Climate Change Risk Assessment of Southampton

Connor Watson[1]

[1]**Low Carbon Comfort Centre of Excellence, School of Engineering, Faculty of Engineering and Physical Sciences, University of Southampton, Southampton, SO17 1BH, Hampshire, United Kingdom; C.Watson@soton.ac.uk**

ABSTRACT

From various sources of literature and data, this report aims to provide an assessment of climate risks affecting the case study city Southampton, United Kingdom. This risk assessment takes flooding reports and previous assessments into account, as well as survey data relating to the city, to determine flood and heat risk facing Southampton today and in the future. Our report is split into 20 primary sections, starting with the introduction and data sources and analysis structure, finishing with the conclusions and recommendations, and the 17 in-between are risk assessments for each ward. The introduction contains information of how Southampton might change, adaptation methods to climate events, definitions of key questions, and information about structure and data sources. Each ward contains a profile outlining indices that may make the ward ill-prepared for flood and heat, and then the heat and flood risks on an low-layer super output area level concluding each section with comparisons to other models and recommendations. The final conclusion section includes general lessons learnt about Southampton and recommendations for these general cases, limitations and data gaps, and priority for specific recommendations. We have concluded that among others, the most vulnerable at-risk neighbourhood for flooding is Northam who faces fluvial flood risk from the River Itchen, and for heat Lordshill faces extreme struggles going forward.

Keywords: Southampton, Climate Change, Population Impact

CONTENTS

1 INTRODUCTION

1.1 Southampton's Changing Climate

1.1.1 How will Southampton change and what must we prepare for?

The Department for Environment, Food & Rural Affairs 2022 Climate Change Risk Assessment acknowledges that climate change is happening now. Not only is it one of the biggest challenges of our generation, but our future generations too, and has already begun to cause damage to our planet that is irreversible for millennia (Solomon et al., 2009; Ridley et al., 2010; Albrich et al., 2020). The Southampton City Council cabinet meeting of 16th April 2019 declared a climate emergency; recognising that the extent and impacts of climate change will depend our success as a society over the coming decades.

Whilst carbon emissions continue to rise, Southampton's climate will also continue to change. The extent of this change will have potentially far-reaching consequences for our communities and the natural environment. Since 1997 to 2023, Southampton has continued to get warmer every year by approximately 0.036°C, a staggering figure considering by 2100, at this linear rate only, our city will be almost 3°C warmer on average. The people who this affects are the people of our city.

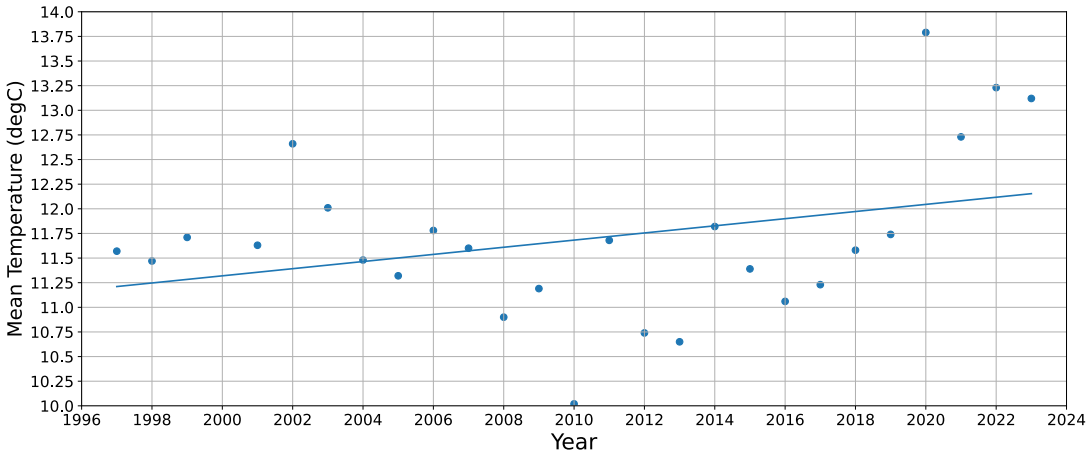

Figure 1. Yearly average temperature in Southampton City Centre (Weather Underground, 2024)

Corroborating this is the ClimateJust Map Tool see in figure 2. This tool can tell us heat risk within wards of Southampton and the greater United Kingdom, as well as using this heat risk data to map socio spatial heat vulnerability of differing communities based on not just neighbourhood and housing environment and properties, but also age, health, income, tenure, English proficiency, internet access, local knowledge, social networks, mobility, crime, infrastructure, GP access, hospital access, and pharmacy access. The indicated highest risk areas are Redbridge, North Millbrook, Freemantle, South-west Shirley, West Coxford, North Swaythling, South Portswood, Bevois, Bargate, Harefield, Thornhill, South Peartree, and Woolston. ClimateJust's central estimate heat exposure map shows Southampton as relatively high risk (orange, 17.61°C), therefore this suggests extremely high risk areas, and especially acute risk areas (North Bargate, East Bevois, South Woolston) are in need of direct and immediate aid to prepare for the upcoming 2025 summer and beyond. Heat related mortality was estimated at 2,295 in 2023, significant in all regions, including South England, with exception of North-east England and East England. One particular place of extremely high risk is Lordshill, a place reported in Shahid (2024) wherein a social housing block became so hot a resident had to resort to makeshift air conditioning, utilising fans and a container of ice, adding that *"We can't breathe, we feel suffocated"*. The article adds context that using data compiled by the University of Manchester, Southampton was ranked one of the most vulnerable areas to the impacts of extreme hot weather in the UK outside of London (Friends of the Earth, 2022). Lordshill in particular is an area with a notable lower density of tall greenery, contributing to the heat island effect in the area (Park et al., 2017). This in particular can exacerbate issues with unprepared areas, and there are more at-risk neighbourhoods in Southampton like this. It's not just our neighbourhoods though; land and water ecology will also be impacted (Grimm et al., 2013; Venegas et al., 2023; Ananthakrishnan et al., 2023; May et al., 2023).

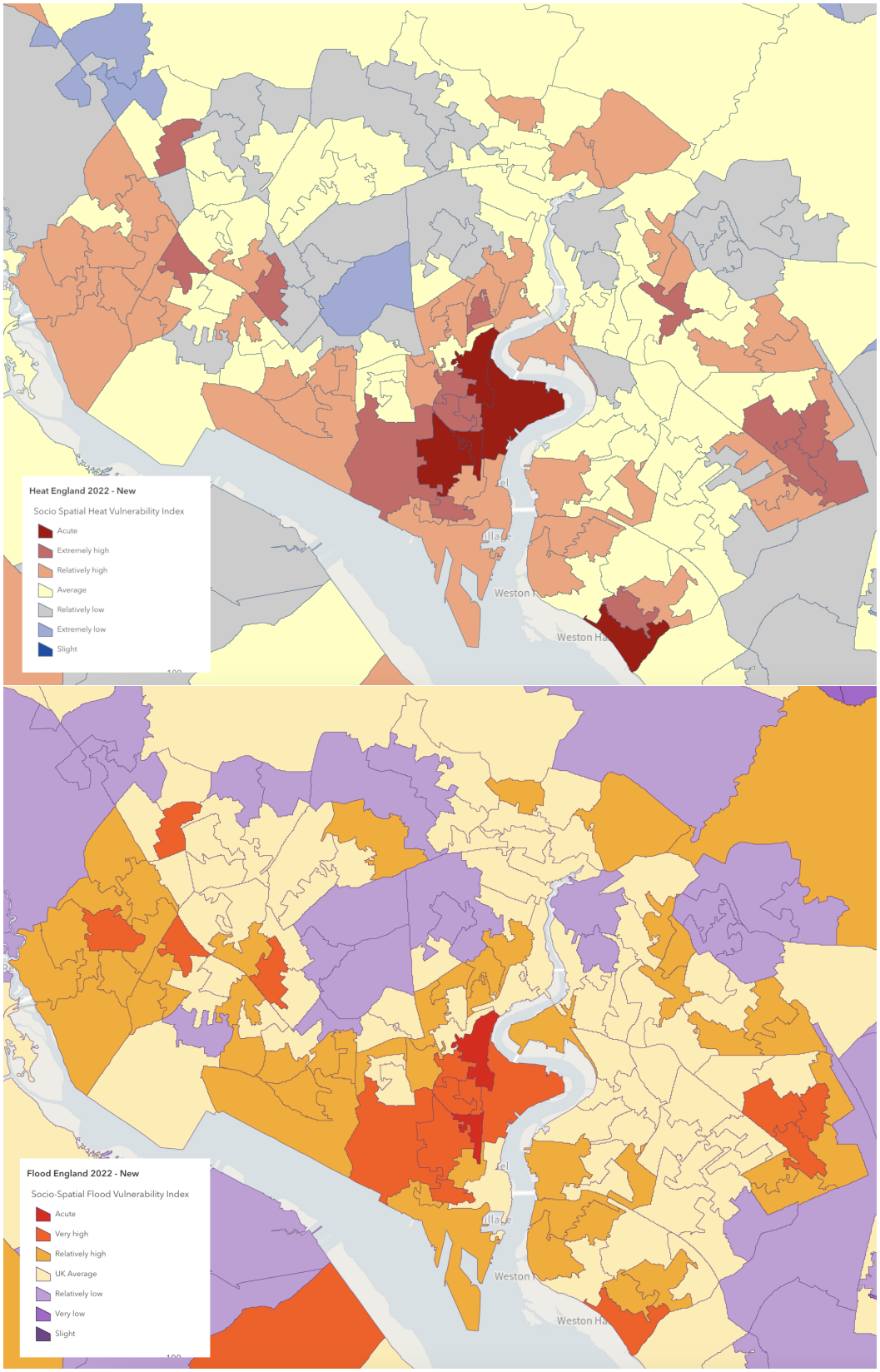

Figure 2. England socio spatial heat and flood vulnerability index respectively, displayed by the ClimateJust (2024) Map Tool.

Not only will temperature become warmer globally, but humidity too, as global temperature increases cause higher moisture capacity of air and higher ocean temperatures. This too is happening in Southampton (Met Office, 2023*a*). This higher humidity not only directly causes a higher 'feels-like' temperature (Steadman, 1979), but also contributes to higher rates of moisture based weather events, such as droughts (Trenberth, 1998) and extreme rainfall (Met Office, 2023*b*).

Southampton and much of southern Great Britain has already had 'hosepipe bans' to preserve water during it's Environment Agency drought status, triggered by the driest summer in 50 years (Bouchard, 2022; Environment Agency et al., 2022). In the UK, this has caused impacted river flows, which primarily brings fish deaths, reduced wading bird breeding, toxic algal outbreaks, impacted plant health, and other ecological stresses. These are among things Southampton has already experienced, such as the Peartree Green fire that destroyed wildlife and killed animals in the affected area and the Common ornamental lake which dried up shrinking its aquatic life during 35°C temperatures, both of which took place during the same August 2022 drought (George, 2022; Liddell, 2022*b*; BBC South, 2022). Similarly during a particularly dry 2019, toxic algal blooms were reported in Southampton, impacting fish and wading bird life heavily (Turner et al., 2021; Orde, 2019; Liddell, 2019; BBC South, 2019*a*,*b*). These have since become commonplace as temperatures continue to soar, and in some cases, these blooms cyclically repeat during summer in the same key areas (Southampton City Council, 2021; Liddell, 2022*a*; George, 2023*g*). The impacts drought has on plant health also negatively affect productivity and economic heavily for the farming sector, exacerbating food insecurity (Environment Agency, 2015; Environmental Agency, 2023).

While in summers we are set to experience hotter and drier temperatures, winter is set to be warmer too, with more rain and less snow, though localised extreme colds will still happen (Met Office, 2022). Extreme rainfall in the UK has increased from past levels, and is projected to increase further, due to increased moisture capacity in the worlds warming air. In Southampton, this has been apparent, with rainfalls of around 1000mm becoming commonplace during the 2010s and beyond. Analysis of Southampton Weather private station data located on the A33 road in the centre of the city shows a 21.1mm increase of rainfall per year in Southampton on average, utilising data from December 2007 - November 2023.

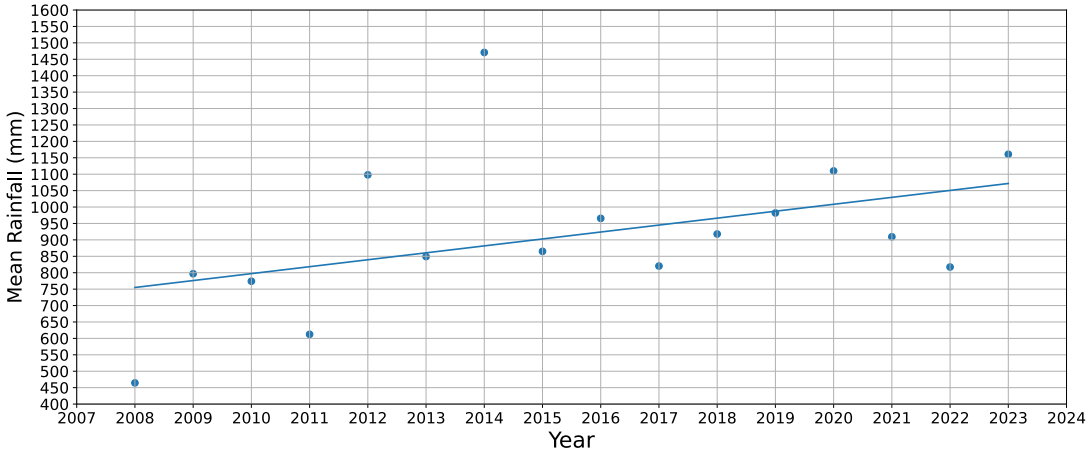

Figure 3. Yearly average rainfall in Southampton City Centre (Southampton Weather, 2024). The data is split into seasons, i.e., each year on the graph is 4 seasons primarily attributable to that year. For example, 2008 means December 2007 - November 2008, etc...

There are many implications of this change in frequency. Originating from flood risk is an increased risk of building and structural damage, increased disruptions to people and services, dangerous driving conditions, overwhelmed urban drainage systems, and dangerous pedestrian conditions (Met Office, 2024*c*). This risk is real in Southampton. Due to low lying land and other factors, along the west bank of the River Itchen and the Southampton side of the River Test river flooding is an identified concern. Further, due to late 1800s to early 1900s construction replacing brooks flowing into both rivers, ageing water infrastructure, and a number of other reasons, Southampton also has a surface water flooding problem (Southampton City Council, 2017*a*,*b*). This flooding can absorb into fragile ground causing landslides (British Geological Survey, 2024), as well as discharge sewage into rivers and streams decreasing water

quality for both humans and reliant ecosystems (Salvidge and Hosea, 2023). Other infrastructures such as dams, levees, and water treatment plants can also fail more often, causing a £56 billion committent to be made to improve infrastructure throughout the country (Department for Environment, Food & Rural Affairs, 2023). Flooding can exert other health effects as well as danger to drinking water; if unprepared, floods can directly cause drowning and injuries including hypothermia and animal bites, disruption of essential medical supplies, and indirectly can cause infected wounds and injury complications, poisoning, poor mental health, communicable diseases, and food insecurity. These indirect causes can then go on to leave a legacy of continued poor mental and physical health if unaddressed (Du et al., 2010). Like droughts, heavy rainfall can also cause crop failure due to overwatering (Knox et al., 2010).

Wind storms are a severe and direct risk, and projected to become more common (Manning et al., 2024). Risks of extreme wind include infrastructure, building, and nature damage and disruption (Bergseng, 2018; Gardiner et al., 2013). Damaged infrastructure can cause power outages and loss of services (Karagiannis et al., 2019), as well as along with building and nature damage injure pedestrians due to rogue wind-caused instabilities such as airborne branches and falling structures. Injury can also be caused by people being blown over during these extreme winds. These are issues that Southampton has experienced. In 2012 strong winds throughout the UK caused buildings and trees around Southampton to be heavily damaged, falling dangerously (BBC, 2012). In 2023 we faced Storm Ciarán which:

- Left schools closed (George, 2023*a*,*b*; BBC South, 2023*b*).
- Flooded areas and housing. This closed areas due to dangerous conditions, in some cases having to rescue those in the area (George, 2023*d*; Marshall, 2023*c*,*a*,*d*).
- Shut down the cities water supply, causing water insecurity in Hampshire (George, 2023*e*; Yandell, 2023*a*).
- Downed trees and infrastructure Marshall (2023*b*); Davey (2023); George (2023*f*).

Read more about Storm Ciarán and it's effects on the city: Yandell (2023*b*); George (2023*c*). In 2024 we also had Storm Henk, which issued a 'do not travel' warning as disruptions spanned Hampshire (Ramos, 2024). Later in the year, Storm Ashley also hit, causing floods and structural collapse, killing a 76-year-old woman (George, 2024; White, 2024). While rainfall will increase, it is hard to know whether storms will increase in wind speed and frequency; some models indicate some regions to increase in both, some indicate neutrality, and others indicate decreases (Watson et al., 2015; Wolf et al., 2020). What is known, is that flooding will become more severe due to increased rainfall and Southampton's floodplain developments (Andrew J. Stevens and Nicholls, 2016), and thus effective coastal area response will become harder. For this reason, and the fact that storms alike the aforementioned are here to stay, preparation and support is necessary.

Increased drought rates, extreme rainfall, flooding, over and underheating, storm surges, and other weather events are not something that can be stopped for years to come as are exacerbated by anthropogenic effects. After net-zero, our climate state is projected to stabilise, and eventually begin to repair to pre-industrial levels after hundreds of thousands of years (Matthews and Weaver, 2010; Hausfather, 2015; Hoegh-Guldberg et al., 2019; Allen et al., 2022). This climate is something we must adapt to, and for generational futures their only mitigation is climate action, so how can the Southampton adapt?

1.1.2 Heat Adaptation Measures in the UK

To combat extreme heat on a national level, the UK government has laid out the Heatwave Plan (Gardiner, 2011). This system forecasts heatwaves and assesses health risk. This is an effective measure, and already in place via email and weather reports in form of the heat-health alert service (Met Office, 2024*b*). This service could also be used to provide recommendations to the community very effectively, spreading awareness for public and private adaptation methods, such as the public right to free water in alcohol serving locations, and do-it-yourself strategies to cool your home (Home Office, 2010). As for physical heat-aid strategies, in the long term, the Heatwave Plan aims to *"increase trees and green space, external shading, reflective paint, loft and wall insulation, and water features, and reduce internal energy and heat"*. These are all conducted on a local level, and Southampton City Council (2023) has already committed to expanding green space and tree cover in the city. Similarly for private land, commercial planning permissions require a certain percentage surface area to be dedicated to green space and maintaining biodiversity (Southampton City Council, 2024*c*). Green space is fantastic at reduction of heat due to urban

heat island effect, an environmental problem wherein urban air temperature is raised over surrounding rural areas, due to non-green urban landscapes that absorb and radiate solar heat in greater quantity than green, and waste heat, the majority of which is from building heat leakage and electricity heat loss (Shahmohamadi et al., 2010).

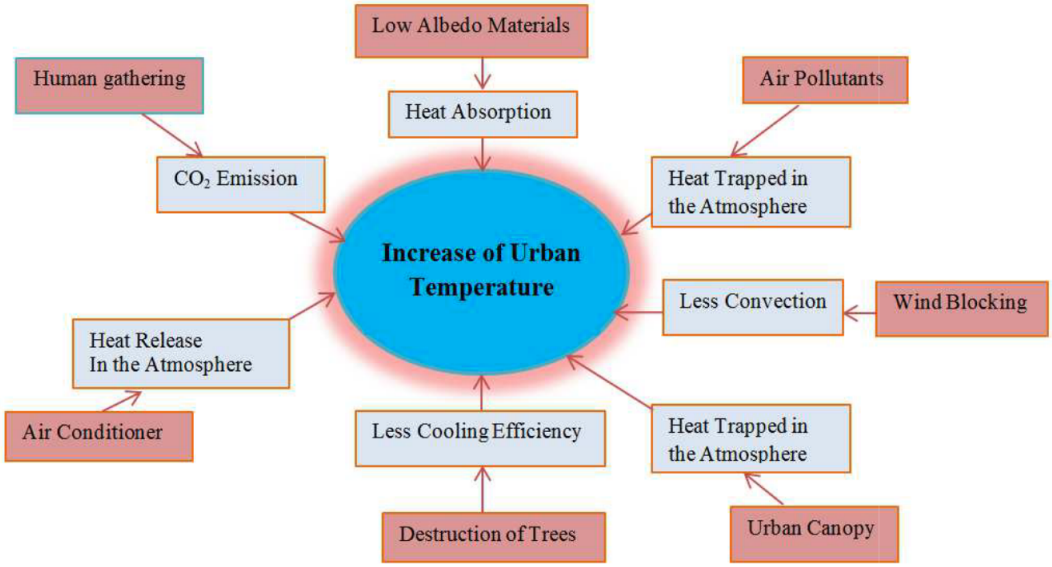

Figure 4. Contributing factors to a higher-than-rural urban temperature, urban heat island effect, from Nuruzzaman (2015)

Utilising the main causes of urban heat island effect, we may also see other council level solutions, such as insulation and other retrofit subsidisation for those disadvantaged and unable to afford, and encouragement and deployment of energy efficiency strategies. Cool roofs, pavements, and roads are also simple retrofit methods that may help. Historically, building colour in the UK has been based on stylistic choices (Homes & Antiques, 2022), and as temperatures rose and the modernism style became more popular, so did commercial building air conditioning as a predominant and reliably consistent cooling method (Met Office, 2024*a*; Pender and Lemieux, 2020; Arnold, 1999). Coating roofs and walls with white or light painted roofs has been shown to reduce cooling usage and improve air temperature of urbanised areas through lower energy and air conditioning usage (Simpson et al., 2024; Nuruzzaman, 2015) and similarly for cool pavements which will reflect more solar radiation thus radiate less heat (Kousis and Pisello, 2023). Green roofs and walls also pose an effective solution providing insulation and heating and cooling savings, unlike cool roofs which may demand an increase in yearly heating energy. A downside to green roofs though is their far higher maintenance demand, and that they may need to use vital water supply in a summer drought (Virk et al., 2015). Both cool and or green structures may also be combined with photovoltaic panels, of which can provide energy as well as a decrease in temperature (Radhakrishnan, 2018).

Building on the Heatwave Plan, is the Adverse Weather and Health Plan (UK Health Security Agency, 2023*a*). This expanded the heatwave plan and laid out how early warning systems and risk assessments will transform going forward, as well as expanding on vulnerable populations and giving care advice for such people. These include planning your day to be indoors or shaded during hottest times (11:00 - 15:00), closing curtains and windows that face the sun, wearing appropriate clothing and sun cream, drinking good levels of non-alcoholic fluids, checking on known vulnerable people, and advertising heatstroke symptoms. A council solution that is more direct support to the individual are emergency cooling stations. This is an active intervention that helps in the extreme case of heatstroke, although without other mitigation and adaptation methods this solution would be quickly overwhelmed (Bedi et al., 2022). Similarly, the 4 dangerous hours of the midday could be enforceable onto companies such as construction, landscaping, and other majority outdoor work, to require them to provide appropriate clothing and shade or indoor work during this time on high-heat days.

Urban temperature can also be exacerbated by pollutant emissions and lessened air convection from wind blocked by larger density and height of buildings. While reduction in building density is hard to do due to historic buildings taking space in most of the UK, efforts to reduce air pollution are very real. The Climate Change Act 2008 (after amendment in 2019) commits to reducing the UK's greenhouse gas emissions to net-zero by 2050 (Department for Business, Energy and Industrial Strategy, 2019). In Southampton, this is is projected for sooner, by 2035; there are also plans to reduce transport pollution in the city though specific pollutants are not considered (Southampton City Council, 2023). A gap exists here for intervention to reduce specific pollutants.

1.1.3 Storm and Flood Adaptation Measures in the UK

Southampton has risk of surface flooding in a wide number of areas (Southampton City Council, 2017*a*). This is primarily because large portions of the city along the coast were built on floodplains. Another cause is that water from rain will attempt to flow into low points on ground, as affected by gravity. Intervention is needed at these low points, generally where old brooks have been built over due to the presence of a now urbanised dell. Permeable ground, such as green space, can be used to prevent flooding in areas that would otherwise contain non-permeable materials such as asphalt. Situational analysis needs to be done into this type of intervention, as if a permeable ground space handles too much water then it might exceed 100% field capacity and cause surface water or groundwater flooding even with this intervention.

Figure 5. Surface flooding in a green space that has reached 100% field capacity (Sky News, 2024)

This process can be aided by the public, with residential encouragement of loose gravel, dirt, and other permeable lawn materials rather than concrete or tarmac. These low-points in land may also be dealt with using culverted and maintained channels, man-made and man-maintained channels for the water to flow through with little resistance so it doesn't flow into nearby areas.

Drainage in problem areas for flooding can also be retrofitted, though this also needs to be done with care as ageing and neglected pipelines can be overwhelmed with too much intake, and become dangerous. Sewer systems in historic wards such as Bargate, Banister & Polygon, Bevois, and Portswood rely on Victorian age sewer systems built between 1840 and 1870 (Rance, 1986). Modern retrofit may also question their structural integrity. Drainage systems must also be well maintained and placed well to keep optimised function. Commonly, drains can fill up over time with land erosion, also facing issues short term with debris including branches and leaves (Gloustershire City Council, 2024). As an example,

during Storm Bert, surface flooding was seen around the city. Figure 6 contains some examples of a neighbourhood debris flooding. Flooding may also occur due to land dips, due to degradation over time. This can be exacerbated with patchwork repairs. Figure 7 shows both cases.

Figure 6. Examples of flooding due to debris on Mayfield Road.

Figure 7. Examples of flooding due to degraded repair (left) and land dips (right) on Woodcote Road.

Encouraging of residential rainwater storage can also help to reduce water entering the sewer network, as well as having water to use during a drought to water a garden or wash a car. Other solutions include geo-cellular crates, retention ponds, infiltration basins and trenches, and swales (Southampton City Council, 2024*a*).

Fluvial (from river) and tidal flooding is also a large risk to Southampton. Strategies to protect our coastal areas can include sea or land walls, breakwaters, artificial reefs, and embankments (Borangic, 2024; Southampton City Council, 2017*a*). Southampton City Council employ many measures to secure our coastlines from flooding, such as the implementing rock armour in Weston Shore, as well as multiple studies on key coastal areas and alleviation schemes to install more flood risk structures (Southampton City Council, 2024*a*).

Buildings may be reinforced with resistance measures. These include flood doors, barriers, gates, and walls. If water enters a house, possessions may be lost and electrical systems may be compromised, causing serious danger to those nearby (UK Health Security Agency, 2023*b*). Flooding may also carry microbial danger to humans. Heavy metals have been found in soil around Hampshire (Vincent and Passant, 2006; Rimmer et al., 2006), and these heavy metals can drain into flood water to cause damage to ecological systems and animals (Foulds et al., 2014). Further, bacterial infections can spawn from floodwater (UK Health Security Agency, 2023*a*). Due to these reasons more publication of the invisible danger of flood water needs to be on the forefront alongside larger physical risks. It is displayed nationally and locally (UK Health Security Agency, 2006; Southampton City Council, 2024*a*). Further, post-flood dampness in buildings can weaken structures (Kelman and Spence, 2003), as well as leave dampness which supports unwanted life such as fungi, pathogens, and volatile organic compounds, which can also emit airborne risks (Taylor et al., 2011).

Storm Ciarán can give us a great view into our response. Necessary highway maintenance, tree repair and clearance, and drainage teams were deployed to deal with locational hazards. Warnings of danger areas and cancellations to transport over dangerous routes were announced and followed through. Higher staffing levels to deal with energy cuts were put into effect, and emergency bottling stations were opened in lieu of tap water which had become contaminated (BBC South, 2023*a*; George, 2023*e*). We focused on protecting the people rather than their personal property; this is good policy but can have long-term effects that need to be on the forefront of concerns. Sandbags and flood reinforcement are prioritised for emergency services and not given to the public to redirect water, recommending that the members of the public purchase or fashion their own sandbags (Southampton City Council, 2024*b*). As an example, those in Bevois are highest risk for flooding from the River Itchen, and also many there are among the 20% most deprived in England (Southampton City Council, 2017*a*; Southampton City Council and Southampton Data Observatory, 2024). Residents there may not be able to afford adequate protection for their property, therefore in cases such as this either rationing of sandbags and other aid, or support in making their home live-able post-flood, or both, is needed. If this is not provided, and those deprived cannot afford to repair their home and remove pathogens, volatile organic compounds, fungi, or heavy metals safely or effectively, this may have serious long term health effects, physical and mental, that pose risks to our already overloaded healthcare system in Southampton. Loss of personal property due to inadequate housing flood defence may also exacerbate mental strain. This was recognised by the community and sandbags were selflessly distributed, but efficiency is impacted when it is one or few that need to cover a whole city or ward (Marshall, 2023*d*). For post-flood repairs, council house occupants should contact the council, homeowners should contact their insurance, and renters should contact their landlords. Effective repair should be accountable and enforced against all responsible parties, and aid given to those who need it. This is where funding shortcomings become apparent. Making post-flood houses live-able takes time, and those in them need alternate accommodation, which can cost thousands per person as flood damage can take several weeks to repair (SDM Property, 2024).

1.1.4 Drought and Water Insecurity Adaptation Measures in the UK

As a product of summer and winter weather, water insecurity response is of high concern. Water insecurity can happen due to flooding and extreme heat, therefore flood defence, cooler temperatures, and storm and heatwave adaptation are all vital in limiting the reach and severity of water insecurity.

Water insecurity may also happen due to water mismanagement (Bevan, 2019). High accountability is very important for water handling companies to prevent leakages - not only will it deter practises that result in long-term water insecurity but also can fund periods of water insecurity response. For example, Southern Water, Southampton's water supplier, leaked 107.5 million litres of water a day on average

based on their 2023-24 annual performance reports, among the 10 worst UK water companies for leakage Kersley (2024). While this was down from last year, it marks a increase of their 3 year rolling average per day leakage by almost 5 million litres (Southern Water, 2024). This has caused the Water Services Regulation Authority (Ofwat) to order Southern Water to return £31.9m of bills for leakages and sewage spillovers. Sewage dumping has been a consistent issue with water companies including Southern Water which has been fined multiple times, at highest £126 million, for dumping sewage illegally (Ofwat, 2019; Department for Environment, Food & Rural Affairs, 2021; Environment Agency, 2024). Not only does this ruin vital ecology, but also pollutes ground water far beyond a suitable level for drinking. But do these fines work? Considering their leakages trend upwards and illegal sewage dumping remain practise in face of consistent fines it is hard to tell. Further, while leakages are a problem draining reservoirs, we have seen in the past rainwater overflow on the River Test cause Southern Water to struggle to treat water for drinking to replenish their reservoirs (Yandell, 2023*a*). In this case, emergency bottled water stations were set up for free public use. This instance is not Southern Water's fault as they are not responsible for flood defence in this area, and the New Forest District Council has published that there is no active shoreline intervention plan in place for this shore on the River Test (New Forest District Council, 2024). Each council must work together with surrounding councils to ensure water security.

On a national level, procedure and policy has been put in place for drought mitigation. Landowners and businesses cannot abstract more than 20 cubic metres of water a day during dry weather using boreholes and wells without an abstraction license (Environmental Agency, 2019). Water allocation, agriculture support packages, and water aerators to aid water ecosystems, as well as national data such as reservoir levels, rainfall, and groundwater level and quality can be used in forecasting drought and water insecurity for a more effective response (Environmental Agency, 2017, 2023). These measures, especially water allocation and rationing, can be reinforced with council support and compliance.

1.2 Risk Assessment Key Questions

Climate change will affect us all. Along with continuing to reduce our carbon emissions, we must consider how we will respond and adapt to climate change to protect the population of our city. This report aims to answer questions:

- What impacts may climate change have on Southampton?
- Where are the current vulnerabilities? What can be done to mitigate effects on vulnerable areas?
- What can we learn from current trends to future proof our city?
- Where does our current knowledge need strengthening?

Answers to these questions inform Southampton's communities, as well as the public and private sectors how we will need to adapt to Southampton's changing climate effectively. This allows us to make efficient future governance and decision making related to climate change adaptation.

2 DATA SOURCES AND ANALYSIS STRUCTURE

Within this report, we use two key words: risk and vulnerability. Risk relates to physical risks involving flooding and heat, such as an areas susceptibility to flooding due to lack of defences or heat due to high density of high-rise buildings. Vulnerability relates to the populations preparedness for heat and flooding, i.e., if they experience an extreme climate event, how well can they prepare, evacuate, and or recover from such event. Our main sources of data are:

- Southampton Data Observatory, public facing repository of multiple census data by the Data, Intelligence and Insight Team in Southampton City Council.
- Southampton City Council strategic flood risk assessment, coming from a number of sources of which under licence agreement and cannot be passed to external sources without the permission from the owner.
- Data from Southampton City Council not, or not yet, made publicly available.
- Feedback from the public and their qualitative issues where specified.

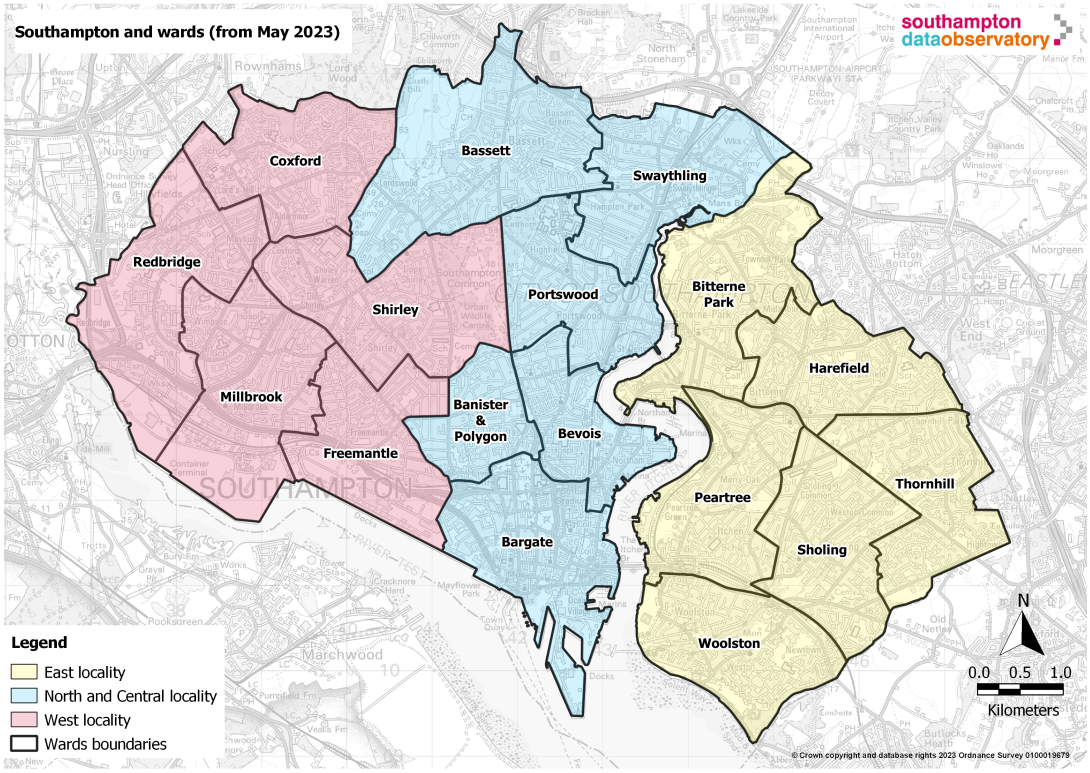

Figure 8. Wards of Southampton.

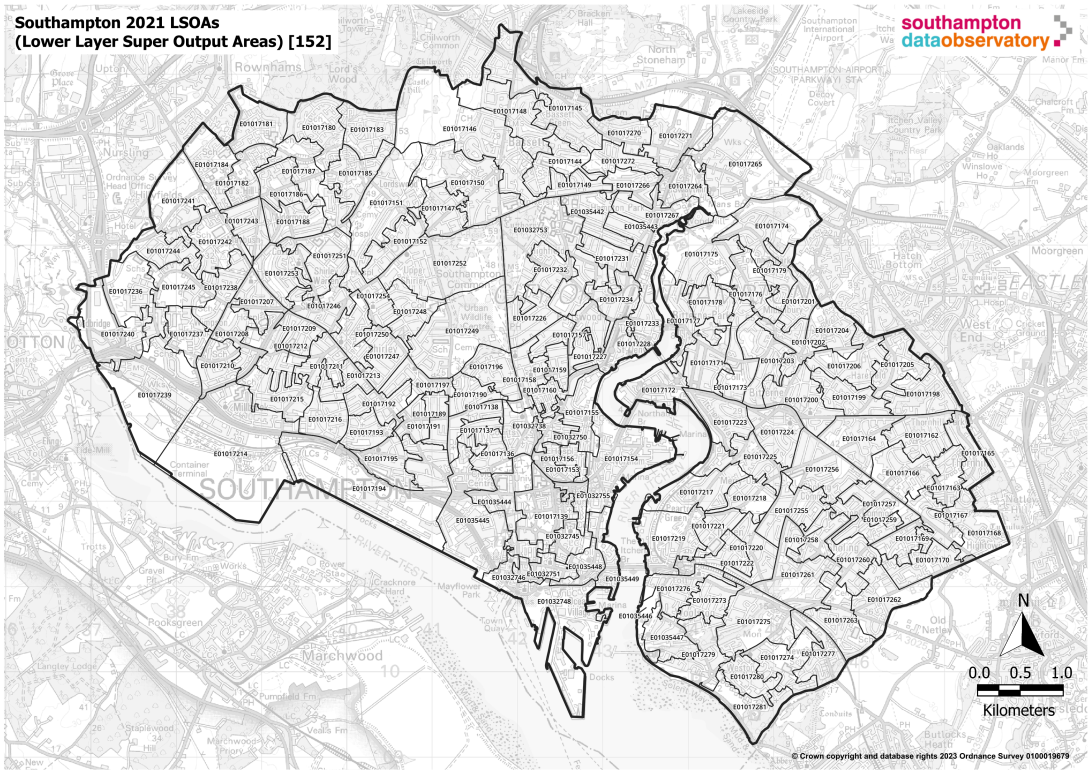

Figure 9. LSOAs of Southampton.

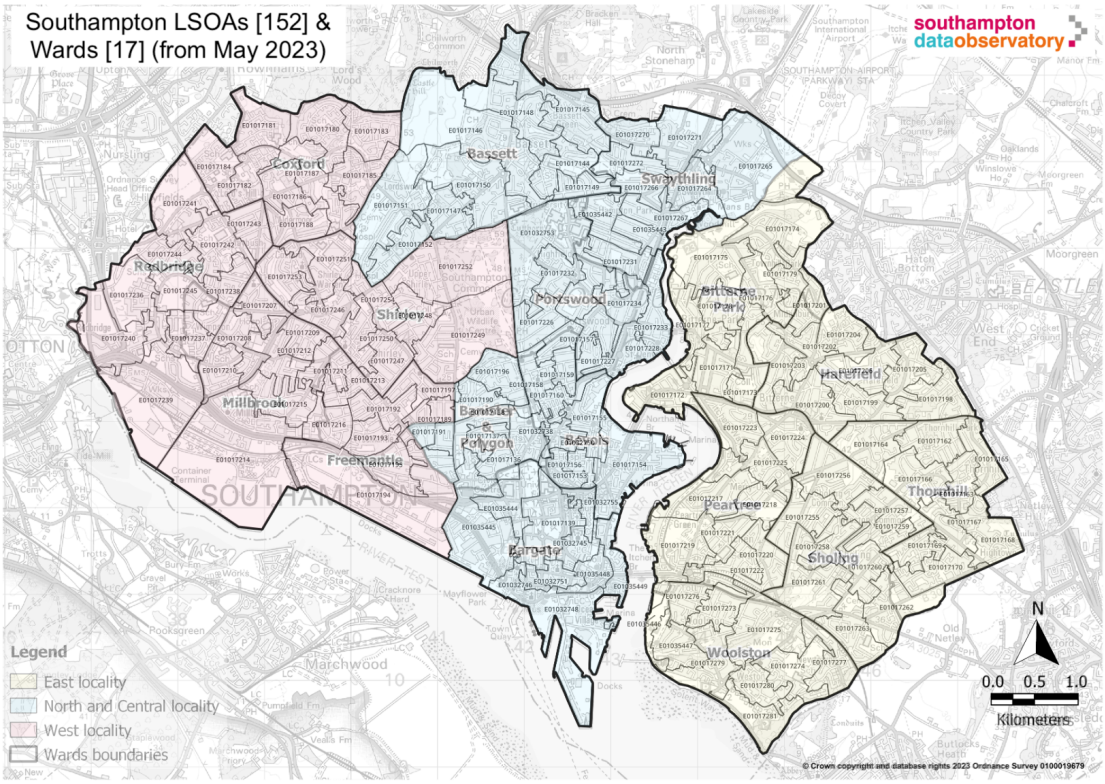

Figure 10. Wards of Southampton (figure 8) overlaid by the LSOAs of Southampton (figure 9).

Data is generally given as a percentage population, rate per sample from population, or decile. Decile is 10 equal groups we split the population into, 1st decile having this statistic most align with them and 10th being the least alignment. For example, a 4th decile vulnerability implies they are within the top 40% most vulnerable, i.e., the bottom 70% least vulnerable. All deciles are given comparatively to England, with the exception of our calculated heat and flood vulnerability based on Southampton Data Observatory data, which is comparatively to Southampton.

We split our analysis into wards shown in figure 8. In each of these wards we discuss a ward profile, then potential heat risk, moving then to areas of problem flooding sorted alphabetically within ward. We make references to Low-layer Super Output Areas, or LSOAs, shown in figure 9. These LSOAs allow us to describe regional issues with higher resolution comparatively to wards. The percentage of economically active residents aged 16 years and over (excluding full-time students) will be specifically omitted, unless applicable as numbers for this in the 2021 census were taken during the COVID-19 pandemic, indicating a high likelihood that this picked up a large amount of noise from persons who were on furlough.

During analysis we consider data that makes the community vulnerable to heat extremes and flooding. What are statistics we need to consider? As a legend, heat risk has bullets coloured red, flood risk has bullets coloured blue, and a risk of both extreme heat and flood events have bullets coloured purple.

- High percentage of resident population aged 65 or over indicates higher heat risk vulnerability. Being aware of these people and their potential health risk, as well as having a place for them to go during these events of extreme heat may be very effective. This is becoming increasingly prevalent due to Southampton's ageing population.

- High percentage of houses with low energy performance certificate rating may indicate worse insulation and building performance, worsening heat risk to that house. This metric may be misleading in places though, as display energy certificates or energy performance operational rating are also commonly used but based on carbon dioxide emissions, and if a building draws on renewable energy but uses a lot of energy then while it is ineffective in operation it maintains a high rating.

- High percentages of households under multiple deprivation and high cost of living vulnerability both indicate a strong inability to prepare or respond to flood and heat risk.
- High percentage of social isolation. Those who are more isolated may be less likely to, know where to, or have the ability to seek aid, as well as being less likely to have people in their lives who know they might need aid in extreme weather.
- High rate of children in need is an excellent method of evaluating the general disparity of a neighbourhood, telling us what resources they might be able to put forward for themselves to aid in long term flood preparation and recovery. Similarly, high percentage of lone parent families with dependant children means parents in this situation need to evacuate a or multiple children on their own, and may work a far more inflexible schedule. They also may have less ability to adapt due to a lowered income comparatively to multiple income sources. Aid must be given to these families.
- A regionally high percentage of population that are minority ethnic groups may cause outreach to be harder for first generation immigrants who might not be aware of programs and aid around them. It is worth noting this may be an unreliable statistic, as UK birth certificates contain no ethnicity, therefore instead this metric is based off of mother's location of birth (Apostille of the Hague, 2024), which may not capture multi-generational minority babies and children. In Southampton, 1 in 7 do not have their main language as English; over 160 languages are spoken throughout the city. Instead or alongside percentage minority ethnic groups, we may evaluate percentage of households that have one or more persons with English as a main language, which can make communication harder if the percentage is low. Both of these can be remedied utilising awareness outreach, as well as translators and translator programs to be able to effectively communicate policy and aid possibility.
- Flood and extreme heat may be exacerbated among populations of: high rates of admission episodes with primary or secondary diagnosis of drug related mental and behavioural disorders, low percentage of children that are a healthy weight, high rate of people currently utilising adult social care services analysed with section 42 enquiries, high rate of child protection plans analysed with safeguarding concerns, and high percentage of population reporting bad or very bad health. This can be solved by having the system be aware of these people, adapting their neighbourhood, and setting aside resources to aid them in face of disaster.
- Heightened rate of anti-social behaviour incidents may help to identify a lower community spirit, causing families to be less likely to aid conjoining families. As well as this, communal resources may become damaged, and people may be lesser inclined to evacuate their home in fear of looting. This statistic must be analysed carefully though and never in isolation, as many areas have specific issues that may not indicate this, such as a nearby nightlife district causing high rates of alcohol and drug offences linking anti-social behaviour incidents.
- Low percentage of green space may make flooding harder to clear and easier to be a problem over coming years, as the ground may be non-permeable and trap water on the surface. Extreme heat is also exacerbated in these areas, as urban heat island effect will increase ground and air temperatures.
- Health based indices may be evaluated using life expectancy and mortality rate indices to provide an overview of the health in the area, although mortality must be taken into account using other metrics too. This is because of outside causes of low mortality that may not affect adaptability to heat and flood, such as Southampton being top 10 in the country for asbestos-related mesothelioma deaths due its long history of ship building industry (Wilson, 2022).
- Self-aid and evacuation in a flood may be made far harder with: high percentage of residents limited a lot by disability, high percentage of pupils with special educational needs, low percentage of children achieving a good level of development at the end of reception, and high rate of inpatient admission rate for mental health disorders aged 0-17 years. This can be solved by having the system be aware of these people, adapting their neighbourhood, and setting aside resources to aid them in face of disaster.

