7-FG8)

The plots confirmed that for the individual domain (in green), agency (AGE) and skills (SKI), were the top ranked factors (matching the Wave 1 findings). Whilst the spread of the other individual context factors (emotions – EMO; habits – HAB; costs & benefits – C&B*;* and values-beliefs-attitudes – VBA) varied. Institutions (INS) and networks & relationships (N&R) dominated the coding for the social domain (blue), whilst norms (NOR) and opinion leaders (OPL) had the lowest occurrence, with the tastes (TAS); meanings (MEA); and relationships & identity (R&I) sandwiched in the middle of the plots. Unsurprisingly, with the emphasis on the shampoo bar and dry shampoo interventions*,* objects (OBJ) were important for the material context (purple), followed by discussions on infrastructure (INF) and technologies (TEC) in respect to the shared shower rooms; low flow showerheads; and Amphiro devices. The Amphiro technology was liked. The softer or more abstract material constructs of time & schedules (T&S) and rules & regulations (R&R) featured less during the focus group conversations. Comparing results across the domains, objects was the most dominant factor, followed by agency, institutions, and networks & relationships.

As per the Wave 1 focus groups, the ISM factors codebook allowed for deductive analysis, whilst simultaneously allowing for other ideas to inductively emerge from the transcripts. This allowed for weaknesses or gaps within the ISM model to be identified and are discussed in Chapter 7.

6.2.4 Summary of end-user insights

The 2018/19 cohort were less water aware compared with the 2017/18 group, reflecting the end of the co-ordinated '*Reduce the juice*' campaign. However, they were more likely to recycle although not all students were aware that bathroom plastic bottles could be placed in the recycling bins in the WCP1 waste compound. Whilst most students expressed a concern for the impact of plastic pollution, this did not always translate into action.

The Wave 2 participants reported significantly shorter showers, on average (8.5 minutes), compared with the 2017/18 cohort, although 65% durations were at least ten minutes, and half reported showering for more than 15 minutes. Whilst some tried to *do the right thing* and reduced their duration, some perversely reported that they increased the length of their showers as they struggled to use the shampoo bars.

Shower frequency varied more for the Wave 2 group, ranging from 3-4 times per week up to more than once per day, although only 38% reported a daily shower. Two-thirds reported no change in frequency (64%) and were unwilling to deviate from their standard routine or were not aware that they could change the default setting. Meanwhile, more than a quarter (27%) indicated a reduction in how often they showered and 32% reduced flow rate due to increased awareness and wanting to rise to the Wave 2 challenge.

The Wave 2 participants used fewer products than the Wave 1 cohort, and 41% reported trying to give up plastic bottled products for the '*go green'* challenge. However, 41% said that they were loyal to their regular shampoo brand, citing cost, effectiveness, and suitability, ethical or environmental considerations, and emotional connections as justifications. A third (35%) read the manufacturers' instructions, although they were not asked if they followed the printed advice.

Manufacturers encourage resource consumption (of products, packaging, energy, and water) by recommending repeat application of shampoo or follow-up with conditioner, and do not provide meaningful advice on how much product should be used for best results. More than half (56.5%) of users reported that they used approximately 30mm diameter of shampoo (equivalent to a £2 coin). Most students (87%) had never tried solid shampoo before the trial.

Students tended to wash their hair before attending to any other process (such as washing their body or face or shaving). About two-thirds followed a standard procedure each time they showered, while the rest varied the steps depending on whether they needed to wash their hair or shave, if they are running late, or had taken part in physical exercise.

Three-quarters (77%) said that they tried to '*go green'* due to: it being easy; financial savings (free products); environmental concern; emotional triggers (scent) or brand attraction (Lush). However, the products did not suit all participants, and some were not willing to adjust their entrenched routines. More than half (59%) said they would be willing to try a solid shampoo bar again.

Almost two-thirds (64%) said that they skipped some showers and benefitted from the time saved or felt permission to be lazy! Those that did not try the '*go gold'* challenge indicated a reluctance to change due to a range of external expectations, including standards for appearance or the definition of what it means to be clean and presentable, and showers were not just about haircare, but about body image and freshening up or relaxing after sport. More than three-quarters (77%) tried the dry shampoo at least once but there was a mixed reception, with enthusiasm for the scent, but worries about its effectiveness. Forty-one per cent said that they would be willing to try dry shampoo again.

Thirty-five per cent of students said that they had changed some aspects of their usual showering routine since arriving at UWE, including increased duration and frequency, time of day or location (not at the gym). Most (83%) students believed that they had self-autonomy over their showering and were not influenced by external factors such as family, peers, or infrastructure.

Half expected that the trial would have no lasting change on their shower durations, but a quarter foresaw a decrease in frequency because of the trial and the associated knowledge and awareness that they had gained. Two-thirds said that they would increase their recycling rates and half would reduce flow rates, although only 15% would reduce the number of in-shower activities. The students were receptive to experimenting and were positive about the need to act sustainably.

The diaries reported lower duration and frequency than the '*UWE standard*' and the shampoo bar was used in more than two-thirds (69%) of showers. The dry shampoo was less successful and had little impact upon frequency, although there is some evidence that it had the potential to reduce duration.

Focus groups were preferred over interviews as an evaluation tool, particularly with males. There was good coverage across all 18 ISM factors, and agency; skills; institutions; networks & relationships; and objects were the dominant themes.

Chapter 7 Discussion and conclusions

The aims of this thesis, introduced in Chapter 1, were:

- *To explore and understand how and why UWE students 'do' showering, and classify their showering routines;*
- *To design, pilot and deliver a mixed-methods research project focusing on showering (as a significant contributor to water use); and,*
- *To evaluate both the* ***efficacy*** *(through volumetric measurement) and user-****acceptability*** *of real-world water conservation interventions to inform future domestic water efficiency programmes.*

A review of the academic and grey literature (Chapter 2) *assessed the extent and efficacy of behaviour change approaches that have been used to reduce household water demand, with a particular focus on showering in England* (objective 1) and set out the theoretical foundations for the research (research questions RQ1.1 to RQ1.4).

The second objective set out *to establish the baseline water consumption by students in UWE managed campus accommodation* was designed to make a empirical and methodological contributions and this was covered in Chapter 3 (water fixtures audit, section 3.3.3) and the first part of Chapter 4 (volumetric water consumption, section 4.1), which presented the Wave 0 baseline results (to address research questions RQ2.1 to RQ2.3). PCC for WCP1 was estimated to be c.100-120 l/*p*/d. At face value, this is lower than the average domestic PCC across England and Wales, at 145 l/p/d (based on 2021 annual returns to Ofwat, see Discover Water, 2022). However, the WCP1 consumption does not include laundry or outside use, which is metered separately. Based on average UK consumption (see Figure 1-9, Environment Agency, 2020), the excluded component of PCC accounts for around 19% (c.28 litres of daily *per capita* use), indicating that the student consumption is broadly in line with the average across the country, despite the modern flow-controlled fixtures and potentially tighter controls on leakage within the university setting compared with general housing stock.

As noted in section 2.3.2, there is limited empirical evidence of the use of SPT to develop practical real-world interventions (Warde, 2005), and SPT has not been systematically adopted to the management and planning of water demand mitigation, although there is growing interest (for example, the research of Browne *et al.*, 2015; Davies and Doyle, 2015; Jack, 2013; Kuijer, 2017; and Strengers and Maller, 2015).

Browne *et al.,* (2015) and Browne, Medd and Anderson (2013) advocate for the need to expand practice-based research to include quantitative methods to fully assess the impacts of SPT-derived interventions on resource use. Therefore, this thesis makes an interesting and novel contribution in a field that is lacking in quantitative research and measured impact on water use. It attempts to evaluate the impact of a SPT-conceived intervention on water use, via a number of different metrics including shower duration, frequency, volume, time of day and products used. Importantly, the mixed-methods design and extensive triangulation between different data sets helps to fill a gap in quantitative enquiry to measure resource consumption in a field is dominate by experiential qualitative research.

The second part of Chapter 4 presented the empirical results from the expansive Q/0 survey of the UWE student population to give *an understanding of the showering routines of the UWE students, and a classification of the styles of showering that the students follow* (objective 3, and research questions RQ3.1 to RQ3.2). The classification demonstrated that it is possible to classify showering routines into different types that serves as an innovative way of targeting interventions. However, it showed that 90% of UWE students adopt a pattern of showering termed the '*UWE standard'* in this study, in which showers are leisurely (c.11.5 minutes duration, on average); occur six times per week; are always undertaken in the student accommodation (i.e., not outsourced); and typically, three showering products are used. However, despite this apparent homogeneity, there was considerable variation in the parameters. There was also a small cohort (8.3%) who adopted a slight variation on this standard style of showering, in which some showers were *outsourced* to the nearby university gym ('*out and about'* showering), but were shorter (9.3 minutes, on average) and slightly more frequent (6.6 times per week).

The Wave 1 and Wave 2 field trials set out to make both *methodological* (combination of quantitative and qualitative research instruments, participant selection of evaluation method, and co-design of interventions) and *empirical* (how students *do* showering) contributions to knowledge through *design, pilot, deliver and evaluate components of a real-world intervention strategy covering multiple levels and contexts* (objective 4). The results for the two intervention trials, presented in Chapter 5 and Chapter 6, respectively, answered research question RQ4.1. Volumetric water consumption at different spatial (household, per capita and at fixture level) and temporal (pre-; during; and post-intervention) scales and changes attributable to the pilot and practice-based intervention programmes were reported. Student showering routines and insights into why students shower in the way that they do were reported and interpreted.

The purpose of this chapter is to reflect upon the research findings and to assess the feasibility and value of the theoretical framework (combining ISM and SPT) in terms of *designing* and *evaluating* successful intervention programmes, and for *operationalising* SPT-based mitigation measures in the real-world, i.e., can practical solutions be designed and deployed based on SPT within an ISM framework? (research question RQ4.3 to RQ4.5):

> *RQ4.3 Does a SPT approach help to identify factors that would be overlooked from a conventional individualistic perspective?*
>
> *RQ4.4 Can some factors be harnessed to alter the current trajectory of showering demand?*
>
> *RQ4.5 What are the benefits and limitations of using the ISM model to design and evaluate showering water demand reduction strategies?*

The findings are discussed in the light of the literature and the theoretical, methodological, and empirical contributions that this thesis makes to delivering action in response to the multiple pressures on the future security of water supplies in England, including climate breakdown, population growth and lifestyle change, are highlighted.

7.1 Theoretical reflections

This section considers the theoretical foundations, based on the ISM framework (introduced in Chapter 1 and discussed further in Chapter 2), with insights supported by and signposted to empirical evidence. The simplified three-elements SPT model (see Figure 1-10, Shove, Pantzar and Watson, 2012), with its requisite elements shaded using the ISM colour scheme (taken from the graphic, Figure 1-11, with the individual context in green, social in blue and material in purple) are explicitly mapped in Figure 7-1 to show how SPT relates to the ISM toolkit or framework.

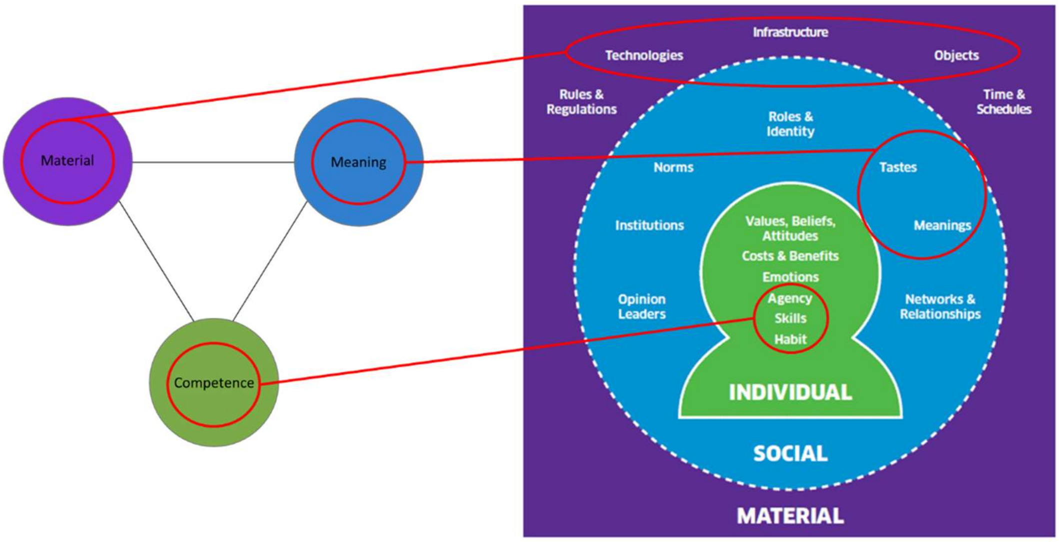


Figure 7-1 Social practice three-elements model mapped onto the ISM model (adapted from Shove, Pantzar and Watson, 2012, p.29 and Darnton and Evans, 2013, p.3)

As stated previously, ISM is not a SPT model *per se*, but it was formulated from an amalgam of many behaviour *and* social change theories arising from different epistemological foundations. It *implicitly* incorporates SPT within its structure, as demonstrated by Figure 7-1. As with any model, the ISM toolkit is a simplistic representation, with overlaps between factors (i.e., they are not mutually exclusive). Situating of the SPT elements within the ISM tool serves to illustrate how the two models relate to each other and how they might be applied in combination, such that ISM acts as a framework from which to hang SPT-derived measures. The ISM toolkit was conceived to overcome the practical challenges in applying theory to real-world issues and its use in this thesis makes a contribution to the literature on designing, deploying and evaluating real-world interventions.

This research demonstrated that ISM can help to operationalise the SPT three elements approach (Shove, Pantzar and Watson, 2012) and improve the accessibility of SPT to practitioners who are tasked with designing, as well as evaluating, real-world intervention programmes, such as those deployed in Wave 1 (evaluate) and Wave 2 (design and evaluate). This helps to mitigate the common critique of SPT being too abstract or theoretical and not practical. This research has demonstrated that the ISM framework can assist in designing actions that can target how *things* are done and therefore makes an important contribution to the literature on SPT-derived interventions. Indeed, the review of the literature (Chapter 2) identified very few practical SPT-conceived interventions in water demand in real-world settings (see section 2.3). Jack's (2013) research on reducing or even eliminating jeans laundry is a notable exception. This research was designed to realise and measure *actual* water savings. Most literature on SPT-inspired water demand interventions are based on prototypes and imagined futures (Kuijer, 2017; Davies and Doyle, 2015) and do not deal with the immediate challenge that policy makers and practitioners are faced with of lowering PCC. The three SPT elements and 18 ISM factors arising from the qualitative analysis of the focus group transcripts, and their links within and across the contexts are examined in turn, in the following sections.

7.1.1 Individual

SPT focuses upon the socio-material structures that shape how everyday life is done – the physical environment, and the shared standards and understandings of how everyday life should be conducted. SPT ignores the individual as a decision-maker, and diverts attention away from the rational actor. Instead, SPT focuses upon *actions* or *doings* as the unit of enquiry – the practice is the *thing* (the entity or object) that is explored. The individual is relegated to the *performer* of the practice, and the practice is sculpted by wider socio-material forces or influences. However, the individual actor is still needed for the practice or observable action to be visible, to exist. If the practice is not repeated, it dies out. The practice needs to be *done* to exist. But without an actor, there can be no practice, no *thing*.

For example, tea-drinking has a long tradition in the UK, dating back to the imperial era when tea was *discovered* by colonialists and brought to the domestic market. At first it was an exotic drink only affordable by the wealthy classes of society. There are cultural differences in how tea is consumed around the world (for example, with or without milk, or time of day). The tradition of tea-drinking has progressed over generations, and its evolution can be tracked back to transitions in physical objects (stove top to electric kettle; china cups and saucers to ceramic mugs to disposable paper/plastic beakers; and, loose-leaf to tea bags of different shapes), in combination with changing social conventions, fashions and tastes, sold to consumers by merchants advertising their wares that generated shared meanings (such as *afternoon* tea; *breakfast* tea; *builders* tea; ideas around warmth, emotional comfort, convenience and refreshment) to stimulate demand.

The evidence from this research confirms that agency and skills (by frequency and extent for both trials) are important influences on how showering is done by students, but clearly, these factors do not sit in isolation within an individual's unfettered control. They exist in response to the *external world*. Indeed, the success of the lone practitioner or individual researcher, was limited by her ability to act (agency); her relative expertise (internal resources); and sources of external assets and support (financial, equipment, etc.). Agency and skills are implicit features of both IBC models and SPT (see Chapter 2, section 2.2 and 2.3, respectively). For example, *efficacy* in the TPB, (Ajzen, 1991); *agency* in Structuration theory (Giddens, 1984); and *competencies* or *skills* element in the Three elements model (Shove, Pantzar and Watson, 2012). Whilst the other individual factors were evident from the focus group discussions, they appeared to be less salient than agency and skills.

However, for the upstream focused stakeholder focus group (FG6) the second most prominent individual factor, after skills, was costs & benefits. Agency was relegated to fourth place of the six individual factors (and 11th or 12th, by frequency or coverage, out of eighteen overall), reflecting the distinctly different perspectives of policymakers and planners compared with end-users. This highlights the importance of having a diversity of representation on planning teams that design mitigation measures, so that they are able to relate to a wide variety of different practices (Hoolohan and Browne, 2018). It demonstrates value in including end-users in co-designing solutions, and not solely relying upon upstream-derived solutions. Teams of professionals may overlook or make incorrect assumptions about how things are done, and themselves, are captured by their own professional and cultural practices (Strengers and Maler, 2015).

Importantly, individual factors do not operate in isolation from the social world, and links can be made between the ISM domains. For example, habits are repeated subconscious actions that may be governed by social expectations, whilst values-beliefs-attitudes, and cost-benefit decisions are shaped by perceptions of the socio-material world (Darnton and Evans, 2013). Emotions may be influenced by social conditioning and cultural identity. For example, gender stereotypes determine that males should normally repress their feelings whilst it is accepted that females can both display and discuss most emotions (although the outward expression of anger is deemed to be a *masculine* trait and not considered to be ‘lady-like’).

There are longstanding tensions and debate on the role and relative merits of individual actions versus systemic change, as illustrated by the tensions exposed in Shove’s seminal ‘Beyond the ABC…’ piece (Shove, 2010) and the subsequent discourse (Kuijer and Bakker, 2015; Shove, 2011; Wilson and Chatterton, 2011; Whitmarsh, O’Neill and Lorenzoni, 2011). The opposing perspectives were aligned to different political perspectives, with individual responsibility the realm of small-state conservative principles versus collective support that forms the backbone of more socialist policies. A push for IBC (or ‘ABC’), such as personal carbon footprints (or per capita water budgets), is problematic if it takes attention away from the need for broader social and political reform.

But putting this political dichotomy to one-side, individual actions matter, as they not only influence combinations or bundles of actions, but also the actions of other people within an individual's close social circles or spheres of influence (through networks & relationships). They foster the antecedent or prerequisite conditions to seed broader social and policy changes. Indeed, individual actions are not separate from or in conflict with the need for wholesale system change but are complimentary to and form a critical component of transformation, but they operate at different scales (Kubit, 2020). Individual actors do not live in isolation, they inhabit informal groups (of friends and family), and access formal networks through employment and services provided by official institutions. In turn, the prevailing cultures of those institutions impact on personal attitudes, beliefs, and actions, through a repetitive or recursive process of influence and reinforcement. Social values and norms change and these drive policy changes and new regulations. Without the early pioneers, adopting and advocating for new ways of doing, there would be no political will to underpin and deliver progressive legal instruments or modernised institutional arrangements, which often lag behind more rapid but casual social changes. And whilst a lone actor is unlikely to shift the dial in terms of the end game – whether that is improving water security or measurably reducing greenhouse gas emissions, they can and do influence their social networks through relationships and connections.

Skills

The qualitative analysis of focus group transcripts revealed that the skills factor was significant across all phases of the study. Indeed, the SKI code featured in the top two individual factors and upper third (top six) of all ISM factors across the Wave 1 and Wave 2 focus groups, and it was the top individual factor for the stakeholder (FG6) workshop (see Figure 5-11, Figure 5-12, Figure 6-28, Figure 6-29, Figure A-17, and Figure A-18, respectively).

Skills are a feature of both IBC and SPT. Skills are implicitly encompassed by efficacy in the TPB (Ajzen, 1991 – see section 2.2.1), whilst skills or competencies are explicitly included in the three elements social practice model (Shove, Pantzar and Watson, 2012 – as described in section 2.3.1). Skills include both procedural (know-how) and factual (know-what) knowledge needed to carry out an action (Darnton and Horne, 2013). It covers general awareness of advice that water companies communicate, distributed through different channels and promotions, and relates to the persistent reliance on patronising 'top-tips' that form the backbone of current water efficiency practice more than a decade into operating with statutory water saving targets. Whilst the academic literature highlights the information-action gap, and demonstrates a failure by consumers to respond logically to information campaigns, there remains a role for information and awareness raising for the sector, given the obscurity of where our water comes from, and public ignorance as to how supplies arrive at our taps (let alone what happens to wastewater once it goes down the plughole and is *taken away*). This links to the recommendation made by Hoolohan (2016a) that consumers need to be *reattuned* with where the water supply system, for example, through clear, visible signage during infrastructure maintenance operations and excavations.

There is need for water planners and demand managers to expand their skills and professional practice. They need to stop relying on information campaigns and projects that are predicated upon rational choice. move away from using look-up tables of assumed but artificial savings, and question whether water meters can reliably and consistently deliver efficiency savings for the consumer. They need to move into the realms of public engagement through stakeholder partnerships and trusted communicators (this links to ISM opinion leaders), to leverage support and provide leadership. This type of work is complex and necessitates working beyond direct spheres of influence. It is not easy to project manage and can appear fuzzy or nebulous. It does not fit easily within departmental silos and tight budgets, that are rigorously monitored by the regulators. It is likely to feel uncomfortable for the engineers that dominate the sector.

In Figure 7-1, the embodied SPT-competence element was mapped to the skills factor of the ISM model. The individual domain covers a broad range of concepts and psychological factors, such as values-beliefs-attitudes; costs & benefits; and emotions that are not explicitly captured by the simple three elements SPT model. This is hardly surprising, as SPT has its origins in sociology - the study of the collective, of cultures and shared patterns of interaction. The sociological paradigm gives primacy to the wider social world 'out there' and discounts or demotes the influences from the internal or psychological perspective. In contrast ISM represents a hybrid of ideas from an amalgam of disciplinary foundations and suggests that the 18 factors and three domains have *equal* significance or influence, although critics note that the individual is situated in the centre of the graphic, suggesting a level of *primacy* for this perspective.

Despite this, it can be argued that the SPT-competence element overlaps with more than just the ISM skills factor and has strong associations with the agency and habits factors. For example, skills are developed through repetition and with repetition neural pathways become hardwired and competence builds to such a degree that routinised actions become easier, subconscious, and eventually habitual or automatic. Understanding of how to perform the practice becomes embodied.

It is also important to note that skills and competence are socially learnt phenomena and have strong links to the ISM networks & relationships factor in the social domain. Knowledge is gained via multiple routes, and through a combination of expectations and social standards, expertise is acquired *formally* via educational institutions; *informally* via word-of-mouth through networks and relationships and opinion leaders; and even *subliminally* via perceptions (norms), preferences (tastes) and tacit understandings (meanings) of how things are or *should* be done.

Agency

Analysis found that agency (or a lack of it) was the most prominent individual factor (by frequency and coverage) for both the Wave 1 and Wave 2 focus groups, although it was less apparent to the upstream stakeholders (FG6), placing it 12th out of all 18 factors, and fourth out of six of the individual factor codes. This finding indicates that the professionals grappling with making change did not recognise their own limited agency in intervening in water use, constrained by their own roles or responsibilities and finite resources (Strengers and Maler, 2015).

As defined by the ISM user guide (Darnton and Horne, 2013), agency is the capacity of an individual to act or perform a task and is dependent upon both intrinsic qualities (motivation, confidence, and skill) and external social rules and material structures that direct, shape, or constrain these actions, in a repetitive process. Whilst an individual's sense of control or ability to act is included within self-efficacy in the TPB model (Ajzen, 1991 – see section 2.2.1), Gidden's Structuration theory (Giddens, 1984) contends that human action and the complex social structures that surround it are intrinsically co-dependent and reflexively intersect with each other (Spotswood, 2016). Human action shapes the social and material landscape, and in turn, the external world has the capacity to influence individual actions (refer to section 2.3.1)

Habit

The HAB code ranked quite low in frequency and coverage in the focus group discussions. For example, habit was placed 11th or 12th (out of eighteen factors), for both Wave 1 (FG1-FG5) and Wave 2 (FG7- FG8), and in last position for the stakeholder FG6.

Habits are automatic, frequent and routinised actions that take place at the same time or in the same place with little thought (Darnton and Horne, 2013). The term stems from an individualist perspective. Whilst the HAB code was not explicitly prominent in the focus group analysis, it is important to note that there is a strong association between habits and the regular enactment, circulation, and reproduction of *practices*.

Habits are a significant feature across individualist (socio-psychological models and behavioural economics) and socio-material approaches. For example, the TIB (Triandis, 1977) recognises the importance of habitual routines in determining actions (Darnton, 2008), whilst Stern (2000) referred to an individual's 'standard operating procedure' (see section 2.2.2). In behavioural economics, routine human actions are governed by heuristic short-cuts that can result in less optimal decisions (Dolan and Galizzi, 2015; Kahneman, 2012; Peters, 2012 – see section 2.2.2). And in socio-material approaches, Bourdieu's (1997) *Habitus* encapsulates the ingrained routines of everyday life, formed by past experiences and future thoughts on how things are done (see section 2.3.1).It is widely believed (originating from the specific observations by Maltz, 1960) that it takes just 21 days to form a *new* habit. This is because newness or novelty keeps it at forefront of the conscious mind and serves to sustain positive cycles of reinforcement. The three-week rule has since been debunked (to *at least* two months), depending upon the habit, individual and (socio-material) context (Lally *et al*., 2009). Missing the occasional chance to practice the new action may not upset the reforming process and implies that building new habits does not require perfection. New habit formation is a process that requires constant repetition and *practice* and small incremental shifts can be more effective than wholesale immediate change (Clear).

It is widely accepted that it is harder to give up or stop an *old* habit due to the strength of neural pathways that become hard-wired with practice and that support old ways of doing things – constant reminders through negative feedback, bolstered by the wider external world. Much habit changing advice is value laden and recommends that *bad* habits need to be substituted for *good* habits, to modify rather than go 'cold turkey' by abstaining. And yet, in the context of student showering routines, most practitioners are unlikely to even be aware that their *long daily* shower habit is a problem. The *rate* is the accepted norm, aided by easy access to unlimited supplies of hot water in comfortable, modern facilities, and the *duration* stretches to fill ample time throughout the day to make showering a leisurely pursuit. The university setting, as the purveyor of privatised tertiary education, and competition for places drives an expectation that the student *experience* is prioritised, and no interventions are permitted that might control, restrict, or risk upsetting the tenants in any way. Hot water is unlimited, continually available, and included in rent, whilst the governance arrangements for privatised water suppliers ensures that the provision of safe water supply is virtually invisible and frictionless to the end-user.

Habits exist to meet a biological need. Problem routines need to be *tweaked* in positive ways to satisfy the desires that drive the actions. Often, changing the socio-material context in which the routinised action occurs is the most promising route to success, as these structures work at a *deeper*-level than individual conscious thought or willpower alone can achieve. It is for this reason that key moments of life transition, such as students leaving home and moving house, present a valuable although infrequent opportunity to intervene in the rhythms of everyday life to drive more sustainable consumption, due to shifts in powerful socio-material structures that shape, disturb or disrupt everyday life.

However, anyone that has tried to lose weight will know, it is more difficult to *modify* an essential routine, to *reduce* or moderate consumption (as opposed to abstaining completely). Whatever weight we need to lose, we still need to eat *regularly*, but consume *fewer* calories from different food types. As noted in Chapter 1 – we all need water to maintain our basic physiological needs, including for drinking, food provision and public health. We cannot *stop* using water, but the pressure on resources necessitates us to *reduce* how much we consume to ensure there is enough to go around. It is not practical or realistic to *give up* showering, and there are constant subliminal signals or reminders within the social and material backdrop to continue the practice, such as shared expectations (norms) of daily showering, ideals for appropriate appearance and standards for the hard infrastructure in our homes (access to hot water, private shower rooms, etc.). Indeed, social norms are thought to have a more powerful influence on action than individual beliefs, even by the most aware and motivated segments of the population (Doherty and Webler, 2016).

During the field trials, students were asked to *modify* how they shower, either through the provision of information (via posters and face-to face engagement), real-time measurement devices (shower timers and Amphiros) or new products (shampoo bars) to *recraft* their showering routines (Spurling and McMeekin, 2015). The Wave 1 interventions were contingent upon material objects intersecting with individual motivations (as highlighted in Table 3-4). The conventional solutions were directed to influence individual decision-making processes via cost-benefit assessments or to act upon existing personal values-based systems to push participants to *do the right thing*.

In contrast, the formulation of the Wave 2 interventions based upon SPT steered consideration of the contemporary social backdrop, to take advantage of the collective mood or public opinion. A lone actor has limited capacity to create any lasting or wide-ranging cultural change. They might be able to influence a few individuals by offering information, like *ripples* on the ocean, but the impact is likely to be ephemeral and of little consequence against the far stronger forces of the external socio-material world, unless they can recruit participants to spread the ideas via their own social networks. With this insight in mind, and in recognition that products (by number and type) have the potential to script the showering process and determine length, the package of interventions was planned to *disrupt* the usual shower routine (Strengers, 2011). It was designed to act upon showering *duration* and *frequency,* by aligning with the powerful collective concern for single-use plastic pollution – the '*Blue Planet*' effect, and affection for and belief in, the trusted views of Sir David Attenborough - a 2018 social phenomenon. The strength of the package of interventions rested on the fact that it made sense and had common meaning to the participants. Participants could readily identify with its significance and its links to the contemporary public discourse and make the necessary connections to their own showering activities. The intervention aimed to disrupt (Strengers, 2011) at the socio-material level and drew upon socially shared meanings and tastes (relying upon market leading and ethical brands) as well as touching upon internal emotions and values.

Emotions

The emotions theme varied widely in its relative importance, across the focus groups, ranging from seventh (Wave 2) to 16th in frequency (FG6), and between 11th and 13th in coverage.

Emotions rule human behaviour, they are hardwired into our psyche, and these feelings are gauged through all the senses – sight, sound, smell, taste, and touch (including texture and temperature). Based 'hot' evaluations of our internal state, emotions drive us to react in the here and now to seek immediate gratification, in preference to responding to rational perceptions based on external signals and delayed benefits as well as internal stimuli (Darnton and Horne, 2013). Emotions are only implied within most IBC models (Darnton, 2008), although they are explicit in the TIB (Triandis, 1977) and can sabotage ration choice in Nudge theory (Dolan and Galizzi, 2015; Kahneman, 2012; Peters, 2012; Thaler and Sunstein, 2008) – see section 2.2. Emotions do not feature in SPT but are included in some of the integrated tools (see section 2.4), such as the AQAL/Integrated quadrant model (Wilber, 2006) and Mindspace (Institute for government, 2009).Being in, on, under or near water is well known to have positive emotional and relaxation benefits (Nichols, 2014). While the greatest health benefits may arise from water in natural surroundings (seas, lakes and rivers), manufactured facilities and fixtures can bring wellbeing and the healing powers of immersive bathing into our cities and homes, for example, the hot springs and spas of the Roman city of Bath, or a hot shower or bath at the end of a tiring day.

The senses of smell and taste are intricately entwined and form powerful triggers on the brain's (primitive) limbic or emotional system. Water naturally has a smell of freshness, and during showering or bathing, natural (essential oils) or manufactured scents in gels, soaps and shampoo products have the power to invoke different emotions and deep-set memories and add to the immersive experience. The sense of touch is triggered by the physical feel of shower water on the skin, though vibrations or the pounding effect on the body, water pressure and the temperature. Hot water has the power to relax sore muscles and improves regulation of the body's physiological processes. In contrast, cold water immersion (and wild swimming) can improve blood circulation, mental resilience, and boost immunity, and has become increasingly popular for its healing properties. The first cold draw at the start of a shower can feel invigorating and awakening whilst a cool blast at the end is thought to improve skin and hair condition by closing pores and smoothing follicles.

The pleasant acoustics of falling water is soothing or calming, and can improve concentration, due to its low frequency, regular wave pattern, harmonic pitch, and low volume (Nichols, 2014). The noise of waves gently lapping on the shore or rain falling into puddles have the capacity to bring feelings of relaxation and tranquillity, to the passive listener, and the sounds from an immersive shower can add a further sensory dimension to the experience.

Turning to visual perceptions, the provision of domestic water is invisible, hidden in underground pipes and underfloor plumbing by design. This 'out of sight, out of mind' principle has the unintended consequence that consumers are simply unaware where their water comes from and can result in a form of cognitive blindness (or denial) which means that warnings of water shortages (for example, via the Wave 1 posters) do not seem to be tangible and fail to register. Humans are hardwired to be self-centred and self-biased, although they do respond to external signals if they are sufficiently powerful (norms). This links with the recommendations of Hoolohan's research to reattune consumers and relocate water services (Hoolohan, 2016a). We will return to this idea of visibility later (in section 7.2 and 7.3).

There is evidence that students specifically and young adults in general, are at a life stage in which there is a high incidence of mental health problems. They live in an always online state of mental overdrive in which they are maturing and consolidating their cognitive abilities, in the midst of intensive learning and stressful assessment which demands a high level of active or directed attention. It may be that the higher intensity style of showering (compared with the wider population) observed during this research releases a calming effect and healing counterbalance to their 'wired and tired' lifestyles.

Costs & benefits

Standard economic theory assumes that individuals will make rational decisions based on the relative balance of costs and benefits and most IBC models align with this assumption (see section 2.2.2). Costs and benefits did not feature prominently in the focus group discussions. The C&B code was rated in eighth or tenth place for Wave 1 (third or fourth of the individual factors), and 17th (fifth or sixth of individual) for Wave 2. However, the stakeholders (FG6) placed a greater emphasis on costs and benefits (ranked fourth or fifth overall and second for individual).

This difference may be explained by the differing perspectives of facilities providers (FG6) who are governed by resource efficiency targets and limited budgets, compared with end-users who have unfettered access to unlimited hot water included in their rental fees. Weighing relative costs (financial and time) with perceived benefits is a clear rational decision-making approach. However, such assessments are mentally effortful and mental shortcuts for frequent or low value calculations are prone to errors and cannot be relied upon to routinely generate the most efficient results (Darnton and Horne, 2013). This suggests that the favoured roll-out of water meters to domestic housing stock may not be the silver-bullet that the sector hopes, although meters do have supply-side benefits for managing the system and monitoring asset performance.Values-beliefs-attitudes

Attitudes are central to most IBC models (see section 2.2.1) and aligns our worldview with economic rational choice (Darnton, 2008), whilst the meanings of social practices are formed through cultural conventions and shaped by attitudes and beliefs (see section 2.3.1). These are the basic elements of a person's motivational system, from broad-based values, through worldviews to opinions on specific activities, objects, or other people (Darnton and Horne, 2013). The VBA code was among the lowest ranked of individual and all ISM factors (placed fifth or six for individual and between 13th and last place for all factors) for the two rounds of end-user focus groups, although the stakeholders rated it as median significance (eight or tenth overall and third for the individual domain).

7.1.2 Social

Institutions

The focus group discussions were dominated by reference to institutions in the constitution of everyday life for students (with the highest frequency and coverage of all ISM codes). This was evident for both Wave 1 and Wave 2, mediated via informal connections between community members or households (through networks & relationships) and more formal bodies such as the university. References to accepted standards of conduct (norms) and the transmittance of shared expectations (tastes) about how things are or should be done, such as the daily shower, were also evident in the data.

The dominance of institutional influence is hardly surprising, given the focus on households within the formal university setting. The university has the power to determine its own culture which affects how community members (staff and students) engage with each other. Mechanisms are both *formal*, such as via the legal system or university regulations, and *informal* through the networks and relationships within friendship groups or households (Darnton and Horne, 2013). Shared notions of expected standards of conduct (norms) are spread through official codes that reflect mandatory obligations (fire safety, *Legionella* risk controls) and voluntary agreements (Universities UK, 2019; UWE, 2018a; 2018b; 2018c), and via the everyday implicit negotiations of household interactions (networks & relationships). In this respect, the university as an institution, bridges both the material and social realms. There are parallels here with the work of Middha on sustainable food provisioning within a university setting (Middha and Lewis, 2022; Middha *et al*., 2021).

Networks & relationships

Analysis of the focus group transcripts indicated that the informal connections between housemates that explain how ideas and actions can spread (Darnton and Horne, 2013), was consistently the second most evident code for the social factors, although eclipsed in extent by aspects from the individual and material realms. The N&R code was seventh overall (of eighteen factors) for Wave 1 and to third (for coverage) or fourth (frequency) for Wave 2. This elevation in importance for the later focus groups may be indicative of the higher participation rates within individual houses compared with Wave 1, and the impact of the trial on engaging most members of the households.

Norms

Social norms are unwritten rules or perceptions (Darnton and Horne, 2013) of how other people act (*descriptive* norms) including family, friends, and close acquaintances (such as housemates) that can have a powerful mediating affect and implicitly determine the correct or socially approved way of doing things (*injunctive* norms), (Cialdini, 2008). The NOR code rated low in the focus group analysis, in 14th or 15th place for Wave 1 and 11th or 15th position for Wave 2 but had higher importance to the stakeholders (FG6), in third or fourth place.

Norms have already been touched upon, in discussing how the individual realm relates to the social context, and the power of peer pressure on individual actions. Indeed, these unwritten rules may provide stronger indications of how things are done in a particular setting than solid personal beliefs (Jachimowicz *et al.,* 2018). However, whilst this might be true for the adoption of sustainable actions, such as participation in community litter picks (recruited through social networks and informal institutions) or the fitting of solar panels as a visible demonstration of more sustainable practices (and a status symbol of home improvement), this may not translate into private showering and other more obscured water-using activities. Indeed, sustainable actions are not the norm and yet to meet stringent carbon reduction targets or secure future water supplies, there needs to be a deep and dynamic shift in norms through visible or articulated actions (Kubit, 2020).

The COVID-19 pandemic was a powerful disrupter event. Work from home orders dismantled historic barriers and transformed video conferencing uptake. Whilst there has been and will continue to be a drift back to the office, evidence suggests that hybrid working has become an accepted norm, with employment contracts now routinely offered on this basis (particularly in response to current labour shortages). On Friday 18

February 2022, storm Eunice (the second of an unprecedented series of three named major storms in a week) advanced across the UK with record breaking wind gusts. Citizens were advised to stay at or work from home due to the risk to life, and there was large-scale compliance with this instruction because this style of working was well practiced and normalised in the wake of the pandemic.

Newly adopted working from home practices have also resulted in a casualisation of clothing and a blurring of boundaries between the home and office. Tailored office wear and cosmetics sales have markedly reduced (Lufkin, 2021; Grant, 2020). The fresh-start effect, coupled with the combination of increased home working and squeeze on household budgets, presents an opportunity for water and energy suppliers and policy makers to try to shift the widely accepted daily showering norm to a less frequent practice. Most conventional water and energy efficiency programmes avoid tackling the dominant *daily* shower norm, as if it is taboo to suggest showering less often is a viable option. The daily shower is an accepted truth that is difficult to challenge, resulting in favoured interventions that tinker around the margins of the status quo - with technological solutions that promise to shave time off shower durations or reduce flow rates to a trickle. However, removing entire showers from daily routines has a greater potential to save not only water, but also energy, carbon, products, packaging and time. This tinkering at the edges is a reflection of the social practice of making policy or managing demand – it needs to operate within fixed parameters, governed by restricted control or influence and limited financial budgets and capabilities (Strengers *et al.,* 2015).

This observation links into the idea that changing how practices *interlock* holds the potential to deliver on a broader-scale changes by renegotiating patterns of everyday life (Spurling and McMeekin, 2015). Rather than viewing current showering practices as a given, this framing allows wider systems and the socio-material landscape to be explored and for 'need' and its contingent and emergent qualities to be exposed or foregrounded (Strengers, 2011; Shove, 2003). From this perspective, showering is not the focus in its own right, but the spotlight shifts to the broader ways that work, education and leisure are organised and scheduled.

Meanings and Tastes

Whilst the SPT *meanings* element was mapped across to the ISM meanings and tastes factors in Figure 7-1, it has connections with the other social factors. Meanings are culturally constructed understandings, shared through images and metaphors, and frame how things are done. Tastes are collective preferences in which people signal their belonging (roles & identity) to particular social groups (networks) (Darnton and Horne, 2013).

The meanings and tastes codes did not appear to be particularly pertinent to the focus group discussions, compared with other ISM factors. For example, the MEA code was ranked ninth (out of 18) for Wave 1 (FG1-FG5) and ninth or tenth (frequency or coverage, respectively) for Wave 2 (FG7-FG8) on average, although it ranked sixth in the analysis of the upstream stakeholder focus group (FG6). The TAS code was even less prominent and ranked 14th or 15th in the Wave 1 and FG6 conversations, but was more obvious for Wave 2, and ranked sixth for frequency, and ninth for coverage, on average.

The Wave 2 trial was focused on hair washing regimes. Hair is a very powerful symbol of identity (Synott, 1987) and it can vary in length, colour and style and can signify identity between different social groups, such as gender (long or short, shaving of face or body hair), ethnicity (straight or wavy Caucasian, or 'kinky' afro), religious (length, head coverings – Sikh turbans or Islamic hijabs) or other cultural divisions (see Roles & identity below, for further considerations of the symbolism of hair by different cultural groups).

Opinion leaders

Individuals can have strong influences over others by shaping social norms (Darnton and Horne, 2013). They connect communities through social networks and include celebrities, influencers, and faith leaders. The premise for the Wave 2 intervention was concern for the impact of single-use plastics, and much of the changed public mood on this was attributable to Sir David Attenborough. Opinion leaders were only touched on in passing during the focus group discussions (ranked between 13th for Wave 2, and 18th place or Wave 1). Participants were asked if there were other cultural influencers who may help with designing water saving interventions. Ideas were limited but included Leonardo Di Caprio, Beyoncé, and the Kardashians. Gary Barlow was also cited having recently confessed to his followers that he had washed his hair for the first time in 14 years (Harrison, 2017).

The data collection phases of this research pre-date the explosion of Greta Thunberg into the public consciousness. Her first school strike took place in late August 2018 and led to the formation of the Fridays for Future student climate strikes that took hold from later 2018 and through 2019 (prior to most protests and public gatherings being shut down by the pandemic). However, Thunberg demonstrated that "*no one is too small to make a* *difference*" (Thunberg, 2019), confirming that individual action is not pointless (Rowlett, 2019).

Roles & identity

Whilst the chance of sharing types of personal washing routine may be determined by age, gender, nationality, and culture (Bourdieu, 1977), the R&I code did not dominate the focus groups evaluation. Domestic water-use has traditionally fallen on female members of a household, with cooking, cleaning and laundry being stereotypically (norm) women's work. Even with modern westernised attitudes and apparent gender equality among the student population, the analysis suggested a strong gender signal. And yet, ISM does not explicitly account for gender differences (Darnton, 2017), so a new GEN sub-code for gender was included in the analysis of showering experiences. Some male participants for example, expressed surprise that females shave (their legs and underarms) in the shower, as the men tended to shave (their faces and heads) over the washbasin in front of a mirror. And hair length, which is usually longer in females, was important when discussing the practicalities of hair washing and new skills needed for choosing and using solid shampoo bars.

The Wave 2 solid shampoo bar intervention was designed to interrupt routine daily hair washing. However, the frequency of shampooing can be determined by a variety of cultural norms, including gender and ethnicity. Ethnicity and hair-type (Q/2A, question 16) data were reviewed for any potential cultural nuances in hair washing practice and with consideration of potential historical and structural racial biases in the research design, particularly as the range of shampoo products was selected (based on limited market research and narrow haircare know-how by the Researcher) to appeal to the majority of study participants (18-22 years, from the UK). Ethnicity is not a characteristic that the university accommodation department routinely collect. Three quarters of all respondents across all phases, identified as white (*n=150*), with Chinese as the next largest group (*n=14*). Just eight questionnaire respondents (4% of all participants) identified as black[64] (all but one was of UK nationality, and they were all female), although none participated in the Wave 2 trial. None signalled that shampooing hair was a typical shower activity, and just one used conditioner.

'Kinky' black afro hair requires a different care regime compared with Caucasian hair. Afro hair is naturally dry and frequent washing can dry it further, making it fragile and tricky to

[64] Six identified as Black African, one was Black Caribbean, and one was White & Black African

style. General advice is to shampoo only once per week and to keep afro hair moisturised to maintain elasticity by using leave-in or by co-washing with conditioners (Corson, 2021). This advice is aligned to the aim of the Wave 2 trial and illustrates how diverse cultural standards of personal presentation can determine different water demands. As none of the Wave 2 participants identified as black no further insights could be gleaned.

7.1.3 Material

Objects

The OBJ code was the most prominent (ranked first) of *all* ISM factors in the Wave 2 focus group discussions and confirmed the object-focused nature of the intervention, in the form of a novel shower product. Objects were less significant for Wave 1 (ranked in fifth place) or the stakeholder focus groups (FG6, in 7th/11th position). Besides the multitude of manufactured showering products available on the market (soaps, shampoos, and gels), other objects of the showering process include towels and bathmats for use *after* immersion (linking to laundry frequency, as explored in the questionnaires); shower timers (a Wave 1 intervention designed to limit duration); sponges, 'shower puffs', pumice stones and loofahs for application and scrubbing; and razors for wet shaving. Kuijer's (2017) improvised 'splashing' proto-practices using buckets and other props to simulate new ways of personal washing illustrates the role of objects (and infrastructure) in such rituals.

As with technologies, objects and users interact, and these physical phenomena have the power to direct processes and diminish a person's autonomy or agency (Darnton and Horne 2013; Giddens, 1984). The Wave 2 trial set out to disrupt the scripting of the showering process by a suite of plastic-bottled products that have the capacity to determine the procedural steps and have an incidental or indirect impact on duration.

Infrastructure

The physical infrastructure of the material world provides firm boundaries in which the social world exists (Darnton and Horne, 2013). Without the provision of shower fittings, the residents would not be able to shower, but the type of fixture can also have a bearing upon how showering is done. For example, the provision of private en suite facilities in the Student Village appear to encourage high intensity showering, as there no social policing or moderating, no queues or anyone waiting or knocking on the door for their turn. Indeed, when asked about showering at university, focus group participants noted that they no longer had their parents or other family members telling them to get out of the shower (because others needed their turn to use it, dictated by schedules, or because of cost-benefit considerations about the water and energy being used). In contrast, Kuijer's (2017) 'splashing' relied upon a wall mounted radiator to maintain a comfortable air temperature in the cubicle, in order to entice the user to spend time on their ablutions.

The INF code was among the top ranked ISM factors, placed first or second for material (and second or fourth across all factors) for Wave 1, second or third material factor (7^{th} or 8^{th} of all) for Wave 2, and the top material factor (third or fifth of 18) for FG6.

Technologies

The TEC code was the third ranked of all ISM factors (and first or second for material) for Wave 1. Analysis of the Wave 2 transcripts indicate it was of a lower order of relevance, positioned between fifth and 12^{th} place (second or third material factor), and 9^{th} or 10^{th} (third material factor) for FG6.

Technology is frequently offered or relied upon as an alternative to changing human behavioural actions (Darnton and Horne, 2013). This reliance can be seen as an excuse for not changing consumer behaviour and is not sufficient to meet the carbon reduction and resource security challenges that we face. Indeed, whilst 71% of carbon emissions are produced by just one hundred businesses, the majority are consumed by the downstream supply chain, and it is estimated that between 20-37% of global emissions could be mitigated by lifestyle changes (Kubit, 2020).

As with objects and other material infrastructures, individuals interact with technologies which can result in unintended consequences or diminished efficacy. For example, the operation of WC dual-flush buttons, which are designed to deliver the appropriate quantity of water to clear the bowl. However, there is much confusion over which button to press – the physical design is not always intuitive, and the logical large button-full flush/small button-half flush is not always the appropriate choice. Assuming they have correctly distinguished between the two options, users may routinely select the half-flush option, as this is the usual or most frequent operational requirement (for clearing away urine) even when they need the benefit of the full flush to remove solids. This then results in a wait while the cistern refills and a further full flush and represents an aggregated 1.5 flushes. Alternatively, distracted users may select the full flush option when the half-flush would suffice, perhaps because, due to its size, it is easier to operate, resulting in a half-flush worth of wasted water.

The Amphiro smart meters were deployed in two houses for both field trials, as an intervention in Wave 1, and as principally a measuring tool for Wave 2 (although they would also have intervened in the showering practices of residents in House G and House J). The Wave 1 results suggest that the Amphiros were effective in reducing water use, and the technology was popular with the students. Some even discussed buying one for their shared house the following year. The students were not given any instruction in how to use them, although those recording diaries were asked to note down the volume of water used at the end of each shower. During the focus group discussions, it became apparent that a few of the students had identified the purpose of the dynamic polar bear graphic, and *perversely* chose to stay in the shower longer to see what would happen if they melted the iceberg habitat and drowned the bear, illustrating how technological solutions can introduce unintended consequences!

