

REDUCING FLOOD RISK: WHICH HOMES ARE MOST SUITABLE FOR PFR?

Phase 2: Area-Specific Analysis

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Executive Summary

Flooding remains one of the most widespread and damaging natural hazards in the UK. Up to 11 million properties are at risk with many unlikely to benefit from formal flood defences in the near term. **Property Flood Resilience (PFR)** offers a practical, scalable solution to reduce the impact of flooding at the household level, particularly in areas where infrastructure investment is not feasible or cost-effective and where properties are impacted by shallow flooding.

This report builds on national-level analysis undertaken in Phase 1 by applying a **local lens** to PFR potential, focusing on four diverse case study areas: **Kensington & Chelsea (London), West Lothian (Scotland), Pontypridd (Wales), and Hull (Yorkshire)**. These areas were selected to reflect a range of flood sources, housing typologies, socio-demographic conditions, and stages of PFR engagement. The analysis aims to identify where PFR can be most effective, cost-efficient, and equitably delivered.

Key findings include:

- Across the four areas, over **75% of flood-exposed properties are structurally suitable for PFR**, with particularly high suitability rates in Pontypridd (88%) and Hull (84%).
- In all areas, **a small number of high-risk properties account for a disproportionate share of total expected losses**, meaning that **targeted PFR delivery could achieve over 50% of potential savings by treating just 10–20% of properties**.
- **Combined Potential Average Annual Loss (AAL) reductions** range from **£260k across West Lothian to £19.5 million across Hull** under comprehensive PFR scenarios.
- For many properties, particularly those exposed to frequent or shallow flooding, **limited PFR measures offer a strong return on investment**, with a significant proportion of homes able to recover installation costs within 20 years or less.
- **Socio-demographic factors**, including tenure, deprivation, disability, and age, **strongly influence the feasibility of voluntary PFR uptake**. In areas with high rental occupancy or vulnerable populations, delivery will require targeted engagement, institutional support, and accessible funding mechanisms.

The analysis demonstrates that **PFR is not only technically and economically viable but integral** to effective flood resilience in many communities. It can protect homes where large-scale flood defences are not present, and it offers flexibility to respond to local risk and community needs. However, to be successful, **PFR programmes must be tailored to their context**, balancing cost-effectiveness with social equity.

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**Shallow flood waters on Shaftesbury Avenue,
Kingston upon Hull during the 2007 flood event**

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Area-Specific Analysis

Our national-level analysis indicates that over 21.8 million homes, around 72% of the UK's housing stock, are structurally suitable for PFR, with approximately 3.1 million exposed to flood depths where PFR is most effective (up to 0.6 m). While full-scale national implementation could reduce average annual flood losses by up to 50%, a more targeted approach focusing on high-frequency flood risk areas could still deliver savings of around £238 million per year. The findings also showed that for over 50,000 properties, the cost of PFR is lower than the expected annual cost of flooding, making it a financially viable investment in many cases.

Despite this, uptake of PFR remains limited due to data gaps, low public awareness, limited scale and scope of public schemes to date, and inconsistent integration into insurance and lending practices. The national analysis made clear that PFR is not a substitute for strategic flood defences, but rather a necessary and cost-effective complement, especially in areas unlikely to benefit from major infrastructure schemes.

Building on these insights, the area-specific analysis shifts focus from the national scale to the local level. It explores how national trends translate into real-world opportunities for intervention, identifying where PFR can be most effectively deployed based on local flood risk, housing stock, and community characteristics. This local-based approach aims to support targeted investment and practical delivery, ensuring that PFR measures reach the properties and people who stand to benefit most.

The four study areas have been selected to reflect a diverse cross-section of flood risk contexts across the UK. Each has experienced a recent significant flood event that affected a substantial number of properties, making them highly relevant for area-specific analysis. They also differ markedly in terms of building stock, socio-demographic characteristics, sources of flooding, and stages of PFR adoption, offering a valuable basis for comparison and tailored intervention strategies.

Area name	Design intent
Kensington & Chelsea	A densely populated, high-value urban borough in London, England, significantly affected by surface water flooding during the 2021 event. It represents an affluent community with complex infrastructure and drainage challenges.
West Lothian	A semi-urban area with hotspots of frequent flooding, West Lothian has a PFR scheme already underway, offering the opportunity to evaluate early implementation and inform future scaling.
Pontypridd	A community affected by river flooding, particularly during Storm Dennis in 2020, with a mix of older housing stock and evolving resilience needs.
Hull	A less affluent urban area with extensive exposure to surface water flooding, most notably during the 2007 floods. It presents a contrasting socio-economic profile and infrastructure challenge.

Together, these areas provide a robust foundation for exploring how national PFR insights can be applied in place-based, practical contexts, tailoring recommendations to real-world needs and local capacity.

Comparative Framework for Assessing PFR Potential

To assess the potential for Property Flood Resilience across the four case study areas, a consistent set of indicators has been applied. These indicators allow for comparison between diverse local contexts and help identify where PFR measures are most likely to be effective, feasible, and impactful. Each area is evaluated using the following criteria:

1. Homes suitable for PFR based on construction and floor level

Building stock varies significantly across the country. Ground-floor properties of standard cavity wall or solid masonry construction are considered suitable for PFR. For the purposes of this study flats above ground floor and homes of non-standard construction material not considered suitable.

2. Homes at risk of flooding and frequent flood exposure

Properties in areas prone to repeated or shallow flooding are among the strongest candidates for PFR interventions. Frequent flooding of these properties means homeowners are aware of the risk and likely to be interested in mitigation.

3. Homes not formally protected by flood defences

PFR is particularly relevant where formal flood infrastructure is absent or insufficient. PFR is also well suited to protecting against typically shallower surface water flooding. Proximity to existing flood defence infrastructure may make homeowners aware of flood risk, equally it may make homeowners complacent believing their home is already entirely protected.

4. Homes where the expected cost of flooding exceeds PFR installation costs

Homeowners are more likely to adopt PFR where there is a clear cost benefit. Here we consider the expected annual cost of flooding (over a 10,000-year long term average) against the cost of PFR installation. Two PFR scenarios are considered, a Limited resistance package protecting up to 0.15m costing £1,500 for solid floor and £3,000 for suspended floor properties, and a Standard resistance package protecting up to 0.6m costing £9,500 / £12,500 per property.

5. Homes with a history of flooding

Quantitative flood risk assessment often overlooks how traumatic flooding can be for the homeowner. Homes of suitable construction type, likely to be affected by shallow water depths, and have recent experience of flooding are likely to be strong candidates for PFR.

6. Cost-effective targeting of high-risk properties

Adoption of PFR entirely driven by the homeowner may not be effective. Successful risk reduction may require community lead schemes. Here we consider how beneficial focused or limited investment might be on mitigating loss the overall loss in each area.

7. Socio-demographic factors that may influence uptake

Vulnerability related to disability, tenure type, or financial capacity may affect the ability of the homeowner to adopt or maintain PFR. These factors are considered at the community level.

Methodology

The area-specific analysis uses a risk analysis methodology consistent with the national-scale analysis. The key differentiator is the inclusion of more detailed property level data allowing for greater granularity in the outputs.

For the Assessment of PFR Suitability & Implementation Cost

For each area, the residential building stock was evaluated for PFR suitability based on structural characteristics to determine PFR suitability and implementation cost.

- **Construction type:** Suitable for PFR if of standard construction material, such as cavity wall or solid masonry.
- **Floor level:** Suitable for PFR if ground-floor dwellings; flats above ground floor were excluded as they are not typically exposed to direct flooding.
- **Floor type:** Properties were further classified as having either solid or suspended ground floors for both a consideration of cost and to determine the depth of flood protection. Research carried out for the Department for Communities and Local Government (DCLG) and the Environment Agency recommends that the use of protection measures should generally be limited to a nominal protection height of 600mm above Ground Level for suspended floors and 600mm above lowest floor level for properties with solid floors. Properties with suspended floors also require additional work to address underfloor voids.

These factors were combined to calculate the proportion of the building stock suitable for limited and comprehensive PFR intervention.

Flood Risk and Exposure Mapping

High-resolution flood hazard data was used to identify properties at risk from **river**, **surface water**, and **coastal flooding** at a range of design return periods. The analysis focused on properties exposed to flood depths of up to **0.6 metres**, where PFR is most effective. Properties at frequent risk, those impacted at or before a 1-in-50-year event, were highlighted to explore cost-effective targeting strategies. The annual average cost of flooding was calculated using JBA's UK Flood Probabilistic Model, containing 106,000 stochastically simulated flood events correlating, rain, river flow and coastal surge across the UK. The comparison between flood extent and depth was carried out at the property coordinate level.



Cost Assumptions for PFR Implementation

Two levels of PFR intervention were assessed across all study areas: limited and standard. Each costed according to property floor type as this significantly affects installation complexity and cost.

- **Limited PFR measures** (designed for shallow or nuisance flooding up to ~0.15m):
 - £1,500 for properties with solid ground floors
 - £3,000 for properties with suspended ground floors
 - Measures typically include airbrick covers, non-return valves, sealants, and puddle pumps.
- **Standard PFR packages** (suitable for flood depths up to ~0.6m):
 - £9,500 for properties with solid ground floors
 - £12,500 for properties with suspended ground floors
 - Measures may include flood doors and barriers, sump and pump systems, raised electrical sockets, waterproof wall and floor finishes, and resilient kitchen or bathroom fittings.

These fixed cost assumptions were used to model the financial viability and cost-effectiveness of PFR interventions for each property. By applying them consistently across the areas, the analysis supports comparison between building types, risk levels, and intervention strategies at both individual and neighbourhood scales.

Evaluating Benefit and Cost-Effectiveness

Each property attributed with its lat/long location, rebuild cost and structural characteristics were evaluated in JBA's Probabilistic UK Flood Model to determine the annual average cost of combined river, surface water and coastal flooding. Suitable properties were then reevaluated with a Limited and Standard PFR protection to allow comparison between investment cost and flood damage avoided. This study assumes PFR measures would protect against flood water up to the design depth. In reality, some leakage is to be expected which may cause minor property damage. Return-on-investment was assessed across multiple thresholds (e.g. where PFR cost is less than 5x, 10x or 20x the AAL), reflecting typical product lifespans and allowing prioritisation of high-impact interventions.

Incorporating Social and Practical Considerations

To inform equitable and effective delivery, socio-demographic indicators were also examined, including:

- **Disability rates** – which may increase vulnerability to displacement and damage.
- **Housing tenure** – recognising challenges in deploying PFR in private rental or social housing sectors.

This approach enables a comprehensive understanding of not just where PFR is feasible, but also where it is likely to be most needed and most effective in practice.

1 Kensington & Chelsea, London, England

Area Highlights

- **High risk from surface water** due to dense urban form and ageing drains.
- **46% of homes suitable for PFR**, including 2,500 basement and 12,500 ground-floor flats.
- **£3.9m/year savings** possible (67% AAL reduction).
- **60% of suitable homes cost-effective** for limited PFR within 20 years.
- Challenges: rental dominance in North Kensington, conservation planning limits, high rebuild costs.

The Royal Borough of Kensington and Chelsea is a densely populated suburb to the west of central London at notable risk from surface water flooding due to its dense urban form and extensive impermeable surfaces. Heavy rainfall can lead to flash flooding, particularly affecting basement flats and lower ground floor properties. A prominent recent event occurred in July 2021, when intense storms caused widespread disruption and internal flooding to residential and commercial properties. While the area benefits from protection against tidal flooding via the Thames Barrier, surface water remains a significant risk.

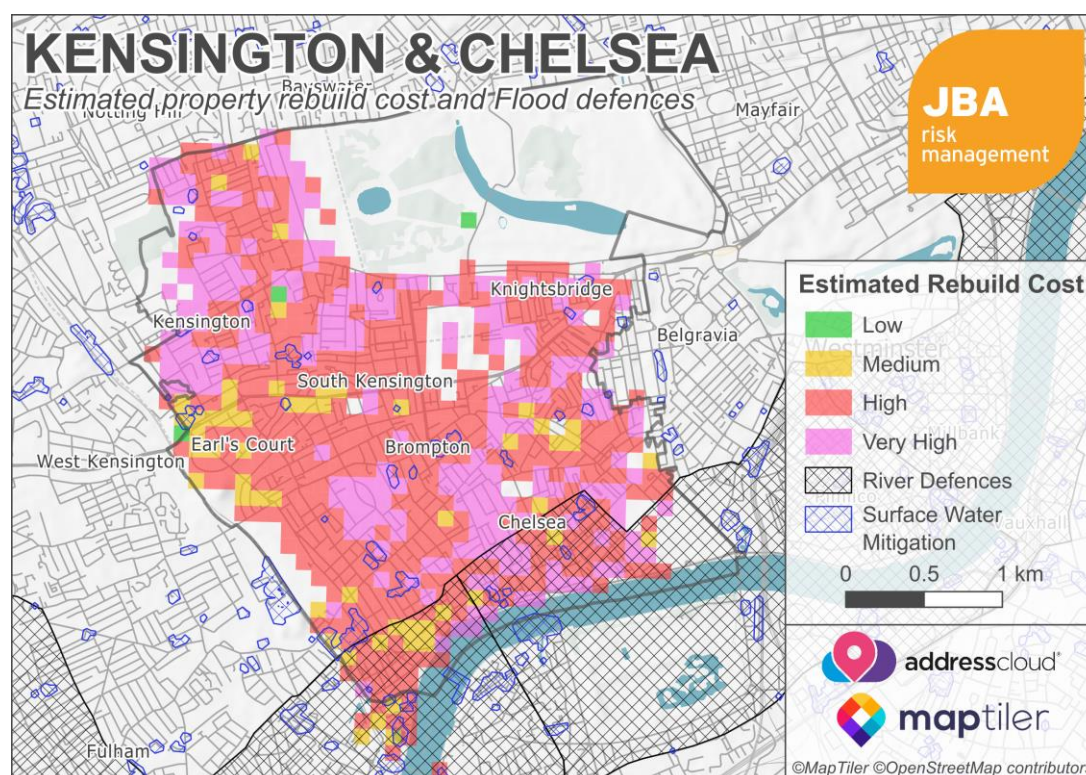


Figure 1-1: Estimated property rebuild costs and spatial extent of flood defences in Kensington and Chelsea.

Figure 1-1 provides insight into the spatial relationship between property rebuild costs and existing flood defence coverage in Kensington and Chelsea. Areas with high and very high estimated rebuild costs are widespread across the Borough, particularly in central and southern neighbourhoods. These areas often contain high-value residential buildings, including heritage or architecturally complex structures, where the cost of post-flood reconstruction is significant. Figure 1-1 further highlights a key consideration for flood risk management in the Borough, the locations with the greatest potential for financial loss are not always those with the most flood protection in place. In such contexts, where traditional flood defences may be limited or impractical due to urban constraints, Property Flood Resilience (PFR) measures offer a valuable opportunity to reduce vulnerability. Targeted investment in PFR, particularly in streets and neighbourhoods with high rebuild exposure and limited defence coverage, can play a central role in improving resilience across the Borough.

1.1 Homes suitable for PFR based on construction and floor level

73% of properties in Kensington and Chelsea are flats with many buildings in the Borough including lower ground floors or basements that are either subdivided into self-contained properties or are integral to the overall property. This can increase the vulnerability of residents to the impacts of flooding. The Borough council recognises that whilst residual risk from coastal and river flooding exists, overtopping of the existing flood defences is unlikely. Critically it is further recognised that over 20,000 properties are at risk of flash flooding (RBKC, 2024). Historically, flash flooding in August 1960 impacted 'hundreds' of properties with flooding in July 2021 impacting over 500.

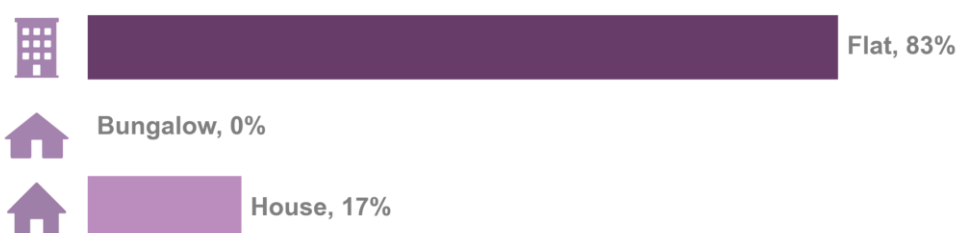


Figure 1-2: Proportion of residential property types in Kensington and Chelsea.

Importantly, many of these high-value areas fall outside the zones served by formal flood defences and are served only by Victorian drainage systems with limited capacity. While the Borough benefits from river defences along the River Thames, surface water infrastructure is more sporadically distributed and does not comprehensively cover areas most at risk.

Table 1-1 provides a breakdown of building types in Kensington and Chelsea with suitability for PFR. The assessment is applied across all buildings in the Borough, regardless of current flood risk or the presence of formal defences.

Table 1-1: Summary of building types and suitability for PFR in Kensington and Chelsea.

Building type		Suitable for PFR		Unsuitable for PFR	Total
		Solid floor	Suspended floor		
House	Detached	263	453	49	765
	Semi	257	453	13	723
	Terrace	3,013	3,796	33	6,842
	Unknown	0	350	27	377
Bungalow		11	7	0	18
Flat	Basement	1,399	1,151	21	2,571
	Ground floor	2,345	9,662	571	12,578
	First floor and above	0	0	26,855	26,855
Total		7,288	15,872	27,569	50,729

Of the 50,729 buildings assessed, **23,160 (46%) are considered suitable for PFR**. This includes 7,288 with solid floors and 15,872 with suspended floors, both of which are capable of accommodating standard PFR interventions such as flood doors, non-return valves, and underfloor drainage adaptations. The remaining **27,569 buildings (54%) are unsuitable**, primarily consisting of flats above ground floor or buildings with construction types that limit retrofitting options.

Kensington and Chelsea's housing stock is dominated by flats, which significantly influences PFR applicability. First floor and above flats account for over 26,800 properties and are considered unsuitable for PFR, as they are not directly exposed to floodwater and therefore unsuitable for property-level measures, though they can still experience significant indirect impacts during flood events. In contrast, ground floor flats and basement flats offer substantial opportunity for intervention: over 12,000 ground floor flats and over 2,500 basement flats are structurally suitable. Applying PFR to basement and ground-floor units can substantially reduce these knock-on effects to above ground flats. By protecting the base of the building, including service entrances and circulation areas, PFR can help maintain access and reduce

recovery times for upper-floor residents. This is particularly relevant in converted or subdivided townhouses and mansion blocks where shared entrances, electrics, and drains can be compromised even if individual dwellings are above the flood level.

While many basement flats are structurally suitable for PFR, it is essential to note that property-level measures are designed to reduce damage to buildings and contents, not to protect life. In a severe flood event, water ingress into basements can occur rapidly and present serious safety risks to occupants. PFR can therefore complement wider resilience strategies by reducing repair costs and disruption, but it must not be relied upon as a substitute for safe evacuation planning or broader community flood risk management.

Terraced houses, though less common than flats, also represent a strong candidate group. Of the 6,842 terraced properties, over 6,800 (99%) meet PFR suitability criteria. Detached and semi-detached houses follow a similar pattern, with the majority falling into the suitable category due to conventional wall and floor construction.