- High rate of emergency hospital admissions due to falls in people aged 65 and over may indicate a lower rate of mobility in otherwise healthy pensioners. This may indicate residents limited a lot by disability would be climbing.

- High percentage of resident population aged either under 16 years or 65 and over may indicate lowered mobility or ability to respond to disaster. Forecast percentage change in resident population aged under 16, 16-64, and 65 and over may also help us identify an ageing population for future issues with this. Once again, having resources set aside for these people may aid in face of disaster.

Note the difference between vulnerability and risk. Vulnerability is how much extreme heat or flooding would affect a community, i.e., whether they are prepared, can actively deal with it, and whether they can recover. Risk is how likely they are to face this extreme heat or flooding. During heat analysis, we consider vulnerable neighbourhoods and specific intervention based on their struggles. During flood analysis, we will be considering flooding reports of repetitive nature, as well as discussing areas of projected flood risk from the strategic flood risk assessment report, backing this data up with neighbourhood specific vulnerabilities. We choose to omit irrelevant and irregular data. Specific recommendations for heat and flood will be made in each section.

3 BANISTER & POLYGON

3.1 Ward Profile

This ward contains LSOA neighbourhoods: all but the south-east of E01017136, E01017137, E01017138, and a small west portion of E01017156, a small south-western tail of E01017158, southern half of E01017189, E01017190 except from a small tail on the west side, south-west of E01017191, a north-eastern portion of E01017194, E01017196, E01032738 except from two small tails on the north-east and south-east, two small north-western and south-western tails of E01032750, and the north end of E01035445. Where appropriate, LSOA data will be discussed.

Compared to the city average, the ward itself has a few indices that may make neighbourhood climate adaptation harder:

- 28.0% to 72.6% A-C EPC rating, minimum in LSOA E01017137.

- A 3rd decile multiple deprivation index towards the south, west, and east of the ward. The north is 8th decile and the center ranges from 5th to 6th.

- High social isolation index for ages 65 plus, specifically in the south-west of the ward at LSOAs: E01017136, E01017137, E01017138, and E01035445. This may be due to the high student population in this area which is less likely to interact with the older population.

- Significantly higher ethnic minority groups, 26.6% verses 19.3%. Further, significantly lower households with one or more persons with English as a main language, 83.4% verses 90.6%, shows these may be first generation immigrants and we may struggle with outreach without proper preparation.

- Low percentage of green space, 3.2% verses 13.4%, impacting the permeability of ground and natural clearance of flood water, as well as increasing urban heat island effect.

- High rate of admission episodes with a primary or secondary diagnosis of drug related mental and behavioural disorders, DSR per 100,000, all ages (3 & 5 years), 404.1 verses 272.6 and 326.4 verses 256.0 respectively. This is climbing, indicating a worsening risk of those affected seeking isolation rather than aid in extreme weather events.

- Female life expectancy and all cause mortality are significantly worse in this ward, but other health and disparity metrics, such as safeguarding issues, children in need, and school absence are significantly better here, as well as children that are a healthy weight and section 42 enquiries being similar to the rest of the city.

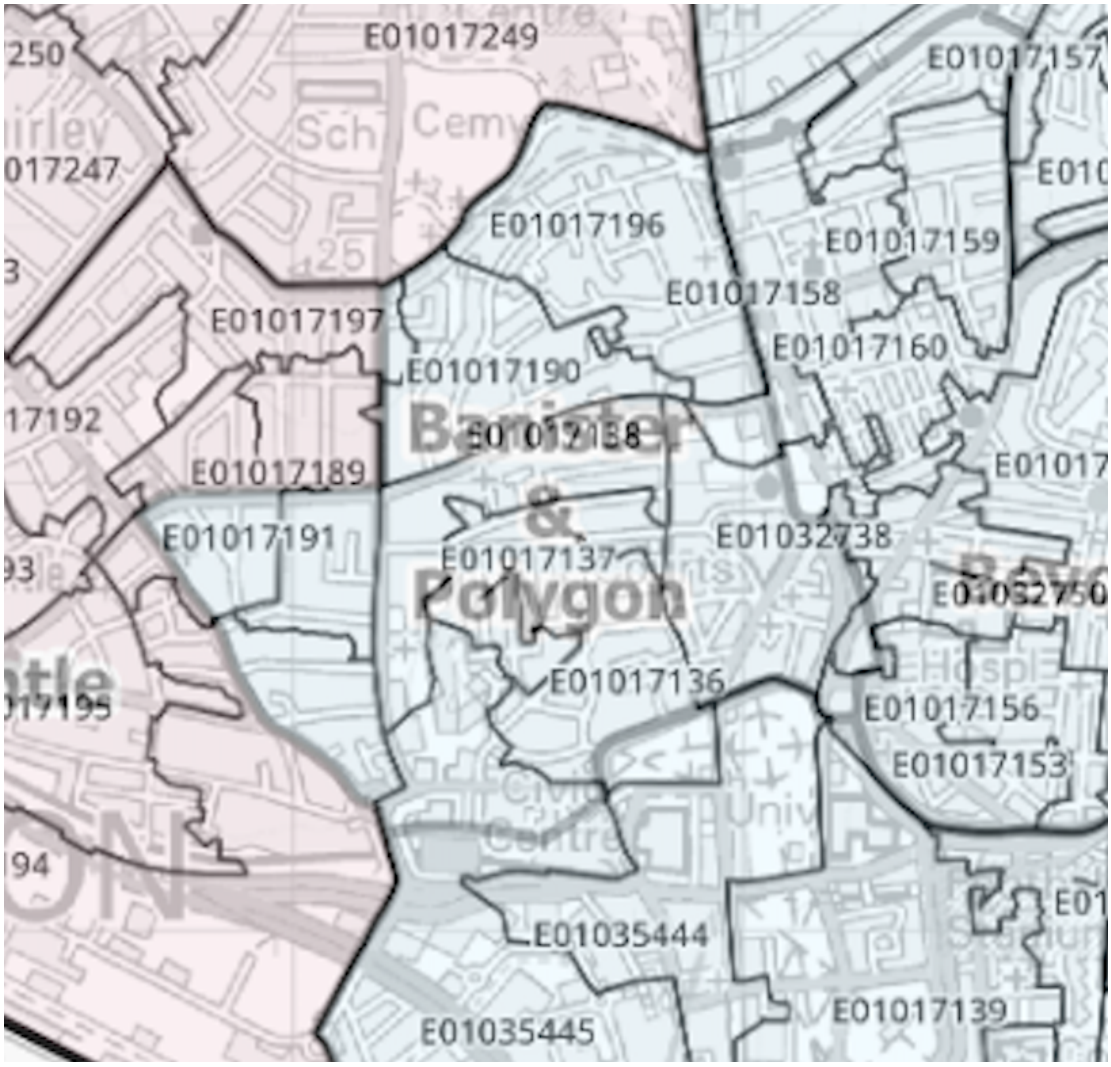

Figure 11. The LSOAs of Banister & Polygon.

3.2 Heat Risk Assessment

E01017137 boasts a particularly high social isolation index for ages 65+. The west of the ward is consistently 5th decile for all-ages social isolation.

The ward loses houses with English speakers as you travel out of the north. In the south, E01017136 is in the 3rd decile for houses with no English speakers, but the west is in need of most intervention as E01017191 and E01017194 are bottom 10% for English speaking households.

This ward also severely lacks green space, including the west of the ward which has no parks and open spaces.

Considering these factors, the west of the ward is in need of most intervention. Conversely, comparatively to the rest of Southampton this ward is not a priority, with all LSOAs being amongst the 50% most prepared comparatively to the rest of the city. This is corroborated by the Heat England 2022 Socio-Spatial Heat Vulnerability Index placing this area under average vulnerability, with the east and west being higher at relatively high. If a recommendation were to be made, greater outreach is needed for different cultures, languages, and social isolation. Addition of green space is needed, but harder as immobile residencies cover the area; greater tree and canopy cover may be considered.

3.3 Flood Risk Assessment

3.3.1 Archers Road Junctions

The Westrow-Archers Road junction faces consistent flooding reports. Multiple of these are depicted as to be blockages of leaves. This can be seen on street level, containing a large number of trees. This surface water sewer also connects the wider higher elevation area to a downstream sewer, meaning debris from these areas too could be impacting this sewer junction. The same could also be happening to the Banister Road, Northlands Road, Silverdale Road, and Hill Lane, junctions with Archers Road. These all flow into a sewer network that runs underneath The Dell residential building and Berkeley Road. There could be a potential issue here, affecting drainage of the junctions to the north and their ability to process debris. Another thing that could cause a back-up of water is the fact that the surface water sewer underneath The Dell also handles culverted watercourse run-off from the Cemetary Lake in the Commons. This constant flow from such a large body of water could make it harder to handle the addition of the neighbourhoods surface water.

3.3.2 Avenue Road (South)

Multiple reports have specified blockages due to debris on the Avenue-London Road junction, with one even recounting green foliage growing out of the drain. These are primarily on the west side of the road, where there is a lot of tree canopy cover. On the east side, the water reaches to the houses and the bus stop, making transport inaccessible to some. The closest sewer network is north of them, which is at a lower elevation but connects The Avenue's sewer network with Dorset Street's sewer network. This is the only surface water sewer-way out of The Avenue's south end. There is not much surface flooding on The Avenue even though it has major tree canopy cover and is very busy, and should encourage debris. It may be that debris from The Avenue is running into this area and causing storm overflows due to debris. Further, during times of high water flow, the area of least resistance for water to back-up is here. This area may need investigation.

3.3.3 Burlington Road

Burlington Road - Wilton Avenue junction is subject to flooding, with risk increasing, as the junction lies lower than both the east and west sides of Wilton Avenue, with Burlington Road also having a lower point approximately 1/3rd of the way down from the north. Further, it lies not far east of a historical brook running parallel to Burlington Road. One report stated *"in torrential rain bins are floating around and there is a car half submerged"*. To address this, there are 4 drains at the low-point of Burlington Road to drain water, but these may in the future become overwhelmed, as this same surface water sewer services the neighbourhood to the north as well as the aforementioned brook. It is clear this neighbourhood is one who may need to deal with this threat increasingly if nothing is done, and adapt and or evacuate in face of overwhelming conditions.

3.3.4 Carlton Road to Bedford Place

The west side of the polling district also has a few instances of flooding not involving much debris. Flooding occurs on Winchester Street, which below lies a sewer connecting the entire neighbourhood to Bedford Place through Waterloo Terrace. One report stated it was fat being dumped down the drains.

On Bedford Place, the connecting sewer is also repeatedly blocked. This drain system is connected to a foul sewer, therefore waste disposal here might be the issue, as there are a mix of primarily food businesses, nightlife businesses, and many residential houses in this area. This issue also occurs higher up on Carlton Road, specifying rubbish in the drain. An issue along this road may be littering on this road due to nightlife, compounding with residential waste and surface water from the area, blocking drains along Bedford Place and backing water up on Winchester Street, a road of lower elevation and thus less resistance for water to travel. Further exacerbating issues, these roads are of high traffic due to there being school on the road, cars could deposit sediment into the drains.

3.3.5 Future Projections and Ward Recommendations

Flooding throughout LSOAs E01017190 and E01017196 is regular and for the most part, widely dispersed. This has been reported as leaves blocking gullies, and is reciprocated in the high levels of trees in the area. These areas are better than the city average for constrained mobility and children in need, indicating a good ability to adapt and prepare, although with green space at just 3% for E01017190 the lack of non-permeable surfaces may make flood severity greater. Further, there is significantly higher adults in social care than the city average in E01017190. Both of these areas are of lower priority though, being top 40% (E01017190) and top 20% (E01017196) for ability to deal with flooding. Bear in mind this information when assessing priority for the aforementioned issues on Westrow-Archers Road junction (E01017190) and the Banister Road, Northlands Road, Silverdale Road, and Hill Lane junctions with Archers Road (E01017190).

The Avenue-London Road junction, Winchester Street, and Carlton Road have issues with surface water flooding, and are all within LSOA E01032738. This LSOA has issues with green space, but otherwise is in the top 50% most able to deal with for flooding.

Burlington Road - Wilton Avenue junction lies within LSOA E01017137. Lack of green space also plagues the area, but there is green space (Rollesbrook Greenway) to the west of the problem area that is not included in this LSOA. Residents here do have issues with childhood obesity, which may affect mobility issues of young children when faced with flooding. This issue needs addressing as is at severe risk, but the population is not vulnerable, at 7th decile for most vulnerable (top 40% least vulnerable) comparatively to other areas, and drainage here at these critical points can prevent the issue from worsening over the years.

This ward is not at risk nor particularly vulnerable for flooding over other key areas. This assessment of wards is not shared with the Flood England 2022 Socio-Spatial Vulnerability Index. Our analysis puts them at an average to low vulnerability, while the Flood England Index places them at average (E01017136, E01017137, E01017190, E01017196), relatively high (E01017138, E01017158, E01017189, E01017191, E01017194, E01032738), and very high (E01017156, E01032750, E01035445) Vulnerability. This may be due to our ranking values being comparative to Southampton, rather than wider England which has a lower average vulnerability.

4 BARGATE

4.1 Ward Profile

This ward contains LSOA neighbourhoods: the south-east tail of E01017136, E01017139, E01032745, E01032746, E01032748, E01032751, E01032755, E01035444, all but the north of E01035445, E01035448, and E01035449. Where appropriate, LSOA data will be discussed.

Compared to the city average, the ward itself has a few indices that may make neighbourhood climate adaptation harder:

- The northern half of Bargate has comparatively lower EPC ratings than that of the south. E01035444 and E01035445 combine to have a total A-C EPC rating of 63.9%. E01017139 sits at 55.0%. E01032755 is the worst at 33.1%. Otherwise, all other LSOAs in Bargate have a A-C percentage of above 70%.

- The northern half of Bargate has higher disparity index than that of the south. E01032745 has a 5th decile disparity index, E01032751 and a combined E01035444 and E01035445 have a 3rd decile disparity, E01017139 has a 2nd decile disparity, and E01032755 are among the 10% most deprived. Otherwise, all other LSOAs in Bargate 7th decile disparity index.

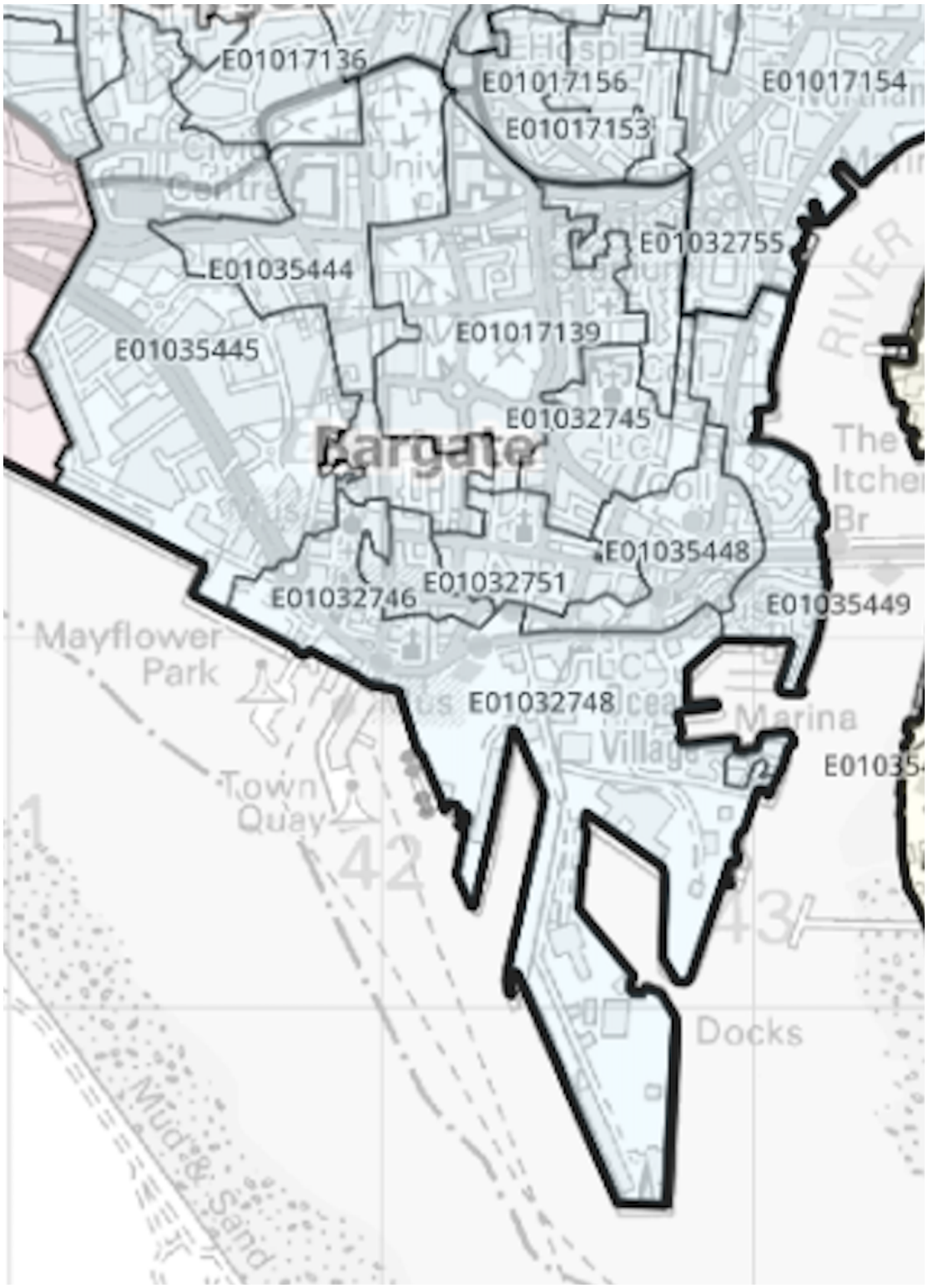

Figure 12. The LSOAs of Bargate.

- E01035445 has a 5th decile social isolation index, E01032755 has a 3rd decile social isolation index, and E01035444 has a 2nd decile social isolation index for all ages; other than this, values sit on or above 6th decile. On the other hand, 65+ ages in the north half of Bargate have 10% highest values on the social isolation index, with exception to E01032745 (2nd decile) and E01032755 (5th decile). Otherwise, it is 8th decile or above.

- Significantly higher ethnic minority groups, 34.0% verses 19.3%. Further, significantly lower households with one or more persons with English as a main language, 80.1% verses 90.6%, shows these may be first generation immigrants and we may struggle with outreach without proper preparation.

- High rate of anti-social behaviour incidents per 1k population, 30.4% verses 11.3%, but this may be due to a high rate of alcohol affected related crimes per 1k population, 24.4% verses 9.4%. On the other hand, total crime (280.2 verses 123.4), violent crime (75.3 verses 48.2), and theft offences (118.7 verses 37.2) per 1k are all significantly worse than the city average, as well as a high and climbing rate of admission episodes with a primary or secondary diagnosis of drug related mental and behavioural disorders, DSR per 100,000, all ages (3 & 5 years), 342.2 verses 272.6 and 317.3 verses 256.0 respectively. This could indicate that alcohol is not primarily to blame for anti-social behaviour incidents, and perhaps there are underlying issues that also may impact inter-community aid in time of crisis. Bargate itself is a ward of high student population as well as densely populated with nightlife zones, through speculation, nightlife zones may be causing violent and alcohol crimes as well as anti-social behaviour incidents and drug misuse through intoxicated persons, but the same intoxicated persons are highly likely to be targeted by theft crime, especially students who live in the area and regularly carry phones, laptops, and other high value items.

- Low percentage of green space, 10.4% verses 13.4%, impacting the permeability of ground and natural clearance of flood water, as well as increasing urban heat island effect.

4.2 Heat Risk Assessment

E01035444 and E01035445 have 3rd decile deprivation, and are 2nd and 5th decile all ages isolation, but top 10% 65+ isolation. E01035444 is top 10% for households that cannot speak English, E01035445 is non-significantly lower in the 6th decile. There is little green space in E01035445 but E01035444 contains a large level of green space, primarily East Park, as well as Palmerston Park, Houndwell Park, and Hoglands Park just to the east, as well as Watts Park to the north.

E01017139 has a 2nd decile deprivation index and top 10% ages 65+ isolation index. It is also in the top 10% for households that cannot speak English, at 74.2% of households having one or more English speakers. It contains a high level of green space, Palmerston Park, Houndwell Park, and Hoglands Park, giving it 34.1% greenspace cover. Looking closer at the LSOA, E01017139 has an above average rate of children in need per 10k (886.9 verses 628.1) and high crime rate, particularly anti-social behaviour incidents per 1k population (50.2 verses 11.3).

E01032755 is in the 10% most deprived and ranks 3rd and 5th decile for isolation score for all-ages and 65+ respectively. It is in the top 10% for households that cannot speak English, and has low green space.

Because of the above, we conclude that north Bargate, including LSOAs: E01017139 (6th decile most vulnerable), E01032755 (3rd decile), E01035444 (3rd decile), and E01035445 (5th decile) are in need of intervention. Bargates risk factor is higher due to immovable heavy urban high-rise development, therefore decreasing vulnerability within the area is paramount. All require social outreach to prevent anti-social crime and support the communities economy, with particular focus on E01032755, being rank 5 on our heat risk ranking. On the other hand, social isolation here may be hard to solve, due to the high levels of students on a 'revolving door' residency in these LSOAs, making it harder to build community. In this case, more permanent solution akin to a social establishment may be required.

Bargate is also a very built up area, primarily high-rise buildings of dense residency. These dense buildings exacerbate urban heat island effect, acting as heat sources due to climate control and electricity usage inside the building. This should be taken into account, as this may mean risk is heightened, especially as Bargate is extremely busy during the summer due to intercity tourism to the shopping, nightlife, and historical areas. Utilising emergency cooling stations here for people in need of relief

is paramount, especially as all demographics come here making it impossible to predict who will be vulnerable to heat during these times of heavy tourism.

Analysis here partially agreed upon by the Heat England 2022 Socio-Spatial Heat Vulnerability Index, ranking E01017139 and E01032755 as acute vulnerability with E01032755 highest and E01035444 and E01035445 as extremely high vulnerability. Our ranking places E01032755 as highest also, but this is followed by E01035444, E01035445, and then E01017139. The Heat England Index also ranks E01032751 as similar vulnerability to E01035444 and E01035445 and the rest of the ward at relatively high vulnerability. E01032751 is not a priority for heat vulnerability over E01035444 and E01035445, although it is in the 3rd decile for deprivation so is advised to be included in outreach initiatives. Similarly is E01032745, in which the primary issue is social isolation which should be improved upon. The assessment that E01032746, E01032748, E01035448, and E01035449 are of relatively high vulnerability of being vulnerable to extreme heat, and the high ranks of others are corroborated though. From this it is clear the only ranking discrepancy is that of priority of LSOA. As a whole, Bargate is in need of heat intervention, especially due to its high density of urbanisation and high-rises which increase risk drastically due to urban heat island effect.

4.3 Flood Risk Assessment

4.3.1 Fluvial Flood Risk

Large portions of Bargate are projected ahead to be underwater by 2100. The SFRA has determined E01035448 and E01035449 is at of high risk of type 2 and 3 Fluvial Flooding, and the projections by Climate Central have shown this also includes LSOAs E01017139 (south and eastern parts), E01032745, E01032746, E01032748, E01032751, E01032755, E01035444 (south and west parts), and E01035445.

4.3.2 Above Bar Street

The centre to northern side of Above Bar Street also enjoys a lot of flooding. In the pedestrian centre, the drain cover is not to be admired. A small slit in trenches on both sides of the pedestrian area tend to get blocked easily from debris and the larger storm drains are sparse. There have been multiple reports around this area of stall vendors that are allowed to sell here pouring fat from food cooking down these drains, exacerbating the issue. Above Bar Streets drains also connect to the foul sewer line, indicating it is very old and outdated. Water from the northern side flows down this route, therefore if these drains are blocked the northern side may also flood. This issue is more apparent in low-lying areas, such as the Civic Centre Road - Above Bar Street junction.

4.3.3 Bargate Street

The 75 meter stretch of Bargate Street by Arundel Tower is the subject of many flooding reports. There have been 24 flood reports in the last 10 years in this small street, and evidently increasing, as 20 have occurred since 2020. Only one in 2022 has been due to *"cooking oil in drain"*. This location has little canopy cover, low-medium traffic, and the majority of the area is closed 8pm. The majority of reports occur outside of 18 Bargate Street; 17 out of 24 of them. Very high foot traffic through the day can be seen north, on Above Bar Street, some of which passes through here to get from shopping areas to a popular bus route and food places. Here, there is a dip in the pavement, leading to a trench drain in the middle of the pavement that is evidently the problem. This is a wide pavement with one trench drain, high foot traffic, and a small pipe leading to a sewer system. Not only this, due to wear the tile path has shifted and now has sunk to be lower than or level with the trench drain towards the east of the pavement, causing water to pool here, giving numerous reports about flooding in form of a large pool of 1 inch depth water. Some drainage support here may aid the issue.

4.3.4 Canute Road

From St. Lawrence Road to Ocean Way, Canute Road has an issue with flooding. These are clearly older sewer ways, as is on a historic road with gullies routed to foul sewers, which is evident to residents wherein foul smells have been reported with floods. Surface water sewers run north-east after Ocean Way. It seems as if these foul sewers run to sewage tanks at Crosshouse and out to the River Itchen. As this road is an low-lying, tide locking may cause flooding here. This is similar for further up the road outside Consulate House which also regularly floods, a low-lying road wherein surface water is expelled by The Itchen Bridge. This is also a similar issue in the Anglesea-Elm Terrace junction, and Endle Street.

4.3.5 Evan's Street - Houndwell Place

Evan's Street - Houndwell Place junction is subject of flooding. This is a low-lying point in the road on all sides, therefore water may congregate here. The road is busy and this low-lying point is managed by one gully, which may become blocked often due to high traffic on the road. There is a subway further down Evan's Street that also becomes often flooded, and multiple reports down Houndwell Place, perhaps due to debris from overhanging tree cover, as it is also a very old drain.

4.3.6 Oxford Street

Oxford Street also floods towards its east end. This is a lower lying street than its surroundings, and is evidently due to that this is the area of least resistance the water can escape when in the surface water system. One resident states referencing their flooding cellar, *"the water pump was quite useless because even though it did the job of pumping the water back into the water system, it just came back into the street and back into his cellar"*. This may be due to the pipe layout in this neighbourhood. The pipe height is constant, but the surface level reaches a minimum on Terminus Terrace, most likely pooling constant water within the pipe, an inefficient setup. Further along Oxford Street where it intersects with Latimer Street, there is little on-road drainage causing floods. One report states drains here were tarmacked over drains outside of 48 Oxford Street. It does not seem to have been addressed.

4.3.7 St. Mary's Street

Notable flooding takes place in and around St. Mary's Street. Gullies, some of which have had previous repair attempts, continue to cause persistent flooding along this road. This is a road of low risk of debris, therefore may be due to the wider sewer system that runs south underneath this road. From the top to the bottom of the road, the pipe height stays constant whereas the road only decreases in height above sea level on average by 30cm. Further, there have been no evident works on these pipes. A mixture of low gradient, ageing infrastructure, and little maintenance may be causing these drains woes.

4.3.8 Town Quay and West Quay Road

Town Quay road (E01032748) and West Quay Road (E01035445) are prone to flooding with multiple reports. These roads have low-lying points which are where the majority of reports are concentrated. This indicates tidal backflow. This is similar for the north end of this polling district, which experiences evenly distributed flooding throughout the region. It may also be debris as West Quay Road experiences high traffic.

4.3.9 Future Projections and Ward Recommendations

A primary concern is to combat the threat of fluvial flooding from both the River Itchen and the River Test, as well as estuarine from Southampton Water. Along the west coast is man-made coastal defence and along the east is maintained channels and demountable defence. This needs to be investigated to perhaps be improved. As for E01032755 (top 20% most vulnerable), E01035448 (top 30% least vulnerable), and E01035449 (top 10% least vulnerable), there exists the River Itchen Flood Alleviation Scheme to aid with this area, north of the River Itchen. We are currently in the design stage of this scheme and aim to complete construction by 2030, seeing this project through and then re-conducting analysis of fluvial threat is advised due to the risk of flooding from the River Itchen. This does not cover eastern River Test shore areas such as E01035445 (top 30% most vulnerable) though, an area which is higher vulnerability to flooding primarily due to high crime rate and a high older ages social isolation score. Flooding of this LSOA is projected by Climate Central, but not by the SFRA. Due to assumptions made by the Climate Central model, the SFRA is more appropriate to utilise for fluvial flooding, but this does not eliminate the surface water flooding risk due to tide locking from higher and higher tides projected into the future, therefore eliminating vulnerability to a flood risk that has not yet shown its worst is recommended. For E01035445 we recommend social events, clubs, and volunteer networks specifically for locals. This area gets a lot of tourism from other areas of the city and as it is harder to travel for 65+ ages due to decreased mobility it would not help older ages' isolation issues to intermingle with those towards the outer borders of the city. These local clubs can also aid in making the wider community aware of those with or those caring for pupils of special educational needs to help them to be more prepared and safeguarded during a weather event. These events need to be geared towards language accessibility too, with a high level of non English speaking households in the ward, and we do not want to further isolate those who don't speak English for their safety. This starts with the community feeling safe; there is a high crime rate in this LSOA and people will not attend if they feel unsafe.

Oxford Street in LSOA E01017139 (top 50% most vulnerable) has risk of fluvial and surface water flooding, meaning vulnerability here could be worked on foremost as is multi-source. With a low percentage of English speaking households and a close proximity to E01035445, this LSOA could be included in local events, clubs, and volunteer networks.

St. Mary's Street and Houndwell Place, both of LSOA E01017139, have a high ages 65+ social isolation and a low rate of English speaking households. Here, eliminating the risk of surface water flooding is recommended due to the single-source risks. Decreasing vulnerability by understanding the languages and communities within this LSOA would be a recommendation too.

This analysis is agreed upon by the Flood England 2022 Socio-Spatial Vulnerability Index. A relatively high to acute rating seen throughout the ward, with least vulnerable towards the south of the ward and most vulnerable towards the north. E01035448 and E01035449 sit at the UK average, but this is a vulnerability index and does not take risk into account, and our vulnerability index agrees with this.

5 BASSETT

5.1 Ward Profile

This ward contains LSOA neighbourhoods: E01017144, E01017145, E01017146, E01017147, E01017148, E01017149, E01017150, E01017151, E01017152, a small eastern section of E01017266, and two small south-eastern portions of E01017272. Where appropriate, LSOA data will be discussed.

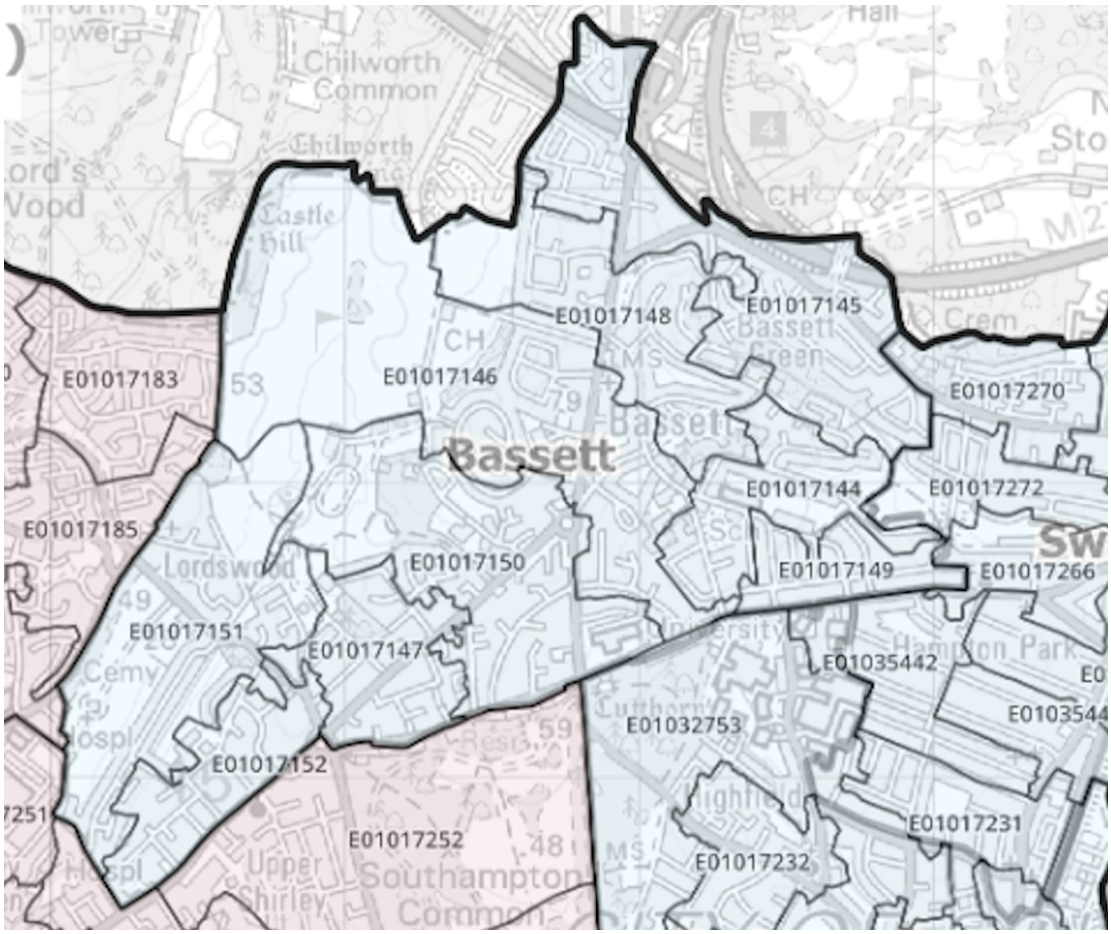

Figure 13. The LSOAs of Bassett.

Compared to the city average, the ward itself has a factor that may make neighbourhood climate adaptation harder:

- Very low EPC ratings are in this ward. The highest is E01017146 at 50.3%, falling as low as 22.2% at E01017151.

- 3rd decile multiple deprivation index in E01017149, 4th decile in E01017151, and 5th in E01017152. Otherwise deprevation index is above 8th decile.
- This area also has a non-significant but large retiree population, at 15% ages 65+ verses a city average of 14.3%, with a ward maximum of 20.2%. These two factors should be noted. The social isolation index for this demographic is generally good, except from E01017149 (2nd decile), E01017150 (4th decile), and E01017151 (5th decile). Other LSOAs are 8th decile or above. E01017151 also has a 3rd decile all-ages social isolation.
- In areas there is a low rate of English speaking households, particularly in E01017149 (4th decile), E01017152 (3rd decile), and E01017144 (2nd decile). Other LSOAs are above 6th decile.
- A climbing and significantly worse than city average inpatient admission rate for mental health disorders crude rate per 100,000 population aged 0-17 years (3 years), 272.7 verses 151.5. This does not pose a threat considering other factors which align with the city average or are significantly better than, such as: pupils achieving a good level of development, low levels of special educational needs pupils, low children in need and safeguarding enquiries, and low percentage of residents reporting bad health.

5.2 Heat Risk Assessment

E01017151 has high all-age social isolation and second highest deprivation in the ward. E01017149 has the highest deprivation in Bassett and 2nd decile 65+ social isolation.

Other than these two LSOAs, the ward is prepared comparatively to other areas of the city. There is a low English speaking household percentage in E01017144 and E01017152, but both have low social isolation score and are above 50% most deprived on the multiple deprivation index. Focusing first on LSOAs E01017149 and E01017151, these two LSOAs could have increased social encouragement. On the other hand, this ward and its LSOAs as a whole do not score highly on list of priorities comparatively to other more deprived and isolated wards; all LSOAs within this ward are top 50% least vulnerable to heat, with the worst scoring being E01017149 at 6th decile most vulnerable.

The Heat England 2022 Socio-Spatial Heat Vulnerability Index partially agrees with this analysis, marking the whole ward as relatively low to average heat vulnerability. This sentiment is agreed upon, other than their finer resolution enumerated ranking. It is not agreed that E01017150 is the highest vulnerability followed by E01017145; we place E01017149 as the highest by far, followed by the western LSOAs E01017151 then E01017152.

5.3 Flood Risk Assessment

5.3.1 Bassett Avenue (south)

The southern side of Bassett Avenue has a consistent level of flood reports, which seem to be, according to Southern Water, due to a 'waste' blockage. This seems to be a historical issue, with most reports happening from 2019, and investigation into the waste needs to be conducted, as in the last couple of years this has affected the roundabout to the north connecting Bassett Avenue with Winchester Road and Little Oak Road, causing flooding here. This is exacerbated by the heavy traffic and large canopy cover Bassett Avenue south experiences.

5.3.2 Bassett Wood

There are a number of flood reports along the length of Bassett Wood. These occur on The Parkway, Copperfield Road, Bluebell Road (western), Carnation Road (western), Bassett Green Village, and Lobelia Road. All of these instances of flooding may be due to heavy rainfall causing an increased flow along the waterway in Bassett Wood. Surface water sewers from the listed roads empty into this waterway, and therefore may be causing flooding at high levels of water. This is evident, as when the waterway becomes culverted the flow is limited, therefore further down to the east of Bassett Green the flooding reports stop. Silt is also cited as a reason for flooding; as Bassett Greens geography is silt, this may cause this debris to wash back through the pipes, leaving sediment and limiting the capability of the pipes. These issues are particularly bad at a low-point in Copperfield Road, which sits almost 10 meters lower than other parts of the road.

5.3.3 Burgess Road

Pointout Close and Burgess Road to the south experience flooding. They are connected via a surface water sewer. The area of flooding on Burgess Road is a gully that sits at a low-point in the road. The surface water sewer leads only north to Pointout Close, and is of similar elevation to the Burgess Road gullies therefore any blockages in Burgess Road pipes or gullies will affect Pointout Close.

At the bottom of Glen Eyre Road, Burgess Road is also very busy and attracts much debris, causing potential blockages here. This is because it is a now urbanised dell causing a low-point in the road at the end of Glen Eyre Road which can overwhelm drains.

5.3.4 Dale Valley Road

Dale Valley Road is at particular risk of flooding. It is in the location of a now urbanised dell. Ample green space lines either side of the Dale Valley Road residential area, but Dale Valley Road is far lower than either side, meaning this non-permeable road may get overwhelmed during heavy rain and storms.

5.3.5 Glen Eyre Road

Flooding also occurs along on Glen Eyre Road, by Glen Eyre Halls. This continues down towards the University, a popular commuter route for students through large areas of tree canopy cover. This would suggest debris from trees and or anthropogenic causes. The fact that it has been reported that some drains in the same vicinity take in water whereas others do not suggests that it is individual drain blockages rather than a piping blockage.

5.3.6 Holly Brook

Holly Brook is next to Holly Hill and Saxholm Way neighbourhoods, which regularly become flooded. In-between these two neighbourhoods is the Bassett Row, Ardnave Crescent, Ridgemount Avenue, and Greenbank Crescent neighbourhoods, which does not become flooded. For both flooding neighbourhoods, the flooding reports are in great detail and it is clearly debris that makes it's way into the surface water sewers. As for the lack of flooding in other neighbourhoods, this could be explained by the presence of ample green space along their roads. A higher level of permeable surfaces in flooding neighbourhoods helps in critical areas.

5.3.7 Lordswood Road

Yearly, mostly during winter-time, Lordswood Road floods and creates a layer of ice on the path and road. On examination, there is a large amount of sediment and organic debris in the drains, which may be rendering them ineffective. The high amounts of traffic (due to a nearby school) and the large canopy cover may be causing this issue. This pipe also connects a few postcodes to Dale Valley, and the high levels of water may explain the regurgitation of sediment and water some gulleys experience. Further investigation into this area is required.

5.3.8 Winchester Road

In the south-west of Winchester Road, many residents document as to why flooding is so regular. The general consensus among residents is that the key issue is sediment deposited by cars, particularly gravel from nearby car parks, which decreases the flow capacity of the gullies. This road is also relatively high traffic, and has had a large number of repairs, contributing to a large number of uneven areas in the road, perhaps decreasing the effectiveness of nearby drains.

To the north-east of Winchester Road, vegetation and canopy cover is far more regular along the road, and many residents report flooding with gullies filled with leaves. Areas such as the Redhill-Winchester Roads junction, and the Abingdon Gardens-Winchester Road junction, have an area of stagnating elevation meaning water may pool around here.

5.3.9 Future Projections and Ward Recommendations

The particular issues of the Glen Eyre Road - Burgess Road junction and issues of Holly Hill lie within LSOA E01017146, and then Glen Eyre Road runs up into E01017144. The former LSOA is within the 2% least vulnerable, with the latter within 40% least vulnerable. This issue does not affect residents therefore does not take priority.

Pointout Close and the adjacent area of Burgess Road lie within LSOA E01017147. Due to low multiple deprivation, low rates of children in need, low crime, and low percentage of lone parent dependent children families this neighbourhood is top 30% least vulnerable.

Saxholm Way of LSOA E01017148 is not vulnerable. With exceptionally low social isolation for all-ages, high qualification earning, low crime, low adult social care dependency, and low percentage of lone parent dependant children families, this area is within the top 10% least vulnerable.

The southern side of Bassett Avenue is in LSOA E01017150. Risks here are not affecting residents, and due to a low multiple deprivation, low rates of children in need, and low percentage of lone parent dependant children families, this neighbourhood is not vulnerable either at top 70% most prepared.

Dale Valley Road, Lordswood Road, and Winchester Road all are within LSOA E01017152, with Lordswood Road also in E01017151. Both LSOAs are within the 40% least vulnerable to flooding. There is little issue with these areas and thus to prevent damage to residencies eliminating the surface water flood risk may be recommended, but not with priority over other wards due to low vulnerability and a non-immediate threat.

Bassett has a low vulnerability to flooding overall, although could aid other wards. Holly Brook and other waterways cause some issues in other wards and utilising green space in Bassett such as Bassett Wood Greenway and the Sports Centre, Golf Course, & Redlodge Belt to create terracing for passive water storage to slow flow downstream would be of use. This is further expanded on in appropriate sections. This analysis of flood vulnerability and risk is generally corroborated by the Flood England 2022 Socio-Spatial Vulnerability Index, placing Bassett as average to relatively low risk. E01017150 is not agreed upon though, with vulnerability being placed at relatively high, whereas it was placed by us as among the least vulnerable upon analysis.

6 BEVOIS

6.1 Ward Profile

This ward contains LSOA neighbourhoods: E01017153 except for the far west tip, E01017154, E01017155, E01017156, E01017157 except from its north, E01017158 except from a small south-western tail and the far north, E01017159, E01017160, two small tails on the north-east and south-east of E01032738, and E01032750 except from two small north-western and south-western tails. Where appropriate, LSOA data will be discussed.