The Consensus Homelabs research of Davies and Doyle (2015) relied on technology to imagine three future scenarios in which water demand from personal washing would be controlled. The 'de-waterise' scenario relies on technology to detect odour levels and technical clothing to neutralise the smells; whilst the 'water control' scenario uses technology to monitor personal water budgets supported with extensive greywater recycling; and efficient appliances, and 'aqua adapt' relies on extensive rainwater harvesting systems. In these future-oriented scenarios, there is no guarantee that they may not play out as planned, and result in perverse effects.

Rules & regulations

Rules and regulations are a form of *soft* infrastructure and include both explicit policies set by formal institutions (such as government or the university) that prescribe or prohibit certain activities, and implicit or socially shared rules through informal associations (such as households or peer groups) that determine appropriate conduct (Darnton and Horne, 2013). The R&R code did not dominate any of the rounds of focus group discussions and was ranked in the mid-range for Wave 1 (tenth or twelfth of 18, and fourth for material) and the stakeholder discussions (between ninth and eleventh), whilst it featured towards the lower positions for Wave 2 in terms of all factors (16^{th} or 18^{th}) and was the lowest rank in for the material domain.

Time & schedules

This is another form of *soft* infrastructure that can confine or restrict human actions. Like money, time is a scarce and finite resource that needs to be allocated across competing demands (Darnton and Horne, 2013). Changes to schedules, such as university timetables, can determine an individual's routines .

The research indicated that students spend a large proportion of their time in their accommodation (see Figure 4-38, Figure 4-39, and Table A-57). Their everyday schedules are more flexible or varied than those in regular full-time work or secondary education. The proximity of their living quarters to their formal education provision on campus and their lecture timetables determine when they get up (as evidenced by the shift in daily diurnal consumption profile, see Figure 4-1). The variation in day-to-day schedules translated in to up to 40% of students reporting that they had no fixed pattern in the time of day that they showered (Figure 4-24 and Table A-31). However, the T&S theme featured little during the focus group discussions and was ranked 17th for Wave 1 and 14th for Wave 2, suggesting that its impact was not recognised.

The Wave 1 diary results indicated that the time of day had the potential to determine the level of water consumption, with morning showers 2.6 minutes quicker than in the evening. However, this finding was not evident in the Wave 2 diary results. Indeed, evening showers (between 6pm and midnight) were the shortest (7.3 minutes on average), almost a minute quicker than morning showers. However, the diarised events in Wave 2 were considerably shorter across all times of day (mean of 8.5 minutes), compared with the Wave 1 findings (11.6 minutes per event, on average). This suggests that the Wave 2 'go green' intervention, designed to act upon duration, had some success, although the impact of social desirability bias cannot be ruled out. The 'go gold' intervention targeted shower frequency, with mixed results. However, there was evidence that dry shampoo use had the potential to reduce shower duration by reducing the number of in-shower processes, even if it was not effective in reducing shower numbers. Some participants appreciated the tacit permission the intervention gave them to be *lazy* and the advantage this brought to their schedules.

7.1.4 Limitations of ISM

The previous sections have highlighted the relative significance of each of the ISM factors in relation to the research findings. There are many linkages and overlaps between and within the ISM contexts. However, qualitative analysis identified a few ideas within the focus group transcripts that did not fit neatly within the 18 factors. As stated in Chapter 2, Darnton previously hinted at weaknesses in ISM around gender and geographical distance (Darnton, 2017). The gendered nature of water use was discussed earlier in relation to roles and identity, with the creation of a GEN sub-code that allowed for additional nuance to emerge with respect to specific practices (for example, shaving, hair washing). However, analysis against this new code seemed to fit within the roles and identity factor, suggesting that it is a superordinate construct.

Initial considerations suggested that distance had little bearing upon the water demand of showering, given the proximity and ease of access to showering fixtures in most situations. However, with deeper reflection, an infrastructure sub-code for location (LOC) was included to cover spatial patterns (as included in Hoolohan and Browne's Change Points framework, 2018). The code was applied to highlight discussions about the location of fixtures or showering practice, including the gym or sports centre ('*out and about'*) and the pressure on shared bathroom facilities at home or future shared housing. Thus, the distance to the desired/intended practice (showering) varied by time (of day, week, etc.) and by situation (for example, antecedent or subsequent-activity) – something that residentially-fixated studies would have a harder time seeing.

Therefore, the LOC code links directly to Hoolohan's recommendation that infrastructure should be *re-located* to shared spaces and *re-designed* to facilitate more efficient resource use recognising different intended outcomes (Hoolohan, 2016a), and points to future accommodation configurations with more communal services and a move away from en suite bathroom facilities (as in the Student Village). This has parallels to the literature on pop-up food stalls as flexible and more sustainable alternatives to mainstream food outlets and their power to disrupt standard food practices (Middha and Lewis, 2022; Middha *et al*., 2021). Contrary to the assumption, 'one size fits all' does not necessarily apply to showering facility design!

Another approach to the communalisation of infrastructure to reduce water demand would be to explore the centralisation of dishwashing by installing efficient dishwashers in kitchens, to tackle wasteful washing-up practices that favour frequent (up to three times a day by 64.4% of students, on average) and solo (72%) washing-up under a running tap (40.9%) – refer to Table A-47 to Table A-49. However, this is not without its challenges. Although more than half the students reported having a dishwasher at home, they acknowledged that a whole new area of household negotiations would be required to agree shared responsibility for the regular loading and unloading, and the purchase of detergent. Moreover, it turns out that the precise manner of loading and unloading can generate difference, tensions and even conflict. Such strategies also have potential for transfer to other communal establishments including laundry. Hoolahan (2016b) discusses the matter of workplace uniforms, but this logic could be extended to non-professional clothing and textiles.

Body image was another sub-theme that was evident in the transcripts and relevant to the research focus on personal grooming and cleanliness, but it was tricky to place it solely within the individual or social contexts. The BIM code transcended the meanings, tastes, and roles & identities factors in the social realm and the values-beliefs-attitudes in the individual domain. This code related to the life stage of the young adults finding their own independence in the wider social world, meeting and forming new relationships with peers and new social groups and understanding or creating their own cultural identities (such as gender, race, or religion, as discussed earlier for the R&I and GEN codes).

The BIM code also had a strong connection to a health and wellbeing theme. Water is vital in maintaining health, both at an individual and at a collective level, and was brought into sharp focus during the pandemic with the emphasis on hand washing for public health. In the early days of the pandemic, it became apparent that there was a strong gender split in hand-washing practice, and the new guidance fits with the rules and regulations factor. New public health habits were adopted despite enduring debate (with respect to face coverings as an outward symbol of compliance) about whether new practices are driven by personal or collective benefit. Throughout the world, queues at men's toilets grew as more men practiced more handwashing than previously. In the domestic realm this new behaviour was visible in increased water use and empty soap shelves in the supermarkets. The HEA code was applied to discussions about the *Legionella* flushing regime during the stakeholder workshop (FG6), and the interpretation of non-Covid specific public health regulations.

7.2 Practical reflections

7.2.1 Technological control of leakage and flow

The privatised water sector in England is an infrastructure-led industry that has been forced by regulators in recent years to turn its focus to managing consumer demand to balance against competing pressures on available supplies, due to changes in climate, population, lifestyles, and environmental needs. Demand management has driven the sector to adopt conventional IBC (the socio-psychological models of Rosenstock, Ajzen, Fishbein and Triandis, see section 2.2) approaches to try to reduce consumption. However, the sector is somewhat blind or ignorant to the strongly held and implicit social rules and expectations of how lives are structured that determine how water (and other) resources are consumed. Its fixation on technical solutions has multiple causes such as: a tradition of environmental engineering and management; the regulatory framework and tightly controlled financial resources necessitating a return on capital investment for shareholders; the relative ease of measurement of devices distributed and consumers engaged (but not water saved); technical skills of staff; and what is within its direct realm of influence. These all conspire to make physical infrastructure solutions the default option, supplemented in the last decade with IBC rational choice solutions (see section 2.2) that make intuitive sense to the practitioners operating at the coal face, tasked with delivering mandatory water (and energy) savings set within the contemporary regulatory and policy landscape.

Leakage control

There is a wealth of technical options or hard measures available to help tackle all kinds of unsustainable resource consumption. In parallel with the hierarchy of energy efficiency that dictates the first tier of practical action is to block heat escaping by installing effective insulation and sealing drafts (before fitting simple low energy gadgets such as LED light bulbs), it is sensible to plug any water wastage first to manage demand, from both the distribution network (the responsibility of the water utility company), and to stop customer-side leaks from domestic plumbing systems. This is the first layer of action in any successful demand reduction strategy and dominated by hard infrastructure and adjustments to the material backdrop.

Fixing network leaks helps to stem the flow but can be technically *complicated* and requires professional expertise, skill, or competence. However, with the appropriate level of training and practical experience, the problem can be isolated, scoped, planned, costed, implemented, measured, and evaluated with relative ease by an army of specialists dedicated to the task. It is complicated work, but within the *direct control* of professional project managers.

However, whilst an isolated leaking tap or WC may make only a small contribution, these diffuse seepages are ubiquitous. Recent sector research (Ricardo Energy & Environment, 2018) has reported that around 4% of WCs may be leaking an average of 215 litres per day, on average. This is the equivalent to having at least one additional occupant effectively squatting in a household. This makes a significant collective contribution to total demand (up to 4.6% of domestic use) and yet can be problematic to fix *en masse* due to its distributed nature. Before domestic leaks can be fixed, there is a dependence upon the consumer to *recognise* that there is a problem in the first place. Low-level losses persist unnoticed or get dismissed, especially if they start slowly, develop over time, and go unmonitored in a room that is occupied only intermittently.

Once acknowledged, inertia in resolving the issue may delay fixing a dripping tap or leaky loo, as the solution requires either the skills of a trained plumber or at the very least, a certain degree of competence, confidence, and agency for the amateur DIYer to resolve. The consumer needs to know how to fix it or who to call, and this requires both internal (desire, motivation, agency) and external or material resources (money, time) to take conscious deliberate action. So, whilst domestic plumbing leaks may appear insignificant and only require a simple fix, they can be more *complex* to remedy, due to a combination of behavioural factors that need to converge before effective action. Fixes that require human action to initiate or engage with become increasing *complex* as it is impossible to isolate the problem from the environmental and social contexts in which they exist. Thus, the fixing of customer-side leakage is more challenging than supply-side losses, due to the dependence upon untrained individuals to act logically and take reparative action on diffuse leaks.

Direct flow controls

Once leaks are resolved, then the next layer in the water efficiency armoury is the fitting of simple low-tech devices that physically restrict or regulate the flow rate at fixture level, such as low-flow showerheads, tap inserts and cistern displacement bags. These basic infrastructure improvements are designed to work independently from how the fixtures are used. They are *passive* controllers, *invisible* in their day-to-day operation and independent of human action.

However, these gadgets can lead to unintended consequences due to compensatory actions. For example, users of low-flow taps or showerheads may extend the *duration* of their operation to fully wash away soap or shampoo suds. And WCs may be repeatedly flushed (increased *frequency*) to remove solids from the pan if a low volume flush fails to clear it the first time. Mitigation options that depend upon human adoption and conscious operational decisions to indirectly reduce water use are *complex*, as their success cannot be divorced from unpredictable and potentially illogical human actions and wider social forces that set the standard processes or norms, and ways of doing things.

And yet the water sector is dependent upon giving away these simple low-cost water efficient devices, supplemented with information and education campaigns to meet its statutory obligations, despite there being little empirical evidence that they save water. Humans are not necessarily rational actors, and there are countless influences on how everyday routines are performed - both internal (or psychological) factors including emotions, which are individually derived, and strong external forces in the social world, that shape how things are done and to which our individual actions are inherently bound. These social influences include community networks and relationships; institutions that influence shared understandings and expectations (norms); the meanings attached to ways of doing things and institutions that shape everyday life (Darnton and Evans, 2013).

7.2.2 Human-technology interactions

Indirect controls

The next layer of influence to reduce consumption relies upon human actions. Active interventions use technological gizmos that interact with end-users, such as (optant) water meters and shower timers. Adoption is contingent on conscious acceptance by householders and dependent upon expected or anticipated human-technology interactions, predicated upon rational and sensible end-user decisions. These interactive solutions rely upon uptake and *prolonged* utilisation by end-users to continually respond *appropriately* to metrics or messages by making conscious decisions to moderate their actions in the expected manner. This technology cannot save water directly but relies upon sending signals to individual end-users with the expectation that they will act in a logical and consistent way, respond to the indicators or parameters (whether displayed as minutes, litres, kilo Watt hours, monetary value, or even norms) and adjust their practices accordingly, as intended.

When a payment meter is first installed (or a household moves into a home with a meter for the first time) the consumer, particularly the bill payer, may be concerned about the relative cost of paying for water the by volumetric units consumed (as opposed to a simple standing charge based on house size) via the metered bill for the first time. The *novelty* of the new setup (physical dwelling configuration and location, billing mechanism, and/or real-time display of a smart meter) helps to put the information into the conscious mind and may moderate behavioural actions in the short-term. However, after any initial shock and affordability concerns fade (this may be prolonged during the current cost-of-living crisis), a new normal routine takes root. The price (or volumetric) signals from the meter become less salient leading to a decay in any initial water saving impact by the meter (although the recent rise in energy prices and squeeze on living standards may present an opportunity to bring water efficiency, particularly hot water use, back into focus). The smoothing of annual bills through monthly electronic direct debits dissociates the price from the quantity used, and make the costs less visible, rendering little long-term impact on consumption by most households, unless they are struggling with long term affordability issues due to low incomes and relative poverty. And *only* the bill payer is likely to pay any attention to the metrics unless they can elicit or impose effective control on consumption by all members of the household.

The moderating impact of shower timers, whether simple sand-timers or more technical Amphiros, is predicated on similar assumptions as payment meters. They act indirectly upon the end-user and rely on conscious decision making. Any initial positive resonance due to novelty rapidly dissipates into the background. This research provides some evidence that the Amphiro devices were popular and effective in reducing shower duration, but the trials were limited to just two weeks and accompanied by active participation through the recording of diaries.

For example, diarists from houses E and F in Wave 1, reported mean shower durations (9.2 minutes) two minutes less, compared with the mean duration (11.2 minutes) reported by all diarists, and almost five minutes shorter than the control (no intervention) diarists (14 minutes). A measured PCC reduction of 42.9% over the two-month monitoring period of the Wave 1 trial also supported the conclusion that the Amphiros were effective, despite operational challenges with the metrology. Indeed, the act of simply installing the Amphiro meters in house G reduced total water use (14.7% less), the shower component (36.8% lower) and event volume (17.1% reduction).

However, there is a risk that the presence of the Amphiro display would fade into the background after a period once it was no longer new and novel. It could therefore have limited long-term influence on end-user showering patterns. For practical reasons, the field trials were run for only a limited period, and it would be interesting to run a prolonged trial with the Amphiro devices to gauge the longevity of any measurable impact.

This research provides no evidence to support the effectiveness of the simple sand-timers despite their popularity as giveaways by the water companies, although they may serve as a relatively low-cost engagement device that grab attention and initiate dialogue. The Wave 1 results showed that the mean shower duration (14.2 minutes) reported by the shower timer diarists (houses E and F) was similar to the control (no intervention) group (houses A and B) of 14 minutes, and three minutes longer than the mean duration (11.2 minutes) recorded by all diarists.

Gamification

Gamification is an area that is gathering interest from utilities managers including water. It is the use of game-playing technology, typically using point scoring or competition, to encourage and reward (either virtually or materially) engagement in an activity, product, or service. For example, the fitness industry has made extensive use of smart tracking devices that link to online apps or portals to reward users for both commitment and improvements in performance and to foster communities of shared interest. Gamification is an attractive concept for the water sector, to encourage uptake of both passive and active water saving devices, and to capitalise upon the large and increasing quantities of data recorded through metered supplies to engage and influence customers in a fun or playful way to drive down consumption in return for prizes and rewards.

An example is the '*Get Water Fit'* app and portal, funded by several water companies in England (via www.SaveWaterSaveMoney.co.uk). Customers calculate their household water use, order free and paid-for water saving kit, make pledges and take part in challenges, plant trees in exchange for online coaching, earn virtual rewards and donate to local charities and schools.

Gamification has the potential to reach younger consumers (who may not be responsible for paying bills) including the target group in this research - students living in university managed accommodation. UWE is signed up to the Accommodation Code of Practice (Universities UK, 2019) which sets out minimum standards for the management of university halls. Section 4.2 specifies that signatories must encourage environmental responsibility in energy and water consumption. To comply, UWE outsourced its sustainability engagement duty in 2016/17 and 2017/18, to 'Reduce the Juice', who organised competitions between houses (WCP1) and blocks (Student Village) with rewards for engagement, sharing ideas and reducing consumption, principally via social media. However, the initiative failed to deliver material savings in resource consumption and consequently, the Code of Practice section 4.2 duty was taken back inhouse, to be delivered in a partnership between the university Energy team and Students' Union.

The focus groups confirmed that there was an appetite for a gamified approach to delivering resource efficiency although very few could recall the activities of 'Reduce the Juice' (Wave 1) or in-house engagement (possibly due to limited reach during Wave 2, early in the academic year). Instead, participants frequently suggested some sort of app to track shower use might be appealing and effective – a Fitbit for showering, particularly if it could link up with the popular Amphiro devices or link to music playlists (with tracks limited in duration to encourage quick showers).

The Amphiro is a form of gamified technology with its dynamic user display with various metrics and a virtual polar bear sitting on a melting iceberg home. The basic a1 edition was used for this study, although the event code functionality was not utilised as it was clunky and time consuming for end-users (having to manually record the code at the end of the shower and enter it via an online portal) and access to the event database for each fixture was not practical for the researcher. Whilst the more advanced Bluetooth-enabled b1 version links to a user app, it was also dismissed for this study due to privacy concerns around sharing fixture event data from shared facilities limitations in the data visualisations within the app, and the added expense of purchasing the more sophisticated models.

PlayWest, a UWE-based games studio enterprise, developed an energy and water game called '*Pipeline Express'*. The app aimed to help users improve their understanding of energy and water measurement; interpret and respond to near-live sub-meter data; galvanise action on consumption via competition; alter consumptive actions through intrinsic and extrinsic motivations; develop the student community; and enrich the student experience in a fun way (King, 2016). However, the game was not adopted as an engagement tool by the UWE Estates team, and therefore did not feature in the interventions assessed for this research.

7.2.3 Alternative water sources

Developing new water sources is the other half of the twin-track supply-demand balance approach, and rests squarely in the material context. The predict and provide principle, in which the environment and its resources are engineered and controlled for human benefit, was the dominant form of water management until the turn of the century. But with increasing pressures on water resources and policy and regulation has focused more on the demand management of downstream consumption. Whilst planning and building new reservoirs is a long-term and expensive task, innovation has driven suppliers to look for more cost-effective alternative infrastructure solutions.

There are two categories of alternative water source, representing opposite ends of the supply process. Rainwater-harvesting is a form of new resource collected directly from roofs and other impermeable surfaces, whilst reclaimed grey- (and black-) water utilises wastewater. Greywater comprises water that is lightly contaminated with detergents and soaps, and includes used laundry, shower, and bath water, whilst blackwater is more polluted and includes WC wastewater and raw sewage (which is only practical on an industrial scale with tight regulations to ensure public health). Desalination is another form of collection from the environment, which treats brackish or sea water at a commercial scale. However, it is an energy and carbon intensive process and not economical in the UK for routine supply and works in the opposite direction to stringent climate targets.

Water treated to high drinking water standards of wholesomeness or potable water, is not essential for all uses of domestic water, for example WC flushing, but the plumbing for such alternative supplies must be clearly marked, stored, and treated appropriately to avoid contamination of potable water supplies (HM Government, 2016). Due to spatial and infrastructural requirements and specialist skills needed to manage water quality risks (compliance with the building and water regulations), rainwater-harvesting and greywater recycling are generally not suitable for retrofitting by amateur DIYers but lie in the realm of new build or development-scale schemes. Rainwater collection via water butts for outside use and garden irrigation is practical for householders, but as external use only accounts for about 9% of total domestic consumption, on average (see Figure 1-9), they make a limited contribution, especially during dry periods without regular recharge through the seasons - the very occasion a back-up supply is needed most.

7.2.4 Convening, collaborations, and consumer engagement

Beyond the engineered and behavioural mitigations described above, agents and institutions operating in this space need to embrace solutions that are rooted in the *complex* social world. This requires a cultural shift, a tsunami or tidal wave of change in the way water efficiency is organised and 'baked into' people's routines and preferences. Whilst this is difficult to achieve, it is more likely to stick than simpler individual actions that are more fragile and prone to relapses. Operating in the realms of social change necessitates leadership with demonstration projects to advocate for modified lifestyles and build trust, convening stakeholders to bring together communities with shared goals and to form effective partnerships, and public engagement.

These activities are increasingly *complex* due to the difficulty in identifying all the contributary factors and separating them from the external world, and the limited degrees of influence that institutions may have over final outcomes that risk unintended consequences. Whilst technical solutions may be *complicated*, these more *complex* social challenges require leadership to engage with diverse groups within the community. For example, this could involve collaborating with haircare product manufacturers and hairdressers. We cannot respond to the challenges of water security without a collective effort to adjust routines. Social pressure is more powerful than individual motivation and sets the standards for everyday life. It has the power to invisibly alter the actions of the most reluctant individuals and laggards. But the problem with acting on complex problems is that there will be gaps in our knowledge and reach, and we cannot separate out the problem from the environment or social context.

In the UK we have never had to deal with water insecurity and are learning as we go. The water resources managers mandated to reduce demand have no direct control over external influences and the competing actions of other actors. It will be difficult to measure success or to credit observed changes to actions, but to address the risk of future water shortages, practitioners will need to act outside their comfort zones and traditional spheres of influence. There is no silver bullet to fixing the supply-demand deficit to combat unsustainable consumption, although there is a range of potential options. However, a reliance on technical solutions and public education alone is unlikely to be sufficient. Even the most committed environmentalists have blind spots and egotistic traits, or simply do not have the awareness that our water resources are under pressure. More to the point, blithely abandoning social and cultural conventions around personal conduct carries social and cultural costs. Successful demand reduction will require changes that go against individual short-term gain and social convention in the interest of long-term common good. This necessitates wholesale system change to social structures and the material landscape.

Technical fixes and engineered solutions – widgets, gizmos, and gadgets, such as low-flow showerheads and smart water meters are the easy bit (they may be complicated, but they are not complex). They are very top-down, but as a society, we are not going to be able to simply retrofit ourselves out of the problem. We are beyond the realms of individual responsibility and need regulation and leadership. Organisations tasked with addressing the water supply challenge will need to actively engage with consumers in two-way dialogue and to listen to them. Even with environmental values and attitudes, the rhythms of everyday life can get in the way of adopting innovative technology. This social side is softer, 'pink and fluffy', difficult, and complex, but without it, it will be much trickier to get the technical solutions adopted.

The continuum between complicated and complex follows a hard-soft split. The (merely) complicated is more tangible because there is a greater level of control, it can be measured, and it is within our comfort zone, whilst the complex is fuzzy or nebulous, and there may be a tendency to shy away from it because it is difficult, messy, and uncontrollable. But we need to do this, no matter how uncomfortable or strange it feels!

7.3 The ISM iceberg of water efficiency

Having reflected throughout this research upon how the ISM model relates to water efficiency, it was re-conceptualised by blending it with the complicated-complex gradient in the climate action planning matrix (Centre for Sustainable Energy, 2020), at different scales. This re-conceptualised model, displayed as an iceberg (see Figure 7-2) presents the visible and tangible interactions above the water line – dominated by IBC factors supported by infrastructure fixes.

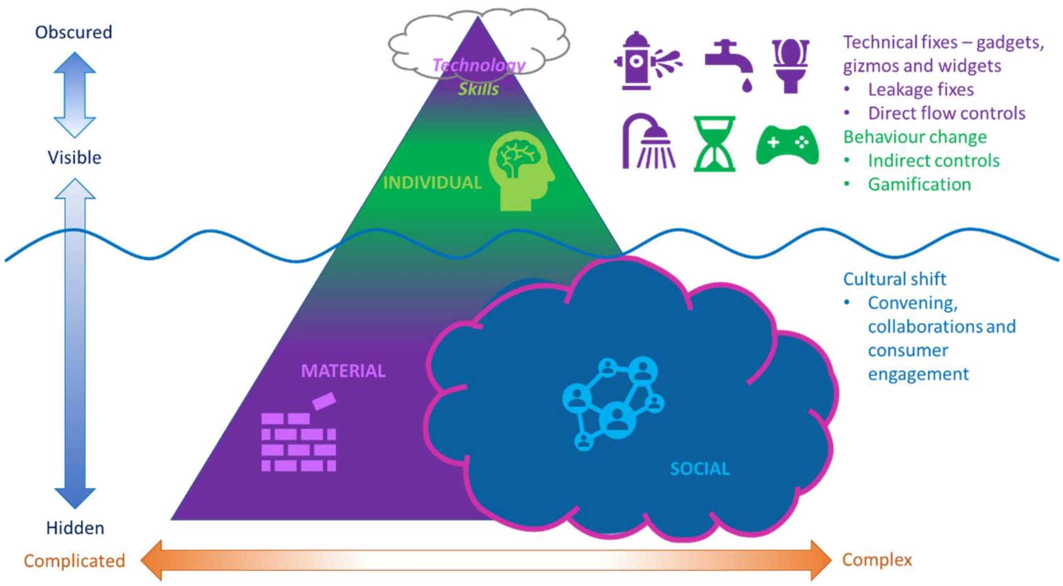


Figure 7-2 ISM iceberg of water efficiency

The very top of the iceberg represents technical leakage fixes delivered by water company specialists that take place away from the gaze of, or without interaction with the general public. Leak detection is dependent upon monitoring night-time use and whilst fixes may be visible, necessitating the digging of holes in the road or pavement, they do interact with the public (other than disrupting traffic flow). There is an opportunity for contractors to provide signage around excavations to inform the public about the works, to raise awareness and re-attune to where our water comes from (Hoolohan, 2016a). Likewise, direct flow control measures are not contingent upon human interactions and therefore, disappear into the background. From this perspective, these first-tier demand reduction mitigations are clouded and obscured.

Water efficiency mitigations such as those deployed in the Wave 1 field trial, that are dependent upon human-fixture interactions sit within the individual realm and rely upon conscious effort, making them more present. Whilst there is a long-standing polarisation over the roles of individual responsibility and systemic social and regulatory reforms in resource sustainability, there is an argument that both levels of change (above and below the water line) are needed to influence and reinforce each other. Whilst at face-value individual actions may have a negligible impact in isolation, they are the visible and authentic actions of those that identify as environmentalists or responsible consumers and send *ripples* of influence through social networks, communities, and institutions.

The material and social domains, represented below the water line, with background infrastructure and tacit social rules, operate in much more complex and non-linear ways than the individual realm. The iceberg diagram shows the material world on the left and the social world to the right, on a *complicated-complex* gradient, and represents the degrees of influence across the divide, with greater direct control on hard measures compared with looser or only indirect control on the softer, public-centred social realm. Water supply is an infrastructure dominated sector with day-to-day operations *hidden* from the public. Indeed, the sector is deliberately regulated to ensure delivery of this essential service has minimal conscious impact upon consumers, to minimise friction and maximise convenience. Whilst the engineered control of the water environment is complicated, it is tangible, can be scoped and managed, and operates independently from the consumers that it serves. In contrast, social or cultural factors cannot be separated from their physical environment, and this complexity makes it difficult to influence and alter consumptive patterns. The Wave 2 interventions were designed to operate in this below the waterline zone, with the shampoo bar objects drawing on the strong social influences of the 'Blue Planet' effect.

Institutions, such as universities, communal establishments, and organisations, are empowered to establish their own cultures and can demonstrate leadership to stakeholders, staff, and service users by setting shared values and expected or accepted norms of conduct. Operating within the social realm requires a diverse set of competences, with success contingent on effective collaborations and leadership.

Engagement and partnerships are the necessary tools for driving a cultural shift in how things are done.

This hierarchy, moving from complicated to the complex, helps to show the relative degrees of influence that the water sector has across different scales, from individuals to populations and from the technically *complicated* to the socially *complex*. At a basic level, leaks can be plugged, and hard interventions can directly reduce flow rates to reduce water demand, but this can result in unintended consequences, and it becomes increasingly difficult to predict how consumers will respond and whether they will act in the way intended. For example, whilst the Amphiros were popular and effective, some participants admitted to acting perversely by extending their shower duration so that they could deliberately drown the virtual polar bear! When operating within the complexities of the social world, simple IBC and fixture-level technical solutions are likely to have only limited effect, with efficacy dependent upon maintaining engagement with the end-user (becoming embedded as part of the practice, Strengers *et al.,* 2015), and the degree of control that a water demand manager has becomes increasingly limited, particularly in the social context, where limited agency makes it difficult to scope, plan and measure intervention programmes.

7.4 Conclusions

This research set out to address three aims and four objectives and has made theoretical, methodological and empirical contributions. A review of the literature (Chapter 2, RQ1.1 to RQ1.4) critiqued the limitations of current water efficiency practice and the sector's dependence upon individualist rational choice (ABC or IBC) approaches was debated. The theoretically grounded Individual-Social-Material model was adopted as a promising and practical tool for developing and testing a SPT-based package of interventions, particularly as there was little evidence that it had been applied in the water sector or for managing resource demand and consumption within the English cultural or political context.

Through a combination of volumetric measurements and analysis, the baseline water demand within the modern and standardised university residential setting was estimated to be above the average (RQ2.1 and RQ2.2) for the wider population (excluding laundry and outside use). The industry standard PCC measure was found to be problematic due to uncertainties in day-to-day occupancy levels (even within an apparently well-known resident population), and lengthy periods of time spent in campus accommodation. This was confounded with evidence of intermittent leaks, *Legionella* risk management protocols, and a mix of incompatible source data. However, with adjustments to telemetry and sensitivity testing, it was shown to be possible to estimate and confirm water use at the shower-fixture scale (RQ2.3) – see Chapter 4 (section 4.1). This finding could inspire future work on water consumption segmentation algorithms (see 7.4.2, below).

In parallel, an initial exploratory questionnaire survey (Q/0), designed to investigate the water using routines of students, generated insights into student showering routines, and a range of other connected or bundled antecedent, micro-, and post-practices, and observations on other water using activities. This empirical evidence contributed to an understanding of how students *do* showering. The private nature of personal washing means that there is very limited data on the water-using practices broken down by different population segments (in this case students), and yet there is evidence that indicates that life stage has a material impact on water use (Browne *et al.*, 2013; Walker and Zygmunt, 2009). Self-reported data on shower frequency, duration, location, and number of products used was input into a series of cluster analyses to classify styles of showering (RQ3.1). The majority (90%) of campus residents adopted a similar type of showering (the '*UWE standard'*), which shared comparable features with the '*attentive*' style (in Browne *et al*., 2013). A frequent (six times per week) but leisurely (11.5 minutes duration, on average) approach to showering in which three products were routinely used (RQ3.2) – see section 4.2. It is also likely that the same individuals were performing a variety of different showering routines in different combinations, determined by a range of influences and bundled practices.

Two periods of intensive fieldwork were undertaken to design, pilot, deliver and evaluate a real-world intervention strategy covering multiple levels and contexts making methodological and practical contributions to water demand management, through a process of continuous improvement; learning by iterative engagement with end-users and facilities managers; and integrated data analysis (RQ4.1) – presented in Chapter 5 and Chapter 6. Packages of conventional IBC (Wave 1) and SPT-based (Wave 2) measures were tested (RQ4.2). Primary and secondary data across the range of scales were analysed, integrated (Chapter 5 and Chapter 6), interpreted and discussed (section 7.1), to assess the relative significance of different ISM factors in the design of effective water-saving programmes (RQ4.3 to RQ4.5), to make recommendations for future water demand reduction strategies and identify limitations (discussed below).

7.4.1 Recommendations for future water efficiency programmes

This research was intended to be of direct practical use to water resource managers who are tasked with balancing demand to secure future water supplies for the next generation, within the constraints and pressures of climate, population, and lifestyle change. Indeed, the final aim was *to inform future domestic water efficiency programmes.* Whilst the research focused on showering, as it represents the largest and growing component of domestic water use (and is also linked to domestic energy consumption), it made sense to gather empirical evidence in parallel for other water-using practices (and opens the possibility of undertaking further research, analysis, and interpretation – see section 7.4.1). This makes sense from a water-saving strategy perspective, although the evidence demonstrates that each micro-component of domestic water consumption needs to be separately considered, through a combination of different approaches as the influences are different. For example, whilst all practices may be done privately or solo, some can be shared in communal spaces (dishwashing, and laundry) but not showering or WC use. And some practices are related to or bundled with other processes, for example, laundry and showering, as clean bodies need clean clothes, towels, and bed sheets! This highlights the influence of different socio-material factors. For example, the definition of work clothing versus non-work clothing, which may be determined by the nature of work, such as manual or office-based, and the potential for sudden transferences between (when work becomes non-work and vice versa).

The experimental design and methods employed in this research could be modified and adopted to intervene in different resource consumptive practices and different scenarios. Whilst this research has practical application to the water sector specifically and it could be followed to improve the water efficiency of dishwashing or laundry practices, for example, it could also be tailored to help control other resource demand and sustainability programmes, such as energy efficiency, active travel, recycling and food waste. in particular, the combination of SPT-derived interventions coupled with mixed-methods approaches to gain end-user insights into how things are done and to evaluate the quantitative impact of solutions on scarce resources.

This research focused on university campus accommodation for several reasons. It was in a spatially convenient location, although access was tightly controlled by institutional gate keepers, and research activity had to be carefully scheduled to allow for regular occupancy fluctuations during university holiday periods. It had modern standardised fixtures and housed a broadly similar population segment (young adults, with known demographics via the university accommodation service) that reset annually. The students were at a spatial and temporal transition phase in their life course, in which high consumption is the norm due to pressure to conform to shared expectations on body image and to fit in with new networks and social hierarchy, and new habits are formed or shaped. This allowed for repeatable science at scale – the 'Holy Grail' of scientific research.

However, whilst the research was very context specific, some of the insights and approaches present an opportunity for a cultural shift and could be translated to other communal residential settings, such as hotels, care homes, military bases, prisons and other institutions that closely control their infrastructure and have the power to develop their own cultures. For example, through shared values (meanings), expected standards of conduct (norms), and internal policies and processes (rules & regulations). The findings may also translate into the wider domestic sector in England, and possibly to other nations, through more careful consideration of the interactions between ISM factors and the recognition that factors themselves are situationally-variable.

The ISM model formed an effective lens with which to design and evaluate interventions, and whilst it was designed for expert practitioners, it was valuable to work directly with non-expert end-users to co-design ideas from their perspective, and to understand why and how they do what they do. By overlaying it with SPT, it was effective at addressing a common challenge for SPT: making social practice more practical (RQ4.3). A common criticism is that SPT is too theoretical, too abstract and can only be applied retrospectively to evaluate past interventions and not to design new ways of doing, particularly by the engineers and scientists who are tasked with driving down demand. It was not perfect and had some limitations (all models are simplifications of reality) but proved to be more effective than the current IBC-based strategies of handing out gadgets and providing information on a hope and a prayer of delivering savings (discussed in section 2.2). It was particularly valuable for refocusing on the social context, beyond the sphere of direct individual control – i.e., moving beyond 'who is doing what' to 'who is doing what *under what set of social expectations and constraints'*.

Effective demand reduction at a population scale needs to engage with the social realm (RQ4.4). This is difficult for isolated teams of demand management professionals as they lack agency to significantly change the social landscape. Instead, being in tune with the research participants' public mood allowed for a coherent package of SPT-based interventions to be effectively deployed, despite limited resources (financial, time and skills), as it tapped into shared meanings, concerns of the target population and provided sufficient momentum to deliver observable and measurable reductions in water demand. Demand managers need to be in tune with the public discourse, and develop the social science skills to convene, engage, collaborate, and partner to co-design effective solutions that make sense to consumers and to capitalise on trends or shifts in the trajectory of everyday life. It would be difficult to overstate how big a step change this represents for a professional community hemmed in on all sides by convention and conservatism in approach. Some suggestions for further research or investigation are given in the next section.

7.4.2 Ideas for further research

This research has developed and tested a new approach to designing and evaluating interventions for water demand management. The following section discusses other opportunities for future academic enquiry that have been sparked by the current thesis, and the thoughts, ideas and reflections that have been triggered that show merit in further academic enquiry.

Ideas for the Wave 2 trials that were considered, before settling on the alternative shampoo intervention, included a focus on wet shaving; rising concerns for mental health; gamified use of virtual utility statements (not bills); and changes to fixtures with the installation of percussion (push-button) taps on the showers of the ilk found in sports centres. Other thoughts emerged from this study in response to empirical findings. These are detailed below.

Kitchen-use

Whilst this research focused on showering, the water fixtures audit and the insights into student washing-up routines pointed to high and unregulated flows at kitchen taps, coupled with reports of frequent, solo washing-up under a running tap. Together, this suggests that a focus on kitchen water use would be a fruitful opportunity for reducing water demand alongside meeting corporate carbon, energy, and water reduction targets. Inline flow regulators could be fitted to the plumbing for the kitchen taps to reduce flow to the taps. This would be an infrastructure modification that would not pose a direct challenge to individual or social contexts. Rather this intervention would (subtly) alter some of the key material affordances involved in dish-cleaning. Further research in this area would be beneficial, particularly around the use of communal infrastructure, such as washing-up bowls and plugs (that frequently go missing), and dishwashers. As noted in

Chapter 4, modern top-rated dishwashers can be more water efficient that cleaning dishes by hand, though as noted earlier in this chapter (section 7.4.1), introducing new devices unavoidably brings new dynamics and opportunities for tension or conflict over use practices, and potentially unintended consequences in the social realm.

There was strong support for dishwashers from the students which would be viewed as an upgrade and modernisation of shared living quarters, with the potential to enhance the student experience. However, the students did also foresee difficulties with informal negotiations between housemates on the social rules regarding shared loading and unloading duties; access to limited stock of pans, crockery, and cutlery to fill the dishwasher; and the shared responsibility for purchasing detergent (with potentially higher upfront costs compared with washing-up liquid, toilet paper and other cleaning supplies). Whilst informal household-level agreements would be important, the university could facilitate by initiating discussions, or even providing sufficient kitchen equipment and supplies of detergent and setting and modelling a culture of cooperation for communal living, through the welcome and induction processes. University accommodation Residential Advisers (commonplace in the USA, and increasingly adopted here in the UK), are senior or more mature students who live and work in student housing to provide pastoral or wellbeing advice to fresh students living away from the family home for the first time. These role-holders could be important modellers of desired behaviours for communal living and conserving resources. The importance of reporting leaking taps and WCs could be promoted (set against the context of the climate emergency) or even rewarded (through discounts in the campus retail outlets), and the university could explicitly list water (and energy) wastage (and failing to sort recycling[65]) as examples of anti-social behaviour. The current focus of the university Code of Conduct is on drugs; tampering with fire safety mechanisms; noise and other nuisances; housekeeping and infrastructure damage; and, aggressive or disrespectful behaviours (UWE, 2018b). Any study on kitchen water-use would be tied up with other kitchen and food practices and cooking rituals. For example, rice-rinsing rituals among those with Asian heritage.

Body and facial hair

Shaving was found to be a significant contributor to shower duration (as highlighted in Figure 6-22). An intervention could be linked to the social campaign '*Movember*' which takes place in November each year to raise awareness and support for male mental health

[65] Note that the university does not currently make provision for students to separate and recycle empty aerosol cans – this is significant in the context of using dry shampoo in the Wave 2 trial.

by encouraging competition in facial moustache growth. The idea was discounted for the Wave 2 trial due to the gendered differences in practice and the challenge of designing an appropriately inclusive intervention that made sense to the target group.

Following the Wave 2 trial, the researcher also learnt about a social campaign (started in 2018) aimed at female empowerment and body confidence called '*Januhairy'*. This discovery came too late for this research study, and the January timing did not easily fit in with the university's schedules and full occupancy, or the need to avoid disrupting students during their exam and assessment period at the start of term 2. There is also a more recent campaign called '*Decembeard'* that encourages beard growth to raise awareness of bowel cancer, but this also carries the same issues of timing and inclusion as the other two projects. However, the UWE Students' Union, which is now tasked with delivering water (and energy) efficiency, could run its own campaign on similar lines at a more appropriate time, and this could be an interesting opportunity to explore the water use of shaving in parallel. However, there is a risk that a combination of all these body hair campaigns may be confusing, and risk mixed- and diluted-messaging about gender stereotypes and the strong forces of the social acceptability for non-head hair on males but not for females.

Mental health and mindful meditation

Linking with rising concern for mental health both within the student population and the wider public, made worse since the pandemic, an intervention programme that aligns with mindfulness was considered and may be an interesting avenue of further research. This idea relates to the apparent efficacy and universal appeal of the Amphiro device and suggestions from focus groups for an app or 'Fitbit' for water efficiency and time-limited music playlists. Although this largely sits within the individual-material domain, the researcher wondered if guided mindfulness could be a way of making showering a more active (less passive), in-the-moment conscious process as a way of breaking the habitual or subconscious nature of everyday practice.

Encouraging students to utilise all their senses, the audio could invite the end-user to *listen* to the flow of the water and the soundtrack, *feel* the temperature and pressure of the water on the skin and suds of shampoo in the hair, and *smell* the scent of the products. It would be set for a specific time-period to limit shower duration, with subliminal messaging about caring for the environment (bringing in a social concern) and a clear signal to end the shower to get on the with day ahead.

Skin health and body odour

The researcher speculated whether there was an angle that frequent immersion in hot water was deleterious to the skin that could be investigated to form an alternative line of enquiry. It is understood that too much water can dry out the skin and this could be used to challenge shared ideas on body image and personal grooming. The suggestion is that regular washing removes *good* bacteria on the skin and too much cleaning may impact the delicate balance of the skin's microbiome, that has a function in immune defence and body odour production (in the same way it is thought that too much hair washing upsets the balance of natural oils in the hair shaft causing overproduction of sebum and greasy hair, as championed by the no poo/low poo movement).

- Is there a possibility that frequent cleaning with harsh chemicals might upset the skins' natural regulation of bacteria that cause odour?
- Is frequent showering *making* us smelly?
- Is this linked to life course and hormones?
- Are some age groups more susceptible to unpleasant odours than others?
- Could this idea be utilised to design a targeted water-saving intervention?

This is a direct challenge to the meaning of hygiene and cleanliness. To what degree is the contemporary definition of cleanliness rooted in a narrative that has been hijacked by manufacturers to create a market to sell more product (Ward, 2019), through promises of freshness, newness or other sorts of social distinction (see section 1.3)? There is a plethora of products on the market, designed to treat or cure a multitude of problems or ailments, such as dry, sensitive, oily or spot-prone skin. Such an approach would need to engage the expertise of a dermatologist, or microbiologist, as a regular water demand manager is unlikely to have the relevant knowledge to confidently propose a solution that challenges a widespread accepted norm that the body needs to be cleaned daily through immersive showering with a plethora of manufactured products, and its links with body image and personal presentation.

Gamification

There were advocates among the students for producing monthly statements of energy and water use, alongside a gamified approach with rewards for improved performance using injunctive norms. Whilst more aligned to IBC approaches (see section 2.2) it was logical and had the potential to raise awareness of water (and energy) use and to engage and prepare them for life beyond university accommodation in the private sector where they may be responsible for paying for their consumption separately from their housing rent in the future.

Consumption is currently invisible to the students living on campus, as their rent is inclusive. Monthly statements have the potential to help prepare students for budgeting and living with limited incomes. And elsewhere (off campus), in the context of the cost-of-living crisis, the rising monetary cost of utilities, is forcing a broader recalibration of individual practices through costs-benefit assessments, giving a SPT angle to gamified solutions. Whilst ISM appears to be relatively silent on matters of class as delineated by access to capital resources, these material considerations are implicit in certain factors within the material context, for example, access to technologies, infrastructure and objects.

Infrastructure solutions

The researcher considered changes to the infrastructure of campus housing and asked for opinions on the fitting of percussion taps. The general view was that this would be seen as a reduced service level and was not welcomed by students or facilities staff concerned with impact on student satisfaction ratings. This highlights a transition in the provision of university accommodation in response to the commodification or marketisation of higher education and changing expectations within the last generation. In the past, university halls were built to a basic utilitarian or functional standard, clean but simple, with shared facilities (perhaps on similar lines to prisons, military bases or other state communal establishments), whilst modern facilities are now expected to be of a higher standard for which higher rental fees can be charged (more like hotels). Percussion taps were seen as being incompatible with the contemporary university experience built on higher standard of living expectations.

However, in the light of the Student Village consumption being significantly higher than WCP1 (see section 4.1), the university was advised to adopt shared showering facilities for any future new accommodation builds, as the presence of en suite facilities appeared to encourage greater water (and by association, energy) consumption.

Data processing

The research also suggests further improvements could be made to telemetry and real-time monitoring of consumption. Whilst the university has a Building Management System with AMR technology, it does not make best use of the large amount of data being collected, due to constraints on staff time and expertise. It would be beneficial to set up automatic leak or high-use alarms so that consumption through individual sub-meters can be monitored and responded for tactical water demand management.

Despite usually being deployed in domestic households, the Silotte loggers worked well in the higher occupancy student houses. However, the segmentation algorithms used for the data processing and event allocation struggled in the original Wave 1 experimental design, as it was difficult to accurately identify separate events and fixture types in the multi-bathroom/fixture setting, as they measured *all* water use through the household sub-meter, and parallel shower events across the four shower rooms in each house had to processed manually. With more data, there is an opportunity to refine the segmentation algorithms to improve assessment in larger communal establishments. However, the compromise solution for Wave 2, with each logger deployed at fixture level, overcame this particular limitation (albeit, an over-engineered solution in terms of sub-metering at the fixture level, and compromised volumetric assessment in order to capture shower duration.

Longitudinal studies

A longer enquiry, not conducive to the time-limited frame of a PhD project, could investigate the water consuming practices of a cohort of students through their university years, through different types of accommodation and into their early post-university careers through a longitudinal study. This is something that Bristol Water is interested in pursuing. Longitudinal or repeated studies would allow for confirmation of patterns and whether the findings are scalable or restricted to the specific university context in which they were generated and would help resolve recruitment and sample population biases, happenstance events (such as the no water event that prematurely terminated the Wave 1 data collection), or the limited end-user data for the control groups that rendered comparisons asymmetric.

Social changes arising from COVID-19 pandemic

The pandemic was a major disrupter event. Ways of working have shifted with many employment contracts rewritten to allow for more flexible modes or hybrid models and an increase in homeworking as a standard practice. More time at home has led to a relocation of water demand (up by 17% in 2021, Menneer *et al.,* 2021). This has been accompanied by a casualisation of work wear. This may present an opportunity for promoting reduced showering and laundry frequencies, if workers are not meeting with colleagues or customers, perhaps the *daily* shower could be targeted to shift the social norm? Most contemporary water efficiency programmes simply accept that the *daily* shower is the norm, and instead focus on shaving off minutes from the duration via shower timers or reducing the volume with low-flow shower heads, rather than targeting the third dimension of the volume-duration-frequency equation.

7.4.3 Limitations

The researcher recognises that the research design contains some weaknesses, and that the findings presented have not fully utilised the vast quantity of data that was collected. In particular, analysis of the eight focus group transcripts was summarised here, but there is a wealth of rich insights still to be gleaned from a deeper thematic analysis of the discussions. There is no reason to believe that this compromises the research findings presented or the original contributions to knowledge made, but the transcripts do warrant further and fuller investigation.

Of course, this research has been limited by the researcher's own agency – the personal (skills, time) and external (financial, access to study site) resources available, within the constraints of a time-limited PhD study. However, a wide range of data have been collected, analysed, and evaluated, and theoretical, methodological, and empirical contributions to the knowledgebase have been made, in terms of how to design and evaluate practical water-saving interventions, the tools needed to assess water consumption and the understanding of student showering routines. Given the limitations of water consumption research to date, new approaches such as that reported here are critical to taking water demand management thinking and practice forwards.

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TOWARDS A SOCIO-MATERIAL APPROACH TO REDUCING THE WATER DEMAND OF CLEANLINESS

Appendices

Author - celebrating International Women's Day, 2021 (Source: C. Jones)[1]

[1] Published: Powell, 2021; Thomas, 2021

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Contents

Appendix A Methodology

A.1 Layout of Wallscourt Park phase 1 study houses

Plans of the layout of the WCP1 study houses, showing the location of the shower rooms (and service cupboards) on the first and second floors are shown in Figure A-1 to Figure A-4.