1.2 Homes at risk to flood and frequent flooding

Of the 50,729 buildings in Kensington and Chelsea included in this study, **20,560 properties are at risk to surface water flooding**, a peril strongly influenced by the Borough's dense urban form and legacy drainage infrastructure. This concentrated risk profile, coupled with the prevalence of basement flats and ground-floor conversions, makes surface water one of the most disruptive and costly hazards in the Borough.

Table 1-2: Summary of number of properties exposed to flood, PFR suitability, and potential Average Annual Loss (AAL) reduction in Kensington and Chelsea.

Total Number of Properties		50,729		Number of at risk properties suitable for PFR		9,338	
Flood Type	No. of properties at risk	% of total properties	Baseline AAL	Limited PFR		Standard PFR	
				AAL	% saving	AAL	% saving
River	-	-	-	-	-	-	-
Surface water	20,560	41%	£5,760,647	£2,790,808	-52%	£1,903,527	-67%
Coastal	-	-					
TOTAL	20,560	41%	£5,766,770	£2,761,975	-52%	£1,885,517	-67%

The potential financial impact is significant: the current expected annual cost of flooding is £5.77 million per year. With Limited PFR measures, losses could be reduced by 52% (to £3 million), and by 67% (to £3.9 million) under Standard PFR measures. Nearly 9,400 properties (46%) are assessed as suitable for PFR cost reduction, particularly in areas where retrofitting resilience into individual buildings is more viable than large-scale infrastructure upgrades. This highlights PFR as a priority strategy for flood mitigation in Kensington and Chelsea, where structural and spatial constraints limit the scope for traditional surface water defences.

While overall exposure is high, the probability of frequent flooding is lower. Only 133 properties are estimated to flood in a 1-in-75-year event (1.5% chance of occurrence), of which 49 are suitable for PFR, illustrating that damage is highly concentrated in certain locations.

Figure 1-3 presents a density heatmap of flood-affected properties across the Borough, highlighting clusters in South Kensington, Earl's Court, Chelsea, and Brompton. These areas align with topographic depressions, high-density development, and historically under-capacity drainage systems. Figure 1-4 maps the percentage of at-risk residential properties that are structurally suitable for PFR. Many southern and western neighbourhoods have suitability rates above 60%, especially in areas with high concentrations of ground-floor and basement dwellings built with conventional construction. These homes are well suited to standard PFR interventions such as flood doors, non-return valves, or raised utilities.

Together, the spatial overlay of impact density and PFR suitability provides a clear case for targeted property-level interventions. In a compact, highly urbanised borough like Kensington

and Chelsea, where large-scale surface water defences are difficult to implement due to constrained space and complex underground infrastructure, PFR offers a practical, property-based solution to mitigate future flood impacts.

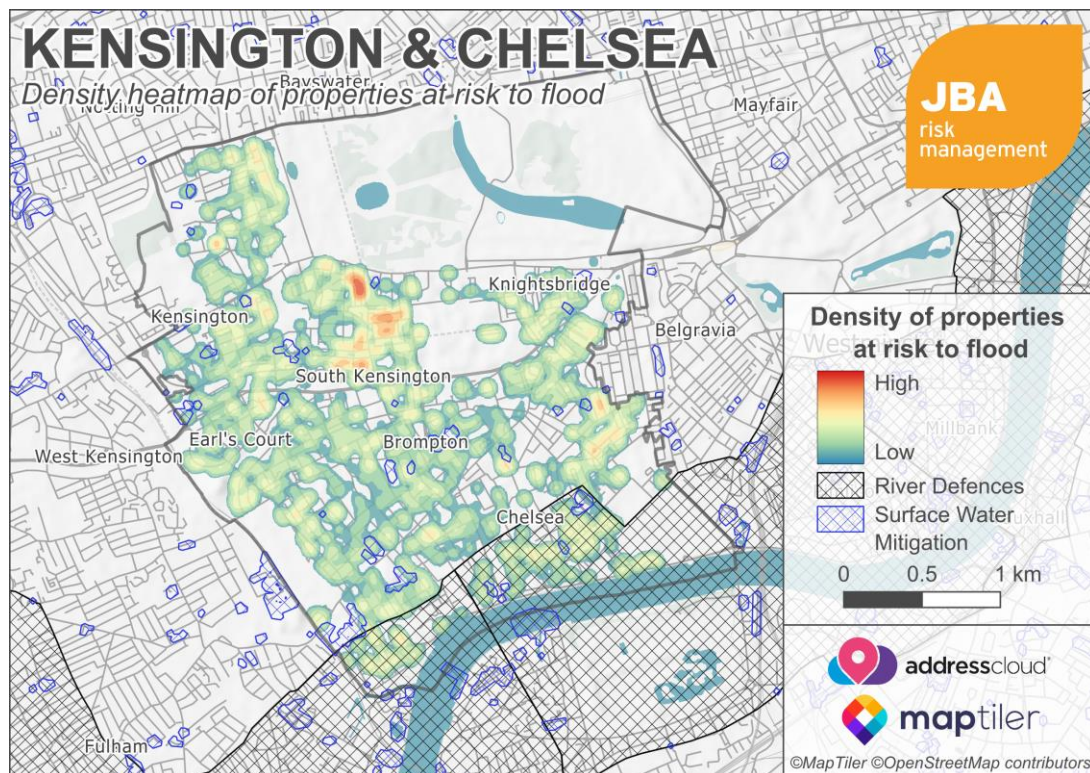


Figure 1-3: Density heatmap of properties at risk to flooding in Kensington and Chelsea.

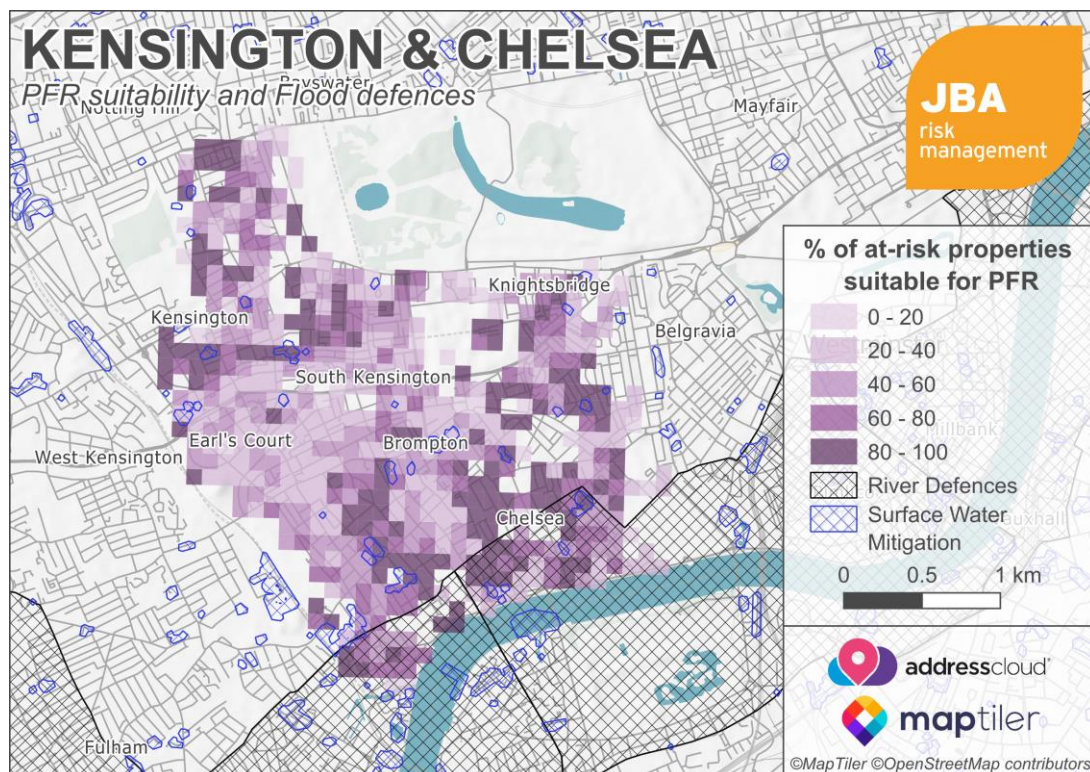


Figure 1-4: Proportion of at-risk residential properties suitable for Property Flood Resilience (PFR) across Kensington and Chelsea

1.3 Homes not formally protected by flood defence

Mitigation from flood defences in Kensington and Chelsea are limited, only 720 of 20,560 properties (4%) benefit measurably from flood protection. This low coverage reflects the Borough's primary exposure to surface water flooding, for which mitigation largely depends on the performance of the underground drainage network rather than conventional flood defences.

Much of the housing stock in Kensington and Chelsea predates modern drainage design standards. The majority of homes were built before 1985, when new-build regulations began to introduce improved surface water drainage requirements. As a result, large parts of the Borough rely on ageing Victorian and early 20th-century sewer systems that were not designed to accommodate the intensity or frequency of rainfall events experienced today. These legacy systems offer only limited mitigation under extreme conditions and cannot be considered a formal defence under national risk mapping criteria.

This highlights the urgent need for alternative or complementary resilience strategies. In a dense urban environment where expanding physical drainage infrastructure is often impractical, solutions such as sustainable urban drainage systems (SuDS), green infrastructure, and PFR measures provide more adaptable and scalable protection for communities at risk.

1.4 Homes where PFR offers a cost-effective return on investment

Understanding where PFR measures deliver the greatest financial return is key to effective targeting and prioritisation. This section identifies properties in Kensington and Chelsea where the cost of implementing either limited or comprehensive PFR measures is outweighed by the expected reduction in flood damages over time at an individual property level. By comparing installation costs with potential AAL reductions, we can estimate how many properties are likely to achieve full cost recovery within 5, 10, or 20 years, the latter corresponding to the typical service life of most PFR interventions.

Table 1-3 summarises the number and proportion of PFR-suitable properties in the Borough where expected AAL savings exceed installation costs, categorised by return-on-investment thresholds.

- For limited PFR measures, nearly 20% of properties are likely to recoup costs within five years, while over 60% are projected to do so within 20 years.
- While comprehensive PFR measures involve higher upfront investment, they are still cost-effective in many cases: 21% of suitable properties are expected to deliver a full return within 20 years.

Table 1-3: Number and proportion of PFR-suitable properties in Kensington and Chelsea where expected Average Annual Loss (AAL) savings exceed installation costs.

PFR Savings	PFR Scenario <i>Limited Measures</i>		PFR Scenario <i>Standard Measures</i>	
	Number of properties	% of total PFR-suitable properties	Number of properties	% of total PFR-suitable properties
<5 x AAL	1,805	19.8	220	2.4
<10 x AAL	3,522	38.6	792	8.7
<20 x AAL	5,497	60.2	1,881	20.6

The stronger performance of limited PFR measures reflects the particular flood profile of Kensington and Chelsea. Most properties at risk experience relatively shallow surface water flooding and damaging events are infrequent. In these circumstances, low-cost interventions such as airbrick covers, non-return valves and pumps are sufficient to avoid the majority of repeat damages, giving them a faster payback period. By contrast, comprehensive packages involve much higher installation costs, but the additional protection they provide is rarely tested given the limited number of deep or severe flooding events in the Borough. This explains why

a much greater proportion of homes achieve cost recovery under the limited scenario than the standard one.

These results underscore the importance of incorporating cost-benefit considerations into PFR planning. For the homes expected to frequently flood, there is a strong financial case for PFR investment. Additionally, the overlap between properties that would benefit from both limited and comprehensive measures allows for flexible implementation strategies depending on budget, building characteristics, and household needs. While final delivery will also rely on practical and social factors, this analysis provides robust evidence to support value-for-money investment decisions in flood resilience.

1.5 Homes that have previously flooded

In July 2021, Kensington and Chelsea experienced one of the most severe surface water flooding events in recent years, driven by intense and prolonged rainfall that overwhelmed drainage infrastructure and caused widespread disruption. The wettest area in London, St James's Park, recorded 41.8mm of rainfall in a single day, close to the city's average for the entire month, with JBA estimating this to be approximately a 1-in-50 to 1-in-100-year event (JBA, 2021). Although a precise count of homes flooded in the Borough is not available, the scale of the event was significant: over 120 residents were evacuated from their homes as a result of flood damage (New York Times, 2021), and Sedgwick, one of the UK's leading loss adjusters, reported receiving over 2,000 flood claims between 12, 17, and 25 July (Insurance Post, 2021a).

By combining the Section 19 flood investigation map of flooded streets (RBKC, 2022) and local authority map with JBA's surface water flood hazard maps we can estimate likely properties impacted by this event. Figure 1-5 below shows areas of surface water flooding in the Kensington area during the July 2021 flood event, based on JBA's 75-year flood map. The map highlights how localised rainfall overwhelmed drainage systems in dense urban areas, leading to significant surface water accumulation, particularly along Holland Road, Russel Road, Warwick Gardens, and Scarsdale Villas. Several residential streets experienced deep flooding close to or exceeding 0.6m (RBKC, 2022), indicating a high potential for internal property damage and disruption.

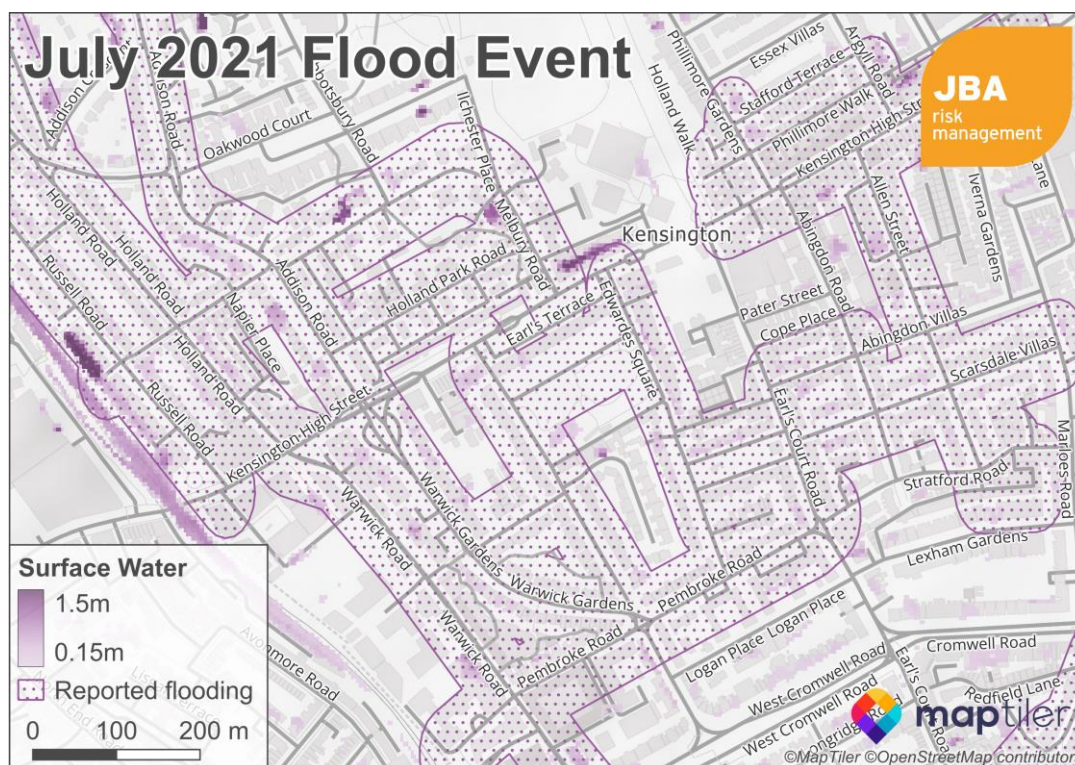


Figure 1-5: Surface water flood depths and reported flooding in Kensington during the July 2021 event. Reported flooded areas from Section 19 flood investigation map of flooded streets available publicly online (RBKC, 2022).

Our assessment found that 2,253 properties in Kensington and Chelsea were situated on streets shown to have flooded and also fall within the areas modelled as at-risk of surface water flooding. **Of these, 946 properties (approximately 42%) meet the structural criteria for PFR measures.** Following this event these homeowners may be keen to invest in PFR to prevent damage in the future.

1.6 Cost-effective deployment of PFR

In a densely developed borough like Kensington and Chelsea, where many properties are exposed to surface water and sewer flooding, a strategic approach to PFR can yield significant benefits. By focusing on the properties with the highest expected annual damages, it is possible to deliver a large share of the potential savings with a relatively modest level of intervention. Figure 1-6 illustrates the cumulative AAL savings that could be achieved through the implementation of PFR measures, plotted against the number of properties with PFR implemented.

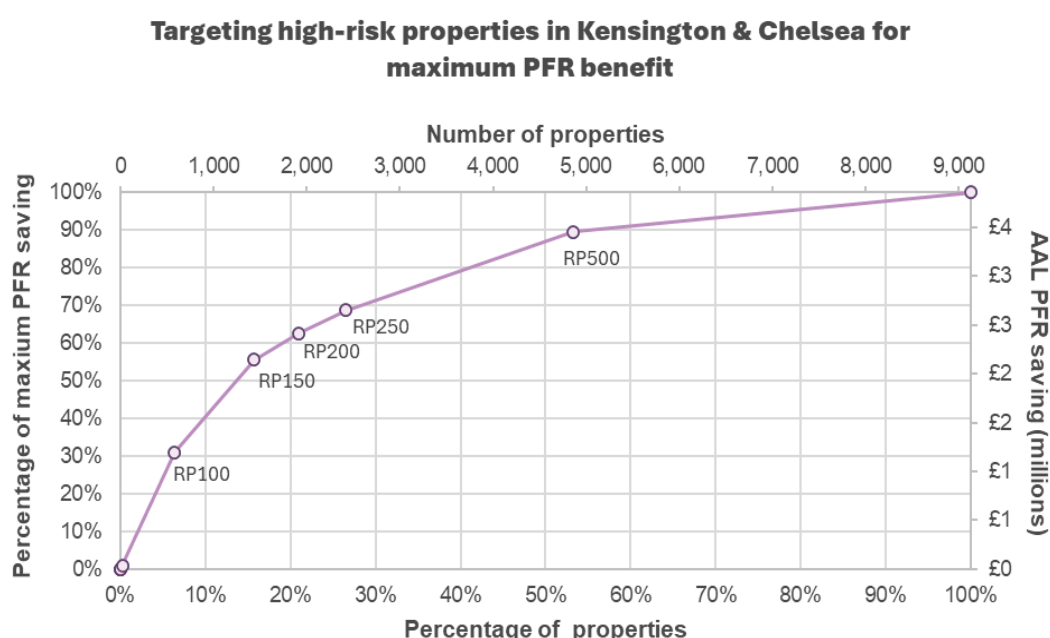


Figure 1-6: The relationship between the potential AAL savings of PFR implementation (y-axis) in Kensington and Chelsea, by number of properties (x-axis) and flood frequency.

Effectively if properties were targeted for PFR implementation by *frequency of flooding*, this plot indicates the number of properties which would benefit and the proportion of the potential total saving.

Alternatively, *if the target of “2,000” properties* were to be protected, what would be the proportion of total potential saving and the likely return period of protection achieved.