Compared to the city average, the ward itself has a few indices that may make neighbourhood climate adaptation harder:

- Bevois has a consistent A-C EPC rating percentage of 36.6% to 57.4%. Eliminating E01017158 reduces the range of values to less than 10%, at 36.6% to 46.5%.
- Bevois is a ward that scores highly on the multiple deprivation index. E01017154 and E01017155 are among the top 10% for deprivation with E01017153, E01017156, and E01032750 being 2nd decile and the rest of the LSOAs being 5th decile.
- Bevois has significantly high mortality rates from cardiovascular disease and all causes, as well as a shorter male life expectancy. The cardiovascular disease mortalities may be attributed to higher levels of smoking indicated by the wards deprivation (Archbold et al., 2023). It is unclear why other health problems arise, as Bevois has a non-significantly lower percentage of residents reporting bad or very bad health.
- High rate of admission episodes with a primary or secondary diagnosis of drug related mental and behavioural disorders, DSR per 100,000, all ages (3 & 5 years), 587.3 verses 272.6 and 635.2 verses 256.0 respectively. This is the worst rates in the city, indicating a risk of those affected seeking isolation rather than aid in extreme weather. Also significantly above average is 5 year averaged all ages admission episodes with a primary diagnosis of poisoning by drug misuse (DSR per 100,000 population, 67.3 verses 40.9).
- All-ages social isolation in Bevois sits at or above the 6th decile except for E01032750 (3rd decile), which is unconcerning. Social outreach is better used on E01017154, E01017155, E01017156 with a 65+ ages 3rd decile social isolation index, E01017153 and E01017157 at 2nd decile, and E01032750 which is at the top 10% values.
- Significantly higher ethnic minority groups, 47.6% verses 19.3%. Further, significantly lower households with one or more persons with English as a main language, 78.3% verses 90.6%,

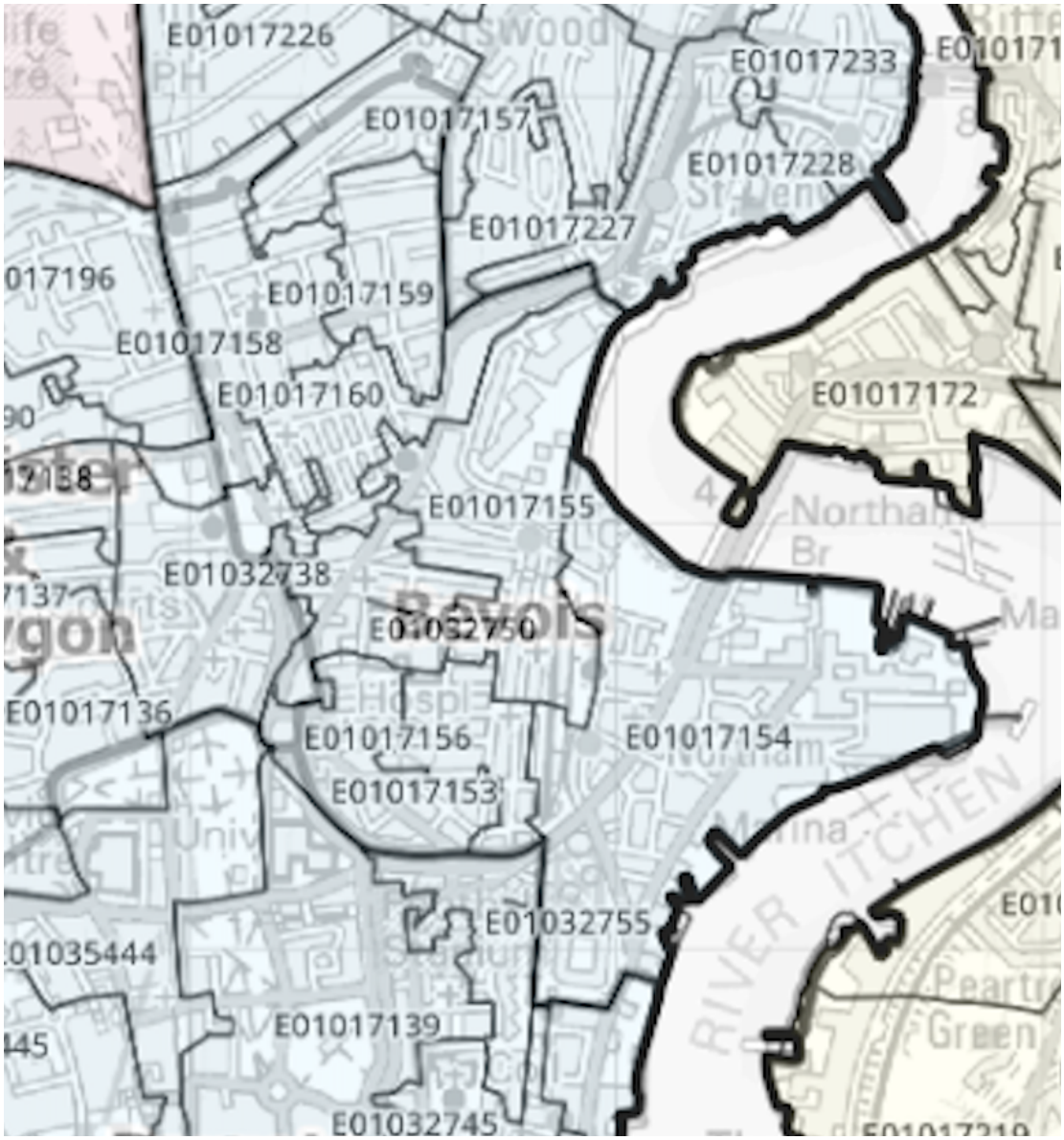

Figure 14. The LSOAs of Bevois.

shows these may be first generation immigrants and we may struggle with outreach without proper preparation. For both of these statistics, it is in-fact rank 1 in the city. In all LSOAs except E01017157 and E01017158, Bevois is bottom 10% for households with one or more English speakers, and the two mentioned LSOAs are instead 2nd decile.

- Significantly higher percentage of resident population aged under 16 years 18.8% verses 17.3%. A large population of young people may impact climate response ability and impact their development. On the other hand, this is trending downwards, as a forecast percentage change of -1.3% by 2029. Not only is the forecast percentage change in resident population aged 16-64 years rising significantly at 13.7% verses 7.5%, but also the forecast percentage change in resident population aged 65 and over, at 39.1% verses 14.3%. While retiree population is significantly low now, 7.3% verses 14.3%, it is projected to increase, indicating mobility and preparation capability of the wards population may deteriorate.

- Significantly worse anti-social behaviour incidents per 1k population (19.0 verses 11.3), as well as significantly worse total crime per 1k population (163.5 verses 123.4), significantly worse violent crime per 1k population (72.3 verses 48.2), and significantly worse rate of domestic abuse related crimes per 1k population (23.7 verses 18.7). This alongside a rank 6 in the city for worst rate of children in need per 10k 0-17 population, although not significantly lower at 667.3 verses 628.1, and a significantly higher eligibility for free school meals 38.2% verses 34.4%, indicates that this may be a heavily deprived area with low community unity strength.

- Very low percentage of green space, 1.8% verses 13.4%, impacting the permeability of ground and natural clearance of flood water, as well as increasing urban heat island effect.

- Rank 1 for significantly high emergency hospital admissions due to falls in people aged 65 and over DSR per 100,000 (5 year pooled), comparatively dangerous conditions for flood evacuation. This is falling with these infrastructure issues being addressed.

6.2 Heat Risk Assessment

Bevois ward is in high need of support during extreme heat. Half of the LSOAs that make up Bevois are within the 50% most vulnerable. E01017156 (top 50% least vulnerable), E01032738 (top 50% least), E01017158 (top 40% least), E01017159 (top 40% least), and E01017160 (top 40% least) are all not comparatively vulnerable to heat, and could become less vulnerable with priority focus on other areas of Bevois.

E01017153, E01017155, E01017157, and E01032750 are all within 5th decile vulnerability, all of which could benefit from heightened green space and clubs, events, and volunteer networks particularly focused on different cultures and minorities to interact with the wider community, especially accessible to 65+ ages. This is due to a high 65+ ages social isolation and a low rate of English speaking households throughout E01017153, E01017157, and E01032750. E01017153 and E01017155 both have issues with spread of information due to high percentage of residents aged 16+ with no qualifications. Clear, accessible information about council action must be given for this ward, perhaps utilising community boards, local workplaces, and social media. E01032750 in particular has a very low score due to high rates children in need; this also comes with a high multiple deprivation index for all four LSOAs.

The priority for Bevois is E01017154, within the top 40% most vulnerable (rank 32). E01017154 has low qualifications earning, low percentages of green space, and high multiple deprivation index. Workplace and community board spread of information could be of use as previously mentioned. The high deprivation indicates information about housing and how to aid them during heat extremes could be of use, possibly gathered through a mailing census. This must be acted upon once data is collected though or neighbourhoods may become disillusioned with the council. Greening and increased canopy cover would also be of use too, due to heightened urban heat island effect because of low green space.

Ranking of Bevois may be underestimated when factoring in risk analysis. Bevois has a high level of large developments like Bargate, but not to the same degree. It has a large amount of industrial estates next to residencies, which use high levels of electricity and can exacerbate urban heat island effect. This likely places Bevois, especially areas such as Northam (E01017154) higher than their 'black box' vulnerability when factoring in risk.

The analysis of the Heat England 2022 Socio-Spatial Heat Vulnerability Index is agreed upon; parts of Bevois are in need of serious intervention. E01017154 we agree on an acute vulnerability. E01017155 is ranked also as acute, but E01017153, E01017157, and E01032750 rank on the same level if not lower than E01017155. With high levels of urban development and seriously low levels of canopy cover and vegetation their risk to extreme heat is extremely high and therefore should be treated with vulnerability priority after E01017154.

6.3 Flood Risk Assessment

6.3.1 Preliminary Statements on the Flood Risk from the River Itchen

The River Itchen is of serious risk of flooding Bevois. As one of the more susceptible wards, this is of upmost concern. Currently, the River Itchen Flood Alleviation Scheme covers these concerns and by constructing appropriate flood defences should alleviate tidal flooding risk to the west bank of the River Itchen, including to areas of Northam, St Marys, and Chapel. It is set to be completed upon 2030, and it is recommended that upon its completion a flood risk report is conducted for this area.

6.3.2 Bevois Hill - Lodge Road Junction

Bevois Hill often floods in the slipway road that runs from Lodge Road to Portswood Road. This area is busy, and the slipway road is flat, which may cause sediment deposits in the sewer. This issue may need further investigation as to why this recurring issue is present.

6.3.3 Nichols Town and Northam

Consider the neighbourhoods west of Derby Road, those including: east Cranbury Avenue and Lyon Street, Alfred Street, Bullar Street, Graham Road, Clovelly Road, Oxford Avenue, and the triangle of Argyle Road, Derby Road, and Brinton's Road, i.e., a large portion of Nichols Town. There are reports in this area of the drains having become degraded and causing blockages this way. These have surface water sewers that conjoin into the Northam industrial estate, then all drain into the River Itchen north of St. Mary's Stadium. Alongside a low level of ground permeability, increased pressure in the sewer system could also cause it to become overwhelmed in this area during heavy rain. There are also multiple busy roads nearby due to industrial estates, which may cause sediment to be deposited in the drain, becoming stagnant and causing a blockage. This issue may also be happening in Northam.

6.3.4 Princes Street

This streets east side is subject to recurring flooding during heavy rains. This is most likely not due to tide locking or heightened tides, as the adjacent Millbank street does not experience this problem at a similar elevation and surface water sewer route to Princes Street. This may be primarily due to poor gradient and or sewer design along the road next to 2 Princes Street. This is also a popular route next to an industrial estate, which may aggravate the issue.

6.3.5 Future Projections and Ward Recommendations

The primary concern of this ward, and for the city in respect to flooding, is to be in aid of Northam. Northam has a severe fluvial flood risk outlined in the SFRA report (Southampton City Council, 2024*a*) if the River Itchen Flood Alleviation Scheme is not completed. A recommendation for this would be to complete the flood defences outlined in the alleviation scheme, and re-evaluate type 2 and 3 fluvial flood risk when completed. If this scheme is not seen through, Northam (E01017154, 3rd decile vulnerability, rank 25), an area of very high flood risk according to the Flood England 2022 Socio-Spatial Vulnerability Index and of 3rd decile flood risk as evaluated here will be left vulnerable. Fluvial flooding in this area will become worsened with climate change, and as Northam is approximately 3 meters above sea level, in 100 years this area may be flooded (Le Bars et al., 2017). Northam is within the 10% most deprived areas; houses in this area must have aid in fortifying homes and recovering if flooded as they cannot afford it themselves. Higher permeable grounds may be necessary too. Another recommendation for this would be to outline the flood alleviation scheme progress more clearly for the public, and distribute information on the works so residents are aware. Northam has a low rate of qualification earning for ages 16+, meaning information accessibility may be of question alongside the high deprivation.

From analysis, Nichols Town has a flood risk from recurring storm attributable surface flooding in key residential areas, which in the future will make the area un-liveable for the current population. As well as this, flooding in this area will render roads out of key industrial areas inaccessible, costing the city economically. The key areas of flooding of Nichols Town are primarily made up of E01017153

(4th decile vulnerability) and E01017157 (5th decile vulnerability), two LSOAs with: low rates of at least one English speakers in households, low percentage of residents aged 16+ with no qualifications, very low green space, higher than average 65+ social isolation, and among the 20% most deprived. In Nichols Town a key focus on understanding the language and cultures that occupy Nichols Town is also required, in order to be able to effectively communicate information centred on the council to this resident population. Non-intrusive and low cost infrastructure improvements are also required. This can include higher permeability of ground and assessment, action to improve drainage systems, and road and pavement repair to prevent dangerous urban conditions.

Within both of these areas, serious social outreach is required. This can include funded social clubs, youth support, events, volunteer networks and non-intrusive health awareness surrounding drug misuse and health problem support. On a resident-by-resident resolution, aid can be offered, but not forced as to not further estrange the resident population. This can include water pumps for basements, flood defences for front doors, and aid in damp clean-up, all of which are points of failure flood reports have identified. If this aid is refused, it should be required to make note of those who refuse it and their risk to flooding, as they may need aid in the future.

This is partially agreed upon by the Flood England 2022 Socio-Spatial Vulnerability Index, with the coastal areas of Bevois ranging from very high to acute vulnerability, and northern Bevois being average to relatively high vulnerability. If risk is factored into this, we argue that the areas not outlined as fluvial flood risk by the SFRA such as Bevois Valley (E01017155) and Queensland (E01017156) move down in ranking, while Northam (E01017154) moves up to Acute and Nichols Town (E01017153) remains very high.

7 BITTERNE PARK

7.1 Ward Profile

This ward contains LSOA neighbourhoods: E01017171, E01017172, E01017173, E01017174, E01017175, E01017176, E01017177, E01017178, E01017179, the northern section of E01017201, and the eastern portion of E01017265. Where appropriate, LSOA data will be discussed.

Compared to the city average, the ward itself has a few indices that may make neighbourhood climate adaptation harder:

- Excluding the south-west of the ward (E01017171, E01017172, and E01017177) the ward has a very low rate of A-C EPC ratings. The south-western portion of this ward has an A-C EPC rating percentage of 52.5%, while the rest sits at 28.05%.
- Bitterne Park has 2 LSOAs that fall below 5th decile deprivation: E01017172 (4th decile) and E01017179 (3rd decile).
- Significantly higher population than average ages 65+, 18.0% verses 14.3%. Forecasted as an aging population. This may impact mobility and heat acclimatisation in years to come.
- 3rd decile 65+ and all-ages social isolation index score at E01017171; other than this this index is on or above 5th decile.

7.2 Heat Risk Assessment

E01017201 will be discussed in the Harefield section as only a few residencies are within Bitterne Park. Similarly, E01017265 will be discounted due to a lack of residencies in the Bitterne Park region. Otherwise, Bitterne Park is at low risk of struggles due to heat extremes. The worst two are 6th decile vulnerability: E01017171 and E01017179. Both, especially E01017179, may be aided by higher levels of green space. E01017171 could use more social outreach as is a hotspot for social isolation in the ward. E01017174 is also in the bottom 30% for English speaking households. This is vulnerability assessment partially agreed upon by the Heat England 2022 Socio-Spatial Heat Vulnerability Index, marking E01017172 and E01017179 as relatively high vulnerability and the rest of the ward as average vulnerability. E01017179 is agreed upon, while E01017172 less so as we have ranked it top 40% least vulnerable, although it does have a statistically significant high percentage of pupils who are not a healthy weight which may make adapting to heat in the future harder.

Figure 15. The LSOAs of Bitterne Park.

7.3 Flood Risk Assessment

7.3.1 Preliminary Statements on the Flood Risk from the River Itchen

Northern Bitterne Park has the benefit of Riverside Park lining its coast. This offers great amounts of permeable ground, lowering the type 2 and 3 tidal flood risk. Southern Bitterne Park however, has far less permeable ground, and is made up largely from slipways and marina. This places houses along the coast at risk of tidal flooding, although this risk is managed by raised man-made defence, maintained channel, and soft mud banks proceeding the shore. As the River Itchen Flood Alleviation Scheme does not include this shore, it would be worth conducting an assessment on this areas risk level to tidal flooding.

7.3.2 Beechwood Gardens

Beechwood Gardens, due to leaves in autumn from a large tree, has flooded over the last few years. This is of particular concern as a few houses, particularly for house numbers 15-20, are downhill from these areas of flooding, across a non-permeable tarmac road. This is a layout that can and has lead to flooding.

7.3.3 Bitterne Road West and Cobden Bridge

With high rates of traffic travelling this area, this road historically may flood due to sediment being deposited in gullies, although pressure should not be an issue as these gullies run off into the River Itchen very close to the gully location. One resident stated: *"The drains are totally silted up and when the yellow line painters painted their lines on the new road, they went across these drains, silt included"*. The issue is generally seen just over the Northam Bridge into Bitterne Road West, and this may be due to that this is a low-point before the road once again begins to rise. This issue is very similar to that of Cobden Bridge and its low-point on the east side of the bridge, as well as how this bridge affects Whitworth Crescent with high levels of sediment deposits.

Further down this Bitterne Road West, a large amount has been flooded in the junction with Athelstan and Bullar Roads. This may be due to that just off of Bitterne Road West, Athelstan and Bullar Roads both have a low-point of non-permeable tarmac with inadequate drainage for a high traffic road, causing a large amount of run-off water and sediment to collect here.

7.3.4 Mansbridge Road

There are repeated flooding instances on Mansbridge Road. This is due to that the road runs through Country Park, with a number of parking spaces in the area being on gravel. The drains are reported to be filled with stones (from parking and sediment), mud (sediment), and leaves (from canopy cover).

7.3.5 Future Projections and Ward Recommendations

There are areas in Bitterne Park of high rates of reports, but most were closed almost 10 years ago. This includes Beech Avenue, Woodmill Lane, and Copsewood Road. These areas require re-evaluation, as these may have either been resolved or residents have stopped reporting them as they have seen them go unresolved year after year.

We can learn a lot from places like Mansbridge Road. This road, running through Country Park, gets a large number of blocked gullies due to natural debris. While Mansbridge Road floods affect only The White Swan pub, places of high traffic urbanisation within or next to green space may become flooded more often. Roadways such as these may benefit from revisions in drainage systems if they often become flooded. Mansbridge Road is a perfect poor example, utilising the older foul sewer. Conversely, a good example is The Avenue, running through The Commons it utilises a far greater numbers of gullies and newer surface water sewers that run off into the water bodies in The Commons.

Beechwood Gardens is also a learning experience. These specific houses are less worth evaluating, but this is indicative of an issue on hilled cul-de-sacs and bends that requires better thought and planning. As a retrofit, smart placement of new drains can be instructed in key water flow areas during flooding. This is not to say Beechwood Gardens isn't worth intervention too wherein some new drains lining the south and east sides of the road, where houses 15-20 are, would be appropriate. This particular neighbourhood may not be vulnerable though, with a 7th decile vulnerability. Its only metric that is worse with statistical significance is a lack of green space, and Beechwood gardens has good canopy cover and some permeable ground.

The wider ward of Bitterne Park gets moderate numbers of residential surface flooding. As Bitterne Park is of lower risk for flooding, there are few active action recommendations to make with priority over other wards. This ward is useful as a case study in specific areas, and in hotspots like Bitterne Road West and throughout the residential areas across Bitterne Park, higher drainage capability could

be utilised to avoid regular reports. This would need to be pro-active support through, as in residential areas of Bitterne Park no trends are present, with flooding relatively evenly dispersed throughout the ward. Overall, Bitterne Park is not particularly vulnerable and is without risk. A higher vulnerability is seen in E01017172 and E01017179, especially the latter, but without major risk both areas fall low on priority. This 'black box' vulnerability assessment is shared by the Flood England 2022 Socio-Spatial Vulnerability Index, but when factoring in risk E01017179 should be lower on priority. E01017172 being relatively high vulnerability is an issue, due to the fluvial risk to residencies on the northern coast of E01017172, outlined in the SFRA. Flood defences and or an inquiry into specific flood risk here is recommended.

8 COXFORD

8.1 Ward Profile

This ward contains LSOA neighbourhoods: E01017180, E01017181, E01017182, E01017183, E01017184, E01017185, E01017186, E01017187, and E01017188. Where appropriate, LSOA data will be discussed.

Figure 16. The LSOAs of Coxford.

Compared to the city average, the ward itself has a few indices that may make neighbourhood climate adaptation harder:

- Coxford has moderate rates of A-C EPC ratings, most values being above 40% with maximum E01017187 at 51.1%. Exceptions to this are: E01017188 at 34.3%, E01017180 at 33.6%, E01017186 at 33.1%, and E01017185 at 25.6% being the worst.
- Coxford is a moderate-high deprived area. While E01017180 and E01017183 are both 8th decile and non-deprived, E01017181, E01017182, E01017186, and E01017188 form a middle line down Coxford of top 20% index values for multiple deprivation. Both E01017184 and E01017185 are in the top 30% of values also, and E01017187 is in the 5th decile.
- The west side of the ward is where Coxford faces most issues. E01017181 and E01017182 face top 10% all-ages social isolation and E01017184 follows this closely in the top 30% with E01017186

and E01017188 following with top 40% values. E01017182 also faces top 10% social isolation index values for 65+ ages, E01017181 following in the 2nd decile, E01017188 at 3rd decile and E01017186 at 4th decile.

- Significantly higher percentage of population aged 65+, 19.2% verses 14.3%. Rate of adults in social care, care act assessment recommendations, and rate of contacts with outcome of information, guidance, and advice is also is high in this ward. This may be due to the aged and aging population. These three indices have a 0.677, 0.782, and 0.577 correlation with percentage of population aged 65+ respectively, and may signify causation. This is further supported by the both non-significantly lower safeguarding concerns and section 42 enquiries throughout the ward. These demographics may have a lower mobility in event of flood, as well as an aging populations lower heat adaptability.

- This ward has high percentages of people reporting bad or very bad health, 6.5% verses 5.0%, as well as a high percentage of residents limited a lot by disability, 7.1% verses 8.8%. Further, there is a high all age mortality rate from all causes (DSR per 100,00 persons 5 year pooled, 960.6 verses 1084.0). This may be due to the older population, but there is also an issue with hospital admissions caused by unintentional and deliberate injuries in children and young people crude rate per 10,000. Metrics: ages 0 to 14 years 5 year pooled (116.5 verses 94.9), ages 15 to 24 years 3 year pooled (198.0 verses 126.8), and ages 15 to 24 years 5 year pooled (187.3 verses 131.1) are all statistically significantly worse than average rates for Southampton. Ages 0 to 14 years is falling, and the 3 year pooled values are not statistically significant (105.7 verses 81.0). It is not immediately apparent nor conclusive why Coxford has these issues, although will impact flood and storm household mobility.

- Significantly higher percentage of resident population aged under 16 years, 18.4% verses 17.3%. This impacts flood mobility, although this younger population is aging out.

8.2 Heat Risk Assessment

E01017180 and E01017183 are not of risk of extreme heat. Comparatively to the rest of Southampton, E01017184, E01017185, E01017186, and E01017187 are of average risk. All four have issues with lack of green space, although they have moderate canopy cover and are near to some large amounts of green space. In order of ranked least to most vulnerable: E01017187 and E01017185 have no other issues, E01017184 has issues with a low percentage of 16+ ages with qualifications impacting information accessibility and childhood obesity impacting physical adaptation to heat, and E01017186 has has issues with a low percentage of 16+ ages with qualifications and a high percentage of residents limited a lot by disability impacting physical adaptation to heat.

E01017188 and E01017181 are rank 18 and 4 respectively for inability to adapt to heat. The former has issues with rates of children in need which is an indicator of disparity, low percentage of 16+ ages with qualifications, low green space, high percentage of residents limited a lot by disability, and high rates of childhood obesity. The latter experiences low percentage of 16+ ages with qualifications, low green space, high percentage of residents limited a lot by disability and high numbers of residents reporting bad or very bad health, and 65+ ages social isolation.

E01017182 is rank 1 for inability to adapt to heat. There are high rates of adult social care which impacts spread of vital information, low percentage of 16+ ages with qualifications, low green space, high percentage of residents limited a lot by disability and high numbers of residents reporting bad or very bad health, and high all-ages and 65+ ages social isolation. This area is also noted to have a lesser amount of canopy cover than other areas of Coxford, increasing temperatures.

These assessments are partially agreed upon by the Heat England 2022 Socio-Spatial Heat Vulnerability Index, aligning in the call to aid E01017182, marking their heat vulnerability as extremely high. With E01017182 at rank 1 vulnerability in our analysis this is not agreed, but this does not take away from the message that an LSOA ranked once as extremely vulnerable and another time as most vulnerable should be aided with serious intervention. The relatively low vulnerability ranking of E01017180, E01017183, and E01017187 is agreed with the average vulnerability of all others also being agreed.

Recommendations for Coxford revolve around E01017181, E01017182, and E01017188, all of which are top 20% most deprived also. In these areas, education could be in need of investigation due to the low rates of qualifications upon graduation of secondary school. Increased funding for schools could lead to a better quality and a higher enthusiasm for education, and increase clubs, events, and volunteer networks

which may encourage higher levels of activity in the ward. Social isolation aid is also needed for ages 65+ and higher numbers of social events would also aid this.

8.3 Flood Risk Assessment

8.3.1 Problem Locations

Through Coxford runs Tanner's Brook, a large brook. While it is relatively well maintained, there are a few points of failure. Sandpiper Road is one of these, wherein a lack of drains at a low-point in elevation causes flooding. Land elevation is also evidently an issue in the eastern half of Lordswood, where a now urbanised dell that lead into Tanner's Brook gets regular issues with mud, leaves, and stones in the neighbourhoods drains. This issue is similar on Conifer Road, the dip where Palm Road and Coxford Drove intercept, and Willow Court. Otherwise, risk from Tanner's Brook and the wider flooding of Coxford is, as of now, not of concern.

8.3.2 Future Projections and Ward Recommendations

Primary concern for Coxford is the aforementioned residential areas wherein land elevation may be causing harm; east Lordswood, Conifer Road, and Willow Court. Eastern Lordswood is the E01017183 LSOA, which is of average to low risk of poor flooding management comparatively to the rest of Southampton (40% least vulnerable). Conifer Road is in E01017186, which is at high risk of poor flooding management (top 30% vulnerable), has high percentage of residents limited a lot by disability and high percentage of pupils with special educational needs, as well as low rate of qualification earning for 16+ ages and low green space. Willow Court is on E01017188 (top 20% vulnerable), which has the same important indices as E01017186 but also struggles with high rates of children in need and childhood obesity. These factors indicate it may benefit from education analysis recommended with the heat risk assessment as well as further recommendations from this assessment; due to shared flood and heat indices improvements in heat vulnerability may decrease flood vulnerability. With this being said, the more effective measure for flooding itself in this ward is prevention. This is because, in all cases here, the flooding sources are from urbanised dells lying on non-permeable areas, this is a singular and accountable source. Fixing the issues here will not eliminate the vulnerability to flood, but can eliminate the flood risk itself. Analysis into these areas may need to be conducted, as it is due to debris and the conclusion of 'more gullies' may not be appropriate.

Our analysis of Coxford is not agreed upon by the Flood England 2022 Socio-Spatial Vulnerability Index. In their analysis E01017182 once again places at extremely high vulnerability with all others (except E01017180 and E01017183 placing at relatively low) being average vulnerability. While E01017180 and E01017183 are the least vulnerable, E01017182 is not particularly vulnerable over others, being in the 3rd decile vulnerability with E01017181 and E01017186, as well as being second to E01017188 in the top 20% most vulnerable. Further, factoring in risk, those under threat have been mentioned to be E01017183, E01017186, and E01017188 with little to no risk shown in E01017182.

9 FREEMANTLE

9.1 Ward Profile

This ward contains LSOA neighbourhoods: the north of E01017189, a small tail on the west side of E01017190, the north and west of E01017191, E01017192, E01017193, E01017194 except from the north eastern tip, E01017195, E01017197 except from a small eastern portion, the south-east and north-eastern 'peninsula' of E01017211, E01017213, and E01017216 except from its western section. Where appropriate, LSOA data will be discussed.

Compared to the city average, the ward itself has a few indices that may make neighbourhood climate adaptation harder:

- Freemantle has good a A-C EPC rating percentage, but it's northern LSOAs struggle here. E01017192, E01017197, and E01017216 all have this percentage below 30%.
- Freemantle's social isolation index is generally not of concern. E01017193 is the only exception, at top 10% and 20% values for ages 65+ and all-ages respectively.
- Freemantle is a moderately deprived area. The entire ward with exception to the northern side is top 30% for deprivation index values, with E01017216 being top 20%. Its northern area is 5th decile, with E01017197 being 7th decile.

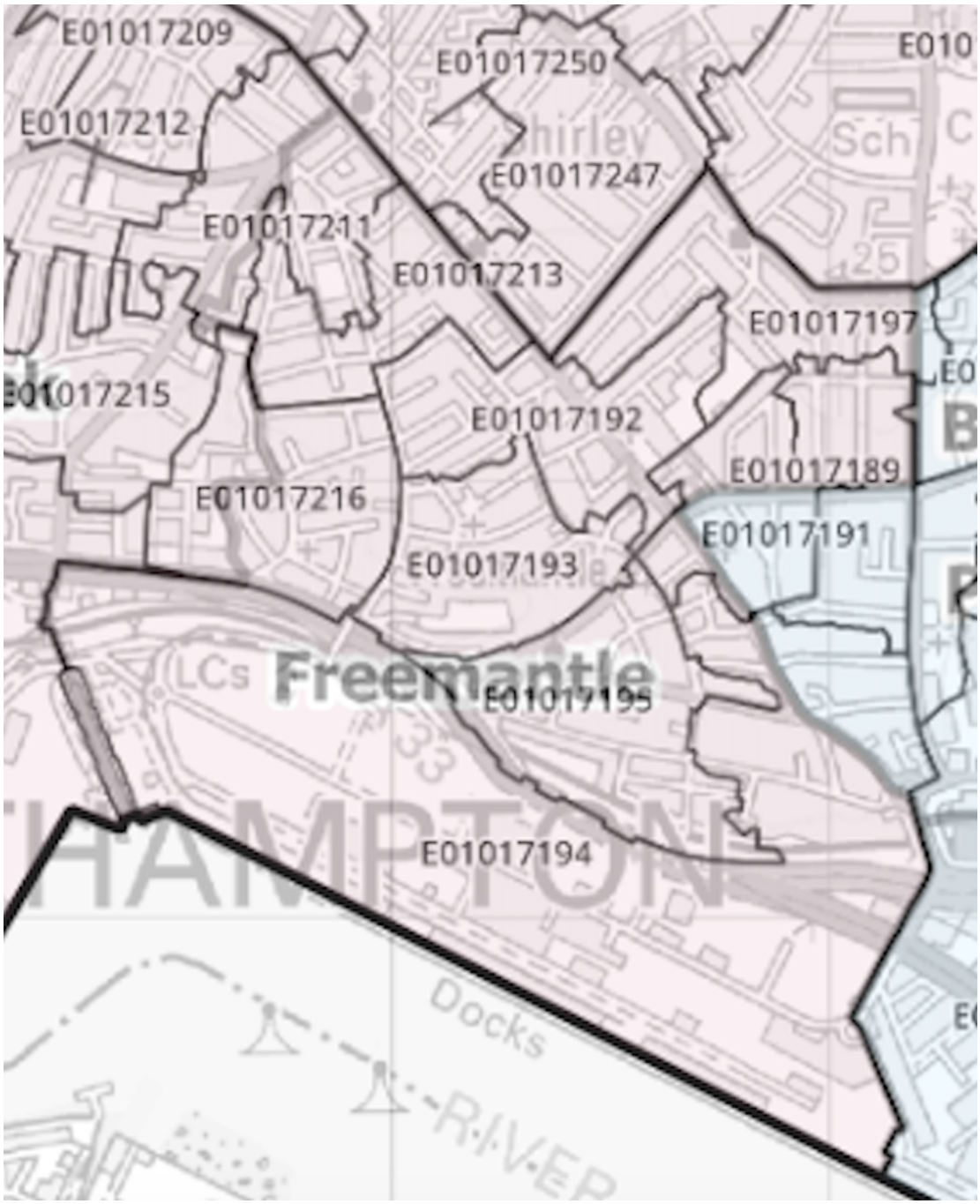

Figure 17. The LSOAs of Freemantle.

- In areas, Freemantle struggles with household English speaking rates. Both E01017191 and E01017194 are bottom 10% for English speaking households, with E01017192 shortly behind at bottom 20% and E01017193 and E01017216 bottom 30%.

- The rates of adults in social care is rising but in-line with averages. Rate of contacts with an outcome of Information, Advice and Guidance per 1k population aged 18+ is the only index that is statistically higher than the city norm, at 31.7 verses 27.9. This may be due to a rising drugs issue within Freemantle. Admission episodes with a primary diagnosis of poisoning by drug misuse, DSR per 100,000 population, all ages (5 years) is worse than other wards but falling (64.8 verses 40.9). Both 3 year pooled and 5 year pooled rates of admission episodes with a primary or secondary diagnosis of drug related mental and behavioural disorders, DSR per 100,000, all ages, is worse than other wards (3 year: 534.1 verses 272.6, 5 year: 470.3 verses 256.0), and rising alongside the rate of contacts with an outcome of Information, Advice and Guidance.

- Very low percentage of green space, 1.1% verses 13.4%, impacting the permeability of ground and natural clearance of flood water, as well as increasing urban heat island effect.

- High crime throughout Freemantle. Alcohol related, domestic abuse, theft, violent, and total crime are all statistically worse than average. Theft offences (46.0 verses 37.2 per 1k population) are notably the most important, as this is the only crime metric rising here, and may impact residents desire to trust their homes alone in event of a flood.

- Consistently high hospital admissions caused by unintentional and deliberate injuries in children and young people (aged 15 to 24 years) crude rate per 10,000 (3 year pooled: 193.9 verses 126.8, 5 year pooled: 195.1 verses 131.1). This could impact mobility in the ward.

9.2 Heat Risk Assessment

A large amount of Freemantle is of average vulnerability to heat. E01017197 is of little to no heat vulnerability, at 8th decile comparatively to the rest of Southampton. E01017190, E01017191, and E01017213 are shortly behind at 7th decile. E01017192, E01017193, and E01017195 are 6th, and E01017189, E01017194, and E01017216 are 5th. The poorest heat vulnerability in the ward is E01017211 in 4th decile, although it is primarily in Millbrook therefore will be discussed in the appropriate section. E01017189, E01017194, and E01017216 all have different issues. E01017189 has issues of high numbers of children in need and low rates of English speaking households; individual and well communicated support against heat is recommended for those in this LSOA. E01017194 has issues of low rates of English speaking households and high crime; providing a safe community here will decrease vulnerability as people may feel safer leaving their homes for support or an air conditioned location such as a cafe, community centre, or emergency cooling station. E01017216 has high rates of children in need and low rates of qualification earning for 16+ ages; supporting education equity including free meals for those who cannot afford it may be an important option.

Freemantle itself can utilise greening. Out of any ward it has the least amount of green space and is heavily built up. All of its LSOAs have less than the city average of green space and as it is also heavily built up urban heat island effect may be poor here. For this reason, the primary recommendation for Freemantle is mitigation of urban heat island effect and increased greening throughout the ward. Translation of council action would also be advised, as there are poor English speaking rates throughout the ward and communication is key when gaining support for policy.

The Heat England 2022 Socio-Spatial Heat Vulnerability Index for this ward is generally agreed upon. E01017197 is of relatively low vulnerability. E01017190 and E01017213 are of average vulnerability, which is agreed upon due to our analysis being comparative to Southampton rather than England which has a lower average vulnerability. E01017191 is at relatively high vulnerability in their rankings which is not agreed, especially as the higher ranked vulnerability LSOA E01017192 Heat England ranked as average vulnerability. Further, E01017216 was one of the higher ranked vulnerable wards at 50% most vulnerable. Comparatively to Southampton it is average vulnerability, but not compared to England like it is ranked in Heat England, as is similar vulnerability to relatively high rated LSOAs such as E01017189 and E01017194. Otherwise, E01017189, E01017193, E01017194, E01017195, and E01017211 being relatively high vulnerability is agreed.

9.3 Flood Risk Assessment

9.3.1 Preliminary Statements on the largest Freemantle Culverted Waterway

The Strategic Flood Risk Assessment for Southampton has shown flood risk running south, and then curving down to the west. This is because of a now urbanised dell, wherein there used to be a stream. Flood risk here is managed now utilising a culverted waterway, the largest in Freemantle. It is managed relatively well with little reports, but there are some areas wherein the land elevation causes higher levels of debris and sediment to be deposited.

Along Newlands Avenue this is particularly apparent, with regular flooding reports. Towards the south-west of the road, a report sheds some light on this area: *"it is an ongoing issue with this particular gully as all the leaf litter and other debris from the street naturally find their way down to this low spot"*. Another report here states: *"erosion of the edge of the road has left the edge of the road lower than the surface of the drain entry, so road water run-off gathers and pools at the road"*. Further up the road to the north-east, flooding occurs less but has occurred nonetheless. Multiple reports here shed light on a new issue residents throughout the city may be facing: *"(the gully being blocked) is preventing water coming off the roof from (my house) from draining away. Consequently, the water is sitting at the end of the guttering and is damaging the wall of my house"*. A separate report further up the road says: *"my living room wall got damp as the down drain from my neighbours house backed up"*. A lot of these reports also occurred in winter, running the risk of icy conditions in a uneven road with gradient changes. This area needs to be properly evaluated, as while there are moderate levels of vegetation this should not be a problem. Multiple reports have complained of sediment in the drains, one report stated overgrown weeds were in the drain, and one report stated the gullies were blocked for *"most of this year"*, therefore it is clearly a persisting issue for a reason that is currently unclear.

Norfolk Road, Western District Cut, Millbrook Road West, and Mountbatten Way (which is adjacent to a school) may also experience flooding due to a low-point in the road. Norfolk Road is not busy road. Western District Cut is busy periodically due to the school zone. Both may begin to affect residents like on Newlands Avenue in the future. Millbrook Road West and Mountbatten Way generally have heavy traffic flow, but this will most likely not affect residents, rather an economic effect due to it being a popular route for lorries to get onto West Quay Road to go to the docks, an area which has also had problems as described in section 4.3.8.

9.3.2 Charlton-Malmesbury Road junction

On this road, there is simply one drain. The corners of the junction are all sunken compared to the middle, and only one drain exists in the western corner. More gullies may be required.

9.3.3 The Gables

The Gables and surrounding areas are projected by the Strategic Flood Risk Assessment to experience major surface water flooding. This may be the case as at it's lowest elevation drops to approximately 2.5 meters above sea level, therefore although it has no flood reports it may in the future, as far lower than most surrounding areas.

On Blightmont Avenue, there have been flooding reports, regularly and lately. This is most likely due to a pipe blockage as there is no history of reports until 2022 and it is reported *"all of the drains are blocked along (Blightmont Avenue)"* and *"there are two blocked drains at the corner of Blighmont Avenue and Waterhouse Lane. The water comes down the hill bypasses the two blocked drains on water house lane and floods Blighmont Avenue"*. This needs to be looked into, as one resident has reported multiple instances of their backyard flooding; this can cause long term damage.

9.3.4 Millbrook Road East

This area has an issue with land elevation, as well as overwhelmed drains along a debris heavy road due to heavy traffic. These issues are highlighted in both the Strategic Flood Risk Assessment as well as flood reports in the area giving more insight into issues here. It has already affected residents heavily, with separate reports of flooded basements and water up to residents doorsteps. Similar issues are seen north on Waterloo Road and Shirley Road.

9.3.5 Future Projections and Ward Recommendations

Areas of highest risk include Newlands Avenue (E01017197), Millbrook Road East (E01017195), and The Gables (E01017216). E01017197 has a low likelihood of being ill prepared for flooding events. It is top 80% in the city, and is better than average for all metrics except from green space. Green space may

not aid this hyper-localised case of recurrent flooding, therefore would be of benefit rather to investigate problems faced. E01017195 has very low green space, at 0% although has plenty of vegetation cover along Millbrook Road East. It is not an area of deprivation, but houses are becoming damaged due to flooding and therefore investigation into this issue and regular gully clearing may be of value.

E01017216 is 4th decile ranked for flood vulnerability. The SFRA projects 1 in 30 surface water flooding for the area including the Solent Business Centre, which already has ample green space and no reports, therefore as long as it is maintained and Blightmont Avenue has their gully blockage fixed surface flooding may not be an issue. An entirely separate issue however is fluvial flooding. Climate Central (2025) using tidal modelling and IPCC Sixth Assessment Report (Arias et al., 2021) project the industrial southern coast of Freemantle to be underwater, with southern E01017216 to also be. A strategy to deal with this issue needs to be formulated and assessed.

The assessment is shared with the Flood England 2022 Socio-Spatial Vulnerability Index. This index places Freemantle primarily at relatively high vulnerability and while its vulnerability assessed here is average comparatively to Southampton, Southampton as a whole is higher vulnerability compared to the England average. Further, the possible risk to southern Freemantle from fluvial flooding may place a higher priority for this ward.

10 HAREFIELD

10.1 Ward Profile

This ward contains LSOA neighbourhoods: E01017198, E01017199, E01017200, the south of E01017201, E01017202, E01017203, E01017204, E01017205, and E01017206. Where appropriate, LSOA data will be discussed.

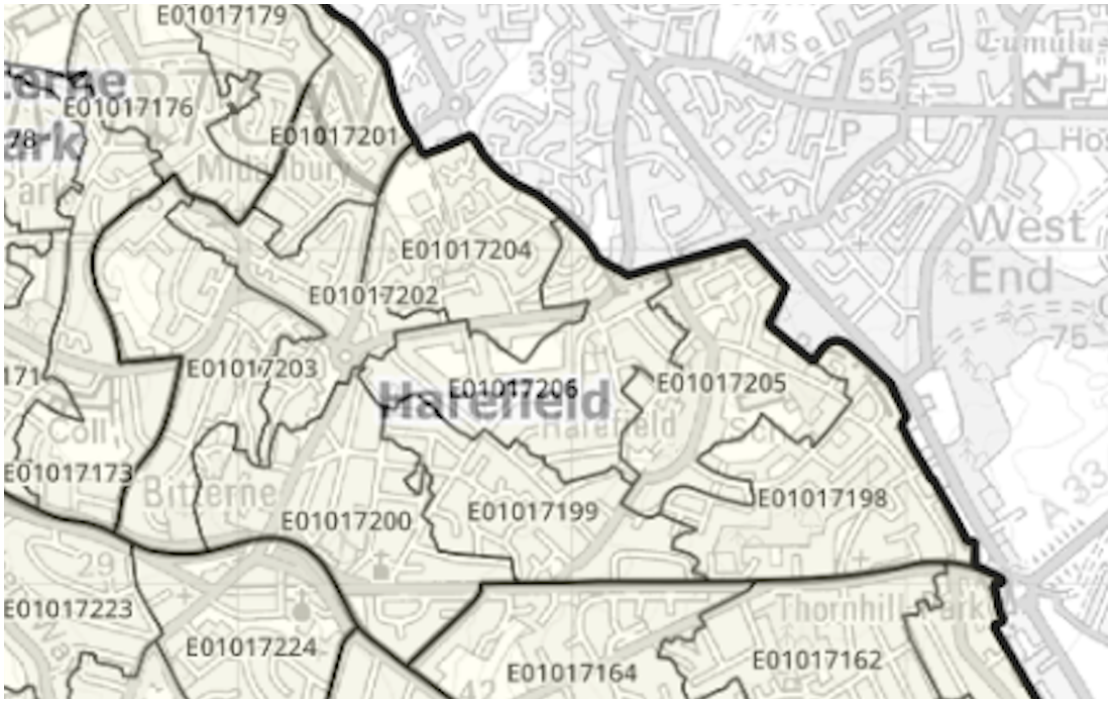

Figure 18. The LSOAs of Harefield.

Compared to the city average, the ward itself has a few indices that may make neighbourhood climate adaptation harder:

- There is a clear gradient running west to east for worsening EPC ratings. This is at a minimum for the western-most LSOAs: E01017202 and E01017203, at 25.4% and 21.8% respectively.
- With deprivation, Harefield has a high rate of Children In Need (747.8 verses 628.1 per 10k 0-17 population). The issue may start with E01017205 at top 10% most deprived, bordered by 4th decile LSOAs. Further, both E01017201 and E01017202 are 2nd decile for deprivation.

- Harefield has poor a social isolation index, primarily for all-ages. E01017198 and E01017199 both have top 10% social isolation scores, with E01017200, E01017201, and E01017202 being of 2nd decile. E01017198, E01017200, and E01017205 also sit at 3rd decile for 65+ ages, and should not be overlooked.

- Harefield is rank 2 in the city for ages 65+ population 19.6% verses 14.3%, projected to increase. This may explain the heightened rate of contacts with an outcome of Information, Advice and Guidance (34.4 verses 27.9 per 1k population aged 18+) and new care request contacts where one of the three outcomes was Care Act Assessment Required (14.7 verses 11.9 per 1k population aged 18+). There is also a high percentage of population reporting bad or very bad health (5.7% verses 5.0%) and residents limited a lot by disability (8.2% verses 7.1%). These suggest at an at-risk mobility throughout the ward, as well as a lesser ability to deal with heat extremes.

- Harefield has a significantly worse rate of non-persistent school absence and suspension rate across the board, possibly impacting quality of education. A high percentage of residents aged 16 and over with no qualifications (20.1% verses 17.3%) and a low percentage of residents aged 16 years and over with level 4 qualifications or above (24.1% verses 31.6%) impacts the accessibility of weather extreme information provided by the council.

- Very low percentage of green space, 3.2% verses 13.4%, impacting the permeability of ground and natural clearance of flood water, as well as increasing urban heat island effect.

- Harefield has a high but falling percentage of resident population aged under 16 years (18.6% verses 17.3%). With a heightened rate of hospital admissions caused by unintentional and deliberate injuries in children (aged 0 to 14 years) crude rate per 10,000 (3 year pooled: 129.4 verses 94.9, 5 year pooled: 122.6 verses 81.0), this may impact youth mobility in time of flood or storm. This risk appears to be falling, though should still be of concern.

10.2 Heat Risk Assessment

Expanding green space and canopy cover in Harefield may also be of use to decrease urban heat island effect. All LSOAs in Harefield are below average for green space in Southampton, and 5 out of 9 LSOAs are on or below 1% green space.