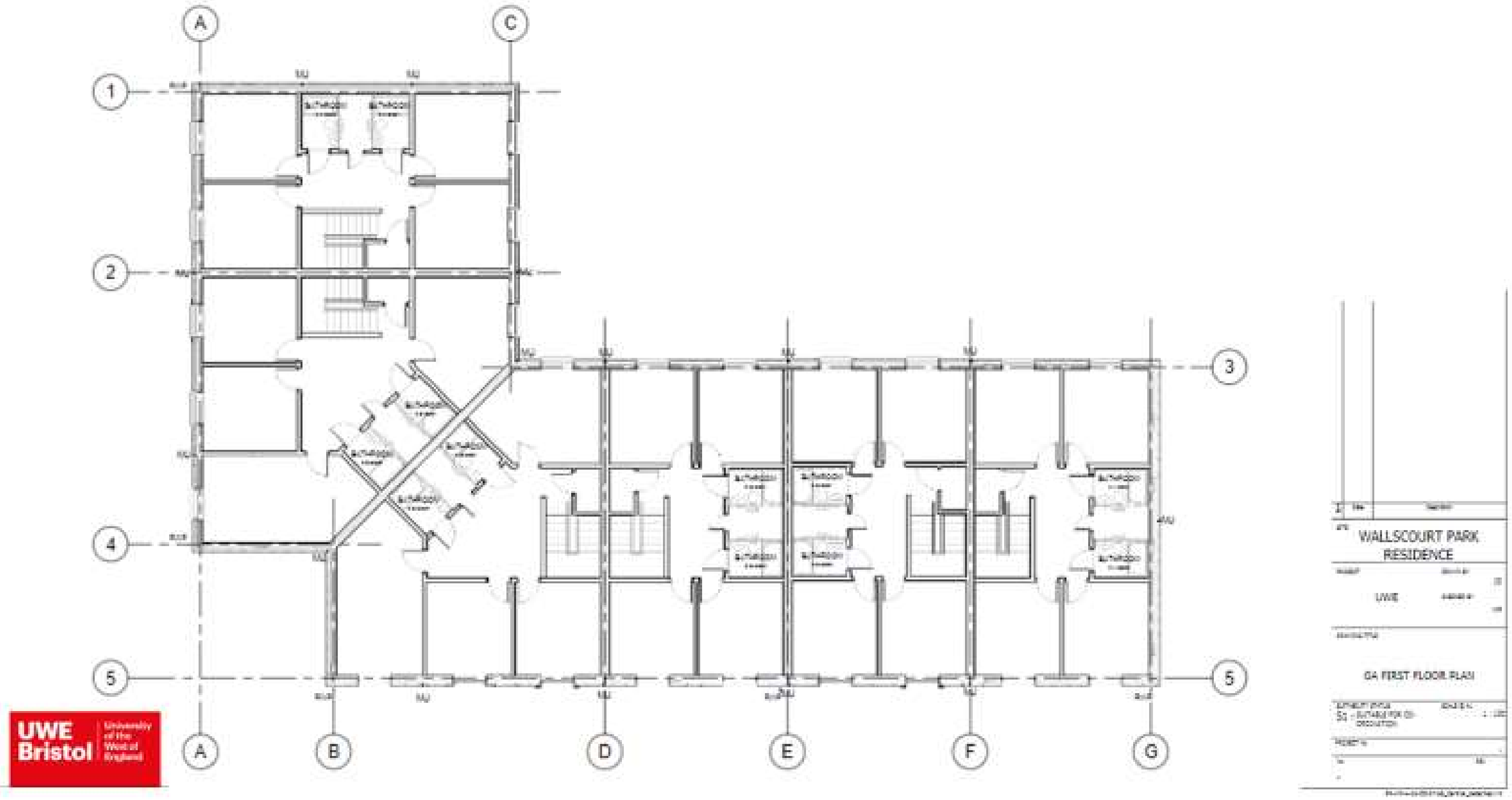


Figure A-1 Plan of layout for houses A to F, first floor bedrooms and shower rooms (source: UWE)

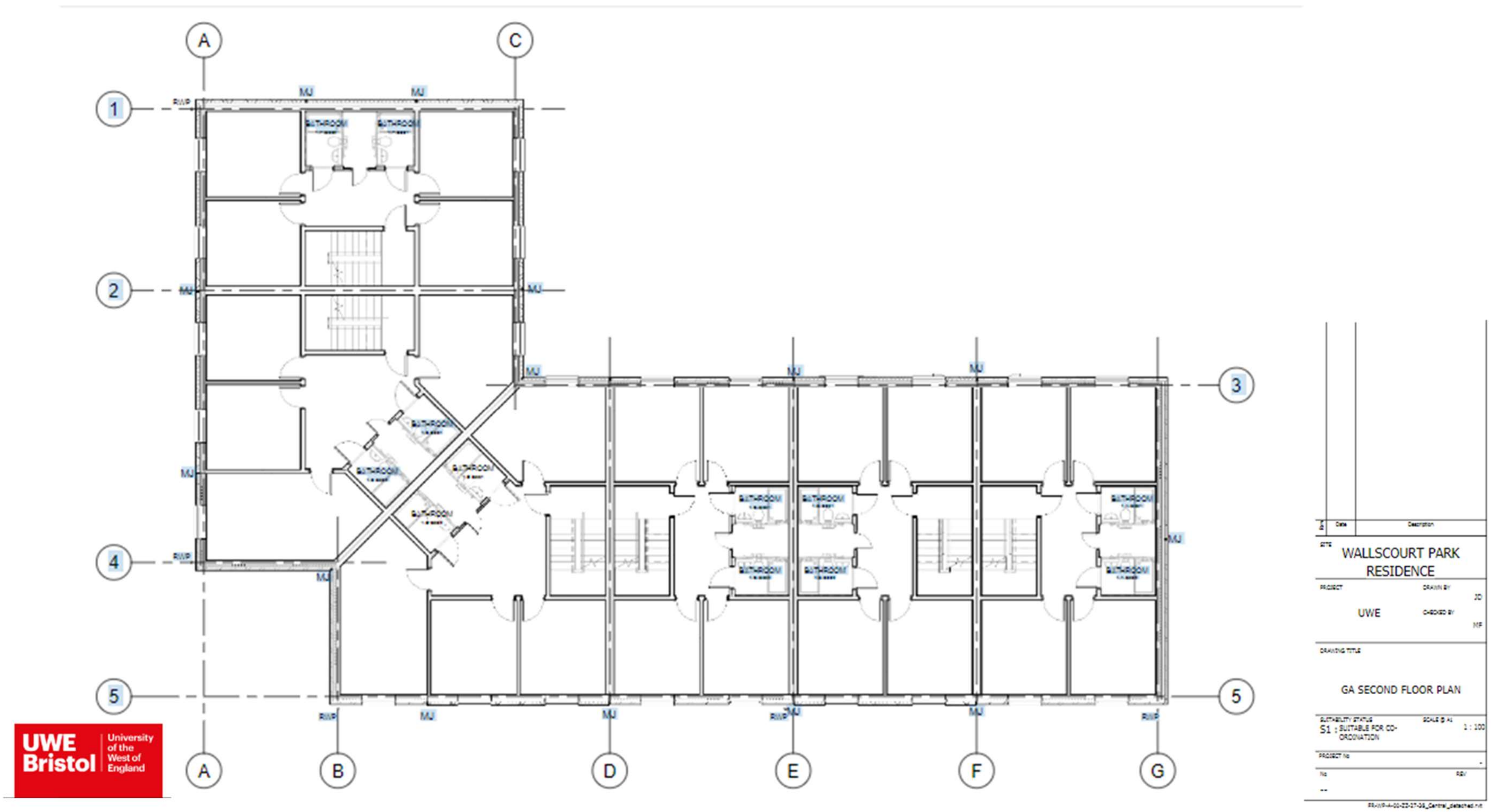


Figure A-2 Plan of layout for houses A to F, second floor bedrooms and shower rooms (source: UWE)

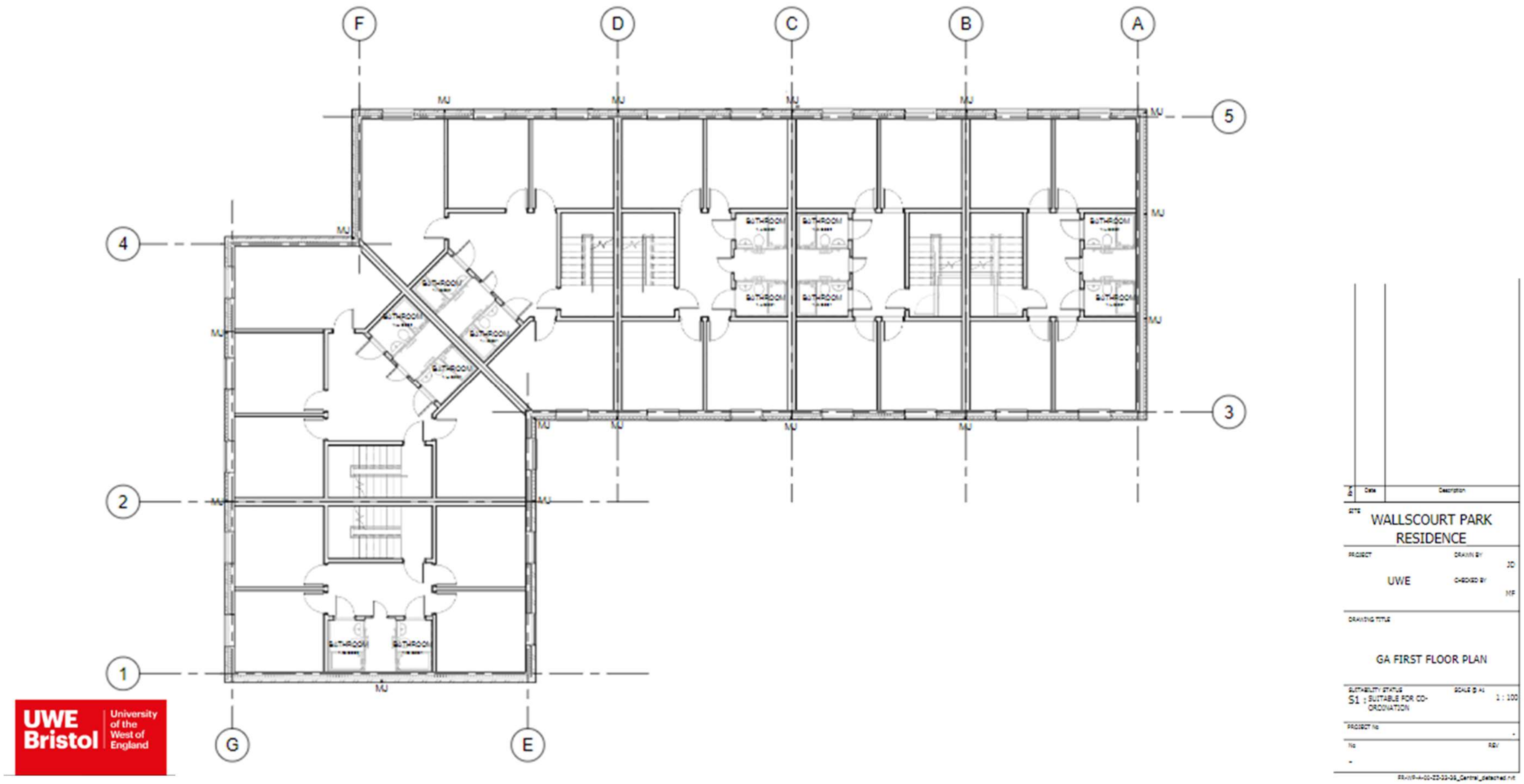


Figure A-3 Plan of layout for houses G to L, first floor bedrooms and shower rooms (source: UWE)

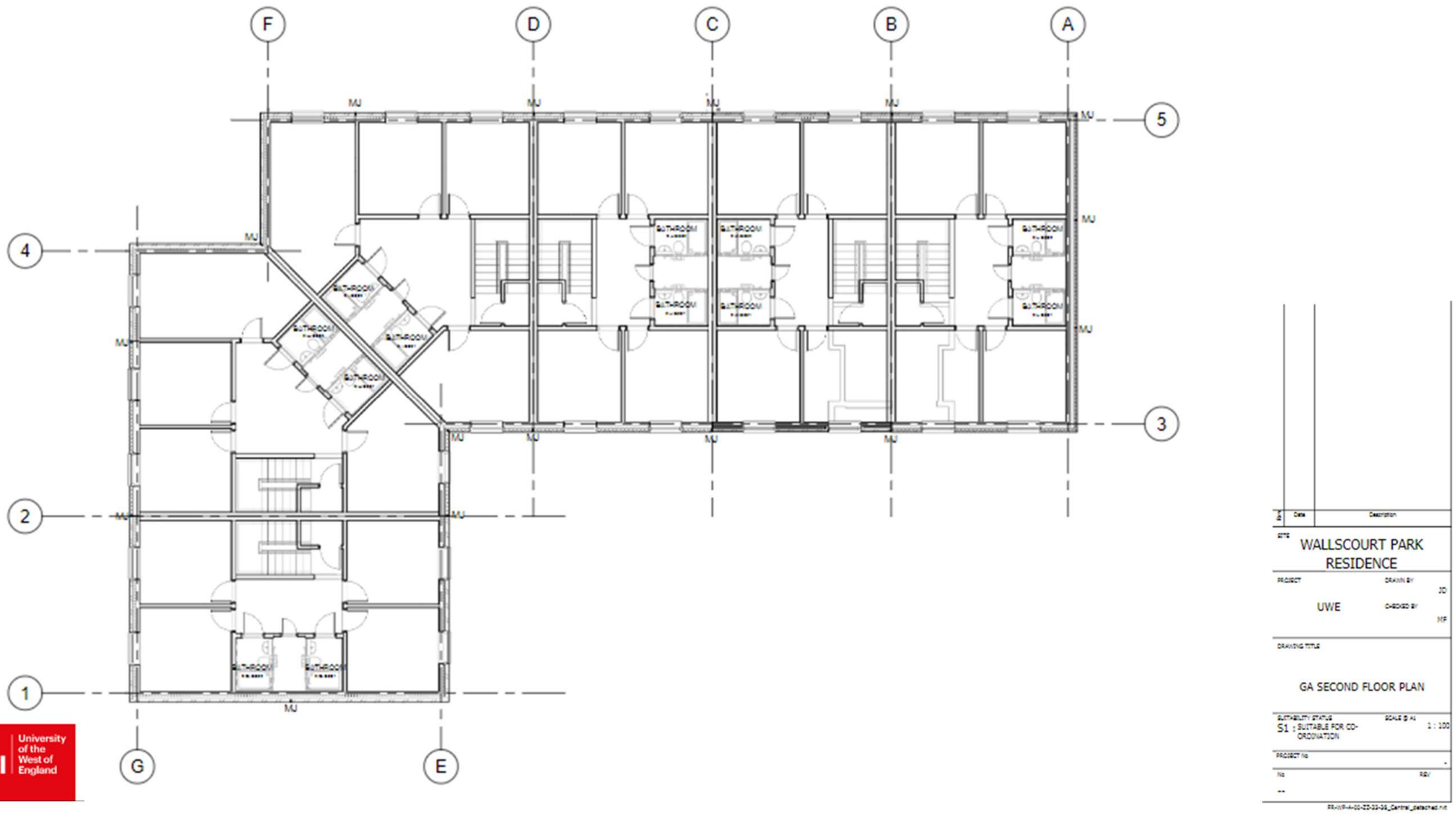


Figure A-4 Plan of layout for houses G to L, second floor bedrooms and shower rooms (source: UWE)

A.2 Water fixtures audit

A.2.1 Experimental WC leak detection

As a precursor to the WCP1 audit, the fixtures in the Student Village were also checked for leaking WCs using a novel dye tracing technique. Three different approaches to detecting leaking WCs were tested.

1. Paper strips: placing strips of blue paper cleaning towels onto the back of unflushed WC bowls to check for the presence of moisture.
2. Dye-tracing:
    a. Food colouring (blue or green) dropped into WC cisterns and return 30 minutes later to check for the presence of discoloured water in the WC bowl.
    b. Blue or green cistern cleansing blocks dropped into WC cisterns (suspended in old tights/stockings so they could be retrieved after testing) and return 30 minutes later to check for the presence of discoloured water in the WC bowl.
3. Look and listen for leaks in the WC bowl – look for trickles down the side of the bowl, rippling of water in the bowl, or the sound of dripping or running water.

As the audit progressed the method was modified to maximise efficiency. Unfortunately, the dye tracing did not find any leaks despite there being obviously signs of water trickling or running into the bowl, either continually or intermittently, often due to the button getting stuck. Whilst the dye dispersed into the cistern and came through in the first flush after introduction to the cistern, it became apparent that the leaky water was coming from the inlet filling the cistern and not directly from the cistern tank. The dye tracing was abandoned for the WCP1 audit.

Of 212 WCs audited, leaks were identified in 10% of WCs but only 3% (a single WC) in the newer WCP1 development. However, the Student Village results may be skewed due to actively looking for leaks systematically through the floors as running water could be heard in the soil pipe running down through the service cupboards in the unoccupied blocks of flats (especially block B4). A further 18% of Student Village WCs showed signs of low-level leaks with rippling in the bowl or damp blue tissue, and a high number (65%) of WCs had sticky flush buttons or weak flushes. The results of the audit were passed to the university Facilities department and were used as evidence to justify the full WC cistern replacement programme that was implemented in the autumn of 2017.

The steps adopted on each day of the audit are summarised in Table A-1.

Table A-1 Audit method

Day 1 – B2, B4, B6	**Day 2 – C5, M4, Q2**	**Day 3 – WCP1 X, Y, Z, B, G**
In each en suite/service cupboard: 1.Put strip of blue paper towel on back of WC bowl to check for moisture 2.Look/listen for water trickling/rippling in the WC bowl 3.Check presence of tap insert (and type) 4.Record type of showerhead 5.Check position of hot and cold inlet valves and turn fully ON if found in half position 6.Visual check for leaks, evidence of historical leaks, condition of inlet valves and cistern valves, absence of cistern lids 7.Listen for leaks – either continually flowing cisterns in the service cupboard or water running down the soil pipes from floors above (indicative of continuous wastage) 8.Drop food colouring/cistern block into each cistern. Return to flat 30 mins later* 9.Visual check for colouration of WC bowl water. Retrieve cistern block* 10.Flush WC using low flush option – note quality of flush (weak, moderate, strong) 11.Once cistern refilled, repeat flush with full-flush option and note quality 12.Note any other maintenance issues to report to Facilities (* due to time constraints, after completing audits on the first four floors of B6 (48 en suites) these steps were abandoned)	In each en suite/service cupboard: 1.Put strip of blue paper towel on back of WC bowl to check for moisture 2.Look/listen for water trickling/rippling in the WC bowl 3.Record type of showerhead 4.Check position of hot and cold inlet valves and turn fully ON if found in half position 5.Visual check for leaks, evidence of historical leaks, condition of inlet valves and cistern valves, absence of cistern lids 6.Listen for leaks – either continually flowing cisterns in the service cupboard or water running down the soil pipes from floors above (indicative of continuous wastage) 7.Flush WC using low flush option – note quality of flush (weak, moderate, strong) 8.Once cistern refilled, repeat flush with full-flush option and note quality Due to slow progress, after completing audits on the first three floors in M4 the method was modified, to maximise the number of leaking WCs (constant flushing) identified, for the remainder of M4, Q2 and C5, as follows: 1.Open service cupboard and listen for leaks – either continually flowing cisterns in the service cupboard or water running down the soil pipes from floors above (indicative of continuous wastage) 2.Identify which WCs were	In each townhouse: 1.Ground floor kitchens – check for leaks, measure flow where possible WC (ground floor) and shared shower rooms (first, second and third floors): 2.Put strip of blue paper towel on back of WC bowl to check for moisture 3.Look/listen for water trickling/rippling in the WC bowl 4.Check presence of tap insert 5.Record type of showerhead 6.Check for tap inserts 7.Measure tap flow rates (hot and cold) 8.Measure shower flowrates (with/without showerheads) 9.Flush WC using low flush option – note quality of flush (weak, moderate, strong). This was undertaken by timing the duration of the flush as a proxy for flow rate 10.Once cistern refilled, repeat flush with full-flush option and note quality

	flushing 3.Stop flushing, if possible, by jiggling the flush button	

A.2.2 Day 1 – Student Village B2, B4 and B6

The auditors (Student Ambassadors, supervised by the researcher) checked most en suite shower rooms in B4 and B6, including the first floor disabled WC and second floor cleaner cupboard in each block. All 84 en suites in B6, and 72 of 84 en suites in B4 were surveyed (time ran out to audit the top floor rooms in B4). It was not possible to audit B2 in the time available.

The dye-tracing methods were not successful in identifying leaks. This may be due to the water not being mixed within the cistern. The dye from the cistern blocks would have been concentrated at the bottom of the cistern, whilst any leaks from the cistern to the bowl may have been from the top where the water was still clear or directly from the inlet. A modification to the method would have been to stir the water in the cistern to distribute the dye. The cistern block method was trialled in the lower floor en suites in Brecon 6 (flats 1 to 8, 48 en suites in total). This method was slow and messy and failed to identify any leaky WCs (no colour present in the WC bowl 30 minutes later), so it was abandoned.

Food colouring was only trialled in the B6 disabled WC only (landing between flats 3 and 4), but the half teaspoon measure (2.5 ml) was insufficient to properly colour the water in the cistern (witnessed on flushing). It became clear that the cistern blocks were more successful in colouring the water (if not at detecting leaks).

The damp blue paper towel and looking/listening for leaks proved more successful and were employed through the rest of the audit, despite being a subjective qualitative test and only indicative of *potential* low-level leaks. The results of the audit are summarised in Table A-2.

Table A-2 Student Village fixtures audit – Day 1

08-Aug-2017	**B2**	**B4**	**B6**
No. en suites (+1 disabled cloakroom) in block	73	85	85
No. en suites (+1 disabled cloakroom) audited	0	73 [85.9%]	85 [100%]
No. constantly flowing WCs		8 [11.0%]	2 [2.4%]
No. possible (low-level) leaking WCs (damp blue paper or visual check)		29 [39.7%]	6 [7.1%]
No. tap inserts		71 [97.3%]	75 [88.2%]

Eight continually flushing WCs were identified in B4 and two were identified in B6. In most cases, the flush button was stuck, resulting in the valve being left open. Most could be fixed by manually jiggling the button – but were indicative of an inherent problem with continually or intermittently leaking WCs between flushes. It was surprising to find the large number in B4 as maintenance staff had recently been retrofitting new WC valves, following the agreement from the UWE sustainability board to implement a programme of water saving retrofits.

In addition to the continually flushing WCs, a 29 WCs B4 and six in B6 showed signs of low-level wastage (damp blue paper towel or visual identification of ripples/trickles). The high number for B4 may not be accurate and could be reflective of recent maintenance work and the WCs may not have been operated for recently. The blue paper test is also subjective and qualitative. Following the audits, maintenance staff revisited B4 to rectify the issues identified and altered their approach for retrofits going forward, despite requiring additional work by the fitters.

A.2.3 Day 2 – Student Village C5, M4 and Q2

The results of the audit are summarised in Table A-3. Ten constantly flushing WCs were identified across the three blocks, representing about 4% of WCs. This aligns with the findings of Thames Water's research (up to 5% including low-level leaks). If 4% of all WCs in the Student Village were constantly leaking, then there were potentially 77 units wasting water 24/7, and using Thames Water's findings that each fix saves 215 litres per day, this is equivalent to 16,555 litres per day wastage (8.6 l/b/d), or 6,043 m^3 per year (at a cost of £11k pa in water and wastewater charges). In addition to the obviously leaking WCs, the audit indicated that a further 15% of the WCs across the development *may* be subject to low-level wastage.

Table A-3 Student Village fixtures audit – Day 2

09-Aug-2017	**C5**	**M4**	**Q2**
No. en suites (+1 disabled cloakroom) in block	85	85	85
No. en suites (+1 disabled cloakroom) audited	3 [3.5%]	4 [4.7%]	46 [54.1%]
No. constantly flowing WCs	3 [3.5%]	3 [3.5%]	4 [4.7%]
No. possible (low-level) leaking WCs (damp blue paper or visual check)		1	7 [15.2% of audited]

A.2.4 Day 3 – Wallscourt Park phase 1

This was the first time the researcher visited WCP1. Unlike the Student Village in which some flats were found to be occupied at the time of the audits, no occupants were present in WCP1. A sample of five townhouses were audited, representing almost 13% of the 404-bed development. Half of the kitchen taps were dripping or leaking, and the high water-pressure on the ground floor meant it was impossible to properly measure the tap flow rates without spraying water around the kitchen and suggests an opportunity for water saving devices to be fitted (for example, inline flow regulators under the kitchen sinks).

Most showers were fitted with *Ideal Standard* branded showerheads, whereas the majority of the Student Village was fitted with *Perfecta* and *Methven* showerheads. Three single occurrences of other showerhead types were recorded. The showerheads were water efficient (7.7 litres per minute, on average) and reduce the flow rate by about 16% or 1.5 litres per minute. However, one shower in house X had an unexpectedly high flow rate both with and without the showerhead (14.4 and 21 litres per minute, respectively). The results of the WC audit are summarised in Table A-4 (see Table 3-1 for the tap and shower audit findings).

Table A-4 WCP1 fixtures audit – WCs

House	Leaking WC	Damp paper	Faulty flush
X[1]		ground floor cloakroom	1st floor – hold for low flush, 2nd floor – hold for low flush, 3rd floor – no low flush/faulty button
Y[1]	3rd floor – dribble	1st and 3rd floor	2nd floor – no full flush/faulty button
Z[1]	2nd floor – leaking/constant flow	ground floor cloakroom and both 1st floor WCs	
B		1st floor	2nd floor – no low flush
G[2]			

[1] Houses X, Y and Z were within the 404-bed Wallscourt Park phase 1 (2014) development, but were larger 12-bed, 4 story townhouses and not part of the intensive field investigations presented for this research
[2] Houses X, Y , Z have 12 single occupancy study bedrooms across four floors, houses B and G have 8 single occupancy study bedrooms across three floors

Of 31 audited WCs, one (in house Z) was found to be continually flushing and another (house Y) was dribbling, representing 6.5% of audited WCs). The WCs in WCP1 were of a different design to those in the Student Village, with pneumatic flush buttons. The auditors were unable to rectify the leaks. A further seven WCs (22.6%) showed possible signs of low-level leaks (damp blue paper). However, the test was subjective, and whilst it was assumed that the WCs had not been flushed for a while, the paper may have become damp due to condensation within the WC bowl.

The quality of the half and full flushes was also checked. Very little discernible difference was detected in the two flush modes. The auditors had no access to the service cupboards, so a measure of the volume of the flush could not be made. Instead, the auditors recorded the length of the flush in seconds as a proxy for the flow. Surprisingly, the results indicated that for houses X and Y, the flushes were generally slightly longer for the low flush option. Twelve out of 28 WCs had a longer duration low flush than the full flush, with another three WCs where only one of the two flush buttons was functional.

A.3 Participant information and consent forms

Ethical approval required participant information and consent forms to be completed by all participants to demonstrate that informed consent was obtained. Paper information sheets and duplicate consent forms (one for researcher and one for participant retention) were issued to the shower diary and focus group participants. These are shown in Figure A-5 to Figure A-10.

For the questionnaires, participants were routed via an online information sheet and consent form using similar wording to the shower diary and focus group documents, embedded within the Bristol Online Survey platform. Only those participants that were able to give full consent via the screening form were guided to complete the rest of the survey.

Participant information sheet
Shower diary
Date:

UWE Bristol | University of the West of England

International Water Security Network

Water consumption, conservation and showering routines of young adults

This research project is being conducted by Karen Simpson, a PhD student from the University of the West of England (UWE) and the International Water Security Network. It is funded by Lloyd's Register Foundation, a charitable foundation helping to protect life and property by supporting engineering-related education, public engagement and the application of research.
Karen.simpson@uwe.ac.uk Tel: +44 (0)7734 717048

Thank you for volunteering to take part in this research project. Before you decide to participate it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. You can keep this participant information and consent sheet. If, after reading this sheet, you decide to take part in the research project, you will be asked to give your consent by signing two copies of this document to confirm your agreement (one copy for you to keep and one for the researcher's records).

What is the research about and what will it do?

The purpose of this research study is to explore attitudes and understandings about water consumption and conservation, and the showering routines and habits of young adults. One element is to collect data on the time of day, flow rate, frequency and duration of shower use, and to record the range of in-shower products used by a small sample of the on-campus resident UWE student population. The results from this shower diary study will inform the design of a set of water-saving interventions. The shower diary will be recorded over a period of two months.

The diary and logger data will be used to inform the development of a set of water-saving interventions for future testing in the UWE Frenchay campus student accommodation in the next academic year. The ideas you have and comments you make in your diary may be quoted, using a fictional name or pseudonym in the final PhD report and other associated documents including academic journal papers.

Why have you been chosen?

You recently completed a survey and volunteered to be involved in some follow-on research. From the survey volunteers, a small cross-sectional group of participants have been chosen for the shower diary study.

Do you have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will have no impact on the standard of care you will

Figure A-5 Shower diary participant information sheet, page 1 of 2 receive. If you withdraw your consent, any information you have provided will be deleted from the reports.

What will happen to me if I take part and what do I have to do?

Your participation in the shower diary study will be confidential and the outputs from the shower diary study will be reported anonymously. Your comments will be quoted under a pseudonym and any images used will not show you. Your personal data will be stored securely on the UWE network and/or a locked cabinet in the researcher's office (paper forms). Data Protection Act requirements will be followed to ensure that your personal information is safeguarded.

A shower logger will be shown to you alongside an information sheet about the logger. With your consent the logger will be installed on the water supply hose of your shower to record duration and frequency of the shower's operation. Alongside the logging of shower use, the participant is asked to keep a shower diary, recording the date, time, duration and products used. A paper template will be provided. If you prefer, you may keep an audio or video diary ('vlog') and include your thoughts around showering. N.B. If you choose to keep a vlog, please do not include any recordings of in-shower footage or naked bodies.

After one month, the researcher will re-visit you to reset the logger. Half of the study participants will be provided with a water-saving intervention. This maybe a one-to-one awareness raising discussion about saving water, or a physical measure such as a new showerhead, shower timer or in -shower display. At the end of the two months, the researcher will collect the diaries and remove the loggers.

What are the possible benefits of taking part?

You will be rewarded for your commitment with a complimentary £20 "Just Eat" voucher at the end of the two month study period. Your input will help to design future water-saving measure(s) and you will be part of an original research project.

What if something goes wrong?

If you wish to make a complaint about the way the focus group has been conducted, please contact the PhD student's Director of Studies, Dr Chad Staddon at Chad.staddon@uwe.ac.uk +44(0)117 32 83214 in the first instance.

What will happen to the results of the research study?

The shower diary and logger data will contribute to the design of water-saving interventions to be piloted in the UWE Frenchay campus student accommodation in Autumn 2017. These measures will be evaluated and be included in the researcher's PhD thesis, due to be submitted in late 2018. The researcher will also disseminate the research findings via the publication of journal papers. The anonymity of all research participants will be maintained in all future reports and publications.

At the end of the project, and with participant consent, the anonymised digital data set may be archived with the UK Data Archive, and made available to other authenticated researchers to maximise its research potential.

Figure A-6 Shower diary participant information sheet, page 2 of 2

Participant consent form
Shower diary
Date:

Taking part

I have read and understood the participant information sheet dated ………… **Yes No**

I have been given the opportunity to ask questions about the project **Yes No**

I agree to take part in the project. Taking part in the project will include participating in a focus group and be recorded (audio or video) **Yes No**

I understand that my taking part is voluntary. I can withdraw from the study at any time and I do not have to give any reasons for why I no longer want to take part **Yes No**

Use of the information I provide for this project only

I understand my personal details such as phone number and address will not be revealed to people outside the project **Yes No**

I understand that my words may be quoted in publications, reports, web pages and other research outputs **Yes No**

I understand that my name will not be used in the above **Yes No**

Use of the information I provide beyond this project

I agree for the data I provide to be archived at the UK Data Archive **Yes No**

I understand that other authenticated researchers will have access to this data only if they agree to preserve the confidentiality of the information as requested in this form **Yes No**

I understand that other authenticated researchers may use my words in publications, reports, web pages, and other research outputs, only if they agree to preserve the confidentiality of the information as requested in this form **Yes No**

So we can use the information you provide legally

I agree to assign the copyright I hold in any materials related to this project to the researcher named below **Yes No**

Name of participant: ……………………………. Signature: ……………………………. Date: …………………………..

Name of researcher: ……………………………. Signature: ……………………………. Date: …………………………..

Figure A-7 Shower diary consent form

Participant information sheet
Focus Group
Date:

UWE Bristol University of the West of England

International Water Security Network

Water consumption, conservation and showering routines of young adults

This research project is being conducted by Karen Simpson, a PhD student from the University of the West of England (UWE) and the International Water Security Network. It is funded by Lloyd's Register Foundation, a charitable foundation helping to protect life and property by supporting engineering-related education, public engagement and the application of research.
Karen.simpson@uwe.ac.uk Tel: +44 (0)7734 717048

Thank you for volunteering to take part in this research project. Before you decide to participate it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. You can keep this participant information and consent sheet. If, after reading this sheet, you decide to take part in the research project, you will be asked to give your consent by signing two copies of this document to confirm your agreement (one copy for you to keep and one for the researcher's records).

What is the research about and what will it do?

The purpose of this study is to explore attitudes and understandings about water consumption and conservation, and the showering routines and habits of young adults. The aim of the focus group is to gather opinions on from a representative cross-section of the on-campus resident UWE student population and to use these insights to co-design a set of water-saving interventions. The focus group will take approximately 1.5 hours.

The discussion will be recorded and transcribed, and a set of water-saving interventions will be developed for future testing in the UWE Frenchay campus student accommodation in the next academic year. The ideas you have and comments you make may be quoted, using a fictional name or pseudonym in the final PhD report and other associated documents including academic journal papers.

Why have you been chosen?

You recently completed a survey and volunteered to be involved in some follow-on research. From the survey volunteers, a small cross-sectional group of participants have been chosen for this focus group.

Do you have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will have no impact on the standard of care you will

Figure A-8 Focus group participant information sheet, page 1 of 2 receive. As the data will be transcribed anonymously to protect your confidentiality, it is not possible to withdraw your contribution after the focus group is complete.

What will happen to me if I take part and what do I have to do?

Your participation in the focus group will be confidential, and ground rules about anonymity and confidentiality will be agreed with all participants at the start. The outputs from the focus group will be reported anonymously. Your comments will be quoted under a pseudonym and any images used will not show you. Your personal data will be stored securely on the UWE network and/or a locked cabinet in the researcher's office (paper forms). Data Protection Act requirements will be followed to ensure that your personal information is safeguarded.

The focus group facilitator will introduce some themes or topics of conversation and guide the discussion around these themes. The facilitator will chair the discussion, giving equal opportunity for all participants to contribute their ideas and opinions, and ensure that there is mutual respect between participants, even if opinions are divided.

What are the possible benefits of taking part?

You will meet some other students who may share or oppose your views. You will be part of a stimulating debate, be a co-creator of water-saving measure(s) and be part of an original research project.

What if something goes wrong?

If you wish to make a complaint about the way the focus group has been conducted, please contact the PhD student's Director of Studies, Dr Chad Staddon at Chad.staddon@uwe.ac.uk +44(0)117 32 83214 in the first instance.

What will happen to the results of the research study?

The focus group outputs will contribute to the design of water-saving interventions to be piloted in the UWE Frenchay campus student accommodation in Autumn 2017. These measures will be evaluated and be included in the researcher's PhD thesis, due to be submitted in late 2018. The researcher will also disseminate the research findings via the publication of journal papers. The anonymity of all research participants will be maintained in all future reports and publications.

At the end of the project, and with participant consent, the anonymised digital data set may be archived with the UK Data Archive, and made available to other authenticated researchers to maximise its research potential.

Figure A-9 Focus group participant information sheet, page 2 of 2

Participant consent form
Focus Group
Date:

Taking part

I have read and understood the participant information sheet dated ………… **Yes No**

I have been given the opportunity to ask questions about the project **Yes No**

I agree to take part in the project. Taking part in the project will include participating in a focus group and be recorded (audio or video) **Yes No**

I understand that my taking part is voluntary. I can withdraw from the study at any time and I do not have to give any reasons for why I no longer want to take part **Yes No**

Use of the information I provide for this project only

I understand my personal details such as phone number and address will not be revealed to people outside the project **Yes No**

I understand that my words may be quoted in publications, reports, web pages and other research outputs **Yes No**

I understand that my name will not be used in the above **Yes No**

Use of the information I provide beyond this project

I agree for the data I provide to be archived at the UK Data Archive **Yes No**

I understand that other authenticated researchers will have access to this data only if they agree to preserve the confidentiality of the information as requested in this form **Yes No**

I understand that other authenticated researchers may use my words in publications, reports, web pages, and other research outputs, only if they agree to preserve the confidentiality of the information as requested in this form **Yes No**

So we can use the information you provide legally

I agree to assign the copyright I hold in any materials related to this project to the researcher named below **Yes No**

Name of participant: …………………………… Signature: …………………………… Date: …………………………..

Name of researcher: …………………………… Signature: …………………………… Date: …………………………..

Figure A-10 Focus group consent form

A.4 Interventions

A.4.1 Wave 1 posters

Images of the posters that were displayed in house C and house D as part of the Wave 1 field trial are shown in Figure A.11 to Figure A-14.

Figure A-11 Poster displayed on back of shower room doors in house C, Wave 1 (A4 size)

Figure A-12 Poster displayed on back of shower room doors in house D, Wave 1 (A4 size)

Figure A-13 Poster displayed on back of downstairs cloakroom door in houses C and D, Wave 1 (A4 size)

Figure A-14   Poster displayed on noticeboard in communal dining area of houses C and D, Wave 1(A3 size)

A.4.2 Wave 2 products and advice booklet

All participants were provided with a list of ingredients and user directions for the hair care products that they were supplied with for the Wave 2 trial, to guard against potential allergic reactions and a risk assessment was prepared to manage this risk. The product ingredients and direction for use are listed in Table A-5.

To supplement the alternative hair care products and to support participants in the '*go gold'* challenge, to try the dry shampoo and reduce the frequency of showering, participants were provided with hair elastics and advice for between shampoo hair styles and transitioning to a low 'poo' lifestyle, gathered by the researcher from the internet. The contents are shown below.

Table A-5 Product ingredients and use directions

Product	Ingredients	Directions for use
Solid shampoo bars		
Avocado *(co-wash)*	Sodium Cocoyl Isethionate, Stearic Acid, Rosemary; Lavender Flower and Nettle Infusion, Fresh Avocado, Glyceryl Stearate & PEG-100 Stearate, Cocamidopropyl Betaine, Propylene Glycol, Water (Aqua), Ethyl Macadamiate, Perfume, Behentrimonium chloride, Bergamot Oil, Litsea Cubeba Oil, Olibanum Oil, Organic Avocado Oil, Cupuaçu Butter, Fair Trade Organic Cocoa Butter, Extra Virgin Olive Oil, Citric Acid, Gardenia Extract, Cetrimonium Chloride, Amyl Cinnamal, *Benzyl Cinnamate, *Cinnamal, *Cinnamyl Alcohol, *Citral, *Limonene, *Linalool, Chlorophyllin, Colour 19140:1, Colour 42090:2, Colour 19140.	Wet your co-wash and work into hands to create a hydrating lather, then apply to wet hair. Co-wash twice or more to thoroughly cleanse hair and scalp, then rinse thoroughly. **How to store:** Let me drain after use and store in a cool, dry place.
Black pepper and vanilla *('Monsters and Aliens' multipurpose 'Fun' putty)*	Cornstarch, Talc, Glycerine, Sodium Laureth Sulfate, Black Pepper Oil, Patchouli Oil, Vanilla Absolute, Gardenia Extract, *Limonene, Perfume, Colour 17200, Colour 42090.	Soap it, shape it, shampoo it. This spicy black pepper and comforting Fair Trade vanilla absolute scented cleansing dough brings fun to wash time. **How to store:** Keep somewhere cool and dry until ready for some good clean fun.
Coconut ('*Trichomania'*)	Sodium Lauryl Sulfate Stearic Acid Creamed Coconut (Cocos nucifera) Glyceryl Stearate & PEG-100 Stearate Dessicated Coconut (Cocos Nucifera) Lauryl Betaine Soya Lecithin Fragrance Vetivert Oil (Vetiveria Zizanoides).	Rub between hands to create a lather, or directly onto hair. Massage into the hair and scalp then rinse clean.
Jasmin *('Godiva')*	Sodium Lauryl Sulfate, Fair Trade Organic Cocoa Butter, Cetearyl Alcohol, Glyceryl Stearate, PEG-100 Stearate, Propylene Glycol, Perfume, Hibiscus Extract, Stearic Acid, Cetearyl Alcohol, Camellia Oil, Organic Jojoba Oil, Macadamia Nut Oil, Extra Virgin Coconut Oil, Cupuacu Butter, Jasmine Absolute, Ylang Oil, Cypress Oil, Palmarosa Oil, Jasmine Flowers, Cetrimonium	Wet both your hair and the bar before sliding the bar three times down the right, middle, and left of your head. Follow up with your favorite LUSH conditioner.

	Bromide, Gardenia Extract, Benzyl Alcohol, *Geraniol, *Limonene, *Linalool.	
Seaweed, sea salt and lemon *('Seanik')*	Sodium Lauryl Sulfate, Irish Moss Gel, Perfume, Nori Seaweed, Fine Sea Salt, Sicilian Lemon Oil, Mimosa Absolute, Orange Flower Absolute, Jasmine Absolute, Sodium Cocoamphoacetate, Hydroxycitronellal, *Limonene, Colour 42090.	Embrace the ocean with this volumising sea salt and lemon shampoo bar. Lather into wet hair and rinse for shinier locks. **How to store:** Leave on the side in a cool dry place, ready for you need it. Between 60 - 80 washes each.
Lavender and geranium *(Friendly Soap from SU shop)*	Coconut oil, vitamin E rich castor oil, olive oil, lavender & geranium essential oils: Sodium cocoate, Sodium olivate, Sodium castorate, Aqua, Lavendula angustifolia (lavender) essential oil contains linalool, limonene, geraniol, Petargonium graveolens (rose geranium) essential oil contains geraniol, citronella, linalool.	Just run the shampoo bar over your head in one direction, from front to back. This will help you to avoid creating any pesky knots. Once you've a good amount of shampoo on your head, massage it into your scalp using your fingers (or if you're owed a treat, ask your other half to). Now rinse your hair with water until every drop of shampoo is out. That's it – you're done. **Storage**: Keep out of direct sunlight. Store in a cool dry place and allow to dry between use.
	Dry shampoo	
Classic *('Original')*	Butane, Isobutane, Propane, Oryza sativa starch, Alcohol denat., Parfum (Fragrance), Limonene, Linalool, Geraniol, Benzyl benzoate, Distearyldimonium chloride, Cetrimonium chloride.	1. Shake the bottle. 2. Section hair, then spray in short, powerful bursts. 3. Massage into roots with fingertips or a brush. 4. Style as desired. Or not. Whatever you're feeling.
Fruity *('Tropical')*	Butane, Isobutane, Propane, Oryza sativa starch, Alcohol denat., Parfum (Fragrance), Coumarin, Distearyldimonium chloride, Cetrimonium chloride.	
**occurs naturally in essential oils*		

UWE showering research

Shower products plastic amnesty

November 2018

Karen Simpson, PhD Researcher

Go green – give up plastic bottles in the shower and use solid shampoo

Go gold – skip showers and use dry shampoo between hair washes

Contents

https://www.liveabout.com/how-to-wear-dirty-hair-3517911

How to Rock Dirty, Unwashed Hair

by Kendra Aarhus

updated July 27, 2018

1.Lessons in Not Washing Your Hair (Even if You Just Went to the Gym)

If there's one lesson we've all heard a thousand times, it's to stop daily hair washing. I have a confession to make. Even though I've been a hairstylist for several years now, I've always washed my hair daily. I hate day old hair. I hate greasy hair. I workout every day, and I want my hair to be smooth, and shiny, and squeaky clean beautiful every single day.

I also know better.

Time to get over that. If you want long, healthier, or coloured hair, daily hair washing is like taking your money and flushing it down the toilet. Not only does your colour fade, but your hair ages prematurely causing breakage and compromises the health of your hair. By simply washing your hair two to four days a week instead of daily (or multiple times a day), you can extend the life of your hair colour and improve the overall health of your hair exponentially.

Besides all that, we all need a lot more time. Styling freshly washed hair is a time-consuming process. If you workout in the morning or during lunch and have a schedule to maintain, who has time to wash, dry, and style?

I always recommend starting to experiment with not washing your hair on a day that you don't have to been seen in public, like a weekend. It takes a certain finesse to figure out what works best for your hair. You also have to get your scalp used to not getting washed and having it's natural oils stripped away. The more you wash your hair, the more sebum (oil) your hair produces to compensate for being stripped of natural oils with soap and shampoo. When you let your hair get into a more natural sebum producing cycle, you'll find going a day or two between shampoo is much easier.

Follow these valuable tips to take a day or two off between shampooing, while still having great hair that doesn't look dirty, greasy, or even flat.

2.Cool Off

You've just had a good workout and your head is a hot mess (literally), the first step in the process is to make sure that your head is cooled off. A hot head equals a sweaty head, and adding any additional sweat to your already dirty hair isn't going to do anyone any favours.

Here are a few tips for getting your head as cool as a cucumber:

Use a well-ventilated room.

Take a minute and brush all that sweat and oil through your head well. As gross as that sounds, it'll help distribute the oil through your hair and act as a conditioning agent. Seriously.

Use a hair dryer, on a warm or cool setting, and dry the sweat out of your hair. Tip your head upside down for increased volume.

If your hair has been up in a ponytail or has a good amount of bed head, spritz your hair with a water bottle or leave-in conditioner and brush through before blow drying to get the kinks out.

3.Use a Dry Shampoo

Dry shampoos are an excellent way to rid yourself of the grease, grime, and sweat of the day as well as a hard workout. You can buy dry shampoo in two different forms, a powder or in an aerosol spray. Both types work to absorb oil, but depending on your hair type you should experiment with different brands to see what works best for your hair.

How to get the most out of your dry shampoo:

Brush your cooled-off hair thoroughly, and then lifting your hair at the root, spray the dry shampoo directly onto the root of your hair.

I do not recommend spraying dry shampoo directly on your part, as it can cause your hair to look dry and ashy.

It's important to play around with your dry shampoo a few times to see how much you'll need for your particular hair type. Remember, you can always add more, if you need it, so start conservatively.

4.Massage and Wait

After applying your dry shampoo, use the tips of your fingers to massage the dry shampoo into your scalp. This step is important to evenly distribute the dry shampoo into your scalp properly.

Then wait. Don't touch your head for the next three to five minutes. This is the part of my non-hair-washing morning that I spend a few minutes on my makeup or get my next cup of coffee. Allowing the dry shampoo to sit on your scalp dries the moisture, sebum, and sweat out of your hair.

This is also where you have to come to grips with the fact that your hair probably isn't going to feel clean. It's not going to feel soft, pretty, or like anything you want to run your hands through. At least that's how I feel about the situation. That was probably the hardest thing for me to get over. I want fresh, clean, soft, and freshly washed hair. In the end, I'd rather have healthy hair. So, I'll settle.

5.Brush and Style

After letting the dry shampoo set for a few minutes, brush thoroughly and style as usual. For this style, I used a flat iron to smooth out a few pieces and some volumizing hairspray to give my hair some texture and hold. Here are a few tips for styles that work best with dirty hair:

Style your hair up whenever possible. Try a loose ponytail or braid for a look that won't let you down all day long.

Play with teasing. Dry shampoo is the perfect foundation for backcombing and teasing your hair a little at the base. This will help get your hair up off your scalp so the oil won't be as apparent.

Instead of flat ironing or blow drying, embrace your hair's natural texture.

Curls love dirty hair. Add a little curl to your dirty hair. It'll help with a more voluminous look and your curls will stay longer.

https://www.cosmopolitan.com/style-beauty/beauty/how-to/a39497/hairstyles-when-you-dont-want-to-wash-your-hair/

6 Hairstyles for When You Just Can't Wash Your Hair

You got dry shampoo and five minutes? You can do this.
By Carly Cardellino

Apr 23, 2015

Some days, you just don't want to wash your hair. Celebrity hairstylist Tommy Buckett is here to save your (bad hair) day — No matter your hair texture! — with six gorgeous, wash-not-necessary styles you can bang out with the help of your BFF: dry shampoo.

Use Buckett's go-to technique: Part your hair in 1-inch increments from your left ear across your head all the way to your right ear, focusing the dry shampoo at the root (with the nozzle about 8 inches away) each time you part it. Then, use the same method from your hairline all the way back to the nape of your neck to ensure you've equally distributed the powder onto all of your roots.

The Pretty (Simple) Pony: Apply dry shampoo onto your roots using Buckett's technique, then tease your hair down the center with a rattail comb. Divide your hair into five sections from the crown of your head to your hairline. Starting at the crown, tease that section of hair five times. Then, moving toward your hairline, tease the next section four times, then the next section three times, the next two times, and finally tease the section at your hairline once. "Using that method gives the hair structure so the teasing doesn't fall flat," he says. Next, gently break up the teased hair with your fingertips and lightly smooth it back from hairline to crown, using a boar bristle brush. Sweep your hair up into a ponytail, securing it with an elastic band.

Wrap a sliver of hair around the hair tie, keep it in place with a bobby pin, and you're done!