The curve demonstrates that substantial savings can be captured by targeting the most at-risk properties early. **Notably, adoption of PFR by to just 10% of properties, those typically first affected at return periods of around 100 years or less, could deliver over 40% of the total potential savings.** Expanding PFR delivery to half of the suitable properties could unlock nearly 90% of available AAL savings.

This distribution highlights the strong value-for-money potential of PFR in Kensington and Chelsea, particularly when directed toward the most flood-prone buildings. In an area where space constraints and infrastructure complexity may limit large-scale engineered solutions, property-level interventions offer a practical and adaptable alternative. Targeting PFR to properties with the highest flood exposure enables efficient use of resources while protecting vulnerable households and valuable building stock.

1.7 Socio-demographic factors which may influence uptake of PFR

In addition to property suitability, flood risk and recent flooding, a range of socio-demographic factors can influence the likelihood and effectiveness of PFR uptake. The maps in Figure 1-7 show how characteristics such as property ownership, deprivation indices, age profile, and disability vary across Kensington and Chelsea, offering insights into how social context may affect implementation pathways (ONS, 2023).

Property ownership rates in Kensington and Chelsea are highly polarised. Some areas, particularly in the southern parts of the Borough (e.g. Chelsea, South Kensington), show ownership rates above 60%, suggesting strong potential for private uptake of PFR, especially among wealthier households. However, large parts of North Kensington, including Notting Dale and Golborne, have ownership rates below 40%, indicating a predominance of social and private rental tenure. In these areas, renters may have limited control over structural modifications, and uptake will depend on the engagement of landlords and housing providers. Delivering PFR here may require alternative strategies, such as coordinated schemes led by social landlords or planning incentives targeting the private rental sector.

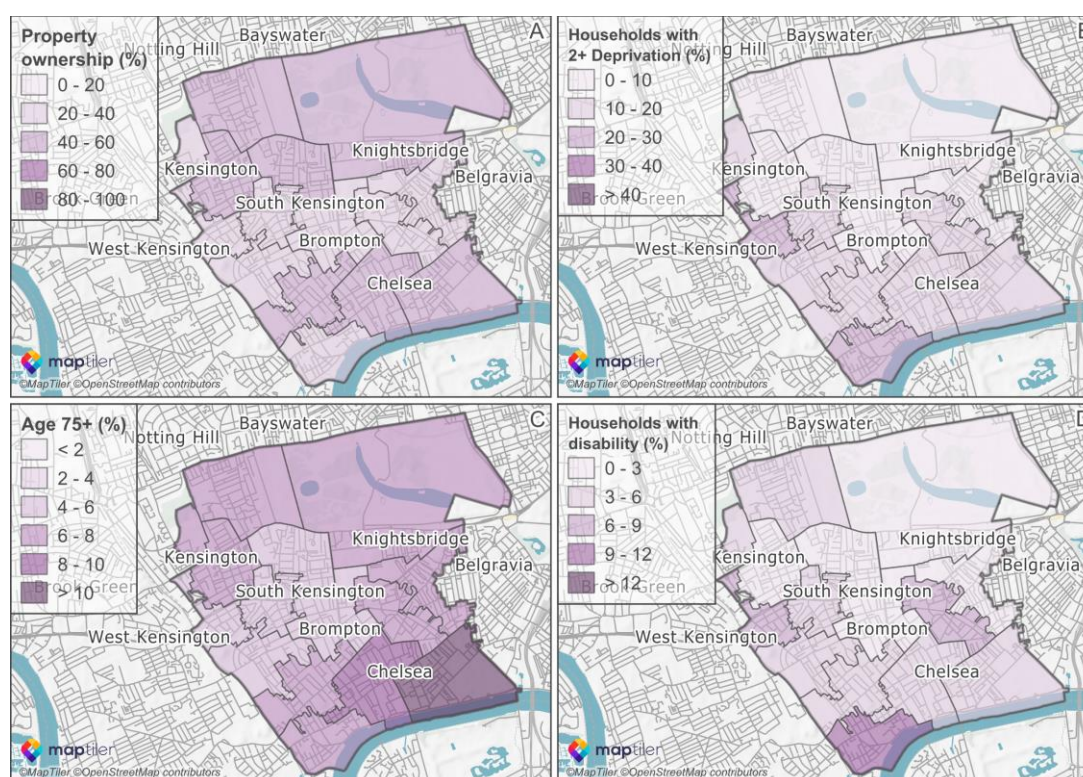


Figure 1-7: Socio-demographic indicators relevant to Property Flood Resilience (PFR) uptake across Kensington and Chelsea (ONS, 2023). A: Proportion of owner-occupied properties, B: Households experiencing two or more types of deprivation, C: Percentage of the population aged 75 and over, and D: Percentage of households reporting disability limiting day-to-day activities.

The proportion of households experiencing two or more forms of deprivation, such as income, housing, education, or health, is notably higher in parts of Earl's Court and the south of the Borough. These areas also include neighbourhoods affected by surface water flooding in 2021, highlighting the intersection of social and physical vulnerability. Residents in these locations may face greater difficulty self-funding resilience measures and may be more susceptible to the financial and emotional consequences of repeated flooding. In such contexts, PFR delivery will need to be supported by public funding, targeted grants, and community-based engagement models to ensure that resilience improvements reach those most in need and do not reinforce existing inequalities.

Age profile also plays a role in PFR suitability. While Kensington and Chelsea has a relatively young population, parts of Chelsea and Notting Hill show a higher proportion of residents over the age of 75. Older residents may face greater challenges in deploying temporary resistance measures and may be more reliant on in-place, low-maintenance solutions such as automatic airbricks, sump pumps, and flood doors. In these areas, installation support and clear maintenance guidance will be especially important to ensure long-term protection.

Although the overall percentage of households reporting disability is relatively low across much of Kensington and Chelsea, there are pockets, particularly in parts of North Kensington and Earl's Court, where over 9% of households include someone whose day-to-day activities are limited by disability. These areas often coincide with higher deprivation and lower ownership rates, suggesting multiple overlapping barriers to resilience. For severely disabled residents, the impact of flooding can be particularly disruptive, especially if homes contain adapted living spaces, medical infrastructure, or care arrangements. In such cases, the cost of displacement is also significantly higher, as alternative specialised accommodation may be required. Here, PFR must prioritise in-place protection that preserves access, functionality, and safety. Delivery should be supported with clear, accessible communication and may require multi-agency coordination to ensure uptake is feasible and equitable.

Taken together, these maps reinforce the need for a context-sensitive approach to PFR planning in Kensington and Chelsea. In affluent, high-ownership neighbourhoods, communications can focus on property value, insurance premiums, and peace of mind. In more deprived, densely populated areas with higher rental occupancy, PFR may need to be delivered via social landlords or community-led schemes. Older and disabled residents across the Borough may also require enhanced support during deployment, with emphasis on the importance of flood plans. As with other areas, incorporating socio-demographic factors into programme design will be essential to ensure that PFR is not only effective, but also fair and widely adopted across the Borough's diverse communities.

1.8 Summary of Property Flood Resilience Potential

Kensington & Chelsea faces high flood risk primarily from **surface water flooding**, exacerbated by its dense urban layout, impermeable surfaces, and ageing drainage systems. The 2021 flood event highlighted the Borough's vulnerability, especially in basement flats and ground-floor dwellings.

- **46%** of properties are structurally suitable for PFR, including over 2,500 basement flats and 12,500 ground-floor units.
- **Over 20,000 properties** are at risk of surface water flooding, with limited protection from formal flood defences.
- PFR could reduce the **Annual Average Loss (AAL) by 67%**, saving nearly **£3.9 million per year**.
- **60%** of suitable homes show a cost-effective return on limited PFR within 20 years.
- Delivery challenges include high proportions of rental properties in North Kensington and planning constraints in conservation areas.
- High rebuild costs and limited drainage infrastructure make PFR a vital complement to local resilience strategies.

2 West Lothian, Scotland

Area Highlights

- **Flooding from rivers and surface water**, especially in Broxburn, Linlithgow, Bathgate.
- **50% of properties suitable for PFR**, mainly terraced/semi-detached houses.
- **About 2,500 homes at risk**, mostly outside defences.
- PFR could cut losses by **£430k/year (28%)**.
- Only **33% of suitable homes cost-effective** within 20 years.
- Small, dispersed flood clusters make PFR more viable than major infrastructure.

West Lothian is a largely semi-rural local authority area in central Scotland that experiences flood risk primarily from river and surface water sources. The Rivers Almond and Avon, which traverse the region, are prone to exceeding their banks during prolonged rainfall, while smaller watercourses also contribute to localised flooding. Areas such as Broxburn and Linlithgow have experienced repeated flooding events, prompting targeted investment in flood alleviation infrastructure and risk mapping.

Historically, West Lothian has been affected by several significant flood events. Broxburn experienced river flooding in 2004, 2005, and 2008, leading to the implementation of the Broxburn River Flood Protection Scheme. More recently, heavy rainfall in August 2020 caused flooding to 21 properties in the Broxburn area. Following a series of near-miss events in 2012, 2017, and 2022, the Liggat Syke Flood Protection Scheme is being designed to provide protection against a 1 in 200-year event (WLC, 2025). However, further large-scale flood protection in the area has been assessed and deemed infeasible (Scottish Government, 2024). As part of local resilience efforts, West Lothian Council is delivering a fully funded Property Flood Resilience (PFR) scheme for 15 private residential properties in New Holygate and Parkwood Gardens in Broxburn.

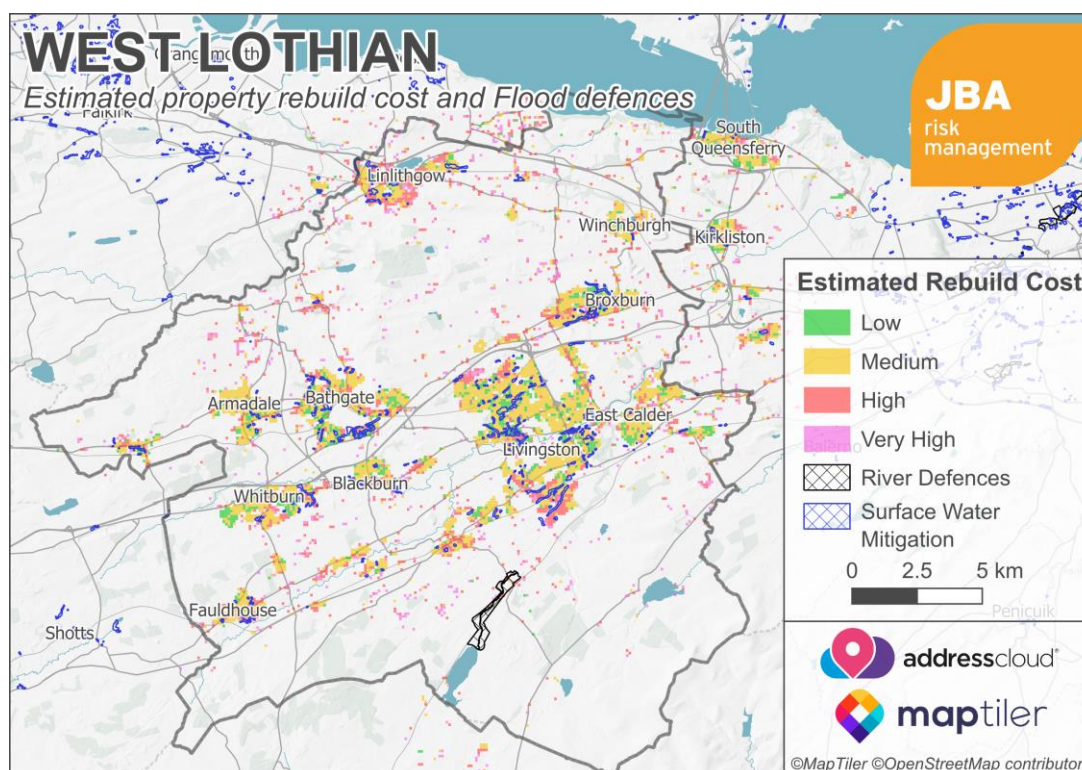


Figure 2-1: Estimated property rebuild costs and spatial extent of flood defences in West Lothian.

While the region's semi-rural character allows for wider floodplain dispersion in some locations, many properties, particularly terraced and semi-detached homes in low-lying areas, remain at elevated risk. Scottish Environment Protection Agency (SEPA) flood maps indicate that key settlements such as Livingston, Bathgate, and Broxburn include neighbourhoods at

medium to high flood risk. As climate change increases the frequency of high-intensity rainfall, the potential for surface water and small catchment flash flooding is expected to rise, challenging the capacity of both drainage systems and emergency response.

Figure 2-1 illustrates the distribution of estimated property rebuild costs across West Lothian alongside the location of existing river flood defences and surface water mitigation measures. Rebuild costs vary spatially across the region. Clusters of high and very high rebuild cost properties are visible throughout the region, especially in and around Livingston, Bathgate, Linlithgow, and Broxburn. These areas typically correspond with more densely developed towns that include a mix of detached and semi-detached housing, as well as newer residential developments.

The distribution of flood defence infrastructure is concentrated in key urban centres, including Broxburn and Bathgate. The dispersed nature of development in West Lothian means that many communities at risk are relatively small and scattered, making large-scale infrastructure schemes less feasible.

2.1 Homes suitable for PFR based on construction and floor level

The majority of properties in West Lothian are houses, comprising 81% of the housing stock. Within this, housing types are relatively evenly split: 28% detached, 24% semi-detached, 29% terraced, and 1% other house types. Flats account for 13% and bungalows for 6% (Figure 2-2). This diverse housing mix reflects a blend of historic townhouses, farms, post-war prefab dwellings, and more recent developments. Detached and semi-detached properties are often found in suburban and peri-urban settings, while terraced housing is more common in town centres and older residential areas.

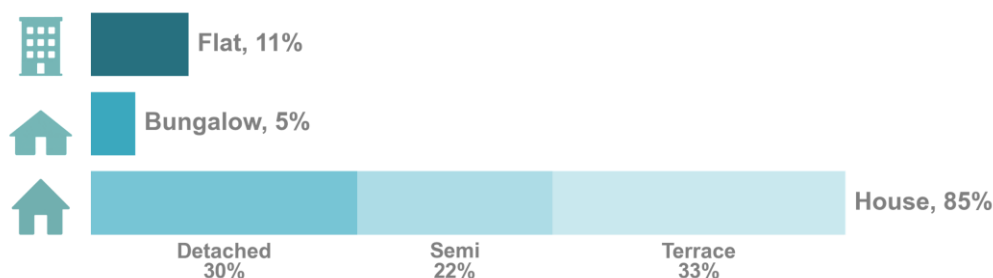


Figure 2-2: Proportion of residential property types in West Lothian.

Table 2-1 summarises the PFR suitability of residential property in West Lothian, based on construction type. Suitability is defined by the presence of solid or suspended ground floors within buildings constructed using standard masonry or cavity wall methods. Buildings classed as unsuitable include those with non-standard construction and all flats located on the first floor or above.

Table 2-1: Summary of building types and suitability for PFR in West Lothian.

Building type		Suitable for PFR		Unsuitable for PFR	Total
		Solid floor	Suspended floor		
House	Detached	3,119	4,589	17,113	24,821
	Semi	1,013	8,642	9,197	18,852
	Terrace	742	20,439	6,271	27,452
Bungalow		87	1,040	2,893	4,020
Flat	Basement	0	3	32	35
	Ground floor	335	2124	6,215	8,674
	First floor and above	0	0	153	153
Total		5,296	36,837	41,874	84,007

84,007 buildings assessed across the region, **42,133 (50%) are considered suitable for PFR**, with 5,296 having solid floors and 36,837 suspended floors. A further 41,874 buildings (50%) are considered unsuitable due to structural constraints or floor level.

Suitability is highest among terraced and semi-detached houses, which together make up the majority of the housing stock. Of the 27,452 terraced houses, over 20,400 (74%) are potentially suitable for PFR due to suspended floors, a construction style common in older properties in towns such as Broxburn, Bathgate, and Linlithgow. Flats, in contrast, present more limited opportunity, with most ground-floor and basement units categorised as unsuitable and all upper-storey flats due to floor level.

2.2 Homes at risk to flood and frequent flooding

Across West Lothian, around 2,500 properties are currently identified as being at risk of flooding. The majority of properties (over 2,000) are exposed to surface water flooding, while around 540 are at risk from river overtopping.

Table 2-2: Summary of number of properties exposed to flood, PFR suitability, and potential Average Annual Loss (AAL) reduction in West Lothian.

Total Number of Properties		84,007		Number of at-risk properties suitable for PFR		1,148	
Flood Type	No. of properties at risk	% of total properties	Baseline AAL	Limited PFR		Standard PFR	
				AAL	% saving	AAL	% saving
River	540	22%	£987,457	£848,213	-14%	£742,216	-25%
Surface water	2,045	82%	£559,537	£443,568	-21%	£375,021	-33%
Coastal	-	-					
TOTAL	2,492	100%	£1,547,419	£1,290,348	-17%	£1,117,236	-28%

The current estimated residential annual cost of flooding across West Lothian is £1.55 million. **Around 1,150 properties (46%) are at flood risk with likely flood depths mitigated by PFR.** Limited PFR protection has the potential to reduce losses by 17% (£260k) and 28% (£430k) with a standard PFR package. While these totals appear modest compared with more urbanised areas, this reflects both the smaller population base in West Lothian and the more dispersed nature of flood risk across semi-rural settlements. However, the relative reduction per property is notable: on average, savings per affected household are broadly comparable with denser urban areas, particularly in towns where localised flooding is recurrent. These findings reinforce West Lothian's approach of combining catchment-based defences with targeted PFR schemes in smaller, high-risk residential clusters, where household-level interventions can deliver meaningful resilience despite lower aggregate savings.