Particularly poor areas for heat preparedness in Harefield are E01017201, E01017202, and E01017205, all three of these being top 40% values for heat vulnerability. E01017202 is rank 22, with E01017201 and E01017205 following shortly after at 27 and 28 respectively. Across the board this ward has lower green space than average, and the three mentioned LSOAs all have higher than average percentage of residents limited a lot by disability. E01017202 has particular issues in children in need. E01017201 has low rates of 16+ ages with qualifications. All three LSOAs have above average deprivation, but E01017205 has a very high deprivation index, previously mentioned to be top 10% in England for multiple deprivation. Information and community is very important here. Encouragement of clubs, events, and volunteer networks will aid in the spread of information and make those who have issues with mobility known to the wider community such that intercommunity aid can be given. Further, during extreme heat very accessible emergency cooling stations can be utilised in this ward in and around these three key LSOAs. E01017201, E01017202, and E01017205 may also be polled to evaluate their houses for heat vulnerability on a resident-to-resident basis. Due to high deprivation support could well used here, especially for E01017205 due to its statistically significant worse multiple deprivation index.

Other LSOAs are 5th decile or above, with 5th decile LSOAs including E01017198 and E01017199. For this reason, the Heat England 2022 Socio-Spatial Heat Vulnerability Index is agreed upon, ranking E01017202 as extremely high vulnerability and E01017198, E01017199, E01017201, and E01017205 as relatively high vulnerability. Otherwise, LSOAs are at average vulnerability, which is agreed.

10.3 Flood Risk Assessment

10.3.1 Exford Avenue

Leaves, litter, and sediment regularly block drains on Exford Avenue. This issue is worth looking at, but due to the elevation of houses and the downward slope of the road, this may not cause an issue for houses around it in a flooding event. A recommendation here is to re-evaluate the location of drains as most are near heavy vegetation which causes blockages, as well as investigating reported pipe leakages which may

be causing more flooding. This zone of flooding may be related to land elevation from an old watercourse connected to Jurds Lake.

10.3.2 Jurds Lake

Jurds Lake is a culverted watercourse that runs in part through Harefield. Land elevation tells us that part of Jurds Lake used to run east and upwards, along Cheriton Avenue. Green space around this area is ample and seems to have been planned well, meaning little flood reports have been identified.

Jurds Lake has particular problems at a now urbanised flat, where the Somerset Avenue - Bitterne Road East junction lies. One report stated flooding here became so bad in 2015 that the water level reached a residents car and had to be written off, multiple others stated damage to cars. Another indicated water coming into their garden up from a gulley, and multiple more residents have said water has entered their garden through other means. This may be an issue of debris, but reports seem to occur all year round, primarily in early-mid winter. This may also be an issue of high pressure during heavy rain. Investigation into this issue is required.

10.3.3 Mousehole Lane

This neighbourhood has had problems for the last 10 years with flooding. A row of houses is at the bottom of a large dip in land elevation, with steeply elevated land around it. As well as this, the only supporting drain is in-between two dropped curbs, pooling water and in residents semi-permeable driveways here rather than where drainage needs to happen. This can, at times, be a result of gullies in allotments around this dip blocking. One resident has reported flooding during a storm as to be as high as 3 foot. Basements have also seen flooding as reported. This road, which sees moderate traffic, should be investigated further.

10.3.4 Thornhill Park Road

Pine Drive has a very high level of canopy cover, possibly causing debris to flow down the surface water sewers and road, causing a blockage where Pine Drive intersects with Thornhill Park Road. This needs to be investigated as while there have been little reports of flooding where the majority of the canopy cover is, further down the road there are many. This has affected residents with one reporting a flooded garage.

Similarly, due to high canopy cover, Thornhill Park Road floods further down near its junction with Hinkler Road. This also happens to be where a dip in land elevation originates. Just north, Woodland Close also experiences this with a similar stagnation in elevation and high canopy cover. Both areas have flooded with reports of flooded front gardens and up to 2 foot of water making its way into back gardens. This can damage residencies.

10.3.5 Future Projections and Ward Recommendations

The neighbourhoods on Thornhill Park Road and Woodland Close both of LSOA E01017198 (4th decile vulnerability) have flooding which is becoming an issue, will become worse over time, and may end up causing permanent damage. According to the wider LSOA data, this area has an issue with childhood school pupil obesity, although primary concern is permanent house damage which may lead to increased household costs for repairs and detrimental health effects therefore does not pose a concern. On the other hand, non-significant but higher than average rates of residents limited a lot by disability and bad health reports may show that here flooding can be more of a challenge for the neighbourhood to clear. For this reason elimination of risk is the primary focus for this neighbourhood, therefore as previously stated a recommendation into causation may be required.

Somerset Ave - Bitterne Road East junction lies within LSOA E01017199 (5th decile vulnerability) and has issues impacting quality of life now for residents, including property and land damage. This is a problem due to heightened vulnerability in key indices: non-significant but worse than average percentage of residents limited a lot by disability, health reports, and all-age social isolation can make it harder for those who live here to clear the flooding, and if left to stagnate until natural clearance it may become a health hazard. It is recommended this situation is also investigated to find the source of the recurring issue, although it is more than likely due to low-points in both roads comparatively to the rest of the roadway.

Mousehole Lane of LSOA is primarily within E01017203, although it leads north into LSOA E01017202. An issue presents itself here as both LSOAs are highly different in vulnerability, with E01017202 being 2th decile and E01017203 being 6th. As Mousehole Lane is around the centre of E01017203 I am more inclined to utilise the values for E01017203 rather than E01017202, but as both have wildly different values it is truly hard to know the distribution of data points without collecting data in the future at a higher resolution than LSOA. E01017203 has little issues that would make it ill-prepared

for flooding. It does have a high rate of special educational needs pupils and this may pose a serious vulnerability as flooding has been reported to be as high as 3 foot, and any evacuation may be made harder as it increases parental responsibility due to higher child needs. A recommendation that would be most appropriate is an expansion into higher drainage capacity, but an on-the-ground investigation is recommended before work is done.

Although risk to residents is low, Exford Avenue in LSOA E01017205 has a high vulnerability. With impacts to mobility including a high percentage of residents limited a lot by disability and pupils of special educational needs, the highly downhill slope of Exford Avenue if iced over due to a flood in winter could cause slips or bad falls. This would be of detriment to health and exacerbate vulnerability. Drainage must be investigated here. My recommendations include moving gullies away from high canopy cover, and perhaps even a winding pathway with railings. This can go down the green space next to Exford Avenue to lower the risk of ice on at least one walkway and even increase disability accessibility. This must not take up too much of the green space though, and would need to be explained with signage to residents as it may be hard at first sight for most residents to understand.

Flood vulnerability is generally agreed upon by the Flood England 2022 Socio-Spatial Vulnerability Index. Our most vulnerable areas are LSOAs: E01017202 (2nd decile vulnerability), E01017205 (3rd decile), E01017201 (4th), E01017198 (4th), E01017199 (5th) and E01017200 (5th). On the Flood England index, all but E01017200 (average) sit at relatively high vulnerability, with E01017200 being agreed upon average as it is the least vulnerable of the 7 LSOAs. All other LSOAs are average vulnerable, which is agreed with. Our analysis places E01017205 and especially E01017202 as higher vulnerability, therefore their rating of relatively high is not corroborated.

11 MILLBROOK

11.1 Ward Profile

This ward contains LSOA neighbourhoods: E01017207, E01017208, E01017209, E01017210, E01017211 except from the south-east and north-eastern 'peninsula', E01017212, E01017214, E01017215, the west of E01017216, E01017237 except from the south and west, the south of E01017238, and the south-east of E01017245. Where appropriate, LSOA data will be discussed.

Compared to the city average, the ward itself has a few indices that may make neighbourhood climate adaptation harder:

- All EPC ratings in Millbrook are above 30% except from E01017209, at 21.6%. Further, E01017214 and E01017215 are the only two below 40%, at 31.0% and 39.3% respectively.
- Millbrook has low disparity, but LSOAs adjacent to Freemantle and Redbridge suffer from heightened disparity. E01017207, E01017208, E01017210, and E01017237 are all top 10% most deprived, with E01017216 and E01017238 in the 2nd decile.
- E01017211 is consistently poor rated for social isolation index, at top 10% most isolated for both 65+ and all-ages. E01017208 and E01017237 also are at 2nd decile for 65+ social isolation and E01017208 and E01017210 are at 3rd decile for all-ages social isolation.
- Very low percentage of green space, 5.4% verses 13.4%, impacting the permeability of ground and natural clearance of flood water, as well as increasing urban heat island effect.
- High percentage of residents aged 16 and over with no qualifications (22.3% verses 17.3%) and low percentage of residents aged 16 years and over with level 4 qualifications or above (25.4% verses 31.6%) both limit the accessibility and reach of vital post, present, and future strategy for dealing with extreme weather events. E01017212 is in the bottom 20% for English speaking households, and may also struggle with this issue.
- Millbrook has a high and consistent rate of people with a current Adult Social Care service (16.7 verses 12.3 per 1k population aged 18+), high rate of Children Looked After (88.9 verses 63.9 per 10k 0-17 population), high rate of Children on Child Protection Plans (151.0 verses 101.0 per 10k 0-17 population), and high domestic abuse (22.6 verses 18.7 per 1k population. These factors may make the distribution of weather extreme information a struggle.

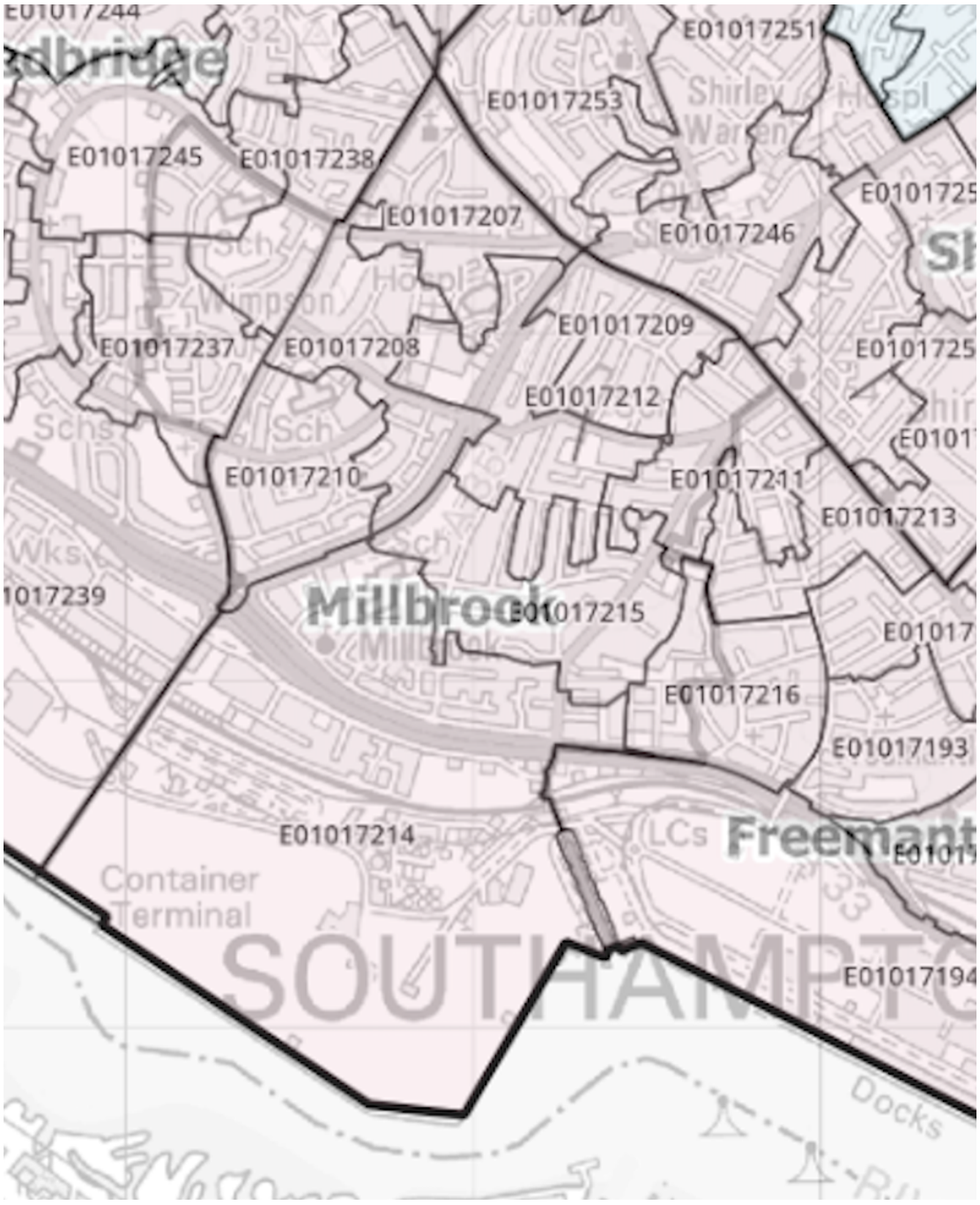

Figure 19. The LSOAs of Millbrook.

- High percentage of resident population aged 65 and over (15.5% verses 14.3%), reporting bad or very bad health (5.7% verses 5.0%), and limited a lot by disability (7.9% verses 7.1%) may limit population mobility.
- High rates of theft offences (50.6 verses 37.2 per 1k population) may cause unwillingness among a community to evacuate during a dangerous weather event in fear of burglary when absent.
- High percentages of lone parent families with dependent children (9.8% verses 7.2%), as well as a high percentage of population under 16 (20.8% verses 17.3% may limit ability to be efficiently prepare and evacuate during a flood.

11.2 Heat Risk Assessment

Both E01017238 and E01017245 primarily have residencies within Redbridge ward therefore will be discussed in the heat risk assessment for Redbridge.

E01017209, E01017212, E01017214, and E01017215 are all within the top 40% least vulnerable and have no apparent issues with ill-preparedness for heat. E01017216 is within the 50% most vulnerable, primarily due to a high but not statistically significant multiple deprivation index. There are also issues with high rates of children in need and low rates of qualifications earning for ages 16+.

E01017208, E01017211, and E01017237 all have a 4th decile vulnerability. All three of these LSOAs have a low qualification rate for 16+ ages. Alongside this, E01017211 has a high rate of adults in social care as well as poor 65+ ages and all-ages social isolation, and E01017208 social isolation has poor 65+ social isolation. These are all things that could impact information spread and accessibility. All three LSOAs could benefit from social events, clubs, and volunteer networks with an emphasis on accessibility due to a higher rate than average of those limited a lot by disability; significantly higher for E01017211 and E01017237. This allows not only a lower level of isolation here, but also with accessibility advertised will attract more of those limited by disability to participate as it eliminates fears of not being able to get there easily. This allows the wider community to be aware of those who are limited by disability so they don't suffer alone or aren't trapped in their homes during a phase of extreme heat. This can also aid those reporting bad and very bad health, and increase the percentage of children that are a healthy weight, an issue highlighted by the data for E01017237. E01017211 and E01017237 can also benefit from an increased amount of vegetation and canopy cover throughout smaller residential roads. Inquiries into the state of housing and their heat vulnerability can also help in E01017208 and E01017237. Whereas E01017211 has a better than average multiple deprivation index, E01017208 has a worse than average deprivation and E01017237 has a significantly worse than average deprivation. Both also having a higher rate of children in need, with E01017208 having the highest of the three.

E01017210 has a 3rd decile vulnerability and is rank 14 in the city, with high rates of children in need and a high multiple deprivation index. This LSOA could use serious support with making residencies more liveable in extreme heat, especially considering a significantly high percentage of residents report bad or very bad health, are limited a lot by disability, and are (children only) not at a healthy weight. The highest priority for this ward in terms of heat, E01017207 (2nd decile, top 20% vulnerable, rank 3 most vulnerable), has very similar issues to E01017210. This is in addition to significantly high rates of adults in social care, and a higher multiple deprivation index. Further, with a low qualification rate for 16+ ages in both LSOAs E01017207 and E01017210, both LSOAs could benefit from inclusion into social community events and clubs.

With E01017207, E01017208, E01017210, and E01017237 all along the west of Millbrook ward, my prime recommendation for this ward is immediate enquiry into increasing heat extreme proofing in residencies throughout. Due to high deprivation in the area, residents may not be able to do this independently and may have nowhere to go otherwise to survive heat in good health. Alongside this, emergency cooling stations can be provided to west Millbrook using community centres, which can also aid isolation mitigation.

The ranking of the Heat England 2022 Socio-Spatial Heat Vulnerability Index is agreed upon in Millbrook ward. It identifies E01017207, E01017208, E01017210, E01017211, and E01017237 all as relatively vulnerable areas, also placing E01017207 at extremely high vulnerability, which was also our most vulnerable LSOA within Millbrook. With exception to E01017215 at relatively low vulnerability, all other LSOAs are average vulnerability, which we agree upon. E01017215 was also our lowest vulnerability in Millbrook ward.

11.3 Flood Risk Assessment

11.3.1 Redbridge Fire Station

An urgent issue with a gulley is seen on Redbrige Hill by Redbridge Fire Station. Over the years, its blockages have coated the slightly dropped in elevation office and muster bay floor of the fire station with 2 inches of water, wherein vital fire kit and appliances are kept. A solution to this could be drains on the outside drive of the fire station, as any affected equipment could at best cost money, at worst cost lives.

11.3.2 Regents Park Road

Due to severe road elevation, the junction between Clifton Road and Regents Park Road regularly floods. This seems to be due to inadequate drainage and a severely raised road, pushing water and debris from vegetation towards one drain. This flooding has seemingly not affected any residencies yet, but the houses on one side of the road are lower than the road and may be affected in the future. This also seems to be on a culverted watercourse, which may affect this with high pressure drains that are already overloaded with water.

11.3.3 Tanner's Brook

Through Millbrook ward flows Tanner's Brook, just joined to the north by Holly Brook. This waterway is well managed, but issues can be seen when the waterway is culverted. For example, Oakley Road experiences high amounts of flooding due to blockages when Tanner's Brook runs underneath the road. This limiting choke-point can cause issues during high rains and has been reported to flow through into backyards of residents and worryingly close to the threshold of houses. Similar flooding occurs further down the road, causing flooding on Percy Road, Creighton Road, and Millbrook Road West. All may be due to tide locked drains caused by a low-point, with the Millbrook Road West situation being exacerbated by sediment deposits on the busy road.

11.3.4 Future Projections and Ward Recommendations

The issue at Redbridge Fire Station is not related to its LSOA as is a place of work and more of a matter of fire safety throughout its catchment area. It is recommended this is investigated immediately.

The Regents Park Road - Clifton Road junction is in LSOA E01017211, and if this area floods property in the future this may be particularly hazardous to residents due to a high percentage of residents limited a lot by disability and high social isolation for both all-ages and 65+ ages. If a residents property floods the fear is that they cannot clear it themselves and would have no-one to go to. This is also the case for Oakley Road, which is within LSOA E01017208, with high percentage of pupils with special educational needs and high 65+ social isolation. For the former (Regents Park Road - Clifton Road junction) this is a single source issue that can be solved with road levelling intervention. For the latter (Oakley Road) it is harder, as it is a water capacity issue and underneath houses the culvert cannot be widened. For this reason it is recommended to terrace the waterway through Land East of Tebourba Way, so the water flow can be slowed down Tanner's Brook and alleviate stress on the culvert underneath Oakley Road. This would also reduce flow down through Percy Road (E01017209 and E01017212) and Creighton Road (E01017214), although these residencies have a low vulnerability.

The Flood England 2022 Socio-Spatial Vulnerability Index generally agreed upon. The most vulnerable according to the Flood England index is E01017207 which is disagreed; we place E01017210 as the most vulnerable within the top 8th of vulnerable areas. Overall, the Flood England index shows the more than average vulnerabilities in E01017207, E01017208, E01017210, E01017211, E01017216, E01017237, E01017238, and E01017245. This is agreed as all of these are 2nd, 3rd and 4th decile vulnerable areas. E01017209, E01017212, and E01017214 are all agreed average vulnerability at 6th, 6th, and 7th decile respectively. The Flood England index displays E01017215 as relatively low risk, corroborated by us as is within the top 30% least vulnerable areas.

12 PEARTREE

12.1 Ward Profile

This ward contains LSOA neighbourhoods: E01017217, E01017218, E01017219, E01017220, E01017221, E01017222, E01017223, E01017224, E01017225, a northern portion of E01017273, the northern tip of E01017275, and the north-west and north-east tips of E01017276. Where appropriate, LSOA data will be discussed.

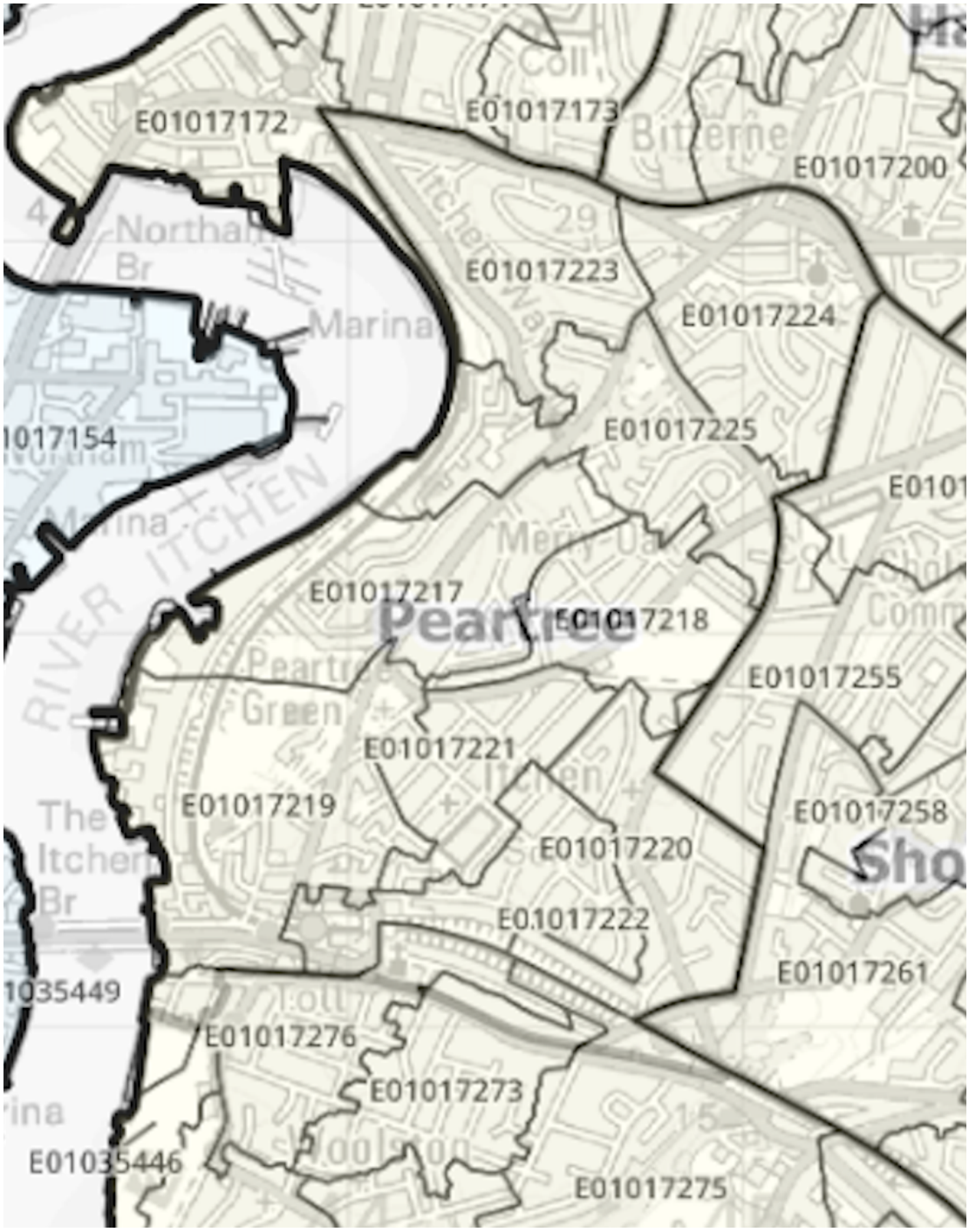

Figure 20. The LSOAs of Peartree.

Compared to the city average, the ward itself has a few indices that may make neighbourhood climate adaptation harder:

- There is a noticable gradient of A-C EPC ratings, with the most A-C ratings being around the southern half of the ward. The four LSOAs along the southern border have an EPC (A-C)% of 39.1%, while the two LSOAs along the northern border are at just 20.1%, the worst in the ward being one of these two, E01017224, at 19.3%.
- Peartree has a moderate but widespread disparity with no clear pattern. E01017218 and E01017219 are both top 20% most deprived, and E01017220 and E01017225 are both 3rd decile. The surrounding E01017217 and E01017222 are both 4th decile.
- In areas, Peartree has a high social isolation (all-ages). E01017219 is of the top 10% most isolated, with E01017217 and E01017220 close behind at top 20%.
- All indices of safeguarding for 18+ year olds in Peartree are higher than average, with rate of contacts with an outcome of Information, Advice and Guidance (36.9 verses 27.9 per 1k population), rate of people with a current Adult Social Care service (17.8 verses 12.3 per 1k population), rate of Safeguarding concerns (8.4 verses 4.9 per 1k population), and rate of Section 42 enquiries (4.3 verses 2.2 per 1k population) being statistically significantly higher. All of these are rank 1 in Southampton for their metrics, with exception to adult social care, which is rank 2. It is not immediately clear why Peartree faces these issues but may affect distribution of vital information and outreach.
- There is a statistically worse percentage of residents aged 16 years and over with level 4 qualifications or above than other wards (27.1% verses 31.6%). This may be an ongoing issue with quality of education after primary school, with absence taking a sharp fall from being significantly better in primary to significantly worse than city average in secondary (10.7% verses 10.3%).
- Very low percentage of green space, 6.7% verses 13.4%, impacting the permeability of ground and natural clearance of flood water, as well as increasing urban heat island effect.
- There are a number of health concerns that may impact mobility of Peartree ward. In emergency hospital admissions due to falls in people aged 65 and over DSR per 100,000 (3 year pooled: 3397.4 verses 2738.1, 5 year pooled: 3610.9 verses 2886.0) Peartree is ranked first in the city for the 3 year pooled values, and second for the 5 year pooled values. Hospital admissions caused by unintentional and deliberate injuries in children and young people (aged 15 to 24 years) crude rate per 10,000 (5 year pooled: 172.3 verses 131.1) are far worse than average city levels too. 5 year male (77.0 verses 78.8) and female (81.1 verses 83.1) life expectancy is also lower, as well as mortality rate from all causes, all ages (persons) DSR per 100,00 persons (3 year pooled: 1140.2 verses 944.1, 5 year pooled: 1220.1 verses 960.6). With all things considered, those limited a lot by disability and reports of bad health are both in line with average rates for the city, therefore is harder to communicate a recommendation.

12.2 Heat Risk Assessment

E01017273, E01017275, and E01017276 are in Woolston for the vast majority, therefore will be reported on in the appropriate section.

Peartree has a low heat vulnerability. E01017221, E01017222, E01017223, and E01017224 are all among the 30% least vulnerable. In the centre, E01017217, E01017218, and E01017225, as well as the south-eastern E01017220, are all within the 50% most vulnerable. These central LSOAs, although in close proximity, they have very separate issues. E01017218 is within the top 20% most deprived, and has some health issues, with above average rates of bad health reports, residents limited a lot by disability, and childhood obesity. E01017217 has issues with high rates of residents limited a lot by disability and adults under social care. E01017225 has high rates of adults in social care. This indicates a within the wards centre an issue with mobility. This can be aided via community action, making sure those who are of decreased mobility have what they need to survive the heat in good health, and making sure the council can provide and that they have someone to go to. This can cover those vulnerable due to the prevalence of adult social care. Particularly, E01017218 needs support due to its higher deprivation.

E01017219 is within the top 30% most vulnerable. It has a moderately high deprivation and a high rate of children in need. It also has issues that may affect mobility such as high reports of bad and very bad health, high rates of residents limited a lot by disability, and high percentage of pupils that are not a healthy weight. All-age social isolation is also high, with a worse than average rate of 16+ ages qualification earning. To be able to aid those of poor mobility and promote the spread of information, community programmes such as clubs, events, and volunteer networks are also recommended here. Along the coast of Peartree ward central and south, emergency cooling stations may also be appropriate.

Values of heat risk were relatively similar to the Heat England 2022 Socio-Spatial Heat Vulnerability Index. Their most vulnerable area by a large margin was E01017219, shared by our ranking. Their second most vulnerable Peartree LSOA was E01017220; for our ranking E01017218 was more vulnerable, but this was by a slim margin. Otherwise, values were agreed upon, with E01017223 relatively low vulnerability and average vulnerability otherwise.

12.3 Flood Risk Assessment

12.3.1 Culverted Watercourse

There exists a culverted watercourse where a brook used to run, down the length of Peartree from the north to south. The issue with this is that without re-levelling the land it may cause issue on places of non-permeable surface without proper drainage. This can be seen throughout the ward, with higher flood reports around areas of lower elevation comparatively to sparse reports in higher elevation areas. As for this watercourse, it is particularly poor in the Edwina Close - Spring Road junction, where ground floors of residencies have been flooded requiring specialist cleaning. Debris has said to be a cause of flooding here, but it may also be due to higher pressure and water overflows during times of heavy rain. Other roads experience this too, such as Bridge Road which has a low-point at it's southern side, and Blackthorn Road cul-de-sac where houses have taken water damage.

12.3.2 Fluvial Flood Risk

Being coastal to the River Itchen, Peartree has a risk of fluvial flooding. This encompasses the coastal industrial and business estate west of Peartree Green, but does not pass through the railway line, which in itself can act as a flood defence for residential areas beyond, as is on a bank and is raised, on-top of a large brick wall. In the far future, reinforcing this rail line against flooding could be an option to protect Peartree's residencies. The industrial estate and business park itself may need fluvial flood defences but this is not a priority as it is non-residential. However, south of this estate there is a small collection of houses that may need aid against fluvial flooding. This will become worse in the next few years as they already experience surface water flooding, possibly due to tidal locking washing water back up the drain.

12.3.3 Gainsford Road

This road is subject to flooding. It is most likely not tide locking, as there is a very low road next to it, Ashburnham Close, which is connected to the same sewer system and leads into the River Itchen. This may be due to inadequate drainage and requires investigation as the water is causing damage to residents houses, with threats of legal action.

Further down the road is Bryanston Road, a cul-de-sac wherein the drains cannot cope with the volume of water during torrential rain. This requires looking into.

12.3.4 Pinegrove Road and Spring Road

A brook ran from where Itchen College is now into Jurds Lake from the west. This now has left behind a lower land elevation in this region. This causes a high flood risk in the area, felt on Spring Road just south of the Wodehouse Road junction and Pinegrove Road north of its junction with Spring Road. Both of these cases may be related to eachother. They could be due to overwhelmed drainage, but for their frequency indicate an underlying problem that requires investigation.

12.3.5 Portsmouth Road

The Portsmouth Road - Fort Road junction experiences recurring flooding with a large number of reports in the last 10 years. Portsmouth Road is a heavy traffic road, while Fort Road has a school on it, another hot-spot. This may cause the junction to experience heavy sediment and debris deposit. One report also has stated that this may be due to the surface water sewer being lower capacity than required to drain the amount of water, which may be accurate as this intersection sits at the bottom of 3 higher road, although

Portsmouth Road running west is lower than this intersection. These reasons do not fully explain the sheer number of reports therefore should be looked into further.

Further west is Portsmouth Road's intersection with Manor Road South, which flooding is reported on and is projected as risk to flooding by the SFRA report. This may be due to the lower land elevation on a busy road causing high deposits of natural debris and sediment. Works have been done here prior, but have reportedly not been successful in stopping surface water flooding, therefore needs to be investigated.

12.3.6 Future Projections and Ward Recommendations

Gainsford Road and Bryanston Road are both within LSOA E01017217 (top 50% vulnerable). While comparatively this area has slightly better deprivation than other areas in Southampton, it also has worse than average adults in social care, pupils of special educational needs, residents limited a lot by disability, and all-age social isolation. Drainage here requires investigation and improvement due to a threat to residents wellbeing.

Bridge Road is in LSOA E01017219, which is top quartile most vulnerable to flooding. A high amount of residents report being limited a lot due to disability and bad or very bad health. There is also a low percentage of children within the LSOA that are a healthy weight, a high percentage of children in need, and high all-ages social isolation. Activity clubs that are accessible would aid this LSOA, providing a place for children to get activity, adults to get information, and reduce isolation in the future.

Due to rising sea levels, while it is not projected for E01017217 and E01017219 to experience fluvial flooding, some areas may experience high drainage pressures due to tide locking in drains, preventing effective drainage. For these issues, capacity can be increased as well as providing flood defences to houses in vulnerable areas along the Peartree coast. Due to high numbers of residents limited a lot by disability, these residency defences must be accessible for residents.

Pinegrove Road and Spring Road in LSOA E01017220 both have threat of damage to housing. This LSOA is top 50% most vulnerable to flooding, but there is no singular issue that is exacerbating vulnerability. For this reason, recommendation is made to investigate the recurrent issue which is most likely a small drain capacity.

In LSOA E01017224 and E01017225 issues are felt from the flooding, with ground floors requiring specialist cleaning. These two areas do not have common issues therefore it is hard to make recommendations for decreasing vulnerability here. For this reason, I recommend aiding residents with the clean-up of flooding that has happened due to surface water clearance failures, as well as an investigation into how this can be eliminated in the future. This may most likely include increasing of drainage capacity. Also in E01017225 is Blackthorn Road, wherein houses have taken water damage. With higher than average rates of adults in social care, residents limited a lot by disability, and reports of bad or very bad health, as well as a 3rd decile deprivation, drainage must be improved.

Issues on Portsmouth road in LSOA E01017273 and E01017276 require investigation. It is more than likely an issue with it being a busy road and the deposits of sediment in areas where elevation on the road changes, therefore levelling the descent of the roadway to a constant downward gradient westward and improved drainage may aid this issue. Decreasing vulnerability is not a priority as E01017273 is within the 7th decile and E01017276 is in the 5th decile, and neither LSOAs have particular vulnerabilities that can be addressed commonly with one another.

Alike the heat risk assessment, the Flood England 2022 Socio-Spatial Vulnerability Index shared a lot of values with our assessment. Their ranking of the most vulnerable LSOA E01017219 was shared, and their second most vulnerable E01017220 was not, with our second most vulnerable being E01017218. E01017223 was their least vulnerable, as was ours.

13 PORTSWOOD

13.1 Ward Profile

This ward contains LSOA neighbourhoods: the north of E01017157, the north of E01017158, E01017226, E01017227, E01017228, two small sections of the south of E01017231, E01017232, E01017233 except from a thin strip on the west of the north side, E01017234 except from a portion of its north, E01017235, E01032753 except from a small section on its east, and the western tip of E01035442. Where appropriate, LSOA data will be discussed.

Compared to the city average, the ward itself has a few indices that may make neighbourhood climate adaptation harder:

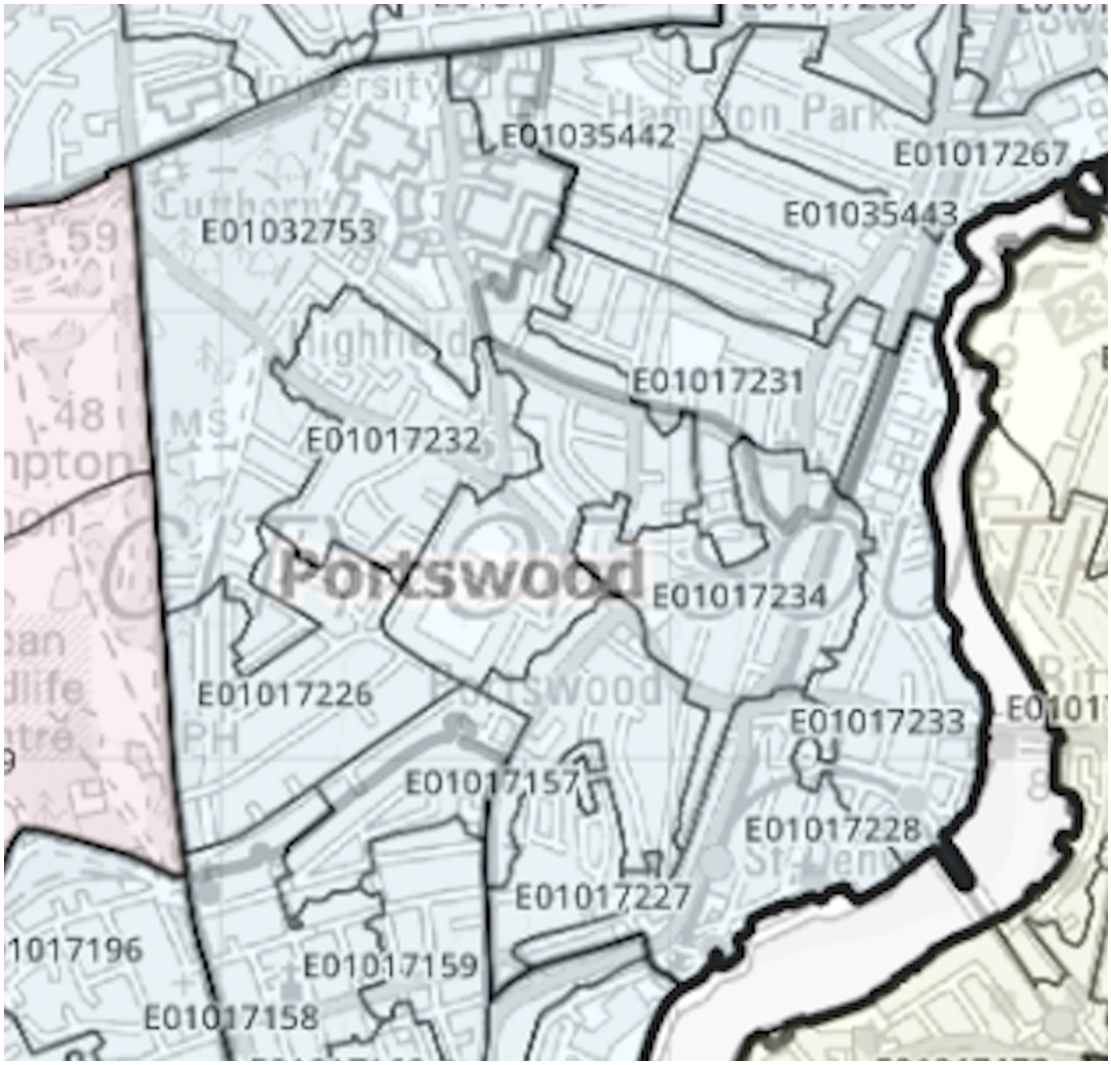

Figure 21. The LSOAs of Portswood.

- The lower rates of A-C EPC ratings exist in the west of the ward, with both sub 30% (A-C)% LSOAs being in the west, E01017232 and E01032753. An exception to this is E01017226, which is in the south-west, but has a 67.1% (A-C)%, the highest in the ward.
- Portswood is, relative to other areas of Southampton, not very deprived. Deprivation increases towards the coast, with the east of the ward being 4th decile or below (3rd decile: E01017227 and E01017228, 4th decile: E01017233, E01017234, E01017235)
- The majority of Portswood has a high household English speaking rate. Exceptions to this are E01017226, which is bottom 20% for English speaking households, and E01017228, E01017233, and E01017234 which are bottom 30%.
- Primary issues with social isolation exist around 65+, as Portswood is popular among working professional age, and has a high percentage of students. E01017235 is top 10% most socially isolated for 65+ ages, with E01017234 being top 20% and E01017226 being top 30%. For all-ages, E01017226 is top 20%, and the coast (E01017228 and E01017233) are top 30% most deprived.
- Moderately low percentage of green space, 12.8% verses 13.4%, impacting the permeability of ground and natural clearance of flood water, as well as increasing urban heat island effect.

13.2 Heat Risk Assessment

As E01017157, E01017158, E01017231, and E01035442 are all primary to other wards, they will be talked about in appropriate sections: Bevois for E01017157 and E01017158, Swaythling for E01017231 and E01035442.

E01032753 is one of the least vulnerable to heat, within the top 10% least vulnerable. E01017226 and E01017232 similarly are not particularly vulnerable to heat, at 8th and 9th decile vulnerability respectively. With E01017228, E01017233, and E01017234 all above the mean vulnerability at 6th decile, the most heat vulnerable areas in Portswood are E01017227 and E01017235 at 5th decile. Both E01017234 and E01017235 adjacent to each-other have similar issues, with high older ages social isolation, low percentage of English speaking households, high levels of school pupil obesity, and low green space. Further, E01017227 and E01017228 both have a lack of green space and high levels of school pupil obesity. Other than the Southampton Common to the west, Portswood ward has no parks and a green corridor: Church Lane. It also has only one tennis court as far as sports infrastructure goes other than a school. Pupils in school may not have many places to go to maintain health, and increasing this may benefit the higher vulnerability of the ward. Canopy cover would also decrease urban heat island effect, as green space may not be an option due to densely built residencies. Clubs, events, and volunteer networks could also benefit this, and gearing these towards child sports, older ages, and other cultures separately or together may help to decrease vulnerability.

The Heat England 2022 Socio Spatial Heat Vulnerability Index is generally agreed upon, but marks E01017227 as extremely vulnerable. While it is among the more vulnerable, being below average for Southampton, we have not ranked it higher vulnerability than E01017235 which by the Heat England index is ranked relatively high vulnerability. For this reason it is disagreed. E01017232 and E01032753 being of low vulnerability is agreed upon. E01017228, E01017234, and E01017235 being relatively vulnerable is agreed, but E01017233 is ranked average along with lower vulnerability LSOAs, although it is ranked as our most vulnerable LSOA in the 6th decile, therefore disagreed.

13.3 Flood Risk Assessment

13.3.1 Culverted Waterways

There are multiple waterways running through Portswood. One of the largest is through the University of Southampton Highfield Campus, beginning just north with a collection of surface water sewers west of Glen Eyre Hall, running culverted through until Lover's Walk, re-culverting in the University twice to run under roadways, but primarily running open. Outside of the University, it runs un-culverted until it reaches a road in which it becomes culverted, but these culverts are not good enough capacity and the road above often floods during heavy rain due to being overwhelmed. In multiple places: Church Lane, Shaftesbury Avenue, and Donnington Grove, flooding during heavy rains for this reason is experienced. Widening these culverts would be of use, but be aware this may cause new issues east nearer the coast due to higher volumes of water transport. Green space along the way can be utilised for water terraces to control the flow of water during heavy rain. This can be implemented on Lover's Walk, Church Lane, and within the University itself.

Running east of the University of Southampton Avenue Campus is a similar low-point in land elevation. Unlike the waterway through Highfield Campus, this waterway is fully culverted. A branch of this waterway may be causing flooding issues throughout Brookvale Road and possibly throughout Westwood Park itself. Multiple areas along Portswood Road are also low-points due to this waterway before running down Tennyson Road; reports are concentrated in these areas also.

13.3.2 Drainage System

A large portion of the drainage system in Portswood, more towards St. Denys, still relies on old foul sewers to manage surface water drainage, causing issues in these areas. Low points such as Thomas Lewis Way and Osborne Road North, as well as the wider coastal areas of Portswood experience flood reports which may be due in part to higher sewer pressures caused by more rainfall and water than these sewers can handle and tide locking with the River Itchen. The aging sewers also have issues with debris, failing to handle it as well as modern sewer systems. This can be seen in hotspots such as Grosvenor Road, Richmond Gardens, Wellbeck Avenue, and throughout St. Denys.

13.3.3 University Road

Towards the top of University Road there are many reports of flooding. Most of these seem to be around 10 years old, but recently has had multiple reports. This is a low-point in the road and seems to gather sediment and leaves as also is very busy.

The intersection with Hilldown Road also has some flood risk. Hilldown Road itself is a gravel road towards the end therefore does not experience flooding as is permeable ground, but this can exacerbate sediment deposit issues further up the road. Just north of the intersection experiences continued gully blockages, citing sediment with weeds growing out of it. Works were started on this road at the 1st of July 2024, but reports have since been filed therefore the clear underlying issue not fixed.

13.3.4 Future Projections and Ward Recommendations

Due to the culverting of the waterway that runs through Highfield Campus, E01017231, E01017232, and E01032753 are all areas that contain residential roads affected by this. All have the resources to be in high preparedness for a flooding event. Affected by culverted waterways from Avenue Campus running east is E01017226 and E01017235, in which the latter seems within top 50% for ill-preparedness to flood risk. Working on the flooding on Portswood Road would aid this, perhaps aiding issues with the drainage systems here such that this road and surrounding areas do not deteriorate over time. Increasing preparation in this LSOA may aid its adaptation by increasing green space and canopy cover to increase permeable land, and encouraging activity clubs, events, and volunteer networks which may help to manage childhood obesity and social isolation in the area.

Further, coastal areas with older sewer systems as discussed, such as E01017228 and E01017233, experience surface flooding attributable to these older systems and also have a high fluvial risk, with portions of residential St. Denys projected to be underwater by the year 2100. This area may benefit in the future from flood defence and works for updated sewer lines. E01017228 itself has mobility issues, taking form of high percentages of pupils with childhood obesity and or special educational needs, meaning aid here is paramount to avoid any unnecessary wellbeing issues. Risk to surface flooding is also felt in E01017234, an area in which has issues also with 65+ ages social isolation, meaning as well as modernised surface water sewers, activity clubs, events, and volunteer networks can be expanded to this LSOA too in aid of decreasing flood vulnerability.