1. **Half-Up Halo Twist**: After you've applied dry shampoo to your roots, comb your hair back from the hairline to the crown of your head with a teasing comb. Next, make a severe part in line with the highest point in your right brow and smooth your hair down lightly with a comb. Take a 2-inch section of hair from the hairline on each side of the part, smooth it back behind each ear, and start tightly twisting the hair on one side. Once one section is twisted, wrap the twist around your head and use a bobby pin to secure the twist behind your ear. Repeat on the other side. If your hair doesn't stay in twists, use a flexible-hold hairspray that's lightweight and doesn't impart a lot of shine, which would instantly make your hair look greasy. Also, make sure your hairspray isn't an anti-humidity version, Buckett says, because these formulas have oil in them that coat the hair to protect it from humidity, which can make it flatten out, and again, make your hair look oily.
2. **The No-Fuss French Twist**: First, apply dry shampoo all over, then curl your hair to give it some texture. If your hair is super-fine and you need even more

grip, flip your head over and apply a texturizing spray. Gather all your hair to one side (left or right). As you hold your hair to one side, put bobby pins into your hair down the centre of your head, from the nape to the crown. The bobby pins should be put in vertically, alternating between pointing up and pointing down. This helps keeps your hair really secure. Now take your hair and roll it back toward the centre of your head to create the twist. Pin it into place with bobby pins along the length of the twist.

3. **Tousled and Textured:** Curling your hair without using dry shampoo creates texture on its own, which can make dirty hair look better instantly. To give your hair a more natural look, curl it in alternating directions. If your hair still looks oily after curling it, hit it with dry shampoo to extend your style another day.
4. **The Tri-Fishtail Braid:** Start by applying dry shampoo for added volume and grip, then section your hair into three parts: one at each side and one in the back. Create messy fishtail braids with each section and secure each with a clear elastic band. (Don't know how to fishtail braid? Click here.) After you've fishtail-braided each section, gently pull apart each braid a little to give it some messy texture. Next, braid all three of the fishtails into one braid, secure it with an elastic, and you're done!
5. **A Tight Twist:** Sometimes when your hair is too oily, it's best to work with the oil and create a sleek style. Make a severe part down the centre of your head using the handle of a teasing comb. Apply your favourite hair oil or pomade to both sides of your part, smoothing your hair down. Next, brush your hair smooth with a boar bristle brush, pulling it into a low ponytail. Once you've secured it with an elastic, split the ponytail into two equal sections of hair, take the pomade or oil, apply it to your palms and fingertips, and smooth it over the two sections as you twirl them around your finger so they coil up. They'll naturally start to crisscross into shape. As they coil into each other, secure the ends with a clear elastic, tuck the hair into itself at the crown of your head, and pin it into place. Boom: instant bombshell status.

https://www.bustle.com/articles/68996-7-hairstyles-you-can-do-when-you-havent-washed-your-hair

7 Hairstyles You Can Do When You Haven't Washed Your Hair

By Maureen Luyun

Mar 12 2015

Raise your hand if you haven't touched your shampoo bottle in three days? Four? FIVE? Me, too! Kudos, you're part of a movement that embraces actually having a life and feeling gorgeous at the same time. The trick? Easy hairstyles for dirty hair. Guess how many times Kim Kardashian washes her hair (or has someone on her team wash it for her?) Once. A. Week. And yes, Gretchen Weiner's hair is so big because it's full of secrets, and the main one she's been keeping from all The Plastics is that she goes the entire week without washing it.

In actuality, it's healthier to keep your cleansing routine to a minimum because the chemicals in shampoo have a tendency to strip your hair of those essential oils that keep your mane shiny. I've been a member of this "no poo" society (A.K.A. #dirtyhairdontcare) for about a year now, and my hair has never been healthier.

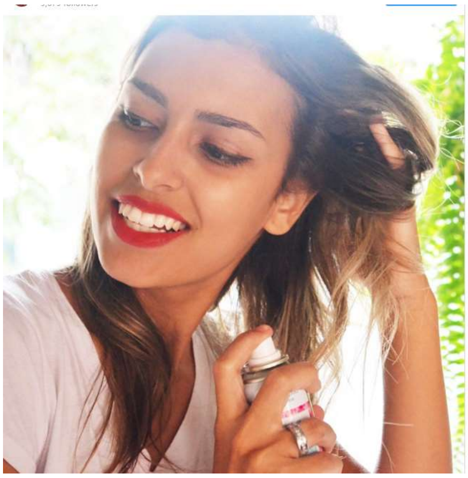
Whatever your reasoning for not washing your hair anymore might be, you're not alone. One of the best parts about adopting a low maintenance hair lifestyle is being able to spend more time doing what you actually want (or need) to do instead of wasting said time in front of the mirror.

Keep scrolling for an entire week's worth of super simple, lazy gal hairstyles (that aren't your basic top knot) that will keep your hair game on point all week long.

1.Lauren Conrad-inspired Waves

I style my hair once a week, and I don't wash it for a good four to six days. When Lauren Conrad revealed her secret method for those signature California Girl waves that we coveted, but never knew how to get, I was surprised there wasn't a nationwide power outage. I've got no shame in admitting that I ran straight to my bathroom and plugged in my curling iron to try it on my naturally curly, frizzy, second-day old hair. It took me about an hour from start to finish, only because I couldn't pull myself away from the mirror for 30 minutes and had a full-fledged selfie shoot — that's how much I was feeling my look. These waves are perfect for a no poo lifestyle because they look great all day, every day and get even better as the week goes on.

2.The Dry Shampoo "Blowout"



Say it with me: DRY SHAMPOO IS MY NEW BEST FRIEND. As a professional cosmetics collector (read: hoarder), I've personally tested my fair share of products that reel me in with their empty promises, but dry shampoo is one of my favourite haircare products by far. When it feels like nothing in your life is going right, that little can of magical hair goodness will be there to save you. Don't be overwhelmed by the myriad of dry shampoo brands and formulas out there. If you're a no poo novice, I recommend an aerosol dry shampoo over a powder formula, but they give the same result.

Spray your roots (with special care to your crown and the area around your forehead) and let the dry shampoo soak up all the ick from yesterday's shenanigans while you brush your teeth. (Warning: you will have grey/white roots so don't let it freak you out.) I let it sit for a solid 5-10 minutes before I zhush it up to restyle. You can use a brush or your fingers to work in until you start to see your natural hair colour again. To get the bed head look, I tease my crown to add volume (native Texan here) and brush out my curled ends and take my curling iron to add in a few pieces for texture. Finish it off with hairspray and be on your way!

3.The Half Updo

For days when it's hella windy, rainy or you're straight up tired of tucking your hair behind your ear, get creative with a handful of bobbi pins. You can pin back a section of your hair for a half updo or add texture to a center part (or deep side part, if that's your thing) and pin back one-inch twists.

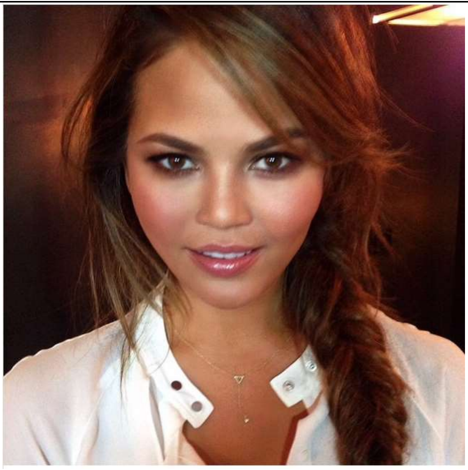
<sorry – picture not available>

4.The Sleek Ponytail

Don't get me wrong, I love a messy top knot. The sleek and chic ponytail is having a major high fashion moment right now. All you need is an elastic (or two) to achieve a sporty and sassy look, whether you're killin' it at the gym or heading to happy hour

5.The Chi Side Braid

Who else is stoked that the messy look is in? It came in waves with ombre (A.K.A. the lazy gal's highlights) and now the natural, windswept look is so hot right now. If you've mastered bed head and messy top knots, perfecting the next-level side braid style is your latest challenge.



6.The Accessorized 'Do

When isn't it a good time to accessorize? If hats or hair turbans aren't your thing, stick to the basics like headbands or barrettes.

7.The Deep Side Part

Huzzah, hooray -- it's the end of the week! Wear your hair down and rock a deep side part this weekend. On Sunday night, go ahead and wash the week out of your hair and start it all over again.

No poo/low poo (shampoo)

For health benefits, pollution reduction and save money.

https://www.healthline.com/health/beauty-skin-care/no-poo

What Is No Poo, How Does It Work, and Should You Try It?
Medically reviewed by Cynthia Cobb, DNP, APRN on September 27, 2017 — Written by Taylor Norris

What is no poo?
In the broadest sense, "no poo" means no shampoo. It's a philosophy and method of cleaning your hair without traditional shampoo. People are attracted to the no-poo method for a number of reasons.

Some want to avoid overly stripping their hair of good and natural oils produced by the scalp. Others want to use fewer unnatural chemicals in their daily routines. And for some people, no poo means rejecting the commercial pressure to spend more money on hygiene than may actually be necessary.

Shampoo contains detergent that cleans your hair and chemicals that make it lather up in suds. "Chemical" doesn't automatically mean something is unnatural or unhealthy. There's growing interest among many people to better understand all of the chemicals we use every day, and how they affect our health and well-being.

Giving up shampoo doesn't mean you have to give up showers or washing your hair.

Instead of shampoo, people who've adopted this hair care technique use baking soda followed by apple cider vinegar, or only use conditioner. You can even buy products off the shelf that cleanse your hair but are technically not shampoo.

No poo is such a phenomenon that online support forums exist to help you learn more and experiment with your preferred way to wash your hair.

What are the benefits of no poo?
The potential benefits of skipping shampoo include:

- healthier hair and scalp that produces a balanced amount of oil
- more voluminous hair
- better textured hair and less need for styling products
- less exposure to potentially irritating chemicals
- less plastic packaging waste
- breaking an artificial cycle of shampooing, which dries out the hair, causing you to use products to add moisture back, and then shampoo again to remove product

Is no poo for you?
Experimenting with no poo is relatively low risk. In fact, daily showers and shampooing are only a recent trend. If you have a history of skin or scalp issues, you should talk with your healthcare provider or dermatologist before attempting it. Otherwise, nearly anyone can try no poo.

Consider the following to determine if no poo is for you:

Skipping shampoo might be more difficult if you have fine or thin hair because your hair will get oilier faster. Before quitting shampoo cold turkey, you can try slowly stretching the time between washes for a few weeks

- People with curly or very coarse hair may see the most benefits of no poo because the natural oils produced by the scalp can make hair smoother and less frizzy.

What's the best no-poo method?

Each no-poo alternative will work better for some people than others. The only way to know if you like the outcome is to try it. If you do try it, remember to pay attention to the health of your hair and scalp. Talk with your healthcare provider or a dermatologist if you have any concerns at any point.

Any no-poo method will take you through an adjustment period where your hair may become oilier than normal. Proponents of no poo say this phase is necessary to help your scalp recalibrate and begin creating the right amount of oil you personally need on your head. Anecdotally, your scalp will produce less oil over time because it's not being stripped by shampooing detergents every day. There aren't any scientific studies to support this claim, however.

	Pros	**Cons**
Baking soda followed by apple cider vinegar	Baking soda makes a good paste for scrubbing, and many people say that apple cider vinegar makes hair shiny. The ingredients are cheap.	This method may irritate your scalp or disrupt your head's natural pH.
Coconut oil	It repels water, which means your hair will be sealed to maintain its natural oils.	It may be difficult to rinse out. It may leave your hair heavy and greasy.
Just conditioner or a specific no-poo product	These are less likely to disrupt your scalp's pH.	They may weigh down your hair if you don't rinse them out thoroughly. These choices don't decrease money spent or plastic used.
Washing only with water	This is the cheapest option. It's completely chemical-free.	Your hair might not feel as clean or look how you'd like it to.

Other tips for healthy hair

The health of your hair is often a sign of your overall health. A healthy, balanced diet and eating enough food is essential for growing healthy hair.

Other ways to keep your hair healthy include:

- Use shampoo only on your scalp, not down to the ends.
- Always use conditioner after you shampoo, and concentrate your conditioner application on the ends of your hair.
- Shampoo as often as you need it. Oily hair may need to be shampooed more

often. But if you're older or have color-treated hair, then you won't need to wash as often.

- Protect your hair while swimming by applying conditioner and wearing a swim cap before getting in a chlorinated pool.

The takeaway

There are many reasons to try the no-poo method of hair washing. There are also many methods of no-poo washing that have different benefits. No poo will work better for some people than others, but it's relatively low risk if you want to give it a try.

https://www.friendlysoap.co.uk/product/lavender-geranium-shampoo-bar/

The transition to natural shampoo, issues and tips

"The Transitional Purge"

There is a transition when you switch from the standard chemical shampoos to a natural shampoo bar, commonly called 'the purge'. When you first begin, your hair or scalp may become oily or dry or a bit of back and forth between the two. Your hair may feel frizzy or waxy like there is a residue still left over in your hair. Don't panic, this is just your hair adjusting, your scalp needs time to rebalance oil production. It usually lasts about a week (depending on how damaged your hair is) and it will go away. Stick with it, once your hair has adjusted it will feel softer, cleaner and more manageable. This is because shampoo bars CLEAN and CONDITION your hair and scalp without stripping it of its natural sebum. If you have dandruff problems, you may find this clears up because your scalp is not getting dried out and your body is no longer reacting to the chemicals.

Tips for an easy transition:

1. Use an apple cider vinegar rinse rather than conditioner, this will help to restore the pH balance of your scalp and remove old chemicals. (recipe below). It will also protect the hair shaft and give your hair shine.
2. Gently brush your hair often, twice a day is good. Brush from scalp to tips to help redistribute your hairs natural oil.
3. Give your hair a few days in between washings to allow it to adjust
4. Rinse thoroughly after washing to remove all of the shampoo.
5. Try using a bit of dry shampoo or corn starch if your hair is feeling oily, rub a small amount into scalp then brush through
6. Try using a little argon oil through your hair to help calm frizz and tangles.
7. If you have a lot of product build up, try the baking soda rinse below before washing your hair with the shampoo bar.

Apple cider vinegar spritz

- 1 part apple cider vinegar (use the type with the mother)
- 4 parts water
- A few drops of your preferred essential oil.

The vinegar smell does not remain once your hair dries

Baking Soda Clarifying Rinse Recipe

Baking soda (sodium bicarbonate) is an easy clarifier to use. Baking soda can help to lifts grease and product residue from your hair.

- 1 tablespoon baking soda

- 1 – 2 cups warm water

Combine the ingredients in a spray bottle or cup. Wet hair and spray the rinse on your hair and work it through. Rinse thoroughly with warm water, then shampoo.

Washing your hair
Run the shampoo bar over your head in one direction (front to back), as to avoid causing unnecessary knots. Once you have a good amount of shampoo on top of your head, massage it into my scalp with your fingers. Rinse with water until ALL the shampoo is out... Done!

A.5 Academic calendar – key dates

The university calendar for the two academic years 2017/18 and 2018/19, summarising the *main* occupancy periods and undergraduate teaching blocks (terms/semesters) are summarised in Table A-6 and Table A-7. The primary data collection and field trial periods (Wave 0, Wave 1, and Wave 2) are shown in the research activity column on the right.

Table A-6 UWE academic year calendar 2017-18

	Week beginning	2017/18	Research activity
9	18-Sep	Welcome week (arrival weekend 16/17-Sep)	
10	25-Sep	Start of undergraduate Teaching Block 1	Wave 0
11	02-Oct		
12	09-Oct		
13	16-Oct		
14	23-Oct		
15	30-Oct		
16	06-Nov		
17	13-Nov		
18	20-Nov		
19	27-Nov		
20	04-Dec		
21	11-Dec	End of Teaching Block 1	
22	18-Dec	Student vacation (3 weeks)	
23	25-Dec		
24	01-Jan		
25	08-Jan	Assessment Period 1	
26	15-Jan	Assessment Period 1	
27	22-Jan	Start of Teaching Block 2	Wave 1
28	29-Jan		
29	05-Feb		
30	12-Feb		
31	19-Feb		
32	26-Feb		
33	05-Mar		
34	12-Mar		
35	19-Mar		

36	26-Mar	Student Vacation (2 weeks) Easter weekend 30 March - 2 April	
37	02-Apr		
38	09-Apr		
39	16-Apr		
40	23-Apr	End of Teaching Block 2	

Table A-7 UWE academic year calendar 2018-19

	Week beginning	2018/19	Research activity
9	17-Sep	Welcome week (arrival weekend 15/16-Sep)	
10	24-Sep	Start of undergraduate Teaching Block 1	Wave 2
11	01-Oct		
12	08-Oct		
13	15-Oct		
14	22-Oct		
15	29-Oct		
16	05-Nov		
17	12-Nov		
18	19-Nov		
19	26-Nov		
20	03-Dec		
21	10-Dec	End of Teaching Block 1	
22	17-Dec	Student vacation (3 weeks)	
23	24-Dec		
24	31-Dec		
25	07-Jan	Assessment Period 1	
26	14-Jan	Assessment Period 1	
27	21-Jan	Start of Teaching Block 2	
28	28-Jan		
29	04-Feb		
30	11-Feb		
31	18-Feb		
32	25-Feb		
33	06-Mar		
34	11-Mar		
35	18-Mar		
36	25-Mar		
37	01-Apr		
38	08-Apr	End of Teaching Block 2	
39	15-Apr	Student Vacation (2 weeks) Easter weekend 19-22 April	
40	22-Apr		

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Appendix B Volumetric measurement

B.1 Tests for normality

The one sample Kolmogorov-Smirnov and Shapiro-Wilk tests were used to assess for normality for the daily volumetric metered consumption data for the WCP1 study houses across a range of time periods (calendar year, academic year, and term). These are standard tests that can handle small sample sizes. The tests were conducted using the SPSS statistical package. The results for the different time periods are summarised in Table A-8 and the individual outputs are shown in Table A9 to Table A-15. For the consumption data to be normally distributed, the significances must be greater than 0.05 (these are highlighted in yellow).

Table A-8 Summary of tests for normality, for different time periods

Table	Period	Field trial	Outcome
A-8	2016 calendar	Exploratory/Wave 0	Null
A-9	2017 calendar (excl. August)	Exploratory/Wave 0	Null
A-10	2016/17 academic	Exploratory/Wave 0	House L (K-S test)
A-11	2017/18 academic	Wave 0 & Wave 1	House C (K-S test)
A-12	Sep-Dec 2017 term 1	Wave 0	House C (K-S test)
A-13	Jan-Mar 2018 term 2	Wave 1	House C, D, J. L (K-S & S-W tests)
A-14	Sep-Dec 2018 term 1	Wave 2	House E (K-S test)

Table A-9 SPSS output - calendar year 2016

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
HouseA	.222	366	.000	.482	366	.000
HouseB	.159	366	.000	.917	366	.000
HouseC	.145	366	.000	.793	366	.000
HouseD	.135	366	.000	.925	366	.000
HouseE	.107	366	.000	.947	366	.000
HouseF	.170	366	.000	.637	366	.000
HouseG	.096	366	.000	.954	366	.000
HouseH	.337	366	.000	.349	366	.000
HouseI	.140	366	.000	.780	366	.000
HouseJ	.232	366	.000	.553	366	.000
HouseK	.144	366	.000	.747	366	.000
HouseL	.086	366	.000	.870	366	.000

a. Lilliefors Significance Correction

Table A-10 SPSS output – calendar year 2017 (excl. August)

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
HouseA	.175	334	.000	.824	334	.000
HouseB	.088	334	.000	.868	334	.000
HouseC	.082	334	.000	.951	334	.000
HouseD	.204	334	.000	.602	334	.000
HouseE	.091	334	.000	.961	334	.000
HouseF	.101	334	.000	.952	334	.000
HouseG	.102	334	.000	.939	334	.000
HouseH	.080	334	.000	.934	334	.000
HouseI	.117	334	.000	.789	334	.000
HouseJ	.350	334	.000	.667	334	.000
HouseK	.076	334	.000	.961	334	.000
HouseL	.081	334	.000	.959	334	.000

a. Lilliefors Significance Correction

Table A-11 SPSS output – academic year 2016/17

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
HouseA	.259	334	.000	.466	334	.000
HouseB	.118	334	.000	.922	334	.000
HouseC	.117	334	.000	.760	334	.000
HouseD	.074	334	.000	.887	334	.000
HouseE	.093	334	.000	.957	334	.000
HouseF	.094	334	.000	.953	334	.000
HouseG	.094	334	.000	.953	334	.000
HouseH	.381	334	.000	.278	334	.000
HouseI	.094	334	.000	.875	334	.000
HouseJ	.316	334	.000	.706	334	.000
HouseK	.069	334	.001	.937	334	.000
HouseL	.037	334	.200*	.981	334	.000

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table A-12 SPSS output – calendar year 2017/18 (covers Wave 0 and Wave 1)

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
HouseA	.231	122	.000	.834	122	.000
HouseB	.187	122	.000	.723	122	.000
HouseC	.075	122	.085	.977	122	.033
HouseD	.315	122	.000	.517	122	.000
HouseE	.111	122	.001	.953	122	.000
HouseF	.090	122	.017	.920	122	.000
HouseG	.145	122	.000	.911	122	.000
HouseH	.140	122	.000	.899	122	.000
HouseI	.156	122	.000	.747	122	.000
HouseJ	.297	122	.000	.441	122	.000
HouseK	.159	122	.000	.916	122	.000
HouseL	.194	122	.000	.864	122	.000

a. Lilliefors Significance Correction

Table A-13 SPSS output – term 1 Sep-Dec 2017 (Wave 0)

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
HouseA	.231	122	.000	.834	122	.000
HouseB	.187	122	.000	.723	122	.000
HouseC	.075	122	.085	.977	122	.033
HouseD	.315	122	.000	.517	122	.000
HouseE	.111	122	.001	.953	122	.000
HouseF	.090	122	.017	.920	122	.000
HouseG	.145	122	.000	.911	122	.000
HouseH	.140	122	.000	.899	122	.000
HouseI	.156	122	.000	.747	122	.000
HouseJ	.297	122	.000	.441	122	.000
HouseK	.159	122	.000	.916	122	.000
HouseL	.194	122	.000	.864	122	.000

a. Lilliefors Significance Correction

Table A-14 SPSS output – term 2 Jan-Mar 2018 (Wave 1)

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
HouseA	.339	32	.000	.728	32	.000
HouseB	.181	32	.009	.828	32	.000
HouseC	.105	32	.200*	.969	32	.476
HouseD	.125	32	.200*	.940	32	.073
HouseE	.199	32	.002	.898	32	.006
HouseF	.184	32	.007	.791	32	.000
HouseG	.274	32	.000	.836	32	.000
HouseH	.239	32	.000	.800	32	.000
HouseI	.202	32	.002	.822	32	.000
HouseJ	.102	32	.200*	.961	32	.298
HouseK	.217	32	.001	.875	32	.002
HouseL	.151	32	.061	.906	32	.009

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table A-15 SPSS output – term 1 Sep-Dec 2018 (Wave 2)

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
HouseA	.208	122	.000	.671	122	.000
HouseB	.145	122	.000	.919	122	.000
HouseC	.148	122	.000	.939	122	.000
HouseD	.132	122	.000	.937	122	.000
HouseE	.071	122	.200*	.960	122	.001
HouseF	.399	122	.000	.296	122	.000
HouseG	.125	122	.000	.850	122	.000
HouseH	.409	122	.000	.569	122	.000
HouseI	.143	122	.000	.899	122	.000
HouseJ	.143	122	.000	.870	122	.000
HouseK	.113	122	.001	.931	122	.000
HouseL	.	122	.	.	122	.

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The results for two calendar years (2016 and 2017) indicated that the volumetric data for all WCP1 study houses was *not* normally distributed. The Kolmogorov-Smirnov test suggested that house L *could* be normally distributed for the academic year 2016/17 (significance was 0.2, Table A-11), although the Shapiro-Wilk test did not support this (significance was 0.000). However, consumption for this house was very low due to low and intermittent occupancy, and the same test for both the 2016 and 2017 calendar years (Table A-9 and Table A-10) did not support this.

The results for the academic year 2017/18 (covering both Wave 0 and Wave 1, Table A-12) indicated that the consumption for house C *could* be normally distributed (Kolmogorov-Smirnov test significance was 0.085), but the Shapiro-Wilk test did not confirm this (significance was only 0.033). This result was mirrored by the term 1 (Sep-Dec 2017, Wave 0) consumption figures (Table A-13). Water consumption for the other eleven houses was *not* normally distributed (<0.05).

The results for term 2, later in the 2017/18 academic year (Wave 1, Table A-14) indicated that the consumption for houses C, D, J and L *could* be normally distributed (significance >0.05 for both tests), whilst water consumption for the other eight houses is *not* normally distributed.

Finally, the results for term 1 of 2018/19 (Wave 2, Table A-15) indicated that the consumption for house E *could* be normally distributed (Kolmogorov-Smirnov significance was 0.2), but the Shapiro-Wilk test did not support this (significance was only 0.001). Note - the resident cohort was reset each academic year. The consumption for the other eleven houses was *not* normally distributed (<0.05).

The results from all the tests in combination indicated that normality cannot be assumed, despite some consumption patterns for a few houses being normally distributed. This was due to the variability or ‘messiness’ of the data For non-normal distributions, non-parametric tests are used. These are not as sensitive as parametric as they are simpler and less powerful.

B.2 Analysis of variance

To test for consistency, analysis of variance (ANOVA) tests were run on daily per *bed* consumption to explore for statistical differences between different days of the week and across the different phases of the trials for each block (Student Village) or house (WCP1). As the data were not normally distributed, non-parametric one-way ANOVA using the Kruskal-Wallis and Tukey HSD (Honestly Significant Difference) tests were run, using the R statistics package, followed by the Dunn’s test (with Benjamini-Hochberg correction) to correct for repeating values.

A comparison between the daily consumption for 21 (of 24) blocks of flats in the Student Village was undertaken (by an undergraduate intern student, M. Poffley, in the Statistics department) to investigate if any specific day of the week tended to have higher or lower water usage compared with other days, for example weekdays versus weekends, or start or end of the week and mid-week. A representative subset of daily consumption data for the period October to November 2016 (with maximum occupancy closest to design bed capacity and a period of standard teaching activities) were analysed using the statistical package R. The results are shown in Table A.16.

Table A-16 ANOVA results for significance in daily consumption between days of the week for each block of flats (Student Village, Oct-Nov 2016)

Block of flats	Results of ANOVA	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
B3	days	6	83	13.90	0.471	0.829	
	Residuals	115	3395	29.52			
B4	days	6	94.8	15.80	0.708	0.644	
	Residuals	115	2567.4	22.33			
B5	days	6	163.1	27.19	1.123	0.353	
	Residuals	115	2783.2	24.20			
B6	days	6	80	13.37	0.134	0.992	
	Residuals	174	17333	99.62			
B7	days	6	194	32.41	0.138	0.99	
	Residuals	24	5624	234.33			
C1	days	6	26.8	4.463	0.34	0.913	
	Residuals	54	709.6	13.140			
C2	days	6	223	37.21	0.529	0.785	
	Residuals	115	8088	70.33			
C3	days	6	106.1	17.69	0.737	0.62	
	Residuals	115	2758.7	23.99			
C4	days	6	74	12.34	0.61	0.722	
	Residuals	115	2327	20.24			
C5	days	6	168.2	28.04	1.51	0.192	
	Residuals	54	1002.6	18.57			
C6	days	6	97.1	16.19	0.412	0.868	
	Residuals	54	2123.2	39.32			
M1	days	6	124.7	20.775	5.197	0.000278	***
	Residuals	54	215.9	3.997			

	Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1						
M2	days	6	47.2	7.866	0.408	0.871	
	Residuals	54	1041.9	19.294			
M4	days	6	238.6	39.76	2.173	0.0598	
	Residuals	54	988.0	18.30			
M5	days	6	64.3	10.71	1.018	0.423	
	Residuals	54	567.8	10.52			
Q1	days	6	264.6	44.10	1.084	0.384	
	Residuals	54	2196.6	40.68			
Q2	days	6	203.4	33.89	0.769	0.597	
	Residuals	54	2379.3	44.06			
Q3	days	6	106.5	17.76	0.388	0.884	
	Residuals	54	2472.0	45.78			
Q4	days	6	142.1	23.69	0.727	0.63	
	Residuals	54	1760.7	32.60			
Q5	days	6	29.3	4.877	0.296	0.936	
	Residuals	54	891.1	16.502			
Q6	days	6	182.6	30.44	1.037	0.412	
	Residuals	54	1585.6	29.36			

The results showed no significant difference in water use between the different days of the week and allows for consumption data to be compared between days and between annual cycles. For 20 of the 21 blocks assessed, there were no statistically significant differences found for the daily water consumption by day of the week, and no statistically significant combinations of days were found, after correcting for multiple comparisons. Just one block (M1), showed a possible statistically significant difference for water consumption by day of the week, for three combinations – between Saturday to Wednesday; Saturday-Thursday; and Sunday-Saturday. However, there was a logical error between the results, meaning that the difference was not significant, and that it was reasonable to compare consumption between days of the week and between years.

A similar comparison between the daily consumption for eleven (of twelve) WCP1 study houses was completed to explore consumption between different phases of the Wave 1 and Wave 2 trials. The results are shown in Table A.17 (significance is indicated for p-values of less than 0.05).

Table A-17 ANOVA results for significance in daily consumption for different phases of the Wave 1 and Wave 2 trials (WCP1 study houses, 2018)

House	Wave 1 (spring 2018)			Wave 2 (autumn 2018)		
	K-W	p-value	Signif.	K-W	p-value	Signif.
A	6.4482	0.03979	1 - 3, 2 - 3	6.4377	0.04	1 - 2, 1 - 3
B	5.5957	0.06094		1.6355	0.4414	
C	10.358	0.005633	1 - 3, 2 - 3	13.584	0.001123	1 - 3, 2 - 3
D	3.8552	0.1455		5.2591	0.07211	
E	9.1412	0.01035	1 - 2, 1 - 3	1.6652	0.4349	
F	0.22054	0.8956		3.3086	0.1912	
G	No meter data			5.3265	0.06972	
H	4.4884	0.106		4.6524	0.09767	
I	5.657	0.0591		2.3795	0.3043	
J	3.1264	0.2095		1.2393	0.5381	
K	7.0514	0.02943	1 - 2, 2 - 3	6.1086	0.04716	2 – 3 (not logically consistent)

B.3 Spearman's Rank correlation coefficient

The 2017/18 *per capita* consumption for each house for term 1 and term 2 were plotted against each other, as illustrated in Figure A-15. Houses A and G were excluded, due to missing BMS values arising from test logger interference (house A in term 1 and house G in term 2), whilst House L was excluded due to unreliable and varying occupancy levels. The trend line indicates a positive correlation between consumption in the two time periods, for example, high consumption in term one is mirrored with high consumption in term two.

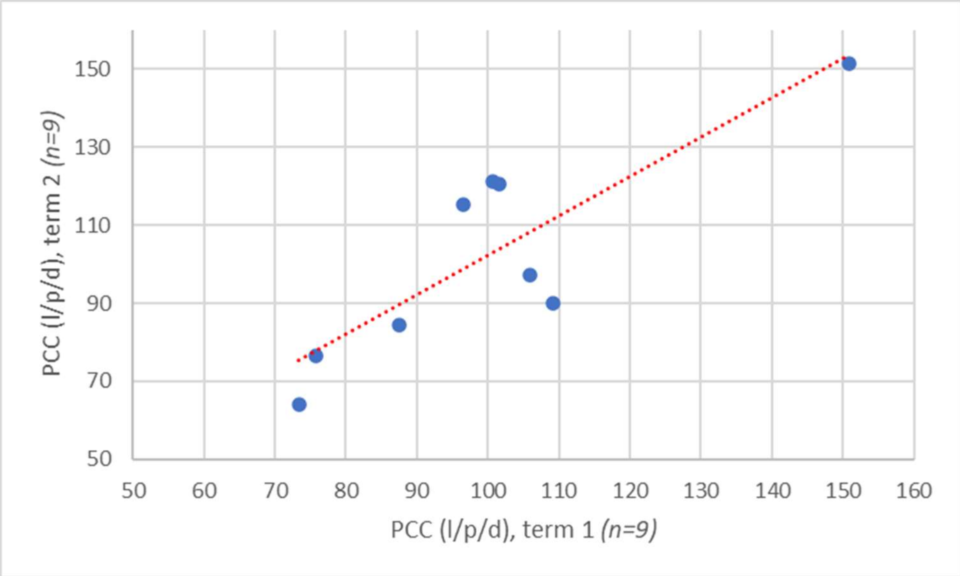

Figure A-15 2017/18 consumption for each house, by term (n=9)

A Spearman's rank correlation was run in SPSS and returned a coefficient of 0.72 (see Table A-18). This indicated a moderate correlation between the two time periods (term 1 and Term 2), suggested that high consumption in one term was moderately matched at the same house by high consumption in the other term. The consumption values indicated that PCC decreased for houses B, D, I and K between term 1 and term 2 (including in the control or no-intervention houses B and K), whilst it increased for houses C, E, F, H and J, despite the interventions. The increase was reflected across the study site, with a small rise in mean consumption between the two terms and for the rest of the development (labelled X).

Table A-18 Spearman's rank correlation coefficient for water consumption between term 1 and term 2

House	Term 1 PCC [Wave 0] *(75 days)*	Rank 1 (1 = high, 9 = low)	Term 2 PCC [Wave 1] *(51 days)*	Rank 2 (1 = high, 9 = low)	Difference (d) (Rank 1 – Rank 2)	d^2
A	*176.647*[1]		*217.203*			
B	87.478	7	84.510	7	0	0
C	150.792	1	151.555	1	0	0
D	105.839	3	97.128	5	-2	4
E	100.660	5	121.348	2	3	9
F	96.493	6	115.431	4	2	4
G	*94.210*		*273.793*[2]			
H	101.575	4	120.696	3	1	1
I	109.257	2	90.022	6	-4	16
J	75.828	8	76.647	8	0	0
K	73.342	9	64.103	9	0	0
L[3]	*34.576*[3]		*58.047*			
Mean (B-K excl G)	*100.557*		*102.409*			**$\Sigma d^2 = 34$**
X	*103.801*		*105.295*			

Term 1: 25-Sep to 08-Dec-2017 (75 days), Term 2:22-Jan to 13-Mar-2018 (51 days)

Spearman's rank correlation coefficient:

$R = 1-((6\Sigma d^2)/(n^3-n))$, where:

d = difference between rank 1 and rank 2; and,

n = number of cases (9 houses)

R = 0.717, representing a moderately positive correlation

[1] *House A – missing term 1 BMS data due to logger interference, PCC based on 51 days*

[2] *House G – missing term 2 BMS data due to logger interference, PCC based on logger data*

[3] *House L – unknown and varying occupancy data – empty house at start of term 1, increased consumption from mid Nov, occupancy of 5 confirmed on 27-Mar-2018*

B.4 Excessive and excellent use

The WCP1 2017/18 consumption data were ranked to identify which houses tended to fall into the minimum or maximum extremes of daily *per bed* consumption. The two houses with the highest consumption, and three houses with the lowest consumption (to allow for the minimal water use by the low occupancy house L) were identified for each day. Ten houses (including three study houses) tended towards high consumption (and appeared only in the high consumption ranks and never in the low consumption ranks, equivalent to the red *excessive* use zone in Figure 4-9). Meanwhile, thirteen houses (three in the study site) tended towards low consumption (ranked in the three lowest positions, equivalent to the blue *excellent* zone in Figure 4-9, and never in the highest two positions).

Table A-19 shows the most frequent (top three) houses that were ranked in the highest and lowest consumption positions. House L was consistently ranked as the lowest (68.4% of the year) or second lowest (21,1% of the year) consuming house, due to low and fluctuating occupancy. House A appeared in both the high and low rankings. However, the low consumption coincided with the logger test period in November 2017, which interfered with the BMS data, resulting in no meter readings. Excluding these two anomalies, three houses (J, Qxviii and Qxx) accounted for the lowest use, whilst four houses (A, C, Qii and Qvi) accounted for the highest ranked consumption.

Table A-19 Raked WCP1 daily consumption, 2017/18 – showing highest and lowest ranked houses

Rank	**Highest**	**Second highest**	**Lowest**	**Second lowest**	**Third lowest**
First	A [21.1%]	Qvi [23.7%]	L [68.4%]	J [28.9%]	J [14.5%]
Second	Qvi [17.1%]	C [19.7%]	A [31.6%]	L [21.1%]	Qxx [10.5%]
Third	Qii [13.2%]	A [15.8%]	n/a	Qxx [13.2%]	Qxviii [9.2%]
Top 3	***51.3%***	***59.2%***	***100%***	***63.2%***	***34.2%***

B.5 Estimates of shower hot water use – Wave 2

The loggers only measured the *cold*-water component of the total shower water use. Therefore, the hot water component had to be estimated. Sensitivity tests were completed using conversion factors based upon a range of different sources, to supplement and validate the fixture level estimates for host water, as presented in Table 6-5. These estimates included house mean conversion factors and weighted mean hot-cold ratios, and temperature data collected elsewhere in the university student accommodation (from Wallscourt Park phase 2 and the Student Village). The details of these sensitivity tests are summarised in Table A-20 to Table A-24. The results show a good similarity between the different methods of estimation and provide confidence in the validity of the findings.

Table A-20 Average TOTAL shower water consumption, based upon HOUSE MEAN hot-cold ratios (houses G and J)

Estimated *total* (HOT and COLD) shower water consumption - Wave 2	**Total** *(litres)*	**Per household** [Total/n days] *(l/h/d)*	**Per capita*** [Per household /8 residents] *(l/p/d)*	**As % of total metered PCC**
House G: *using house G mean hot-cold ratio 43.5-56.5*				
Weekday *(n=31 days)*	4105	132.4	16.6	21.3
Weekend *(n=12 days)*	1561	130.1	16.3	21.8
1.Pre-intervention *(n=12 days)*	1846	153.8	19.2	21.0
2.Intervention *(n=15 days)*	1996	133.1	16.6	19.7
3.Post-intervention *(n=16 days)*	1824	114.0	14.2	20.7
All days *(n=43 days)*	**5666**	**131.7**	**16.5**	**20.4**
House J: *using house J mean hot-:cold ratio 32.6-67.4*				
Weekday *(n=31 days)*	5007	161.5	20.2	23.6
Weekend *(n=12 days)*	1751	145.9	18.2	25.2
1.Pre-intervention *(n=12 days)*	1925	160.4	20.1	23.1
2.Intervention *(n=15 days)*	2479	165.3	20.7	24.6
3.Post-intervention *(n=16 days)*	2353	147.1	18.4	23.3
All days *(n=43 days)*	**6758**	**157.2**	**19.6**	**23.7**
Between 19.7 – 21.8 and 23.1 – 25.2% of PCC House J shower more than house G Shower PCC reduced thru trial house G (7/8 residents), increased house J (4/8 residents)*				

Table A-21 Average TOTAL shower water consumption, based upon WEIGHTED mean hot-cold ratios (houses G and J)

Estimated *total* (HOT and COLD) shower water consumption - Wave 2	**Total** *(litres)*	**Per household** [Total/n days] *(l/h/d)*	**Per capita*** [Per household /8 residents] *(l/p/d)*	**As % of total metered PCC**
House G: *using weighted mean hot-cold ratio 38.0-62.0*				
Weekday *(n=31 days)*	3744	120.8	15.1	19.4
Weekend *(n=12 days)*	1424	118.7	14.8	19.8
1.Pre-intervention *(n=12 days)*	1684	140.3	17.5	19.2
2.Intervention *(n=15 days)*	1821	121.4	15.2	18.0
3.Post-intervention *(n=16 days)*	1664	104.0	13.0	18.9
All days *(n=43 days)*	**5168**	**120..2**	**15.0**	**19.6**
House J: *using weighted mean hot-cold ratio 38.0-62.0*				
Weekday *(n=31 days)*	5447	175.7	22.0	25.7
Weekend *(n=12 days)*	1905	158.7	19.8	27.4
1.Pre-intervention *(n=12 days)*	2094	174.5	21.8	25.1
2.Intervention *(n=15 days)*	2697	179.9	22.5	26.8
3.Post-intervention *(n=16 days)*	2560	160.0	20.0	25,3
All days *(n=43 days)*	**7352**	**171.0**	**21.4**	**25.8**
**PCC based on design occupancy of 8 students per house 4 loggers per house Between 18.0 – 19.8% and 25.1 – 27.4% bigger gap*				

Table A-22 Average TOTAL shower water consumption, based upon WCP2 hot-cold ratios (houses G and J)

Estimated *total* (HOT and COLD) shower water consumption - Wave 2	**Total** *(litres)*	**Per household** [Total/n days] *(l/h/d)*	**Per capita*** [Per household /8 residents] *(l/p/d)*	**As % of total metered PCC**
House G: *using WCP2 mean hot-cold ratio 30.8-69.2*				
Weekday *(n=31 days)*	3353	108.2	13.5	17.4
Weekend *(n=12 days)*	1275	106.3	13.3	17.8
1.Pre-intervention *(n=12 days)*	1508	125.7	15.7	17.2
2.Intervention *(n=15 days)*	1631	108.7	13.6	16.1
3.Post-intervention *(n=16 days)*	1490	93.1	11.6	16.9
All days *(n=43 days)*	**4629**	**107.6**	**13.5**	**16.7**
House J: *using WCP2 mean hot-cold ratio 30.8-69.2*				
Weekday *(n=31 days)*	4878	157.4	19.7	23.0
Weekend *(n=12 days)*	1706	142.2	17.8	24.5
1.Pre-intervention *(n=12 days)*	1876	156.3	19.5	22.5
2.Intervention *(n=15 days)*	2416	161.0	20.1	24.0
3.Post-intervention *(n=16 days)*	2293	143.3	17.9	22.7
All days *(n=43 days)*	**6584**	**153.1**	**19.1**	**23.1**
**PCC based on design occupancy of 8 students per house* *4 loggers per house* *Average hot-cold ratio calculated from metered total consumption and metered feed (cold) into hot water boiler for ten houses between 7-21 Nov 2020 (this data was not available for 2018 when the Wave 2 trial was undertaken. Dates selected to match Wave 2 trial to cover variations due to seasonality and prevailing ambient temperature.*				

Table A-23 Average TOTAL shower water consumption, based upon Student Village mean hot-cold ratios for 40°C mixed (houses G and J)

Estimated *total* (HOT and COLD) shower water consumption - Wave 2	**Total** *(litres)*	**Per household** [Total/n days] *(l/h/d)*	**Per capita*** [Per household /8 residents] *(l/p/d)*	**As % of total metered PCC**
House G: *using Student Village mean hot-cold ratio 37.5-62.5 (assuming 40°C mixed)*				
Weekday *(n=31 days)*	3713	119.8	15.0	19.3
Weekend *(n=12 days)*	1412	117.7	14.7	19.7
1.Pre-intervention *(n=12 days)*	1670	139.1	17.4	19.0
2.Intervention *(n=15 days)*	1806	120.4	15.0	17.8
3.Post-intervention *(n=16 days)*	1650	103.1	12.9	18.7
All days *(n=43 days)*	**5125**	**119.2**	**14.9**	**18.5**
House J: *using Student Village mean hot-cold ratio 37.5-62.5 (assuming 40°C mixed)*				
Weekday *(n=31 days)*	5401	174.2	21.8	25.4
Weekend *(n=12 days)*	1889	157.4	19.7	27.1
1.Pre-intervention *(n=12 days)*	2077	173.1	21.6	24.9
2.Intervention *(n=15 days)*	2674	178.3	22.3	26.5
3.Post-intervention *(n=16 days)*	2538	158.7	19.8	25.1
All days *(n=43 days)*	**7289.6**	**169.5**	**21.2**	**25.6**
**PCC based on design occupancy of 8 students per house* *4 loggers per house*				

Table A-24 Average TOTAL shower water consumption, based upon Student Village hot-cold ratios for 38°C mixed (houses G and J)

Estimated *total* (HOT and COLD) shower water consumption - Wave 2	**Total** *(litres)*	**Per household** [Total/n days] *(l/h/d)*	**Per capita*** [Per household /8 residents] *(l/p/d)*	**As % of total metered PCC**
House G: *using Student Village mean hot-cold ratio 42.9-57.1 (assuming 38°C mixed)*				
Weekday *(n=31 days)*	4064	131.1	16.4	21.1
Weekend *(n=12 days)*	1546	128.8	16.1	21.5
1.Pre-intervention *(n=12 days)*	1828	152.3	19.0	20.1
2.Intervention *(n=15 days)*	1976	131.8	16.5	19.5
3.Post-intervention *(n=16 days)*	1806	112.9	14.1	20.5
All days *(n=43 days)*	**5609**	**130.5**	**16.3**	**20.2**
House J: *using Student Village mean hot-cold ratio 42.9-57.1 (assuming 38°C mixed)*				
Weekday *(n=31 days)*	7850	253.2	31.7	37.0
Weekend *(n=12 days)*	2745	228.8	28.6	39.5
1.Pre-intervention *(n=12 days)*	3019	251.6	31.4	36.2
2.Intervention *(n=15 days)*	3887	259.1	32.4	38.6
3.Post-intervention *(n=16 days)*	3690	230.6	28.8	36.5
All days *(n=43 days)*	**10595**	**246.4**	**30.8**	**37.1**
**PCC based on design occupancy of 8 students per house* *4 loggers per house*				

The Student Village ratios in Table A-24, were based on the findings of a master's student dissertation that focused on domestic hot water use in the Student Village (Machen, 2016), in which the hot water was measured to be 60°C, whilst cold water was 12°C. Taking these figures, an assumed linear mixing calculation was performed to estimate the hot-cold ratio for different mixed (shower) water temperatures:

> Mixed temperature at 40°C requires 1 litre of hot to 1.667 litres of cold water = 37.5 hot to 62.5 cold
>
> Mixed temperature at 38°C requires = 1 litre of hot to 1.333 litres of cold water = 42.9 hot to-57.1 cold

Note – the true relationship between hot and cold water is not linear due to different water densities at different temperatures, but it was deemed to be an acceptable assumption for the purpose of the sensitivity testing.

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Appendix C Questionnaires

C.1 Descriptive statistics

Questionnaires Q/0, Q/1 and Q/2A were broadly similar, with a few tweaks between rounds to clean up typographical and survey routing errors. Responses to the later surveys were used to validate the Q/0 survey findings (particularly those that related to students living on campus, as reported in Chapter 4), and were only highlighted in Chapter 5 and Chapter 6 by exception. For completeness, the responses across the questionnaires are summarised here. Table A-25 provides a guide by question type and directs the reader to the relevant Appendix table.

Table A-25 Summary guide for questionnaire responses, by type of question

Topic of question	**Q/0** Wave 0	**Q/1** Wave 1	**Q/2A** Wave 2	**Appendix table**
Environmental awareness and action				
Environmental awareness and water use	q2, q3	q2, q3	q2, q3	A-26
Recycling	q4	q4	q4	A-27
Water campaigns	q18	q18	q24	A-28
Showering practice				
Shower duration	q5	q5	q5	A-29
Shower frequency	q6	q6	q6	A-30
Time of day	q7	q7	q7	A-31
Gym membership	q36	q35	q44	A-32
Outsourced showers	q36a	q35a	q44b	A-33
Number of shower products	q9	q9	q12	A-34
Types of shower activities	q10	q10	q11	A-35
Typical steps during a shower	N/A	N/A	Q/2B- q13abc	A-36
Wastage from first cold draw	q8	q8	q8	A-37
Impact of trials				
'Go Green'/'Go Gold' challenge	N/A	N/A	Q/2B-q4 & q6	A-38
Change in duration since trial	N/A	q5a	Q/2B-q9	A-39
Change to shower dimensions	N/A	N/A	Q/2B -q9; q10; q11; q12; q13; q14	A-40
Activity with greatest impact	N/A	N/A	Q/2B-q13cde	A-41
Plans for future change	N/A	N/A	Q/2B-q15	A-42
Other washing using practices				
Laundry loads	q11	q11	q17	A-43
Clean bed sheet frequency	q12	q12	q18	A-44
Clean towel frequency	q13	q13	q19	A-45
Frequency of jeans laundry	q14	q14	q20	A-46
Frequency of washing-up dishes	q15	q15	q21	A-47
Style of washing -up	q16	q16	q22	A-48
Washing-up process	q17	q17	q23	A-49

Family dishwasher ownership	q28	q28	q34	A-50
Infrastructure and life at home				
Water meter at home	q29	q29	q35	A-51
Water quality at home	q30	q30	q36	A-52
Era of family home	q20	q20	q26	A-53
Number of bathrooms at home	q26	q26	q32	A-54
Type of shower fixtures at home	q27	q27	q33	A-55
Influence over shower routine	N/A	N/A	q37	A-56
Occupancy				
Weekday occupancy at UWE	q37	q36	q45	A-57
Weekend occupancy at UWE	q38	q37	q46	A-58
Socio-demographics				
Gender	q40	q39	q48	A-61
Age	q39	q38	q47	A-63
Level of course	q33	q32	q41	A-64
Faculty	q34	q33	q42	A-65
Year of study	q35	q34	q43	A-66
Town or country of parental home	q19	q19	q25	A-68
Ethnicity	q43	q40	q49	A-69
Religion	q44	q41	q50	A-70
Religious practice	q44b	q41b	q50b	A-71
Marital status	q41	N/A	N/A	A-72
Dependents	q42	N/A	N/A	A-73
Number of family at home	q21	q21	q27	A-74
Wage earners at home	q22	q22	q28	A-75
Type of dwelling	q23	q23	q29	A-76
Tenure of parental home	q24	q24	q30	A-77
Number of bedrooms at home	q25	q25	q31	A-78
Hair type	N/A	N/A	q16abc	A-79
Feedback/comments on research	q46	q42	Q/2A-q51 Q/2B-q16	A-80

C.1.1 Environmental awareness and action

Table A-26 Environmental and water use awareness

	Q/0 Wave 0			**Q/1** Wave 1	**Q/2A** Wave 2
	On campus *(n=90)*	**Off-site** *(n=66)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
q2. Do you think of yourself as being environmentally aware?					
Yes	79 [87.8%]	63 [95.5%]	142 [91.0%]	16 [84.2%]	21 [91.3%]
No	11 [12.2%]	3 [4.5%]	14 [9.0%]	3 [15.8%]	2 [8.7%]
q3. Have you ever considered how much water you use each day?					
Yes	69 [76.7%]	59 [89.4%]	128 [82.1%]	13 [68.4%]	13 [56.5%]
No	21 [23.3%]	7 [10.6%]	28 [17.9%]	6 [31.6%]	10 [43.5%]

Table A-27 Do you sort and recycle your waste, including food waste?