Across West Lothian of the 2,492 properties at risk, 139 are likely to be flooded frequently, as they are exposed to the 1 in 25-year return period (4% chance of occurrence), **only 58 of those properties are suitable for PFR.**

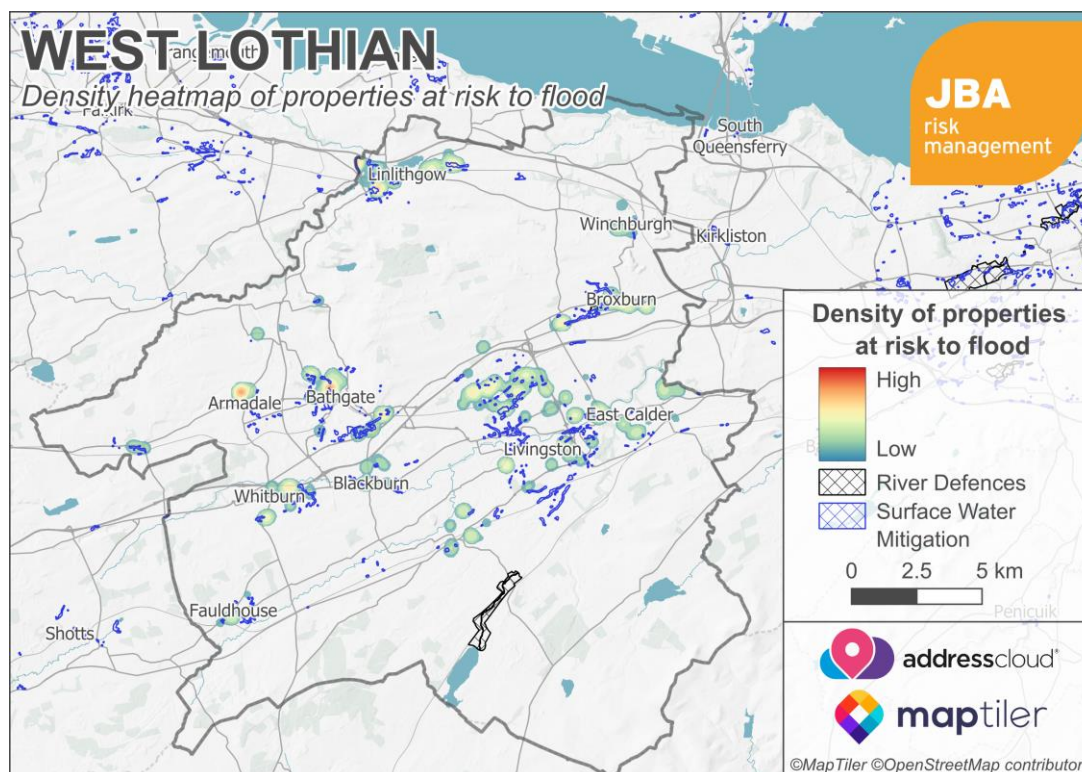


Figure 2-3 shows a density heatmap of at flood risk properties, with Figure 2-4 focusing on three areas of particular interest, Bathgate, north Livingston, and Broxburn, showing the percentage of flood-exposed properties within each area that are structurally suitable for PFR. The analysis reveals that many of the flood-affected zones also demonstrate high PFR suitability, with several neighbourhoods showing over 60% of properties deemed appropriate for resilience measures. This trend is particularly evident in modern housing developments with standard construction and accessible ground floors, which are common in these urban areas.

While there are numerous localised hotspots of flood risk, the total number of affected properties within each area tends to be relatively low. This makes large-scale engineered flood defence schemes difficult to justify on a cost-benefit basis. Instead, PFR offers a more proportionate and economically viable approach to managing risk, allowing communities to build resilience where it is most needed without the significant capital and maintenance costs associated with traditional infrastructure.

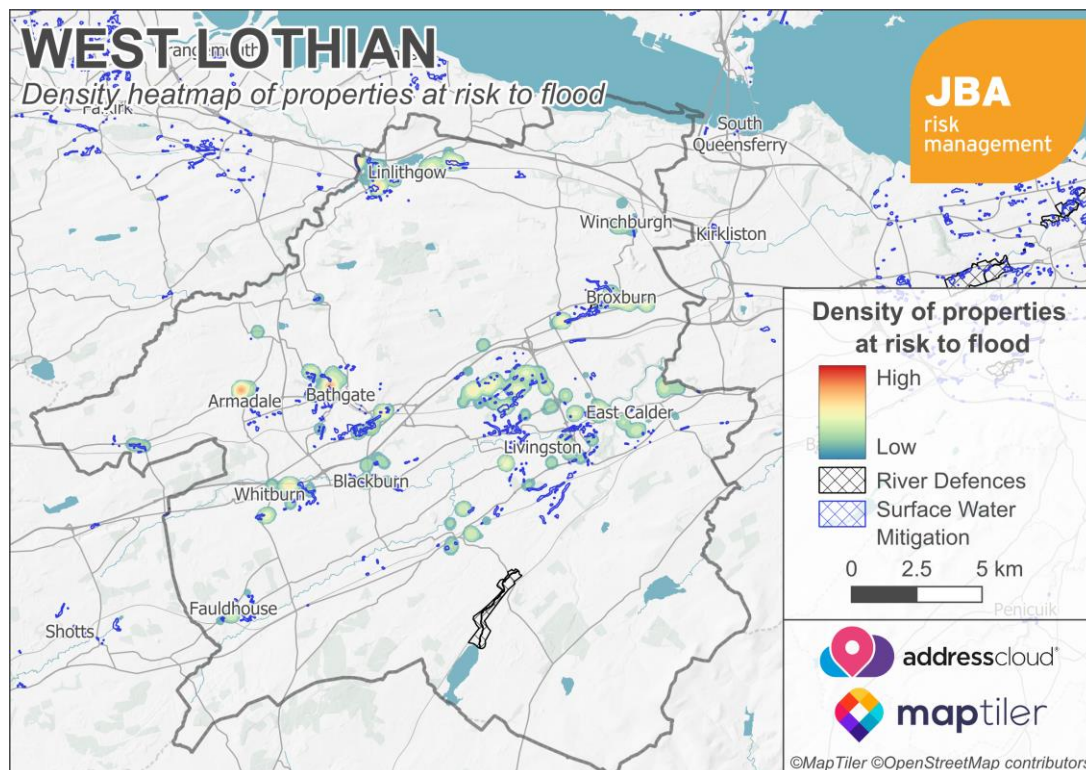


Figure 2-3: Density heatmap of properties at risk to flooding in West Lothian.

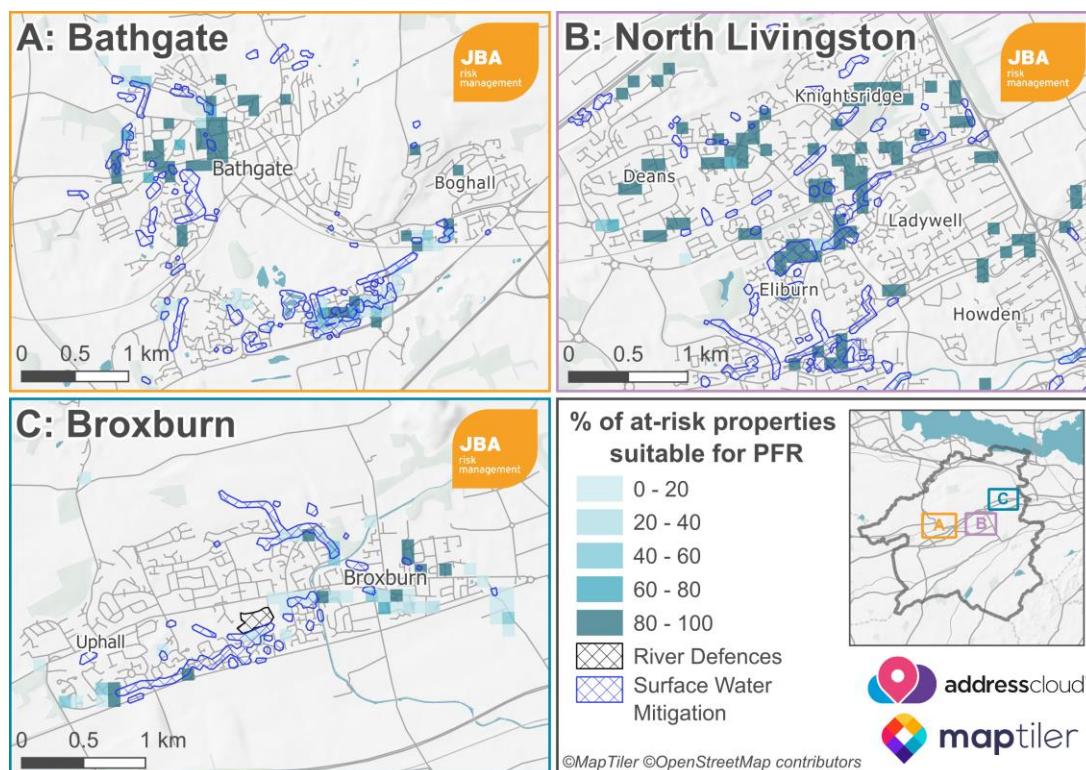


Figure 2-4: Proportion of at-flood-risk residential properties suitable for Property Flood Resilience (PFR) for three detailed areas across West Lothian: Bathgate, Broxburn and north Livingston.

2.3 Homes not formally protected by flood defence

Of the 2,492 properties identified as being at risk of flooding in West Lothian, only 621 properties (25%) are located within areas benefiting from formal flood defences. The remaining 1,871 properties (75%) are outside these protected zones, highlighting a significant portion of homes that remain vulnerable to flood impacts, particularly from surface water and smaller streams not currently covered by engineered schemes. Among the 1,871 undefended properties, 882 buildings (47%) are considered structurally suitable for PFR measures.

This low coverage is partly due to the distributed and varied nature of flood risk across West Lothian, which includes both fluvial systems like the Brox Burn, Caw Burn, and Linthouse Water, as well as widespread surface water flooding in urban areas such as Bathgate, Linlithgow, and West Calder. While major investments, such as the Broxburn Flood Protection Scheme, have successfully reduced risk in certain high-impact areas, many at-risk properties are still exposed to residual flooding, especially during intense rainfall events that exceed drainage capacity.

2.4 Homes where PFR offers a cost-effective return on investment

In areas with smaller numbers of flood-prone properties, PFR can offer a more practical and financially efficient approach than large-scale flood defence schemes. In West Lothian, targeted delivery of PFR measures may represent the most viable route to reducing flood risk, particularly in dispersed or lower-density residential settings where traditional defences are unlikely to be cost-effective.

Table 2-3 shows the number and proportion of PFR-suitable properties in West Lothian where expected savings in AAL exceed the cost of installing limited or comprehensive measures, grouped by return-on-investment thresholds. Under the limited scenario, around 6% of properties are expected to recover costs within five years, rising to 33% within a 20-year timeframe, closely aligning with the expected lifespan of most PFR interventions. While comprehensive measures are more costly, they remain financially justifiable for nearly 9% of suitable homes within the same 20-year period.

Table 2-3: Number and proportion of PFR-suitable properties in West Lothian where the expected Average Annual Loss (AAL) savings exceed PFR installation costs.

PFR Savings	PFR Scenario <i>Limited Measures</i>		PFR Scenario <i>Standard Measures</i>	
	Number of properties	% of total PFR-suitable properties	Number of properties	% of total PFR-suitable properties
<5 x AAL	71	6.4	28	2.5
<10 x AAL	171	15.4	55	4.9
<20 x AAL	369	33.2	97	8.7

The relative cost-effectiveness of limited measures in West Lothian reflects the area's flood risk profile. Many at-risk homes are exposed to surface water or smaller water courses, with shallow depths and dispersed flooding across multiple towns. In this context, low-cost measures provide meaningful reductions in damage, while the higher investment required for comprehensive packages is harder to justify given the lower frequency of severe flooding. This explains why a larger share of properties recover costs under the limited scenario, and why standard measures only become cost-effective for a smaller subset of homes.

These figures demonstrate that while the total number of PFR-suitable properties is relatively modest, a substantial share could benefit from cost-effective protection. In this context, PFR represents a scalable, flexible alternative to major capital works, allowing resources to be focused directly on individual properties where the benefit is greatest. This targeted approach is particularly well suited to the West Lothian context, where flood risk is distributed across multiple small settlements rather than concentrated in a single, dense urban area.

2.5 Homes that have previously flooded

West Lothian has a long history of flooding from both river overtopping and surface water flooding. Multiple towns are designated as Potentially Vulnerable Areas under SEPA's National Flood Risk Assessment. The council's Strategic Flood Risk Assessment (WLC, 2025), developed in support of the Local Development Plan 2, identifies past flood events in every major settlement and emphasises the need for spatially targeted mitigation. Historical incidents in Broxburn (2008, 2012, 2020), Bathgate, Linlithgow, Whitburn, West Calder, and other towns have caused property damage, road closures, and community disruption. Several of these events, including the August 2008 flood in Broxburn, have resulted in the development of formal flood protection schemes, such as embankments and culverts to reduce future risk.

In August 2008, the town of Broxburn in West Lothian experienced one of the most severe and disruptive flood events in the area's recent history. Intense and sustained rainfall fell over already saturated ground, causing a rapid rise in water levels within the Brox Burn and Caw Burn catchments, leading to widespread flooding throughout the town. Properties in West Main Street, Pyothall Court, Nicol Road, Burnside, and Station Road were among the worst affected, with several homes and businesses experiencing internal flooding.

Hydrological analysis conducted as part of a post-event review estimated flows along the Brox Burn during the event to be equivalent to between a 1-in-60 and 1-in-100-year return period, depending on the location within the catchment (Halcrow, 2009). Observed flood depths at key locations were substantial, modelled flood levels reached over 1.5 metres in several residential areas. The event was made worse by blocked culverts and restricted bridge structures, with blockage factors of up to 100% assigned to some critical crossings such as Miller's Bridge and the Union Canal bridge.

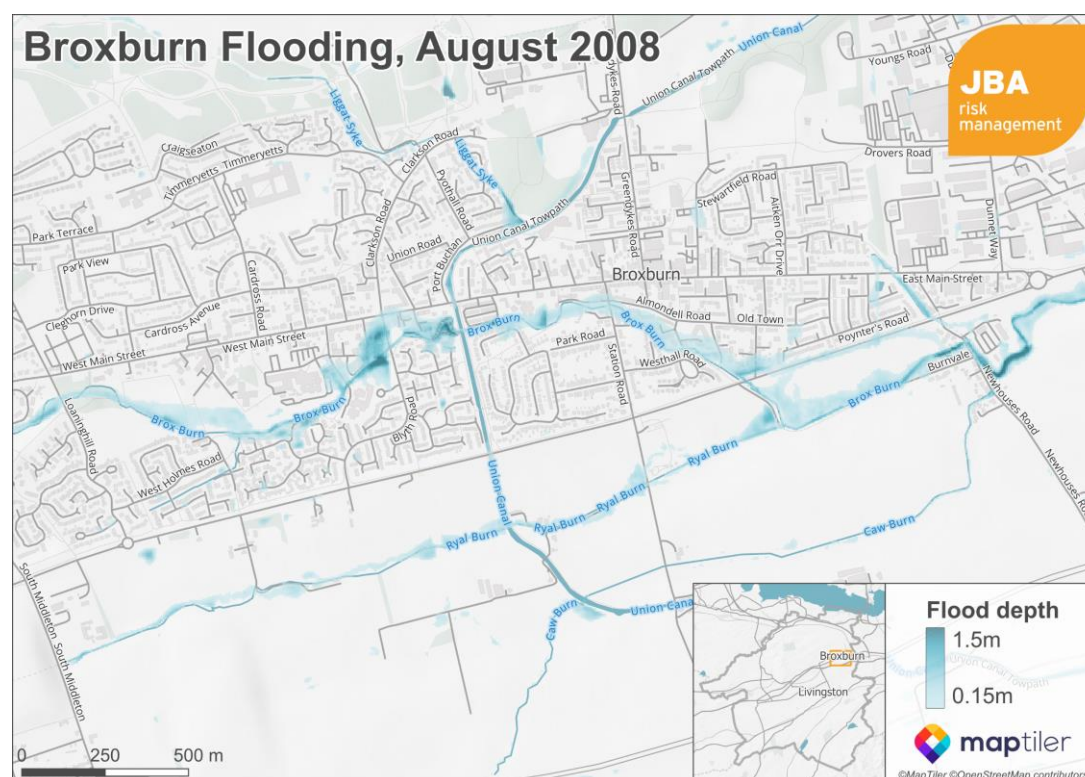


Figure 2-5: Modelled flood depths and flood extents in Broxburn during the August 2008 flood event.

Figure 2-5 shows the modelled extent and depth of flooding across Broxburn during the August 2008 event, highlighting how topography, constrained infrastructure, and intense rainfall combined to produce a highly damaging flood. Our analysis indicates that currently 207 homes in Broxburn are at risk of flooding. Of these, 83 properties were directly impacted in the modelled representation of the 2008 flood extent. **Only 23 of these properties are considered structurally suitable for PFR measures, with the remaining 60 properties deemed unsuitable due to non-standard construction.**

2.6 Cost-effective deployment of PFR

Delivering PFR cost-effectively in West Lothian requires a targeted approach that focuses on the small proportion of properties most vulnerable to frequent flooding and high annual losses. By identifying those properties that contribute most significantly to the area's overall flood damages, it is possible to maximise the benefits of PFR investment with a relatively limited number of installations.

Figure 2-6 shows the cumulative AAL savings achievable through PFR implementation, plotted against the percentage of properties with PFR implemented. The curve rises sharply at the outset, showing that a large proportion of the total savings can be secured by adoption of PFR by a small subset of high-risk properties. Specifically, adoption of PFR by just 10% of properties could deliver over 60% of total AAL savings. Adoption by 40% captures more than 90% of the potential savings.

This steep efficiency curve reflects that in West Lothian, flood risk is concentrated in just a handful of locations. Most homes are not exposed, but where flooding does occur it often affects the same clusters of properties, such as those close to small rivers or in local low-lying areas. Because a relatively small number of homes account for much of the potential damage, targeting PFR to these properties offers a strong return on investment. In places with fewer but repeatedly affected homes, PFR can provide a practical and cost-effective alternative to major flood defence schemes.

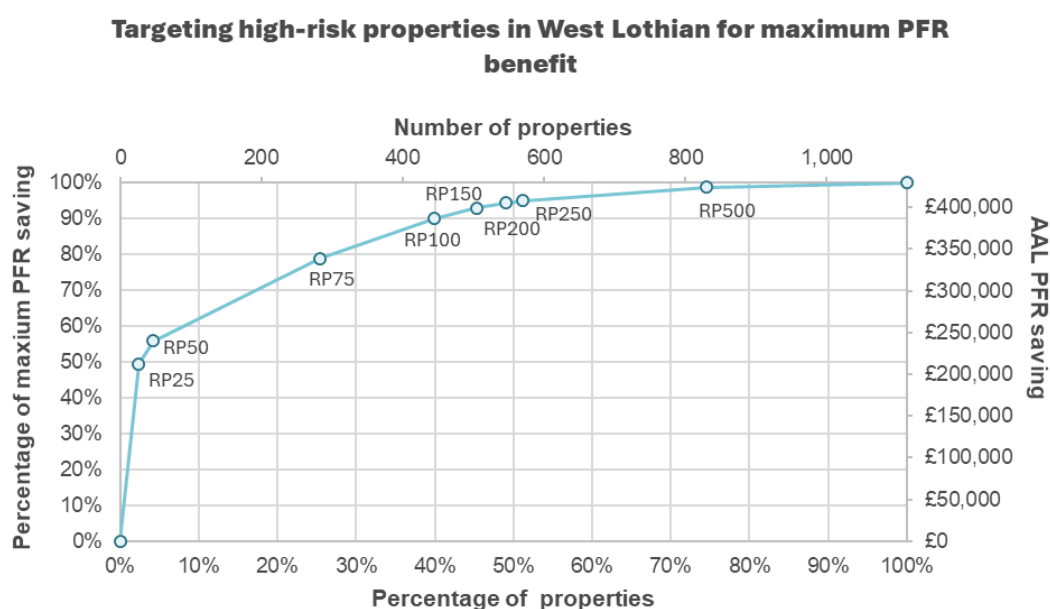


Figure 2-6: The relationship between the potential AAL savings of PFR implementation (y-axis) in West Lothian, by number of properties (x-axis) and flood frequency.