These assessments are not shared with the Flood England 2022 Socio-Spatial Vulnerability Index. While the western LSOAs have a shared relatively low vulnerability (E01017232 at 8th decile and E01032753 at 10th decile), I believe E01017226 and E01017231 also to have a relatively low vulnerability both at 8th decile. The highest vulnerability we found is the coastal E01017228 (4th decile) which was also not shared, being lower vulnerability on the Flood England index than E01017227 (6th decile), E01017234 (5th decile), and E01017235 (5th decile).

14 REDBRIDGE

14.1 Ward Profile

This ward contains LSOA neighbourhoods: E01017236, the south and west of E01017237, the north of E01017238, E01017239, E01017240, E01017241, E01017242, E01017243, E01017244, and E01017245 except from the south-east. Where appropriate, LSOA data will be discussed.

Compared to the city average, the ward itself has a few indices that may make neighbourhood climate adaptation harder:

- Redbridge EPC ratings are generally good. Only one LSOA has an A-C rating percentage of less than 40%, being E01017240 at 38.1%.
- Redbridge is a ward of high disparity. All LSOAs of Redbridge except E01017243 (5th decile) are within the 30% most deprived in England. E01017236, E01017237 (primarily in Millbrook), E01017240, E01017241, and E01017245 are all top 10% most deprived. E01017238, E01017239, and E01017244 are all top 20%, and E01017242 is top 30%. Redbridge is also rank 3 in the city for Rate of Children In Need (794.1 verses 628.1 per 10k 0-17 population) and rank 2 for percentage of pupils eligible for Free School Meals (44.3% verses 34.4%). Serious focus on improvements to this far west side of Southampton is needed.
- In areas, Redbridge ward has a high level of social isolation. For all-ages: E01017241 is top 10% most isolated, E01017246 is top 20%, and E01017240 and E01017245 are top 30%. E01017241 is

Figure 22. The LSOAs of Redbridge.

interestingly top 10% for ages 65+ also, with E01017245 and E01017247 falling shortly behind at 20%, and E01017236 at 30% most deprived.

- Redbridge has a good level of English speaking households, with exception to E01017242 which is in the bottom 20%.
- Redbridge has a high percentage of residents aged 65+, 15.3% verses 14.3%. This may impact heat adaptability and extreme weather mobility. High and rising inpatient admission rate for mental health disorders (264.3 verses 151.5, crude rate per 100,000 population aged 0-17 years, 3 years), high percentage of residents limited a lot by disability (8.6% verses 7.1%), and high percentage of population reporting bad or very bad health (5.9% to 5.0%) may also limit adaptability to extreme weather events.
- Redbridge has some information accessibility issues. The rate of Children on Child Protection Plans is significantly higher than city average (151.3 verses 101.0 per 10k 0-17 population). Rate of domestic abuse related crimes (24.2 verses 18.7 per 1k population) is worse than city average. On the same vein of information accessibility, with a high non-persistent absence across the board from school which may be cause of a high percentage of residents aged 16 and over with no qualifications (23.6% verses 17.3%) and a rank 2 low percentage of residents aged 16 years and over with level 4 qualifications or above (31.6% verses 21.6%).
- Redbridge has some impacts to resident population mobility during a flood. Percentage of lone parent families with dependent children (11.1% verses 7.2%, rank 2) is much higher than the city average. Percentage of resident population aged under 16 years (22.1% verses 17.3% is rank 1 in the city. Percentage of pupils with Special Educational Needs (26.5% verses 20.3%) is rank 1 in the city. Hospital admissions caused by unintentional and deliberate injuries in children (aged 0 to 14 years) crude rate per 10,000 (3 year pooled: 126.6 verses 81.0, 5 year pooled: 120.3 verses 94.9).

14.2 Heat Risk Assessment

A large area of Redbridge has been flagged to be of relatively high risk. 8 out of 10 LSOAs in Redbridge ward are below the city average for heat preparedness, the ones above being E01017242 (6th decile) and E01017243 (7th decile). E01017238, E01017239, and E01017244 are all within the 5th decile.

E01017237, E01017240, E01017241, and E01017245 are all within the 4th decile, and E01017236 is in the 3rd decile. Each of these LSOAs have a highly worse than average deprivation, residents limited a lot by disability, ages 16+ qualification holders, and school pupil obesity rate (except from E01017241 which has a lower than but near to average of school pupils a healthy weight). First of all we will evaluate these LSOAs as a whole. There may be an underlying issue of education in these areas limiting spread of vital information. While absence rates are higher than average across the board, suspension rates are low with exception for E01017240 which is in line with the city average. This may indicate an unwillingness to engage with curriculum rather than disciplinary issues, or illness or family issues. For Redbridge ward as a whole, children are reaching an above average level of development by the end of reception, and exceed the percentage of pupils meeting the expected standard in reading, writing, and maths. In E01017236, E01017241, and E01017245, rates of contacts with outcome of information, advice, and guidance was significantly high, but this most likely does not matter as the correlation for these LSOAs only between this and qualification holders that are 16+ ages is non-significant at -0.27. Further, taking the same correlation instead using reports of bad or very bad health is 0.41, more significant but non-conclusive. Further, forecast change in population for Redbridge ward is positive and lower than average for non-dependant ages, i.e., 16+ ages meaning population movement is scarcely happening comparatively. For this reason, further inquiry into education in this ward is required. Overall, the primary recommendation for these wards is inquiry into house type and preparedness for heat extremes such that those vulnerable in other ways do not become of ill health attributable to heat within their own homes.

Evaluating E01017236, E01017237, E01017240, E01017241, and E01017245 separately, we see E01017236 has issues of high rates of children in need, high reports of bad or very bad health, and high all-ages and 65+ ages social isolation. Combatting isolation is important here, therefore it is recommended to aid those who are of bad health to be able to 'de-isolate'. This can be done through accessibility improvements, technology, or transportation aid to clubs, events, or volunteer networks. A similar solution could be used with E01017241, which has the same issues but also high rates of adults in social care.

This coverage by social care may make going above and beyond in this way easier, as we already know may be vulnerable. E01017240 and E01017245 both have issues with high rates of children in need, and E01017237 has higher than average reports of bad and very bad health; both of these can be remedied with the general solution of improving household heat preparedness throughout the 5 most vulnerable LSOAs.

This ranking is partially agreed upon by the Heat England 2022 Socio Spatial Heat Vulnerability Index. The least vulnerable LSOA, E01017243, is also ranked as relatively low vulnerability. Where these reports diverge though is the classification of E01017242, which is ranked by them as relatively high and is disagreed by us, especially considering their classification of average vulnerability of E01017244 which was ranked by us as more vulnerable than E01017242. Otherwise, the relatively high vulnerability ranking of all remaining LSOAs is agreed. Their ordering of values is not agreed though, as our highest vulnerability LSOA E01017246 is less vulnerable than a lot of other LSOAs within this same ward.

14.3 Flood Risk Assessment

14.3.1 Preliminary Statements on the Land Elevation

Redbridge ward suffers from surface flooding throughout the entire ward. When looking at historical maps, the majority of these reports exist along the old watercourses that have now been urbanised and exist as urban dells, with land lying lower than its surroundings.

14.3.2 Redbridge Road

There have been multiple flooding reports along Redbridge Road. This is a large problem as it affects people, with flood reports spilling over into residential areas, as well as this road being a vital artery into the city for work transit and trade.

Multiple have been on or around its roundabout connecting to Millbrook. This may be as it is a non-permeable road surface with elevation below its surroundings. There is small amounts of green space next to the roundabout but it is behind raised curbs and naturally elevated, therefore less effective. With high traffic depositing debris and sediment into the drains, the gullies on the roundabout might not be able to cope. This is evident in the flood reports, which are regular and has happened in recent years.

14.3.3 Parkside Avenue

Parkside Ave has been repeatedly subject of flooding continuing since 2018. This is in need of intervention, as Parkside Ave is a residential area. 7/9 of the reports have been due to storm overflows and blocked gullies due to recent heavy rains, one report stating water up to front doors. One of the reports was classed as severe flooding with no blocked gullies reported. A final report was due to a leak addressed by Southern Water causing a gully blockage. Parkside Avenue is low, elevation is flat from the busy Redbridge Road to this neighbourhood, therefore it poses a low resistance for the water.

The reports on Parkside Avenue do not just happen in Autumn, and there is low canopy tree cover there. This suggests that it is more likely overwhelmed drainage somewhere else which causes it to discharge along this road, or that traffic may be using this small residential road to access Kendel Avenue. This area may benefit from a flood and gully reassessment to ensure the leak, or any other unknown persisting factors such as traffic not fit for this road, will not be of detriment to current residents.

14.3.4 Test Lane

In neighbourhoods close to the shore and the Redbridge Causeway, gully blockages are common. This may be the cause of gully blockages, exacerbated by the tide from the River Test back-washing water up the drains due to southern Test Lane being lower than surrounding street levels. This wash can also cause sediment deposits in the bottom surface of the drains, increasing their proneness to blockages. Test Lane and further down Old Redbridge Road are also at risk of type 2 and 3 fluvial flooding. Natural channels formed by the River Test and clay, silt, and sand banks are the flood defence for this area, but may become overwhelmed with the River Test water levels rising. This risk affects a number of residential houses, and may require analysis into flood defence.

14.3.5 Future Projections and Ward Recommendations

Flooding on Redbridge Road and Parkside Avenue takes place in LSOA E01017239, an area of poor preparedness for flooding within the top 40% most vulnerable. Amending this possibly overwhelmed drainage is required, as within this LSOA there are high percentages of pupils who are overweight and with special educational needs, therefore the risk may place this demographic in harms way.

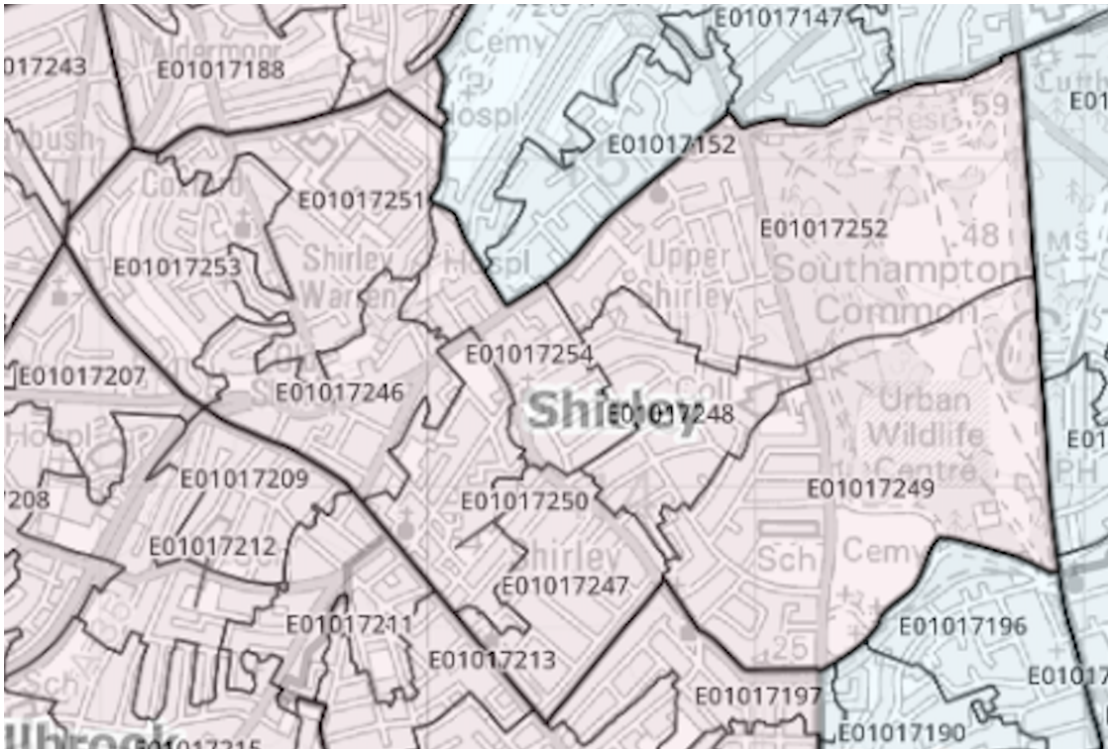

Figure 23. The LSOAs of Shirley.

On Test Lane and the south-western shore, the east of E01017239 is at risk as well as the entirety of LSOA E01017240. Evaluating E01017240 we see a very high vulnerability to flooding, within the top 20% most vulnerable at rank 17 in Southampton. The SFRA also indicates risk of type 2 and 3 fluvial flooding as well as 1/30 and 1/100 surface water flooding. This area has high deprivation and children in need. Like E01017239, the demographic is less mobile and at-risk too, with high percentages of pupils with special educational needs, childhood obesity, and single parent families with dependant children. Finally, the spread of information is limited, with high percentages of ages 16+ with no qualifications. We see a spread of issues that have no clear unified solution, therefore so we do not further deprive this community. Houses require aid in reinforcement and recovery from storms, not just from the coast but also surface water flooding due to high pressure in drains during heavy rainfall.

The Flood England 2022 Socio-Spatial Flood Vulnerability Index is generally agreed upon. Once again E01017243 is the lowest ranked in both our and the Flood England index. Our lowest two is E01017236 and E01017245 both at top 15% most vulnerable; rank 9 and 10 respectively. While the very high vulnerability of E01017245 is mirrored in the Flood England index, it is agreed that E01017236 is far lower in vulnerability. Otherwise, the relatively high vulnerability of all others is corroborated.

15 SHIRLEY

15.1 Ward Profile

This ward contains LSOA neighbourhoods: E01017246, E01017247, E01017248, E01017249, E01017250, E01017251, E01017252, E01017253, and E01017254. Where appropriate, LSOA data will be discussed.

Compared to the city average, the ward itself has a few indices that may make neighbourhood climate adaptation harder:

- Shirley generally has a higher A-C EPC rating percentage on the west side of the ward. The entire wards (A-C)% is 35.7%, but split into east and west this becomes 23.8% and 41.2% respectively.
- Shirley wards west side has a growing disparity problem. Of particular concern is E01017250, at top 10% most deprived. Further, E01017253 is top 20% and E01017246 is top 30%.

- For both all-ages and 65+, E01017250 has a high level of social isolation at top 10% for both. For 65+ this is followed by E01017251 (top 20%) and E01017253 (top 30%).
- North-central Shirley has a low rate of English speaking households. This is particularly evident in E01017246, at bottom 10%. E01017250 and E01017254 are at bottom 20% and E01017251 and E01017252 are bottom 30%.
- Shirley has a high rate of contacts with an outcome of Information, Advice and Guidance (34.7 verses 27.9 per 1k population aged 18+) and a high rate of Safeguarding concerns (6.7 verses 4.9 per 1k population aged 18+). Although these both have a high positive correlation, in this instance they both seemingly are independent of one another, with the former trending upwards and latter trending downwards.
- High percentage of resident population aged 65 and over (15.7% verses 14.3%) may cause in-adaptability to heat extremes and low mobility during flooding.
- High percentage of resident population aged under 16 years (19.5% verses 17.3%) may cause inefficient flood preparation and management issues.

15.2 Heat Risk Assessment

Shirley contains the rank 2 and 4 most heat prepared LSOAs, E01017249 and E01017252 respectively, both within the top 5%. This can be argued it is ranked here due to the Southampton Common meaning these areas have an incredible amount of green space (77.7% and 62.8% respectively), but if this green space is reduced down to the city average of 13.4% these two LSOAs maintain the rank of 10 and 9 respectively for extreme heat preparedness.

Other LSOAs are highly prepared too: E01017248 is in the 9th decile, E01017246, E01017247, and E01017254 are all in the 7th decile, and E01017251 and E01017253 are both in the 5th decile. E01017251 could use aid in improving social isolation for 65+ ages and those of other cultures due to low rates of English speaking households. E01017253 could utilise aid in making houses more heat prepared due to high rates of children in need and deprivation.

Neither E01017251 and E01017253 are priority over E01017250 though, which is top 10% most vulnerable and rank 2 for heat vulnerability in the city. Mobility is very impacted in this LSOA, with very high reports of bad and very bad health, residents limited a lot by disability, and childhood obesity. This LSOA is also among the top 10% most deprived and has an issue with high rates of children in need. Spread of vital information about how to protect yourself and safeguarding issues are also of concern during hot weather, with high rates of adult social care, low rates of qualification holding for 16+ ages, and high social isolation for both all-ages and ages 65+. A top priority is investigation into housing state in this LSOA, such that residents can become more prepared with aid to buy extreme heat mitigation home strategies, such as insulation. There also should be a focus on education in this LSOAs catchment area, due to persisting education shortcoming, evident in worse than average absence and suspension rates across the board. Further, higher funding for health resources within this LSOA is necessary, facilitating the spread of health and non-alarming common sense heat preparation information. This may also be done utilising emergency cooling stations in community buildings, and integrating clubs, events, and volunteer networks into the community to decrease isolation and spread information.

The Heat England 2022 Socio Spatial Heat Vulnerability Index for the most part agrees with this assessment. E01017249 is at extremely low vulnerability, followed by E01017248 then E01017252 at relatively low vulnerability. Although contradictory to our results, this is actually agreed upon, as factoring out green space percentage E01017248 is shown as more prepared for extreme heat than E01017252. E01017247 and E01017254 are also relatively low vulnerability, which is agreed. E01017251 and E01017253 are average vulnerability which is agreed. Our rankings differ at E01017246 and E01017250. E01017246 is ranked as relatively high vulnerability, while in our ranking it was 7th decile ranked among those ranked within relatively low vulnerability. Finally, E01017250 was ranked extremely high vulnerability; we argue this should be higher.

15.3 Flood Risk Assessment

15.3.1 Bellemoor Road and Wilton Crescent

On the Bellemoor Road - Shanklin Road junction, there has been reported flooding over the years, as well as being an area of SFRA surface flooding. At this junction and low-lying part of the road, there is a 4-way

intersection of surface water sewer lines underneath the gully. This is possibly causing this particular area to become overwhelmed with water capacity at high rainfall. This low-point continues down onto Wilton Crescent, causing issues perhaps with overwhelmed surface water sewers on it's intersection with Wilton Road. This may be affecting Bellemoor Roads inability to handle high levels of water too. The other of the surface water sewer lines that runs downhill goes to Cemetary Lake, which may cause water flow stagnation when its levels are high due to heavy rainfall, especially as the lakes outflow becomes culverted, limiting flow. It has been reported recurrently throughout the years this issue has existed that residents properties have become flooded. There may also be issues with the foul sewer, with one resident reporting flow-back of sewage into their garage.

15.3.2 St. James Close

In some small areas of Shirley, surface water drainage is still relying on old foul sewers. This is most evident in St. James Close, which experiences regular flooding due to this.

This may also be an issue in Harland Crescent, which although the presence of a surface water sewer exists the residents report floods with a bad smell.

15.3.3 Future Projections and Ward Recommendations

Bellemoor Road and Wilton Crescent are both areas which are in E01017252 and E01017249 respectively. Both LSOAs are top 10% for flood preparation, being some of the least vulnerable in the city. This makes the risk manageable. These two LSOAs may be rated least vulnerable due to their vast green space, containing the majority of the Southampton Common. This is not the sole reasoning though, as setting their green space to 0% shows us that they are still in the top 20% least vulnerable of communities.

Harland Crescent is in LSOA E01017248, which has low green space but is within the top 20% least vulnerable for flood risk. St. James Close is in LSOA E01017254, which is within the 60% most vulnerable. This makes a large majority of Shirley ward not a priority over other wards for flood risk.

Some areas such as Wordsworth Road, St. James' Road - Bellemoor Road junction, and South View Road have a large amount of blockages due to debris which will become worse over time with higher rainfall. This is also particularly evident in LSOA E01017250, which is number 5 for flood vulnerability. If these areas are regularly cleared, this eliminates the risk to Shirley ward and resources for infrastructure change can be directed to other areas with issues unsolvable by regular cleaning.

Assessment of vulnerability is agreed upon by the Flood England 2022 Socio-Spatial Vulnerability Index, showing high vulnerability in E01017250, low vulnerability to LSOAs E01017249 and E01017252, and average vulnerability elsewhere. In our ranking, E01017250 has issues of significantly worse than average adults in social care, children in need, ages 16+ qualification earning, pupils with special educational needs, green space percentage, bad or very bad health reports, residents limited a lot by disability, childhood obesity, 65+ and all-ages social isolation, and multiple deprivation. Eliminating flood risk here takes priority for this ward, and then can come working on vulnerability, as improving these indices may take time and houses are vulnerable to damage now. Throughout this process, communication with the residents is important and E01017250 is in the bottom 20% for English speaking households. Therefore I would also recommend investigation into what languages and cultures are living there to effectively communicate information and the councils priority such that residents do not become disenfranchised.

16 SHOLING

16.1 Ward Profile

This ward contains LSOA neighbourhoods: E01017255, E01017256, E01017257, E01017258, E01017259, E01017260 except from a small tail to the east, E01017261, E01017262 except from its north-eastern half, and E01017263. Where appropriate, LSOA data will be discussed.

Compared to the city average, the ward itself has a few indices that may make neighbourhood climate adaptation harder:

- Sholing ward has a moderately good rate of A-C EPC ratings, at 35.2% for the whole ward. This percentage rises to 37.8% with elimination of one LSOA, E01017260, which has a 16.8% (A-C)%.
- Comparatively to other wards, Sholing has a moderate to lesser level of deprivation. On the other hand, E01017257 and E01017263 are top 30% most deprived, and gradually degrading further and

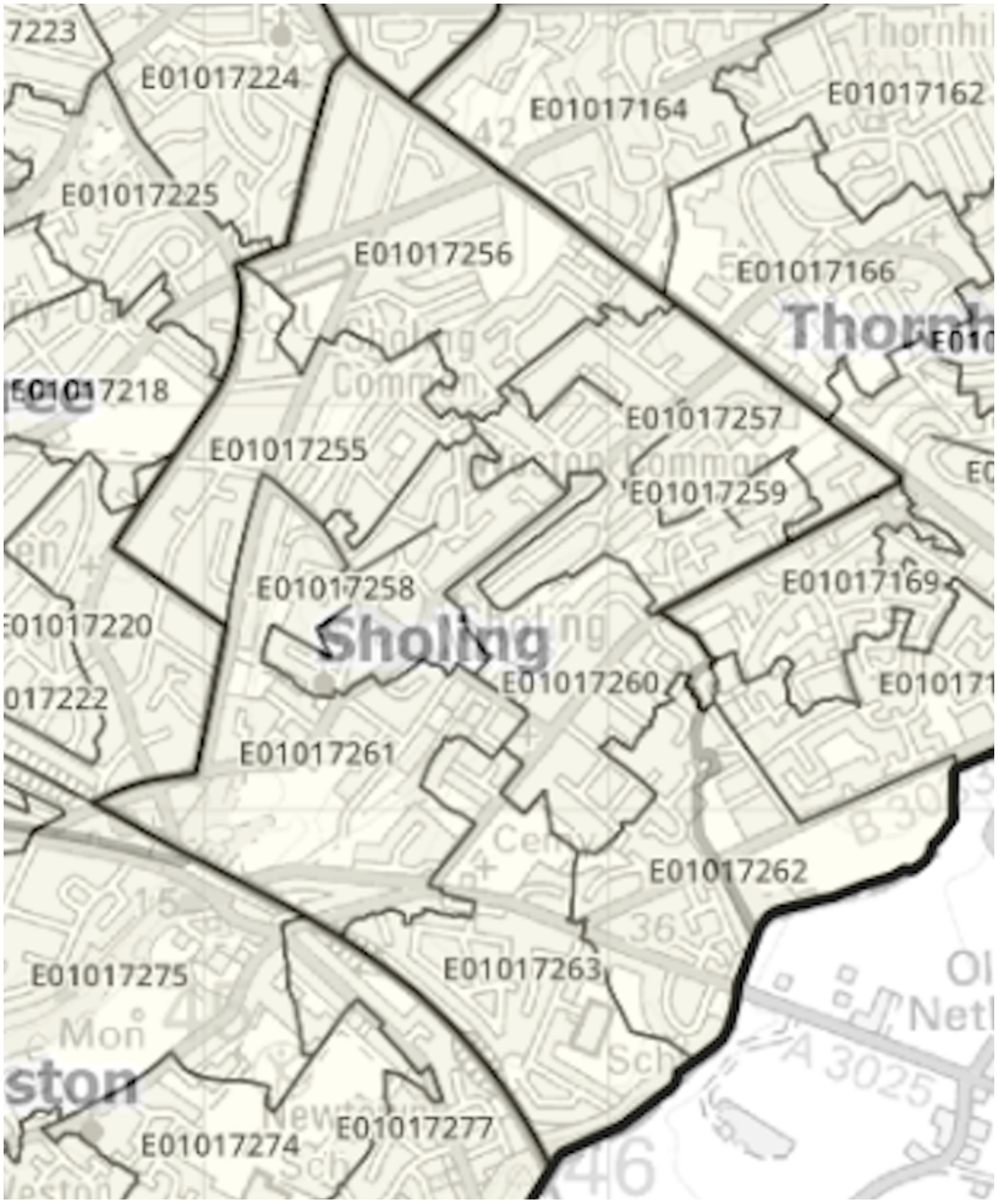

Figure 24. The LSOAs of Sholing.

fast, among the top 20% of deprivation drops from 2015 to 2019 values. E01017262 is the only LSOA that has not increased in deprivation in Sholing.

- Sholing ward has a relatively good community with little isolation. This is exception to E01017260 LSOA, with top 10% all-age social isolation.
- Sholing has a severely aging population. It is rank 1 for percentage of resident population aged 65 and over (20.2% verses 14.3%), and rank 1 for forecasted loss of resident population aged 16-64 years (-0.3% verses 7.5%). Forecast percentage change in resident population aged under 16 years is also negative (-3.6% verses -1.8%) and forecast percentage change in resident population aged 65 and over is positive (11.0% verses 18.7%).
- Percentage of residents aged 16 and over with no qualifications is high (19.7% verses 17.3%) and percentage of residents aged 16 years and over with level 4 qualifications or above is low (22.8% verses 31.6%). Quality of education affects information accessibility, although it is not certain why this ward has these issues as suspension rate is normal, absence rate is good, and children early on are achieving a good level of development.
- Very low percentage of green space, 6.0% verses 13.4%, impacting the permeability of ground and natural clearance of flood water, as well as increasing urban heat island effect.
- Hospital admissions caused by unintentional and deliberate injuries in children and young people aged 15 to 24 years is high (crude rate per 10,000, 3 year pooled: 181.9 verses 126.8, 5 year pooled: 169.5 verses 131.1). It is not immediately certain why, and other health problems do not persist as common nor safeguarding issues, but this may impact ward mobility.

16.2 Heat Risk Assessment

Sholing ward is well prepared for heat. Only one LSOA is below average vulnerability, being E01017260 at 5th decile. E01017256 is at 8th decile, E01017255 and E01017259 are at 7th decile, and E01017257, E01017258, E01017261, E01017262, and E01017263 are all 6th decile vulnerability. Recommendations to E01017260 include all-ages clubs, events, and volunteer networks with focuses on accessibility or improving accessibility around the ward, as high percentages of residents report being limited a lot by disability and bad or very bad health. There is also high social isolation for all-ages. These three issues may be related to the high resident population ages 65+ within this area. This would aid in spread of vital information, which would be beneficial due to high social isolation and high percentages of 16+ residents with no qualifications.

The Heat England 2022 Socio Spatial Heat Vulnerability Index is not agreed upon. This index has placed E01017259 and E01017262 as the least vulnerability at relatively low, while our index ranks the north-west of the ward, E01017255 (7th decile vulnerability) and E01017256 (8th decile), as lower vulnerability. They are closely ranked though with E01017259 at 7th decile and E01017262 as 7th. The Heat England index also ranks E01017257 as the highest vulnerability (relatively high vulnerability), while for us this LSOA is not particularly vulnerable (6th decile). Average risk can be agreed for each other LSOA within this ward.

16.3 Flood Risk Assessment

16.3.1 Jurds Lake

Jurds Lake are two waterways that flow through Sholing, becoming un-culverted at the Sholing Common and Weston Common. It may cause issue in places it has to become briefly re-culverted due to capacity, such as: South East Road, Botany Bay Road, Portsmouth Road, and Station Road. Floods in this manner have potential to damage houses due to fast flowing water in heavy rain.

Similarly, water stagnation, sediment and debris, and tide locking can occur on adjacent roads to this brook. At a low-point, Alfriston Gardens becomes flooded during rain due to sediment and natural debris depositing into the drain. With elevated houses, this road is not of priority as it does not damage houses.

16.3.2 Kathleen Road

This road used to be vulnerable, as a gully was not in place. This issue was aimed to be amended by the install of a gully, but it seems to often become overwhelmed. There is little sign of debris, and this is most likely due to it being linked into the older foul sewer underneath Kathleen Road, rather

than the appropriate surface water infrastructure being built. One resident reported: *"The last visit and survey established that the current drains are inadequate for effective removal of rain downpours"*. It is recommended this is investigated, as multiple reports have cited damage to housing, including flooding garages, cracking house walls, and concerns of flooding houses. This can be very detrimental as this flood water is foul sewage, and may leave behind pathogens, mould, and other things that may cause long-term illness.

16.3.3 Weston Greenway

A waterway runs south along Southampton's border. This is contained in green space and generally shows no issue of flood risk, although where one branch of the dell starts lies above Botley Road, running culverted through this road. For this reason Botley Road is on low-lying land and is often flooded. This is due to both debris, silt sediment, and the drains becoming overwhelmed with the volume of rainfall. This is causing internal flooding in peoples homes, and must be addressed to increase capacity of the system in this vital area.

16.3.4 Future Projections and Ward Recommendations

Areas due to culverting of the Jurds Lake waterways are in LSOA E01017261, a relatively non-vulnerable neighbourhood of 6th decile most vulnerable. Aiding this area would include making terraced water storage in both the Sholing Common and the Weston Common, slowing down the flow and alleviating the overwhelmed culverts without long works to widen them in major areas.

Kathleen Road is in LSOA E01017257, which is more vulnerable at top 50%. The issue of inadequate drainage here is recommended to be improved such that these people are not at risk. This is similar to areas like Alfriston Gardens between LSOAs E01017259 (top 50%) and E01017260 (top 60%), and Botley Road in E01017262 (top 50%), which could benefit from analysis into what issues they are facing with drainage. All of these have non-complex single cause attributable flooding, and therefore eliminating risk is paramount over reducing vulnerability in a neighbourhood that is already more prepared comparatively than nearly half of Southampton.

The Flood England 2022 Socio-Spatial Vulnerability Index generally agrees with this assessment, placing the ward under average vulnerability. The exception is E01017262 which is ranked relatively low vulnerability, although our ranking disagrees with this priority over other LSOA (6th decile).

17 SWAYTHLING

17.1 Ward Profile

This ward contains LSOA neighbourhoods: E01017231 except from two small sections of the south, a thin strip on the west of the north side of E01017233, a portion of the north of E01017234, E01017264, E01017265 except from the eastern portion, E01017266 except from a small eastern section, E01017267, E01017270, E01017271, E01017272 except from two small south-eastern portions, a small section on the east of E01032753, E01035442 except from its western tip, and E01035443. Where appropriate, LSOA data will be discussed.

Compared to the city average, the ward itself has a few indices that may make neighbourhood climate adaptation harder:

- With exception to E01017265, the north of Swaythling is has a poor percentage of A-C EPC ratings. Both E01017270 and E01017271 are 19.7% and 24.3% respectively.
- Swaythlings northern side is more deprived than its south. It's southern LSOAs are both 6th and 8th decile, while in it's northern half: E01017265, E01017266, and E01017272 are all top 20% most deprived, E01017264, E01017267, E01017270 are all top 30%, with E01017271 being 5th decile.
- Swaythling in areas struggles with low levels of English speaking households. LSOAs of particular interest are E01017271 and E01035443 at bottom 10%, E01017231, E01017272, and E01035442 at 2nd decile, and E01017264 at 3rd.
- Swaythling has a generally working age population, meaning social isolation for 65+ is high. E01017270 and E01035443 are both top 10% most isolated and E01017265 follows behind at top 30%. For all ages, E01017265 is instead top 10% of values, with E01017270 as top 20%. Persistent issues with isolation are apparent in these northern sects of Swaythling.

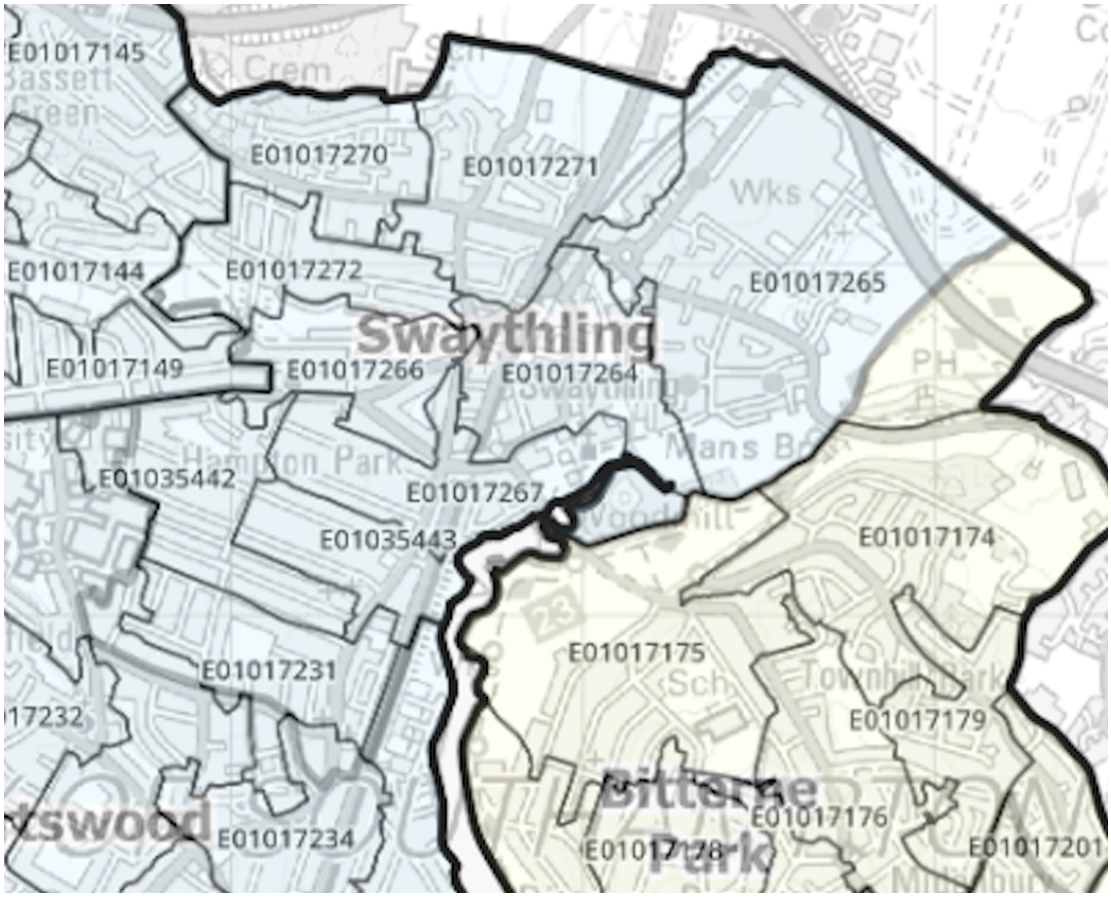

Figure 25. The LSOAs of Swaythling.

- Swaythling has a high level of early persistent absence from schooling, which may be why percentage of residents aged 16 years and over with level 4 qualifications or above is low (28.8% verses 31.6%). This impacts information access. Young people of this ward are also impacted by the rising risk of mental health. Both 3 year and 5 year pooled inpatient admission rate for mental health disorders aged 0-17 years are rank 1 in the city (crude rate per 100,000 population, 3 year pooled: 278.6 verses 151.5, 5 year pooled: 221.8 verses 144.0)
- Moderately low percentage of green space, 8.7% verses 13.4%, impacting the permeability of ground and natural clearance of flood water, as well as increasing urban heat island effect.

17.2 Heat Risk Assessment

As E01017231 and E01032753 are both primary to Portswood ward, they will be talked about within the Portswood heat risk assessment.

Swaythling as a whole is relatively average for heat risk. E01017271 and E01035442 are both 8th decile vulnerability, E01017264 and E01017267 are both 7th decile, and E01017233, E01017234, E01017266, E01017272, and E01035442 are all 6th decile.

Below the average is E01017270 (top 50% most vulnerable) and E01017265 (top 40%). These are both in the north of the ward, and have similar heat vulnerabilities. Both LSOAs have a high percentage of residents 16+ with no qualifications, high rates of residents limited a lot by disability, high levels of reported bad and very bad health, and high levels of all-age social isolation. E01017270 and also has high levels of 65+ social isolation and E01017265 also has high deprivation, top 20% for England. The spread of information in this ward could be improved. Clubs, local events, and volunteer networks can aid in this, geared towards accessibility for people or making the community more accessible. Included in this can also be an emphasis on culture and language inclusion with translated information, due to the low rates of one or more person per house who can speak English.

The Heat England 2022 Socio Spatial Heat Vulnerability Index agrees with this assessment partially. The most vulnerable areas of this ward, E01017265 and E01017270, are also the most vulnerable at relatively high vulnerability, although their priority flipped, with E01017270 rated more vulnerable than E01017265. Following shortly behind is E01017264, which is also rated relatively high vulnerability; using our ranking this LSOA is lower vulnerability than others which are ranked lower on the Heat England index. Otherwise it is agreed other LSOAs are ranked average, although scoring of each LSOA is not agreed with some discrepancy, such as E01017271 and E01035442 which have 8th decile vulnerability and a higher Heat England index vulnerability than others ranked higher vulnerability by us.

17.3 Flood Risk Assessment

17.3.1 Natural Debris and Sediment

Swaythling is an area with high canopy cover and vegetation, alike a lot of other northern areas in Southampton. Issues with debris can be seen in locations of low relative elevation. For example, Stoneham Lane has issues with flooding primarily due to a low-point by the Bowling Green and high levels of canopy cover clogging the drains. This issue is very similar for Leaside Way, Mansbridge Road, Monks Way, multiple places on Portswood Road, Willis Road, and Woodmill Lane.

Willis Road is an interesting case, one report stated: *"last time it was dug out the workmen commented on how it was full of roots and was blocked beyond where they could dig"*, indicating damage to the drainage system due to tree root encroachment.

Woodmill Lane is a place of interest as there are a very high number of reports, and the area in question is a very small pedestrian walkway with a single car width roadway. If this is flooded this can make it very dangerous for pedestrians. Increased capacity for drainage into the River Itchen below is a much needed alteration.

17.3.2 Monks Brook

Monks Brook is a waterway that runs through Bassett Wood Greenway. Along this greenway it becomes culverted, and the space it has to flow through cannot deal with the volume of water during heavy rainfall, flooding the Daisy Dip and Lobelia Road to the east. This water level can back up, causing overflow in low, connected surface water sewer areas, such as Carnation Road.

Two low areas flow into Monks Brook also from Burgess Road. The first continues from Daisy Dip, reaching where Burgess Road merges onto High Road then Stoneham Way, with high levels of SFRA flooding projected but little reports, indicating adequate drainage as of now although this is still worth attention as may become worse. The second begins towards the east of Highfield Campus, at a major dip in the road outside of 218 Burgess Road and running south-east. In this dip, debris and sediment pool due to it being a busy road, blocking the drains and causing flooding. Increased reports due to this may also be seen at the Woodcote Road - Mayfield Road junction and Portswood Road.

17.3.3 Future Projections and Ward Recommendations

Swaythling may be impacted heavily in the future from surface water flooding due to heavy natural debris. For all LSOAs within this ward, it is recommended to make note of problem areas below for regular clearing of gullies, or an on-call team discussed in the concluding remarks.

Monks Way resides in LSOA E01017264, an area within top 50% vulnerability to flooding. There is a lot that can be done here to decrease vulnerability mainly focusing around youth population, due to a low percentage of school children of which are a healthy weight, high percentage of pupils with special educational needs, and a high rate of children in need. Support in schooling would decrease vulnerability of this area, increasing focus on after school activity with inclusion, as well as free school meals for those in need.

Issues on Mansbridge Road affect residents in LSOA E01017265. Within the top 30% most vulnerable, this area is a priority for Swaythling. Primary issues in this area are related to mobility, with high reports of residents limited a lot by disability, high reports of bad or very bad health, and high percentage of pupils with special educational needs. Further, limiting spread of information is the lack of qualifications 16+ ages hold that live in the LSOA. This combination of poor information spread and low mobility is daunting considering the significantly high levels of all-ages isolation within the LSOA. Clubs, events, and volunteer networks can be utilised to decrease isolation and create a more accessible local neighbourhood for this area.

Woodmill Lane is in LSOA E01017267, within the 6th decile. Due to a lack of particular vulnerabilities, it would be recommended to increase drainage to eliminate risk to the neighbourhood.

Stoneham Lane and Willis Road both are within LSOA E01017271 within the 8th decile for vulnerability. For this reason improvements in vulnerabilities are not recommended, rather eliminating risk. For the latter this should be investigating any issues with the drains being impacted by roots. Leaside Way is within LSOAs E01017270 and E01017271. It is harder to tell what issues this particular row of residencies is having as is in-between two highly differing in vulnerability LSOAs, the former being 4th decile and latter being 8th decile. For this reason, vulnerability reduction measures are harder to recommend, although it would definitely be recommended to decrease the high all-ages and 65+ ages isolation as well as mobility issues E01017270 experiences. This can be done utilising clubs, events, and volunteer networks to make the neighbourhood more accessible for those who are disabled.

Carnation Road is within LSOA E01017272, a 5th decile LSOA with issues of high percentages of 16+ ages without qualifications and high percentages of pupils with special educational needs. Being aware of these families and being able to effectively distribute information to them is very necessary.

The affected area of Burgess Road is within LSOA E01035442 (7th decile). This is a highly prepared flood area, and is unlikely to affect any residencies due to houses being elevated, although businesses and traffic may be affected. For this reason resident vulnerability is inappropriate to improve on this issue. The Woodcote Road - Mayfield Road junction is also within LSOA E01035442 but also E01035443 (5th decile). Similarly, affected areas of Portswood Road are within LSOAs E01017231 (8th decile) and E01035443. These areas are relatively well prepared, although have a low level of English speakers within households. For this reason it is recommended to eliminate risk by investigating arising issues and communicate this effectively to residents of different primary language such that frustration is not fostered.

With the two relatively high vulnerability LSOAs being EO1017265 and E01017270 and the remaining average, the Flood England 2022 Socio-Spatial Flood Vulnerability Index is generally agreed upon. Alike a lot of areas though, enumerated vulnerability index is disagreed upon. Our highest vulnerability is EO1017265 while the Heat England index places E01017270 as higher. The order of vulnerability ranking is also different for average vulnerability rated areas. For example: E01017271 is placed higher vulnerability than a lot of other LSOAs we have ranked higher and similarly EO1017266 is ranked lower vulnerability than EO1017267 which is swapped in our ranking.

18 THORNHILL

18.1 Ward Profile

This ward contains LSOA neighbourhoods: E01017162, E01017163, E01017164, E01017165, E01017166, E01017167, E01017168, E01017169, E01017170, and the north-eastern half of E01017262. Where appropriate, LSOA data will be discussed.

Compared to the city average, the ward itself has a few indices that may make neighbourhood climate adaptation harder:

- In most of Thornhill, the percentage of A-C EPC ratings is approximately 40%. This is in exception to the northern-most two LSOAs E01017162 and E01017165, at 32.2% and 27.0% respectively.
- Thornhill, especially inner Thornhill, is a severely deprived. E01017163, E01017166, and E01017167 are all top 10% most deprived. E01017165, E01017168, and E01017169, are all top 20%, E01017170 is top 30%, with the remaining wards E01017162 and E01017164 being top 40%.
- E01017166 and E01017169 are both top 20% most isolated. All of Thornhill is top 30% for all-age social isolation. E01017167 and E01017168 in particular are top 10%, and E01017162, E01017163, E01017165, E01017166, and E01017169 are all top 20%.
- Across the board, all social care indices are higher. Rate of contacts with an outcome of Information, Advice and Guidance (36.1 verses 27.9 per 1k population aged 18+), rate of new care request contacts where one of the three outcomes was Care Act Assessment Required (16.6 verses 11.9 per 1k population aged 18+), rate of people with a current Adult Social Care service (13.7 verses 12.3 per 1k population aged 18+), rate of Safeguarding concerns (7.0 verses 4.9 per 1k population aged

Figure 26. The LSOAs of Thornhill.

18+), rate of Section 42 enquiries (3.3 verses 2.2 per 1k population aged 18+), rate of Children Looked After (136.7 verses 63.9 per 10k 0-17 population), and rate of Children on Child Protection Plans (195.9 verses 101.0 per 10k 0-17 population). For the latter two, Thornhill is rank 1 in the city as well as rank 1 in the strongly correlated rate of Children In Need (1106.3 verses 628.1 per 10k 0-17 population). Further, although the rate of theft offences is significantly better, Thornhill has significantly worse rates of domestic abuse offences (rank 1, 34.6 verses 18.7 per 1k population) and violent crime (65.4 verses 48.2 per 1k population).