Waste recycling	**Q/0** Wave 0			**Q/1** Wave 1	**Q/2A** Wave 2
	On campus *(n=90)*	**Off-site** *(n=66)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
q4.1 At home					
Always	49 [54.4%]	48 [72.7%]	97 [62.2%]	9 [47.4%]	17 [73.9%]
Sometimes	28 [31.1%]	18 [27.3%]	46 [29.5%]	7 [36.8%]	6 [26.1%]
Never	13 [14.4%]	0 [0.0%]	13 [8.3%]	3 [15.8%]	0 [0.0%]
q4.2 At UWE					**q4.2 At Wallscourt Park?**
Always	59 [65.6%]	48 [72.3%]	107 [68.6%]	11 [57.9%]	19 [82.6%]
Sometimes	30 [33.3%]	18 [27.3%]	48 [30.8%]	8 [42.1%]	4 [17.4%]
Never	1 [1.1%]	0 [0%]	1 [0.6%]	0 [0.0%]	0 [0.0%]
					q4.3 Around the UWE campus?
				Always	5 [21.7%]
				Sometimes	15 [65.2%]
				Never	3 [13.0%]

Table A-28 Have you heard of any water saving campaigns of messaging at UWE?

Water saving campaigns	**Q/0** Wave 0 (q18)			**Q/1** Wave 1 (q18)	**Q/2A** Wave 2 (q24)
	On campus *(n=90)*	**Off-site** *(n=66)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
Yes	11 [12.2%]	6 [9.1%]	17 [10.9%]	5 [26.3%]	1 [4.3%]
No	79 [87.8%]	60 [90.9%]	139 [89.1%]	14 [73.7%]	22 [95.7%]

C.1.2 Showering practice

Duration

Table A-29 Approximately how may minutes do you spend in the shower (each time you shower)?

Shower duration (minutes)	**Q/0** Wave 0 (q5)					**Q/1** Wave 1 (q5. Before the trial, …)	**Q/2A** Wave 2 (q5. On average, …)
	On campus *(n=90)*	***Student Village*** *(n=63)*	***WCP*** *(n=20)*	**Off-site** *(n=66)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
Short: 3-6	11 [12.2%]	*3 [4.8%]*	*4 [20.0%]*	19 [28.8%]	30 [19.2%]	4 [21.1%]	5 [21.7%]
Norm: 7-8	13 [14.4%]	*11 [17.4%]*	*2 [10.0%]*	6 [9.1%]	19 [12.2%]	2 [10.5%]	3 [13.0%]
'UWE norm': 9-14	26 [28.9%]	*20 [31.7%]*	*5 [25.0%]*	26 [39.4%]	52 [33.3%]	3 [15.8%]	10 [43.5%]
Long: 15-20	35 [38.9%]	*26 [41.3%]*	*7 [35.0%]*	14 [21.2%]	49 [31.4%]	9 [47.4%]	4 [17.4%]
Excessive: >20	5 [5.6%]	*3 [4.8%]*	*2 [10.0%]*	1 [1.5%]	6 [3.8%]	1 [5.3%]	1 [4.3%]
Mean	*13.0*	*13.5*	*13.0*	*10.6*	*12.0*	*12.9*	*10.7*
Median	*10*	*12*	*10*	*10*	*10*	*15*	*10*
Mode	*15*	*15*	*10*	*10*	*10*	*15*	*10*
Minimum	*3*	*3*	*4*	*4*	*3*	*3*	*4*
Maximum	*60*	*60*	*30*	*50*	*60*	*30*	*25*

Frequency

Table A-30 How often do you shower?)

Shower frequency	**Q/0** Wave 0 (q6)					**Q/1** Wave 1 (q6)	**Q/2A** Wave 2 (q6)
	On campus *(n=90)*	***Student Village*** *(n=63)*	***WCP1*** *(n=20)*	**Off-site** *(n=66)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
More than once per day	10 [11.1%]	*5 [7.9%]*	*3 [15.0%]*	3 [4.5%]	13 [8.3%]	0 [0.0%]	3 [13.0%]
Every day	51 [56.7%]	*39 [61.9%]*	*8 [40.0%]*	27 [40.9%]	78 [50.0%]	15 [78.9%]	8 [34.8%]
4-6 time per week 5-6 times per week	18 [20.0%]	*13 [20.6%]*	*5 [25.0%]*	20 [30.3%]	38 [24.4%]	4 [21.1%]	6 [26.1%]
Up to 3 times per week 3-4 times per week	8 [8.9%]	*5 [7.9%]*	*3 [15.0%]*	11 [16.7%]	19 [12.2%]	0 [0.0%]	5 [21.7%]
About once per week	2 [2.2%]	*0 [0.0%]*	*1 [5.0%]*	3 [5.5%]	5 [3.2%]	0 [0.0%]	0 [0.0%]
Other[1]	1 [1.1%]	*1 [1.6%]*	*0 [0.0%]*	2 [3.0%]	3 [1.9%]	0 [0.0%]	1 [4.3%]
[1]q6a. If you selected Other, please specify:		*"3 or 4 times per week"*		*"3-4"* *"once every 2 days"*			*"Sometimes more than once a day"*

Time of day

Table A-31 When do you shower?

Time of day	**Q/0** Wave 0 (q7)			**Q/1** Wave 1	**Q/2A** Wave 2
	On campus *(n=90)*	**Off-site** *(n=66)*	**All** *(n=156)*	(q7) *(n=19)*	(q7) *(n=23)*
(Mostly) first thing in the morning	28 [31.1%]	30 [45.5%]	58 [37.2%]	7 [36.8%]	9 [39.1%]
(Usually) before going out in the evening	4 [4.4%]	1 [1.5%]	5 [3.2%]	1 [5.2%]	2 [8.7%]
(Usually) before going to bed	19 [21.1%]	17 [25.8%]	36 [23.1%]	4 [21.1%]	3 [13.0%]
No fixed pattern	36 [40.0%]	17 [25.8%]	53 [34.0%]	7 [36.8%]	7 [30.4%]
Other[1]	3 [3.3%]	1 [1.5%]	4 [2.6%]	0 [0.0%]	
Afternoon					2 [8.7%]
[1]q7a. If you selected Other, please specify:	*"Morning ad some evenings"* *"Morning, Sometimes in the afternoon, Before going to bed"* *"Generally in the evening"*	*"Cycle so when arrive at Uni and then when arrive back at home. None uni* [sic] *days would be first thing in the morning and then only after getting messy (cycling, decorating etc)"*			

Outsourcing

Table A-32 Are you a member of a gym and if so, which?

Gym membership	**Q/0** Wave 0 (q36)			**Q/1** Wave 1 (q35)	**Q/2A** Wave 2 (q44)
	On campus *(n=90)*	**Off-site** *(n=66)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
UWE sports centre	38 [42.2%]	6 [9.1%]	44 [28.2%]	7 [36.8%]	
Yes (UWE sports centre or offsite gym)					12 [52.2%]
Offsite gym/sports centre	1 [1.1%]	18 [27.3%]	19 [12.2%]	2 [10.5%]	
Not a member of any gym/sports centre	51 [56.7%]	42 [63.6%]	93 [59.6%]	10 [52.6%]	
No (not a member of any gym/sports centre)					11 [47.8%]

Table A-33 If you are a member of a gym, where do you shower after sport?

Where do you shower after sport?	**Q/0** Wave 0 (q36a)			**Q/1** Wave 1 (q35a)	**Q/2A** Wave 2 (q44b)
	On campus *(n=90)*	**Off-site** *(n=66)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
Gym/sports centre	5 [5.6%]	8 [12.1%]	13 [8.3%]	2 [10.5%]	1 [4.3%]
My own bathroom	85 [94.4%]	58 [87.9%]	143 [91.7%]	17 [89.5%]	22 [95.7%]

Products and in-shower activities

Table A-34 How may (different personal shower) products do you use?

Products	**Q/0** Wave 0 (q9)			**Q/1** Wave 1 (q9)	**Q/2A** Wave 2 (q12)
	On campus *(n=90)*	**Off-site** *(n=66)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
0	0 [0.0%]	0 [0.0%]	0 [0.0%]	0 [0.0%]	1 [4.3%]
1	5 [5.6%]	10 [15.2%]	15 [9.6%]	3 [15.8%]	1 [4.3%]
2	29 [32.2%]	15 [22.7%]	44 [28.2%]	1 [5.3%]	8 [34.8%]
3	28 [31.1%]	25 [37.9%]	53 [34.0%]	3 [15.8%]	6 [26.1%]
4	21 [23.3%]	10 [15.2%]	31 [19.9%]	9 [47.4%]	5 [21.7%]
5	4 [4.4%]	6 [9.1%]	10 [6.4%]	2 [10.5%]	2 [8.7%]
More than 5*	3 [3.3%]	0 [0.0%]	3 [1.9%]	1 [5.3%]	0 [0.0%]
Mean	*3.0*	*2.8*	*2.9*	*3.5*	*2.8*
Median	*3.0*	*3.0*	*3.0*	*4*	*3*
Minimum	*1*	*1*	*1*	*1*	*0*
Maximum	*>5*	*5*	*>5*	*>5*	*5*

*'More than 5' converted to 6 to calculate mean

Table A-35 Which activities do you undertake during a typical shower?

In-shower activities	**Q/0** Wave 0 (q10)			**Q/1** Wave 1 (q10)	**Q/2A** Wave 2 (q11)
	On campus *(n=90)*	**Off-site** *(n=66)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
Shampoo once	83 [92.2%]	55 [83.3%]	138 [88.5%]	14 [73.7%]	20 [87.0%]
Shampoo twice	10 [11.1%]	7 [10.6%]	17 [10.9%]	2 [10.5%]	3 [13.0%]
Condition hair	50 [55.6%]	35 [53.0%]	85 [54.5%]	13 [68.4%]	11 [47.8%]
Wash body	87 [96.7%]	64 [97.0%]	151 [96.8%]	19 [100%]	21 [91.3%]
Wash face				14 [73.7%]	16 [69.6%]
Shave	27 [30.0%]	19 [28.9%]	46 [29.5%]	7 [36.8%]	6 [26.1%]
Exfoliate	21 [23.3%]	11 [16.7%]	32 [20.5%]	5 [26.3%]	6 [26.1%]
Brush teeth	12 [13.3%]	6 [9.1%]	18 [11.5%]	4 [21.1%]	1 [4.3%]
Face pack	15 [16.7%]	1 [1.5%]	16 [10.3%]	3 [15.8%]	0 [0.0%]
Other[1]	3 [3.3%]	6 [9.1%]	9 [5.8%]	3 [15.8%]	1 [4.3%]
Total[2]	**298**	**197**	**495**	**82 {68[3]}**	**85 {69[3]}**
Mean	*3.3*	*3.0*	*3.2*	*4.3 {3.6[2]}*	*3.7 {3.0[2]}*
[1]a. If you selected Other, please specify:	*"Wash face" "Sometimes shave" "But I always turn off the water for the time that I use to Shampoo etc!"*	*"Face wash" "Face wash" "Wash face" "Beard shampoo" "Use face wash" "Face wash"*		*"Singing" "Sometimes fake tan" "Shampoo and Condition Beard"*	*[4] Pee in the shower"*

[2] N.B Total is >100%

[3] Excluding 'wash face' to allow for comparison with Q/0 results}

[4] Participant 46F was living in WCP1 during the 2017/18 academic year, and whilst did not directly participate in the Wave 1 trial via diaries, focus groups or questionnaire 2, she was familiar with the messaging

Table A-36 Do you always follow the same steps in the same order, or does your shower routine vary depending on the day, time, or context? (Q/2A Wave 2)

Typical steps during a shower *(n=23)*	**Regular shower routine**	**Routine varies and is context dependent**	
q13a Do you always follow the same steps in the same order?	14 [60.9%]	9 [39.1%]	
q13b. Do you ever vary your showering routine in any of the following ways?	**Often**	**Sometimes**	**Rarely**
1. Frequency (how often you shower)	6 [26.1%]	10 [43.5%]	7
2. Duration (how long you shower for)	8 [34.8%]	10 [43.5%]	5 [21.7%]
3. In-shower activities (the procedural steps of your shower)	4 17.4%]	9 [39.1%]	10 [43.5%]
	Yes – mostly	**No - only sometimes**	
q13c. Do you usually wash your hair when you shower?	14 [60.9%]	9 [39.1%]	

The first cold draw

Table A-37 When you first turn the shower on, do you…?

Wastage from first draw	**Q/0** Wave 0 (q8)			**Q/1** Wave 1 (q8)	**Q/2A** Wave 2 (q8)
	On campus *(n=90)*	**Off-site** *(n=66)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
Wait a short while for the water to warm up before getting under	62 [68.9%]	45 [68.2%]	107 [68.6%]	12 [63.2%]	15 [65.2%]
Start showering straight away	21 [23.3%]	10 [15.2%]	31 [19.9%]	6 [31.6%]	6 [26.1%]
Turn the shower on, then do something else while you wait for it to warm up	7 [7.8%]	10 [15.2%]	17 [10.9%]	1 [5.3%]	2 [8.7%]
Other[1]	0 [0.0%]	1 [1.5%][1]	1 [0.6%]	0 [0.0%]	0 [0.0%]
[1]q8a. If you selected Other, please specify:		*""I use a bucket shower that I built myself. There is no wastage!"*			

Impact of trials

Table A-38 Did you manage to do this? (Q/2B Wave 2)

'Go Green' (q4)	*(n=22)*	**'Go Gold'** (q6)	*(n=22)*
Yes - for all showers	9 [40.1%]	Yes	14 [63.6%]
Yes - for some showers	8 [36.4%]	No	8 [36.4%]
No	5 [22.7%]		
Other	0 [0.0%]		

Table A-39 Has shower duration changed as a result of the trial?

Q/1 Wave 1 (q5a) *(n=19)*	**Q/2B** Wave 2 (q9) *(n=22)*
q5a. Has this changed since the trial?	**q9. During the trial, did the DURATION of your shower change?**
Yes = 3 [15.8%]	Decreased time in the shower = 4 [18.2%]
	Increased time in the shower = 4 [18.2%]
No =11 [57.9%]	No change – stayed the same = 10 [45.5%]
Don't know = 5 [26.3%]	Other = 4 [18.2%]
q5ai If yes, please describe how this has changed:	**q9a. If you selected Other, please specify:)**
"I have shortened my showers" *"I was more aware of the time I was spending in the shower"* *"By few more minutes less shower"*	*"It varied throughout"* *"It fluctuated, some shower I decreased in time others it increased"* *"varied"* *"Fluctuated slightly"*

Table A-40 Changes to shower dimensions (Q/2B Wave 2)

Changes to shower dimensions (Q/2B Wave 2)	**Yes**		**No change -stayed the same**	**Other**
During the trial: *(n=22)*	**decreased**	**increased**		
q9. Did the DURATION of your shower change?	4 [18.2%]	4 [18.2%]	10 [45.5%]	4 [18.2%]
q10. Did the FREQUENCY change?	6 [27.3%]	1 [4.5%]	14 [63.6%]	1[1] [4.5%]
q11. Did the TIME-OF-DAY change?	2 [9.1%]		19 [86.4%]	1[2] [4.5%]
q12. Did you change the FLOW RATE?	7 [31.8%]	0 [0.0%]	15 [68.2%]	0 [0.0%]
q13. Did you change any of the ACTIVITIES?	7 [31.8%]		15 [68.2%]	0 [0.0%]
q14. Did the number of different personal shower PRODUCTS change?	9 [40.9%]	0 [0.0%]	13 [59.1%]	0 [0.0%]

[1]*"I accidentally showered twice in one day, but other than that it didn't change - I had to shower in the morning after a very long weekend and forgot I had had one that morning. It was a very long day."*
[2]*"Don't have a select time I shower"*

Table A-41 Which in-shower activity do you think has the greatest impact on…

Q/2B Wave 2 *(n=22)*	**Duration** (q13c) *(i.e., which takes the longest)?*	**Frequency** (q13d) *(i.e., which makes you shower more often)?*	**Flow rate** (q13e) *(i.e., which makes you adjust the flow rate)?*
Shampoo hair;	6 [27.3%]	9 [40.9%]	6 [27.3%]
Condition hair;	2 [9.1%]	0 [0.0%]	3 [13.6%]
Wash body	5 [22.7%]	12 [54.5%]	4 [18.1%
Wash face	0 [0.0%]	1 [4.5%]	1 [4.5%]
Shave	7 [31.8%]	0 [0.0%]	0 [0.0%]
Face-pack	1 [4.5%]	0 [0.0%]	0 [0.0%]
Other[1]	1 [4.5%]	0 [0.0%]	8 [36.4%]
[1] q13xi If you selected Other, please specify:	*"Thinking about life"*		*"personal preference"* *"I dont* [sic] *adjust the flow rate"* *"None, I keep the flow the same"* *"none really matter to me, i usually increase the flow rate if i'm very cold though"* *"always on max"*

Table A-42 As a result of the [Wave 2] trial, will you be making any changes to your shower routine in the future? In what way?

Q/2B Wave 2 *(n=22)* **Plans to change shower routine**	**Higher/more** (q15.1)	**Same - no change** (q15.2)	**Fewer/less/lower** (q15.3)
Duration	0 [0.0%]	11 [50.0%]	11 [50.0%]
Frequency	0 [0.0%]	15 [68.2%]	5 [22.7%]
Flow rate	0 [0.0%]	13 [59.1%]	8 [36.4%]
In-shower activities	0 [0.0%]	17 [77.3%]	3 [13.6%]
In-shower products	0 [0.0%]	14 [63.6%]	7 [31.8%]
Recycle empty product containers	14 [63.6%]	5 [22.7%]	2 [9.1%]

C.1.3 Other water using practices

Laundry

Table A-43 How many loads of personal laundry loads do you do in an average week?

Laundry loads per week	**Q/0** Wave 0 (q11)			**Q/1** Wave 1	**Q/2A** Wave 2
	On campus *(n=90)*	**Off site** *(n=66)*	**All** *(n=156)*	(q11) *(n=19)*	(q17) *(n=23)*
Less than one	15 [16.7%]	6 [9.1%]	21 [13.5%]	5 [26.3%]	5 [21.7%]
One	57 [63.3%]	36 [54.5%]	93 [59.6%]	13 [68.4%]	9 [39.1%]
Between one and two	16 [17.8%]	17 [25.8%]	33 [21.2%]	1 [5.3%]	9 [39.1%]
Three	2 [2.2%]	5 [7.6%]	7 [4.5%]	0 [0.0%]	0 [0.0%]
Four	0 [0.0%]	2 [3.0%]	2 [1.3%]	0 [0.0%]	0 [0.0%]

Table A-44 How often do you change and launder your bed sheets?

Bed sheet laundry	**Q/0** Wave 0 (q12)			**Q/1** Wave 1	**Q/2A** Wave 2
	On campus *(n=90)*	**Off site** *(n=66)*	**All** *(n=156)*	(q12) *(n=19)*	(q18) *(n=23)*
Weekly	9 [10.0%]	7 [10.6%]	16 [10.3%	1 [5.3%]	9 [39.1%]
Fortnightly	37 [41.1%]	28 [42.4%]	65 [41.7%]	10 [52.6%]	5 [21.7%]
Every 3 weeks				2 [10.5%]	2 [8.7%]
Monthly	36 [40.0%]	22 [33.3%]	58 [37.2%]	5 [26.3%]	6 [26.1%]
Termly	5 [5.6%]	8 [12.1%]	13 [8.3%]	1 [5.3%]	1 [4.3%]
Other[1]	3 [3.3%]	1 [1.5%]	4 [2.6%]	0 [0.0%]	0 [0.0%]
[1] q12a. If you selected Other, please specify:	*"Like every month and a half"* *"Every 3 weeks"* *Every three weeks"*	*"Quarterly"*			

Table A-45 How often do you use fresh/clean towels?

Fresh clean towels	**Q/0** Wave 0 (q13)			**Q/1** Wave 1	**Q/2A** Wave 2
	On campus *(n=90)*	**Off site** *(n=66)*	**All** *(n=156)*	(q13) *(n=19)*	(q19) *(n=23)*
Daily	3 [3.3%]	1 [1.5%]	4 [2.6%]	0 [0.0%]	2 [8.7%]
Twice a week				1 [5.3%]	5 [21.7%]
Weekly	40 [44.4%]	23 [34.8%]	63 [40.4%]	8 [42.1%]	10 [43.5%]
Fortnightly	31 [34.4%]	23 [34.8%]	54 [34.6%]	6 [31.6%]	4 [17.4%]
Monthly	14 [15.6%]	16 [24.2%]	30 [19.2%]	4 [21.1%]	2 [8.7%]
Termly	2 [2.2%]	1 [1.5%]	3 [1.9%]	0 [0.0%]	0 [0.0%]
Other[1]	0 [0.0%]	2 [3.0%]	2 [1.3%]	0 [0.0%]	0 [0.0%]
[1] 13.a. If you selected Other, please specify:		*"Quarterly"* *"3 days"*			

Table A-46 How many times do you typically wear a pair of jeans before laundering them?

Jeans wears between laundering	**Q/0** Wave 0 (q14)			**Q/1** Wave 1	**Q/2A** Wave 2
	On campus *(n=90)*	**Off site** *(n=66)*	**All** *(n=156)*	(q14) *(n=19)*	(q20) *(n=23)*
Once or twice	12 [13.3%]	4 [6.1%]	16 [10.3%]	2 [10.5%]	4 [17.4%]
Three or four times	34 [37.8%]	13 [19.7%]	47 [30.1%]	6 [31.6%]	4 [17.4%]
Up to weekly (x5-7 days)	8 [8.9%]	7 [10.6%]	15[9.6%]	2 [10.5%]	5 [21.7%]
Ten times	3 [3.3%]	2 [3.0%]	5 [3.2%]	0 [0.0%]	0 [0.0%]
Two weeks	1 [1.1%]	0 [0.0%]	1 [0.6%]	1 [5.3%]	1 [4.3%]
Monthly	0 [0.0%]	0 [0.0%]	0[0.0%]	1 [5.3%]	0 [0.0%]
Two monthly	0 [0.0%]	1 [1.5%]	1 [0.6%]	0 [0.0%]	0 [0.0%]
Until they get dirty/smelly	32 [35.6%]	37 [56.1%]	69 [44.2%]	7 [36.8%]	9 [39.1%]
Never	0 [0.0%]	1 [1.5%]	1 [0.6%]	0 [0.0%]	0 [0.0%]

Washing-up

Table A-47 How often do you wash-up your cooking pans and dirty dishes?

Washing-up frequency	**Q/0** Wave 0 (q15)			**Q/1** Wave 1	**Q/2A** Wave 2
	On campus *(n=90)*	**Off site** *(n=66)*	**All** *(n=156)*	(q15) *(n=19)*	(q21) *(n=23)*
Once per day	23 [25.6%]	25 [37.9%]	48 [30.8%]	5 [26.3%]	4 [17.4%]
Up to 3 times per day (after every meal) 2 or 3 times per day (after every meal)	54[2] [60.0%]	29 [43.9%]	83 [53.2%]	 14 [73.7%]	 17[3] [73.9%]
When I have run out of clean pans/dishes	8 [8.9%]	1 [1.5%]	9 [5.8%]	0 [0.0%]	1 [4.3%]
When my housemates complain	2 [2.2%]	0 [0.0%]	2 [1.3%]	0 [0.0%]	0 [0.0%]
Other[1]	3 [3.3%]	4 [6.1%]	7 [4.5%]	0 [0.0%]	1 [4.3%]
[1]a. If you selected Other, please specify:	*"1/2 times a day (I only have 1 or 2 meals)"* *"Got no pans or dishes of my own"* *"Whenever I cook(it can change every day)"* [2]*"I only have one set of dishes. My flatmates leave the water running when they do their dishes so I prefer to do it myself to save water."*	*"Everyone in the house takes it in turns to do all the washing up - this happens 3-4 times per week"* *"Twice a day"* *"once every day or 2 days"* *"When the dishwasher becomes fully loaded"*			*"I wash as I go"* [3]*"The second i finisg"* [sic]

Table A-48 Do you usually wash-up just your own dishes or do you take it in turns with your housemates to wash up communally?

Washing-up style	**Q/0** Wave 0 (q16)			**Q/1** Wave 1	**Q/2A** Wave 2
	On campus *(n=90)*	**Off site** *(n=66)*	**All** *(n=156)*	(q16) *(n=19)*	(q22) *(n=23)*
Communal washing-up	4 [4.4%]	13 [19.7%]	17 [10.9%]	0 [0.0%]	0 [0.0%]
Just my own dishes	60 [66.7%]	32 [48.5%]	92 [59.0%]	16 [84.2%]	19 [82.6%]
A mix of both	26 [28.9%]	21 [31.8%]	47 [30.1%]	3 [15.8%]	3 [13.0%]
Other[1]	0 [0.0%]	0 [0.0%]	0 [0.0%]	0 [0.0%]	1 [4.3%]
[1]a. If you selected Other, please specify:					*"In my uni house share i dont concern myself with other peoples things, at my house share back in swansea, ill wash up whatever i see jn the sink ehen* [sic] *i pass it"*

Table A-49 How do you usually wash-up your dishes?

Washing-up process	**Q/0** Wave 0 (q17)			**Q/1** Wave 1	**Q/2A** Wave 2
	On campus *(n=90)*	**Off site** *(n=66)*	**All** *(n=156)*	(q17) *(n=19)*	(q23) *(n=23)*
In a washing-up bowl	43 [47.8%]	21 [31.8%]	43 [27.6%]	5 [26.3%]	9 [39.1%]
In the dishwasher	0 [0.0%]	9 [13.6%]	9 [5.8%]	0 [0.0%]	0 [0.0%]
In the sink with the plug in	15 [16.7%]	13 [19.7%]	28 [17.9%]	0 [0.0%]	2 [8.6%]
Under a running tap	31 [34.4%]	22 [33.3%]	53 [34.0%]	12 [63.2%]	11 [47.8%]
Other[1]	1 [1.1%]	1 [1.5%]	2 [1.3%]	2 [10.5%]	1 [4.3%]
[1]a. If you selected Other, please specify:	*"in the sink only"*	*"Dishwasher & Intermittant* [sic]*Tap"*		*"I briefly rinse my dishes. 2. I soap my dishes. 3. I rinse them for the final time."* *"wash them with soap first then rinse all at once"*	*"If i have a lot in the sink with a plug. If one or two things i run the tap."*

Table A-50 Does your family own a dishwasher?

Family dishwasher ownership	**Q/0** Wave 0 (q28)			**Q/1** Wave 1	**Q/2A** Wave 2
	On campus *(n=90)*	**Off site** *(n=66)*	**All** *(n=156)*	(q28) *(n=19)*	(q34) *(n=23)*
Yes	47 [52.2%]	44 [66.7%]	91 [58.3%]	9 [47.4%]	15 [65.2%]
No	43 [47.8%]	22 [33.3%]	65 [41.7%]	10 [52.6%]	8 [34.8%]

C.1.4 Infrastructure and life at home

Meters

Table A-51 Is there a water meter at home

Water meter at home		*n=*	Yes	No	Don't know
Q/0 Wave 0 (q29)	**On campus**				
	UK	*60*	30 [50.0%]	15 [25.0%]	15 [25.0%]
	UK - from south or east England	*25*	14 [56.0%]	5 [20.5%]	6 [24.0%]
	International	*30*	19 [63.3%]	7 [23.3%]	4 [13.3%]
	Total	*90*	*49 [54.4%]*	*22 [24.4%]*	*19 [21.1%]*
	Off site				
	UK	*59*	26 [44.1%]	19 [32.2%]	14 [23.7%]
	UK - from south or east England	*39*	21 [53.8%]	8 [20.5%]	10 [25.6%]
	International	*7*	7 [10.6%]	0 [0.0%]	0 [0.0%]
	Total	*66*	*33 [50.0%*	*19 [28.8%]*	*14 [21.2%]*
	All				
	UK	*119*	56 [47.1%]	34 [28.6%]	29 [24.4%]
	UK - from south or east England	*64*	35 [54.7%]	13 [20.3%]	16 [25.0%]
	International	*37*	26 [70.3%]	7 [18.9%]	4 [10.8%]
	Total	*156*	82 [52.6%]	41 [26.3%]	33 [21.2%]
Q/1 Wave 1 (q29)	UK	*15*	5 [33.3%]	5 [33.3%]	5 [33.3%]
	UK - from south or east England	*6*	1 [16.7%]	2 [33.3%]	3 [50.0%]
	International	*4*	4 [100%]	0 [0.0%]	0 [0.0%]
	All	***19***	**9 [47.4%]**	**5 [26.3%]**	**5 [26.3%]**
Q/2A Wave 2 (q35)	UK	*19*	10 [52.6%]	3 [15.8%]	6 [31.6%]
	UK - from south or east England	*8*	2 [25.0%]	2 [25.0%]	4 [50.0%]
	International	*4*	2 [50.0%]	2]50.0%]	0 [0.0%]
	All	***23***	**12 [52.2%]**	**5 [21.7%]**	**6 [26.1%]**

Water quality

Table A-52 Is the water at home: hard or soft?

	Water quality at home	*n=*	Hard	Soft	Don't know
Q/0 Wave 0 (q30)	**On campus**				
	UK	*60*	21 [35.0%]	22 [36.7%]	17 [28.3%]
	UK - from south or east England	*25*	12 [48.0%]	7 [28.0%]	6 [24.0%]
	International	*30*	5 [16.7%]	11 [36.7%]	14 [46.7%]
	Total	*90*	*26 [28.9%]*	*33 [36.7%]*	*31 [34.4%]*
	Off site				
	UK	*59*	27 [45.8%]	16 [27.1%]	16 [27.1%]
	UK - from south or east England	*39*	23 [59.0%]	8 [20.5%]	8 [20.5%]
	International	*7*	4 [57.1%]	1 [14.3%]	2 [28.6%]
	Total	*66*	*31 [*	*17 [*	*18 [*
	All				
	UK	*119*	48 [40.3%]	38 [31.9%]	33 [27.7%]
	UK - from south or east England	*64*	35 [54.7%]	15 [23.4%]	14 [21.9%]
	International	*37*	9 [24.3%]	12 [32.4%]	16 [43.2%
	Total	*156*	*57 [36.5%]*	*50 [32.1%]*	*49 [31.4%]*
Q/1 Wave 1 (q30)	UK	*15*	6 [40.0%]	7 [46.7%]	2 [13.3%]
	UK - from south or east England	*6*	4 [66.7%]	1 [16.7%]	1 [16.7%]
	International	*4*	1 [25.0%]	3 [75.0%]	0 [0.0%]
	All	***19***	**7 [36.8%]**	**10 [52.6%]**	**2 [10.5%]**
Q/2A Wave 2 (q36)	UK	*19*	6 [31.6%]	8 [42.1%]	5 [26.3%]
	UK - from south or east England	*8*	4 [50.0%]	1 [12.5%]	3 [37.5%]
	International	*4*	1 [25.0%]	0 [0.0%]	3 [75.0%]
	All	***23***	**7 [30.4%]**	**8 [34.8%]**	**8 [34.8%]**

House era

Table A-53 Approximately in which era was your [parental] home built?

Era of family home	**Q/0** Wave 0 (q20)					**Q/1** Wave 1 (q20)	**Q/2A** Wave 2 (q26)
	On campus *(n=90)*	**Off-site** *(n=66)*	**UK** *(n=119)*	**International** *(n=37)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
Pre 1960s	18 [20.0%]	23 [34.8%]	37 [31.1%]	4 [10.8%]	41 [26.3%]	3 [15.8%]	1 [4.3%]
1960-79	15 [16.7%]	13 [19.7%]	25 [21.0%]	3 [8.1%]	28 [17.9%]	2 [10.5%]	2 [8.7%]
1980-99	26 [28.9%]	14 [21.2%]	25 [21.0%]	15 [40.5%]	40 [25.6%]	1 [5.3%]	4 [17.4%]
Since 2000	21 [23.3%]7	10 [15.2%]	20 [16.8%]	11 [29.7%]	31 [19.9%]	7 [36.8%]	6 [26.1%]
Don't know	7 [7.8%]	5 [7.6%]	11 [9.2%]	1 [2.7%]	12 [7.7%]	6 [31.6%]	10 [43.5%]
Other[1]	3 [3.3%]	1 [1.5%]	1 [0.8%]	3 [8.1%]	4 [2.6%]	0[2] [0.0%]	0[2] [0.0%]
[1]a. If you selected Other, specify:	None provided					*[2]Responses given ("2014+" and "1901") allowed appropriate allocation to categories*	*[2] Response given ("it's a new building. It was built before 2 years") allowed appropriate allocation*

Bathrooms

Table A-54 How many bathrooms/en suites/shower rooms are there at home?

Number of bathrooms	**Q/0** Wave 0 (q26)					**Q/1** Wave 1 (q26) *(n=19)*	**Q/2A** Wave 2 (q32) *(n=23)*
	On campus *(n=90)*	**Off-site** *(n=66)*	**UK** *(n=119)*	**International** *(n=37)*	**All** *(n=156)*		
1	32 [35.6%]	27 [40.9%]	52 [43.7%]	7 [18.9%]	59 [37.5%]	7 [36.8%]	11 [47.8%]
2	27 [30.0%]	26 [39.4%]	41 [34.5%]	12 [32.4%]	53 [34.0%]	5 [26.3%]	5 [21.7%]
3	23 [25.6%]	9 [13.6%]	20 [16.8%]	12 [32.4%]	32 [20.5%]	5 [26.35}	4 [17.4%]
4	5 [5.6%]	3 [4.5%]	3 [2.5%]	5 [13.5%]	8 [5.1%]	1 [5.3%]	2 [8.7%]
More than 4	3 [3.3%]	1 [1.5%]	3 [2.5%]	1 [2.7%]	4 [2.6%]	1 [5.3%]	1 [4.3%]

Shower fixtures

Table A-55 What type of showers are installed at home?

Type of shower fixtures	**Q/0** Wave 0 (q27)					**Q/1** Wave 1 (q27)	**Q/2A** Wave 2 (q33)
	On campus *(n=90)*	**Off-site** *(n=66)*	**UK** *(n=119)*	**International** *(n=37)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
Electric (cord or switch to turn on)	36 [40.0%]	26 [39.4%]	54 [45.4%]	8 [21.6%]	62 [39.7%]	7 [36.8%]	9 [39.1%]
Over-bath mixer (hose comes from bath mixer tap)	22 [24.4%]	28 [42.4%]	37 [31.1%]	13 [35.1%]	50 [32.1%]	8 [42.1%]	8 [34.8%]
Power-shower (high pressure/flow)	23 [25.6%]	21 [31.8%]	32 [26.9%]	12 [32.4%]	44 [28.2%]	4 [21.1%]	8 [34.8%]
Separate shower cubicle	29 [32.2%]	19 [28.8%]	39 [32.8%]	9 [24.3%]	48 [30.8%]	5 26.3%]	4 [17.4%]
Wet room	5 [5.6%]	2 [3.0%]	5 [4.3%]	2 [5.4%]	7 [4.5%]	0 [0.0%]	2 [8.7%]
Other[1]	2 [2.2%]	0 [0.0%]	1 [0.8%]	1 [2.7%]	2 [1.3%]	0 [0.0%]	0 [0.0%]
None	3 [3.3%]	0 [0.0%]	2 [1.7%]	1 [2.7%]	3 [1.9%]	0 [0.0%]	0 [0.0%]
[1]a. If you selected Other, please specify:	*"Dont know how to describe. But water is heated by solar panels". "Bath"*		*"Bath"*	*"Dont know how to describe. But water is heated by solar panels". "Bath"*	*"Dont know how to describe. But water is heated by solar panels". "Bath"*		
Sum is >n							

Influence over shower routine

Table A-56 On reflection, who has most influence over your showering routine at UWE?

Q/2A Wave 2 (q37)	*(n=23)*
My family upbringing	4 [17.4%]
My peers	0 [0.0%]
My own self-autonomy, not my family or my peers	19 [82.6%]
Other	[0.0%]

C.1.5 Occupancy

Table A-57 On average, how many hours (per 24 hours) do you spend in your student accommodation on weekdays, including sleep?

Weekday hours	**Q/0** Wave 0 (q37)					**Q/1** Wave 1 (q36) *(n=19)*	**Q/2A** Wave 2 (q45) *(n=23)*
	On campus *(n=90)*	**Off site** *(n=66)*	**UK** *(n=119)*	**International** *(n=37)*	**All** *(n-=156)*		
Up to 10 hours	10 [11.1%]	5 [7.6%]	9 [7.6%]	6 [16.2%]	15 [9.6%]	1 [5.3%]	1 [4.3%]
10-15 hours	35 [38.9%]	35 [53.0%]	54 [45.4%]	16 [43.2%]	70 [44.9%]	7 [36.8%]	13 [56.5%]
16-20 hours	34 [37.8%]	16 [24.2%]	39 [32.8%]	11 [29.7%]	50 [32.1%]	9 [47.4%]	6 [26.1%]
20+ hours	10 [10.1%]	7 [10.6%]	14 [11.8%]	3 [8.1%]	17 [10.9%]	2 [10.5%]	2 [8.7%]
Other[1]	1 [1.1%]	3 [4.5%]	3 [2.5%]	1 [2.7%]	4 [2.6%]	0 [0.0%]	1 [4.3%]
[1]a. If you selected Other, please specify:	*"6hours"*	*"don't live in accommodation"* *"Private"* *Student accommodation is also my home - probably 10-15 hours"*		*"6hours"*			*"Not many, only to sleep"*

Table A-58 Do you tend to stay at UWE at the weekend, or go away?

Weekend occupancy	**Q/0** Wave 0 (q38)					**Q/1** Wave 1	**Q/2A** Wave 2
	On campus *(n=90)*	**Off site** *(n=66)*	**UK** *(n=119)*	**International** *(n=37)*	**All** *(n-=156)*	(q37) *(n=19)*	(q46) *(n=23)*
Stay at UWE most weekends	65 [72.2%]	36 [54.5%]	73 [61.3%]	28 [75.7%]	101 [64.7%]	14 [73.7%]	18 [78.3%]
About 2 weekends in 4	17 [18.9%]	14 [21.2%]	27 [22.7%]	4 [10.8%]	31 [19.9%]	4 [21.1%]	4 [17.4%]
Go away most weekends	7 [7.8%]	6 [9.1%]	8 [6.7%]	5 [13.5%]	13 [8.3%]	1 [5.3%]	1 [4.3%]
Other[1]	1 [1.1%]	10 [15.2%]	11 [9.2%]	0 [0.0%]	11 [7.1%]	0 [0.0%]	0 ‘[0.0%]
[1]a. If you selected Other, please specify:	*“Go home once a month”* [UK]	“i private rent” “Permanently residing in Bristol” “varies throughout term time” “Private” “I live in my home both in and out of term time. It is my permanent residence, off campus “Stay at uni in Brighton” “Live in bristol” “I live in Gloucester, so I commute home daily.” “i live at home not uwe” “Stay at home address - 1 in 4 visit family elsewhere”					

C.1.6 Socio-demographics

Gender

Table A-59 Sex profile of students living in university campus accommodation (source: UWE Accommodation Services department)

Year	**2015/16** Wave 0 *as of 30-Nov-15*	**2016/17** Wave 0 *as of 30-Nov-16*	**2017/18** Wave 0/1 *as of 27-Mar-18*	**2018/19** Wave 2 *as of 28-Sep-18*
Location	*Student Village*	*WCP1*	*WCP1*	*WCP1*
Female	805 [42.2%]	223 [56.4%]	215 [54.6%]	225 [58.0%
Male	1104 [57.8%]	172 [43.5%]	179 [45.4%]	163 [42.0%]
Total	**1909**	**395**	**394**	**388**

Table A-60 Sex profile of students living in WCP1 study houses A-L (source: UWE Accommodation Services department)

Year	**2016/17** Wave 0 *as of 30-Nov-16*	**2017/18** Wave 0/1 *as of 27-Mar-18*	**2018/19** Wave 2 *as of 28-Sep-18*
Female	62 [63.3%]	60 [60.6%]	40 [44.0%]
Male	36 [36.7%]	39 [39.4%]	51 [56.0%]
Total	**98**	**99**	**91**

Table A-61 What is your gender?

Age (years)	**Q/0** Wave 0 (q40)			**Q/1** Wave 1 (q39)	**Q/2A** Wave 2 (q48)
	On campus *(n=90)*	**Off-site** *(n=66)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
Female	60 [66.7%]	42 [63.6%]	102 [65.4%]	15 [78.9%]	12 [52.2%]
Male	29 [32.2%]	23 [34.8%]	52 [33.3%]	4 [21.1%]	11 [47.8%]
Other	1 [1.1%]	1 [1.5%]	2 [1.3%]	0 [0.0%]	0 [0.0%]
	"Non-binary"	*"Non-binary"*			

Age

Students living in campus accommodation are more likely to be younger, in their first year living away from home, and taking their first steps into autonomous, independent adulthood. A snapshot of age data provided by the university Accommodation Services department is summarised in Table A-62 for comparison with the Q/0 survey age and year of study responses (Table A-63 and Table A-66). Both sources confirm that most students living in university accommodation are aged 18-22 years (between 92-95%), compared with 71% of off-site respondents in this age bracket. The average (mean) age of all Q/0 respondents was 20.8 years, whilst the median was 20, and mode was 18 years. Split by accommodation location, respondents living on campus were younger (mean 19.7 years, median 19 years, and, mode 18 years) compared with off-site housing (mean 22.7 year, median 21 years, and mode 20 years). A review of the year of study indicated that 55% of all Q/0 respondents were first year students, rising to 80.0% of those living on campus.

Table A-62 Age profile of students living in university campus accommodation (source: UWE Accommodation Services department)

Year	**2015/16** Wave 0 *as of 30-Nov-15*	**2016/17** Wave 0 *as of 30-Nov-16*	**2017/18** Wave 0/1 *as of 27-Mar-18*	**2018/19** Wave 2 *as of 28-Sep-18*
Location	*Student Village*	*WCP1*	*WCP1*	*WCP1*
Under 18	29 [1.5%]*	0 [0.0%]	0 [0.0%]	4 [1.0%]
18-22	1,755 [91.9%]	371 [93.9%]	366 [92.9%]	369 [95.1%]
23-29	113 [5.9%]	23 [5.8%]	25 [6.3%]	15 [3.9%]
30+ years	12 [0.6%]	1 [0.3%]	3 [0.8%]	0 [0.0%]
Total	**1,909**	**395**	**394**	**388**
**The under 18s in the Student Village are likely to be students with the Kaplan International School*				

Table A-63 What is your age (in years)?

Age (years)	**Q/0** Wave 0 (q39)			**Q/1** Wave 1 (q38)	**Q/2A** Wave 2 (q47)
	On campus *(n=90)*	**Off-site** *(n=66)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
18-22	83 [92.2%]	47 [71.2%]	130 [83.3%]	16 [84.2%]	23 [100.0%]
23-29	7 [7.8%]	15 [22.7%]	22 [14.1%]	3 [15.8%]	0 [0.0%]
30+ years	0 [0.0%]	4 [6.1%]	4 [2.6%]	0 [0.0%]	0 [0.0%]
Mean	*19.7*	*22.3*	*20.8*	*20.3*	*19.8*
Median	*19*	*21*	*20*	*20*	*20*
Minimum	*18*	*18*	*18*	*18*	*18*
Maximum	*29*	*47*	*47*	*25*	*22*

The participants in Wave 1 were slightly older than Wave 0, but this, in part, reflects the time of year that the surveys were conducted, with Q/0 early in the new academic year in October 2017 and Q/1 (Wave 1) some five months later in March 2018, within the same academic year and capturing the same cohort of students. The mean age from Q/1 was 20.3 years, compared with 19.7 years for Q/0, with a median of 20 instead of 19 years. However, 84% were aged 18-22 years, compared with 92% in this age bracket for Q/0, and 93% across WCP1 reported by the university Accommodation Service (in March 2018).

University course

Table A-64 What type of course are you studying?

Level of course	**Q/0** Wave 0 (q33)			**Q/1** Wave 1 (q32)	**Q/2A** Wave 2 (q41)
	On campus *(n=90)*	**Off site** *(n=66)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
Foundation	6 [6.7%]	4 [6.1%]	10 [6.4%]	2 [10.5%]	1 [4.3%]
Undergraduate (Bachelors)	78 [86.7%]	58 [87.9%]	136 [87.2%]	16 [84.2%]	20 [87.0%]
Postgraduate (Masters or Doctorate)	6 [6.7%]	4 [6.1%]	10 [6.4%]	1 [5.3%]	2 [8.7%]

Table A-65 Which faculty are you based in?

Faculty	**Q/0** Wave 0 (q34)			**Q/1** Wave 1 (q33)	**Q/2A** Wave 2 (q42)
	On campus *(n=90)*	**Off site** *(n=66)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
Arts, Creative Industries & Education	9 [10.0%]	3 [4.5%]	12 [7.7%]	2 [10.5%]	1 [4.3%]
Business & Law	33 [36.7%]	11 [16.7%]	44 [28.2%]	7 [36.8%]	7 [30.4%]
Environment & Technology	31 [34.4%]	30 [45.5%]	61 [39.1%]	5 [26.3%]	7 [30.4%]
Health & Applied Sciences	14 [15.6%]	21 [31.8%]	35 [22.4%]	5 [26.3%]	7 [30.4%]
Other[1]	3 [3.3%]	1 [1.5%]	4 [2.6%]	0 [0.0%]	1 [4.3%]
[1]a. If you selected Other, please specify:	*"Philosophy. Not quite sure what that fits under"* *"Engineering"* *"Psychology with Criminolohy* [sic]*"*	*"Engineering"*			*"Social Sciences"*

Table A-66 What year of your course are you in?

Year of study	**Q/0** Wave 0 (q35)			**Q/1** Wave 1 (q34)	**Q/2A** Wave 2 (q43)
	On campus *(n=90)*	**Off site** *(n=66)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
First	72 [80.0%]	14 [21.2%]	86 [55.1%]	13 [68.4%]	18 [78.3%]
Second	3 [3.3%]	26 [39.4%]	29 [18.6%]	3 [15.8%]	3 [13.0%]
Third	11 [12.2%]	19 [28.8%]	30 [19.2%]	1 [5.3%]	1 [4.3%]
Fourth	2 [2.2%]	6 [9.1%]	8 [5.1%]	0 [0.0%]	0 [0.0%]
Other[1]	2 [2.2%]	1 [1.5%]	3 [1.9%]	2 [10.5%]	1 [4.3%]
[1]If you selected Other, please specify:	*BPTC Full time"* *"Master"*	*"Foundation"*		*"BPTC Bar Professional Training Course"* *"Foundation"*	"0"

Nationality and religion

A snapshot of nationality data from the university Accommodation Service is summarised in Table A-67, whilst responses to the survey question on where the students came from (UK town or country) is shown in Table A-68. Table A-68 shows that more than three quarters (76.3%) of Q/0 respondents (question 19) were from the UK. However, split by accommodation location, it was apparent that overseas students tended to opt to live in university halls (33% of residents compared with 11% of off-site accommodation). The university supplied data (Table A-67) shows that 82.2% of WCP1 residents were from the UK in 2017/18 (the same period that the survey was completed), with numbers ranging from 70 to almost 90% in any one year, and across the different accommodation developments. This indicates that the Q/0 questionnaire sample had a slightly higher response rate by overseas students than the known (on campus) resident population. However, for Wave1 the results indicate that there may have been an opposite recruitment bias with more UK-based participants (79%) compared with the 63.5% reported for houses A-L by the university Accommodation Services.