2.7 Socio-demographic factors which may influence uptake of PFR

In addition to property suitability, flood risk and recent flooding, a range of socio-demographic characteristics can influence the likelihood and effectiveness of PFR uptake. Figure 2-7 shows the spatial distribution of three key indicators across West Lothian: property ownership, age profile, and disability prevalence (NRS, 2023). These provide insight into where community support, engagement strategies, or delivery mechanisms may need to be adapted to ensure equitable and effective implementation of PFR measures.

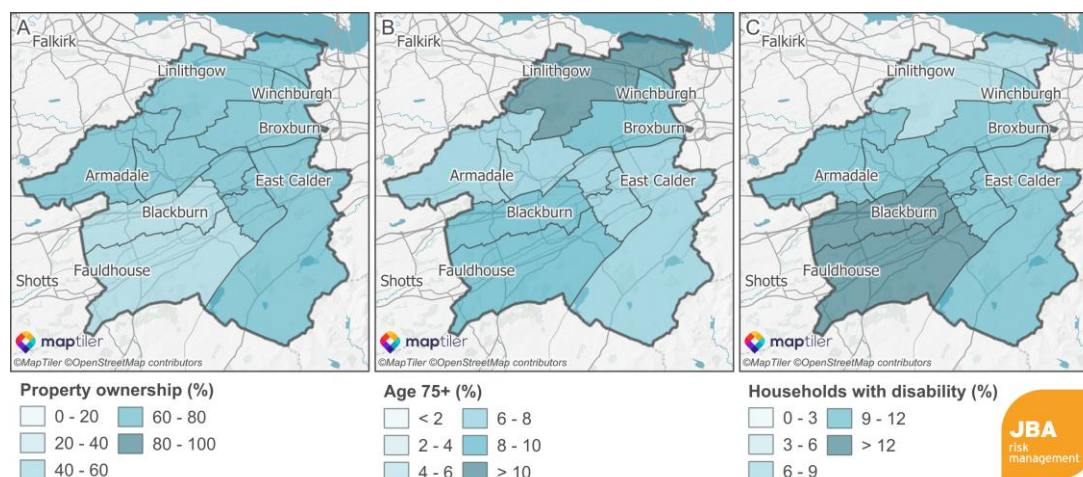


Figure 2-7: Socio-demographic indicators relevant to Property Flood Resilience (PFR) uptake across West Lothian (NRS, 2023). A: Proportion of owner-occupied properties, B: Percentage of the population aged 75 and over, and C: Percentage of households reporting disability limiting day-to-day activities.

Homeownership rates across West Lothian are relatively high, with most areas reporting ownership levels of 60% or above. These patterns suggest a strong baseline for voluntary PFR uptake, as owner-occupiers are more likely to invest in property-level measures. However, lower-ownership pockets are visible in areas such as Blackburn, Fauldhouse, and Livingston, where private or social renting may be more prevalent. In these communities, uptake may be limited unless landlords are incentivised or supported through targeted delivery programmes. Social housing providers in particular may be well-positioned to implement PFR at scale, but coordinated engagement will be essential.

The age profile of West Lothian indicates that most areas have a relatively young population, with over 90% of residents under the age of 75. This may reduce the physical barriers to adopting and deploying temporary PFR measures in most households. However, in some southern and rural communities, where older populations are slightly more concentrated (e.g. Fauldhouse), passive and maintenance-free PFR options, such as self-activating barriers or sump pumps, may be more appropriate. In such contexts, PFR delivery should also consider household resilience during emergencies, including evacuation and temporary relocation challenges for older residents.

Disability prevalence varies across the region, with certain areas, especially in Blackburn, Fauldhouse, and parts of Armadale, reporting that more than 12% of households include someone whose disability limit their day-to-day activities. This represents a higher level of impairment and has important implications for flood resilience planning. These households may rely on adapted living environments, assistive technologies, or ongoing care arrangements, making them particularly vulnerable to disruption during and after a flood event. In such cases, in-place resilience is essential, ensuring that homes remain habitable and accessible even in the face of flooding. Tailored communication, inclusive engagement, and close collaboration with social care and housing services will be crucial to reach and support these residents effectively.

Taken together, the socio-demographic profile of West Lothian suggests that while a significant proportion of the population may be well-positioned to adopt PFR voluntarily, there are pockets of social vulnerability where uptake may be lower without targeted support. In low-

ownership or high-disability areas, programmes may need to prioritise funded schemes, social landlord engagement, and low-disruption installation methods. A socially responsive delivery model—one that aligns with both flood exposure and the lived experience of residents—will be critical to ensuring that PFR reaches those most at risk and delivers meaningful resilience benefits across the region.

2.8 Summary of Property Flood Resilience Potential

West Lothian is a semi-urban region with flood risk from both **rivers and surface water**, particularly affecting towns like Broxburn, Linlithgow, and Bathgate. The area is already engaging with PFR, including a funded pilot scheme in Broxburn.

- **50%** of all properties are structurally suitable for PFR, especially terraced and semi-detached homes with suspended floors.
- Flood exposure is lower in absolute terms (**~2,500 properties at risk**) but highly localised given this is an area of small rivers rather than a large wide floodplain.
- **75% of at-risk properties** lie outside formal flood defences.
- Only 139 properties are likely to be flooded frequently, at the 1 in 25-year return period (4% chance of occurrence), **only 58 of those properties are suitable for PFR.**
- PFR could reduce AAL by **£430k/year (28%)** under comprehensive measures.
- Only **33%** of suitable homes break even on limited PFR within 20 years.
- The region's dispersed risk and small settlements make PFR a scalable alternative to large infrastructure schemes.
- Socio-demographic indicators show high homeownership in many areas, but elevated disability rates in parts of Blackburn and Fauldhouse may require tailored, low-disruption delivery approaches.

3 Pontypridd, Rhondda Cynon Taf, Wales

Area Highlights

- **High fluvial and surface water risk**, exemplified by Storm Dennis (2020).
- **88% of properties suitable for PFR**, especially terraced/semi-detached homes.
- Over **2,150 homes at risk**, with 90% suitable for PFR.
- Potential **45% AAL reduction (£395k/year)** from PFR.
- **34% of homes break even** on limited PFR within 20 years.
- Challenges: deprivation, low ownership, and high disability rates limiting uptake.

Pontypridd, located in Rhondda Cynon Taf in South Wales, is highly susceptible to fluvial and surface water flooding due to its position at the confluence of the River Taff and River Rhondda. Steep surrounding hills contribute to rapid runoff during intense rainfall, significantly increasing flood risk to the town and surrounding communities. One of the most impactful recent events occurred in February 2020 during Storm Dennis, when widespread flooding affected hundreds of homes and businesses across the town centre and along the river valleys. Historic flooding has also been documented in the early 2000s and late 20th century, with climate change likely to exacerbate the frequency of such these highly localised intense rainfall events.

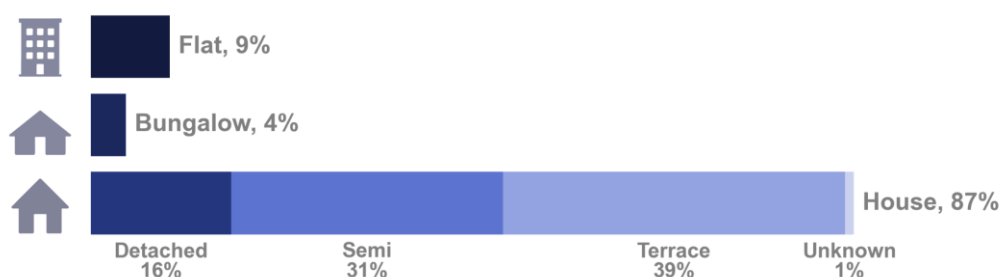


Figure 3-1: Proportion of residential property types in Pontypridd.

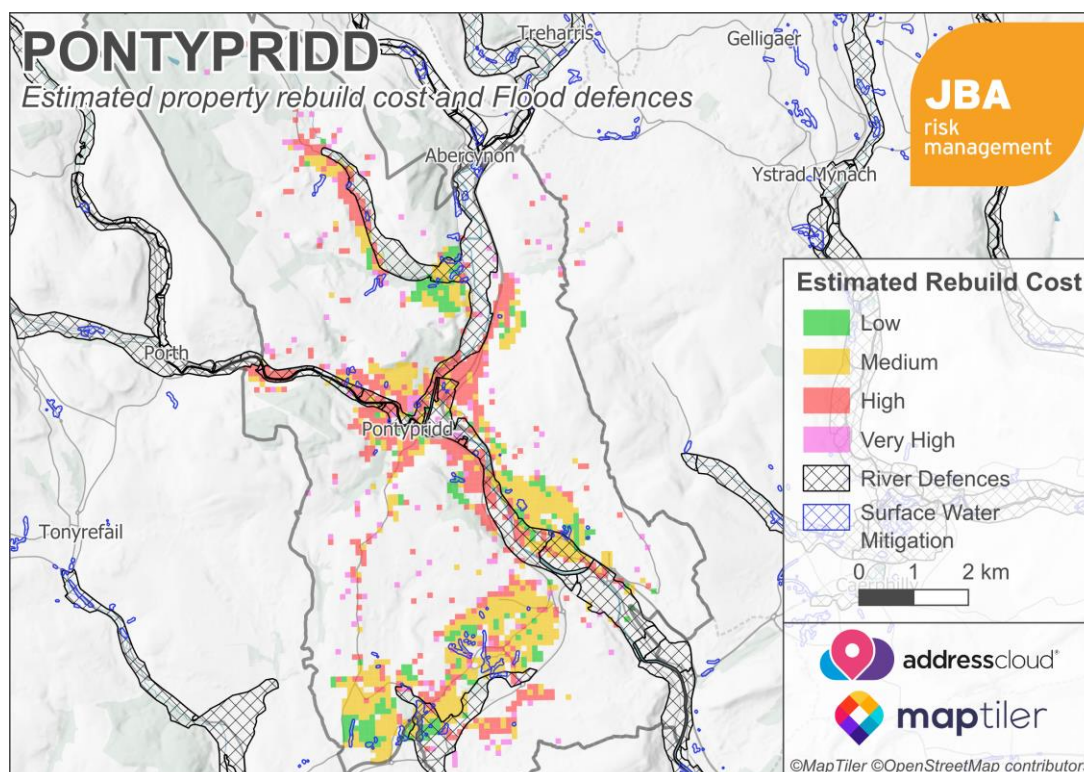


Figure 3-2: Estimated property rebuild costs and spatial extent of flood defences for Pontypridd.

Figure 3-2 shows the spatial distribution of property with estimated property rebuild costs, overlaid with existing flood defences. Higher rebuild cost zones are concentrated along the river corridors, including in central and southern areas of the town. These often coincide with dense residential areas at risk of fluvial flooding. Coverage from river defences is extensive along the Taff and Rhondda rivers, while surface water drainage is a mix of design standards and are more limited and spatially fragmented. In Wales, PFR measures are eligible under the Welsh Government's FCERM capital Programme and through their Small Scale Works Grant to local authorities. Following the Storms of February 2020, the Welsh Government made £1.17 million available to local authorities for PFR schemes across Wales. This included projects in Rhondda Cynon Taf, Caerphilly, Monmouthshire and Powys, which estimate to have benefitted up to 594 homes across all areas.

3.1 Homes suitable for PFR based on construction and floor level

The majority of homes in Pontypridd are houses, which make up 87% of the housing stock, including a high proportion of terraced (39%) and semi-detached (31%) dwellings (Figure 3-1). Detached homes are less common (16%), while flats account for 9% and bungalows for 4%. Many residential properties are situated along narrow valley floors or on steep hillsides, often in close proximity to rivers and areas of steep topography. These locations heighten vulnerability to river flooding and limit the scope for installing large-scale engineered protection measures.

Table 3-1 provides an overview of the building stock in Pontypridd and its suitability for PFR, based on construction type and floor level. Buildings with either solid or suspended floors and standard masonry construction are considered suitable for PFR. Those with non-standard construction or located on upper storeys are categorised as unsuitable.

Table 3-1: Summary of building types and suitability for PFR in Pontypridd.

Building type		Suitable for PFR		Unsuitable for PFR	Total
		Solid floor	Suspended floor		
House	Detached	1,633	2,392	486	4,511
	Semi	3,791	3,853	1,007	8,651
	Terrace	6,526	4,087	292	10,905
	Unknown	0	304	47	351
Bungalow		704	215	71	990
Flat	Basement	14	33	27	74
	Ground floor	626	596	254	1,476
	First floor and above	0	0	1,116	1,116
Total		13,294	11,480	3,300	28,074

28,074 buildings were assessed, of which 24,774 (88%) are considered structurally suitable for PFR, comprising 13,294 with solid floors and 11,480 with suspended floors. Only 3,300 buildings (12%) are considered unsuitable.

The majority of Pontypridd's housing stock consists of terraced and semi-detached homes, which collectively represent over 70% of all buildings in the area. Of the 10,905 terraced properties, over 10,600 (97%) are suitable for PFR, a high proportion that reflects the prevalence of traditional masonry construction and suspended floor designs in these homes. Semi-detached and detached houses also show strong suitability, with around 90% of properties in each category meeting the criteria for PFR.

Bungalows in Pontypridd are few in number (990 total) but are also largely suitable, with 919 (93%) capable of accommodating PFR measures. Flats, while less common, show more variation. Of the 1,476 ground-floor flats, 1,222 (83%) are suitable.

3.2 Homes at risk to flood and frequent flooding

Approximately **2,150 properties in Pontypridd are exposed to flooding**, with 1,600 at risk from river flooding and 1,230 from surface water flooding.

Table 3-2: Summary of number of properties exposed to flood, PFR suitability, and potential Average Annual Loss (AAL) reduction in Pontypridd.

Total Number of Properties		28,074		Number of at risk properties suitable for PFR		1,932	
Flood Type	No. of properties at risk	% of total properties	Baseline AAL	Limited PFR		Standard PFR	
				AAL	% saving	AAL	% saving
River	1,604	6%	£258,033	£210,305	-18%	£176,274	-32%
Surface water	1,229	4%	£620,883	£402,598	-35%	£306,976	-51%
Coastal	-	-					
TOTAL	2,152	8%	£879,883	£614,000	-30%	£485,436	-45%

The current estimated residential annual cost of flooding across Pontypridd is £880,000. Limited PFR has the potential to reduce losses by 30% (£266k) and by 45% (£395k) with standard PFR. **90% of at-risk properties are considered suitable for PFR, reflecting the town's dense and consistent housing typology.**

Despite the significant number of properties at risk of flooding, only 3 properties are expected to flood in the 1 in 25-year return period (4% annual exceedance probability) and 170 PFR suitable properties in the 1 in 50-year (2% annual exceedance probability). Notably this climbs to 948 PFR suitable properties in the 1 in 500-year, reflective of the extensive coverage of preexisting river flood defences.

Figure 3-3 shows the spatial distribution of at risk to flood properties in Pontypridd and the surrounding Taff valley. The heatmap highlights intense concentrations of potential flood risk in the town centre and adjacent areas such as Hopkinstown, Rhydyfelin, and along the river corridor extending southwards. These clusters correspond with historic flood events, including the major flooding experienced during Storm Dennis in 2020.

Figure 3-4 indicates that the vast majority of flood-exposed properties are structurally suitable for PFR. Most of the valley corridor, where flood risk is greatest, shows suitability rates above 80%, reflecting a housing stock made up largely of terraced and semi-detached homes with standard construction. This strong alignment between flood exposure and retrofit potential makes Pontypridd a clear candidate for targeted, community-scale PFR implementation. In this narrow, topographically constrained valley, the ability to expand traditional defences is limited. As such, property-level measures offer a practical and cost-effective way to reduce household risk, improve resilience, and minimise disruption during future flood events.

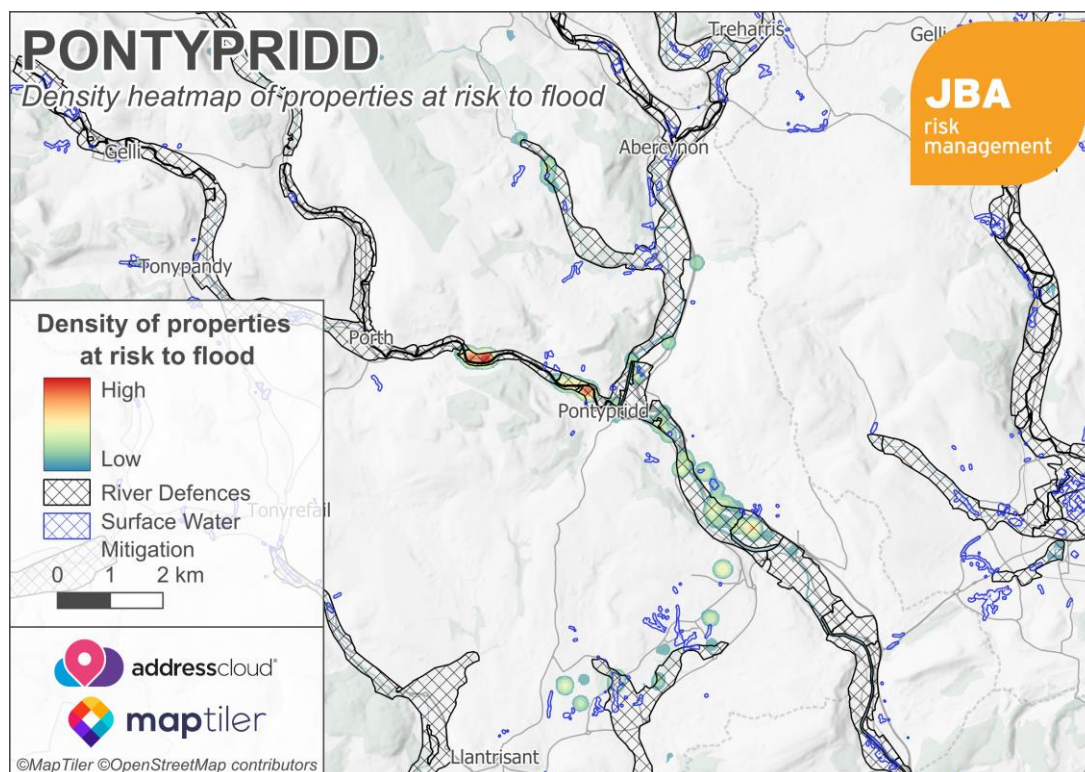


Figure 3-3: Distribution of properties (heatmap) at risk to flood in Pontypridd.