- High percentage of resident population aged 65 and over (16.0% verses 14.3%) may cause inadaptability to heat extremes and low mobility during flooding.
- Across the board, education quality metrics are worse than average. 12 out of 16 of these indices are ranked lowest in the city, and the 4 which are not the lowest ranked in the city are the second lowest. This (non-exhaustively) includes: percentage of residents aged 16 and over with no qualifications (25.1% verses 17.3%), % Overall Absence (10.7% verses 8.1%), percentage of key stage 2 pupils meeting the expected standard in reading, writing and maths (33% verses 55.3%), and suspensions rate (19.4 verses 10.3 per 100 pupils). This ward has severe issues with education quality and heavily impacts spread and distribution of information.

- A number of health metrics are of concern in Thornhill. This includes across the board higher levels hospital admission due to drug use, rank 1 mortality rate from cancer, higher than average mortality from respiratory and cardiovascular disease, higher than average hospital admissions caused by unintentional and deliberate injuries in children, higher than average all-cause mortality, lower life expectancy across the board, rank 2 for percentage of pupils with Special Educational Needs, and rank 1 for 5 year pooled percentage of school child obesity. 6.8% (verses 5.0%) of the ward reports bad or very bad health, and 10.1% (verses 7.1%) of the ward reports they are limited a lot by disability, both metrics are rank 1. This limits heat adaptability and mobility throughout the ward.
- Very low percentage of green space, 5.2% verses 13.4%, impacting the permeability of ground and natural clearance of flood water, as well as increasing urban heat island effect.
- Thornhill is rank 1 in the city for a high percentage of lone parent families with dependent children, 13.3% verses 7.2%. This may make for harder for parents to get children to a safe place during flooding.
- High percentage of resident population aged under 16 years (21.5% verses 17.3%) may cause inefficient flood preparation and management issues.

18.2 Heat Risk Assessment

As residential areas of E01017262 are primarily in Sholing ward, they will be talked about within the Sholing heat risk assessment.

Thornhill is at very high vulnerability for extreme heat. All areas primary to Thornhill ward are below the average for vulnerability. All areas of Thornhill have above average percentage of residents limited a lot by disability. A focus needs to be presented to the entirety of Thornhill to increase its accessibility such that those vulnerable are not trapped in their homes during extreme heat.

The lowest vulnerability is E01017164, followed by E01017162 and E01017170, all 5th decile. E01017164 has a low percentage of school pupils that are a healthy weight. E01017162 has high percentages of 16+ ages with no qualifications, low green space, low percentage of school pupils that are a healthy weight, and high all-ages social isolation. The first two, E01017162 and E01017164, both in the north of Thornhill present a common issue: low mobility and heat adaptability due to high levels of child obesity. These two LSOAs are a 'dark spot' for outdoor sport facilities, having none within the ward that is not a school. Accessibility and encouragement into non-school recreation grounds may improve this, or opening school recreation grounds for children to use without organisation or administration presence. This could also decrease social isolation and help to spread information. To encourage this also, clubs, events, and volunteer networks could be utilised especially for E01017162. E01017170 has high reports of bad or very bad health and high percentages of 16+ ages with no qualifications. For this reason an increased focus on social care could be utilised for spread of information and determining qualitatively what those reporting bad health could need to deal with the extreme heat going forward.

Within the 4th decile is E01017163 and E01017165. E01017165 is the less vulnerable of the two, with higher than average reports of bad or very bad health, low green space, and high percentages 16+ ages with no qualifications. A similar solution to that of E01017170 could be utilised: focusing more on social care to determine the preparation methods at-risk residents could use. E01017163 has high rates of children in need, high multiple deprivation index, high percentage of residents ages 16+ with no qualifications, high reports of bad or very bad health, low percentages of pupils that are a healthy weight, and high social isolation for all-ages and 65+ ages. Clubs, events, and volunteer networks with focus on activity and making the community more accessible could be used to decrease social isolation, improve mobility, improve health, and improve the spread of vital information on how to deal with extreme heat. Economic support for residents within E01017163 in affixing homes with heat mitigation retrofits is also paramount due to the high deprivation as affordability may be an issue, therefore investigation on a resident-to-resident basis on what residents may need is a fantastic first step.

The worst LSOAs are within central Thornhill ward: E01017169, E01017168, E01017167, and E01017166, all in the top 30% most vulnerable, in order of least to most vulnerable. These LSOAs are ranks 15, 11, 10, and 7 respectively for heat vulnerability in Southampton. All of these LSOAs have similar issues to one another, with every single one having high rates of children in need, high deprivation, high percentage of residents 16+ ages with no qualifications, low green space, high reports of bad or very bad health, and high all-ages social isolation. E01017168 also has a low percentage of

pupils who are a healthy weight, and E01017166 has a high 65+ ages social isolation. These LSOAs could utilise heightened social care to be aware of those who need aid. This has been a theme for a few LSOAs within Thornhill. Utilising values for each ward, we see rate of those in adult social care has a significant proportionality to reports of bad or very bad health, at approximately 0.58. This is strange considering LSOAs such as E01017166 and E01017167 have a rate of those in adult social care far below average. This must be focused on as it is also a fantastic avenue to determine what those at risk need to proof their residency against extreme heat, which is also recommended (for all in these LSOAs) due to high deprivation. Clubs, events, and volunteer networks could also be utilised to spread information, improve health, and decrease social isolation within these LSOAs. Emergency cooling stations are also recommended for central Thornhill, although is is emphasised heavily that these must be highly accessible locations due to a low physical mobility of the Thornhill ward population.

The Heat England 2022 Socio Spatial Heat Vulnerability Index partially agrees with this assessment. They have highlighted central Thornhill as most vulnerable. The three least vulnerable were E01017162 (average), E01017164 (average), and E01017170 (relatively high), which agrees with our assessment. Their next most vulnerable were E01017165 and E01017169 at relatively high vulnerability; while this agrees E01017165 was less vulnerable of the two, this places E01017169 as less vulnerable than E01017163 at extremely high vulnerability which is not agreed upon. Otherwise, E01017166, E01017167, and E01017168 are agreed as extremely vulnerable. The Heat England index places E01017167 as the most vulnerable and E01017166 as the second most, which is flipped on our index.

18.3 Flood Risk Assessment

18.3.1 Jurds Lake

Through Thornhill flows two watercourses, both branches of Jurds Lake. The north-western branch, running through LSOA E01017164, causes surface water flooding issues on Bitterne Road East, as discussed in the Harefield section. It becomes un-culverted running south through Bitterne Road Allotments, re-culverting on reaching Upper Deacon Road. In this location flooding can become very bad. A police officer reported: *"Junction is flooded due to the road being on a dip. The water is 1m deep and impassable. Two vehicles are currently stuck".* Southern Water has also told residents that the backup from Jurds Lake is the issue. The flooding here seems to have stopped being reported with only a few reports outside of the year range 2014-2017, therefore the issue may either have been dealt with or people have given up on reporting; this requires investigation due to the risk of it getting worse over time.

The eastern branch runs west into Thornhill culverted. On Hinkler Road this may cause some issues, with reports of the entirety of the road being underwater. Issues may also happen on Ellwood Avenue. Otherwise for this waterway, it seems to be well managed. Due to increasing rainfall, this may change, therefore is worth close attention. The primary areas this eastern branch or Jurds Lake affects residents with flooding is on the brooks that lead to it, due to them being urbanised fully with inappropriate surface water sewer capacity below. This issue is apparent on Farringford Road, where it is exacerbated by natural debris, causing up to waist high flooding that has damaged residencies.

18.3.2 Siddal Close

Although is not a SFRA projected area of flooding, Siddal Close still experiences flooding. This has been reported as about a foot deep. This has begun to occur recently, and is unclear if reports are accurate as this area may not be able to accommodate a foot of flooding. Either way, flooding here has begun to sink the ground and may cause damage to residencies, therefore warrants an investigation into potential issues.

18.3.3 Upper Deacon Road

Upper Deacon Road tends to flood in areas of high canopy cover, indicating an issue with natural debris clogging gullies. A similar issue happens just north on Barnes Road. Both roads report that this causes flooded garages and gardens, which can potentially damage houses.

18.3.4 Weston Greenway Waterway

Culverted branches that feed into the Weston Greenway waterway may be developing issues of capacity. A few reports have begun to happen in the last 2 years on a land elevation dip along Coates Road. In years approaching, flooding here may reach levels as poor as Botley Road as both are along the same waterway with Botley Road downstream. Reports on this road state multiple instances of flooding into residencies of up to a foot in height, provided pumping stations being inadequate. Flood defences, particularly flood doors, have been provided to houses here but one report states there was once 3 foot of flooding outside,

living in concern that if this gives way they will have 2 foot of flooding inside their house. The issues along this road have been reported to be exacerbated by canopy cover natural debris. Bursledon Road, although upstream from Botley Road, also experiences heavy flooding. This is at a higher level than Coates Road as it experiences heavy traffic. Flooding has been reported as high as 6-7 inches, occurring near a Paint Pots Nursery and Hightown Fire Station. Regular issues with debris also occur within Wood Close which may be related.

18.3.5 Future Projections and Ward Recommendations

Issues on Ellwood Avenue are split between LSOAs E01017163 and E01017165. Both of these LSOAs have a different vulnerability, although it is clear something must be done to support this community as both are vulnerable, with E01017163 being top 10% most vulnerable to flooding (rank 4 in Southampton) and E01017165 being top 30% (rank 27). Within E01017163 we see high percentages of lone parent families with dependant children, high percentages of pupils with special educational needs, high percentages of residents reporting bad or very bad health, high percentages of residents that are limited a lot by disability, and high percentage of school pupils of which are not a healthy weight; all of these pose serious mobility challenges and are a threat to the effective and safe usage of personal flood mitigation infrastructure. Further, residents here are above average for all-age and 65+ age social isolation, meaning the people who are at-risk and may not be able to independently utilise flood alleviation infrastructure might not have someone to depend on at this time. Finally, high percentages of children in need and high multiple deprivation means that recovery for flooding here may become a hardship, and a high percentages of 16+ ages with no qualifications held may mean information is poorly accessible. As for E01017165, all indices mentioned but the percentage of school pupils of which are not a healthy weight are also worse than average. Hinkler Road close by is also within E01017165. As for both of these cases there are no clear solutions to risk, as the dell in which they both sit is urbanised fully and therefore terracing of the waterway cannot be utilised. The surface water sewer also runs under multiple houses therefore capacity may be extremely hard to increase. If houses are to remain here, strategies to lower risk must be investigated here, and vulnerability must be reduced. Farringford Road is also in E01017165, but the affected area sits at the intersection of also E01017162 and E01017166. E01017162 is top 40% least vulnerable, while E01017166 is top 5% most vulnerable at rank 2 for flood vulnerability in Southampton. This LSOA has very similar issues to that of E01017163. Farringford Road is extremely high priority due to its high vulnerability, damage to housing, and projections to worsen.

Upper Deacon Road is in LSOA E01017164, which has issues of high rates of school child obesity and residents limited a lot by disability. This LSOA has a 5th decile vulnerability. Although its vulnerability means it may not be a priority for this ward, it has a very high risk to residencies therefore should be considered to evaluate and reduce risk.

Within LSOAs E01017167 and E01017168 is Bursledon Road. E01017167 is rank 1 for flood vulnerability in Southampton, while E01017168 is 2nd decile. Both LSOAs have a similar overlap in issues, having: high percentages of lone parent families with dependant children, high percentages of pupils with special educational needs, high percentages of residents reporting bad or very bad health, high percentages of residents limited a lot by disability, above average percentages of school children who are not a healthy weight, high percentages of 16+ ages with no qualifications, high rates of children in need, and high deprivation. Once again, these issues are similar to that of E01017163; a reason for this may be that they are adjacent to one another.

Siddal Close, Wood Close, and Coates Road are all within E01017169, with Coates Road also bordering E01017170. E01017169 has very similar issues to that of E01017167 and E01017168. Coates Road in LSOA E01017170 and also Botley Road which is within E01017170 have similar issues to E01017167, E01017168, and E01017169 also, only with above average percentage of school children that are a healthy weight. This similarity and shared vulnerability factor is a clear trend for at-risk areas in this ward. With the E01017163, E01017165, E01017166, E01017167, E01017168, E01017169, and E01017170 all having the same vulnerabilities as one another, ward-wide work can be done to decrease vulnerability. This can be started by installation and resident education on personal flood defences in at-risk areas in Thornhill, such as flood doors and water pumps, that are accessible to those of lower mobility and making sure specific residents have someone that can aid them; if not social care can be utilised. Clubs, events, and volunteer networks can be used to make the ward more accessible and less isolated. Increased drainage and more permeable ground can also be used to reduce risk. Finally, due to a high rate of school absences and high suspension rate from schooling, highest in the most vulnerable

areas (central Thornhill: E01017163, E01017166, and E01017167), an investigation into and acts towards the improvement of education in this area may decrease vulnerability. High levels of communication and effective follow-through in all at-risk areas needs to happen with residents of these areas to avoid frustration.

The Flood England 2022 Socio-Spatial Flood Vulnerability Index agrees with this assessment. At very high vulnerability is E01017163, E01017166, and E01017167. The order of vulnerability is agreed upon by us, with E01017167 being worst, followed by E01017166 then E01017163, although their ranking could be argued as acute vulnerability. In relatively high risk is E01017165, E01017168, E01017169, and E01017170. Their order of vulnerability is also agreed upon. Finally, E01017162 and E01017164 are both average vulnerability, and their order is also agreed.

19 WOOLSTON

19.1 Ward Profile

This ward contains LSOA neighbourhoods: E01017273 except from a northern portion, E01017274, E01017275 except from the northern tip, E01017276 except from the north-west and north-east tips, E01017277, E01017279, E01017280, E01017281, E01035446, and E01035447. Where appropriate, LSOA data will be discussed.

Figure 27. The LSOAs of Woolston.

Compared to the city average, the ward itself has a few indices that may make neighbourhood climate adaptation harder:

- E01035447 has a fantastic EPC A-C rating percentage, at 75.9%. The rest of the ward, with older builds, is lower at an average of 45.7%. Its minimums are the northernmost LSOAs, with E01017275 being the lowest at an (A-C)% of 32.3%.

- Woolston is a deprived area. E01017274, E01017280, and E01017281 are all among the top 10% most deprived areas, with the latter two being the 3rd and 2nd most deprived areas in Southampton respectively. E01017276 is also within the top 20% most deprived.
- E01017276 is in the bottom 20% for households wherein one person speaks English. Otherwise, Woolston has a high percentage of English speakers.
- The south-east of Woolston is very socially isolated, particularly for all-ages. E01017274, E01017280, and E01017281 are all top 10% most isolated for all-ages, with E01017275 top 30%. For 65+ ages, E01017274 remains top 10%, while E01017280 and E01017281 are now top 20%.
- Woolston may be affected by inadequate eduction quality which may be of detriment to spread of vital information. 18.6% (verses 17.3%) of those aged 16 and over have no qualifications, just 27.3% (verses 31.6%) aged 16 years and over have level 4 qualifications or above, the ward has 9.1% (verses 8.1%) overall absence from school and is very persistent, and Woolston is rank 1 for overall suspensions from school (28.6 verses 10.3 per 100 pupils).
- Woolston has a number of health problems that may be detrimental to heat adaptability and safety in a flood due to poor mobility. 8.7% (verses 7.1%) are limited a lot by disability and 5.6% (verses 5.0%) are reporting bad or very bad health. As well as this, all cause mortality is worse, life expectancy is lower across the board, ages 65+ are hospitalised more for falls, and there are more inpatient admissions for drug attributable mental health disorders.
- High percentage of resident population aged 65 and over (15.3% verses 14.3%) may cause in-adaptability to heat extremes and low mobility during flooding.
- High percentages of lone parent families with dependent children (9.4% verses 7.2%), as well as a high percentage of population under 16 (20.8% verses 17.3% may limit ability to be efficiently prepare and evacuate during a flood.
- High percentage of resident population aged under 16 years (20.0% verses 17.3%) may cause inefficient flood preparation and management issues.

19.2 Heat Risk Assessment

Woolston has heat vulnerability primarily in the south-eastern area of the ward. E01035446 and E01035447 are both 8th decile vulnerability, E01017277 and E01017279 are 7th decile, and E01017273, E01017275, and E01017276 are all 6th decile. The south-eastern LSOAs E01017274, E01017280, and E01017281 are all 3rd decile and ranked almost adjacent to one another at ranks 8, 9, and 6 respectively for heat vulnerability in Southampton. They are ranked close due to their similar issues to similar degrees. Each of these three LSOAs has issues of high rates of children in need, high deprivation, low percentages of residents aged 16+ with no qualifications, high percentage of residents limited a lot by disability, high reports of bad or very bad health, and high all-ages and 65+ age social isolation. The first priority is to investigate what residents here can utilise to proof their house against extreme heat; due to high deprivation they may not be able to afford to make these retrofits without help. Improving of community is also necessary; clubs, events, and volunteer networks here can aid in the: spread of information, decreasing of isolation, improvement of health, and improvement of accessibility throughout the area to make those who report disability limitations more mobile. Increased adult social care can also be implemented in these LSOAs too, particularly E01017280 and E01017281, which are below the average for adult social care usage. Emergency cooling stations can also be used for those vulnerable.

The Heat England 2022 Socio Spatial Heat Vulnerability Index partially agrees with this. E01017274 (relatively high), E01017280 (extremely high), and E01017281 (acute) are the most vulnerable with exception to E01017276 which is more vulnerable than E01017274 and ranked relatively high vulnerability. This is disagreed, although E01017276 is ranked our fourth most vulnerable. Further, it can be argued that E01017274, E01017280, and E01017281 ranks rather as acute based on our index. E01017273, E01035446, and E01035447 are also relatively high vulnerability although the latter two we have ranked in the 8th decile therefore is heavily disagreed. E01017275, E01017277, and E01017279 are all average vulnerability; this is agreed upon.

19.3 Flood Risk Assessment

19.3.1 Estuarine and Fluvial Flooding Risk

There is a high risk from type 2 estuarine and fluvial flooding in neighbourhoods below Shoreburs Greenway west of Archery Road from Southampton Water and the River Itchen. These are protected by the permeable ground of Weston Shore, but otherwise do not have defence. It is recommended to investigate shoreline flood risk at this location to assess if and when flood defences are appropriate to invest in. As it is a type 2 risk, this is projected at a 0.1-1% probability to annually flood, therefore is less than other areas such as Northam (Bevois) which is primarily type 3 (>1% probability), but at risk nonetheless.

19.3.2 Hazeleigh Avenue

Works on Hazeleigh Avenue were done to reduce surface water flooding, but they clearly have not been enough. There is a vast number of flood reports along this road, most of which are contained within a SFRA projected area of flooding. This area is within a slight dip in the road. Flooding has been reported consistently at 6-9 inches, and has affected residencies gardens, with some residents concerned at the risk of interior home flooding. One resident reported: *"In 2018 the flood waters washed away our garden walls resulting in expensive rebuilding works"*, which is unacceptable as not only caused damage but could cause damage further to the main structure of the residency. One resident even reported they cannot get out of their house.

Communication with a council specialist highlighted that these works were investigation by Southern Water and gully installation by Balfour Beatty. CCTV analysis has since revealed investigation was conducted in the wrong area, and is most likely an infrastructure issue. It was also communicated trial pits and sounding are required to locate the line and restore connection, which is set to be completed.

19.3.3 John's Road

Flooding on John's Road is contained in a SFRA projection for flooding. This is reported to be due to blocked drains elsewhere causing water to flow to this low-point from other roads. This leads to the drains on this road being overwhelmed and not being able to take in more water. Gullies also may become blocked on John's Road, exacerbating issues of surface water flooding. One report stated the flooding became so high that water gathered around and came into residents properties.

19.3.4 Jurds Lake and Victoria Road

Jurds Lake runs un-culverted south-west-west along Woolston ward, and has caused little issue. Towards the shore it becomes culverted and causes heavy flooding on Victoria Road, reported as up to 6-9 inches. This is due to overflow as the sewers do not have high enough capacity to deal with both Victoria Road and Jurds Lake, especially during rainfall.

19.3.5 Kingsclere Avenue

Kingsclere Avenue has begun to get a number of reports recently. This area sits in a land dip therefore this may be the cause, leading to overwhelmed drains and or high debris flow into the drains.

19.3.6 Newtown Road

Flooding on Newtown Road may occur primarily on areas where road elevation gradient stagnates. Further, these reports seem to be primarily due to debris, which is not validated by the lack of canopy cover nearby but is validated by the nearby school which may cause increased sediment onto the road due to it being busy during the school run. One report towards the east of the road says: *"In July of this year the heavy rain and amount of water on the road just pushed straight into our driveway and then flooded the whole downstairs of our house resulting in all floors being ripped up, appliances and furniture being disposed of"*. This is very poor, and risk to flooding here needs to be investigated.

19.3.7 Obelisk Road

Flooding occurs on the Obelisk Road junctions with Longmore Avenue and St. Anne's Road, as well as in-between houses 139 and 163. In-between these residencies, gullies are routed into an older foul sewer, and gullies become regularly blocked with a high level of debris in the sewers; updating these gullies to feed into a surface water sewer may eliminate risk here. Both junction areas also report specifically debris clogging the drains.

19.3.8 Swift Road

On its junctions with Bedford Avenue and St. Anne's Road, Swift Road has a collection of flood reports. For the former, this may be due to land elevation changing by negative 4 meters from one end of Bedford Avenue to the other, running into an area of stagnation on Swift Road. It may also be due to its proximity to Jurds Lake, feeding the surface water sewer into the waterway directly below this gully, therefore it may be causing tide locking or overwhelmed drains attributable to Jurds Lake. For the latter, due to a 2.5 meter difference in elevation between St. Anne's Road and Swift Road which changes gradient where reports are showing, this may cause a pooling of sediment and debris on this 'flatter' area, therefore causing gully blockages.

19.3.9 Future Projections and Ward Recommendations

As a preliminary statement, one stated that it was found that some sewer pipes in Woolston are small in diameter and degraded, which may explain a noticeable increase in reports within the ward. This must be addressed as a primary issue for the ward.

Hazeleigh Avenue is in LSOA E01017273. This LSOA is within the 7th decile for flood vulnerability, but with significantly high residents limited a lot by disability and higher than average adult social care, risk must be eliminated. Obelisk Road is also in E01017273 but also is within LSOA E01017275 as the roadway is on the border. E01017275 has the same issues as E01017273 and is also 7th decile.

John's Road is primarily in LSOA E01017276, within the 5th decile. Making sure blocked gullies that affect John's Road do not become blocked is the primary recommendation for this case, as vulnerability indices are generally average and uniform in this ranking. The largest vulnerability is the above average deprivation which may impact recovery from flooding, but eliminating risk means recovery cost is not a concern.

Affected areas of Newtown Road are primarily in LSOA E01017277, but also may affect a small area of E01017274. These bordering LSOAs are widely different in flood vulnerability, with the former being 6th decile in Southampton and the latter being 2nd. For this reason it is hard to know the true vulnerability of those than are affected without an increase in data sample area resolution. The risk to housing is still great though, and it is recommended these roads and or drains are regularly cleared to eliminate risk.

Swift Roads affected areas are in LSOA E01017279 but may also affect those in E01017275. E01017279 also has a risk of estuarine flooding. Both of these LSOAs are within 7th decile vulnerability therefore is not a priority, although increased drainage capacity may be utilised in key areas to eliminate risk for surface water flooding. As for estuarine flood risk it may be appropriate to invest in coastal flood defence in the future, or strategic flood management by utilising Weston Shore City Park more effectively where channel and pond infrastructure can be built that can redirect water back into Southampton Water. Victoria Road is within LSOAs E01035446 and E01035447, both LSOAs which also have a estuarine and fluvial flood risk. Being closer to the shore, you can no longer depend on amendments to Weston Shore and another solution needs to be used. Once more vital flood defences, such as for Bevois, are completed, it is recommended to complete on-the-ground work to seek solutions also for this area.

Kingsclere Avenue is within LSOAs E01017280 and E01017281. With it beginning to get a larger number of reports due to land dips, it is recommended to increase drainage to this area and regularly clear gullies if possible. This is high priority to eliminate risk due to the high vulnerability, with E01017280 being top 15% most vulnerable and E01017281 being top 5%. Due to a single source risk and a complex vulnerability (high rates of children in need, high percentage of lone parent families with dependant children, high percentage of 16+ ages with no qualifications, high percentage of residents reporting bad or very bad health, high percentage of residents limited a lot by disability, 65+ age and all-age social isolation, high deprivation), it is recommended to reduce the risk here such that there is no damage to residencies.

The Flood England 2022 Socio-Spatial Flood Vulnerability Index partially agrees with this assessment. Both indexes rank E01017281 as the most vulnerable in the LSOA, although with the Flood England index ranking this area as very high vulnerability it could be argued its vulnerability reaches acute. E01017280 is the next highest at relatively high vulnerability which is also agreed. E01017273, E01017274, and E01017276 are all approximately equally ranked as the highest after E01017280 and E01017281, but this is disagreed. E01017274 (2nd decile) has been ranked just underneath the vulnerability of E01017280, with E01017276 and E01017273 being far less vulnerable at 5th and 7th decile respectively. E01035446 and E01035447 have been ranked next at relatively high vulnerability but this is not corroborated due to their 7th and 6th decile vulnerability. Finally, E01017275 (7th decile), E01017277 (6th), and E01017279

Flood Investigation Process

FRM will likely follow the process outlined below when flood incident reports are received. The responding officer will then establish whether a desk-based or Section 19 Investigation will be carried out.

1. A flood incident is reported to Southampton City Council.
2. The corresponding officer will review the information provided to determine whether the incident meets the threshold for a desk-based or Section 19 Investigation. If the incident does not meet the threshold for an investigation it will be recorded on the Council's flood records.
3. If the incident meets the threshold for an investigation, the corresponding officer will contact the reporter to gain any further information including photos and/ or videos of the incident.
4. The corresponding officer will determine the appropriate action(s) which could include: contacting the relevant Risk Management Authority(s), conducting a site visit, raising the incident at the Surface Water Drainage Board or Flood Risk Management Board, amongst others.
5. The corresponding officer will draft an Investigation Report.
6. The Investigation Report will be circulate to all relevant stakeholders for review and will update the report with any necessary revisions e.g. actions undertaken.
7. In the case of a Section 19 Investigation, the final report will be published online at www.southampton.gov.uk.

Figure 28. The flood investigation protocol, taken from the Flood Investigation Protocol.

(7th) are agreed upon, having an average vulnerability, although their order of vulnerability is different to our ranking, with their least vulnerable out of the three being E01017277 and most being E01017279, and ours being E01017275 for least and E01017277 for most.

20 CONCLUSIONS AND MITIGATION STRATEGY RECOMMENDATIONS AND PRIORITY

20.1 Lessons Learnt: Where Will Get Worse?

20.1.1 Regular Flooding due to Debris

Throughout a vast majority of Southampton's neighbourhoods, regular flooding is occurring due to debris and sediment. In areas of high canopy cover and green space, the solution is not to urbanise these areas, as this will increase urban heat island effect and cause the ground to be non-permeable, which may increase flooding. Widening sewer piping throughout the city is also an unreasonable solution, as this would cost a vast amount of money, kneecap the cities economy due to heavy road works, and would be physically impossible in some areas as this would cause damage to listed and protected buildings. The issue here may start with Southampton's response to flooding. Figure 28 shows the procedure undertaken when a flood report is received.

The issue of a threshold for flooding investigation is that a lot of the time reports have shown hidden dangers to people. This can manifest as issues such as icy conditions that may develop due to flooding, inaccessibility for those with limited mobility, or areas that can be a risk to pedestrians attempting to avoid the flooded area by walking into the road. Further, this process passes flood reports through various departments and people; context can be lost. This has caused recurrent issues in neighbourhoods with surface water flooding that has damaged houses, property, and seen a few reports threatening legal action. An investigation into *why* should be conducted, but investigations do not eliminate immediate danger for residents, especially considering the rise of flood events and extreme weather due to climate change. One solution to this is regular clearing of gullies around the city, but equality in gully treatment with wide coverage can become economically detrimental. For this reason, we can instead rely on residents themselves to call in suspected blockages. Therefore, my recommendation for this issue is a dedicated team in Southampton that occupy gulley suckers and equipment to clear gullies that residents can call.

This is of concern of Southampton City Council *and* Southern Water, therefore could be funded by both. This used to be a part of the highways team, but since has seen cuts and is now not in practise. With this issue becoming more prevalent this funding must return, at least seasonally when autumn and early winter see natural debris in form of leaves.

Further, an on-the-ground report could even aid the investigation process and give some contextual information. In both cases of natural and anthropogenic debris, a flood response team could identify flood causes by eye and make note of cause and recurring areas, increasing their efficiency to operate and possibly identifying solutions that cannot be reached by desk investigation. There are also some areas where regular flooding occurs that is not caused by blockages, due to issues such as tide locking or inadequate sewer capacity. These are separate and harder to fix issues entirely, and if not fixed then advice, support, and protection could be given to the calling residents as a temporary aid. If the gully does not clear on rainfalls end or lower tide then, or the gully itself is visibly silted up or blocked, then it should still be investigated. To avoid overwhelming the team too, residents could be told that others have also called about this issue recently, and then told the steps the council is taking to fix the issue and why.

Regular flooding due to debris can also occur due to human-made debris, such as litter. This is particularly evident in schools and nightlife areas. A solution to this as far as schools go is information and learning materials distributed to schools, to educate children and parents. As well as this bins in and around the schools can be very effective, as not only is it children causing this mess, but adults too who may be eating while waiting for their child to finish school. Nightlife areas are known to Southampton council and a campaign to increase bins here could be launched which will decrease surface flooding and drain blockages. Funding attainment could be aided by a investigation into whether bin density in nightlife zones has a bearing on flood reports. Further, flood reports have indicated this may also happen due to oil disposal via gulleys, a practise that must be investigated when oil is flagged as a causation of blockages, and it must be clear to businesses in these zones that they will be investigated by the council and they will be fined.

20.1.2 Man-made Flooding Hot-spots

A number of unavoidable anthropogenic hot-spots for flooding exist, primarily due to the build up of debris in these areas. The most noticeable driver of these hot-spots are busy roads. Busy roads with high rates of traffic deposit sediment attached to cars into gullies and faster rates, lowering the capacity of sewer pipes making them more susceptible to being overwhelmed or blocked. Debris that is moved by cars can also make its way into the drains more often, including non-natural debris. This causes some roads become blocked as they are a highly important through-road for trade and work travel, such as motorways and dual-carriageways through the city. Bridges are also an example of a busy road hot-spot, as they are a choke-point for traffic travelling across a natural obstacle. Bridges also at either end often have sudden change in elevation causing stagnation of sediment and debris, causing blockages. This is shown in Southampton, with every one of Southampton's bridges having multiple flood reports on and or at either side. Due to the school run, roads adjacent to schools also show a large number of flood reports. Finally, most likely due to sharp turns dislodging debris from vehicles, junctions often had higher reports of flooding. This may also be due to surface water sewer pipe junctions too being easier to block; in this case shallower turns in underground pipes may cost more but make fluid flow smoother. A general solution for these areas of sediment and debris is regular maintenance.

A number of reports have also shown that construction and development can cause gully blockages. Even if rubble is not deposited in gullies, drains may become blocked due to the large amount of sediment and dust construction can leave behind. This is unavoidable, therefore making note of areas of construction such that their drainage can be evaluated a few months after is a proactive solution to prevent disaster in these areas during a storm.

Another source of high amounts of sediment is gravel and dirt car parks, which can attach sediment to cars to block nearby drains. Green space, although good for flooding due to permeable ground, can also block gullies due to natural debris and dirt sediment. For these more permanent areas, gravel grids can be used at the edge of both to stop the travel of sediment. Gullies can also be located in areas not shaded by trees to avoid natural debris blockages. If pipes are too close to trees too, roots from the tree can burrow into the pipe causing leakage and damage to the pipe, which can lead to high soil saturation, which causes groundwater flooding and can sink land. Another solution is the use of sustainable drainage systems rather than gullies in these areas with high levels of debris. Finally, being aware of these gullies at risk to blockages can be vital, as they can be subject to regular maintenance rather than being left to clog.

Being a low-point, subways are also a hot-spot for flooding. Flooding here can be aided using pumps, re-routing water flow, or installing flood barriers. Otherwise, they are hard to keep not flooded. For this reason it is suggested to instead invest in above ground pedestrian bridges across roads as an alternative.

Outdated foul sewer systems that also deal with surface water found throughout Southampton, particularly as mentioned on Portswood, which can cause tide locking, overwhelmed pipes, and more blockages than a dedicated surface water sewer line. This is due to a number of reasons. One is that they deal with far more sources of water input. Another is that the knowledge and technology is far greater now than then, particularly where to run them; they tend to run in lines along roads rather than following land elevation. The large and old foul sewer lines also handle far greater areas of sewers too, meaning they handle a greater water influx during storms. Finally, degradation over time can limit the functionality of these sewer lines and cause leaks and blockages. All of these can cause a higher pressure in the sewer line which leads to the above issues. A solution to this is installation of modern surface water sewers and re-routing of gullies to these lines.

Similarly to this, there are many small areas throughout the city of degraded or even defective sewer infrastructure, such as previously mentioned in Woolston and particularly on Hazeleigh Avenue. These areas of regular flooding must be investigated and flagged for improvements if an issue is seen.

20.1.3 Land Elevation Causing Flooding

Concentrations of flood reports occur heavily in areas where the road goes from being sloped to flattening out; all it takes is for a piece of land to be low in relation to the land around it. This is because sediment and debris settle here, as when transported by vehicle or person displacement, rainfall, or wind, sediment and debris have gravitational force moving them downhill. When this downhill flattens or becomes a more shallow slope there is less force moving them along, therefore they stagnate. This point of stagnation also often happens to be where gullies are, as gullies are designed to be at low-points where water flows into. This is particularly bad in low-points of multiple sides, or an urbanised dell. Surface water sewers running along these dells can aid flood mitigation, but up to a set capacity, as culverted waterways limit the flow of water and cause high pressure in the system if overwhelmed, leading to backwash. Debris may also go downstream to these low-points, stagnating and causing gulley blockages. There is no widespread solution for these areas, but recurrent problems may be investigated to find a solution. It could be any issue from tide locking on sea level, debris from high vegetation, sediment from busy roads, overwhelmed drainage, or bad sewer gradients. As for debris and sediment, this can be aided by regular gully maintenance; solutions to other causes are more expensive and permanent. Increased drainage and sewer capacity could be utilised to aid overwhelmed drainage, but this is costly to implement and unpractical if underneath residential houses or listed buildings. This issue, as well as poor pipe gradient, can be aided by re-routing piping or providing an alternate route for water to travel. Finally, tide locking can be aided with flap valves to make water only travel one way, or a pump system (which would also aid poor gradient pipes) such that water can still be drained during high tide.

On a larger scale, culverting open watercourses is not good to avoid flooding. For example, in Daisy Dip, the watercourse has been culverted but land gradient has not changed, meaning that water still pools. Another example is Oakley Road, wherein Tanner's Brook goes from open to culverted making it more vulnerable to blockages and in heavy rain also limits flow with or without a blockage, and has flooded nearby buildings. In this larger scale, two solutions present themselves. The first is opening up these culverts, causing a larger gap for water to flow increasing its capacity. In places, this is unreasonable though as, for example, on Millbrook Road West if you opened up Tanner's Brook to be larger then it would cost a lot and disrupt vital economic road traffic. Rather, we can look further upstream to a second solution, to rather increase water storage capacity and slow down flow, as if the water is fast and greater quantity then it has a higher capacity to flood due to momentum. Staying with the Tanner's Brook example, we can use Lordsdale Greenway as storage, by creating terraces off from Tanner's Brook for water to go during heightened flow, naturally storing water. You can also reroute the waterway by making it instead wind downstream rather than flow straight, which would also reduce flow speed. Both would prevent Tanner's Brook from flooding downstream by naturally managing its own water flow. This specific example is of upmost importance as in-between Holly Brook and Tanner's Brook is the General Hospital, and a flooding event here could risk knock on effects to the entire city. A similar approach can be taken in Lordswood Greenway, Lordswood, Bassett Wood Greenway, Shoreburs Greenway, Weston Greenway, and Southampton Common.

Large swaths of land with lower elevation also used to be mud flats. Mud flats are formed by the

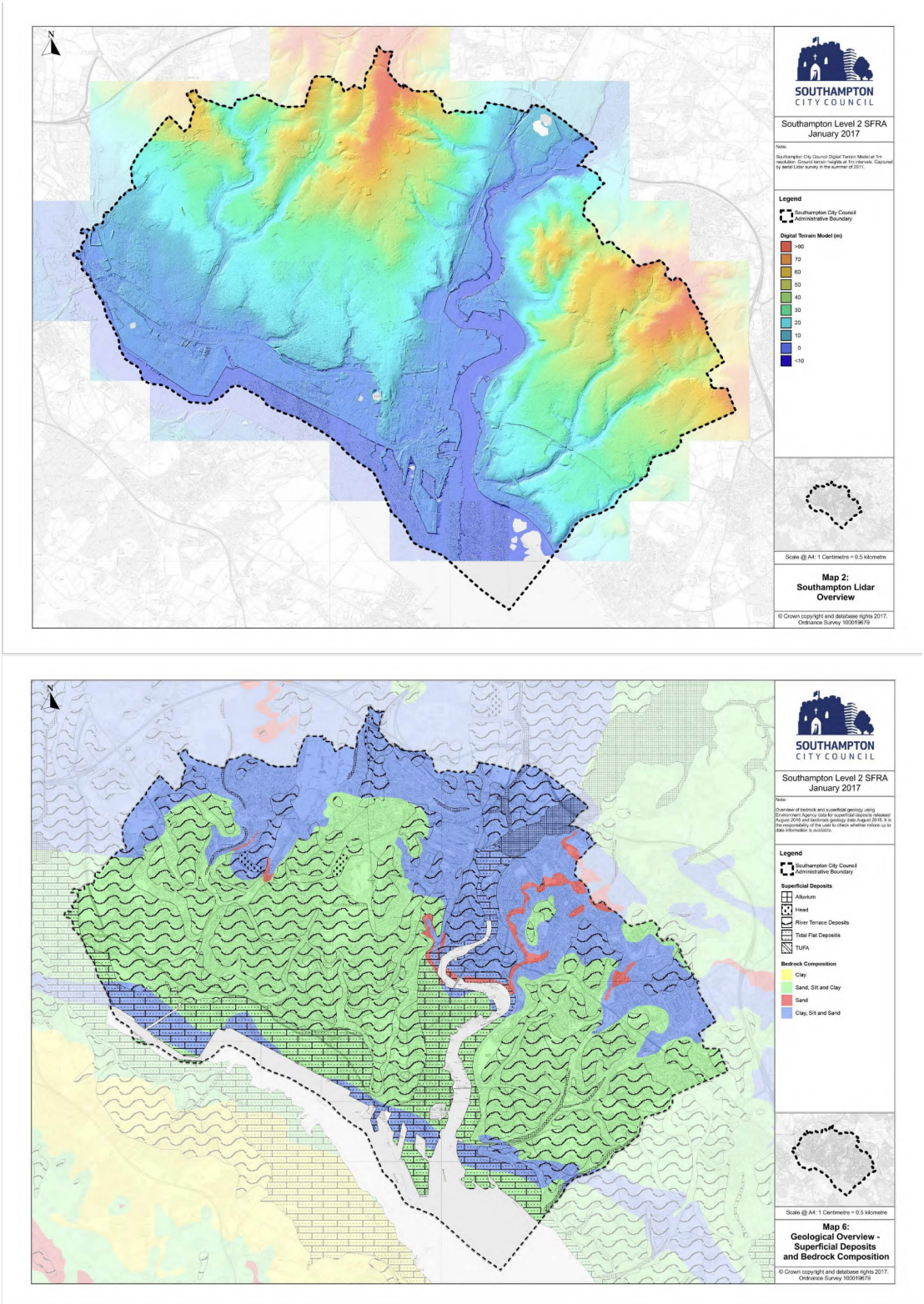

Figure 29. LiDAR and Geological survey of Southampton respectively (Southampton City Council, 2017*b*).

depositing of fine sediments on low flow coastal areas. Mud flats are regularly flooded in nature, as is their purpose - they store water. If this water storage is eliminated, the pressure against the now non-permeable structure there is extremely high. Southampton's ancient mud flats can be seen using two resources: LiDAR elevation and geological survey, shown in figure 29.

Here we can see the flood risk a large amount of Southampton faces from fluvial sources due to it's lack of mudflats. This will only become worse over time, and does not only risk the industrial south coast but also a majority of Redbridge, Bargate, Bevois, Bitterne Park, Freemantle, Millbrook, Portswood, and Woolston. These are places that cannot relocate, therefore flood defence and preparation for these still low areas is necessary. This starts with Bevois as Northam is a highly at risk area, continuing with Redbridge which also needs aid with tide locking from the River Test. Other areas then must be evaluated for priority. While Bargate is very at risk, the shared surface water and foul sewers in Portswood often experience tide locking leading to surface water flooding, and Bitterne Park, Freemantle, Millbrook, and Woolston also have large communities built upon mud flats.

Assessing flood vulnerability and risk suggests the priority for flood defence (including areas that are not built on mud flats) may be Bevois, then Redbridge, Portswood, Peartree, Bitterne Park, Woolston, and Bargate, but how this will change and recommendations beyond this are unclear and needs investigation. Another side effect of building on mudflats is that due to the elevation stagnation, there seems to be far greater surface water flooding reports at the foot of this elevation, i.e., where the historical mudflats begin. Alike the suggestion for low-points in land elevation, increased drainage and sewer capacity could be utilised, as well as greater focus on gully maintenance.

20.1.4 Flood and Heat Information

For both flooding and heat risk, the lack of spread and availability of information is a big issue within Southampton. This may be due to a number of factors. A low percentage of households that have one or more persons with English as a main language means information (primarily in English) will not reach these people who cannot speak English. Being able to translate this information is paramount to aiding these communities; this can be done using a translator app, or preferably a dedicated employee who can analyse qualitatively what cultures and languages make up a specific community. A low percentage of residents aged 16 and over with no qualifications may also impact information accessibility, being less enthused to research on climate crisis and its impact on them (Hoekstra et al., 2024). Finally, social isolation may impact information accessibility due to a large amount of spread information being word-of-mouth. The broadest suggestion has been the council funding and encouragement of clubs, social events, and volunteer networks in multiple different formats, which can decrease isolation in a neighbourhood. The primary four drives for a club has been a focus on older ages which should involve light activity with plenty of sedentary breaks, a focus on youth which should involve all ranges of activity levels, a focus on other languages and cultures which should include opportunity for those external to the language and culture to interact with people and practises of those languages and cultures, and a focus on accessibility which should include making the surrounding neighbourhood more accessible for those of limited mobility and poor health. A Venn diagram of recommended areas to use this approach can be found as figure 30. From figure 30, you can see that recommendations were scarcely made with a singular vulnerability. All recommendations with culture and language also had a focus on older ages, which is not expected as percentage of English speakers within a household and 65+ ages social isolation have a low-moderate negative correlation (-0.25). The LSOAs outside the Venn diagrams borders are those in which it was recommended generally to have clubs, social events, or volunteer networks with no particular focus. There are also LSOAs in which need to be reduced in crime rate, such as E01035445, as residents may not feel safe going to these social spaces.