Table A-67 Wallscourt Park phase 1 - nationality (source: UWE Accommodation Services department)

Nationality	**2016/17** Wave 0 *as of 30-Nov-16*	**2017/18** Wave 0/1 *as of 27-Mar-18*	**2018/19** Wave 2 *as of 28-Sep-18*
WCP1 houses A-X	*n=395/404 [97.8%]*	*n=394/404 [97.5%]*	*n=388/404 [96.0%]*
UK	344 [87.8%]	324 [82.2%]	273 [70.4%]
Overseas	48 [12.2%]	70 [17.8%]	115 [29.6%]
Study site houses A-L	*n=98/104 [94.2%]*	*n=104/104 [100%]*	*n=96/104 [92.3%]*
UK	70 [71.4%]	66 [63.5%]	51 [53.1%]
Overseas	28 [28.6%]	38 [36.5%]	45 [46.9%

Table A-68 Which town (or country, if you are not from the UK) is home? (i.e., where you live with your family when not at UWE)

[Where] is home?	**Q/0** Wave 0 (q19)			**Q/1** Wave 1	**Q/2A** Wave 2
	On campus *(n=90)*	**Off-site** *(n=66)*	**All** *(n=156)*	(q19) *(n=19)*	(q25) *(n=23)*
UK	60 [66.7%]	59 [89.4%]	119 [76.3%]	15 [78.9%	19 [82.6%]
UK - from south or east England	24 [26.7%]	15 [22.7%]	39 [25.0%]	5 [26.3%]	7 [30.4%]
Overseas	30 [33.3%]	7 [10.6%]	37 [23.7%]	4 [21.1%]	4 [17.4%]

Table A-69 What is your ethnicity?

Ethnicity	**Q/0** Wave 0 (q43)			**Q/1** Wave 1 (q40) *(n=19)*	**Q/2A** Wave 2 (q49) *(n=23)*
	On campus *(n=90)*	**Off site** *(n=66)*	**All** *(n=156)*		
Arab	1 [1.1%]	0 [0.0%]	1 [0.6%]	0 [0.0%]	0 [0.0%]
Bangladeshi	0 [0.0%]	0 [0.0%]	0 [0.0%]	0 [0.0%]	1 [4.3%]
Black African	1 [1.1%]	3 [4.5%]	4 [2.6%]	2 [10.5%]	0 [0.0%]
Black Caribbean	1 [1.1%]	0 [0.0%]	1 [0.6%]	0 [0.0%]	0 [0.0%]
Chinese	11 [12.2%]	0 [0.0%]	11 [7.1%]	3 [15.8%]	0 [0.0%]
Gypsy/ traveller	1 [1.1%]	0 [0.0%]	1 [0.6%	0 [0.0%]	0 [0.0%]
Indian	3 [3.3%]	2 [3.0%]	5 [3.2%]	1 [5.3%]	0 [0.0%]
Other	1 [1.1%]	0 [0.0%]	1 [0.6%]	0 [0.0%]	0 [0.0%]
Other Asian background	5 [5.6%]	0 [0.0%]	5 [3.2%	0 [0.0%]	0 [0.0%]
Other Mixed background	6 [6.7%]	2 [3.0%]	8 [5.1%]	0 [0.0%]	1 [4.3%]
Pakistani	1 [1.1%]	0 [0.0%]	1 [0.6%]	0 [0.0%]	0 [0.0%]
Prefer not to say	0 [0.0%]	1 [1.5%]	1 [0.6%]	0 [0.0%]	0 [0.0%]
White	58 [64.4%]	58 [87.9%]	116 [74.4%]	13 [68.4%]	19 [82.6%]
White & Black African	1 [1.1%]	0 [0.0%]	1 [0.6%]	0 [0.0%]	0 [0.0%]

Table A-70 What is your religion?

Religion	**Q/0** Wave 0 (q44)			**Q/1** Wave 1 (q41)	**Q/2A** Wave 2 (q50)
	On campus *(n=90)*	**Off site** *(n=66)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
Buddhist	8 [8.9%]	0 [0.0%]	8 [5.1%]	1 [5.3%]	0 [0.0%]
Christian	26 [28.9%]	18 [27.3%]	44 [28.2%]	5 [26.3%]	4 [17.4%]
Hindu	2 [2.2%]	0 [0.0%]	2 [1.3%]	1 [5.3%]	0 [0.0%]
Muslim	4 [4.4%]	0 [0.0%]	4 [2.6%]	0 [0.0%]	0 [0.0%]
No religion	44 [48.9%]	34 [51.5%]	78 [50%]	9 [47.4%]	13 [56.5%]
Other[1]	1 [1.1%]	1 [1.5%]	2 [1.3%]	1 [5.3%]	1 [4.3%]
Prefer not to say	2 [2.2%]	5 [7.6%]	7 [4.5%]	1 [5.3%]	1 [4.3%]
Spiritual	3 [3.3%]	7 [10.6%]	10 [6.4%]	1[5.3%]	0 [0.0%]
[1]a. If you selected Other, please specify:	*"Russian orthodox"*	*"Believe in a higher power whatever that may be"*		*"Agnostic"*	*"Pagan"*

Table A-71 Do you practice your religion?

Religious practice	**Q/0** Wave 0 (q44b)			**Q/1** Wave 1 (q41b)	**Q/2A** Wave 2 (q50b)
	On campus *(n=90)*	**Off site** *(n=66)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
Yes Always	13 [14.4%]	13 [19.7%]	26 [16.7%]	4 [21.1%]	 1 [4.3%]
Sometimes	21 [23.3%]	7 [10.6%]	28 [17.9%]	2 [10.5%]	5 [21.7%]
No Never	23 [25.6%]	19 [28.8%]	42 [26.9%]	6 [31.6%]	 6 [26.1%]
Not applicable	33 [36.7%]	27 [40.9%]	60 [38.5%]	7 [36.8%]	7 [30.4%]

*Marital status and dependents *(Wave 0, only)*

Table A-72 What is your marital status? (Q/0 Wave 0, only – question 41)

Marital status	**On campus** *(n=90)*	**Off-site** *(n=66)*	**All** *(n=156)*
Single	87 [96.7%]	59 [89.4%]	146 [93.6%]
Married	0 [0.0%]	2 [3.0%]	2 [1.3%]
Widowed	0 [0.0%]	1 [1.5%]	1 [0.6%]
Other[1]	2 [2.2%]	4 [6.1%]	6 [3.8%]
Left blank	1 [1.1%]	0 [0.0%]	1 [0.6%]
[1]q41a. If you selected Other, please specify:	*"in a relationship"* *"Relationship"*	*"Commited* [sic] *"Living with partner"* *"Mated before awah* [sic]*."* *"Partner"*	

This question was not asked for Wave 1 or Wave 2 as it was assumed that all residents on campus were single.

Table A-73 Do you have any dependents? (Q/0 Wave 0, only) (question 42)

Dependents	**On campus** *(n=90)*	**Off-site** *(n=66)*	**All** *(n=156)*
Yes	0 [0.0%]	4 [6.1%]	4 [2.6%]
No	90 [100%]	61 [92.4%]	151 [96.8%]
Left blank	0 [0.0%]	1 [1.5%]	1 [0.6%]

This question was not asked for Wave 1 or Wave 2 as it was assumed that all residents on campus would have no dependents.

Parental/family home

Table A-74 How many people normally live at your home [parental] address (excluding you)?

Size of family	**Q/0** Wave 0 (q21)					**Q/1** Wave 1 (q21)	**Q/2A** Wave 2 (q27)
	On campus *(n=90)*	**Off-site** *(n=66)*	**UK** *(n=119)*	**International** *(n=37)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
0	0 [0.0%]	2 [3.0%]	2 [1.7%]	0 [0.0%]	2 [1.3%]	0 [0.0%]	0 [0.0%]
1	6 [6.7%]	8 [12.1%]	14 [11.8%]	0 [0.0%]	14 [9.0%]	3 [15.8%]	3 [13.0%]
2	13 [14.4%]	22 [33.3%]	30 [25.2%]	5 [13.5%]	35 [22.4%]	2 [10.5%]	6 [26.1%]
3	33 [36.7%]	16 [24.2%]	40 [33.6%]	9 [24.3%]	49 [31.4%]	8 [42.1%]	7 [30.4%]
4	20 [22.2%]	14 [21.2%]	22 [18.5%]	12 [32.4%]	34 [21.8%]	1 [5.3%]	3 [13.0%]
5	11 [12.2%]	2 [3.0%]	7 [5.9%]	6 [16.2%]	13 [8.3%]	4 [21.1%]	3 [13.0%]
More than 5	7 [7.8%]	2 [3.0%]	4 [3.4%]	5 [13.5%]	9 [5.8%]	1 [5.3%]	1 [4.3%]

Table A-75 How many of the people living at your family home are wage-earners?

Family wage-earners	**Q/0** Wave 0 (q22)					**Q/1** Wave 1 (q22)	**Q/2A** Wave 2 (q28)
	On campus *(n=90)*	**Off-site** *(n=66)*	**UK** *(n=119)*	**International** *(n=37)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
0	3 [3.3%]	3 [4.5%]	6 [5.0%]	0 [0.0%]	6 [3.8%]	0 [0.0%]	1 [4.3%]
1	21[23.3%]	19 [28.8%]	31 [26.1%]	9 [24.3%]	40 [25.6%]	6 [31.6%]	8 [34.8%]
2	41 [45.6%]	37 [56.1%]	60 [50.4%]	18 [48.6%]	78 [50.0%]	10 [52.6%]	10 [43.5%]
3	17 [18.9%]	5 [7.6%]	17 [14.3%]	5 [13.5%]	22 [14.1%]	2 [10.5%]	2 [8.7%]
4	4 [4.4%]	1 [1.5%]	3 [2.5%]	2 [5.4%]	5 [3.2%]	0 [0.0%]	2 [8.7%]
5	0 [0.0%]	0 [0.0%]	0 [0.0%]	0 [0.0%]	0 [0.0%]	0 [0.0%]	0 [0.0%]
More than 5	1 [1.1%]	0 [0.05]	0 [0.0%]	1 [2.7%]	1 [0.6%]	0 [0.0%]	0 [0.0%]
Left blank (not answered)	3 [3.3%]	1 [1.5%]	2 [1.7%]	2 [5.4%]	4 [2.6%]	1 [5.3%]	0 [0.0%]

Table A-76 What type of dwelling best describes your [parental] home?

Type of dwelling	**Q/0** Wave 0 (q23)					**Q/1** Wave 1 (q23)	**Q/2A** Wave 2 (q29)
	On campus *(n=90)*	**Off-site** *(n=66)*	**UK** *(n=119)*	**International** *(n=37)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
Detached	26 [28.9%]	25 [37.9%]	39 [32.8%]	12 [32.4%]	51 [32.7%]	5 [26.3%]	3 [13.0%]
Flat	12 [13.3%]	9 [13.6%]	9 [7.6%]	12[32.4%]	21 [13.5%]	1 [5.3%]	3 [13.0%]
Maisonette	3 [3.3%]	1 [1.5%]	1 [0.8%]	3 [8.1%]	4 [2.6%]	1 [5.3%]	0 [0.0%]
Semi-detached	32 [35.6%]	24 [36.4%]	47 [39.5%]	9 [24.3%]	56 [35.9%]	9 [47.4%]	10 [43.5%]
Terraced	17 [18.9%]	6 [9.1%]	22 [18.5%]	1 [2.7%]	23 [14.7%]	3 [15.8%]	End: 2 [8.7%] Mid: 5 [21.7%]
Left blank (not answered)	0 [0.0%]	1 [1.5%]	1 [0.8%]	0 [0.0%]	1 [0.6%]	0 [0.0%]	0 [0.0%]

Table A-77 What tenure is your [parental] home?

Type of tenure	**Q/0** Wave0 (q24)					**Q/1** Wave 1 (q24)	**Q/2A** Wave 2 (q30)
	On campus *(n=90)*	**Off-site** *(n=66)*	**UK** *(n=119)*	**International** *(n=37)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
Owner-occupied/mortgaged	64 [71.1%]	46 [69.7%]	83 [69.7%]	27 [73.0%]	110 [70.5%]	15 [78.9%]	15 [65.2%]
Private rented	13 [14.4%]	14 [21.2%]	21 [17.6%]	6 [16.2%]	27 [17.3%]	4 [21.1%]	5 [21.7%]
Social rented (e.g., Housing Association or council)	7 [7.8%]	5 [7.6%]	11 [9.2%]	1 [2.7%]	12 [7.7%]	0 [0.0%]	2 [8.7%]
Don't know	5 [5.6%]	1 [1.5%]	3 [2.5%]	3 [8.1%]	6 [3.8%]	0 [0.0%]	0 [0.0%]
Other[1]	1 [1.1%]	0 [0.0%]	1 [0.8%]	0 [0.0%]	1 [0.6%]	0 [0.0%]	1 [4.3%]
[1]a. If you selected Other, please specify:	*"Shared Ownership"*		*"Shared Ownership"*		*"Shared Ownership"*		*"flat belongs to my mother"*

Table A-78 How many bedrooms are there at home?

Number of bedrooms	**Q/0** Wave 0 (q25)					**Q/1** Wave 1 (q25)	**Q/2A** Wave 2 (q31)
	On campus *(n=90)*	**Off-site** *(n=66)*	**UK** *(n=119)*	**International** *(n=37)*	**All** *(n=156)*	*(n=19)*	*(n=23)*
1	2 [2.2%]	2 [3.0%]	2 [1.7%]	2 [5.4%]	4 [2.6%]	1 [5.3%]	1 [4.3%]
2	11 [12.2%]	11 [16.7%]	17 [14.3%]	5 [13.5%]	22 [14.1%]	5 [26.3%]	1 [4.3%]
3	39 [43.3%]	31 [47.0%]	56 [47.1%]	14 [37.8%]	70 [44.9%]	5 [26.3%]	10 [43.5%]
4	21 [23.3%]	16 [24.2%]	29 [24.4%]	8 [21.6%]	37 [23.7%]	5 [26.3%]	7 [30.4%]
5	12 [13.3%]	4 [6.1%]	12 [10.1%]	4 [10.8%]	16 [10.3%]	2 [10.5%]	4 [17.4%]
More than 5	5 [5.6%]	2 [3.0%]	3 [2.5%]	4 [10.8%]	7 [4.5%]	1 [5.3%]	0 [0.0%]

Hair type (Wave 2, only)

Table A-79 How would you describe your hair length, natural hair type and hair condition? (Q/2A Wave 2, only - question 16a, b, c)

Hair length, type, and condition	**Q/2A** Wave 2 *(n=23)*
q16a. How would you describe your hair length?	
Very short	1 [4.3%]
Short	10 [43.5%]
Mid-length (at shoulder)	7 [30.4%]
Long	5 [21.7%]
q16b. How would you describe your natural hair type?	
Straight	8 [34.8%]
Curly	3 [13.0%]
Kinky	3 [13.0%]
Wavy	8 [34.8%]
Other[1]	1 [4.3%]
[1]q16bi. If you selected Other, please specify:	*"I don't know"*
q16c. Would you describe your hair as:	
Dry	4 [17.4%]
Normal	14 [60.9%]
Greasy	4 [17.4%]
Other[2]	1 [4.3%]
[2]q16ci. If you selected Other, please specify:	*"Depends on the products used as alot* [sic] *of them dry my scalp really badly."*

Unsurprisingly, hair length was split down gendered lines, and most of the males reported *short* or *very short* hair and just two had *mid-length* (at the shoulder) hair, whilst most females had *mid-length* to l*ong* hair, with two in the *short* hair category.

Participant feedback on research

Table A-80 Would you like to make [do you have] any further comments about this survey or the topics of showering or water conservation?

Q/0 Wave 0 (q46)
"Could you send me information on the best ways to save water." *"Water-saving devices should be fitted on the taps/faucets/showerheads."* *"I have the feeling that the UK is behind Germany, e.g., in our home at use* [sic] *we use rain water to flush the toilets. Its collected in a tank in our backyard. The water is also heated with solar energy. I also want to add that I find it important that one turns off the water in the shower while shampooing, shaving etc. I missed that latter part in the survey."* *"All taps should have filter "* *"My shower is so low pressure that I only use it once a week after workout, it's not strong enough to wash my hair. I was my hair in the bath (with a jug) twice a week. It's concerns me the amount of water that myself and my housemates use by bathing often instead of showering! I have reported to UWE repairs and maintenance three times. It means it's hard for us to conserve water!"* *"Yes, I would like to offer some changes to be made in hostel accommodation facilities, in order to save more water. "*

"Not at the minute although I would like to take part in the research as it is a field which "I am interested in going into." *"Should change questi0n which asks if you stay at UWE most weekends to stay at your term time accommodation."* *"I use an eco shower head, which reduces water flow, reducing the amount of water I shower in. I use a washing machine with an eco cycle, a dishwasher with an eco cycle, and my metered water bill for my two bed home is £350 a year. I consider myself to be pretty responsible with water usage. My garden is watered from rainwater collected from the guttering. I have a soakaway in the garden, reducing water run off to the drainage system, and I believe myself to be environementally* [sic] *responsible"* *"Needs a option for people that live at home in their own house."*
Q/1 Wave 1 (q42)
"It's very interesting and I'm hoping it makes more people more aware of what their water usage is, and how it could affect the world." *"Thanks for making me more water aware!"* *"This was interesting! I look forward to the results…"* *"It gave me an insight into the different ways I could save water and how much water I actually use"* *"None, other than the entire affair has been handled very well by Karen, and I feel I confident that the study will yield tangible results."*
2Q/2A Wave 2 (q51)
"I would like to learn more about it" *"feel delighted to be a part of it"*
Q/2B Wave 2 (q16)
"Really enjoyed using new products and experimenting with my routine" *"It was fun and would love to participate in more surveys in the future!"* *"Maybe a different product designed to wash hair "* *"i think everyone should try to switch to a more sustainable way of showering or at least try "* *"I'm sorry for not doing it. Been busy and felt it was too late to start."* *"This experiment made me much more aware of my water consumption and I will focus on reducing this now2*

C.2 Showering types

C.2.1 Socio-demographics

Students living in campus accommodation are more likely to be younger, in their first year living away from home, and taking their first steps into autonomous, independent adulthood. A snapshot of age data provided by the university Accommodation Services department is summarised in Table A-62, and the questionnaire age and year of study responses are shown in Table A-63 and Table A-66. Both sources confirm that most students living in university accommodation are aged 18-22 years (between 92-95%), compared with 71% of off-site respondents in this age bracket. The average (mean) age of all Q/0 respondents was 20.8 years, whilst the median was 20, and mode was 18 years. Split by accommodation location, respondents living on campus were younger (mean = 19.7 years; median = 19 years; and, mode = 18 years) compared with off-site housing (mean 22.7 years, median 21 years, and mode 20 years). A review of the year of study indicates that 55% of all Q/0 respondents were first year students, rising to 80.0% of those living on campus.

The membership of the showering types that emerged from the cluster analysis of the Q/0 Wave responses were reviewed by a range of socio-demographic information. The results are shown in Table A-81 to Table A-86. The results indicate that socio demographics had little influence on the membership of the clusters, with the '*UWE standard' (cluster 2*) generally mirroring the sampled student population (Q/0 survey). For example, 65.4% of *all* the Q/0 students were female, whilst 66% of the cluster 2 cohort were female (Table A-81). Whilst the similarity in socio-demographics between the surveyed population and the cluster 2 membership may be a function of the *dominance* of the cluster 2 style of showering (90% of the sample), it suggests that *socio-demographics have little influence on the type* of showering routine followed.

Table A-81 Gender, by cluster

Gender (q40)	**All** *(n=156)*	**Cluster 1** *(n=13)*	**Cluster 2** *(n=141)*	**Cluster 3** *(n=2)*
Female	102 [65.4%]	8 [61.5%]	93 [66.0%]	1 [50%]
Male	52 [33.3%]	5 [38.5%]	46 [32.6%]	1 [50%]
Other	2 [1.3%]	0 [0.0%]	2 [1.4%]	0 [0%]

Table A-82 Nationality, by cluster

UK or overseas (q19)	**All** *(n=156)*	**Cluster 1** *(n=13)*	**Cluster 2** *(n=141)*	**Cluster 3** *(n=2)*
UK	119 [76.3%]	10 [76.9%]	108 [76.6%]	1 [50%]
Overseas	37 [23.7%]	3 [23.1%]	33 [23.4%]	1 [50%]

Table A-83 Parental dishwasher ownership, by cluster

Dishwasher (q28)	**All** *(n=156)*	**Cluster 1** *(n=13)*	**Cluster 2** *(n=141)*	**Cluster 3** *(n=2)*
Yes	91 [58.3%]	7 [53.8%]	83 [58.9%]	1 [50%]
No	65 [41.7%]	6 [46.2%]	58 [41.1%]	1 [50%]

Table A-84 Era of parental home, by cluster

Era of house (q20)	**All** *(n=156)*	**Cluster 1** *(n=13)*	**Cluster 2** *(n=141)*	**Cluster 3** *(n=2)*
Pre 1960s	41 [26.3%]	5 [38.5%]	36 [25.5%]	0 [0%]
1960-79	28 [17.9%]	6 [46.2%]	21 [14.9%]	1 [50%]
1980-99	40 [25.6%]	1 [7.7%]	39 [27.7%]	0 [0%]
Since 2000	31 [19.9%]	1 [7.7%]	30 [21.3%]	0 [0%]
Don't know	12 [7.7%]	0 [0.0%]	12 [8.5%]	0 [0%]
Other	4 [2.6%]	0 [0.0%]	3 [2.1%]	1 [50%]

Table A.85 Size of family, by cluster

Size of family (q21)	**All** *(n=156)*	**Cluster 1** *(n=13)*	**Cluster 2** *(n=141)*	**Cluster 3** *(n=2)*
0	2 [1.3%]	0 [0.0%]	2 [1.4%]	0 [0%]
1	14 [9.0%]	2 [15.4%]	12 [8.5%]	0 [0%]
2	35 [22.4%]	2 [15.4%]	33 [23.4%]	0 [0%]
3	49 [31.4%]	4 [30.8%]	44 [31.2%]	1 [50%]
4	34 [21.8%]	4 [30.8%]	29 [20.6%]	1 [50%]
5	13 [8.3%]	1 [7.7%]	12 [8.5%]	0 [0%]
More than 5	9 [5.8%]	0 [0.0%]	9 [6.4%]	0 [0%]

Table A-86 Number of family wage earners, by cluster

Wage earners (q22)	**All** *(n=156)*	**Cluster 1** *(n=13)*	**Cluster 2** *(n=141)*	**Cluster 3** *(n=2)*
0	6 [3.8%]	2 [15.4%]	4 [2.8%]	0 [0%]
1	40 [25.6%]	4 [30.4%]	35 [24.8%]	1 [50%]
2	78 [50.0%]	5 [38.5%]	72 [51.1%]	1 [50%]-
3	22 [14.1%]	1 [7.7%]	21 [14.9%]	0 [0%]
4	5 [3.2%]	1 [7.7%]	4 [2.8%]	0 [0%]
5	0 [0.0%]	0 [0.0%]	0 [0.0%]	0 [0%]
More than 5	1 [0.6%]	0 [0.0%]	1 [0.7%]	0 [0%]
Left blank	4 [2.6%]	0 [0.0%]	4 [2.8%]	0 [0%]

C.2.2 Cluster sensitivity testing and validation

SPSS was used to calculate summary statistics for comparison of the three dominant showering style clusters. The outputs are presented in Table A-87 to Table A-90.

Table A-87 Descriptive statistics for variables used for cluster analysis (SPSS output), All Q/0 survey responses(n=156)

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
5. Approximately how many minutes do you spend in the shower (each time you shower)?	156	3	60	11.95	7.477
6. How often do you shower? as numeric	156	1	10	6.03	2.019
9. How many different personal shower products do you use during a typical shower.	156	1	6	2.91	1.138
Valid N (listwise)	156				

Table A-88 Descriptive statistics for variables used for cluster analysis (SPSS output), Cluster 1 (n=13)

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
5. Approximately how many minutes do you spend in the shower (each time you shower)?	13	4	20	9.92	5.484
6. How often do you shower? as numeric	13	3	10	6.62	1.609
9. How many different personal shower products do you use during a typical shower.	13	1	6	2.92	1.320
Valid N (listwise)	13				

a. Cluster = 1

Table A-89 Descriptive statistics for variables used for cluster analysis (SPSS output), Cluster 2 (n=141)

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
5. Approximately how many minutes do you spend in the shower (each time you shower)?	141	3	35	11.52	5.650
6. How often do you shower? as numeric	141	1	10	5.94	2.033
9. How many different personal shower products do you use during a typical shower.	141	1	6	2.89	1.126
Valid N (listwise)	141				

a. Cluster = 2

Table A-90 Descriptive statistics for variables used for cluster analysis (SPSS output), Cluster 3 (n=2)

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
5. Approximately how many minutes do you spend in the shower (each time you shower)?	2	50	60	55.00	7.071
6. How often do you shower? as numeric	2	7	10	8.50	2.121
9. How many different personal shower products do you use during a typical shower.	2	4	4	4.00	.000
Valid N (listwise)	2				

a. Cluster = 3

The latter stage (four-, five- and six-way) groupings from the first-round cluster analysis were checked to understand their relationship with the main three-way clusters. This is summarised in Table A-91.

Table A-91 Development of multi-way clusters (round 1)

Round 1	3-way	4-way	5-way	6-way
Cluster 1 - *Out & about*	*n=13*	*n=13*	*n=13*	*n=11*
Cluster 2 - *UWE standard*	*n=141*	*n=139*	*n=136*	*n=136*
Cluster 3 – *Excessive*	*n=2*	*n=2*	*n=2*	*n=2*
Cluster 4 *(n=2)*	N/A	2F 123F	2F 123F	2F 123F
Cluster 5 *(n=3)*	N/A	N/A	180F 208M 247F	180F 208M 247F
Cluster 6 *(n=2)*	N/A	N/A	N/A	119F 214F
Green = on campus; Red = off-site; Blue = Parent cluster; Highlight = new cluster				

The dominant Cluster 2 ('*UWE standard*') acted as the *parent* and donated child members to Clusters 4 and 5. However, the final six-way cluster was formed from a sub-set of the '*out and about'* Cluster 1. These additional clusters comprised only two or three members and were therefore deemed to be not significant as they did not suggest the presence of any other meaningful showering types within the research population, and simply represented the extremes or outliers of the main or substantive, three groupings. The dimensions of the variables for the latter (round 1 four-, five- and six-way) clusters are summarised in Table A-92, supplemented with corresponding demographic data and potential descriptive cluster names.

Table A-92 Membership and dimensions of variables for latter (round 1) clusters (4-, 5- and 6-way analysis)

Participants	Round 1 cluster	Q31. On campus/Off-site	Variables used in cluster analysis				*Demographics*		Descriptor
			Q5. Duration	Q6. Frequency	Q36a. Outsourced	Q9. Products	*Q40. Gender*	*q19. UK/Overseas*	
2F 123F	4	On On	15 20	>1/day >1/day	☒ ☒	6 6	*Female* *Female*	*UK* *UK*	'High intensity self-care'
180F 208M 247F	5	On Off Off	3 4 10	1/week 1/week 1/week	☒ ☒ ☒	1 1 1	*Female* *Male* *Female*	*Overseas* *Overseas* *Overseas*	'Simple, low impact'
119F 214F	6	On Off	15 20	>1/day Every day	☑ ☑	6 5	*Female* *Female*	*Overseas* *UK*	'High impact outsourcing'

The variables indicated that:

- Cluster 4 members were *high frequency* showerers (more than once per day) and spent *above average duration* (even for the student population) in the shower (15-20 minutes) using *many* products (more than five). This style was described as '*high intensity self-care'* and were derived from the extreme (high) end of the '*UWE standard'* range.
- In contrast, Cluster 5 showering recruits practiced *short duration* and *low frequency* showering, with just a *single* product – and were the polar-opposite to the Cluster 4 -type. A '*simple, low-impact'* way of showering, and were born from the opposite (low) end of the '*UWE standard'* range.
- Cluster 6 was similar to Cluster 4 and comprised *high frequency*, *above average duration* recruits whose showers were scripted by *many* in-shower products. The only discernible difference between Clusters 4 and 6 was that Cluster 6-types took their practice *out and about* to the gym. This style could be described as '*high impact outsourcing'*.

To further validate the Cluster 2-type ('*UWE standard'*), the members of this cluster were run through a repeated (round 2) hierarchical cluster analysis, to explore sub-groups of Cluster 2. The analysis was run for groupings from two- to six-way, and the membership and dimensions were checked for meaningful sub-clusters. Table A-93 shows the members of each new (round 2) sub-cluster.

Table A-93 Secondary (round 2) analysis - development of sub-clusters from the 'UWE standard' (Cluster 2)

Round 2	**2-way**	**3-way**	**4-way**	**5-way**	**6-way**	**Observation**
Parent = Round 1 Cluster 2	*n=139*	*n=136*	*n=133*	*n=130*	*n=129*	
Sub-cluster 2	2F 123F	2F 123F	2F 123F	2F 123F	2F 123F	*= Cluster 4 (round 1)*
Sub-cluster 3	N/A	180F 208M 247F	180F 208M 247F	180F 208M 247F	180F 208M 247F	*= Cluster 5 (round 1)*
Sub-cluster 4	N/A	N/A	108M 132M 142M	108M 132M 142M	108M 132M 142M	*New cluster*
Sub-cluster 5	N/A	N/A	N/A	107F 131F 205O	107F 131F 205O	*New cluster*
Sub-cluster 6	N/A	N/A	N/A	N/A	183F	*New cluster*
Green = on campus; Red = off-site; Blue = Parent cluster; Highlight = new cluster						

In summary, the:

- *Original* (round 1) Cluster 4 ('*high intensity self-care'*) was the same as the secondary (round 2) analysis Sub-cluster 2 (derived from parent Cluster 2 '*UWE standard'*) – drawn from the extreme end of the '*UWE standard'* Cluster 2;
- *Original* (round 1) Cluster 5 ('*simple, low impact'*) was the same as the secondary (round 2) analysis Sub-cluster 3 (derived from parent '*UWE standard'* Cluster 2) – the opposite (low) end of the distribution to Cluster 4;
- *Original* (round 1) Cluster 6 ('*high impact outsourcing'*) derived from parent Cluster 1 *'Out and about'* did not feature in secondary (round 2) analysis due to different parental lineage); and,
- *Secondary* (round 2) Sub-clusters 4, 5 and 6 were new sub-divisions of *original* (round 1) Cluster 2 ('*UWE standard'*).

The membership and dimensions of these new (round 2) sub-clusters are summarised in Table A-94. The new sub-clusters 4 and 5 were more difficult to describe in summary than sub-clusters 2 and 3, that match the original (round 1) Cluster 4 and 5, respectively. This is because there was a less obvious similarity between the variables:

- Sub-cluster 4 comprised three males that took *long* showers almost *every day*, but only used two products to wash their hair and body, suggesting that showering for them may not be just about getting clean. Perhaps they use the shower to relax and destress (only one had gym membership, so unlikely to be relaxing tired muscles from doing sport)?
- The two members of sub-cluster 5 typically used *several* products (4 or 5), but not as many (6 or more) as Sub-cluster 2 and showered at *low frequency.*
- Sub-cluster 6 comprised just a single member and is unlikely to represent any distinct or meaningful style of showering.

The secondary sub-cluster (round 2) analysis helped to validate the original (round 1) analysis and confirmed the division into just three substantive clusters representative of showering types for the research population for the purpose of designing practical water efficiency interventions for this study.

Table A-94 Membership and dimensions for (round 2) sub-clusters of the 'UWE standard' parent Cluster 2

	Sub-cluster	On campus /Off-site	Duration	Frequency	Outsourced	Products	*Gender*	*UK/Overseas*	Descriptor
2F 123F	2	On On	15 20	>1/day >1/day	☒ ☒	6 6	*Female* *Female*	*UK* *UK*	*"High intensity self-care"*
180F 208M 247F	3	On Off Off	3 4 10	Once/week Once/week Once/ week	☒ ☒ ☒	1 1 1	*Female* *Male* *Female*	*Overseas* *Overseas* *Overseas*	*"Simple, low impact"*
108M 132M 142M	4	On On On	30 30 35	Every day 4-6x /week Every day	☒ ☒ ☒	2 2 2	*Male* *Male* *Male*	*Overseas* *UK* *UK*	*"Long and frequent, hair and body only"*
107F 131F 205O	5	On On Off	25 20 6	Once/week Up to 3x /w'k Once/week	☒ ☒ ☒	4 5 5	*Female* *Female* *Other*	*UK* *UK* *UK*	*"Low frequency"*
183F	6	On	3	>1/day	☒	4	*Female*	*Overseas*	*"High frequency /low duration"*

C.2.3 Confirmation of representativeness of showering types

The UWE showering types were derived from the Wave 0 questionnaire (Q/0) responses and used to design and target water saving interventions in the later stages of the research (Wave 1 and Wave 2). It was not feasible to directly analyse the later survey responses for showering styles (repeat the cluster analysis) due to small sample sizes. However, to check that the showering typology derived from the Wave 0 cluster analysis was representative of the subsequent cohorts of participants, descriptive statistics for four the showering dimensions (cluster attributes) were compared with the Wave 1 and Wave 2 survey responses (Q/1 and Q/2A). These are shown in Table A-95 to Table A-98. The results indicate that there is no reason to believe that the showering typology was not applicable to the later participant responses. Note, that the text responses to Q/0 question 6 on shower frequency were converted to a numeric scale (see Table 3-11) to allow for the cluster analysis. However, the text answer options were tweaked in later iterations of the surveys (to reduce the numbers of respondents selecting the '*other*' option). In Table A-96, the original numeric scale was applied, meaning that '*3-4 times*' per week was converted to 4, whilst '*5-6 times*' a week was allocated 5.

Table A-95 Comparison of shower duration dimensions by cluster and fieldwork trial

Duration *(q5. Approximately how may minutes do you spend in the shower, each time you shower?)*		**Mean**	**Median**	**Minimum**	**Maximum**
Wave 0	Cluster 1 (*n=13*)	9.3	10	4	20
	Cluster 2 (*n=141)*	11.5	10	3	35
	Cluster 3 (*n=2*)	55.0	55	50	60
	Q/0 All (*n=156*)	11.6	10	3	60
	Q/0 WCP1 (*n=20)*	13.0	10	4	30
Wave 1	Q/1 (*n=19*)	12.9	15	3	30
Wave 2	Q/2A (*n=23*)	10.7	10	4	25

Table A-96 Comparison of shower frequency dimensions by cluster and fieldwork trial

Frequency *(q6. How often do you shower?)*		**Mean**	**Median**	**Minimum**	**Maximum**
Wave 0	Cluster 1 (*n=13*)	6.6	7	3	10
	Cluster 2 (*n=141)*	5.9	7	1	10
	Cluster 3 (*n=2*)	8.5	8.5	7	10
	Q/0 All (*n=156*)	6.0	7	1	10
	Q/0 WCP1 (*n=20)*	6.1	7	1	10
Wave 1	Q/1 (*n=19*)	6.6	7	5	7
Wave 2	Q/2A (*n=23*)	5.9	5	3	10

Table A-97 Comparison of outsourced showers by cluster and fieldwork trial

Outsourcing *(Where do you shower after sport?)*		**At the gym** (%)	**Own bathroom** (%)
Wave 0	Cluster 1 (*n=13*)	100	0
	Cluster 2 (*n=141)*	0	100
	Cluster 3 (*n=2*)	0	100
	Q/0 All (*n=156*)	8.3	91.7
	Q/0 Campus (*n=90)*	5.6	94.4
Wave 1	Q/1 (*n=19*)	10.5	89.5
Wave 2	Q/2A (*n=23*)	4.3	95.7

Table A-98 Comparison of product use by cluster and fieldwork trial

Number of products		**Mean**	**Median**	**Minimum**	**Maximum**
Wave 0	Cluster 1 (*n=13*)	2.9	3	1	6
	Cluster 2 (*n=141)*	2.9	3	1	6
	Cluster 3 (*n=2*)	4	4	4	4
	Q/0 All (*n=156*)	2.9	3	1	>5
	Q/0 WCP1 (*n=20)*	3	3	1	>5
Wave 1	Q/1 (*n=19*)	3.5	4	1	>5
Wave 2	Q/2A (*n=23*)	2.8	3	0	5

Appendix D Qualitative analysis

D.1 Codebook and emergent themes

A codebook based upon the 18 ISM factors, supplemented with codes representing different styles of showering, and the dimensions of showering was created. The content of each transcript was coded by highlighting sections of text within the NVivo software and allocating relevant codes to it. The transcripts were also coded inductively by creating and assigning new codes as new ideas and sub-themes emerged through the iterative process. The NVivo codes and their definitions are listed in Table D-99.

Table A-99 Codebook

	Code name	Code label	Definition *(ISM factors from Darnton & Evans, 2013)*
Individual	Agency	AGE	Self-control and confidence to undertake the behaviour in question and see it through to completion.
	Costs & Benefits	C&B	Cost/benefit calculation is the basic method of decision making in which perceived benefits (or 'utility') of acting are weighed against perceived costs of doing so (including non-monetary costs such as time).
	Emotions	EMO	Emotional response is one aspect of behavioural decision making – how people feel about something. *Hot* evaluations are based on emotions, whilst *cold* evaluations are based on attitudes and rational choice.
	Habit	HAB	Automatic and frequent behaviours or routines, with little conscious thought, usually in the same time or place.
	Skills	SKI	Things a person needs to know to carry out a behaviour. Include procedural and factual knowledge ('know how' and 'know what').
	Values, beliefs attitudes	VBA	Basic elements of an individual's motivational system: Values - abstract and broad based (pursuit of wealth, power) Beliefs or particular world views (preserve environment for future generations) Attitudes – individual's views on specific things, objects, activities, other people (I should not have to pay more for sustainable products)
Social	Institutions	INS	Institutions influence how groups of individuals behave when they are engaging in particular activities or interacting with other people. Can be formal (e.g., legal, university) or informal (e.g., family life, households). Shared expectations about how members should behave are transmitted, whilst shared understanding may take shape as explicit rules and regulations.
	Meanings	MEA	Culturally constructed understandings of daily life, including images, ideas, metaphors and associations. They set the frame for a behaviour or practice and influence how it is done and how it is understood.
	Networks & relationships	N&R	Connections between individuals, which people identify and draw upon to identify and carry out actions (also known as 'social capital'). Networks help to explain how ideas, innovations and behaviours can spread.
	Norms	NOR	Perceptions of how other people (especially 'significant' others) would view their behaviour. Have a strong influence on behavioural decisions.

	Opinion leaders	OPL	Individuals who have a strong influence over others, e.g., shape social norms. Network nodes who connect together numerous others. For example, faith leaders, celebrities.
	Roles & identity	R&I	Roles are different repertoires of behaviours and attitudes, based on role they are fulfilling at the time. Identity is a person's innate sense of who they are.
	Tastes	TAS	Preferences through which people signal belonging to particular social groups. Collectively developed and based on shared understandings of appropriate or desirable conduct.
Material	Infrastructure	INF	Hard infrastructure relate to physical boundaries presented by the environment and can prevent even motivated people. Soft infrastructure features also bound individual action but are not concrete (e.g., time & schedules, and rules & regulations).
	Objects	OBJ	A lack of necessary objects can stop a practice from being done. Objects interact with users and can heavily influence an individual's actions.
	Rules & regulations	R&R	Set out by formal institutions, e.g., government, to prescribe or prohibit certain actions. Can also be implicit, such as determining appropriate conduct for individuals in informal institutions.
	Technologies	TEC	Technological fixes are sometimes presented as an alternative to behaviour change, but individuals interact with technologies and this can influence the effectiveness of a technology. Interaction also enables new practices and their meanings to emerge and take hold.
	Time & schedules	T&S	Finite resource that gets used in everyday activities. Like money, it is a scarce resource that needs to be allocated across competing demands. Changes in schedules (set by formal institutions) can result in changes to practices.
Cluster type/dimensions	Attentive	ATT	'UWE standard' cluster and Browne *et al.* (2013b)
	Bathing	BAT	Low and high frequency - Browne *et al.* (2013b)
	Diversity	DIV	Browne *et al.* (2013b)
	Flow rate	FLW	Sub-set of QUL
	Location	LOC	Related to O&A
	Low frequency	LFS	Browne *et al.* (2013b)
	Out and about	O&A	'UWE standard' cluster and Browne *et al.* (2013b)
	Quality	QUL	Temperature, pressure, hardness

	Simple daily	SDS	Browne *et al.* (2013b)
	Time	TIM	Duration, time of day, changes over time
Emergent themes	Body image	BIM	Transcends meanings, tastes, and roles & identities (social) and the values-beliefs-attitudes (individual). Important to life stage of the young adults finding their own independence in the wider social world, meeting and forming new relationships with peers and new social groups and understanding or creating their own cultural identities. Strong connection to the social aspects of the health and wellbeing (HEA) theme
	Gender	GEN	Sub-code of R&I - gendered nature of household water use (cooking, cleaning and laundry), plus shaving and hair length (link to BIM).
	Health & wellbeing	HEA	Individual AND collective/public health (social). Relevant to pandemic hand-washing rules and legionella flushing regimes.
	Location	LOC	Sub-set of infrastructure code (material) and relates to Hoolohan's (2016) thoughts around *re-locating* to shared spaces/communalisation and *re-designing* for more efficient use.

D.2 Stakeholder focus group (FG6)

The stakeholder workshop (FG6) was run as an interim and upstream facing step between the two substantive field trials. The workshop set out to gather expert views on the preliminary findings of the Wave 1 trial, and to elicit ideas for a novel, practice-based intervention programme. However, an important benefit of this particular focus group was to continue liaison with relevant staff, manage expectations, demonstrate competence, and build trust, such that the loan researcher had the support of all relevant stakeholders and the appropriate permissions to continue, without fear of any negative impacts on student experience or satisfaction ratings.

From an invitation list of 16 relevant staff and 20 interested students, eight individuals actively participated, as summarised in Table A-100. The low numbers reflected the timing of the workshop, just after the main examination period, following the late May bank holiday and during the school half-term holidays whilst staff were on leave. The focus group in action is illustrated in Figure A-16.

Table A-100 Participants of stakeholder focus group, 30 May 2018

Stakeholder role	Participants
Academic (excluding researcher)	42F
Accommodation	40F
Estates/Facilities	38M, 39M, 41M
SU (student) sustainability committee	35F, 36M, 37M

Figure A-16 Photos taken during the stakeholder focus group, 30 May 2018 (Source: S. Ward)

The coded transcript was analysed by two measures - the frequency (number of times the code was used) and the coverage (per centage of transcript that was coded) of each ISM factor, and the results are summarised in Figure A-17 and Figure A-18, respectively. The plots show that for the *Individual* domain (in green), the different factors appeared in the same ranked order for both measures. *Skills* (SKI) and *Costs & Benefits* (C&B) were the top ranked factors, whilst *Habits* (HAB) and *Emotions* (EMO) featured the least.

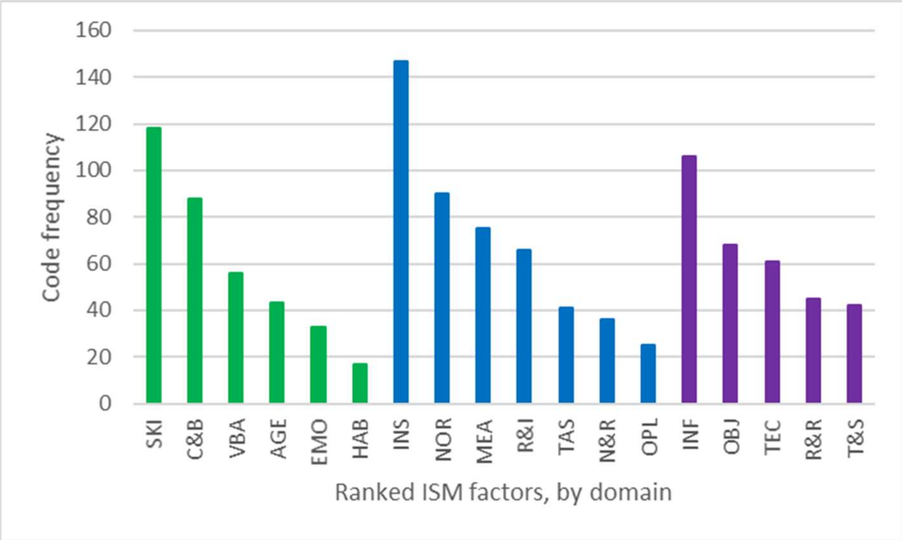

Figure A-17   Frequency of ISM factors (FG6)

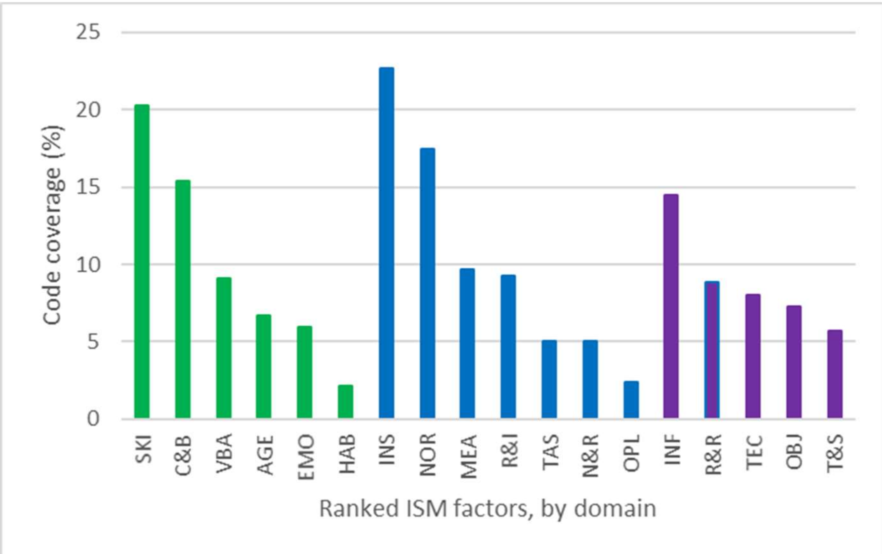

Figure A-18   Coverage by ISM factors (FG6)

The ranked *social* realm factors also followed the same order for each measure. *Institutions* (INS) and *Norms* (NOR) dominated, whilst *Networks & Relationships* (N&R) and *Opinion Leaders* (OPL) were less prominent. However, for the *Material* context, there was some variation between the two measures for each factor. References to *Infrastructure* (INF) appeared the most, a reflection of having three stakeholders present from the Estates/Facilities department, with responsibility for university infrastructure. *Times & Schedules* (T&S) appeared the least, whilst the order of the other three *material* factors, sandwiched in the middle, changed between the two measures. The relative order of each factor in the discussions were likely to be reflective of the upstream perspectives of the experts and stakeholder participants, and not necessarily representative of the lived experiences of the shower-using residents.

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Appendix E Manufacturer product labels analysis

Question 15 in the Q/2A survey indicated that just over a third (36%) of respondents read the manufacturers' instructions on shower products. This finding prompted a supplementary investigation into the directions for use printed on shampoo and conditioner packaging. Labels were reviewed to see whether the advice provided might lead to longer *duration*, more *frequent* showers and/or increased resource consumption (product and packaging) should (a third of) users follow the recommended or prescribed steps. For example, leaving the product for an ascribed *time*, *repeated* application or using *another* in-shower product (from the brand range) such as following with conditioner.

A sample of products from the leading shampoo brands, along with brands used by the students, including the Wave 2 trial shampoo bars (and others that were available in the researcher's home at the time), were reviewed. Products were also allocated a price point (price per 100ml) within a range, from budget price (less than £1 per 100ml), mid- (£1 to £2 per 100ml) and top-of-the-range (more than £2 100ml, including specialist or medicated and luxury brands) to investigate whether price had any bearing. This was not a systematic review, but a representative snapshot, to help with the interpretation of the responses to question 15 (Q/2A) on brand and instructions .

For best effect, eleven of the 19 shampoo products listed (and seven of the leading ten) in Table A-101 recommended users to follow with the branded conditioner (highlighted in yellow), encouraging not only brand loyalty, but also increased product *consumption* and shower *duration*. Many shampoos contain sulphates to clean the hair, but in the process this strips hair of its natural oils. Conditioners are then needed to replace the natural oils that the shampoo has removed. This stripping can upset the natural oil balance within the hair, encouraging a *dependency* on the manufactured products and demonstrates the ability of objects to act back, or have agency on how showering is done.

Six products (from budget to high-price point) directed the user to *repeat* the application of shampoo (highlighted in magenta). The fact that none of the leading brands recommended a *repeat* application tends to support the evidence presented in Chapter 4 that the practice of shampooing *twice* is no longer the norm, with just eleven per cent repeating shampoo application (13% for the Wave 2 participants) and supports the idea that modern brands are formulated to reduce the need for repeated applications.