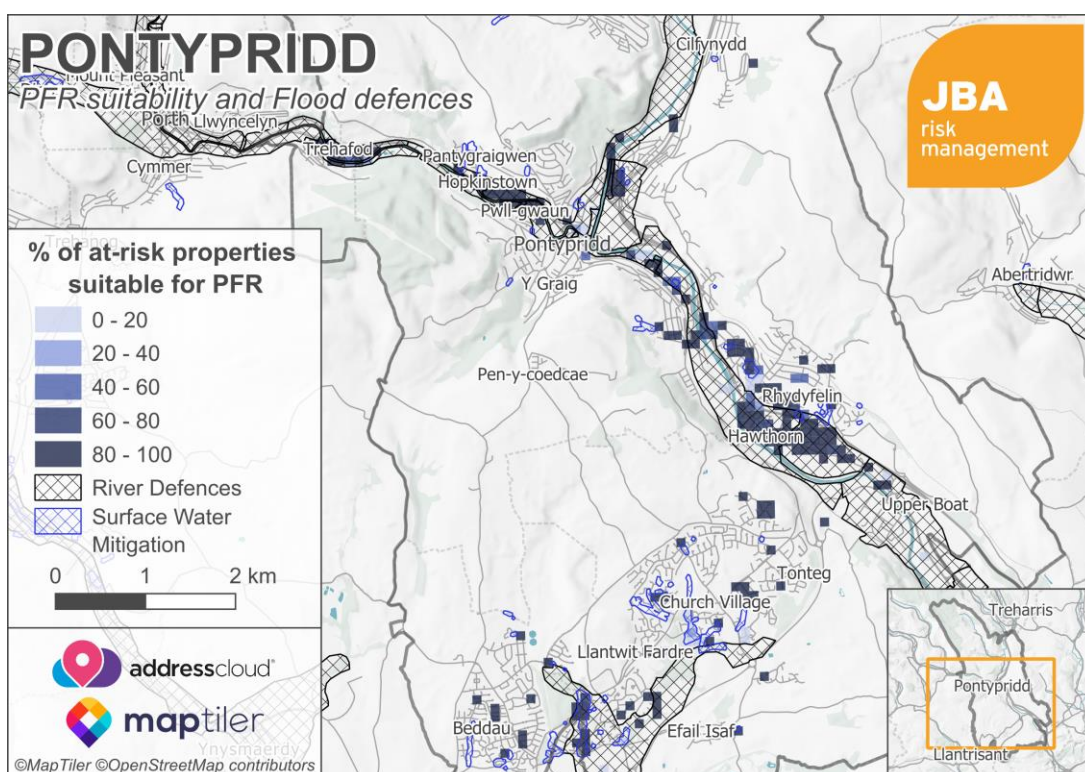


Figure 3-4: Proportion of at-risk residential properties suitable for Property Flood Resilience (PFR) across Pontypridd.

3.3 Homes not formally protected by flood defence

A more detailed review of flood defence coverage in Pontypridd shows that 1,655 properties (77%) at risk of flooding are located within areas benefiting from existing fluvial defences. These defences, concentrated along the River Taff and River Rhondda, have played a critical role in reducing flood exposure and limiting the extent of recent damage from events such as Storm Dennis. However, 497 properties (23%) remain outside of these formally protected zones. Among these, **423 properties (approximately 85%) are considered structurally suitable for Property Flood Resilience (PFR) measures.**

This distribution highlights the ongoing residual risk faced by a significant minority of households, likely due to surface water flash flooding, surcharged drainage systems, or fluvial overtopping during extreme return period events.

3.4 Homes where PFR offers a cost-effective return on investment

In flood-prone towns like Pontypridd, where property-level risk is concentrated but not extensive, PFR offers a targeted and cost-efficient approach to reducing flood damages. Rather than relying solely on large-scale defences, which may be less viable in constrained urban valleys, prioritising PFR can deliver meaningful benefits to households most at risk.

While Table 3-2 shows that PFR could reduce overall annual losses in Pontypridd by up to 45%, Table 3-3 reveals that these savings are concentrated in a relatively small share of properties. A minority of high-risk homes account for most of the avoided damages, with around one-third of suitable properties delivering the majority of the cost-effective benefits. This concentration reflects local flood dynamics, where shallow but frequent surface water flooding affects clusters of properties, while rarer deeper floods impact fewer homes. As such, wider measures appear to have a more concentrated impact because targeting a relatively small number of households can unlock a large share of the potential savings.

Table 3-3 presents the number and proportion of PFR-suitable properties in Pontypridd where expected AAL reductions outweigh the cost of installing limited or standard PFR measures. Under the limited PFR scenario, around 12% of properties show a payback period within five years, with 34% expected to recover costs within 20 years, broadly in line with the lifespan of most PFR installations. Standard measures, while significantly more expensive, remain financially justifiable for approximately 13% of suitable properties when assessed over a 20-year period.

Table 3-3: Number and proportion of PFR-suitable properties in Pontypridd where expected Average Annual Loss (AAL) savings exceed installation costs.

PFR Savings	PFR Scenario <i>Limited Measures</i>		PFR Scenario <i>Standard Measures</i>	
	Number of properties	% of total PFR-suitable properties	Number of properties	% of total PFR-suitable properties
<5 x AAL	222	11.6	6	0.3
<10 x AAL	399	20.8	51	2.7
<20 x AAL	643	33.6	243	12.7

The pattern in Pontypridd highlights how local flood dynamics shape the value of different PFR options. Limited measures deliver strong cost-effectiveness because many properties experience shallow or more frequent surface water flooding, where relatively inexpensive interventions can avoid repeated damages. Standard measures are more costly and provide additional benefit mainly during rarer, higher-depth river floods. As a result, only a smaller proportion of homes show full payback for comprehensive packages, while limited interventions offer a more practical and financially viable option for most households.

These figures highlight a clear opportunity to deliver value-for-money resilience to a significant share of vulnerable properties, particularly under the limited PFR scenario. In areas like Pontypridd, where terrain and urban form limit the feasibility of conventional defences, PFR provides a flexible and responsive alternative. By focusing on properties where cost recovery is likely within the measure's lifetime, PFR schemes can deliver targeted protection with high potential for local impact.

3.5 Homes that have previously flooded

Natural Resources Wales has designated flood warning areas throughout the Rhondda Valley. Within these areas, 1,355 at-risk properties are suitable for PFR, while a further 118 properties are not suitable for PFR (NRW, 2025). In Pontypridd, analysis of the Environment Agency's Recorded Flood Outlines data (2024) indicates that **320 PFR-suitable properties have previously experienced flooding** and are likely strong candidates for PFR measures. An additional 22 properties are also shown to have flooded but are not structurally suitable for PFR.

On 15-16 February 2020, Pontypridd experienced some of the most severe flooding in its recent history as a result of Storm Dennis, a powerful and widespread weather event designated by the Met Office. Across the UK, Storm Dennis caused major flooding in hundreds of communities, with over 2,700 properties flooded in Wales, making it one of the most impactful flood events of the decade (Ashfield Solutions, 2021). During the storm, the River Taff reached its highest level on record at 5.32 metres, nearly four times its typical height and exceeding the design standard of local flood defences (RCTCBC, 2022). The resulting overtopping caused flooding in over 1,000 residential properties in Rhondda Cynon Taff, with **some streets in Pontypridd reporting flood depths of up to 1.8 metres – significantly exceeding protection offered by PFR.**

Surface water runoff from intense rainfall further worsened the impacts, particularly in low-lying areas and locations with limited drainage capacity. Pontypridd town centre, including Berw Road, Sion Street, Taff Street and Mill Street, was among the worst-affected zones, with widespread disruption to infrastructure and significant economic and social impacts on the community (RCTCBC, 2022). Storm Dennis has since been recognised as a 1-in-200-year flood event, prompting both Natural Resources Wales and Rhondda Cynon Taf Council to undertake detailed flood modelling and initiate multiple risk reduction measures (RCTCBC, 2021).

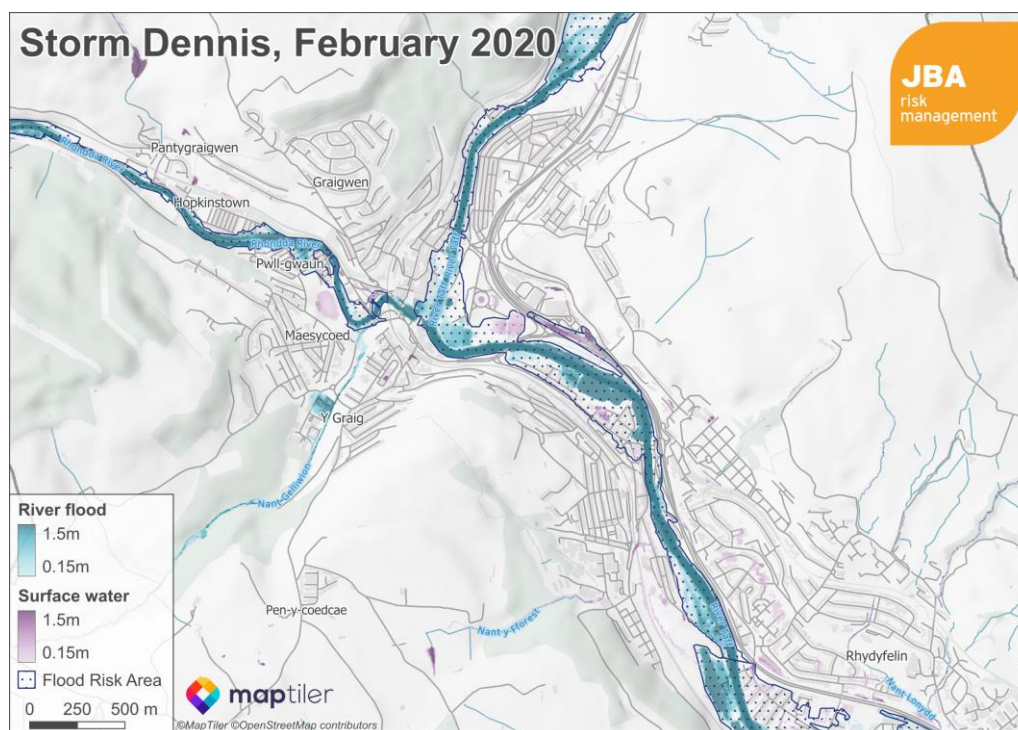


Figure 3-5: Modelled river and surface water flooding in Pontypridd during Storm Dennis (February 2020), based on JBA's 1-in-200-year flood maps with the NRW-designated Flood Risk Area is shown with a dotted area (NRW, 2025).

Figure 3-5 shows the extent of modelled river and surface water flooding in Pontypridd during Storm Dennis, using JBA's 1-in-200-year return period flood maps. Within this area, an estimated **830 properties are suitable for PFR** and 63 properties unsuitable for PFR. These findings highlight the potential scale of impact from extreme flood events and provide an evidence base for prioritising PFR interventions in high-risk zones.

3.6 Cost-effective deployment of PFR

Cost-effective deployment of PFR measures requires a targeted approach that focuses on the properties with the greatest potential to reduce damages. By analysing the distribution of flood risk and expected loss across the town's building stock, it is possible to identify a relatively small number of high-risk properties that contribute disproportionately to overall flood losses.

Figure 3-6 shows the cumulative AAL savings that could be achieved through PFR implementation, plotted against the proportion of properties with PFR implemented. The curve rises steeply, indicating that substantial benefits can be delivered by focusing on a small number of high-risk properties. Notably, adoption of PFR by 10% of properties, those typically first affected at return periods of greater than 50 years could capture 35% of the total potential savings. Adoption of PFR by 50% of properties unlocks over 90% of the available AAL savings.

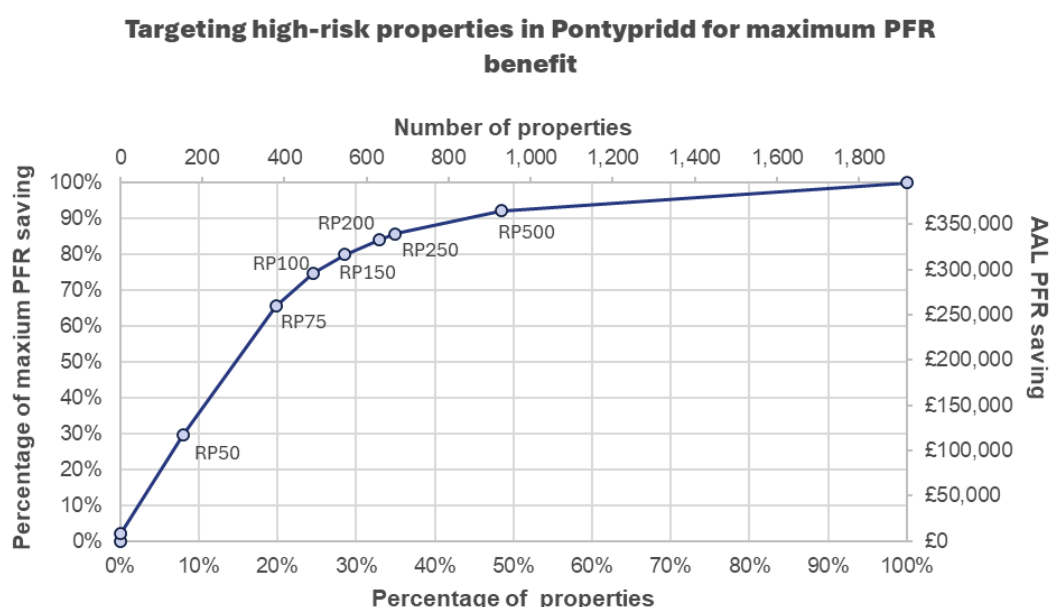


Figure 3-6: The relationship between the potential AAL savings of PFR implementation (y-axis) in Pontypridd, by number of properties (x-axis) and flood frequency.

This analysis highlights the strong return on investment achieved by targeting properties with the highest expected damages. In an area like Pontypridd, where at-risk properties are concentrated in vulnerable zones and resources for flood mitigation may be limited, such an approach enables flood resilience efforts to be delivered efficiently and with high impact.

3.7 Socio-demographic factors which may influence uptake of PFR

In addition to property suitability, flood risk and recent flooding, a range of socio-demographic characteristics can influence the likelihood and effectiveness of PFR uptake. Figure 3-7 illustrates the distribution of relevant indicators across Pontypridd and the surrounding communities, including property ownership, multiple deprivation indices, age profile, and disability prevalence (ONS, 2023). These insights help identify where additional support, targeted engagement, or alternative delivery approaches may be needed to ensure resilience measures are equitable and effective.

The proportion of owner-occupied properties varies considerably across the area. While many communities show relatively high ownership rates above 60%, several parts of central Pontypridd, as well as areas around Abercynon and south towards Llantrisant, fall into lower ownership bands of 40-60%. These areas likely include higher concentrations of private or social renting, which can present practical barriers to PFR adoption. Tenants may lack the authority to carry out property-level adaptations, while landlords, particularly in lower-income areas, may have limited awareness or motivation to invest. In such contexts, the success of PFR schemes may depend on targeted engagement with housing associations, incentives for private landlords, or coordinated community-based programmes.

Deprivation is a significant factor across much of the study area. Households experiencing two or more types of deprivation are concentrated in the more urbanised and valley-floor communities, including much of central Pontypridd, parts of Porth, and surrounding settlements. These areas often coincide with known fluvial flood risk zones, amplifying vulnerability. Financial barriers, limited access to information, and competing priorities can all reduce the likelihood of voluntary PFR uptake in such areas. Effective delivery will require proactive outreach, accessible funding, and clear communication that links resilience measures to everyday wellbeing and long-term security.

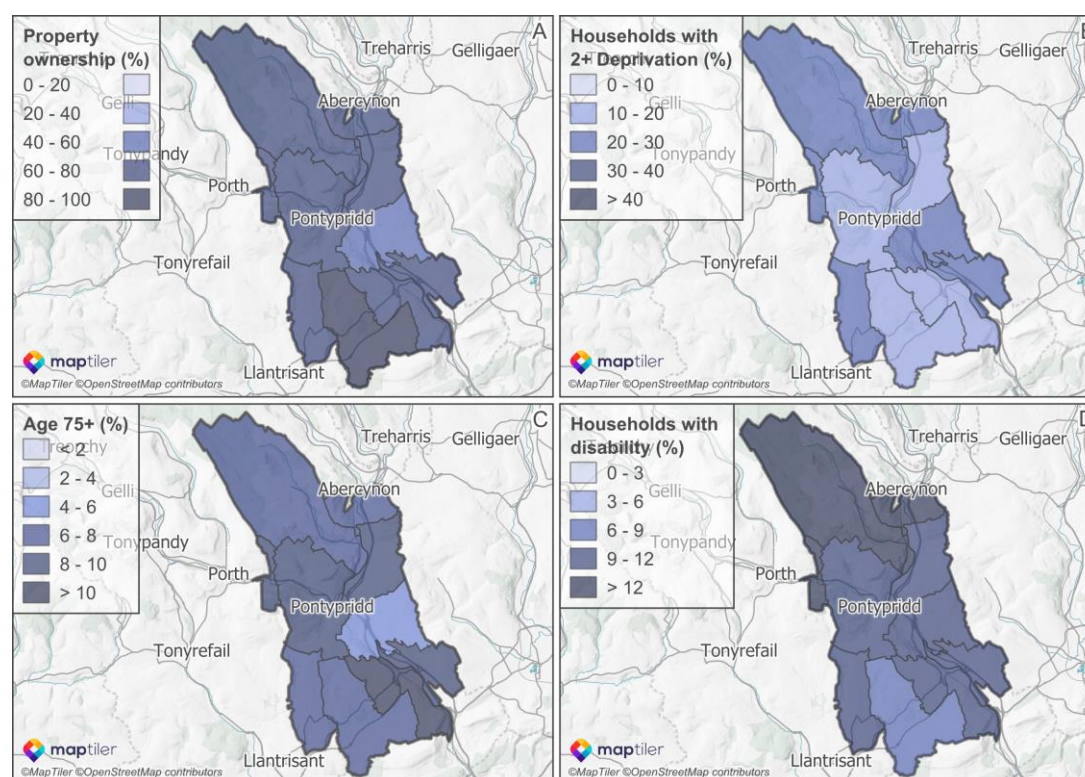


Figure 3-7: Socio-demographic indicators relevant to Property Flood Resilience (PFR) uptake across Pontypridd (ONS, 2023). A: Proportion of owner-occupied properties, B: Households experiencing two or more types of deprivation, C: Percentage of the population aged 75 and over, and D: Percentage of households reporting disability limiting day-to-day activities.

In terms of age profile, the population across Pontypridd is relatively young, but some areas show a higher proportion of residents aged 75 and over. These older communities may face greater physical or practical barriers to implementing or maintaining PFR, and may be less able to recover quickly from flood-related disruption. In such cases, passive, low-maintenance solutions, such as self-activating barriers, automatic airbricks, or sump pumps, may be more appropriate. Older residents may also face additional challenges during flood events, such as difficulties evacuating or accessing temporary accommodation, making reliable in-place protection especially valuable.

Disability prevalence is particularly high across much of the study area, with many neighbourhoods, especially around Abercynon, Porth, and central valley settlements, reporting that over 12% of households include someone whose day-to-day activities are limited by disability. In such households, the impact of flooding can be especially acute. Evacuation may be difficult or unsafe, and recovery, both physical and emotional, can be prolonged and complex. For these communities, PFR must provide reliable in-place protection that reduces disruption, preserves accessibility, and maintains health and safety. Delivery should be supported by clear, accessible communication, tailored engagement, and ongoing maintenance support to ensure that interventions are inclusive, effective, and sustainable. Close collaboration with health, care, and housing services may also be necessary to reach those most in need.