A product of information disorganisation would be that some may not be able to prepare for floods or heat, or effectively deal and recover from it when it happens. They may also not know where to go if they do not know how to deal with it. For example, St Denys is a high risk area for flooding due to low capacity old drains in Portswood that cannot deal with storms, and residencies have door barriers, but these not working as intended and it is suspected by the council this is due to improper use. Continued community engagement and topical education can make them more effective. Further, similarly to discussions of a flood phone line that residents can call, during a heatwave a helpline can be implemented that allows struggling residents to call for advice of how to deal with extreme heat. Taking this a step further, those mobile can be given advice on where to go and those with mobility issues can be aided physically rather than over the phone to give needed support. As heatwaves are predictable and not year round, a network

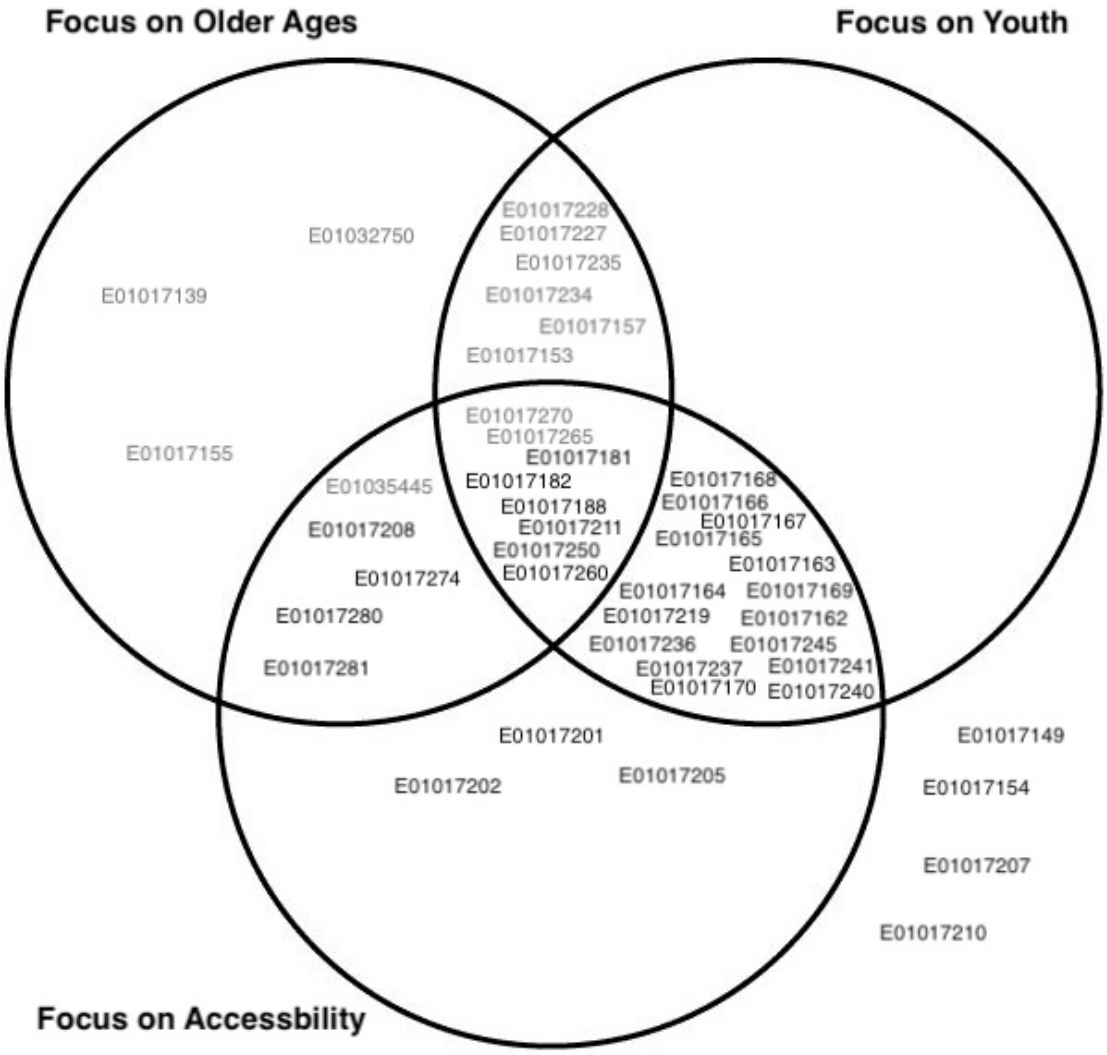

Figure 30. A Venn diagram of recommended LSOAs for clubs, events, and volunteer networks and for what reason. Grey coloured labels are for LSOAs which also require a focus on different cultures and languages.

of heat related illness volunteers or temporary workers can be utilised for staffing.

20.2 Limitations

20.2.1 Foreword

A large recommendation of this study is to gather more information where necessary. The following section is about areas where it has been identified more data is required, it is beyond this projects current scope, and a future study would be appropriate.

20.2.2 Effectiveness of Information Gathering

It was raised by Southampton City Council survey workers to this project that there are true struggles with even houses that contain people who do not speak English, and being able to reach them to survey. Further, some areas of isolation, especially those with older populations, were reported by council surveyors to not answer the door. Reasons for this may be feeling unsafe, mobility, or distrust due to a fear of scams. Information from these groups may be missing from surveys. It is also recommended to investigate whether these groups, particularly migrants, produce less flood reports, relating to information

accessibility and those dealing with flooding not knowing where to report flooding. This idea came to mind as not one flood report was in a language other than English, although 1 in 7 Southampton residents do not have their main language as English. A future study could be done with high resolution datasets to determine this correlation. A dataset of longitude and latitude locations of flood reports could be counted into LSOA sets. The count of these reports could then be used with the percentage of English speakers and or isolation in an LSOA to see if a correlation exists.

20.2.3 Investigation Into Debris Hotspots

Another study which could be appropriate is to determine more sources of debris such that these areas can be aided. A few areas have been speculated on throughout this report but have seen no consistent evidence. One is if the absence of bins causes more flood reports. Another is social areas such as health centres and activity venues; an example of the former would be the Living Well Partnership (Weston Lane Surgery), wherein a collection of reports were seen with one stating that: *"they have disabled clients who can't access first floor because of this"*. Bin and social area location and flood report hotspots could be compared to see if a correlation exists. During tide locking in sewers, gullies may also expel sediment onto the road. Non-fluid halted traffic may also deposit more debris in specific areas than fluid moving traffic which widely disperses sediment and debris along the road; this may cause traffic lights to have more debris issues. A study which samples the amount of sediment around tide locked drains verses functional drains and examines reports of flooding around busy road traffic lights may be appropriate.

20.2.4 Missing Data

Some data is also missing on an LSOA level. This was identified as:

- Rate of new care request contacts where one of the three outcomes was Care Act Assessment Required per 1k population aged 18+
- Rate of people with a current Adult Social Care service per 1k population aged 18+
- Rate of Children In Need per 10k 0-17 population
- Rate of alcohol affected crimes per 1k population
- Rate of anti-social behaviour incidents per 1k population
- Rate of domestic abuse related crimes per 1k population
- % Persistent Absence Primary
- % Overall Absence Secondary
- Percentage of pupils eligible for Free School Meals (FSM)
- Percentage of pupils with Special Educational Needs (SEN)
- Suspensions Rate (per 100 pupils)

In select LSOAs, this data was not present. This can be as the data value is so low that it cannot be shown. There are also some groups of data that has not been gathered. One of the most important ones relating to this is homeless concentration, i.e., areas that are popular, particularly for sleeping, among the homeless. This is important as they have low mobility and their wellbeing could be at-risk during heat, drought, or flooding events.

20.2.5 Buildings and Infrastructure

Another missing data group is in-depth buildings and infrastructure data. Sewer pipe size is one that could aid the council in seeing poor capacity pipes. A scoring index of houses and surrounding areas that are hard to navigate for those of limited mobility could be useful in determining areas that need investments for those of limited mobilities' safety. Data about specific residencies' insulation, heating system, and flood defence can tell us how proofed a building is for heat and flood. EPC rating data exists for the city but is unreliable as buildings not rented or bought after October 2008 do not have EPC ratings. Knowledge on if a specific house is rented or owned can tell if a low deprivation household is likely to make retrofits to flood and heat proof the house. This data is particularly important as we already know

a lot of information about specific building types and their effectiveness to deal with heat and flooding, as well as their ability to be retrofitted. With increasing population leading to housing demand and little space for sprawling development within the bounds of the Southampton unitary authority, most new builds within our border tend to be flats. Flat blocks, especially those built in the 2000s and 2010s, tend to have a large amount of windows and glass comparatively to low density housing which contribute to high heat due to injection of solar radiation into the indoor spaces. Flats also tend to have single cavity natural ventilation, which sports a far worse air turnover rate than intake-outlet natural ventilation, causing hotter temperatures within. Older, post-war housing stock is also not built for hotter temperatures. They were built quickly which lead to poor orientation, smaller rooms, and low shading, as well as having little insulation due to lower fuel prices in that time period. These houses, as well as those older, may also be hard to retrofit due to deterioration or a proximity to vital infrastructure such as a rail line, or they may even be heritage assets, areas of archaeological interest, or areas of ecological sensitivity, which cannot be added upon. Historic England (2024) has guidance for historic building retrofits that should be considered. Working on identifying these buildings and if they have been retrofitted, as well as if and how they can be retrofitted such that we can effectively aid residents is key.

20.2.6 Economic Mobility

An economic mobility index, i.e., the ability of an entity to improve their economic status, would also be useful. In place of this, we have multiple deprivation index, and qualification indices such as 16+ ages with no qualifications which is useful as qualification level is proportional to income (Social Mobility Comission, 2024). This would be directly useful for extreme climate event risk as this gives an insight into the ability for a residency to improve their multiple deprivation index, move home, or make retrofits over a long period of time.

20.2.7 Comments on the Heat and Flood England Index

Throughout this report references to the Heat and Flood England index have been made. This index utilises England wide data from the Office for National Statistics. For this study, our index was based upon Southampton Data Observatory data. Therefore, both use some different data. The England indexes drew from far greater sources of data as well as utilising weighting for different indices, while our index used local data where possible and was not weighted. Both measure vulnerability through different data structure, and the benefit of comparison is validation, i.e., if an area shows an extremely high vulnerability on both indexes then there is a clear vulnerability in this area. For future work, my recommendation would be the combination of both datasets. This would draw from both Office for National Statistics surveys and local surveys to create a more precise index. A good starting point would be the investigation into index label weighting, and to see if all required data has been released by the Office for National Statistics after May 2023, to reflect the new LSOA structure in Southampton.

20.2.8 Investigation Into Unknown Issue Causes

Throughout the report some areas were recommended to be investigated as through data and mapping tools issues were seen but not given a definitive causation. It is recommended to conduct specialist on-the-ground analysis of these locations.

20.2.9 Limitation Conclusion

Because of the limitations this study faces, it is recommended to conduct a larger study into climate risk and vulnerability over a longer period of time to either address these limitations or compile them once addressed separately. This should be conducted within the next few years, preferably when significant progress or even finalisation is made to both the River Itchen Flood Alleviation Scheme and data incorporating new LSOAs.

20.3 Specific Priority

20.3.1 Heat

Without in-depth buildings data, it is hard to evaluate specific areas of heat risk. Without the usage of EPC ratings, due to their unreliability explained in the data sources section, the only evaluator of risk we have is percentage not green space. We assume the city gets uniformly hot throughout time with the only variance being heightened temperatures in areas of higher urbanisation.

There are particular areas that have small amounts of green space. Within the top 5 wards are Freemantle, Bevois, Coxford, Banister & Polygon, and Harefield from least to most. As percentage green

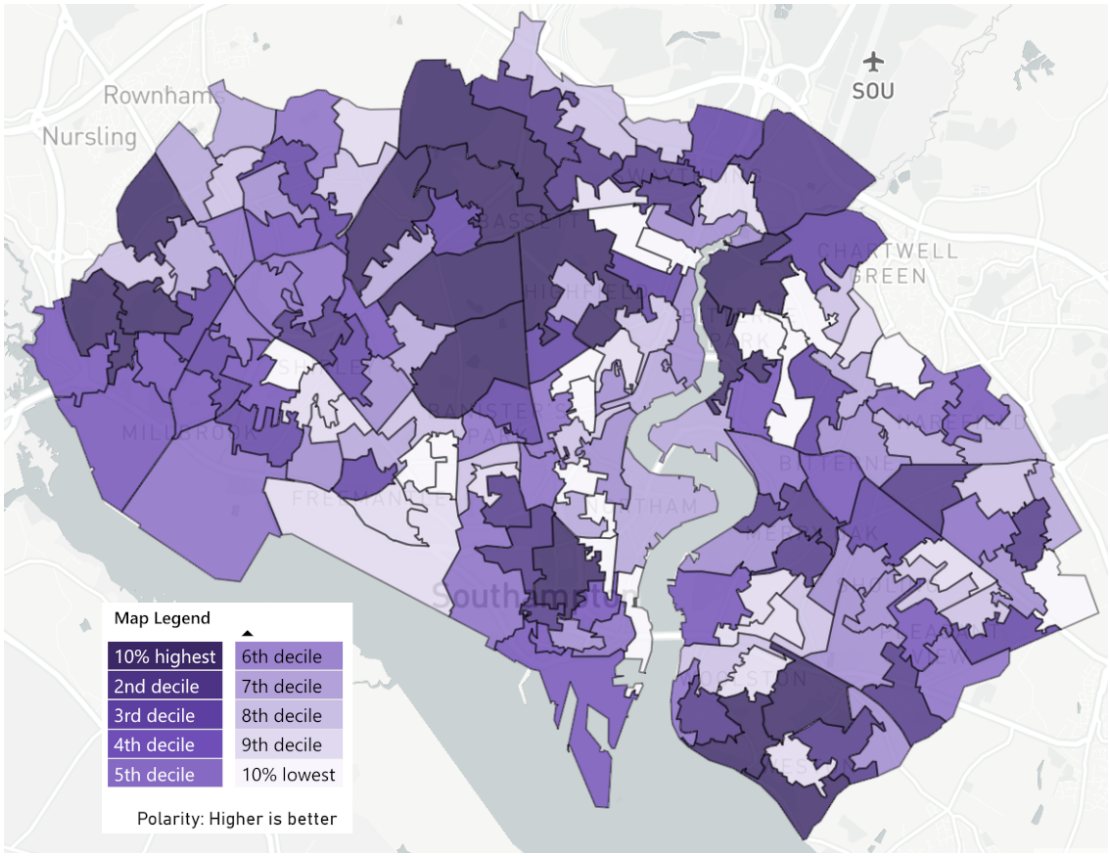

Figure 31. Percentage of green space in Southampton in bins of decile relating to England wide values.

space can be quantitively analysed, it has been placed in our vulnerability ranking. Figure 32 is a map of heat vulnerability, including risk due to low percentage of green space. Figure 32 takes into account:

- Rate of people with a current Adult Social Care service per 1k population aged 18+,
- Rate of Children In Need per 10k 0-17 population,
- Rate of total crime per 1k population,
- Percentage of households that have one or more persons with English as a main language,
- Percentage of residents aged 16 and over with no qualifications,
- Percentage of Greenspace,
- Percentage of population reporting bad or very bad health,
- Percentage of residents limited a lot by disability,
- Percentage of Year R children that are a healthy weight (5 year pooled),
- Social Isolation Score (All-ages),
- Social Isolation Score (65+),
- Multiple Deprivation Index Score.

The ranking is tabulated in the appendix. It is recommended to begin with top 3rd decile LSOAs to decrease their vulnerability. These can be generalised into 3 areas visible on the map: the far west, the far east, and a central band including Freemantle, north Bargate, Bevois, and west Peartree. Each LSOA

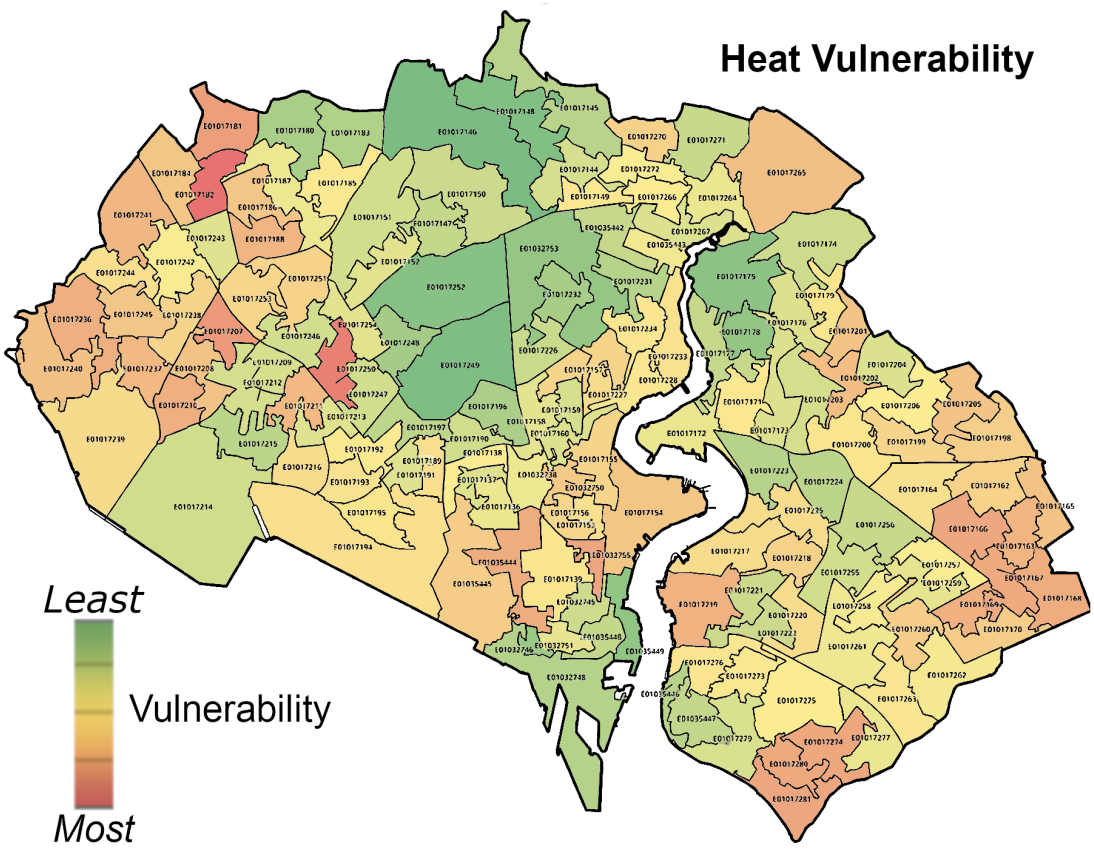

Figure 32. Vulnerability to heat on an LSOA level according to our index.

has differing vulnerabilities, and it is highly recommended to look at the specific sections for top most vulnerable LSOAs.

Decreasing vulnerabilities takes a long time and requires high social planning, therefore risk can be mitigated in vulnerable areas. Southampton has large amounts of green space, although this green space is often is concentrated within parks. More widespread green space in urbanised areas may decrease urban heat island effect in these critical areas. Encouraging of private greening may aid too, discouraging 'non-perme-ation', i.e., the replacing green front and back gardens with non-permeable surfaces. Another risk decreasing strategy is the decreasing of poor air quality in the city, as higher CO_2 levels contribute to urban heat island effect. This recommendation can be seen as a recommendation to continue or even expand the green city plan (Southampton City Council, 2023). The council may also place accessible emergency cooling centres such that those may get information on how to deal with extreme heat, as well as recover and provide a safe place away from home and away from the heat. These centres must not only be placed in vulnerable areas, but also areas of local tourism, such as Bargate, which becomes busy during summer weekends as it is a popular shopping location containing both The Marlands Shopping Centre and West Quay Shopping Centre. Similarly, to get aid to residents who need it, an aforementioned heat call centre could be set up in times of a heatwave, a volunteer or temporary worker hotline to give advice and physical aid to those vulnerable. Finally, we know how to proof houses against extreme heat, therefore to help those in need, data is required. This data includes building and infrastructure data such that retrofits can be made in vulnerable communities, and general health data such that we can take steps to give them what is needed to adapt to extreme heat through good health. For this reason, issues discussed in this report fall as great interest to public health employees in Southampton City Council, and actionable steps are being taken based on what we know. Priorities for this sect of the council include: the wellbeing of children, young people, and pregnant individuals, improvement of alcohol and drug health, improvement of mental wellbeing, greater food quality and health, and greater sexual health and protection. A research collaboration is also planned to determine detrimental effects on health city wide, and is currently working with communities to understand their health and wellbeing priorities. Further, Sport England have also identified those areas as need for support for being inactive and having the most challenges to being active, and are working on breaking down these barriers.

As well as physical heat residents will also be faced with products of heat, primarily drought. Increased greening can aid in drought resilience by utilising permeable surfaces to store water. Fixing leaks in pipes and encouraging Southern Water to do so is also paramount as leading up to and during a drought 107.5 million litres of water a day inexcusable (Kersley, 2024). Other measures may include reviewing of water allocation leading up to a drought, and encouragement or council funded voluntary installation of private reservoirs in homes such that vulnerable areas can rely on their own reservoirs rather than the mains water during a drought.

20.3.2 Flood

Figure 33 is a map of flooding vulnerability. Figure 33 takes into account:

- Rate of people with a current Adult Social Care service per 1k
- population aged 18+
- Rate of Children In Need per 10k 0-17 population
- Rate of total crime per 1k population
- Percentage of households that have one or more persons with English as a main language
- Percentage of lone parent families with dependent children
- Percentage of residents aged 16 and over with no qualifications
- Percentage of pupils with Special Educational Needs (SEN)
- Percentage of Greenspace
- Percentage of population reporting bad or very bad health
- Percentage of residents limited a lot by disability

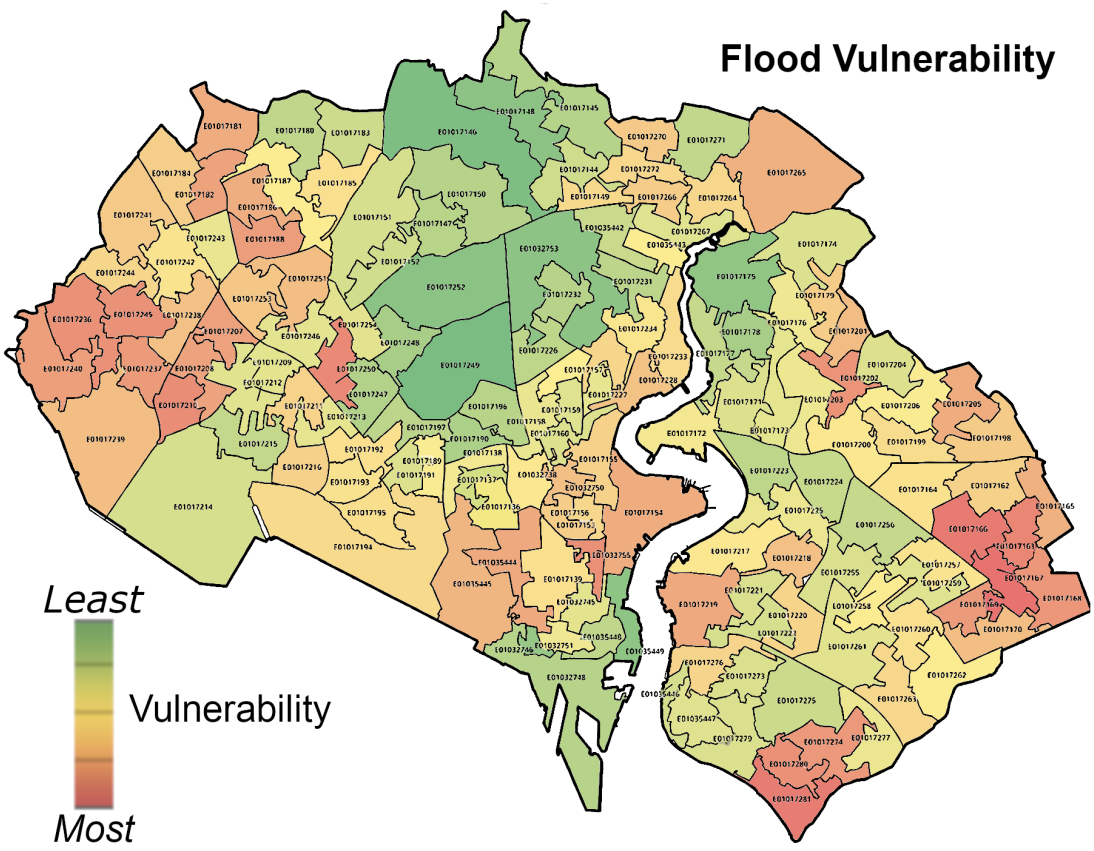

Figure 33. Vulnerability to flooding on an LSOA level according to our index.

- Percentage of Year R children that are a healthy weight (5 year pooled)
- Social Isolation Score (All-ages)
- Social Isolation Score (65+)
- Multiple Deprivation Index Score

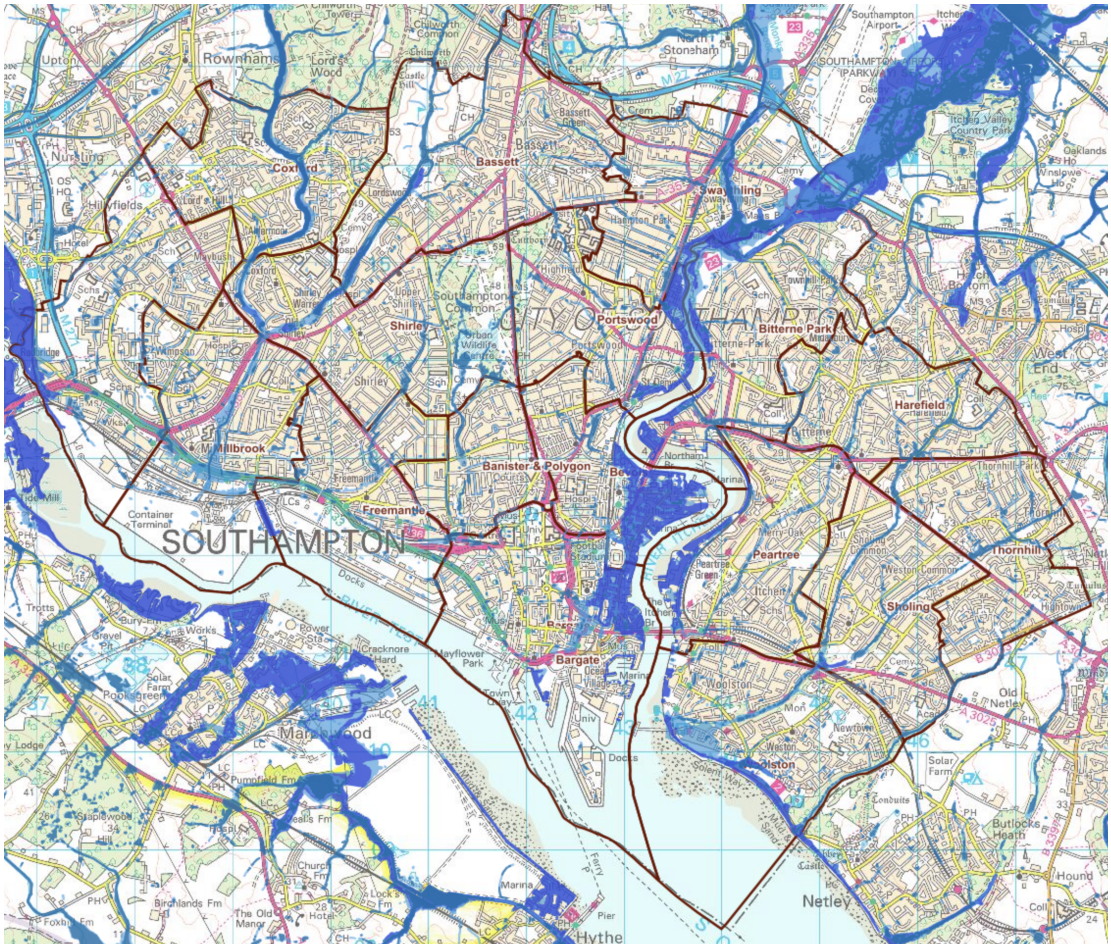

Figure 34. A map of Southampton displaying 1/30 and 1/100 surface water flooding and types 2 and 3 surface flooding.

The ranking is tabulated in the appendix. Risk is out of the scope of this current study to display on the map effectively. There are many qualitative risks to residents throughout Southampton, which have been touched upon in appropriate ward sections, and how their risk weights on an enumerated scoring system is unclear without further investigation. Further, we recognise that flood reports are used in this report as tools to learn about current issues facing neighbourhoods, and not necessarily projections of places to be affected by flooding in the future. However, the SFRA is primarily for projection. SFRA projections used in this report are 1/30 yearly chance of surface flooding, 1/100 yearly chance of surface flooding, and type 2 and 3 fluvial flooding. Type 2 fluvial flooding indicates a yearly probability of river flooding between 0.1% and 1% and sea flooding between 0.1% and 0.5%, whereas type 3 fluvial flooding indicates a yearly probability of river flooding over 1% and sea flooding over 0.5%. This is displayed in 34

Using this mapped data, we can combine risk and vulnerability to list all LSOAs of an above 1% chance of surface flooding and above 0.1% chance of fluvial flooding; find this in figure 35.

This image is tabulated in the appendix. 41 (27% of total 152) LSOAs were removed. From figure 34 and 35, it is clear that Northam, i.e., E01017154, is very at risk of flooding. The first priority for the city

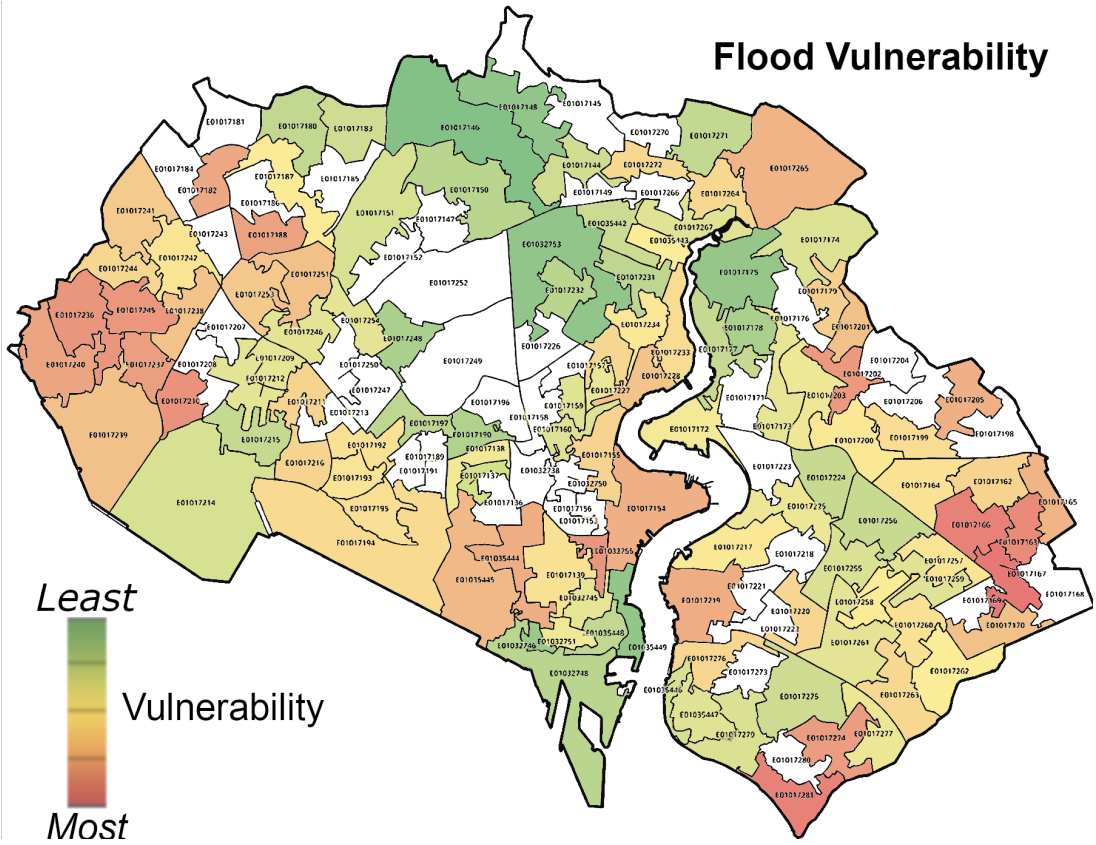

Figure 35. Vulnerability to flooding on an LSOA level according to our index, discounting areas not at SFRA projected risk (recoloured in white).

verses flooding should be to reinforce the bank where this high probability of fluvial flooding is projected. For this reason the primary recommendation is to continue the River Itchen Flood Alleviation Scheme under threat of some of our most vulnerable losing their homes and possessions within the next 100 years.

After this a priority should move to gathering data to fill limitations, investigating at-risk areas mentioned in this report, and implementing suggestions from the prior section on lessons learnt from writing this report. As the River Itchen Flood Alleviation Scheme is a large undertaking, these tasks can be completed simultaneously. A reason current issues are a priority is because areas, Coates Road as an example, are already having flooding increases with drainage demand increasing proportionally to storms. Current issue areas will also become worse in other ways, such as surface water flooding causing land to sink, and sewer degradation. The highest recommendation after the River Itchen Flood Alleviation Scheme, and a low-cost priority recommendation, is the aforementioned call line for flooding, which will restructure our flood response and aid many at-risk throughout the city. A heavily recommended aspect of flood management from previously in this report is sustainable drainage systems, such as terracing of waterways and copying of natural drainage systems. This is particularly useful as a primary recommendation for heat was increasing green in select areas throughout the city, which also increases natural debris and therefore flooding in traditional drains nearby. With sustainable drainage systems, drainage can be achieved but without traditional drains, instead with soil permeability, although this should be approached with caution as Southampton's infrastructure was not built with this in mind.

Vulnerabilities can be addressed too as a background priority, as it takes time comparatively to works to eliminate risk. Priority of vulnerable communities can be seen in appropriate ward sections and figure 35. Some areas of vulnerability are already being addressed, for example workshops with children are already being done to improve education on flooding disasters (University of Southampton, 2024), but there needs to be a more co-ordinated and central effort to reduce vulnerability.

20.4 Concluding Remarks and Approach Going Forward

This report has identified vulnerable and at-risk areas in Southampton to climate extremes, and provided specific and general recommendations to areas in which risk may become worse over the next 100 years. While the climate crisis is a pressing issue among the council, the public may not feel the same. It is worth bearing in mind that most of the time, the public does not think about the climate crisis until an event happens (Capstick and Pidgeon, 2014). As life becomes more complex day-by-day, the average person has a lot of information on their mind at any time, and cannot take an answer until they need one, at which time may be too late. This is why communication of priority with the public is key.

The council has very thoroughly outlined their priority going forward, with climate plans up till 2030. On the other hand, those in the public do not have the time in an increasingly busy life to read things such as the Green City Action Plan, Southampton's flood response documents, or the Southampton Renaissance Vision. Digital communication can be effective, but only in bite-size amounts as people have low attention span for digital media that is not entertainment, as people use the internet for escape in most cases. There is also a large community of those who are moving away from, or have not transitioned into, a digitally integrated lifestyle. It follows then the council must reach people when they are most receptive to information. This can be digital and a continuation with this is recommended, but it must be supplemented with physical information, such as billboards, posters, flyers, and aforementioned social events and clubs with a strong council presence. Events can also include non-traditional, more neighbourhood tailored information distribution, wherein relevant council employees can be face-to-face with members of the public in public spaces to discuss their priorities. This way the public are more likely to remember and spread this priority information, as they had a good experience with the council with a mentally engaging two-way discussion that voluntarily took time out of their day, rather than a faceless glance at a post on a phone.

This thorough and effective communication is very important. Take for example the aforementioned Southampton Renaissance Vision. This investment into the city centre promises to regenerate and protect from fluvial flooding one of the largest and highest deprivation collection of LSOAs in the city. While a good report, the council did not bundle city wide priority in with this report leading to other large areas of high deprivation to feel left behind (Marshall, 2025). Similarly deprived wards such as Redbridge, Thornhill, and Woolston did not get effective communication of priority or a report, something which they deserve as much as those who live in the catchment area for the Southampton Renaissance Vision, and they are valid in feeling 'forgotten'. A large reason these areas have not gotten their own

Southampton Renaissance Vision is because the council does not have the funds, something which has been on the forefront of minds during this report. With the University of Southampton, Solent University, Network Rail, Southampton FC, and Red Funnel to name a few having a vested interest in the city centre, funding can be secured for this area. This is fantastic news, but the council cannot be seen to give preferential treatment to certain vulnerable areas, running the risk of furthering deprivation and feelings of abandonment, even if there is an internal deadline for revitalisation of these areas.

In face of the climate crisis we need to aim for all, not one or none. Unity, strength, and communication are our most valuable assets as a city community. Southampton's people and leadership have shown fantastic qualities and forward thinking in face of the climate crisis in recent years, and as the gateway to the world we have the capability to shine a leading torch for the United Kingdom and all communities that call themselves part of our bright city of Southampton.

ACKNOWLEDGEMENTS

The author would like to acknowledge those who aided in the writing of this report, starting with Sustainable Projects Officer Melanie Robertson, Sustainable Projects Lead Jessica Lewis, and Environment and Sustainability Service Manager Lindsay McCulloch, the three of which were instrumental in writing this report. Further, people such as Hayden Collins, James Cording, Amy Devine, Sam Foulds, Vicky Toomey, and Becky Wilkinson contributed contextual information throughout one or more interviews that aided instrumentally in the report.

APPENDIX

Tabulated LSOAs Belonging to Wards

LSOA	Wards		LSOA	Wards		LSOA	Wards
E01017136	Banister & Polygon, Bargate		E01017192	Freemantle		E01017245	Redbridge, Millbrook
E01017137	Banister & Polygon		E01017193	Freemantle		E01017246	Shirley
E01017138	Banister & Polygon		E01017194	Freemantle, Banister & Polygon		E01017247	Shirley
E01017139	Bargate		E01017195	Freemantle		E01017248	Shirley
E01017144	Bassett		E01017196	Banister & Polygon		E01017249	Shirley
E01017145	Bassett		E01017197	Freemantle, Banister & Polygon		E01017250	Shirley
E01017146	Bassett		E01017198	Harefield		E01017251	Shirley
E01017147	Bassett		E01017199	Harefield		E01017252	Shirley
E01017148	Bassett		E01017200	Harefield		E01017253	Shirley
E01017149	Bassett		E01017201	Harefield, Bitterne Park		E01017254	Shirley
E01017150	Bassett		E01017202	Harefield		E01017255	Sholing
E01017151	Bassett		E01017203	Harefield		E01017256	Sholing
E01017152	Bassett		E01017204	Harefield		E01017257	Sholing
E01017153	Bevois		E01017205	Harefield		E01017258	Sholing
E01017154	Bevois		E01017206	Harefield		E01017259	Sholing
E01017155	Bevois		E01017207	Millbrook		E01017260	Sholing,
E01017156	Bevois		E01017208	Millbrook		E01017261	Sholing
E01017157	Bevois, Portswood		E01017209	Millbrook		E01017262	Sholing, Thornhill
E01017158	Bevois, Banister & Polygon, Portswood		E01017210	Millbrook		E01017263	Sholing
E01017159	Bevois		E01017211	Millbrook, Freemantle		E01017264	Swaythling
E01017160	Bevois		E01017212	Millbrook		E01017265	Swaythling, Bitterne Park
E01017162	Thornhill		E01017213	Freemantle		E01017266	Swaythling, Bassett
E01017163	Thornhill		E01017214	Millbrook		E01017267	Swaythling
E01017164	Thornhill		E01017215	Millbrook		E01017270	Swaythling
E01017165	Thornhill		E01017216	Freemantle, Millbrook		E01017271	Swaythling
E01017166	Thornhill		E01017217	Peartree		E01017272	Swaythling, Bassett
E01017167	Thornhill		E01017218	Peartree		E01017273	Woolston, Peartree
E01017168	Thornhill		E01017219	Peartree		E01017274	Woolston
E01017169	Thornhill		E01017220	Peartree		E01017275	Woolston, Peartree
E01017170	Thornhill		E01017221	Peartree		E01017276	Woolston, Peartree
E01017171	Bitterne Park		E01017222	Peartree		E01017277	Woolston
E01017172	Bitterne Park		E01017223	Peartree		E01017279	Woolston
E01017173	Bitterne Park		E01017224	Peartree		E01017280	Woolston
E01017174	Bitterne Park		E01017225	Peartree		E01017281	Woolston
E01017175	Bitterne Park		E01017226	Portswood		E01032738	Banister & Polygon, Bevois
E01017176	Bitterne Park		E01017227	Portswood		E01032745	Bargate
E01017177	Bitterne Park		E01017228	Portswood		E01032746	Bargate
E01017178	Bitterne Park		E01017231	Swaythling, Portswood		E01032748	Bargate
E01017179	Bitterne Park		E01017232	Portswood		E01032750	Bevois, Banister & Polygon
E01017180	Coxford		E01017233	Portswood, Swaythling		E01032751	Bargate
E01017181	Coxford		E01017234	Portswood, Swaythling		E01032753	Portswood, Swaythling
E01017182	Coxford		E01017235	Portswood		E01032755	Bargate
E01017183	Coxford		E01017236	Redbridge, Millbrook		E01035442	Swaythling, Portswood
E01017184	Coxford		E01017237	Millbrook, Redbridge		E01035443	Swaythling
E01017185	Coxford		E01017238	Redbridge, Millbrook		E01035444	Bargate
E01017186	Coxford		E01017239	Redbridge		E01035445	Bargate, Banister & Polygon
E01017187	Coxford		E01017240	Redbridge		E01035446	Woolston
E01017188	Coxford		E01017241	Redbridge		E01035447	Woolston
E01017189	Freemantle, Banister & Polygon		E01017242	Redbridge		E01035448	Bargate
E01017190	Banister & Polygon, Freemantle		E01017243	Redbridge		E01035449	Bargate
E01017191	Freemantle, Banister & Polygon		E01017244	Redbridge			

Table 1. A table of which LSOAs belong to which wards.

Tabulated Heat Vulnerability Ranking

Rank	LSOA	Decile	Scoring		Rank	LSOA	Decile	Scoring		Rank	LSOA	Decile	Scoring
1	E01017182	0	-5.260801238		52	E01017225	5	-2.358486436		103	E01017160	7	-1.317662289
2	E01017250	1	-4.816083502		53	E01017227	5	-2.349295273		104	E01017267	7	-1.296575127
3	E01017207	2	-4.136582795		54	E01017216	5	-2.332543289		105	E01017204	7	-1.295484866
4	E01017181	3	-3.971690891		55	E01017189	5	-2.292148104		106	E01017279	7	-1.245224934
5	E01032755	3	-3.78899147		56	E01017244	5	-2.266905673		107	E01017209	7	-1.21146934
6	E01017281	3	-3.787368233		57	E01017194	5	-2.264450147		108	E01017159	7	-1.191762036
7	E01017166	3	-3.782331769		58	E01017164	5	-2.244122004		109	E01017144	7	-1.182028867
8	E01017274	3	-3.744360428		59	E01017156	6	-2.238640141		110	E01017203	7	-1.16068529
9	E01017280	3	-3.712282368		60	E01017233	6	-2.219679614		111	E01017212	7	-1.15468609
10	E01017167	3	-3.664840958		61	E01017193	6	-2.194866987		112	E01017151	7	-1.131401739
11	E01017168	3	-3.606773707		62	E01017195	6	-2.118414239		113	E01017255	7	-1.119655288
12	E01035444	3	-3.580678638		63	E01017179	6	-2.117694973		114	E01017246	7	-1.100675382
13	E01017236	3	-3.541247357		64	E01017139	6	-2.113537885		115	E01017247	7	-1.100353837
14	E01017210	3	-3.538415951		65	E01017200	6	-2.104473064		116	E01017190	7	-1.075004259
15	E01017169	3	-3.520240623		66	E01017234	6	-2.098028918		117	E01017214	7	-1.054117664
16	E01017219	3	-3.452169244		67	E01017263	6	-2.096410682		118	E01032745	8	-0.998330721
17	E01017163	4	-3.400335828		68	E01017276	6	-2.08756828		119	E01017174	8	-0.991943377
18	E01017188	4	-3.396187674		69	E01017228	6	-2.080853773		120	E01017221	8	-0.976429548
19	E01017241	4	-3.345731534		70	E01017149	6	-2.061914671		121	E01017150	8	-0.964975007
20	E01017237	4	-3.282360868		71	E01017171	6	-2.060003834		122	E01017222	8	-0.964974866
21	E01017211	4	-3.274017089		72	E01017273	6	-2.03831272		123	E01017226	8	-0.944225058
22	E01017202	4	-3.165098698		73	E01017192	6	-2.01292178		124	E01017271	8	-0.893766363
23	E01017265	4	-3.140220331		74	E01017185	6	-2.003833473		125	E01017256	8	-0.885251217
24	E01017240	4	-3.070068542		75	E01017275	6	-1.960639773		126	E01035442	8	-0.848643762
25	E01017165	4	-3.019356867		76	E01017266	6	-1.959758382		127	E01017177	8	-0.838214224
26	E01017208	4	-3.003627439		77	E01017206	6	-1.938601731		128	E01017147	8	-0.819728937
27	E01017201	4	-2.975074956		78	E01017138	6	-1.930921296		129	E01035448	8	-0.810735593
28	E01017205	4	-2.971279701		79	E01017257	6	-1.906682189		130	E01035447	8	-0.788920441
29	E01017245	4	-2.962310868		80	E01017272	6	-1.898945659		131	E01017197	8	-0.705132784
30	E01017186	4	-2.95781362		81	E01017242	6	-1.876424048		132	E01017224	8	-0.642213776
31	E01017184	4	-2.927931883		82	E01017258	6	-1.839636322		133	E01017215	8	-0.635330159
32	E01017154	4	-2.925266414		83	E01017262	6	-1.785743892		134	E01035446	8	-0.59725165
33	E01032750	5	-2.833583389		84	E01035443	6	-1.740009925		135	E01017145	8	-0.58845011
34	E01035445	5	-2.746780144		85	E01017261	6	-1.704477191		136	E01017223	8	-0.543849633
35	E01017260	5	-2.743895634		86	E01032738	6	-1.672947366		137	E01017231	8	-0.503492795
36	E01017170	5	-2.743122063		87	E01017187	6	-1.654267401		138	E01032748	8	-0.487414251
37	E01017198	5	-2.699488173		88	E01017136	6	-1.644622429		139	E01017183	9	-0.399526988
38	E01017218	5	-2.659893527		89	E01017277	7	-1.636567758		140	E01017196	9	-0.298666566
39	E01017270	5	-2.639771297		90	E01017264	7	-1.60298567		141	E01017180	9	-0.238472377
40	E01017162	5	-2.619060531		91	E01017172	7	-1.595381702		142	E01017232	9	-0.205564856
41	E01017251	5	-2.613953671		92	E01032751	7	-1.55232797		143	E01017248	9	-0.152983747
42	E01017238	5	-2.583566852		93	E01017259	7	-1.518959586		144	E01032746	9	0.04267234
43	E01017157	5	-2.583484578		94	E01017158	7	-1.461164442		145	E01032753	10	0.178386879
44	E01017199	5	-2.571988928		95	E01017254	7	-1.452974496		146	E01017178	10	0.21075753
45	E01017155	5	-2.555560653		96	E01017152	7	-1.425170985		147	E01035449	10	0.280285055
46	E01017235	5	-2.553881709		97	E01017213	7	-1.370820523		148	E01017175	10	0.358165123
47	E01017153	5	-2.513225987		98	E01017243	7	-1.369892507		149	E01017252	10	0.49117426
48	E01017253	5	-2.511153752		99	E01017191	7	-1.355707255		150	E01017148	10	0.595589368
49	E01017239	5	-2.387964055		100	E01017137	7	-1.34429233		151	E01017249	10	0.690743447
50	E01017220	5	-2.37298923		101	E01017176	7	-1.337232009		152	E01017146	10	0.777210799
51	E01017217	5	-2.369400512		102	E01017173	7	-1.33384897					

Table 2. Heat vulnerability ranking including risk of low green space; decile is comparative to other LSOAs of Southampton.