Table A-101 Manufacturer directions on shampoo products

Brand	Product	Price point	Directions
TRESemmé	Luxurious moisture **shampoo** with vitamin E	£	*Apply to wet hair from roots to tends. Work into a lather and gently massage the scalp. Rinse thoroughly. Follow with TRESemmé Luxurious Moisture **Conditioner** …*
L'Oréal (Elvive)	Dream lengths restoring **shampoo**	££	*Apply on wet hair, massage your scalp and rinse with **cold water** to make hair shinier. Follow with our Detangling **Conditioner** for nourishment and our No Haircut Cream to improve the look of your lengths…*
Head & Shoulders	Classic clean **shampoo**	£	*… For best results use with H&S **conditioner** that deeply moisturises your hair and scalp to give you beautiful hair with a lightweight finish.*
Pantene Pro V	Nutrient blend formula - Repair & Protect **shampoo**	££	*Massage into wet hair to create lather. Rinse*
Aussie	Mega **shampoo**	££	*Massage into your wet hair and fill your entire bathroom with that delicious Aussie smell. Rinse out and follow with Mega **conditioner** for MEGA results*
Dove	Intensive repair **shampoo**	££	*Apply to wet hair, gently lather and rinse.*
Alberto Balsam	Sunkissed raspberry **shampoo**	£	*Wet hair, use a **good size dollop** of shampoo, lather then rinse thoroughly….*
Garnier Ultimate Blends	The colour illuminator, with argan oil & cranberry **shampoo**	£	*Massage into wet hair, lather, rinse & follow with our **Conditioner**…*
Clairol Herbal Essences	Bee strong, honey essences **shampoo**	£	*Apply a **good squidge**, lather up, rinse way. Complete your routine with Herbal Essences' **conditioner***
John Frida	Frizz ease dream curls **shampoo**	£££	*Apply shampoo to wet hair, lather, rinse well. Follow with Frizz Ease Dream Curls **Conditioner**.*
Fruity (Superdrug)	Coconut **shampoo** for dry or damaged hair	£	*Wet hair. Massage a **generous amount** of shampoo into your hair and scalp, then rinse thoroughly. **Repeat if required**. For best results follow with Superdrug Fruity coconut **conditioner***

Nutmeg (Morrisons)	Classic anti-dandruff **shampoo**	£	*Wet hair, massage into hair and scalp. Rinse thoroughly and **repeat if necessary**. For best results continue to use regularly to help control dandruff and prevent it recurring.*
Wilko (own brand)	**Shampoo** – coconut & vanilla with argan oil	£	*Massage into wet hair, lather and rinse well. **Repeat if necessary**. For best results use with Wilko coconut & vanilla **conditioner**.*
Friendly soap*	Lavender & geranium **shampoo** bar	£	*Just run the shampoo bar over your head in one direction, from front to back. This will help you to avoid creating any pesky knots. Once you've a **good amount** of shampoo on your head, massage it into your scalp using your fingers (or if you're owed a treat, ask your other half to). Now rinse your hair with water until every drop of shampoo is out. That's it – you're done.*
Davines	Solu **shampoo**	£££	*Apply a **small amount** to wet hair, gently massage into scalp; roots to ends of hair. **Repeat if needed**. After rinsing out follow with **conditioner***
Lush*	Avocado **co-wash**	£££	*Wet your co-wash and work into hands to create a hydrating lather, then apply to wet hair. **Co-wash twice or more** to thoroughly cleanse hair and scalp, then rinse thoroughly*
	Seanik **shampoo** bar	££	*Embrace the sea with this volumising sea salt and lavender shampoo bar. Lather into wet hair and wash out.*
Simple	Kind to hair gentle care cleansing **shampoo**	£££	*For best results... Lather up shampoo by gently massaging into hair and scalp. Rinse thoroughly and **repeat as necessary**. Follow up with our Gentle care **conditioner**.*
T-gel	Revitalising scalp **shampoo**	££	*For cutaneous use only. **Liberal amounts** of NEUTROGENA® T/Gel® Therapeutic Shampoo should be applied and massaged into the wet scalp and **left for several minutes**. The scalp should be rinsed, **the application repeated** and then the scalp rinsed thoroughly. NEUTROGENA® T/Gel® Therapeutic Shampoo should be used two to three times weekly for the treatment of scalp disorders.*

**Shampoo bar product interventions used in the Wave 2 trial*

Users recommended to follow with branded conditioner; Users recommended to repeat application; Users recommended to use an ambiguous amount of to use regularly.

Three of the shampoo bars used in the Wave 2 trial (Friendly Soap and Lush) were included in the analysis above. The Lush Avocado *co-wash* was the most popular product selected by participants in the market research. It is a conditioner rather than a shampoo and does not contain sulphates. It was recommended by a staff member at Lush as a suitable single product for all shower ablutions. However, the directions for use indicated a need for *repeated* applications, effectively cancelling out the planned single product/reduced *duration* aim of the intervention, suggesting that offering this product may have been counter-productive to the intended consequence. The Seanik shampoo bar would have been a better product to meet this objective had the researcher had more experience and knowledge of products and hair-care needs!

Five shampoo products suggested an ambiguous *quantity* of product should be used, with the budget priced bottles using *meaningless* qualitative terms such as '*good sized dollop'* or '*good squidge'* (highlighted in green), to encourage the user to consume more product, to either sell more or because the formulation was not as good as other leading brands. Two of the medicated or specialist products recommended regular use of the shampoo (also highlighted in green), although *daily* use was not suggested.

Seventy per cent of the leading shampoo brands that were reviewed recommended application should be *followed* with the same brand conditioner, the instructions on a sample of twelve conditioner bottle labels from the same range (though not necessarily the matching product in Table A-101) were reviewed, as listed in Table A-102. Three of the top seven brands directed the user to leave the conditioner on for a *duration* ranging from 1-3 minutes (highlighted in magenta) and a fourth product recommended *repeating* the application, all giving the potential to add to shower *duration*. Three products suggested an ambiguous quantity of product should be applied, using the terms '*blob'* and '*generous amount'* (shown in green). With only a third of students reading the product labels, the amount used is likely to have been learnt from parents or hair cutting professionals and based upon practical experience as to what *works* for an individual's hair type and length, and how much is needed to achieve the desired or expected lathering effect.

Table A-102 Manufacturer directions on hair conditioner products

Brand	Product	Price point	Directions
TRESemmé	Cleanse & replenish Remoisturising **conditioner** with pro-vitamin B5 & aloe	£	*Start with TRESemmé Deep Cleansing Shampoo. Apply from mid lengths to ends. Run a **wide-tooth comb or fingers** from roots to tips to detangle and work into hair. **Leave on for 2-3 minutes**. Rinse thoroughly. Style with your favourite TRESemmé products*
L'Oréal (Elvive)	Dream lengths detangling **conditioner**	££	*Apply conditioner on lengths**, leave for one minute** and rinse. Follow with our No Haircut Cream to improve the look of your lengths and reduce the appearance of split ends…*
Head & Shoulders	Classic **conditioner**	£	*For best results gently massage onto scalp and hair and use with H&S shampoo to get beautiful hair with lasting dandruff protection. Rinse and **repeat if desired**.*
Pantene Pro V	Repair & protect nutrient blend **conditioner**	£	*Apply to the length of your hair and work your way up to the roots. Rinse out thoroughly. For best results, use with Repair & Protect shampoo and treatments.*
Aussie	Mega **conditioner**	££	*… Apply to freshly Mega shampoo'd hair. Rinse out thoroughly for hair as soft and bouncy as the white clouds over Canberra.*
Dove	Intensive repair **conditioner**	££	*Apply to wet hair after shampooing, massage and rinse.*
Alberto Balsam	Sunkissed raspberry **conditioner**	£	*After you've shampooed, use a **good size dollop** of conditioner. **Leave it on for 1-2 minutes** then rinse thoroughly*
Garnier Ultimate Blends	**Conditioner** with argan oil	£	*Smooth generously into wet hair and rinse thoroughly. Use after our shampoo. For intense care, indulge in one of our treatments.*
Clairol Herbal Essences	Beautiful ends, pomegranate essences **conditioner**	£	*After shampooing, **squeeze a blob**, apply through strands and rinse. Et voila.*
John Frida	Frizz ease dream curls curl-defining **conditioner**	£££	*Start with Dream curls shampoo. Smooth conditioner through wet hair, applying **generously** as it quickly absorbs into curls. Rinse well.*

Fruity (Superdrug)	Coconut **conditioner** for dry or damaged hair	£	*Massage a **generous amount** of conditioner into your hair and scalp, then rinse thoroughly. For best results use with Superdrug Fruity coconut shampoo.*
Wilko (own brand)	**Conditioner** – coconut & vanilla with argan oil	£	*Massage into wet hair from root to tip and rinse well. For best results use with Wilko coconut & vanilla shampoo.*
Users recommended to leave condition on for a specified duration or to repeat the application; Users recommended to use an ambiguous amount or to use regularly.			

Appendix F Publications arising from research

Simpson, K., Staddon, C. and Ward, S. (2019) Challenges of researching showering routines: From the individual to the socio-material. *Urban Science* [online]. 3(1), pp. 1-19.

Simpson, K., Staddon, C., Spotswood, F. and Ward, S. (2018) Challenges of researching showering routines. *Watef Network Conference proceedings* [online]. Aveiro - Portugal, 05-07 September 2018 (paper) pp. 243-252.

Staddon, C., Toher, D. and **Simpson, K.** (2016) Socio-cultural drivers of water demand in student residential accommodation. *Watef Network, Proceedings of the 4th Annual Water Efficiency conference* [online]. Coventry, 07-09 September 2016, pp. 74-86.

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Article

Challenges of Researching Showering Routines: From the Individual to the Socio-Material

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Abstract: In the UK, water supplies are under pressure from climate, population and lifestyle change. Showering is the largest component of domestic water consumption. Young adults are high water-users at a transitional life-stage, when practices are dynamic, and habits shaped. This paper presents the methodology, early findings and reflections on challenges of working with different data types and scales, to explore real-world water-saving through a mixed-methods approach, focusing on showering patterns of first year university students in campus accommodation at the University of the West of England, Bristol, UK. Combining household meter, logged water-fixture micro-component, personal-use questionnaire, user diary and stakeholder focus group data with the Scottish Government Individual-Social-Material model, typical showering demand reduction interventions were evaluated and insights into alternative interventions were generated. Results indicate Estates' routine equipment maintenance and database management affect data quality and consistency. Despite these issues a profile of daily student water use was derived (equivalent to 114 L per person per day) but with high variability between different households (from 83 to 151 L per person per day). Average shower durations (self-reported 10–12 min) were higher than reported UK norms, although frequency was similar to the UK daily shower norm. Average measured shower volumes (51 L in one house) were not excessive, indicating shower fixtures provided a contribution to water saving.

Keywords: behaviour change; Individual-Social-Technical toolkit; mixed-methods; showering; water efficiency; young adults

1. Introduction

The privatised water supply companies in England and Wales have had a statutory duty to promote the efficient use of water since the 1990s [1] and in 2010 Ofwat (the economic regulator of the privatised water companies in England and Wales) introduced new prescriptive water saving targets [2]. Water policy-makers deal in the language of average "per capita consumption" (PCC) measured in litres per person per day (L/p/d), as a key metric for domestic water use. The estimated average PCC in England is about 150 L/p/d [3], although the latest reports, following seven years of highly publicized targets indicate that this figure is now reducing (141 L/p/d [4]). The current government ambition is to reduce average PCC to 130 L/p/d by the year 2030 [5].

This conservation goal presents several challenges for water companies in understanding the dynamics of daily water-using routines [6]. PCC is only an estimate [7] and can be calculated based on the measured water volume supplied to domestic properties divided by the estimated population served or based on a panel study of metered households for which water companies hold more reliable occupancy data [8]. In addition, only about half of domestic households are currently metered, although this number is increasing, with extensive regional metering programmes in some areas.

In contrast, calculating the PCC for students living in university accommodation is easier and the results more reliable than calculations for the wider population, as information on lettings and corresponding occupancy is more readily available. However, assumptions still need to be made on actual occupancy levels, as a let flat may not be fully occupied, with tenants opting to spend much of their time living elsewhere with friends or, for UK-based students, returning home at weekends and holidays. Conversely, rooms may be over-occupied with house guests staying occasionally, regularly or on a semi-continual basis.

One methodological problem with relying on average PCC is that it represents an underestimate of *total* personal consumption. Water is not consumed by individuals solely within the household meaning that for most of the UK population, average PCC excludes personal water-use in places of work, education and leisure, through sanitation and hygiene (WC flushing and hand washing) or process water from the provision of drinks and meals consumed away from home (cooking and dishwashing). For example, daytime office use may add a further 16–28 L/p/d to personal consumption [9] to the current official estimate of PCC [5].

Another challenge is that the process of aggregating and averaging individual water use hides the variations in everyday personal water use patterns. There is growing interest in understanding more precisely *how* water is consumed in the course of everyday life, so that behaviourally-focused interventions can be designed to reduce consumption [10]. Micro-component studies indicate that there is a great variety in individual household patterns of consumption [11,12], made more difficult to measure when almost two thirds of consumption occurs in the privacy of a locked bathroom.

There is growing interest in viewing increasingly resource-intensive routines from a social practices perspective to examine the dimensions and dynamics of everyday life. This perspective helps to reveal the material cultures that underpin patterns of consumption, by daylighting the role of the constituent elements of material, skills and social understandings and their linkages that govern the reproduction and transformation of practices, and how material and social structures can limit individual agency [13]. Browne, et al. [14] have used cluster analysis to classify personal washing routines (showering and bathing) according to frequency, diversity, technology and out-sourcing, with social-demographic information layered upon the resulting practice clusters to describe and interpret the classification. Qualitative research into water use is clearly necessary, though difficult to organise.

Working with average PCC values also hides the differences between different demographic groups (age, gender or nationality). Research by Waterwise [15] indicates that younger people shower for about two-minutes longer than older population segments. Whilst education is seen to be important for creating more sustainable behaviours in both children directly and with other members of the household by 'pester-power' [16], there is little evidence of any effect on water use from the many environmental educational programmes delivered in UK schools [17], despite self-reporting of pro-environmental attitudes. Some research suggests that older generations may be more environmentally conscious and less consumptive [18]. There are likely to be stronger social pressures working in the opposite direction of rising environmental awareness among young adults, partly because of life-course stage and the need to conform to higher standards related to body-image and lifestyle aspirations. Young adults are at the transition point between maturing from dependent children into independent autonomous adults and universities can play an important role in facilitating social change to address important issues [19–21].

This research is focused upon the UK context, in terms of utility governance, infrastructure, supply pressures and social drivers but the authors recognise that there is a larger literature focusing on such issues outside the UK, including [22–26].

In this study the variations in showering routines amongst a group of mostly first year under-graduate students living in on-campus university accommodation were observed using a range of data including water consumed at both household and shower component level and self-reported data collected from user-questionnaires and diaries. These insights were combined with outputs from a series of focus groups, to evaluate a range of conventional technological and behavioural water-saving interventions, to collectively design alternative action programmes. The focus group discussions and outputs were structured using the Scottish Government "Individual-Social-Material" toolkit to move discussions beyond traditional individual behaviour change ideas to encompass wider social and material determinants. The ISM model is based on theory and was developed out of an international review of successful behaviour change initiatives [27]. It has been refined through research and the evaluation of alternative environmental behaviour change interventions.

A mixed-method approach was adopted, in which both quantitative volumetric and qualitative end-user data were collected. Data processing and analysis is on-going. The research is aiming to:

1. Develop experimental methods to test the efficacy of real-life water-saving interventions in a living laboratory (the initial design and some of the challenges faced with the complexity of triangulating between different epistemological and methodological approaches to combine volumetric and end-user reported data are reported in this paper);
2. Explore and analyse the variation and complexity of showering routines of young adults (early findings are reported here) and use these insights to;
3. Develop targeted practical and novel water efficiency interventions underpinned by theories of behaviour change and social practice (next steps, beyond the scope of this paper).

2. Materials and Methods

2.1. Participants and Setting

The fieldwork was conducted during the first quarter of 2018 and set out to explore the showering routines and associated water consumption by student residents. The study site concentrated on ten townhouses comprising 88 beds, within a larger 404-bed development, built in 2014 at the University of the West of England (UWE) main Frenchay campus located in Bristol. The water consumption for all 37 houses in the development is measured by sub-meters at 30-min intervals, as part of the Building Management System managed by the university Estates department. Two thirds of the houses in the development are comprised of twelve single study bedrooms. However, this study focused on ten of the smaller eight and ten-bed houses (total design occupancy of 88 persons), clustered together around a courtyard (labelled A-J in this paper to help preserve participant anonymity). In each house, the ground floor has a communal kitchen/diner with two mixer-tap sinks (high flow, no regulators) and a single dual-flush WC with wash-hand basin (with flow regulating tap aerators). Some leaking kitchen taps were identified and reported to the Estates department for fixing. The exterior of the development is shown in Figure 1 and a plan illustrating the configuration of the houses, arranged around a central courtyard is presented in Figure 2.

Figure 1. Exterior of university housing development (from rear corner of houses H and I). Used with permission of the creator.

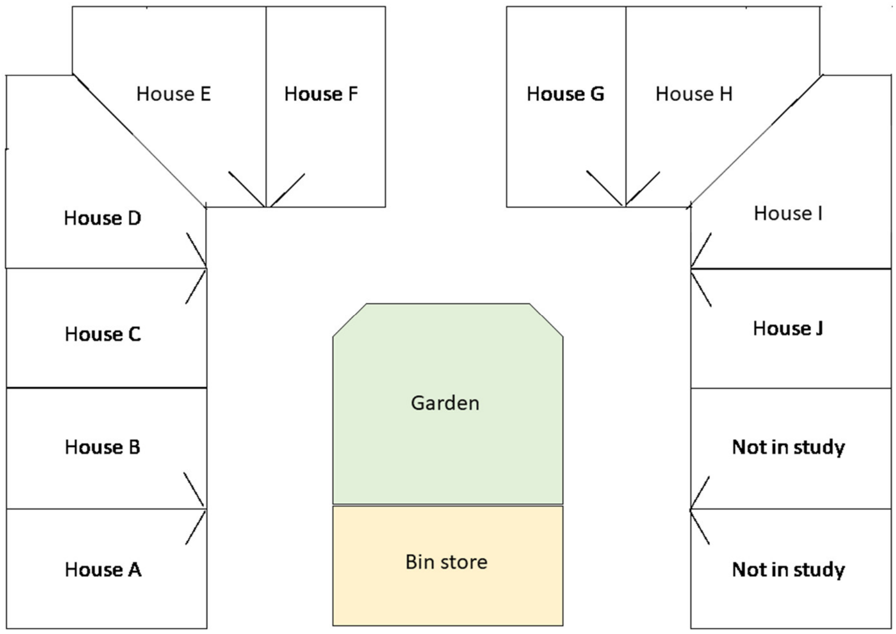

Figure 2. Plan of study site (not to scale).

Six of the ten townhouses (A, B, C, F, G, J) comprise eight single bed study rooms with four shared WC/shower rooms (Figure 3) arranged across two upper stories (four bedrooms and two WC/shower rooms per floor). Four slightly larger corner-aspect townhouses (D, E, H, I) have the capacity for ten occupants, with one twin/shared bedroom, three single occupancy bedrooms and two shared WC/shower rooms on each of the upper two floors. The shower rooms include a shower enclosure with water efficient showerhead (c.8 litres per minute, L/m), wash-hand basin (tap-aerators, flow regulated to c.4–5 L/m) and a dual-flush (pneumatic) WC. Laundry facilities are provided centrally for residents in a separate building and are outside the scope of this study. There is no outside water use such as gardening or car washing that needs to be accounted for. Accommodation fees are inclusive of all water and energy and therefore, the residents are unlikely to be sensitised to the water-energy nexus of showering resource demand.

Figure 3. Shower/WC room. Used with permission of the creator.

Demographic data from the university Accommodation Services are summarised in Table 1. The research team had no influence over the demographic allocation of residents to the study site.

There were only two void beds (house E), whilst houses A, C and F were female only, to accommodate cultural expectations. Thirty-five residents (41%) had UWE gym membership (another location where showering might take place).

Table 1. Demographics of residents in the study site.

House	Occupancy	Gender Ratio (Female:Male)	Age Range (18–22 Years:23–29 Years)	UWE Gym Membership	Nationality (UK, EU, Non-EU)
A	8	8:0	3:5	5	1, 0, 7
B	8	4:4	8:0	2	7, 0, 1
C	8	8:0	7:1	4	0, 0, 8
D	10	5:5	6:4	2	5, 0, 5
E	8 (2 void)	5:3	7:1	4	6, 0, 2
F	8	8:0	8:0	2	5, 2, 1
G	8	4:4	8:0	2	5, 2, 1
H	10	3:7	9:1	4	8, 2, 0
I	10	4:6	9:1	7	8, 2, 0
J	8	4:4	7:1	3	7, 1, 0
Total	*86*	*53:33*	*72:14*	*35*	*52, 9, 25*
%	*97.7% of max*	*62:38%*	*84:16%*	*41%*	*61, 11, 29%*

Ethical approval for this research involving human participants, using loggers, diaries, questionnaires and focus groups was approved by the University Research Ethics Committee in May 2017. The research was conducted in accordance with the UWE Bristol Code of Good Research Conduct [28].

2.2. Water Fixtures Audit

In August 2017, during the summer void period, the Researcher undertook an audit of the water fixtures within the un-occupied development to familiarise herself with the plumbing installations. Flow-rate data were collected for five townhouses across the wider 37-house development including two within the study site (houses B and G) and are indicative of the relatively standardised fixtures for each house across the estate. Note, the showerheads (manufactured by Ideal Standard) and tap aerators are exchanged (removed, cleaned and replaced) on a quarterly basis by the Estates department, as part of the Legionella control management protocol and are not necessarily replaced with identical fittings but with whatever is available at the time. The water fixtures are also flushed on a weekly basis during periods of no occupancy (not relevant for the period of this study).

2.3. Water Consumption Monitoring

Each townhouse within the development is sub-metered at 30-min intervals as part of the university's Business Management System (BMS). To supplement the BMS data, the ten townhouses in the study were also fitted with "Silhouette" loggers (supplied by Artesia Consulting, see Figure 4), which record a pulse for every 500 mL of water through the meter. This finer resolution is enough to identify individual shower events and allow analysis of flow, duration and frequency profiles within a household without being overwhelmed with data points (it is acknowledged that 500 mL is not sufficiently fine to accurately identify tap use at a fitting level). Application of segmentation algorithms allows researchers to bridge the gap between direct measurement of household-scale consumption and the specific contributions of individual water-using fixtures.

Figure 4. Silhouette logger (black box) attached to water meter. Used with permission of the creator.

Following an 18-day test using one logger (from 15 November 2017, to check for metering system compatibility), Silhouette loggers were installed with splitter cables from each sub-meter on 18 and 19 December 2017 and removed on 26 March 2018.

2.4. Water-Saving Interventions

Conventional water-saving interventions of the sort deployed by current water company water-efficiency programmes were tested during the study in pairs of households. These are summarised in Table 2 and illustrated in Figures 5 and 6.

Table 2. Summary of water-saving interventions tested.

House	Intervention	Location
A/B	Nil—control group	
C/D	Posters *(installed 14-February, removed 07-March 2018)*	Generic water-saving messages in communal area notice board/downstairs WC (back of door) *'Share a shower'* (house C) and *'Pee in the shower'* (house D) in shower rooms (back of door) (see Figure 5)
E/F	4-mintue shower timers *(left with diary participants on 21-February 2018)*	One per resident
G/H	Amphiro a1 smart shower meter *(installed 14-February, diary participants briefed on 21-February 2018)*	Installed in each shower room (see Figure 6)
I/J	Face-to-face engagement *(28-February 2018, 2.30 pm in house J)*	Communal area—all residents invited, refreshments provided

Figure 5. Posters displayed on back of shower room doors in houses C ('Share a shower') and D ('Pee in the shower'). Used with permission of Bristol Water PLC.

Figure 6. Amphiro a1 smart shower device. Used with permission of the creator.

2.5. Qualitative End-User Data Collection

To complement the volumetric data, user data from individuals was also collected to help understand the drivers, attitudes and perceptions underlying shower routines of student residents. Participants were principally recruited by door-knocking and leafleting of the target houses, with recruited participants subsequently asking their housemates to join in.

Initially, residents were asked to keep a simple shower diary for two weeks (21 February to 07 March 2018). The Researcher aimed to recruit two or three diary participants per house (20–30 in total, representing between a quarter and a third of the population). Active consent was obtained from all volunteers, as per the approval granted from the University's research ethics governance process. Participants were compensated for their time and commitment with a £20 shopping voucher of their choice on return of completed diaries. Participants were provided with a simple two page template (one page per week), to record, for each shower:

- Date
- Time of day
- Duration
- Location (shower room or off-site)
- Volume (Amphiro users only—houses G/H)
- Products used
- In-shower activities
- Thoughts or emotions during the shower.

A series of five focus groups were conducted, one for each pair of houses/intervention type. The focus group workshop for houses I/J was conducted at the mid-way point of the diary fortnight, on 28-February 2018. This focus group had a dual purpose as it formed both the water-saving intervention itself (in the form of face-to-face education and engagement), and served to co-design future water-saving actions. The four subsequent focus groups followed a similar structure to evaluate and co-design interventions and these were run on Wednesday afternoons on 07 March (houses G/H); 14 March (2 focus groups, houses C/D, followed by houses E/F); and 21 March 2018 (houses A/B). The final focus group was used as a 'wash-up' session and any diarists that had been unable to attend earlier focus group were invited.

Diary participants were actively invited to take part and they were also encouraged to ask their housemates to join in. The Researcher also advertised the focus groups by delivering leaflets a few days before the planned sessions with the promise of refreshments and entry into a prize draw for a £20 shopping voucher for all participants of the focus groups. Each focus group was run within the downstairs communal dining/sitting area of one of the pairs of houses (with prior agreement from the residents, pragmatically selected based on the higher number of engaged participants to ensure maximum attendance) and lasted for about 1.5 h. Once the research ethics consent forms were completed over refreshments, an audio-recording of the discussion was made for later transcription.

The discussion started by setting ground rules; discussing why there is a need for water efficiency; how water is used in the home (with showering and bathing accounting for about a third of demand and growing [29]); and a description of conventional water-saving interventions. The rest of the focus group used the "Individual-Social-Material" toolkit [30] to structure dialogue to both evaluate trialled interventions and co-design future actions to tackle a specific showering metric (chosen by the focus group, such as flow rate, duration, frequency or in-shower activities). The 18 factors from the three ISM contexts (see Figure 7) were introduced with definitions on a set of prepared flashcards. Each factor was discussed in turn and colour-coded notes were made by the group on an A3 sheet (green for Individual, blue for Social and black for Material contexts).

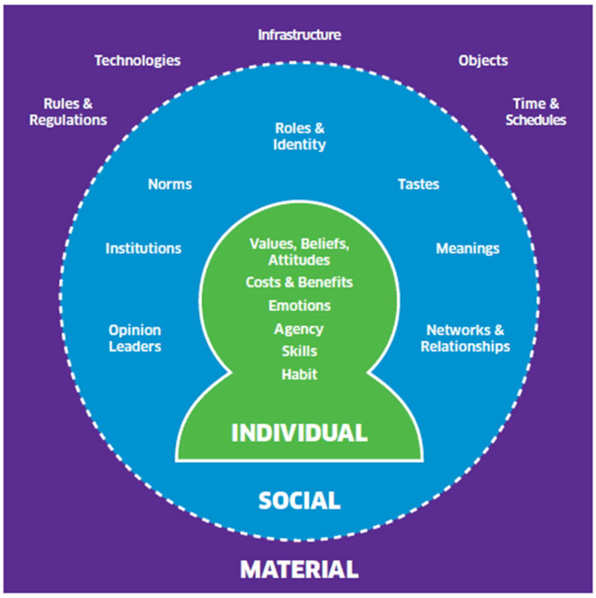

Figure 7. Individual-Social-Material model (Crown Copyright). From Darnton and Horne (2013) [30].

At the end of the diary fortnight, an online questionnaire was launched (07 to 21 March 2018) and all previously recruited research participants (directly by email) and other residents (via leaflets and word of mouth) in houses A-J were invited to take part. The questionnaire collected information on environmental awareness, showering habits and other water-using routines, water fixtures at home and demographic information. The questions were similar to a wider questionnaire targeted at all UWE students in October 2017. Participation was incentivised with entry into a prize draw for a £20 shopping voucher. Example questionnaire questions relating specifically to showering routine included:

1. Duration: *Before the trial, approximately how many minutes do you spend in the shower (each time you shower)? Has this changed since the trial? [yes, no, don't know] If yes, please describe how this has changed.*
2. Frequency: *How often do you shower? [More than once per day, Every day, 5–6 times per week, 3–4 times per week, 2 times per week, About once a week, Other]*
3. Time of day: *When do you usually shower? [Mostly first thing in the morning, usually before going out in the evening, usually before going to bed, No fixed pattern, Other]*

4. Flow: *When you first turn the shower on, do you: [Start showering straight away, wait a short while for the water to warm up before getting under, Turn the shower on then do something else while you wait for it to warm up, Other]*
5. Products: *How many different personal shower products do you use during a typical shower? For example: shampoo, conditioner, shower gel, soap, shaving gel/mousse, exfoliator, face-wash, face-pack, etc. [0, 1, 2, 3, 4, 5, more than 5]*
6. Activities: *Which activities do you undertake during a typical shower? Please tick ALL that apply. [Shampoo hair once, Shampoo hair twice, Condition hair, Wash body, Wash face, Exfoliate, Shave, Face-pack, Brush teeth, Other]*

3. Results and Discussion

3.1. Quantitative Consumption Data Analysis

The results of the water fixtures audit are summarised in Table 3. Despite the same standard of fittings broadly installed across the estate, the water audit found some variability in flow rates. Most of the 26 showerheads tested were water efficient, ranging between 7 and 9 L/m and manufactured by Ideal Standard. However, one showerhead delivered a flow of more than 14 L/m (regulating the flow from 21 L/m without the showerhead). In contrast, one showerhead only delivered 4.2 L/m (with a flow of just 4.4 L/m without the showerhead).

Table 3. August 2017 water fixtures audit—summary of shower flow rates.

House	Number of Showers	Mean Showerhead Flow Rate (L/m)	Mean Unregulated Shower Flow (no Showerhead, L/m)
B	4	8.0	8.7
G	4	7.7	11.3
Q1	6	8.9	10.1
Q2	6	7.5	9.6
Q3	6	6.6	6.9
Total	*26*	*7.7*	*9.2*

In analysing the metered water consumption data from the BMS, it became apparent that the telemetry sometimes sticks. There were several periods before, during and after the trial in which the consumption value for a 30-min period was repeated in the next and subsequent time steps and this pattern could be detected across multiple sub-meters for the same time steps. This discovery puts a question mark over the reliability and accuracy of the BMS sub-meter water consumption data for this specific trial. Fortunately, higher quality data covering a period later in the year are available, as are data from other student accommodations on the same campus.

During the focus group and questionniare phase, the estate experienced a major water mains-burst event which resulted in a large proportion (c.40%) of the campus estate, including the trial site, having no mains-supplied water for a period of more than 30 h (from 02:30 h 14 March to 12:00 h 15 March 2018). When the water was turned back on following the repair, debris was pulled through into the pipework and resulted in several sub-meters including one of the trial houses (house A) being damaged (and flat-lining). In addition, for the duration of the trial, there is no BMS data for house G.

The BMS water consumption by paired household for the study period is summarized in Table 4. Preliminary analysis reveals that houses A/B (controls) had substantially higher PCCs than other houses in the study, including before interventions, whilst houses I/J had the lowest PCC for most of the study (except house H in the last week of the monitoring period). Change in average PCC between the different trial phases, from pre- to post-intervention showed a modest reduction for the houses with the posters (C/D, 5.1%) and shower timers (E/F, 5.5%). Whilst these reductions are greater than the control houses (A/B, 3.9%), further statistical analysis is required to assess if these changes are significant. Houses G/H (Amphiro) revealed the greatest PCC reduction (13.3%). Houses I/J, that received the face-to-face engagement session/focus group intervention showed a slight increase in PCC (+1.5%) but they consistently had the lowest PCC during the monitoring period.

Table 4. Per Capita Consumption for different phases of monitoring across the study site (L/p/d).

House	Whole Study Period	Pre-Intervention	Interventions Deployed	Diaries	Post-Diaries	Change in PCC (L and %)
	22 January–13 March	22 January–13 February	14 February–20 February	21 February–07 March	08 March–13 March	Between pre-/post-intervention
Interventions (poster/timer/Amphiro)		None	Installed (as Table 2)	Diaries (see Section 3.2)	Remain in situ	
No. days	**51**	23	7	15	6	
A/B	**150.9**	157.0	140.6	148.1	146.3	10.6 (3.9%)
C/D	**124.4**	131.1	134.9	119.8	97.8	33.2 (5.1%)
E/F	**106.3**	112.4	111.9	100.7	90.1	22.3 (5.5%)
G [1]/H	**106.6**	123.0	110.2	95.9	68.8	54.3 (13.3%)
I/J	**83.3**	82.1	89.0	78.5 [2]	93.4	+11.2 (+1.5%)
Mean	***114.3***	*121.1*	*117.3*	*108.4*	*99.3*	*21.8 (5.6%)*

[1] *Siloette logger data used in lieu of BMS failure for house G.* [2] *intervention (focus group) deployed 28 February.*

Artesia Consulting downloaded the Silhouette logger data. Unfortunately, only one logger (house G, with the Amphiro smart meter intervention and 8 residents) recorded any pulses for the duration of the main trial. Subsequent investigation has shown that the splitter cables did not operate as expected and, in most cases, failed to send pulses to the loggers. For house G, the pulses were recorded at the expense of main sub-meter data recorded by the BMS. A solution to this problem was worked on prior to a repeated trial(s).

For house G, a total of 263 shower events were identified across 51 days of monitoring (from 22 January when the teaching term commenced, and full occupancy was assumed, to 13 March 2018, before the mains-burst 'no water' event). These results are summarised in Table 5. The top half of the Table shows that a mean per household consumption (PHC) for all days of 740.7 L per household per day (L/h/d) and assuming eight occupants, this equates to a modest PCC of 92.6 L/p/d. Showering activities account for just over one third of total household consumption (35.7%). Total water use is higher on weekdays, compared with weekends, with a slightly higher shower component. Average shower frequency for house G is notably lower (only 5.2 showers per day, equating to 0.65 per person per day) but of a slightly higher duration (9.1 min) than reported UK norms (of a daily 7 or 8-min shower [15]). Average shower volumes of 51.1 L are not excessive, indicating that the shower fixtures help to curtail consumption despite slightly longer durations.

Table 5. Summary of Per Household Consumption and shower micro-component, house G.

Variable	Number of Days	Mean PHC (L/h/d)	Shower Volume Component of Mean PHC (L/h/d and %)	Mean Shower Event Frequency (L/h/d)	Mean Shower event Duration (Digital Minutes)	Mean Shower Event Volume (L)
All days:	51	740.7	264.7 (35.7%)	5.2	9.1	51.1
Weekday	*37*	*788.9*	*284.8 (36.1%)*	*5.4*	*9.3*	*52.2*
Weekend	*14*	*613.5*	*211.6 (34.5%)*	*4.4*	*8.7*	*47.4*
Amphiro in situ	28	687.2	209.6 (30.5%)	4.5	8.8	30.5
Diaries only	15	618.7	195.5 (31.6%)	4.7	8.4	31.6
Diaries to end	21	606.4	189.4 (31.2%)	4.2	9.0	31.2

The lower half of Table 5 provides summary consumption, shower frequency and durations for varying periods within the study period (for all days) that correlate with interventions. It illustrates that the installation of the Amphiro devices on 14 February appears to lower both total PHC (by 7%) and the shower component by an impressive 21% from 264.7 to 209.6 L/h/d. In addition, the shower frequency reduced by 13.5% (from 5.2 to 4.5) and the volume reduced by a significant 40.3% (from 51.1 to 30.5 L).

There are several explanations for this. The presence of the Amphiro appeared to slightly lower the mean shower flow from 6 L/min to 5.7 L/min (5% flow reduction) and the physical presence of the in-shower display facilitated a behavioural change in showering practice. During the period that participants were keeping diaries (21 February to 07 March 2018, see Section 3.2—only two out of eight occupants), the act of recording diaries brought the showering routines into their consciousness and altered the participant shower behaviours. Finally, during the later stages of the monitoring period, PHC and per household shower use reduced due to reduced occupancy, as students took early vacations or trips home to prepare end of term assignments.

Figure 8 shows the correlation in the proportion of daily PHC (ranked from high to low)) with the associated showering component (red portion of the bars, 35% on average). Bars with no coloured outline represent days prior to intervention (before 14 February 2018, 23 days). Fifteen of the highest ranked days (top 25 days, above the median) correspond to pre-intervention days, with only seven pre-intervention days in the lower PHC days. The day that the Amphiro devices were installed (14 February 2018) is outlined in pink (ranked 14th out of 51 days by PHC volume). The days that diaries were recorded are outlined in green (21 February to 07 March 2018), whilst the days when the Amphiros were in situ, (but not diaries) are outlined in orange.

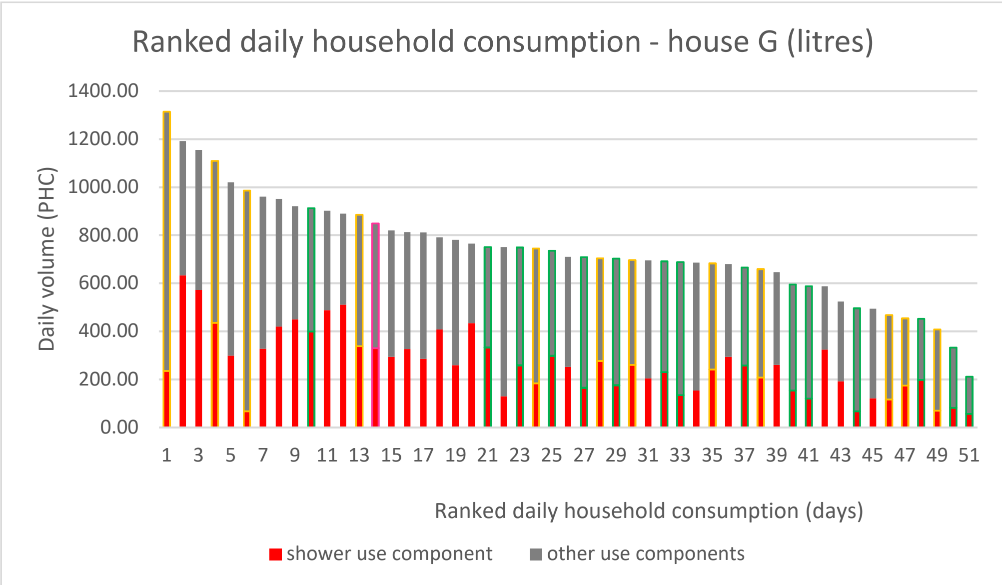

Figure 8. Ranked daily Per Household Consumption assigned to showers and other uses (house G).

3.2. *Qualitative End-User Data Analysis*

There were 34 unique participants across all the user data collection methods, representing a 34% participation rate (adjusted for five participants recruited from outside the main study site). Participation (split by gender) is summarised in Table 6. There were nine participants (six females and three males) that contributed to all three methods (diaries, focus groups and questionnaire), representing 10% of the study population.

The diary method had the highest participation (19 female including three from outside the study site and 7 male). This high recruitment may be because the Researcher set out to recruit participants to keep diaries first; they were guaranteed a £20 shopping voucher on completion; and it was earlier in the semester, before end-of-term assessments loomed. Even removing the three female participants from site Q, the sample was skewed towards female participation (69% sample, versus 62% population). This may be due to recruitment bias on the part of the female Researcher or it may be evidence that females are more willing to be engaged in this sort of research.

Table 6. Summary of participants (split by gender).

House	Intervention	Diaries	Focus Groups	Questionnaire Responses
Q	Control	3♀ [1]	2♂ [2]	1♀,1♂ [3]
A	Control	1♀	0	0
B	Control	1♀ 1♂	1♀ 1♂	1♀
C	Poster 1	1♀	0	2♀
D	Poster 2	2♀, 1♂	2♀ 3♂	1♀ 1♂
E	Shower timers	2♀	0	2♀
F	Shower timers	3♀	3♀	4♀
G	Amphiro	2♀	0	1♀
H	Amphiro	2♀ 3♂	1♀ 5♂	2♀ 1♂
I	Face-to-face	2♀	2♀	0
J	Face-to-face	2♂	1♀ 3♂	1♀,1♂
Total		19♀, 7♂	10♀, 12♂	15♀, 4♂

♀ = *female*, ♂ = *male*.

[1] *diaries = 3 females from site Q (outside study site, within 37-house development)*

[2] *focus groups—2 males from site Q (outside study site, attended house C/D focus group)*

[3] *questionnairess = 1 male from site Q (outside study site, (also attended house C/D focus group).*

The shower characteristics as self-reported in shower diaries are summarized in Table 7. The diaries confirm the norm of a near daily shower (0.98 showers per day), although this ranges from 0.4 (for a participant in house G, equivalent to every 2 or 3 days) through to 1.8 (nearly twice a day for a resident in house 'Q.' Most participants reported above social norm durations, with the mean for all diarists 11.2 min. House I/J bucked the trend and reported average durations in line with the UK 7 to 8-min norm, ranging from 3 to 20 min. The participants from the other houses collectively reported some excessively long showers of more than half an hour. Participants used an average of 2.5 products (shampoo, shower gel, etc.) and undertook 3.4 in-shower activities (such as shampooing hair, conditioning hair, washing body or face, shaving etc.) per shower.

Table 7. Summary of shower characteristics self-reported in shower diaries.

Houses	Mean Frequency (per Day)	Frequency Range (Min-Max, per Day)	Mean Duration (Minutes)	Duration Range (Min-Max, Minutes)	Average Number of Products	Average Number of In-Shower Activities
A/B/Q	0.98	0.5–1.8	14.0	5–30	2.7	3.6
C/D	1.05	0.8–1.4	10.0	2–48	2.9	3.2
E/F	1.06	0.9–1.1	14.1	3–43	3.3	3.7
G/H	0.89	0.41.1	9.4	2–34	1.9	3.3
I/J	0.96	0.7–1.1	7.6	3–20	2.1	2.9
All	*0.98*		*11.2*		*2.5*	*3.4*

Following the gender imbalance in diary participants, dominated by females, the pendulum swung in the opposite direction for the focus groups with more male participants (including two new recruits, from site Q). The immediacy of the activity being situated within the student house and the opportunity for free food (pizza) and juice may have influenced this change in gender participation; or because attendance at the focus group was perceived as less of a time commitment. Alternatively, females may be more reluctant to discuss private showering habits within the collective context of a focus group, preferring more private means of communication. These ideas will be explored in subsequent research.

Only in the first focus group on 28 February 2018, hosted by house J, did participants from the other paired house participate, despite multiple invitations via email, leaflet and door-knocking.

This workshop was also the only gender-balanced group. As noted above, it also doubled up as the intervention itself (Table 2) and therefore, it was important that the diarists participated. The scheduling also meant that it was early into the participation process and did not get jeopardised by course assignment deadlines and other distractions.

The ISM model was used to structure discussions to evaluate conventional interventions (such as shower-timers, low-flow showerheads, posters, education and smart meters (Amphiros) and to co-design potential novel interventions. The ISM framework helped to capture a broad range of influences around shower use and the features of flow, duration, frequency and in-shower activities. The discussion meandered around because the disparate factors from the different domains (of Individual, Social and Material) are interconnected and complex. The ISM model helped to reach beyond individual determinants and uncover some of the wider social influences on showering routines. Whilst the participants struggled to relate some of the factors to their own experiences, those from houses C/D and E/F could relate more readily to the realities of water shortages, as these focus groups took place on 14 March 2018 during the 'no water' event, making the issue more tangible.

Focus group participants that had received the poster interventions, were favourable towards the '*Pee in the shower*' poster but felt that it simply made the practice socially legitimate for those that already do it and therefore, would not actually result in any real water savings. The '*Share a shower*' poster was deemed to be less practical and had the potential to result in longer duration showers, especially with having to negotiate space to access products or water flow within the confined space of the cubicle.

The Amphiro smart meters were favourable with the participants (especially those from house H who had experience of using them), as the device has power to interact with individual values and beliefs (to avoid drowning the polar bear) and setting norms for individual performance (litres used). Several participants that did not trial the Amphiro, voiced a need for an (at the point of use) in-shower technology (via a water proof visual display or audio play list), coupled with a Fitbit-type device or mobile phone app (several participants reported taking their phones into the shower room to play music). The device also served as a topic of conversation within the household (house H), bringing in the social dimension of comparison and competition. Some considered purchasing an Amphiro for their shared house the following academic year as a way of monitoring hot water use to make the division of water and energy bills more equitable.

The evaluation questionnaire had the lowest uptake, with 19 participants (15 female). This lower participation was disappointing as it provided rich background information on the student's water-using routines along with socio-demographic information to supplement Accommodation Services lettings and demographic data. However, the Researcher also has the results of a similar questionnaire from October 2017 targeted as all UWE students, in which 158 responses were received (66% female, 33% male).

The questionnaires confirmed that young adults shower for longer durations than the general population, with average self-reported shower durations of 10–12 min, up to a maximum of 60 min (October 2017 questionnaire). Half of respondents take a daily shower with a further quarter showering between 4 and 6 times per week and 8% showering more than once per day. There is no clear pattern in terms of the time of day but morning showerers spend two- minutes less time performing their ablutions. The majority use at least three products (such as shampoo, conditioner, shower gel, etc.) and perform at least three activities (wash hair, condition hair, wash body, shave, etc.) in the shower.

4. Conclusions

This research is at an early stage and the first phase of fieldwork described in this paper has been used to test the experimental design. The research aims to use a combination of different metrics, including sub-meter PHC data alongside shower micro-components to quantify the showering routines of young adults. The initial development of an experimental design to test the efficacy of real-life water-saving interventions in a living laboratory has been described. Prior to undertaking the research stakeholders from Estates and Accommodation services were engaged and the research team familiarised themselves with the configuration, infrastructure and fixture performance of the houses to be tested. Challenges with the physical measurement of water consumption at both the household and shower fixture scale have been reported.

Despite apparent standardisation of water fixtures across the estate, there remains some inherent variability within the shower flow rates, compounded by the routine swapping of showerheads during Legionella risk management processes. Further investigation is needed to understand why the BMS consumption data is not completely reliable and accurate and a solution will be developed for the household meters to operate in parallel with the micro-component loggers in the next round of data collection.

Traditional volumetric data has been complemented with the collection of end-user insights into the complexity, heterogeneity and reality of how showering is practiced among the target user group, and how it might change during the transition from home to adult independence. The Researcher developed a degree of trust via dialogue with students living in the selected houses within the study site, to recruit end-users willing to accept water-saving interventions, record their showering routines (via diaries), share aspects of their personal and very private showering patterns (via questionnaires) and discuss influencing factors across individual, social and material domains on their showering behaviours, facilitated using the ISM model to bring rigour to evaluate and design of real-world water-saving interventions.

The next step is to combine the different strands of quantitative water consumption data with the qualitative insights to fully evaluate the efficacy of a range of conventional water-saving interventions. This appraisal will provide a platform to design novel water-saving approaches that can be tested using a modified experimental design (to address some of the challenges and limitations as reported here). The future intervention(s) will focus on the showering practices of users that have extended the purpose of showering beyond a personal cleaning function, into a leisure activity in the pursuit of high-intensity personal grooming standards (termed 'Attentive cleaning' [14]). The novel intervention(s) will focus on lengthy hair washing/conditioning routines of those that have multiple bottles of products lined-up in the shower cubicle, who take lengthy showers in the afternoon and evening, benefiting from the unlimited supply of hot water included in their housing rent, by making a connection to the social aspects of showering. Approaches to target other types of shower pattern, such as reducing the duration of 'Simple daily showering' [14] will also be explored.

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Challenges of researching showering routines – from the individual to the socio-material

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ABSTRACT

Water supplies are under threat from climate change, population growth and modern lifestyles. Excessive demand wastes money, energy and carbon. Evidence indicates that young adults are particularly high water-users. This population segment is at a transitional life-stage, leaving home to become independent adults. It is a time when new life-long habits can be shaped, but also when there is pressure to conform to high standards of cleanliness and body-image required to fit with new social groups and form intimate relationships with peers. Showering is the largest and growing component of domestic water consumption. This paper sets out the study design, presents early findings and reflects on the challenges faced by a doctoral researcher in working with different types and scales of data to explore how theories of behavioural and social change can help to inform a real-world programmes of water efficiency measures underpinned by rigorous research. It focuses on the showering patterns of first year students living in campus accommodation at the University of the West of England, Bristol. The Scottish Government Individual-Social-Material model, underpinned by cross-disciplinary behaviour and social change theories, was applied to evaluate typical showering demand reduction measures and co-design alternative or novel ideas. A mixed-methods approach explored the inherent variability of personal showering routines and the relationship with conventional household metrics of water consumption by combining household meter, logged water-fixture micro-component, personal-use survey, user diary and stakeholder focus group data.

Keywords: behaviour change, Individual-Social-Technical toolkit, mixed-methods, showering, water efficiency, young adults

1. INTRODUCTION

The privatised water supply companies in England and Wales have had a *duty to promote the efficient use of water* since the 1990s [1] and in 2010 Ofwat introduced new statutory water saving targets [2]. Water policy-makers deal in the language of average per capita consumption (PCC) measured in litres per person per day, as a key metric for domestic water use. The estimated average PCC in England is about 150 l/p/d [3], although the latest reports, following seven years of targets indicate that this figure is now reducing (141 l/p/d [4]).

The measure presents several challenges for water companies in understanding the dynamics of daily water-using routines [5]. PCC is only an estimate [6] and can be calculated based on the measured water volume supplied to domestic properties divided by the estimated population served, or based on a panel study of metered households, for which water companies hold more reliable occupancy data [7]. In contrast, calculating the PCC for students living within the university is more reliable than calculations for the wider population, as information on lettings and corresponding occupancy is more readily available. However, assumptions still need to be made on actual occupancy levels, as a let flat may not be fully occupied, with tenants opting to spend much of their time living elsewhere with friends or, for UK-based students, returning home at weekends and holidays. Conversely, rooms may be over-occupied with house guests staying occasionally, regularly or on a semi-continual basis.