Taken together, these findings highlight that while much of Pontypridd may be technically suitable for PFR, uptake and effectiveness will be shaped by complex local realities. In high-deprivation, low-ownership areas, resilience programmes will require sustained public investment and coordination with landlords or housing providers. In communities with high disability rates, delivery should prioritise low-disruption, passive protection with built-in support. A socially responsive approach, one that blends physical risk, structural suitability, and social context, will be essential to ensure that PFR reaches the most exposed and most vulnerable households across the region.

3.8 Summary of Property Flood Resilience Potential

Pontypridd lies at the confluence of two rivers and is highly exposed to **fluvial and surface water flooding**, as seen during **Storm Dennis (2020)**. Whilst extensive river flood defences exist, topographical challenges limit further flood defence construction and residual risk remains, especially from surface water. PFR may therefore be a potentially effective method in reducing risk.

- **88%** of properties are suitable for PFR, primarily traditional terraced and semi-detached houses.
- Over **2,150 properties** are exposed to flood risk, with 90% of these suitable for PFR.
- PFR could reduce the expected annual cost of flooding by **45% around £395k per annum** with standard PFR measures.
- **34% of properties** would recoup limited PFR investment within 20 years.
- Flood defence coverage is strong for fluvial risk, but **23% of at-risk properties remain unprotected**, particularly from surface water.
- Socioeconomic vulnerabilities including high deprivation and high disability rates may limit PFR adoption.

4 Kingston upon Hull, Yorkshire, England

Area Highlights

- **Multi-peril flood risk** (river, tidal, surface water); major event in 2007.
- **84% of homes suitable for PFR**, mainly terraced/semi-detached houses.
- **66,500+ homes at risk**, with AAL of **£34.4m/year**.
- PFR could reduce losses by **£19.5m/year (57%)**.
- **38% of homes cost-effective** within 20 years; 11% within 5 years.
- 44% of at-risk homes outside formal defences; high deprivation and rental tenure pose barriers.

The city of Hull, located in the East Riding of Yorkshire, is among the most at-risk to flood urban areas in the UK. Positioned on low-lying land adjacent to the Humber Estuary and intersected by the River Hull, the city faces notable flood risk from tidal, fluvial, and surface water sources. A major flood event occurred in June 2007, when extreme rainfall overwhelmed the local drainage network, resulting in flooding to more than 8,000 properties and significant infrastructure disruption (Coulthard & Frostick 2010). Despite major investment in flood defence infrastructure since, including tidal barriers and improved drainage, the city remains highly vulnerable, particularly to surface water flooding.

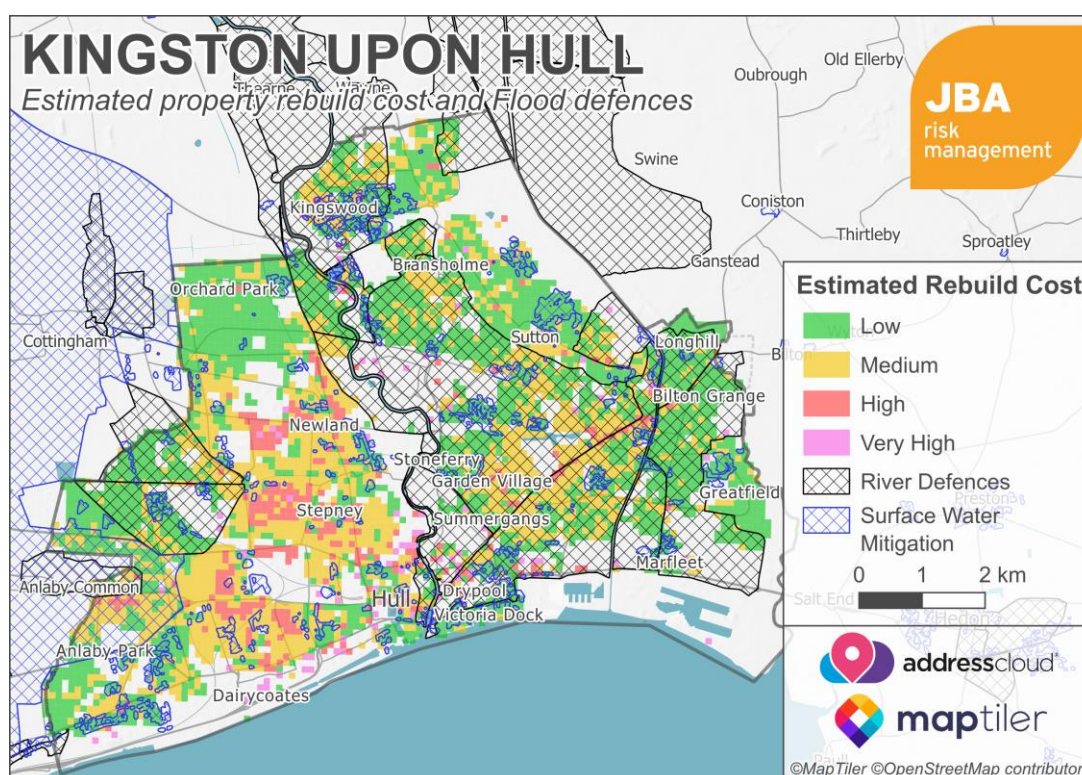


Figure 4-1: Estimated property rebuild costs and flood defence coverage in Hull.

Flood defence infrastructure is widespread, with significant coverage from river defences along both the Humber and River Hull, and extensive networks of surface water mitigation measures. The map highlights that many properties, particularly in the western and northern suburbs, fall outside the reach of surface water schemes. Given Hull's topography and reliance on pumped drainage systems, surface water flooding remains a persistent and challenging hazard.

4.1 Homes suitable for PFR based on construction and floor level

Most residential properties in Hull are houses, accounting for 79% of the housing stock, including a high proportion of terraced housing (52%) and semi-detached (20%) dwellings. Detached houses make up 6%, with flats representing 15% and bungalows 6% (Figure 4-2). This housing mix reflects Hull's working-class heritage and urban development pattern, with large areas of closely packed terraces in low-lying locations, often with ground-floor living space. Figure 4-1 shows the distribution of estimated property rebuild costs across Hull, alongside the location of existing flood defence infrastructure. Much of the city falls into the low or medium rebuild cost categories, reflecting the relatively modest construction values across large parts of the housing stock. However, pockets of high and very high rebuild costs are evident, particularly in more recently developed or regenerated areas.

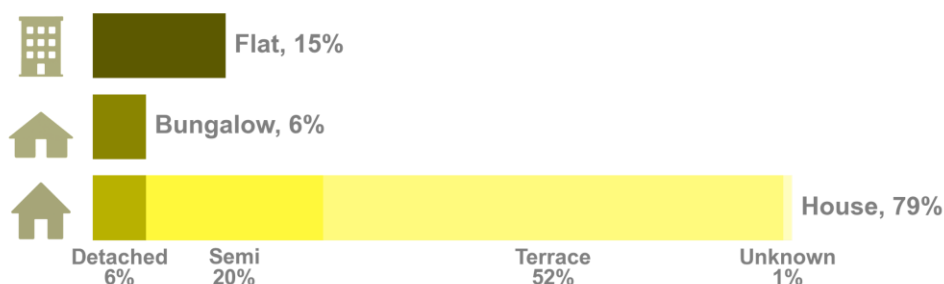


Figure 4-2: Proportion of residential property types in Hull.

Table 4-2 summarises the building stock in Hull and its suitability for PFR based on construction type and floor level. Buildings with solid or suspended ground floors and standard masonry or cavity wall construction are classified as suitable. Properties considered unsuitable include those with non-standard construction or flats located above ground level.

Table 4-1: Summary of building types and suitability for PFR in Hull.

Building type		Suitable for PFR		Unsuitable for PFR	Total
		Solid floor	Suspended floor		
House	Detached	1,983	5,270	495	7,748
	Semi	6,009	16,263	1,712	23,984
	Terrace	15,325	42,449	5,663	63,437
	Unknown	3	851	221	1,075
Bungalow		3,109	3,028	633	633
Flat	Basement	51	124	33	208
	Ground floor	2,773	5,160	743	8,676
	First floor and above	0	0	9,576	9,576
Total		29,253	73,145	19,076	121,474

Of the 120,000 buildings assessed, **102,398 (84%) are suitable for PFR**, comprising 29,253 with solid floors and 73,145 with suspended floors. The remaining 19,076 buildings (16%) are unsuitable.

Hull's housing stock is heavily dominated by terraced and semi-detached houses, which together account for more than 70% of all buildings. The vast majority of building stock is suitable for PFR, 91% of terraced housing, 93% of semi-detached homes, 94% of detached houses and 91% of bungalows. Flats, which are less prevalent in Hull than in other urban areas, present mixed suitability. Most of the 8,676 ground-floor flats (92%) are considered potentially suitable. Basement flats offer limited but notable opportunities, with 175 out of 208 identified as suitable.

4.2 Homes at risk to flood and frequent flooding

Over 66,500 properties in Hull are exposed to at least one form of flood risk. **More than 61,900 properties are at risk from river flooding, while 8,600 properties are exposed to surface water flooding, and nearly 1,600 face coastal and tidal flood risk from the Humber Estuary.** These figures underline Hull's exposure to multiple interacting flood hazards, consistent with its geography and flood history.

Table 4-2: Summary of number of properties exposed to flood, PFR suitability, and potential Average Annual Loss (AAL) reduction in Hull

Total Number of Properties		121,474		Number of at-risk properties suitable for PFR		57,140	
Flood Type	No. of properties at risk	% of total properties	Baseline AAL	Limited PFR		Standard PFR	
				AAL	% saving	AAL	% saving
River	61,978	51%	£33,455,316	£22,017,699	-34%	£14,706,899	-56%
Surface water	8,643	7%	£546,139	£207,087	-62%	£172,541	-68%
Coastal	1,578	1%	£110,346	£69,290	-37%	£50,554	-54%
TOTAL	66,580	55%	£34,372,130	£22,431,649	-35%	£14,848,678	-57%

Without PFR intervention but considering the preexisting formal flood defences, annual average flood damages in Hull are estimated at £34.4 million per year. However, this could be reduced by 35% (£12 million) with the implementation of a limited PFR packages, and by 57% (£19.5 million) with standard PFR. **86% of properties at flood risk in Hull are suitable for PFR-based risk reduction indicating widespread suitability across the city.**

Given the widespread defence infrastructure, only **5,622 properties are at risk to frequent flooding at the 1 in 25-year return period** (or 4% annual exceedance probability (AEP)). 6,392 properties at risk to the 1 in 50-year 2% AEP event.

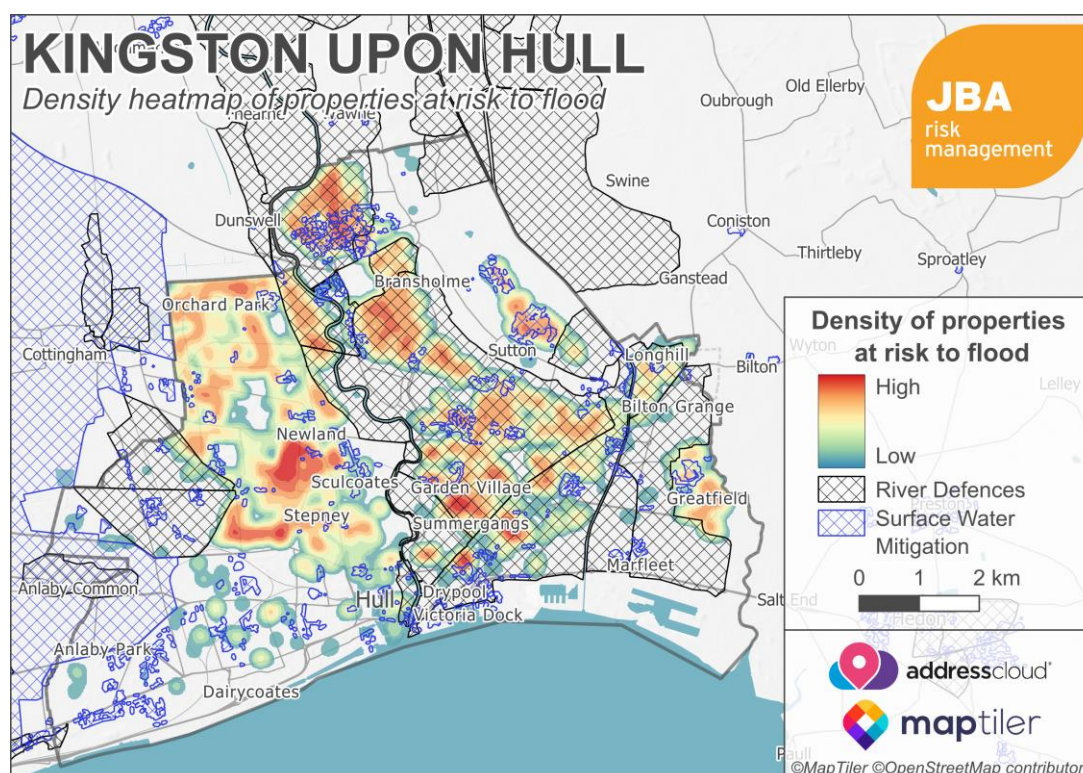


Figure 4-3: Density heatmap of properties at risk to flooding in Hull.

Figure 4-3 illustrates the spatial distribution of properties at risk to flood across Hull. The heatmap clearly highlights several neighbourhoods where flooding has been most concentrated, particularly in Avenues, Newland, Garden Village, and Stoneferry, while additional clusters appear in areas such as Orchard Park, Greatfield, and Summergangs.

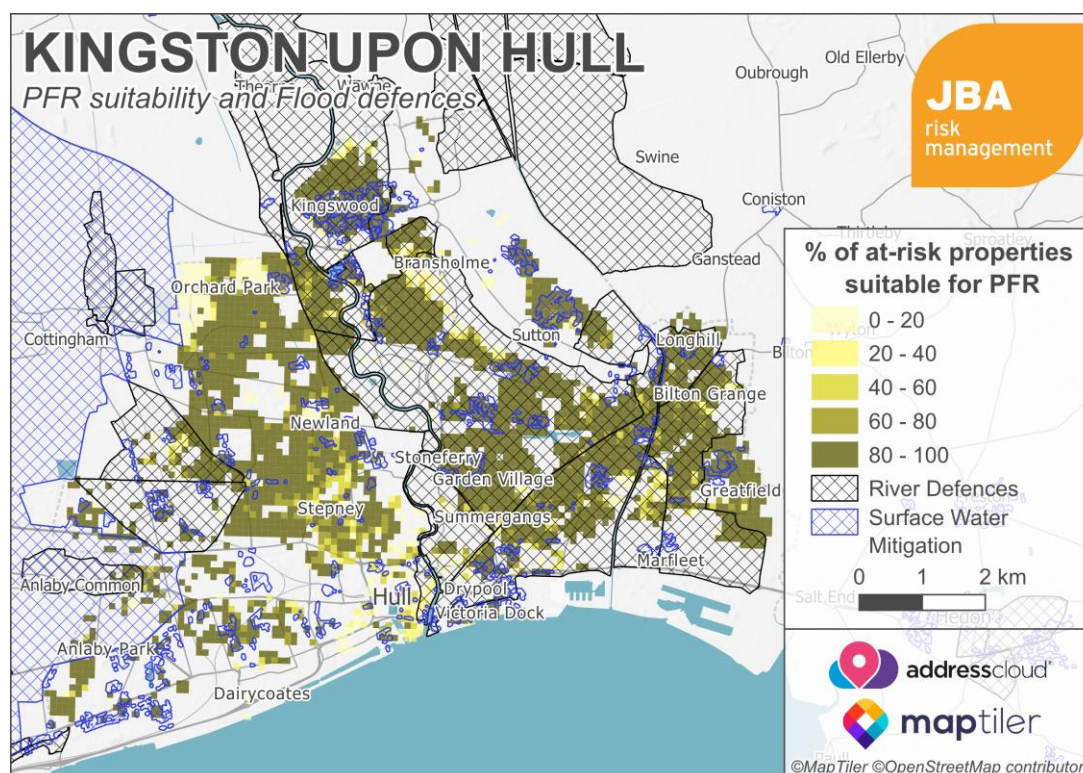


Figure 4-4: Proportion of at-risk residential properties suitable for Property Flood Resilience (PFR) across Hull.

Figure 4-4 illustrates the proportion of those homes at risk that are suitable for PFR with much of central, eastern, and northern Hull showing over 80% of flood-affected homes classified as suitable.

4.3 Homes not formally protected by flood defence

37,244 residential properties (56%) benefit from existing flood defences, demonstrating the significant role of the city's formal flood infrastructure, including tidal barriers, pumping stations, and urban drainage systems in reducing losses during major flood events.

29,336 properties (44%) however still experience considerable losses even with the preexisting defences considered, this indicates significant residual flood risk, particularly from surface water flooding. Among these undefended properties, **23,992 buildings are assessed as suitable for PFR measures**. These homes present a major opportunity for targeted resilience investment. Implementing PFR in these locations could significantly reduce the financial and social impacts of future flood events, particularly where large-scale infrastructure upgrades may be unfeasible due to cost, disruption, or physical constraints

4.4 Homes where PFR offers a cost-effective return on investment

Understanding where PFR measures offer the greatest return on investment is crucial for prioritising delivery. This section identifies properties where the cost of implementing limited or comprehensive PFR is outweighed by the expected flood damages avoided over the lifetime of the intervention. By comparing installation costs with modelled AAL reductions, we can assess the proportion of properties where PFR is likely to be financially justifiable within a 5-, 10-, or 20-year period, the latter reflecting the typical lifespan of most PFR measures.

Table 4-3 presents the number and proportion of properties in Hull where expected flood damages avoided exceed the cost of implementing limited or standard PFR, grouped by return on investment thresholds. **For limited PFR, approximately 11% of properties show a payback period of under five years (cost <5x AAL), while 38% fall within a 20-year return period, aligning with the typical lifespan of PFR measures.** Although standard PFR has higher upfront costs, it remains financially viable for up to 15% of properties within the same 20-year threshold.

Table 4-3: Number and proportion of PFR-suitable properties in Hull where expected Average Annual Loss (AAL) savings exceed installation costs.

PFR Savings	Low-PFR Scenario <i>Limited Measures</i>		High-PFR Scenario <i>Standard Measures</i>	
	Number of properties	% of total PFR-suitable properties	Number of properties	% of total PFR-suitable properties
<5 x AAL	6,256	10.9	1,050	1.8
<10 x AAL	12,690	22.2	4,547	8.0
<20 x AAL	21,802	38.2	8,315	14.6

In Hull, the broad suitability of the housing stock means that both limited and standard measures can be applied widely. However, limited PFR remains more cost-effective for the majority of homes because much of the city's exposure is to frequent surface water or shallow river flooding. Standard measures still provide substantial protection in high-exposure zones, but their higher costs mean fewer households achieve full payback within the 20-year lifespan. This explains the stronger performance of limited interventions in the analysis, despite Hull's history of multi-peril flood events.

These findings highlight the value of integrating cost-effectiveness into PFR delivery strategies. Most properties suitable for comprehensive PFR are also candidates for limited measures, providing flexibility in how schemes are targeted and rolled out. While implementation will also depend on practical considerations such as property characteristics and resident engagement, the analysis offers a strong evidence base for prioritising investment where the potential return is greatest.