Tabulated Flood Vulnerability Ranking

Rank	LSOA	Decile	Scoring		Rank	LSOA	Decile	Scoring		Rank	LSOA	Decile	Scoring
1	E01017167	0	-5.236045151		52	E01017235	5	-2.831296549		103	E01017259	6	-1.70014263
2	E01017166	1	-4.99281167		53	E01017244	5	-2.830383243		104	E01017159	7	-1.693054683
3	E01017281	1	-4.982519991		54	E01017272	5	-2.804436095		105	E01017204	7	-1.646039972
4	E01017163	1	-4.736152658		55	E01017156	5	-2.794450245		106	E01017160	7	-1.641219415
5	E01017250	2	-4.640697322		56	E01017264	5	-2.790484811		107	E01017171	7	-1.63432947
6	E01017210	2	-4.55494471		57	E01017263	5	-2.790161325		108	E01017191	7	-1.634139204
7	E01032755	2	-4.455986798		58	E01017149	5	-2.738241056		109	E01017174	7	-1.606142052
8	E01017280	2	-4.447791342		59	E01017194	5	-2.705199904		110	E01017255	7	-1.586044352
9	E01017236	2	-4.438406454		60	E01017233	5	-2.691764894		111	E01017273	7	-1.580371364
10	E01017245	2	-4.416828205		61	E01017199	5	-2.659731329		112	E01017221	7	-1.575889112
11	E01017202	2	-4.370339324		62	E01017195	5	-2.631813336		113	E01017279	7	-1.565057769
12	E01017168	2	-4.312123436		63	E01017139	5	-2.605512021		114	E01017214	7	-1.481501953
13	E01017274	2	-4.283175701		64	E01017185	5	-2.601115173		115	E01017151	7	-1.478596272
14	E01017237	2	-4.224654632		65	E01017192	5	-2.592905597		116	E01017222	7	-1.467742437
15	E01017169	2	-4.22123935		66	E01017260	5	-2.581696974		117	E01017137	7	-1.45811073
16	E01017188	2	-4.166947274		67	E01017164	5	-2.563511873		118	E01035446	7	-1.450732424
17	E01017240	2	-4.13176107		68	E01017193	5	-2.525399756		119	E01017152	7	-1.361683529
18	E01017207	2	-4.066789127		69	E01017257	5	-2.514314359		120	E01017144	7	-1.32011845
19	E01017208	3	-4.018482601		70	E01017242	5	-2.498466191		121	E01017183	7	-1.290529752
20	E01017182	3	-3.993925139		71	E01017234	5	-2.469148266		122	E01017275	7	-1.252483921
21	E01017219	3	-3.88864014		72	E01017217	5	-2.428543477		123	E01035442	7	-1.207197973
22	E01035444	3	-3.884369778		73	E01032738	5	-2.41281286		124	E01017224	7	-1.157592063
23	E01017181	3	-3.810525499		74	E01017200	5	-2.408415444		125	E01017256	7	-1.11540391
24	E01017205	3	-3.78143912		75	E01017258	5	-2.330223476		126	E01017177	8	-1.104853774
25	E01017154	3	-3.778831954		76	E01017187	5	-2.324279356		127	E01017215	8	-1.093040881
26	E01017186	3	-3.734459614		77	E01017157	5	-2.311549493		128	E01017271	8	-1.027095924
27	E01017165	3	-3.676254632		78	E01035443	5	-2.296698853		129	E01017180	8	-0.994968984
28	E01017265	3	-3.672922984		79	E01017262	6	-2.281406904		130	E01035448	8	-0.988996462
29	E01035445	3	-3.573586399		80	E01017206	6	-2.249943146		131	E01017223	8	-0.949066715
30	E01017201	4	-3.40703707		81	E01017189	6	-2.246875828		132	E01017226	8	-0.945412374
31	E01017251	4	-3.388225549		82	E01017172	6	-2.109365147		133	E01017197	8	-0.918606444
32	E01017170	4	-3.38540479		83	E01017138	6	-2.069791557		134	E01017231	8	-0.88828003
33	E01017239	4	-3.38399154		84	E01017136	6	-2.059442374		135	E01017196	8	-0.818932282
34	E01032750	4	-3.356995282		85	E01032751	6	-2.044063372		136	E01017147	8	-0.807303355
35	E01017218	4	-3.313275917		86	E01017176	6	-2.041868792		137	E01017150	8	-0.782845168
36	E01017238	4	-3.303974545		87	E01017203	6	-2.002456048		138	E01017232	8	-0.766710873
37	E01017228	4	-3.275148822		88	E01017225	6	-1.9822898		139	E01032748	8	-0.759991332
38	E01017253	4	-3.15149588		89	E01017277	6	-1.97507045		140	E01017145	8	-0.733546899
39	E01017241	4	-3.115009541		90	E01017158	6	-1.900955176		141	E01017247	8	-0.704778289
40	E01017270	4	-3.083594973		91	E01017243	6	-1.898266351		142	E01017190	8	-0.566855633
41	E01017198	4	-3.079126456		92	E01017227	6	-1.878978043		143	E01017178	9	-0.418835233
42	E01017266	4	-3.041864439		93	E01017213	6	-1.848097991		144	E01017248	9	-0.416285553
43	E01017179	4	-3.030337809		94	E01017173	6	-1.820541467		145	E01032746	9	-0.039936356
44	E01017153	4	-3.018541293		95	E01032745	6	-1.80031138		146	E01017175	10	0.094987508
45	E01017184	4	-2.979339014		96	E01017209	6	-1.793092291		147	E01035449	10	0.158545925
46	E01017216	4	-2.943397787		97	E01017246	6	-1.784447889		148	E01032753	10	0.202805837
47	E01017155	4	-2.932187827		98	E01017261	6	-1.779989825		149	E01017148	10	0.222555942
48	E01017162	4	-2.927995552		99	E01017254	6	-1.767056801		150	E01017252	10	0.265213043
49	E01017211	4	-2.913073319		100	E01017212	6	-1.757663372		151	E01017146	10	0.56073294
50	E01017276	5	-2.868242491		101	E01035447	6	-1.710377561		152	E01017249	10	0.665336721
51	E01017220	5	-2.840608092		102	E01017267	6	-1.704273998					

Table 3. Flood vulnerability ranking; decile is comparative to other LSOAs of Southampton.

Tabulated Flood Vulnerability Ranking with Low-risk Areas Removed)

Rank	LSOA	Decile	Scoring		Rank	LSOA	Decile	Scoring		Rank	LSOA	Decile	Scoring
1	E01017167	0	-5.236045151		38	E01017244	5	-2.830383243		75	E01035447	6	-1.710377561
2	E01017166	1	-4.99281167		39	E01017272	5	-2.804436095		76	E01017267	6	-1.704273998
3	E01017281	1	-4.982519991		40	E01017264	5	-2.790484811		77	E01017259	6	-1.70014263
4	E01017163	1	-4.736152658		41	E01017263	5	-2.790161325		78	E01017159	7	-1.693054683
5	E01017210	2	-4.55494471		42	E01017194	5	-2.705199904		79	E01017160	7	-1.641219415
6	E01032755	2	-4.455986798		43	E01017233	5	-2.691764894		80	E01017174	7	-1.606142052
7	E01017236	2	-4.438406454		44	E01017199	5	-2.659731329		81	E01017255	7	-1.586044352
8	E01017245	2	-4.416828205		45	E01017195	5	-2.631813336		82	E01017279	7	-1.565057769
9	E01017202	2	-4.370339324		46	E01017139	5	-2.605512021		83	E01017214	7	-1.481501953
10	E01017274	2	-4.283175701		47	E01017192	5	-2.592905597		84	E01017151	7	-1.478596272
11	E01017237	2	-4.224654632		48	E01017260	5	-2.581696974		85	E01017137	7	-1.45811073
12	E01017188	2	-4.166947274		49	E01017164	5	-2.563511873		86	E01035446	7	-1.450732424
13	E01017240	2	-4.13176107		50	E01017193	5	-2.525399756		87	E01017144	7	-1.32011845
14	E01017182	3	-3.993925139		51	E01017257	5	-2.514314359		88	E01017183	7	-1.290529752
15	E01017219	3	-3.88864014		52	E01017242	5	-2.498466191		89	E01017275	7	-1.252483921
16	E01035444	3	-3.884369778		53	E01017234	5	-2.469148266		90	E01035442	7	-1.207197973
17	E01017205	3	-3.78143912		54	E01017217	5	-2.428543477		91	E01017224	7	-1.157592063
18	E01017154	3	-3.778831954		55	E01017200	5	-2.408415444		92	E01017256	7	-1.11540391
19	E01017165	3	-3.676254632		56	E01017258	5	-2.330223476		93	E01017177	8	-1.104853774
20	E01017265	3	-3.672922984		57	E01017187	5	-2.324279356		94	E01017215	8	-1.093040881
21	E01035445	3	-3.573586399		58	E01035443	5	-2.296698853		95	E01017271	8	-1.027095924
22	E01017201	4	-3.40703707		59	E01017262	6	-2.281406904		96	E01017180	8	-0.994968984
23	E01017251	4	-3.388225549		60	E01017172	6	-2.109365147		97	E01035448	8	-0.988996462
24	E01017170	4	-3.38540479		61	E01017138	6	-2.069791557		98	E01017197	8	-0.918606444
25	E01017239	4	-3.38399154		62	E01032751	6	-2.044063372		99	E01017231	8	-0.88828003
26	E01017238	4	-3.303974545		63	E01017203	6	-2.002456048		100	E01017150	8	-0.782845168
27	E01017228	4	-3.275148822		64	E01017225	6	-1.9822898		101	E01017232	8	-0.766710873
28	E01017253	4	-3.15149588		65	E01017277	6	-1.97507045		102	E01032748	8	-0.759991332
29	E01017241	4	-3.115009541		66	E01017243	6	-1.898266351		103	E01017190	8	-0.566855633
30	E01017179	4	-3.030337809		67	E01017227	6	-1.878978043		104	E01017178	9	-0.418835233
31	E01017216	4	-2.943397787		68	E01017173	6	-1.820541467		105	E01017248	9	-0.416285553
32	E01017155	4	-2.932187827		69	E01032745	6	-1.80031138		106	E01032746	9	-0.039936356
33	E01017162	4	-2.927995552		70	E01017209	6	-1.793092291		107	E01017175	10	0.094987508
34	E01017211	4	-2.913073319		71	E01017246	6	-1.784447889		108	E01035449	10	0.158545925
35	E01017276	5	-2.868242491		72	E01017261	6	-1.779989825		109	E01032753	10	0.202805837
36	E01017220	5	-2.840608092		73	E01017254	6	-1.767056801		110	E01017148	10	0.222555942
37	E01017235	5	-2.831296549		74	E01017212	6	-1.757663372		111	E01017146	10	0.56073294

Table 4. Flood vulnerability ranking with low-risk areas removed; decile is comparative to other LSOAs of Southampton.

REFERENCES

Albrich, K., Rammer, W. and Seidl, R. (2020), 'Climate change causes critical transitions and irreversible alterations of mountain forests', *Global Change Biology* **26**(7), 4013–4027. doi: 10.1111/gcb.15118.

Allen, M. R., Friedlingstein, P., Girardin, C. A., Jenkins, S., Malhi, Y., Mitchell-Larson, E., Peters, G. P. and Rajamani, L. (2022), 'Net zero: Science, origins, and implications', *Annual Review of Environment and Resources* **47**(Volume 47, 2022), 849–887. doi: 10.1146/annurev-environ-112320-105050.

Ananthakrishnan, S., Lalkhumliana, F., Chauhan, S., Sharma, J., Verma, M. and Sharma, A. (2023), 'Climate change-induced soil temperature rise and associated impacts', *IMPACT OF CLIMATE CHANGE ON AGRICULTURE AND FOOD PRODUCTION* p. 10.
URL: *https://www.researchgate.net/profile/Christina-Cathrine/publication/383000638_Hailstorms_and_Their_Impact_on_Indian_Agriculture/links/66b711528f7e1236bc48c29e/Hailstorms-and-Their-Impact-on-Indian-Agriculture.pdf#page=20*

Andrew J. Stevens, D. C. and Nicholls, R. J. (2016), 'Trends in reported flooding in the uk: 1884–2013', *Hydrological Sciences Journal* **61**(1), 50–63. doi: 10.1080/02626667.2014.950581.

Apostille of the Hague (2024), 'Birth certificates'. [Online; accessed 13-01-2025].
URL: *https://www.hagueapostille.co.uk/birth-certificates*

Archbold, M., Davies, B. and Mais, D. (2023), 'Deprivation and the impact on smoking prevalence, england and wales: 2017 to 2021'. [Online; accessed 17-01-2025].
URL: *https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/drugusealcoholandsmoking/bulletins/deprivationandtheimpactonsmokingprevalenceenglandandwales/2017to2021*

Arias, P., Bellouin, N., Coppola, E., Jones, R., Krinner, G., Marotzke, J., Naik, V., Palmer, M., Plattner, G.-K., Rogelj, J., Rojas, M., Sillmann, J., Storelvmo, T., Thorne, P., Trewin, B., Achuta Rao, K., Adhikary, B., Allan, R., Armour, K., Bala, G., Barimalala, R., Berger, S., Canadell, J., Cassou, C., Cherchi, A., Collins, W., Collins, W., Connors, S., Corti, S., Cruz, F., Dentener, F., Dereczynski, C., Di Luca, A., Diongue Niang, A., Doblas-Reyes, F., Dosio, A., Douville, H., Engelbrecht, F., Eyring, V., Fischer, E., Forster, P., Fox-Kemper, B., Fuglestvedt, J., Fyfe, J., Gillett, N., Goldfarb, L., Gorodetskaya, I., Gutierrez, J., Hamdi, R., Hawkins, E., Hewitt, H., Hope, P., Islam, A., Jones, C., Kaufman, D., Kopp, R., Kosaka, Y., Kossin, J., Krakovska, S., Lee, J.-Y., Li, J., Mauritsen, T., Maycock, T., Meinshausen, M., Min, S.-K., Monteiro, P., Ngo-Duc, T., Otto, F., Pinto, I., Pirani, A., Raghavan, K., Ranasinghe, R., Ruane, A., Ruiz, L., Sallée, J.-B., Samset, B., Sathyendranath, S., Seneviratne, S., Sörensson, A., Szopa, S., Takayabu, I., Tréguier, A.-M., van den Hurk, B., Vautard, R., von Schuckmann, K., Zaehle, S., Zhang, X. and Zickfeld, K. (2021), 'Climate change 2021: The physical science basis. contribution of working group i to the sixth assessment report of the intergovernmental panel on climate change'. doi: 10.1017/9781009157896.

Arnold, D. (1999), 'Air conditioning in office buildings after world war ii', *ASHRAE journal* **41**(7), 33.

BBC (2012), 'Heavy winds pound southampton'. [Online; accessed 20-11-2024].
URL: *https://www.bbc.co.uk/news/av/uk-16398326*

BBC South (2019*a*), 'Southampton boating lake closed after blue-green algae found'. [Online; accessed 19-11-2024].
URL: *https://www.bbc.co.uk/news/uk-england-hampshire-49247294*

BBC South (2019*b*), 'Toxic blue-green algae warning for dog owners and swimmers'. [Online; accessed 19-11-2024].
URL: *https://www.bbc.co.uk/news/uk-49344232*

BBC South (2022), 'Uk heatwave: Hampshire and isle of wight officially in drought'. [Online; accessed 19-11-2024].
URL: *https://www.bbc.co.uk/news/uk-england-hampshire-62521106*

BBC South (2023*a*), 'Hampshire and isle of wight braced for impact of storm ciarán'. [Online; accessed 26-11-2024].
URL: *https://www.bbc.co.uk/news/uk-england-hampshire-67289646*

BBC South (2023*b*), 'Storm ciarán: Southampton schools to shut amid 'risk to life' warning'. [Online; accessed 20-11-2024].
URL: *https://www.bbc.co.uk/news/uk-england-hampshire-67288983*

Bedi, N. S., Adams, Q. H., Hess, J. J. and Wellenius, G. A. (2022), 'The role of cooling centers in protecting vulnerable individuals from extreme heat', *Epidemiology* **33**(5). doi: 10.1097/EDE.0000000000001503.

Bergseng, A. M. (2018), 'Indicators and trends: Extreme weather and infrastructure'. [Online; accessed 20-11-2024].
URL: *https://www.climatexchange.org.uk/projects/indicators-and-trends-2/*

Bevan, J. (2019), 'Escaping the jaws of death: ensuring enough water in 2050'. [Online; accessed 13-03-2025].
URL: *https://www.gov.uk/government/speeches/escaping-the-jaws-of-death-ensuring-enough-water-in-2050*

Borangic, I. (2024), 'Innovative approaches for coastal protection'. [Online; accessed 26-11-2024].
URL: *https://www.aggregate.com/blog/innovative-approaches-coastal-protection*

Bouchard, A. (2022), 'Environment agency confirms drought in areas such as winchester, southampton and portsmouth'. [Online; accessed 15-11-2024].
URL: *https://www.hampshirechronicle.co.uk/news/20627829.environment-agency-confirms-drought-areas-winchester-southampton-portsmouth/*

British Geological Survey (2024), 'Landslides and rainfall'. [Online; accessed 17-11-2024].
URL: *https://www.bgs.ac.uk/geology-projects/landslides/landslides-and-rainfall/*

Capstick, S. B. and Pidgeon, N. F. (2014), 'Public perception of cold weather events as evidence for and against climate change', *Climatic Change* **122**(4), 695–708. doi: 10.1007/s10584-013-1003-1.

Climate Central (2025), 'Land projected to be below annual flood level in 2100'. [Online; accessed 05-02-2025].
URL: *https://coastal.climatecentral.org/map/12/-1.3874/50.8902/?theme=sea_level_rise&map_type=year&basemap=roadmap&contiguous=true&elevation_model=best_available&forecast_year=2100&pathway=ssp3rcp70&percentile=p50&refresh=true&return_level=return_level_1&rl_model=coast_rp&slr_model=ipcc_2021_med*

ClimateJust (2024), 'Climatejust map tool'. [Online; accessed 14-11-2024].
URL: *https://www.climatejust.org.uk/map.html*

Davey, M. (2023), 'Storm ciarán: Tree collapses at southampton fc training ground'. [Online; accessed 20-11-2024].
URL: *https://www.dailyecho.co.uk/news/23896673.storm-ciaran-tree-collapses-southampton-fc-training-ground/*

Department for Business, Energy and Industrial Strategy (2019), 'The climate change act 2008'. [Online; accessed 22-11-2024].
URL: *https://www.legislation.gov.uk/uksi/2019/1056/article/1/made*

Department for Environment, Food & Rural Affairs (2021), 'Southern water fined record £90m for dumping sewage'. [Online; accessed 25-11-2024].
URL: *https://deframedia.blog.gov.uk/2021/07/12/southern-water-fined-record-90m-for-dumping-sewage/*

Department for Environment, Food & Rural Affairs (2022), 'Uk climate change risk assessment 2022'. [Online; accessed 12-11-2024].
URL: *https://assets.publishing.service.gov.uk/media/61e54d8f8fa8f505985ef3c7/climate-change-risk-assessment-2022.pdf*

Department for Environment, Food & Rural Affairs (2023), 'Government response to bbc reporting on storm overflows'. [Online; accessed 18-11-2024].
URL: *https://deframedia.blog.gov.uk/2023/09/05/government-response-to-bbc-reporting-on-storm-overflows/*

Du, W., FitzGerald, G. J., Clark, M. and Hou, X.-Y. (2010), 'Health impacts of floods', *Prehospital and Disaster Medicine* **25**(3), 265–272. doi: 10.1017/S1049023X00008141.

Environment Agency (2015), 'Drought management for england'. [Online; accessed 15-11-2024].
URL: *https://www.gov.uk/government/publications/drought-management-for-england*

Environment Agency (2024), 'Stream polluted by 'negligent' southern water'. [Online; accessed 25-11-2024].
URL: *https://www.gov.uk/government/news/stream-polluted-by-negligent-southern-water#:~:text=2%2C000%20fish%20die%20as%20double,edge%20of%20the%20South%20Downs.*

Environment Agency, Department for Environment, Food & Rural Affairs, Double, S. and The Rt Hon George Eustice (2022), 'Environment agency chairs national drought group as parts of country move into drought'. [Online; accessed 15-11-2024].
URL: *https://www.gov.uk/government/news/environment-agency-chairs-national-drought-group-as-parts-of-country-move-into-drought*

Environmental Agency (2017), 'Drought response: our framework for england'. [Online; accessed 25-11-2024].
URL: *https://assets.publishing.service.gov.uk/media/5a820510ed915d74e62355a0/LIT_10104.pdf*

Environmental Agency (2019), 'Abstracting water? think before you drill'. [Online; accessed 22-11-2024].
URL: *https://www.gov.uk/government/news/abstracting-water-think-before-you-drill*

Environmental Agency (2023), 'Creating a better place: Drought explained'. [Online; accessed 15-11-2024].
URL: *https://environmentagency.blog.gov.uk/2023/07/31/drought-explained/*

Foulds, S., Brewer, P., Macklin, M., Haresign, W., Betson, R. and Rassner, S. (2014), 'Flood-related contamination in catchments affected by historical metal mining: An unexpected and emerging hazard of climate change', *Science of The Total Environment* **476-477**, 165–180. doi: 10.1016/j.scitotenv.2013.12.079.

Friends of the Earth (2022), 'Who suffers most from heatwaves in the uk?'. [Online; accessed 14-11-2024].
URL: *https://policy.friendsoftheearth.uk/insight/who-suffers-most-heatwaves-uk*

Gardiner, B., Schuck, A., Schelhaas, M., Orazio, C., Blennow, K. and Nicoll, B. (2013), 'Living with storm damage to forests'.

Gardiner, P. (2011), 'Heatwave plan: 2011'. [Online; accessed 21-11-2024].
URL: *https://assets.publishing.service.gov.uk/media/5a7c83bde5274a559005a655/dh_127235.pdf*

George, M. (2022), 'Peartree green fire: What we know after the fire in southampton'. [Online; accessed 19-11-2024].
URL: *https://www.dailyecho.co.uk/news/20635563.peartree-green-fire-know-fire-southampton/*

George, M. (2023*a*), 'Eastleigh college closes as storm ciarán sweeps in'. [Online; accessed 20-11-2024].
URL: *https://www.dailyecho.co.uk/news/23896523.eastleigh-college-closes-storm-ciaran-sweeps/*

George, M. (2023*b*), 'New forest: Schools with 'no running water' forced to close'. [Online; accessed 20-11-2024].
URL: *https://www.dailyecho.co.uk/news/23899085.new-forest-schools-no-running-water-forced-close/*

George, M. (2023*c*), 'Storm ciarán in southampton: this is how the day unfolded'. [Online; accessed 20-11-2024].
URL: *https://www.dailyecho.co.uk/news/23898166.storm-ciaran-southampton-day-unfolded/*

George, M. (2023*d*), 'Storm ciarán: Itchen bridge in southampton reopens'. [Online; accessed 20-11-2024].
URL: *https://www.dailyecho.co.uk/news/23896400.storm-ciaran-itchen-bridge-southampton-reopens/*

George, M. (2023*e*), 'Storm ciarán: Southern water customers in hampshire left without water'. [Online;

accessed 20-11-2024].
URL: *https://www.dailyecho.co.uk/news/23898916.storm-ciaran-southern-water-customers-hampshire-left-without-water/*

George, M. (2023*f*), 'Storm ciarán: Yellow weather warnings for southampton'. [Online; accessed 20-11-2024].
URL: *https://www.dailyecho.co.uk/news/23893358.storm-ciaran-yellow-weather-warnings-southampton/*

George, M. (2023*g*), 'Toxic blue-green algae found at lakeside country park'. [Online; accessed 19-11-2024].
URL: *https://www.dailyecho.co.uk/news/23765895.toxic-blue-green-algae-found-lakeside-country-park/*

George, M. (2024), 'Flood alerts issued in southampton as storm ashley hits'. [Online; accessed 20-11-2024].
URL: *https://www.dailyecho.co.uk/news/24664941.flood-alerts-issued-southampton-storm-ashley-hits/*

Gloustershire City Council (2024), 'Flooding (drainage and gullies)'. [Online; accessed 26-11-2024].
URL: *https://www.gloucestershire.gov.uk/roads/flooding-drainage-and-gullies/*

Grimm, N. B., Chapin III, F. S., Bierwagen, B., Gonzalez, P., Groffman, P. M., Luo, Y., Melton, F., Nadelhoffer, K., Pairis, A., Raymond, P. A., Schimel, J. and Williamson, C. E. (2013), 'The impacts of climate change on ecosystem structure and function', *Frontiers in Ecology and the Environment* **11**(9), 474–482. doi: 10.1890/120282.

Hausfather, Z. (2015), 'Explainer: Will global warming 'stop' as soon as net-zero emissions are reached?'. [Online; accessed 15-11-2024].
URL: *https://www.carbonbrief.org/explainer-will-global-warming-stop-as-soon-as-net-zero-emissions-are-reached/*

Historic England (2024), 'Adapting historic buildings for energy and carbon efficiency'. [Online; accessed 21-03-2025].
URL: *https://historicengland.org.uk/images-books/publications/adapting-historic-buildings-energy-carbon-efficiency-advice-note-18/heag321-adapting-historic-buildings-energy-carbon-efficiency/*

Hoegh-Guldberg, O., Jacob, D., Taylor, M., Bolaños, T. G., Bindi, M., Brown, S., Camilloni, I. A., Diedhiou, A., Djalante, R., Ebi, K., Engelbrecht, F., Guiot, J., Hijioka, Y., Mehrotra, S., Hope, C. W., Payne, A. J., Pörtner, H.-O., Seneviratne, S. I., Thomas, A., Warren, R. and Zhou, G. (2019), 'The human imperative of stabilizing global climate change at 1.5°c', *Science* **365**(6459), eaaw6974. doi: 10.1126/science.aaw6974.

Hoekstra, A. G., Noordzij, K., de Koster, W. and van der Waal, J. (2024), 'The educational divide in climate change attitudes: Understanding the role of scientific knowledge and subjective social status', *Global Environmental Change* **86**, 102851. doi: https://doi.org/10.1016/j.gloenvcha.2024.102851.

Home Office (2010), 'Licensing act 2003 (mandatory licensing conditions) order 2010'. [Online; accessed 22-11-2024].
URL: *https://www.legislation.gov.uk/uksi/2010/860/contents/made*

Homes & Antiques (2022), 'British house styles across the ages'. [Online; accessed 22-11-2024].
URL: *https://www.homesandantiques.com/interiors/homes/discover-500-years-of-british-homes*

Karagiannis, G. M., Cardarilli, M., Turksezer, Z. I., Spinoni, J., Mentaschi, L., Feyen, L., Krausmann, E. et al. (2019), 'Climate change and critical infrastructure–storms', *Publications Office of the European Union, Luxembourg* .

Kelman, I. and Spence, R. (2003), 'A flood failure flowchart for buildings', *Proceedings of the Institution of Civil Engineers - Municipal Engineer* **156**(3), 207–214. doi: 10.1680/muen.2003.156.3.207.

Kersley, A. (2024), 'Water firms in england and wales lost more than 1tn litres from leaks last year'. [Online; accessed 25-11-2024].
URL: *https://www.theguardian.com/business/article/2024/sep/08/water-firms-in-england-and-wales-lost-more-than-1tn-litres-from-leaks-last-year*

Knox, J., Morris, J. and Hess, T. (2010), 'Identifying future risks to uk agricultural crop production: Putting climate change in context', *Outlook on Agriculture* **39**(4), 249–256. doi: 10.5367/oa.2010.0016.

Kousis, I. and Pisello, A. (2023), 'Evaluating the performance of cool pavements for urban heat island mitigation under realistic conditions: A systematic review and meta-analysis', *Urban Climate* **49**, 101470. doi: 10.1016/j.uclim.2023.101470.

Le Bars, D., Drijfhout, S. and de Vries, H. (2017), 'A high-end sea level rise probabilistic projection including rapid antarctic ice sheet mass loss', *Environmental Research Letters* **12**(4), 044013. doi: 10.1088/1748-9326/aa6512.

Liddell, E. (2019), 'Swan dies after blue-green algae bloom in southampton common lake'. [Online; accessed 19-11-2024].
URL: *https://www.dailyecho.co.uk/news/17835514.swan-dies-blue-green-algae-bloom-southampton-common-lake/*

Liddell, E. (2022*a*), 'Southampton common boating lake 'left to rot' and fish seen 'gasping for air''. [Online; accessed 19-11-2024].
URL: *https://www.dailyecho.co.uk/news/20579752.southampton-common-boating-lake-covered-algae/*

Liddell, E. (2022*b*), 'Southampton lake begins to dry up as drought hits southern england'. [Online; accessed 19-11-2024].
URL: *https://www.dailyecho.co.uk/news/20626490.southampton-lake-begins-dry-drought-hits-southern-england/*

Manning, C., Kendon, E. J., Fowler, H. J., Catto, J. L., Chan, S. C. and Sansom, P. G. (2024), 'Compound wind and rainfall extremes: Drivers and future changes over the uk and ireland', *Weather and Climate Extremes* **44**, 100673. doi: 10.1016/j.wace.2024.100673.

Marshall, R. (2023*a*), 'Bartley water burst its banks due to impact of storm ciarán'. [Online; accessed 20-11-2024].
URL: *https://www.dailyecho.co.uk/news/23896497.bartley-water-burst-banks-due-impact-storm-ciaran/*

Marshall, R. (2023*b*), ''major disruption' for hampshire trains due to storm ciarán'. [Online; accessed 20-11-2024].
URL: *https://www.dailyecho.co.uk/news/23896215.storm-ciaran-precarious-tree-disrupts-rail-services-around-fareham/*

Marshall, R. (2023*c*), 'Man trapped on top of van due to storm ciarán flooding'. [Online; accessed 20-11-2024].
URL: *https://www.dailyecho.co.uk/news/23897517.man-trapped-top-van-due-storm-ciaran-flooding/*

Marshall, R. (2023*d*), 'Storm ciarán hits southampton and hampshire - live updates'. [Online; accessed 20-11-2024].
URL: *https://www.dailyecho.co.uk/news/23896154.storm-ciaran-hits-southampton-hampshire---live-updates/*

Marshall, R. (2025), 'Upset as southampton resident says 'we feel forgotten''. [Online; accessed 25-03-2025].
URL: *https://www.dailyecho.co.uk/news/24954136.upset-southampton-resident-says-we-feel-forgotten/*

Matthews, H. D. and Weaver, A. J. (2010), 'Committed climate warming', *Nature Geoscience* **3**(3), 142–143. doi: 10.1038/ngeo813.

May, C., Williams, I., Hudson, M., Osborne, P. and Zapata Restrepo, L. (2023), 'The solent strait: Water quality trends within a heavily trafficked marine environment, 2000 to 2020', *Marine Pollution Bulletin* **193**, 115251. doi: 10.1016/j.marpolbul.2023.115251.

Met Office (2022), 'Ukcp headline findings'. [Online; accessed 18-11-2024].
URL: *https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/summaries/headline-findings*

Met Office (2023*a*), 'New global dataset shines a light on humidity extremes'. [Online; accessed 14-11-2024].
URL: *https://www.metoffice.gov.uk/about-us/news-and-media/media-centre/weather-and-climate-news/2023/new-global-dataset-shines-a-*

light-on-humidity-extremes

Met Office (2023*b*), 'New research shows increasing frequency of extreme rain'. [Online; accessed 14-11-2024].
URL: *https://www.metoffice.gov.uk/about-us/news-and-media/media-centre/weather-and-climate-news/2023/new-research-shows-increasing-frequency-of-extreme-rainfall-events*

Met Office (2024*a*), 'Haduk-grid: Uk and regional series'. [Online; accessed 22-11-2024].
URL: *https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-and-regional-series*

Met Office (2024*b*), 'Heat-health alert service'. [Online; accessed 22-11-2024].
URL: *https://www.metoffice.gov.uk/weather/warnings-and-advice/seasonal-advice/heat-health-alert-service*

Met Office (2024*c*), 'Uk and global extreme events – heavy rainfall and floods'. [Online; accessed 17-11-2024].
URL: *https://www.metoffice.gov.uk/research/climate/understanding-climate/uk-and-global-extreme-events-heavy-rainfall-and-floods*

New Forest District Council (2024), 'Strategic flood risk assessment'. [Online; accessed 25-11-2024].
URL: *https://www.newforest.gov.uk/article/2810/Strategic-Flood-Risk-Assessment*

Nuruzzaman, M. (2015), 'Urban heat island: Causes, effects and mitigation measures - a review', *International Journal of Environmental Monitoring and Analysis* **3**(2), 67–73. doi: 10.11648/j.ijema.20150302.15.

Ofwat (2019), 'Pn 21/19: Ofwat confirms southern water will pay £126m following investigation'. [Online; accessed 25-11-2024].
URL: *https://www.ofwat.gov.uk/pn-21-19-ofwat-confirms-southern-water-will-pay-126m-following-investigation/*

Orde, T. (2019), 'Algae turns water red at ocean village in southampton'. [Online; accessed 19-11-2024].
URL: *https://www.dailyecho.co.uk/news/17744666.algae-turns-water-red-ocean-village-southampton/*

Park, J., Kim, J.-H., Lee, D. K., Park, C. Y. and Jeong, S. G. (2017), 'The influence of small green space type and structure at the street level on urban heat island mitigation', *Urban Forestry & Urban Greening* **21**, 203–212. doi: 10.1016/j.ufug.2016.12.005.

Pender, R. and Lemieux, D. J. (2020), 'The road not taken: Building physics, and returning to first principles in sustainable design', *Atmosphere* **11**(6). doi: 10.3390/atmos11060620.

Radhakrishnan, S. (2018), 'Green roofs boost solar energy output compared to white roofing: Study'. [Online; accessed 13-03-2025].
URL: *https://www.ibtimes.com/green-roofs-boost-solar-energy-output-compared-white-roofing-study-2637581*

Ramos, J. (2024), 'Storm henk: Major disruption as gale-force winds hit southampton'. [Online; accessed 20-11-2024].
URL: *https://www.dailyecho.co.uk/news/24023645.storm-henk-major-disruption-gale-force-winds-hit-southampton/*

Rance, A. (1986), *Southampton: an illustrated history*, Milestone. ISBN: 0-903852-95-0.

Ridley, J., Gregory, J. M., Huybrechts, P. and Lowe, J. (2010), 'Thresholds for irreversible decline of the greenland ice sheet', *Climate Dynamics* **35**(6), 1049–1057. doi: 10.1007/s00382-009-0646-0.

Rimmer, D. L., Vizard, C. G., Pless-Mulloli, T., Singleton, I., Air, V. S. and Keatinge, Z. A. (2006), 'Metal contamination of urban soils in the vicinity of a municipal waste incinerator: One source among many', *Science of The Total Environment* **356**(1), 207–216. doi: 10.1016/j.scitotenv.2005.04.037.

Salvidge, R. and Hosea, L. (2023), 'Hundreds of potentially toxic road runoff outfalls polluting england's rivers'. [Online; accessed 17-11-2024].
URL: *https://www.theguardian.com/environment/2023/oct/05/potentially-toxic-road-runoff-outfalls-polluting-england-rivers*

SDM Property (2024), 'Fire, smoke & flood damage in southampton'. [Online; accessed 26-11-2024].
URL: *https://sdmproperty.co.uk/southampton/fire-smoke-flood-damage/*

Shahid, N. (2024), 'Muslim and minority communities are likely to be most affected by rising

temperatures as extreme heat exposes failings in the uk's housing stock'. [Online; accessed 13-11-2024].
URL: *https://hyphenonline.com/2024/09/09/we-feel-suffocated-hot-housing-social-uninhabitable-in-heat-summer/*

Shahmohamadi, P., Che-Ani, A., Ramly, A., Maulud, K. and Mohd-Nor, M. (2010), 'Reducing urban heat island effects: A systematic review to achieve energy consumption balance', *International Journal of Physical Sciences* **5**(6), 626–636.
URL: *https://academicjournals.org/journal/IJPS/article-full-text-pdf/DBB8AC426195*

Simpson, C. H., Brousse, O., Taylor, T., Grellier, J., Taylor, J., Fleming, L. E., Davies, M. and Heaviside, C. (2024), 'Modeled temperature, mortality impact and external benefits of cool roofs and rooftop photovoltaics in london', *Nature Cities* **1**(11), 751–759. doi: 10.1038/s44284-024-00138-1.

Sky News (2024), 'Storm bert: Footballers turn flooded gloucestershire pitch into swimming pool'. [Online; accessed 26-11-2024].
URL: *https://news.sky.com/video/storm-bert-footballers-turn-flooded-gloucestershire-pitch-into-swimming-pool-13260456*

Social Mobility Comission (2024), 'Charting your course: Earnings boost after university and college'. [Online; accessed 20-03-2025].
URL: *https://socialmobility.independent-commission.uk/app/uploads/2024/08/Value-of-Qualifications.pdf*

Solomon, S., Plattner, G.-K., Knutti, R. and Friedlingstein, P. (2009), 'Irreversible climate change due to carbon dioxide emissions', *Proceedings of the National Academy of Sciences* **106**(6), 1704–1709. doi: 10.1073/pnas.0812721106.

Southampton City Council (2017*a*), 'Southampton level 2 strategic flood risk assessment'. [Online; accessed 17-11-2024].
URL: *https://www.southampton.gov.uk/media/s1znees1/southampton-level-2-sfra-main-report-may-2017_tcm63-390513.pdf*

Southampton City Council (2017*b*), 'Southampton level 2 strategic flood risk assessment - appendix a: Mapping to accompany level 2 sfra'. [Online; accessed 17-11-2024].
URL: *https://www.southampton.gov.uk/media/j5ajrhgq/southampton-level-2-strategic-flood-risk-assessment_tcm63-437164.pdf*

Southampton City Council (2019), 'Public document pack, cabinet: Tuesday, 16th april, 2019 at 4.30 pm'. [Online; accessed 13-11-2024].
URL: *https://www.southampton.gov.uk/moderngov/documents/g3834/Public%20reports%20pack%2016th-Apr-2019%2016.30%20Cabinet.pdf?T=10*

Southampton City Council (2021), 'Facebook status: 13th august 2021 - we're aware that algae has formed on the boating lake on southampton common...'. [Online; accessed 19-11-2024].
URL: *https://www.facebook.com/photo.php?fbid=4524457410932577&id=724303417614681&set=a.724698480908508*

Southampton City Council (2023), 'Southampton city council green city action plan 2023-2030'. [Online; accessed 21-11-2024].
URL: *https://www.southampton.gov.uk/our-green-city/*

Southampton City Council (2024*a*), 'Flood risk management'. [Online; accessed 26-11-2024].
URL: *https://www.southampton.gov.uk/environment/emergencies-and-severe-weather/flood-risk-management/*

Southampton City Council (2024*b*), 'Sandbags'. [Online; accessed 26-11-2024].
URL: *https://www.southampton.gov.uk/environment/emergencies-and-severe-weather/flood-risk-management/flood-risk-advice/sandbags/*

Southampton City Council (2024*c*), 'Southampton green space factor guidance 2024'. [Online; accessed 21-11-2024].
URL: *https://www.southampton.gov.uk/media/kajkr23v/green-space-factor-guidance-2024.pdf*

Southampton City Council and Southampton Data Observatory (2024), 'Southampton strategic assessment: Deprivation and poverty'. [Online; accessed 26-11-2024].
URL: *https://data.southampton.gov.uk/economy/deprivation-and-*

poverty/

Southampton Data Observatory (2024), 'Southampton data observatory: Your insight into southampton'. [Online; accessed 03-12-2024].
URL: *https://data.southampton.gov.uk/*

Southampton Weather (2024), 'Seasonal rainfall summary (mm)'. [Online; accessed 17-11-2024].
URL: *https://www.southamptonweather.co.uk/wxrainseason.php*

Southern Water (2024), 'Annual performance report: Regulatory reporting 2023–24'. [Online; accessed 25-11-2024].
URL: *https://www.southernwater.co.uk/media/n0lnxzl5/annual_performance_report_2023_24.pdf*

Steadman, R. G. (1979), 'The assessment of sultriness. part i: A temperature-humidity index based on human physiology and clothing science', *Journal of Applied Meteorology and Climatology* **18**(7), 861 – 873. doi: 10.1175/1520-0450(1979)018<0861:TAOSPI>2.0.CO;2.

Taylor, J., man Lai, K., Davies, M., Clifton, D., Ridley, I. and Biddulph, P. (2011), 'Flood management: Prediction of microbial contamination in large-scale floods in urban environments', *Environment International* **37**(5), 1019–1029. doi: https://doi.org/10.1016/j.envint.2011.03.015.

Trenberth, K. E. (1998), 'Atmospheric moisture residence times and cycling: Implications for rainfall rates and climate change', *Climatic Change* **39**(4), 667–694. doi: 10.1023/A:1005319109110.

Turner, S., Barker, L. J., Hannaford, J., Muchan, K., Parry, S. and Sefton, C. (2021), 'The 2018/2019 drought in the uk: a hydrological appraisal', *Weather* **76**(8), 248–253. doi: 10.1002/wea.4003.

UK Health Security Agency (2006), 'Flooding and health: advice for the public'. [Online; accessed 26-11-2024].
URL: *https://www.gov.uk/government/publications/flooding-and-health-public-advice/flooding-and-health-advice-for-the-public*

UK Health Security Agency (2023*a*), 'Adverse weather and health plan'. [Online; accessed 22-11-2024].
URL: *https://www.gov.uk/government/publications/adverse-weather-and-health-plan*

UK Health Security Agency (2023*b*), 'How to prepare for flooding'. [Online; accessed 26-11-2024].
URL: *https://www.gov.uk/government/publications/flooding-and-health-advice-for-frontline-responders/how-to-prepare-for-flooding*

University of Southampton (2024), 'School students learn about flooding from university experts'. [Online; accessed 24-03-2025].
URL: *https://www.southampton.ac.uk/news/2024/10/school-students-learn-about-flooding-from-university-experts.page*

Venegas, R. M., Acevedo, J. and Treml, E. A. (2023), 'Three decades of ocean warming impacts on marine ecosystems: A review and perspective', *Deep Sea Research Part II: Topical Studies in Oceanography* **212**, 105318. doi: 10.1016/j.dsr2.2023.105318.

Vincent, K. and Passant, N. (2006), 'Assessment of heavy metal concentrations in the united kingdom'. [Online; accessed 26-11-2024].
URL: *https://uk-air.defra.gov.uk/reports/cat16/0604041205_heavy_metal_issue1_final.pdf*

Virk, G., Jansz, A., Mavrogianni, A., Mylona, A., Stocker, J. and Davies, M. (2015), 'Microclimatic effects of green and cool roofs in london and their impacts on energy use for a typical office building', *Energy and Buildings* **88**, 214–228. doi: 10.1016/j.enbuild.2014.11.039.

Watson, S. J., Kritharas, P. and Hodgson, G. J. (2015), 'Wind speed variability across the uk between 1957 and 2011', *Wind Energy* **18**(1), 21–42. doi: 10.1002/we.1679.

Weather Underground (2024), 'Southampton, england, united kingdom weather history'. [Online; accessed 13-11-2024].
URL: *https://www.wunderground.com/history/monthly/gb/southampton*

White, M. (2024), 'Woman died after unsafe wall collapsed during storm'. [Online; accessed 20-11-2024].
URL: *https://www.bbc.co.uk/news/articles/cd0z042krxzo*

Wilson, E. (2022), 'Southampton in top ten uk areas for asbestos cancer deaths'. [Online; accessed 13-01-2025].
URL: *https://www.dailyecho.co.uk/news/20270394.southampton-among-worst-asbestos-cancer-deaths/*

Wolf, J., Woolf, D. and Bricheno, L. (2020), 'Impacts of climate change on storms and waves relevant to the coastal and marine environment around the uk', *MCCIP Science Review* **2020**, 132–157. doi: 10.14465/2020.arc07.saw.

Yandell, C. (2023*a*), 'Storm ciarán: Hampshire southern water customers face loss of supply'. [Online; accessed 20-11-2024].
URL: *https://www.dailyecho.co.uk/news/23898797.southern-water-customers-face-low-pressure-loss-supply/*

Yandell, C. (2023*b*), 'Storm ciarán hits southampton: Everything you need to know'. [Online; accessed 20-11-2024].
URL: *https://www.dailyecho.co.uk/news/23894981.storm-ciaran-hits-southampton-everything-need-know/*