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One flaw in relying on PCC is that it represents an underestimate of total personal consumption. Water is not consumed by individuals solely within the household meaning that PCC excludes personal water-use in places of work, education and leisure, through sanitation and hygiene (WC flushing and hand washing) or process water from the provision of drinks and meals consumed away from home (cooking and dishwashing). For example, day-time office use is reported to add a further 16–28 l/p/d to personal consumption [8] , with more associated with leisure-time pursuits.

Another challenge is that the process of aggregating and averaging individual water use hides the variations in everyday personal water use patterns. There is growing interest in understanding how water is consumed in the course of everyday life so that behavioural-based interventions may be designed to reduce consumption [9], Micro-component studies indicate that there is a great variety in individual household patterns of consumption [10, 11], made all the more difficult to measure when almost two thirds of consumption takes place in the privacy of a locked bathroom.

Working with averages also hides the differences between different demographic groups (age, gender or nationality). Research by Waterwise [12] indicates that younger people shower for about two-minutes longer than older population segments. Whilst education is seen to be important to creating more sustainable behaviours by both children directly and with other members of the household by 'pester-power' [13], there is little evidence of any effect on water use from the many environmental educational programmes delivered in UK schools [14], despite self-reporting of pro-environmental attitudes. Evidence suggests that older generations are more environmentally conscious [15]. There are likely to be stronger social pressures working in the opposite direction of rising environmental awareness among this age-group, partly as a result of life-course stage and the need to conform to higher standards of body-image. Young adults are at the transition point between maturing from dependent children into independent autonomous individuals, and universities can play an important role in facilitating social change to address important issues [16, 17, 18].

The variations in showering routines amongst a group of mostly first year under-graduate students living in on-campus university accommodation were observed using a range of metrics including water consumed at both household and shower component level, and self-reported data collected from surveys and diaries. These insights were combined with outputs from a series of focus groups, to evaluate a range of conventional technological and behavioural water-saving measures, to collectively design alternative programmes of measures. The focus group discussions and outputs were structured using the Scottish Government Individual-Social-Material toolkit to move discussions beyond traditional individual behaviour change ideas to encompass wider social and material determinants. The ISM model is based on theory and developed out of [19] an international review of successful behaviour change initiatives. It has been refined through research and the evaluation of environmental behaviour change interventions.

A mixed-method approach was adopted, in which both quantitative and qualitative data were collected. Data processing and analysis is on-going. This paper reports on some initial findings and the challenges faced when undertaking real-world research and the process of triangulating between different epistemological and methodological approaches.

2. METHODOLOGY

2.1 Participants and setting

Fieldwork was conducted during the first quarter of 2018 and set out to explore the showering routines and associated water consumption by student residents. The study site concentrated on ten townhouses comprising 88 beds, within a larger 404-bed development, built in 2014 at the University of the West of England (UWE) main Frenchay campus, Bristol. The water consumption for all 37 houses in the development are sub-metered at 30-minute intervals, as part of the Building Management System. Two thirds of the houses in the development comprise 12 single study bedrooms. However, this study focused on ten of the smaller eight and ten-bed houses (total design occupancy of 88 beds), clustered together around a courtyard (labelled A-J in this paper to preserve anonymity). In each house, the ground floor has a communal kitchen/diner with two mixer-tap sinks (high flow, no regulators) and a single dual-flush WC with wash-hand basin (with flow regulating tap aerators). Some leaking kitchen taps were identified and reported to the Facilities department for fixing by the Researcher during the study.

Six of the ten townhouses (A, B, C, F, G, J) comprise eight single bed study rooms with four shared shower/WCs across two floors (four bedrooms and two shower room/WCs per floor). Four slightly larger corner-aspect townhouses (D, E, H, I) have the capacity for ten occupants, with one twin/shared bedroom, three single occupancy bedrooms and two shared shower/WCs on each of the upper two floors. The shared shower rooms include a shower enclosure with water efficient showerhead (c.8 litres per minute), wash-basin (tap-aerators, flow regulated to c.4-5 l/m) and a dual-flush (pneumatic) WC. Laundry facilities are provided centrally for residents in a separate facility and are outside the scope of this study. There is no outside water use. Demographic data from the university Accommodation Services reveal that within the study site, there are two void bed (house E), 53 females and 33 males; 72 (84%) are aged 18-22 years; 35 (41%) have UWE gym membership; and there are 52 (61%) UK nationals, 9 (11%) from the EU and 25 (29%) are non-EU international students.

2.2 Water fixtures audit

In Aug 2017, during the summer void period, the Researcher undertook an audit of the water fixtures within the un-occupied development to familiarise herself with the plumbing installations. Flow-rate data were collected for five townhouses across the wider 37-house development including two within the study site (houses B and G) and are indicative of the relatively standardised fixtures for each house across the estate.

2.3 Water consumption monitoring

Each townhouse within the development is sub-metered at 30-minute intervals as part of the university's Business Management System (BMS). To supplement the BMS data, the ten townhouses in the study were fitted with Siloette loggers (supplied by Artesia Consulting, see Fig.1.), which record a pulse for every 500 ml of water through the meter. The finer resolution allows for detailed analysis of flow, duration and frequency profiles and identification of water-using events by individual types of fittings within a household, such as showers, WCs and taps. These micro-components help to bridge the gap between measurement of household consumption by metering and individual water-using routines.

Fig.1. Siloette logger attached to water meter

Following an 18-day test using one logger from 15 Nov 2017, to check for metering system compatibility, Siloette loggers were installed with splitter cables from each sub-meter (to allow for the BMS to continue to record 30-minute water consumption and the loggers to record 500 ml water use) on 18 and 19 Dec 2017, and removed on 28 Mar 2018.

2.4 Water-saving interventions

Conventional water-saving measures of the sort deployed by current water company water-efficiency programmes were tested during the study in pairs of households. These are summarised in Table 2.

Table 2. Summary of water-saving measures tested

House	Measure	Location
A & B	Nil – control group	
C & D	Posters *(installed 14-Feb, removed 07-Mar)*	Generic water-saving messages in communal area notice board/downstairs WC (back of door) *'Share a shower'* (house C) and *'Pee in the shower'* (house D) in shower rooms (back of door)
E & F	4-mintue shower timers *(left with diary participants on 21-Feb)*	One per resident
G & H	Amphiro a1 smart shower meter *(installed by Estates on 14-Feb, diary participants briefed on 21-Feb)*	Installed in each shower room
I & J	Face-to-face engagement *(28-Feb, 2.30pm in house J)*	Communal area – all residents invited, refreshments provided

2.5 Qualitative data collection

To complement the quantitative data at both household and shower fixture scale, qualitative data from individuals was also collected to help understand the shower routines of student residents. Participants were principally recruited by door-knocking and leafleting the target houses, with recruited participants subsequently asking their housemates to join in.

Initially, residents were asked to keep a simple shower diary for two weeks (21 Feb to 07 Mar 2018). The Researcher aimed to recruit two or three diary participants per house (20-30 in total, representing between a quarter and a third of the population). Active consent was obtained from all volunteers, as per ethics approval requirements. Participation was incentivised by compensating students for their time and commitment with a £20 shopping voucher of their choice on return of completed diaries.

A series of five focus groups were conducted for each pair of houses/intervention type. The focus group workshop for houses I and J was conducted at the mid-way point of the diary fortnight, on 28-Feb. This focus group had a dual purpose as it formed both the water-saving measure of itself (in the form of face-to-face education and engagement) and served to co-design future water-saving measures. The four subsequent focus groups followed a similar structure to evaluate interventions, and these were run on Wednesday afternoons on 07-Mar (houses G and H);14-Mar (2 focus groups, houses C and D, followed by houses E and F); and 21-Mar (houses A and B). The final focus group was used as a 'wash-up' session and any diarists that had been unable to attend their own focus group were invited.

Diary participants were actively invited to take part, and they were encouraged to ask their housemates to join-in. The Researcher also advertised the focus groups by delivering leaflets a few days before the planned sessions with the promise of refreshments, and entry into a prize draw for a £20 shopping voucher for all participants of the focus groups. Each focus group was run within the downstairs communal dining/sitting area of one of the pairs of houses (with prior agreement from the residents, pragmatically selected based on the higher number of engaged participants to ensure maximum attendance), and lasted for about 1.5 hours (active consent was obtained from all participants, in-line with research ethics protocols). Once the consent forms were completed over refreshments, an audio-recording of the discussion was made on the Researcher's mobile phone for later transcription.

The discussion started by setting ground rules; discussing why there is a need for water efficiency; how water is used in the home (with showering accounting for 25% of demand and growing); and a description of conventional water-saving measures. The rest of the focus group used the Individual-Social-Material toolkit [20] to structure discussion to both evaluate existing measures and co-design future interventions to tackle a specific showering determinant (selected by the focus group, such as flow rate, duration, frequency or in-shower activities). The 18 factors from the three ISM contexts (see Table 3) were introduced with definitions on a set of prepared flashcards. Each factor was discussed in turn, and colour-coded notes were made by the group on an A3 sheet (green for Individual, blue for Social and black for Material contexts).

Table 3. Individual-Social-Material toolkit

Context	Factors
Individual	Values, Beliefs & Attitudes; Costs & Benefits; Emotions; Agency; Skills; Habit
Social	Opinion Leaders; Institutions; Norms; Roles & Identity; Tastes; Meanings; Networks & Relationships
Material	Rules & Regulations; Technologies; Infrastructure; Objects; Time & Schedules

At the end of the diary fortnight, an online survey was launched (07 to 21 Mar) and all research participants (directly by email) and the residents (via leaflets and word of mouth) in houses A-J were invited to take part. The survey collected information on environmental awareness, showering habits and other water-using routines, water fixtures at home and demographic information. The questions were very similar to a wider survey targeted at all UWE students Oct 2017. Participation was incentivised with entry into a prize draw for a £20 shopping voucher.

3. RESULTS AND DISCUSSION

3.1 Quantitative data analysis

Despite the same standard of fittings broadly installed across the estate, the water audit found some variability in flow rates. Most of the 26 showerheads tested were water efficient, ranging between 7 and 9 l/m, and manufactured by Ideal Standard. However, one showerhead delivered a flow of more than 14 l/m (regulating the flow from 21 l/m without the showerhead). In contrast, one showerhead only delivered 4.2 l/m (with a flow of just 4.4 l/m without the showerhead). Showerheads (and tap aerators) are changed (removed, cleaned and replaced) every few months as part of the Estates department routine *legionella* control management programme, and are not necessarily replaced with identical fittings, but with whatever is available at the time.

In analysing the metered water consumption data from the BMS, it became apparent that the meters sometimes stick. There were several periods before, during and after the trial in which the consumption value for a 30-minute period was repeated in the next and subsequent time steps, and this pattern could be detected across multiple sub-meters for the same time steps. This discovery puts a question mark over the reliability and accuracy of the BMS sub-meter water consumption data.

During the focus group and survey phase, the estate experienced a major water mains-burst event which resulted in a large proportion (40%) of the campus estate, including the trial site, having no water for a period of more than 30 hours (from 02:30 hrs 14 Mar to 12:00 hrs 15 Mar). When the water was turned back on following the repair, debris was pulled through into the pipework and resulted in several sub-meters including one of the trial houses (house A) being damaged (and flat-lining). In addition, for the duration of the trial, there is no BMS data for house G, due to the splitter cables for the Siloette loggers not working as expected.

Artesia Consulting downloaded the Siloette logger data. Unfortunately, only one logger (house G) recorded any pulses for the duration of the main trial. Subsequent investigation has shown that the splitter cables did not operate as expected, and in most cases failed to send pulses to the loggers. For house G, the pulses were recorded at the expense of main sub-meter data recorded by the BMS. A solution to this problem will be worked on prior to a repeated trial in the autumn 2018.

To-date only the limited test dataset (house A) has been analysed for shower micro-components. A total of 160 shower events (and 4000 WC flushes and tap uses) were identified from the 18-day test logger (15 Nov to 4 Dec, house A), although there was a 4-day mid-week period (21-24 Nov) in which no pulses were recorded. It is not clear why this happened and it warrants further exploration.

The limited results available to-date are summarised in Table 4. They should be viewed with caution due to limited dataset and skewed demographics of house A (all eight female, mostly non-EU international, and slightly older students). There is little difference in the median per household consumption (PHC) for weekends and weekdays (equivalent to a PCC of 211 l/p/d), but the spread on weekends is larger, revealing greater variability in routines at weekends. Average shower duration and frequency are notably higher than reported UK norms (of 7-8 minutes duration daily showers [12]). However, average shower volumes of about 62 litres are not excessive, indicating that the shower fixtures help to curtail consumption despite the longer durations.

Table 4. Summary of PHC and shower micro-components (test period, house A)

Variable	Median PHC (l/ h/d)	Mean PHC (l/ h/d)	Mean shower volume (litres)	Mean shower frequency (per day)	Average shower PHC (l/ h/d)	Mean duration (mins)
Weekday	1,689.5	1,439.2	56.2	8.92	501.12	12.5
Weekend	1,690.3	1,608.5	64.8	8.83	572.40	11.6
All days	*1,689.5*	*1,495.6*	*62*	*8.89*	*551.18*	*12.2*

Figure 2 shows the correlation in the proportion of daily PHC (ranked from high to low)) with that associated showering component (in red), and confirms that showering represents about a third of daily consumption. Weekend showers are taken later during weekend mornings (not before 10:30am) whilst weekday showers start between 6-8am.

3.2 Qualitative data analysis

There were 34 unique participants across the qualitative data collection methods, representing a 34% participation rate (adjusted for five participants recruited from outside the main study site). Participation (split by gender) is summarised in Table 5. There were nine participants (six females and three males) that contributed to all three methods (diaries, focus groups and survey), representing 10% of the study population.

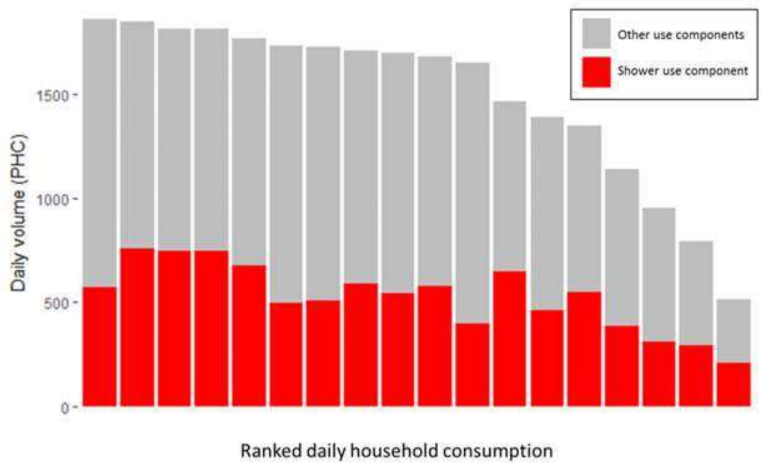

Fig.2. Daily Per Household Consumption assigned to showers and other uses (test period, house A)

Table 5. Summary of participants (split by gender)

Houses/intervention	Diaries	Focus groups	Survey responses
A, B & Q - Control	1♀, 1♀ 1♂, 3♀[1]	0, 1♀ 1♂, 0	0, 1♀, 1♀ 1♂[3]
C & D - Posters	1♀, 2♀	0, 2♀ 3♂[2]	2♀, 1♀ 1♂
E & F - Shower timers	2♀, 3♀	0, 3♀	2♀, 4♀
G & H - Amphiro	2♀, 2♀ 3♂	0, 1♀ 5♂	1♀, 2♀ 1♂
I & J - Face-to-face	2♀, 2♂	2♀, 1♀ 3♂	0, 1♀,1♂
Total	19♀, 7♂	10♀, 12♂	15♀, 4♂

♀= female, ♂ = male
[1] diaries = 3 females from site Q outside study site, within 37-house development
[2] focus groups – 2 males from site Q, outside study site
[3] surveys = 1 male from site Q, outside study site (also house C/D focus group)

The diary method had the highest participation (19 female including three from outside the study site, and 7 male). This high recruitment may be because the Researcher set out to recruit participants to keep diaries first; they were guaranteed a £20 shopping voucher on completion; and it was earlier in the semester, before end-of-term assessments loomed. Even removing the three female participants from site Q, the sample was skewed towards female participation (69% sample, v 62% population). This may be due to recruitment bias on the part of the female Researcher or it may be evidence that females are more willing to be engaged in the topic. Data analysis is ongoing, but deciphering handwriting is proving a challenge!

However, the pendulum swung in the opposite direction for the focus groups with more male participants (including two new recruits, from site Q). The immediacy of the activity being situated within the student house and the opportunity for free food (pizza) and juice may have influenced this change in gender participation; or because attendance at the focus group was less of a time commitment. Alternatively, females may be more reluctant to discuss private showering habits within the collective context of a focus group.

Only in the first focus group on 28 Feb, hosted by house J, did participants from the other paired house participate, despite multiple invitations via email, leaflet and door-knocking. This workshop was also the only gender-balanced group. It doubled up as the intervention and therefore it was important that the diarists participated. The scheduling also meant that it was early into the participation process and perhaps didn't get jeopardised by course assignment deadlines. Diary and survey participants who had been unable to attend the previous sessions were invited to attend the final focus group on 21 Mar (or to participate in one-to-one semi-structures interviews instead, if they were more comfortable discussing their showering routines with the Researcher in private). However, this focus group comprised just two participants and one of those (male) was via Skype, meaning that there was a lot of leftover pizza! No students volunteered to be interviewed.

Focus groups for houses C/D and E/F took place on 14 Mar during the 'no water' event. This made the reality of water shortages very tangible and resulted in interesting discussions. The 'no water' event presented challenges to the Researcher too. The Student's Union was unable to the supply pre-ordered pizza due to the supply interruption, so an off-site alternative was ordered. The Researcher assumed that they would be delivered directly to the houses hosting the focus groups at the booked times. Instead, they had to be collected from a designated collection point on the opposite side of the campus, a good 5-minute walk. The mobile phone signal within the study site was poor making it difficult to liaise with the delivery operative. Delivery for the second focus group was attempted before the late-running first session was complete. The Researcher gave instructions for the focus group to complete the discussion on the ISM factors, left her mobile to record the discussion, and went to collect the delivery for the next workshop. On return, she discovered that not only had she missed the discussion, her audio recording had stopped due to the delivery phone call interruption!

Focus group transcription and analysis is on-going. The discussion will be categorised using the ISM factors and their linkages between contexts or levels, to present an evaluation of the conventional water-saving measures tested and to develop a programme of alternative interventions. The ISM structure guides the discussion to consider wider social and material structures and their interactions beyond more tactical and intuitive individualised behavioural factors. This results in a more strategic view of the multiple factors and scales that shape the way things (in this case showering) are done. A further focus group with supply-side stakeholders including university estates, facilities, accommodation and sustainability representatives is planned to complement the demand-side student-focused research summarised in this paper.

The survey had the lowest uptake, with 19 participants (15 female). This lower participation was disappointing as it provides rich background information on the student's water-using routines along with socio-demographic information to supplement Accommodation Services lettings and demographic data. However, the Researcher also has the results of a similar survey from Oct 2017 targeted as all UWE students, in which 158 responses were received (66% female, 33% male).

4. CONCLUSION

This research aims to use a combination of different metrics, including sub-meter PHC data alongside shower micro-components to quantify the showering routines of young adults. Quantitative data has been complemented with the collection of qualitative insights into the reality of how showering is practiced, and how it changes during the transition from home to adult independence. This has been facilitated using the ISM model to bring rigour to evaluation and design of real-world water-saving measures.

Despite apparent standardisation of water fixtures across the estate, there remains some inherent variability within the shower flow rates, compounded by the routine swapping of showerheads during Legionella risk management processes. Further investigation is needed to understand why the BMS consumption data is not completely reliable and accurate, and a solution will be developed to the household meters to operate in parallel with the micro-component loggers.

Recruitment of student participants via door-knocking proved to be successful, although the Researcher will reflect upon how to improve the demographic representativeness of the different research approaches and will consider adding semi-structured interviews into the mix. Finally, the timing of future fieldwork will be mindful of schedules of the potential participants to avoid busy assessment periods and holidays.

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The Researcher is grateful to the 34 committed student residents who kept diaries, completed the evaluation survey, and/or hosted and participated in focus groups. Finally, thanks go to Rosie for helping prepare 18 ISM factor flashcards for use in the focus group sessions.

COMPETING INTERESTS

None

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Water Efficiency Conference 2016

Socio-cultural Drivers of Water Demand in Student Residential Accommodation

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ABSTRACT:

In 2012 UWE, Bristol entered into partnership with Bristol Water to initiate a longitudinal, multimethod study of water consumption by students in first year accommodations on the main UWE campus at Frenchay, Bristol. Now in the third cycle (each runs from September to June, following the academic year) of this study we are in a position to report on patterns of water consumption, underlying socio-economic drivers and the impacts (or not) of both "hard" (new fixtures such as low flow showerheads) and "soft" (conservation messaging) attempts at achieving greater water savings. So far, one of the "surprise" findings has been that behavioural adaptation to hard interventions can easily offset any initial water savings. We have also found that our growing dataset has considerable application in facilities management as well as water conservation programming.

Keywords:

1. INTRODUCTION

In late 2012 UWE, Bristol and Bristol Water Plc agreed to jointly support a long-term programme of research into water use at an on-campus student accommodation facility known as the "UWE Student Village". Total occupancy for the Village as at 01/02/2015 was 1878 students against a total capacity of 1932. In effect, the Student Village became a "laboratory" for studying the effects of different sorts of interventions on water consumption. Both UWE, Bristol and Bristol Water expected that this work could improve the information base for such measures elsewhere and help both institutions achieve business objectives (e.g. UWE's KPI around water demand and, indirectly, energy consumption and Bristol Water's company targets around demand management).

Scientifically the Student Village is very useful because it is well-understood both in terms of infrastructure and also demographics, and changes over 100% each summer. This means that, almost uniquely, it is possible run and re-run "experiments" in water efficiency through "hard" (e.g. new fittings) and "soft" (behaviour change) measures for water efficiency. It was also felt, especially after Bristol Water completed a site investigation in July 2012, that there were also changes to the overall site facilities (e.g. water tanks, pumps, etc.) that could realise additional water efficiencies and cost savings.

In this paper we focus on what has been learned to date about the patterns of water use within the Student Village and the relative impact of certain "hard" versus "soft" water conservation measures. We end with a brief discussion of planned activities for the 2016-2017 phase of the project.

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According to peer-reviewed and gray literature, water efficiency can be achieved essentially through either "hard" or "soft" measures. Hard water efficiency measures are devices and fixtures installation resulting in reduction of water uses. Soft water efficiency measures are behaviour-based methods, usually involving user education towards more sustainable use. These measures are important in influencing consumer behaviour and in ensuring the take-up and use of water efficiency devices and products. Soft measures are generally underpinned by theoretical assumptions about the links between attitudes and behaviours. Such assumptions fall into three broad classes:

- Those who view resource use choices as largely determined by the associated material incentive (price). Such models tend to depend heavily on the idea of "price elasticity of demand", something for which there is only weak evidence in residential water systems
- Behavioural models which, whilst acknowledging the importance of price elasticity, also insist that non-materially focussed attitudes, perceptions and beliefs also play a part in constraining resource use choices.
- Practice based models which proceed from a rejection of the individual decision maker as the unit of analysis and instead focus attention on resource-using practices such as showering or car-washing or gardening practices.

A number of studies find the association between positive attitudes toward water conservation and actual water conservation behaviour to be weak (Bagozzi. 1979; Miller and Buys, 2008). This means some individuals may have positive attitudes in relation to water conservation but may not put them into practice. Nevertheless, most attention to "soft" measures has tended to focus on measuring attitudes and then attempting to change them. Our approach is broadly behavioural, but eschews crude message based didacticism in favour of more sophisticated ways of engaging study participants. These are currently under development for implementation in the 2016-2017 cycle and will be discussed briefly in the final section of this paper.

In recent decades, University and Educational institutions have become increasingly interested in measures, such as those noted in Table 2, to reduce water consumption and therefore, costs. In 2013, Yale University's Office of Sustainability released a Sustainability Strategic Plan for 2013–2016. The university identified four technologies that could provide the best water efficiency:

- Sub-Metering: Yale relies on water meters capturing the total extent of campus water use. The university installed 23 additional building-level sub-meters in 2012 to obtain more detailed water-use data. The intent of this effort was to permit building-level water consumption benchmarking.
- High-efficiency plumbing fixtures: The university installed high-efficiency plumbing fixtures within all buildings. Installations generally included low-flow appliances and the sorts of measures noted in Table 2.
- Reclaimed water systems: System that retains non potable water to be used for non-potable demand. Yale has installed seven reclaimed water systems in six buildings since 2005, with various design and operational approaches and a range of performance outcomes.
- Water-Use Monitoring: Real-time monitoring of makeup and losses in campus enabled quick response in the case of leaks.

The Smith College has conducted a study on soft measures in 2011. The purpose of the study was to test the hypothesis that increased signage, shower timers, and educational events would change behavioural patterns and encourage students to reduce water consumption. The campus consists of seven houses, each with a water meter. Three houses were chosen for the study based on their capacity to meter daily water use. Two houses received educational materials while one did not, and the impacts on water consumption were measured and compared to data recorded before the educational programme. The results of the study provided support that educational materials and increased awareness of water could alter behavioural patterns and encourage students to conserve more water. In addition, students across campus were encouraged to participate in an online survey to measure water-use patterns. Findings from the online surveys also supported the proposed need for increased education and transparency.

2. METHODOLOGY

The UWE Student Village was opened and occupied for the first time in 2005. As Figure 1 shows, the Student Village is made up for four "Courts" (Brecon, Cotswold, Mendip and Quantock), each constituted of two seven or eight story "Blocks" arranged in facing pairs across "Courtyards". Each Courtyard contains a few small communal buildings, including reception, post and laundry facilities, which are water metered separately and do not form part of this study.

Each building is made up of contiguous of physically and functionally separate Blocks. Each Block is comprised of seven or eight levels, with two flats on each level, either side of a small landing/common space. Flats typically have 6 rooms, though some flats may have only five where larger rooms have been designed to accommodate disabled students. Each room is provided with a single toilet/shower room, which includes a hand washer basin, a shower with a thermostatic control valve and a dual flush lavatory. The five or six occupants of a single flat share a dedicated communal kitchen/lounge area equipped with a wash basin, two hobs, two refrigerators and sofas and chairs.

Each Block is separately metered, with the supply meter located in the nearby externally accessed services room, implying a meter coverage of one meter per 66 to 84 students depending on the exact configuration of each Block. These meters report every 30 minutes directly into the university building management system (BMS) and reports are sent on to us monthly by the UWE Estates Department. We are therefore receiving data one month in arrears. Work is underway to have the meter readings report directly to a different system which would be automatically available to the study team, providing much nearer to real time data access (a key issue to support real-time alarms and other decision triggers).

In line with the aims of the project, it was decided to analyse water consumption using an experimental approach, by means of different degrees of intervention and the implementation of specific water efficiency measures in each of the Courts. Specifically, Mendip (400 rooms) has been selected as a representative Court, with no intervention (the "control"). For the other Courts, both "hard" and "soft" measures were implemented, as shown in Table 1. Simple tap inserts were installed in all hand basins in Brecon Courtyard (564 rooms). Tap inserts and low flow showerheads were installed in Cotswold Courtyard (500 rooms). In Quantock Courtyard (468 rooms) soft measures including shower timers and paper posters promoting water conservation were installed. Using the reported water consumption data we hoped to test the following commonly-held ideas:

- Hard measures such as flow restrictors and low flow showerheads should reduce water consumption by "forcing" users to use less water per activity (e.g. teeth brushing or showering)
- Additional soft measures, such as shower timers and passive messaging may further reduce water consumption, though the additionality may be transitory.

We were also able to explore the relationships, such as they may exist, between water consumption and certain demographic and lifestyle characteristics of the studied population, including:

- Is there a measurable difference between male and female water use?
- Are there differences in water use by national/regional origin?
- Does involvement in sporting activities increase water use?

Exploration of these questions has thus far involved use of anonymised occupancy data provided by UWE Accommodation Services but in future could involve direct surveys of the student-occupants themselves.

Each month, monthly per occupant consumption figures are examined to ensure that obvious discrepancies (e.g. leaks) can be quickly observed and discussed with the estates team. Boxplots are produced to visualise the distribution of the consumption values, usually reported as "per capita consumption" on a half-hourly or daily basis, by Block and Courtyard. Statistical comparison with available demographic data highlighted that some observed differences could be due, in part at least, to the quite different demographic make-up of the different blocks in the study. As students are not randomly allocated to rooms, but are often grouped together for their own comfort, this has made the analysis much more complex.

General linear models were then used to model the per occupant consumption based on occupancy figures in February 2015, including "day number" [number of days since October 1st]; the day of the week; whether the date was during the academic teaching block; the proportion of UK students; proportion of gym members; proportion of females and the proportion of African/Asian students as explanatory variables. Consumption was modelled for each courtyard separately, with the socio-demographic factors used to help explain the differences in consumption within each courtyard.

3. RESULTS & DISCUSSION

Figure 2 shows the median water consumption per capita per Courtyard across an average day during February 2015. Extreme outliers (see below) have not been removed from this calculation. The diurnal water consumption pattern revealed is similar to what one sees in other studies of residential water consumption. From a late evening/early morning low, water consumption quickly rises during the "waking up" period towards a peak before falling off again as occupants attend to their daily affairs. Because these students live on campus and because they often prefer to study in their flats, water use does not fall off as much as might be expected in more "normal" residential communities. There is a second early evening peak in water use which falls off after about 11 pm as occupants either retire for the evening or go out.

Intriguingly Figure 2 suggests that, visually at least, the control Courtyard did not actually consume less water than the test Courtyards, in fact Mendip seems to have recorded the lowest water use. This obviously runs counter to original expectation, and the finding caused us to very carefully explore and re-validate the meter data system and to re-engage with Student Accommodation Services regarding occupancy rates and the rules/procedures for allocating students to rooms and flats. Data systems were found to be valid and reliable and, as we discuss below, demographic variables do seem to make a measurable difference to water consumption, but there are other issues at work too.

First among these is intra-Courtyard variability. Figure 3 shows box and whisker plots for all the constituent Blocks within the four Courtyards. As is readily apparent, intra-Block variability is considerable, particularly within Cotswold and Quantock. By Block median consumption ranges from about 120 litres/day to well over 300, a phenomenal range given average domestic consumption across the UK ranges from 140-160 litres per person per day. Also, the *spread* of values around the medians (the thicker black lines within the boxplots) challenges our initial assumptions about homogeneity within Blocks and perhaps even Flats. Holding that issue to one side for a moment, if we remove the more extreme outliers (M1, B4, B7, C4-6) from consideration then we obtain average water consumption figures more in line with expectation: Mendip=135 lpd, Brecon=160 lpd, Cotswold=125 lpd and Quantock about 150 lpd. As we will see below (from the regression model presented later on in this paper) part of this variability can be explained by different habitation styles linked to different student national origins. Another portion of this variability is, however, due to inefficiency in fittings themselves, including leaky loos and user tampering with fittings, something that we discuss in the conclusion to this paper.

The original design of this study was predicated on an assumption, confirmed in 2013 with Accommodation Services, that students were allocated non-systematically to rooms and Flats. The results reported above caused us to go back to Accommodation Services to probe this issue further and we then discovered that there are in fact allocation rules, though they are somewhat ad hoc. For example, whilst there is no general policy to create majority male or female Blocks, this has been done for some non-EU nationals where it has been deemed culturally-suitable. So, for example, during academic year 2014-2015, Brecon 6 was 100% female and Cotswold 6 was 75% male (all other Blocks were at least 60:40 or better). The gender composition of Brecon 6 is not easily explained as a function of the cultural needs of non-EU nationals, since 50% of its population were actually UK nationals. Cotswold 6 was 85% non-EU. Comparing with the 2013-2014 and 2015-2016 study cycles we discovered similar non-randomness, with the added complication that different Blocks are implicated each year – e.g. whilst Cotswold 6 was 85% male in 2014-15, it was only 53% male in 2013-2014. This had implications for our research in the 2015-2016 academic cycle (still under review) and caused us to create a different strategy for defining our control Blocks in future.

With the above constraints and discoveries in mind, we used regression modelling to see if we could explain a useful proportion of the variance in water consumption with reference to a variety of variables including:

- Day of week
- Day number within the month
- % UK nationals
- % male

More detailed results of this analysis are the subject of future papers, but we can report here that:

- Time of day explains about 25% of hourly per capita water consumption
- There is a modest falling off of water consumption as the study month progresses, perhaps as a function of students disengaging, travelling, etc.
- UK nationals consume less water, possibly as a function of spending more time at home
- Males tend to consume less water overall, though there is a high degree of intra and inter Courtyard variability on this measure.

Within our models there remain considerable residuals and the errors around the beta parameter estimates are reasonably large and non-uniform between Block and Courtyards. This is prima facie evidence for complex interactions between independent variables, the need to identify additional independent variables (to account for remaining residuals) and the possibility of systematic variations in fixtures and fittings. It may be that Factor Analytic techniques are a useful way forward.

Complicating the interpretation of data is the mounting evidence, from maintenance records and periodic audits, that there is considerable water consumption as a function of leaky and poorly maintained fittings and fixtures.

4. CONCLUSIONS

Generally, 2014-2015 results have marked a leap forward toward a better understanding of water consumption dynamics within the Student Village. Water meters have consistently reported "cleaner" data during the academic year, which has given the opportunity to work with 383,162 (out of a possible maximum of 384,792) half-hourly readings. In addition, 2013-2014 results have been analysed more in depth and used as a temporal baseline for subsequent years. Finally, with the new academic year student arrivals, we were able to analyse the effects of demographic changes for the first time.

Overall, the following key findings were identified:

- Demographics seem to play a big role in water consumption.

  The discrepancy between the Mendip actual data and the expected values has been an important matter for the whole year. After confirming that appliance issues could explain all the variation, demographic analysis was undertaken. The models produced attempt to explain the inconsistency looking at the important demographic differences found between the two years as well as day of week and time within the academic term. The models confirm that demographics seem to play a big role in water consumption. In 2016-2017 we hope to intervene in the allocation of students such as a large enough group of Blocks is essentially randomly assigned.

- Maintenance is still a big factor

  Many extreme readings were reported throughout the whole year. While part of the explanation could be explained by the periodical flushing done for maintenance purposes (esp. Legionella control), poor water systems maintenance is also clearly a culprit (confirmed also during "Water Audits" conducted in summer 2015). Consequently we have engaged with Accommodation Services to help them design a more robust water systems maintenance programme, which may actually save the University thousands of pounds per year in unnecessary water charges. Switching over to a fully automatic telemetry system (e.g. Elcomponent) will also enable the creation of an "alarms" system that could notify Accommodation Services whenever there are water use anomalies. This will benefit maintenance schedules and costs.

- Within-Courtyard variability is so high that a Block-level control (reference) group is required

  The "Mendip baseline issues" showed the importance of a much more sophisticated approach to defining the control group. The models proposed for the project have the benefit of being extremely flexible, permitting to work on different levels. However, it has showed that Courtyard-level analysis are not "fine" enough. Specifically, within the same Courtyards the results and the demographics have been different year on year. This pushes the project towards the identification of Court-level representative groups for the no-intervention and water-efficiency measures.

- Analysis of “soft measures” and “student behaviour” is likely to become an important requirement for the project in future.

  The significance of demographics in explaining this year’s results confirms that user attributes and behaviour is an important factor in water consumption. While “hard measures” effects have been easier to calculate, behavioural compensation is a much more powerful confounding factor than originally anticipated. “Soft” measures require more work. The results of both academic years imply that “hard measures” simply reinforce lower water consumption without really affecting behaviour – those who want or need to consume more water usually find ways to do so.

The work programme for 2016-2017 calls for the testing of a particular hard measure, pressure-reducing flow restrictors, in the UWE Student Village. Research to date suggests that pressure management is as important as flow control because users often value pressure highly and often intervened when it was found unsatisfactory. The devices selected for study are less visible and therefore less likely to be tampered with than low flow shower heads (which were often removed and replaced) and work to regulate both pressure and flow.

In another area of recently completed student accommodation we are proposing a focus on soft measures, in particular the roll-out of in-unit messaging (standard didactic model) alongside a phone based game which draws on near real time data to enable users to actually “game the data”. Such “gamification” processes are gaining traction in environmental thinking and may offer an exciting way forward.

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COMPETING INTERESTS

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FIGURES & TABLES

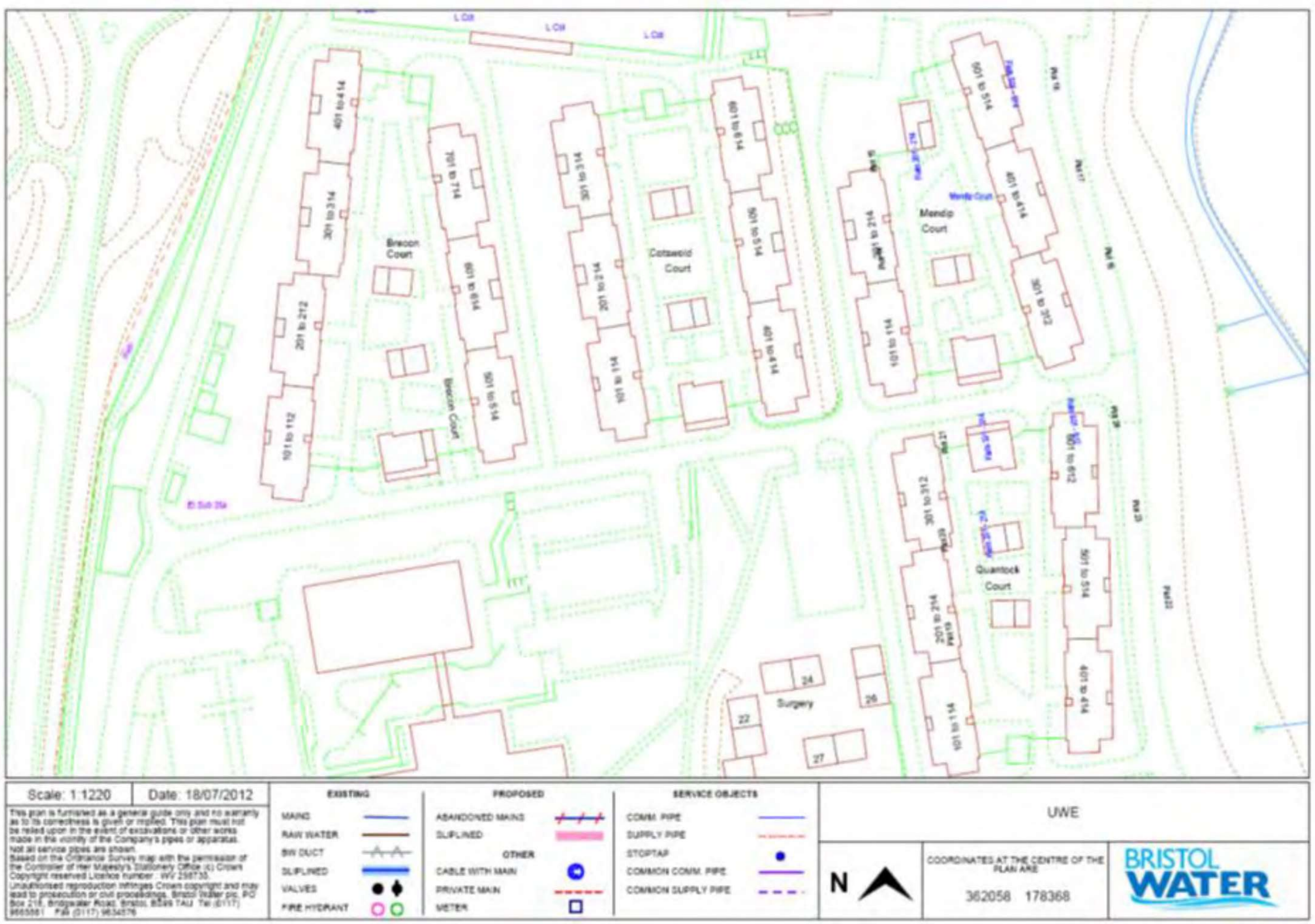

Figure 1: plan view of the UWE Student Village

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	Mendip	*Brecon*	*Cotswold*	*Quantock*
Experimental Measures	*No intervention*	*Flow Restrictors*	*Flow Restrictors* *Low Flow Showerheads*	*Flow Restrictors* *Showerheads* *Shower Timers and other conservation messaging*

Table 1. Water efficiency measures implemented in Spring/Summer 2013

Water Efficient Technologies	Examples
Efficient showers	Low flow shower heads, aerated shower heads, thermostatic controlled showers and auto shut off showers
Efficient taps	Automatic shut off taps, electronic taps, low flow screw-down/lever taps and spray taps
Efficient toilets	Low flush toilets, retrofit water closet flushing devices and urinal controls
Efficient washing machines	Efficient continuous tunnel washers, efficient professional washer extractors

Flow controllers	Flow limiting devices and control devices
Grey water recovery and re-use equipment	Standardised grey water recovery and re-use units
Leakage detection equipment	Data loggers, pressure reducing valve controllers, remote meter reading and leak warning devices
Rainwater harvesting equipment	Monitoring and control equipment, rain water filtration equipment and rain water storage vessels

Table 2: Hard Measures. SOURCE: DEFRA, 2003

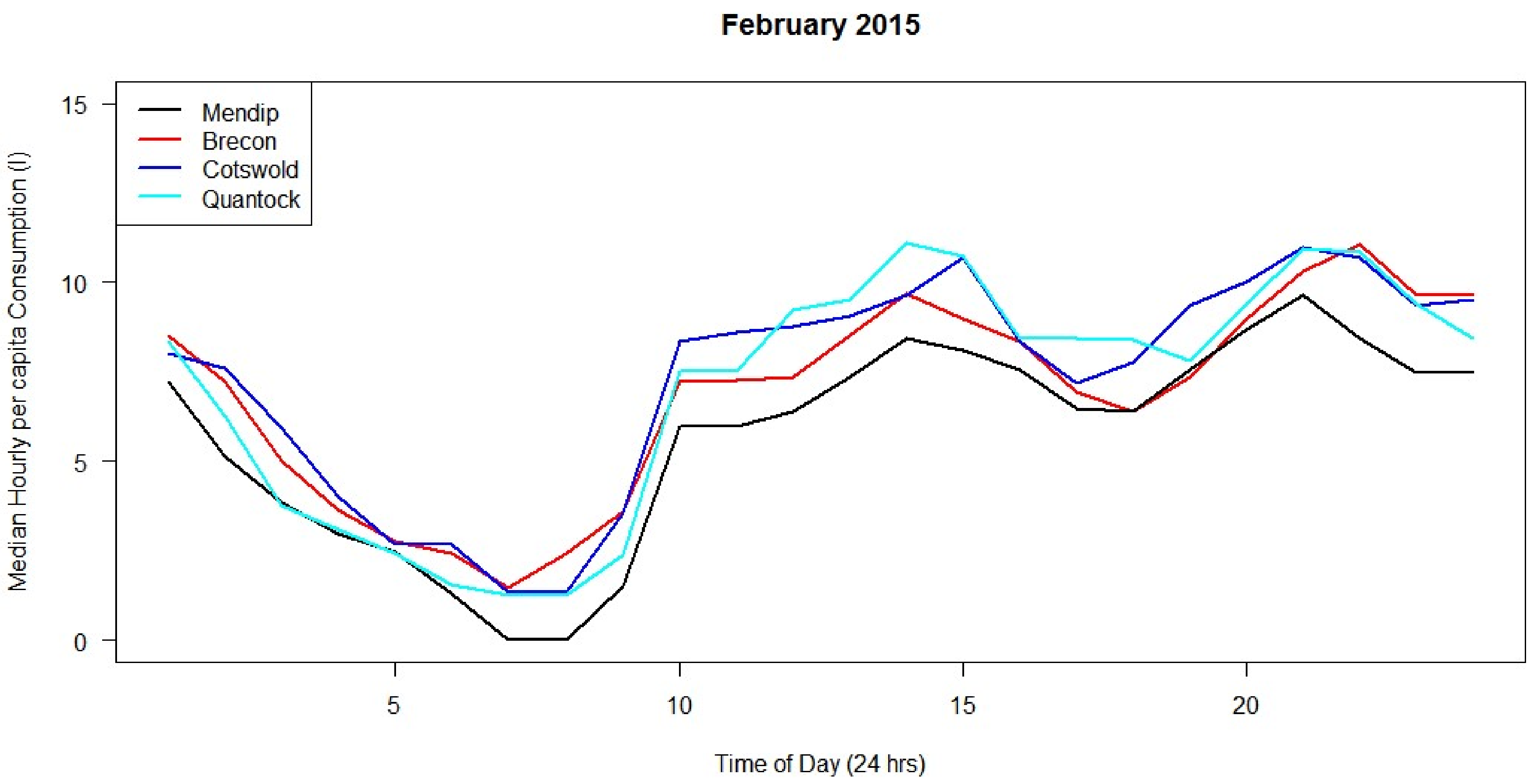

Figure 2: Median Hourly Water Consumption Per Capita, February 2015

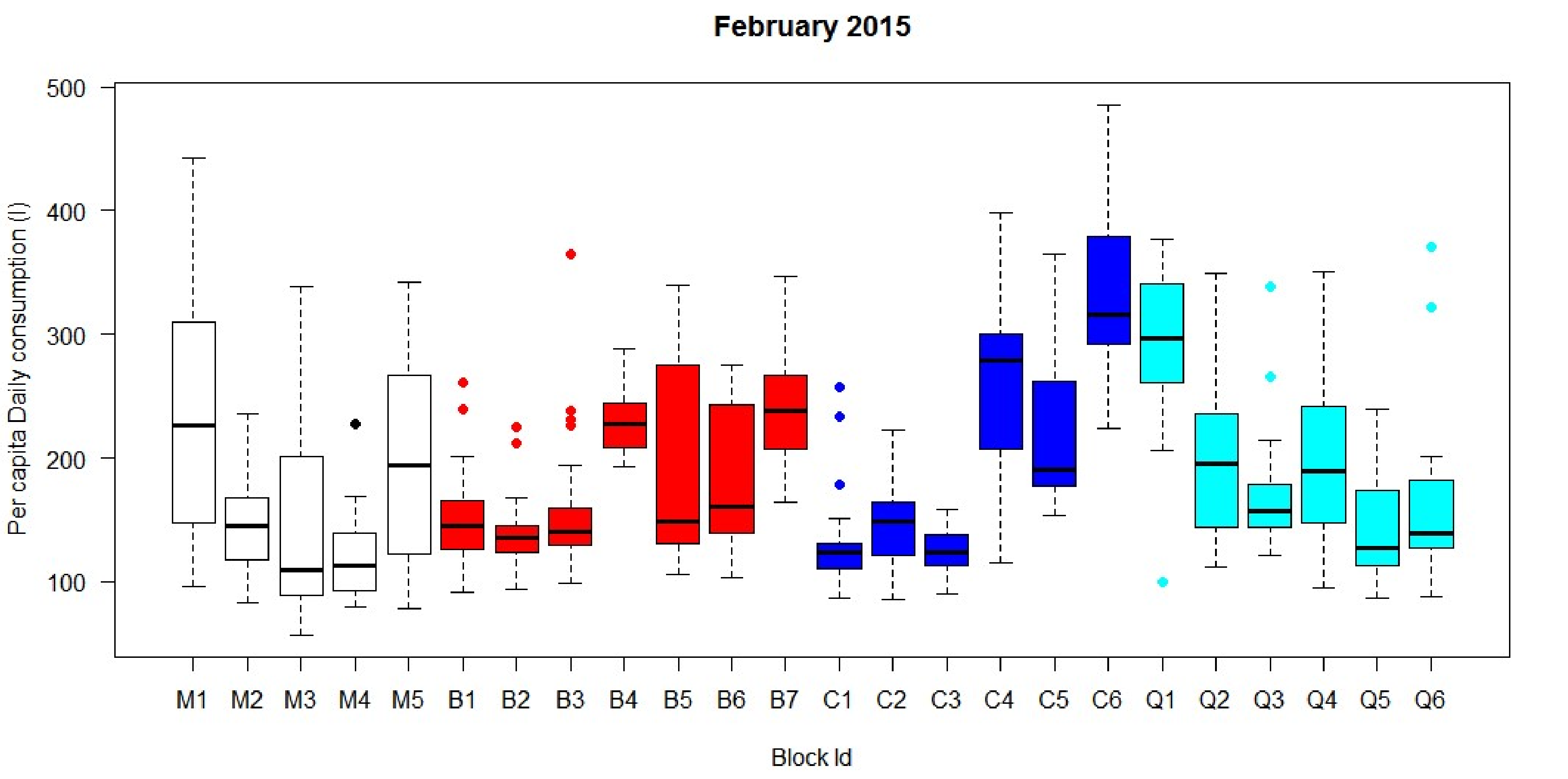

Figure 3: Median Per Capita Daily Water Consumption (in litres) by Block, February 2015