4.5 Homes that have previously flooded

In June 2007, Hull experienced one of the most damaging urban flood events in recent UK history, caused by prolonged, intense rainfall that overwhelmed surface water drainage systems and resulted in extensive property flooding. Nationally, over 55,000 properties were flooded during the summer 2007 events, with Hull among the worst-affected cities. The flooding caused widespread disruption with damage to 8,600 residential properties and over 1,300 businesses across the city (Pitt, 2008). Around 20,000 residents were directly affected, with widespread disruption to schools, healthcare, and transport infrastructure. For many, the aftermath (displacement, insurance delays, and the emotional toll of recovery) proved more challenging than the flood itself.

JBA's modelled flood footprint for the Summer 2007 event which includes detailed extents and depths for both river and surface water flooding (Figure 4-5). The model shows extensive river flooding along the River Hull corridor, affecting areas such as Bransholme, Sutton, and Orchard Park. Although Kingswood was only partially built in 2007, parts of the estate already developed at that time were also affected. In addition, surface water flooding was widespread

in central and western areas including Avenues, Anlaby, and Newland, driven by intense rainfall and limited drainage capacity in densely developed neighbourhoods.

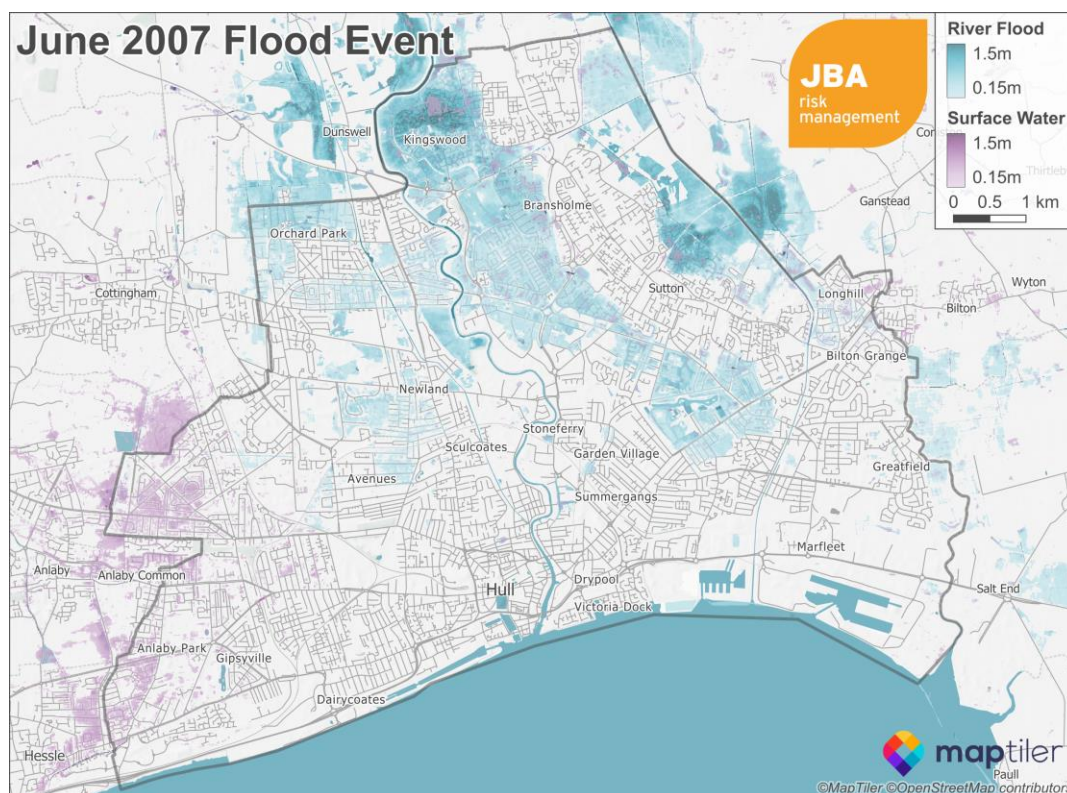


Figure 4-5: Flood-affected areas in Hull during the June 2007 event, showing river (blue) and surface water (purple) flood extents and depths.

Within the modelled 2007 event footprint, **10,510 properties are currently assessed to be suitable for PFR**, with a further 2,976 properties unsuitable for PFR. The model highlights how multiple drainage pathways, including the River Hull, Barmston Drain, and Engine Drain, contributed to the spread of flooding across low-lying and topographically constrained areas of the city. While this figure exceeds the ~8,600 properties reported as flooded in 2007, there has been significant development in the area in the intervening 18-years.

Although substantial investment has been made in formal flood defences since 2007, residual risk remains, particularly from high-intensity rainfall and surface water flooding. Many of the worst-affected areas in 2007, such as Bransholme, Sutton, and Orchard Park continue to face elevated risk. These neighbourhoods are well suited for targeted PFR measures, and prior flood experience may improve homeowner engagement and uptake. Prioritising PFR delivery in these locations offers a practical and cost-effective way to enhance resilience, especially where defences may be exceeded or overwhelmed during future events.

4.6 Cost-effective deployment of PFR

To ensure cost-effective deployment of PFR measures, it is essential to understand where the greatest benefits can be achieved. By analysing the distribution of flood risk across Hull's building stock, we can identify properties that contribute disproportionately to overall flood losses. This section explores how targeting PFR interventions at the most vulnerable properties, those with the highest expected annual damages, can deliver a significant proportion of the potential savings, even when only a small percentage of the total property stock is treated.

Figure 4-6 illustrates the cumulative AAL savings achieved through the implementation of PFR measures in Hull, plotted against the proportion of properties with PFR implemented. The curve shows a steep initial rise, indicating that targeting a small proportion of high-risk properties yields significant benefits. Notably, adoption of PFR by just 10% of properties, those first impacted at return periods of around 25 to 50 years, could deliver approximately 50% of the total potential savings. With adoption of PFR by 50% of properties, nearly 90% of the maximum savings can be realised. Given that Hull has around 57,000 properties suitable for PFR, this means that implementing PFR for fewer than 6,000 of the highest-risk properties could capture half of the available savings. This demonstrates the strong return on investment when PFR is focused on properties with the highest flood exposure.

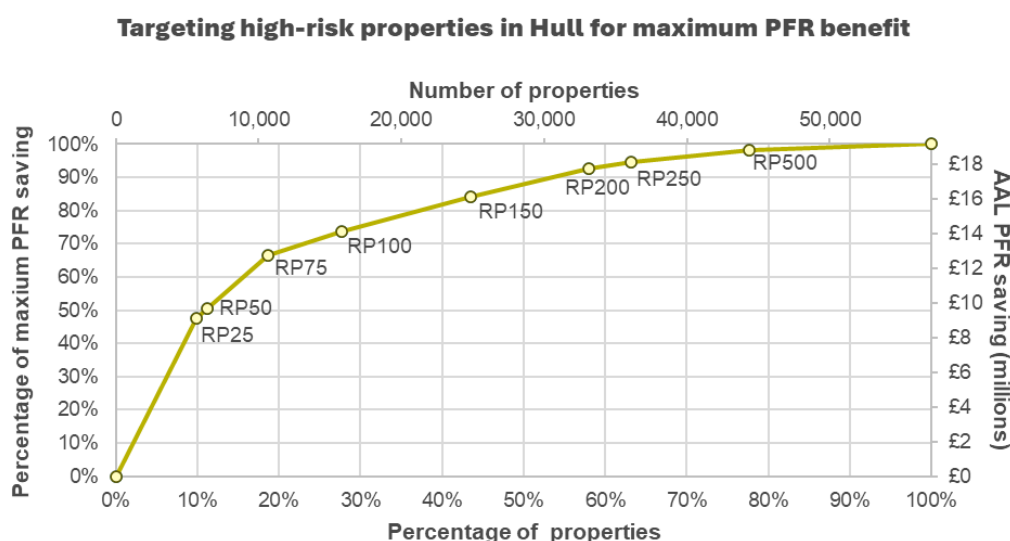


Figure 4-6: The relationship between the potential AAL savings of PFR implementation (y-axis) in Hull, by number of properties (x-axis) and flood frequency.

4.7 Socio-demographic factors which may influence uptake of PFR

In addition to technical suitability and flood risk, a range of socio-demographic factors can influence the likelihood and effectiveness of PFR uptake. The maps in Figure 4-7 explore how characteristics such as property ownership, deprivation, age profile, and disability are spatially distributed across Hull, helping to identify where tailored approaches may be required to support equitable and impactful delivery (ONS, 2023).

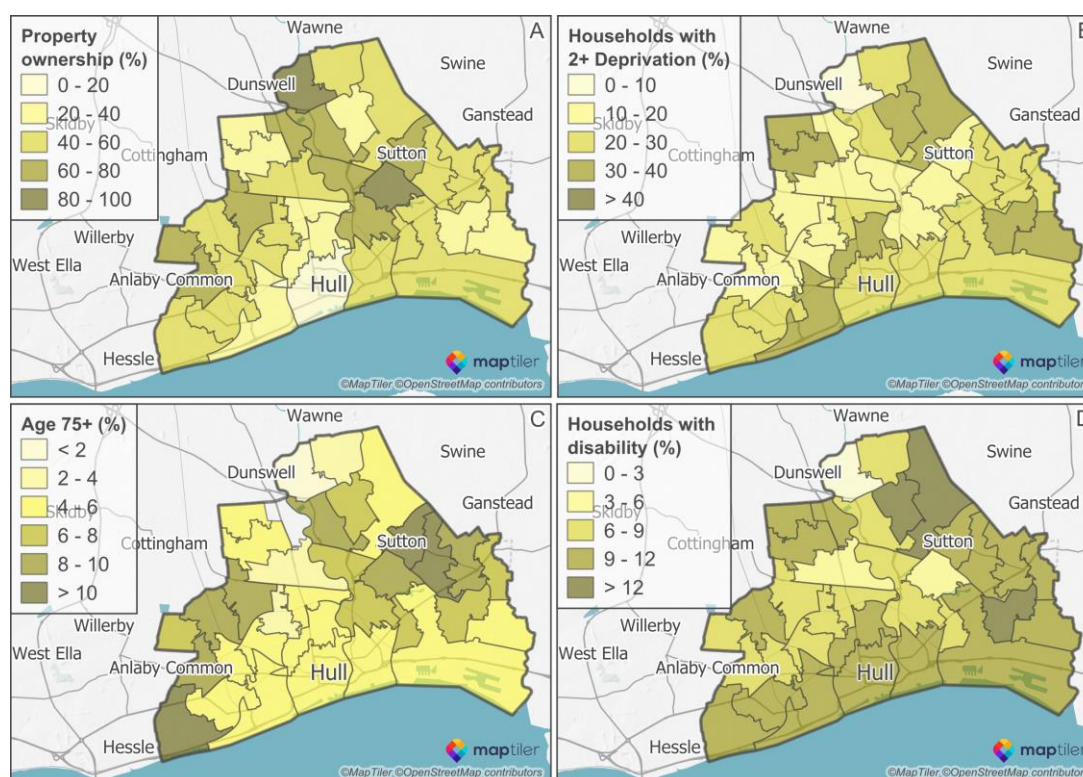


Figure 4-7: Socio-demographic indicators relevant to Property Flood Resilience (PFR) uptake across Hull (ONS, 2023). A: Proportion of owner-occupied properties, B: Households experiencing two or more types of deprivation, C: Percentage of the population aged 75 and over, and D: Percentage of households reporting disability limiting day-to-day activities.

The proportion of owner-occupied properties varies significantly across the city, with some central neighbourhoods showing ownership rates below 40%. This has important implications for PFR uptake. Owner-occupiers are more likely to invest in property-level resilience measures themselves, while private renters typically depend on landlords, who may have limited incentives to act, especially in low-income or high-turnover areas. Social housing providers may offer greater capacity to implement PFR at scale, but uptake will be shaped by funding, organisational priorities, and external support. In neighbourhoods with low ownership and high flood risk (e.g. Bransholme), delivery may require institutional engagement strategies, such as incentives for landlords or minimum resilience standards within housing policy.

The percentage of households experiencing two or more types of deprivation (e.g. income, education, employment, or health) reveals further challenges. Areas with higher levels of multiple deprivation are likely to face financial constraints that limit the ability to self-fund resilience improvements. These communities may also show lower awareness of flood risk or struggle to navigate complex grant application processes. Moreover, the wider social impacts of flooding, such as displacement, loss of income, and mental health stress, can be amplified in already vulnerable populations. As a result, community-based delivery models and targeted public support will be essential to ensure that PFR is accessible to those who stand to benefit most.

Some parts of Hull also show a higher proportion of residents aged 75 and over, particularly in outer suburban areas. Older communities may face physical or practical barriers to deploying temporary resistance measures, and may be less able to recover quickly from flood-related disruption. In such cases, in-place, low-maintenance PFR, such as automatic airbrick covers or passive sump systems, may be more appropriate. Additional support may also be needed to assist with installation and maintenance.

The proportion of households reporting disability is particularly high in parts of west and north Hull. In these areas, over 12% of households include someone whose day-to-day activities are limited a lot, indicating significant health or mobility challenges. These neighbourhoods often overlap with zones of high deprivation and flood risk, compounding vulnerability. For households with severe disability, evacuation may be unsafe or impractical, and disruption to home-based care or medical equipment can pose serious risks. In such cases, reliable, in-place PFR is essential to help residents shelter safely and recover more quickly. Co-designed solutions, supported installation, and follow-up engagement are especially important to ensure these measures are not only effective, but inclusive of those with the highest needs.

Together, these findings highlight the need for a socially informed approach to PFR planning in Hull. While physical suitability and flood exposure define where interventions are technically feasible, successful implementation will depend on the capacity and circumstances of the communities involved. In renter-heavy or deprived areas, institutional or publicly funded models may be needed. In communities with higher proportions of older or disabled residents, simplicity, passive protection, and support services will be key. Meanwhile, in higher-ownership areas, engagement can focus on the long-term benefits of property protection, including insurance savings and peace of mind. Integrating social indicators into programme design will help ensure that resilience measures are not only effective, but also equitable and widely adopted.

4.8 Summary of Property Flood Resilience Potential

Hull is one of the most **flood-prone urban areas in the UK**, with exposure to **river, surface water, and tidal flooding**. Despite significant investment since the 2007 floods, residual risk remains high due to topography, clay soils, and reliance on pumped drainage.

- **84%** of properties are suitable for PFR, predominantly terraced and semi-detached homes with suspended floors.
- Over **66,500 properties** are exposed to flood risk, with an estimated AAL of **£34.4 million/year**.
- PFR could reduce AAL by **£19.5 million (57%)** under comprehensive deployment.
- **38%** of suitable homes would recover limited PFR costs within 20 years; 11% within 5 years.
- **44%** of flood-exposed properties remain outside formal flood defence coverage.
- High levels of deprivation, low ownership, and a large private rental sector necessitate **institutional delivery models and public support**.

5 Comparison of Area-Specific information

The four study areas, Kensington & Chelsea, West Lothian, Pontypridd, and Hull, represent a diverse range of communities at risk to flooding in the UK.

Across all areas, a high proportion of flood-exposed properties are structurally suitable for PFR, with suitability rates ranging from 46% in Kensington & Chelsea to 88% in Pontypridd. These differences reflect both housing typologies and elevation profiles, urban flats and basement dwellings dominate in London, while traditional terraced and semi-detached housing is more prevalent in the other areas.

In terms of flood hazard, all four areas experience surface water flooding, though the relative risk varies. Kensington & Chelsea is almost exclusively at risk from surface water, while Pontypridd and West Lothian face dual exposure to river and surface water flooding. Hull stands out for its multi-peril exposure, with significant risk from river, surface water, and coastal sources. Notably, only a small proportion of properties at risk are protected by formal flood defences in most areas, just 4% in Kensington & Chelsea and 25% in West Lothian, emphasising the potential for PFR to address this residual flood risk.

When comparing the financial impact, Hull has the highest present day expected annual cost of flooding, exceeding £34 million, and also offers the largest potential for risk reduction with PFR (£19.5 million under the standard scenario). Similarly across all areas, PFR update by just 10–20% of the most at-risk properties delivers over 50% of the total potential savings, underscoring the value of supporting the most at-risk properties.

Cost-effectiveness also varies by context. Kensington & Chelsea shows the highest proportion of properties with a strong return on investment under both limited and comprehensive PFR scenarios, largely due to high rebuild costs and concentrated surface water risk. In contrast, West Lothian and Pontypridd demonstrate smaller absolute savings, but with high relative benefits, especially where engineered defences are limited or infeasible.

Socio-demographic context plays a significant role in shaping the feasibility and design of PFR delivery. In Hull and parts of Pontypridd, high deprivation and low homeownership rates may act as barriers to voluntary uptake, reinforcing the need for funded community-wide schemes. Conversely, affluent areas of Kensington & Chelsea may support higher rates of self-funded uptake, though challenges remain in adoption by tenants and those in conservation areas. Across all areas, communities with higher rates of disability or older residents require tailored solutions that prioritise passive protection and minimise disruption.

Overall, the findings confirm that PFR has the potential to be a viable, cost-effective, and socially relevant strategy in each of the four case study areas, but that delivery models must be adapted to local housing, risk, and demographic conditions to maximise impact.

6 Summary

This area-specific analysis has demonstrated how the national potential for Property Flood Resilience (PFR) can be translated into actionable local strategies. Using detailed property and flood risk data, four contrasting areas, Kensington & Chelsea, West Lothian, Pontypridd, and Hull, were assessed to explore how PFR can reduce flood damages, where it is most suitable, and how implementation may be influenced by local context.

Across the four areas, more than 190,000 residential properties were assessed. Of these, over 75% of flood-exposed properties are structurally suitable for PFR, confirming that PFR can play a meaningful role in managing flood risk at the community level. In all areas, a small proportion of high-risk properties account for a large share of potential flood losses, indicating that targeted interventions offer strong returns and efficient resource use.

The analysis found that PFR is not only technically feasible but financially justified in a significant number of cases. In most areas, a notable percentage of properties could recover installation costs within the typical 20-year lifespan of the measures. Where limited PFR is sufficient, such as for shallow or surface water flooding, cost-effectiveness is particularly strong. Even standard PFR however can be justified in areas with higher exposure or rebuild costs.

Importantly, the findings highlight that successful delivery of PFR requires more than technical suitability or favourable cost-benefit ratios. Uptake and effectiveness are shaped by socio-demographic factors including tenure, deprivation, disability, and prior flood experience. Tailoring delivery to account for these realities, through landlord engagement, grant support, or targeted communications, will be critical to achieving equitable resilience outcomes.

The study reinforces that PFR is not a one-size-fits-all solution. Instead, it is a flexible and adaptable tool that can complement existing flood defences, close gaps in protection, and provide targeted benefits where large-scale infrastructure is impractical or unaffordable. Looking ahead, these findings can inform the design of future PFR programmes by:

- Prioritising high-impact properties based on AAL and structural suitability
- Identifying locations where social vulnerability may limit uptake without support
- Supporting place-based delivery models that reflect local capacity and need

By embedding local context into national flood resilience planning, PFR can help ensure that communities across the UK are better protected, better prepared, and better able to recover from flooding, at present and in the future.

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