Burscough Level 2 Surface Water Management Plan

SWMP Report & Action Plan

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Burscough Level 2 Surface Water Management Plan

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Contents

1. Introduction

1.1 Commission

In February 2018, Lancashire County Council commissioned Jacobs UK Ltd. to undertake a Level 2 Surface Water Management Plan (SWMP) study covering the small town of Burscough within West Lancashire.

Shortly after the project started, it was put on hold for several months whilst ongoing network modelling was undertaken by United Utilities. This dataset was considered critical to the completion of the SWMP. The project started up again in November 2018, with the updated network model provided March 2019.

This report documents the findings of the Burscough Level 2 SWMP.

1.2 Background

Lancashire County Council, as Lead Local Flood Authority (LLFA) under the Flood and Water Management Act (2010) [1] has several powers, duties and responsibilities with respect to the management of flood risk from local sources. In this context, local flood sources describe flooding from sewers, drains, groundwater, and runoff from land, small watercourses and ditches that occurs because of heavy rainfall. How Lancashire County Council intends to manage the risk from these local sources is set out in its Local Flood Risk Management Strategy (2014)[2].

Central to delivering the objectives of the strategy, is the need to undertake studies and investigations to understand the extent, frequency and impact of local flooding and to then carry out these powers, duties and responsibilities in a coordinated way with other Risk Management Authorities (RMAs) to minimise the likelihood and consequence of flooding.

A SWMP is an extremely useful study undertaken in consultation with key local partners responsible for surface water management and drainage in their area, with each partner working together to understand the causes and effects of surface water flooding to agree the most cost-effective way of managing surface water flood risk for the long term.

1.2.1 Burscough Catchment

Burscough is a small town located within the Borough of West Lancashire, approximately 2km north east of Ormskirk.

Figure 1-1 illustrates the boundary of the SWMP study area along with the local topography and the towns location in the context of the wider area. The study area has been defined to cover the local surface water catchment and know flooding hotspots and was informed by stakeholder engagement discussed in Section 1.4. These hotspots include Burscough Junction, Burscough Bridge, Burscough Industrial Estate and New Lane.

Burscough is located across two separate natural river catchments. The western half of the catchment is located within the Alt-Crossens catchment, whilst much of the eastern half of the catchment is located within the River Douglas catchment. The majority of Burscough town sits within the Alt-Crossens catchment. The catchment is relatively flat with land gently falling north west towards the Burscough Wastewater Treatment Works and Martin Mere. The study area east of the A59, falls to the north east.

The town itself is largely residential. Burscough Industrial Estate sits to the west, which contains most commercial properties. The study area also contains a large proportion of open green space used as public open space and agricultural land. In line with the Burscough Parish Neighbourhood Plan (2019)[3] and the West Lancashire Local Plan (2013)[4], the area is identified for development including Yew Tree Farm Strategic

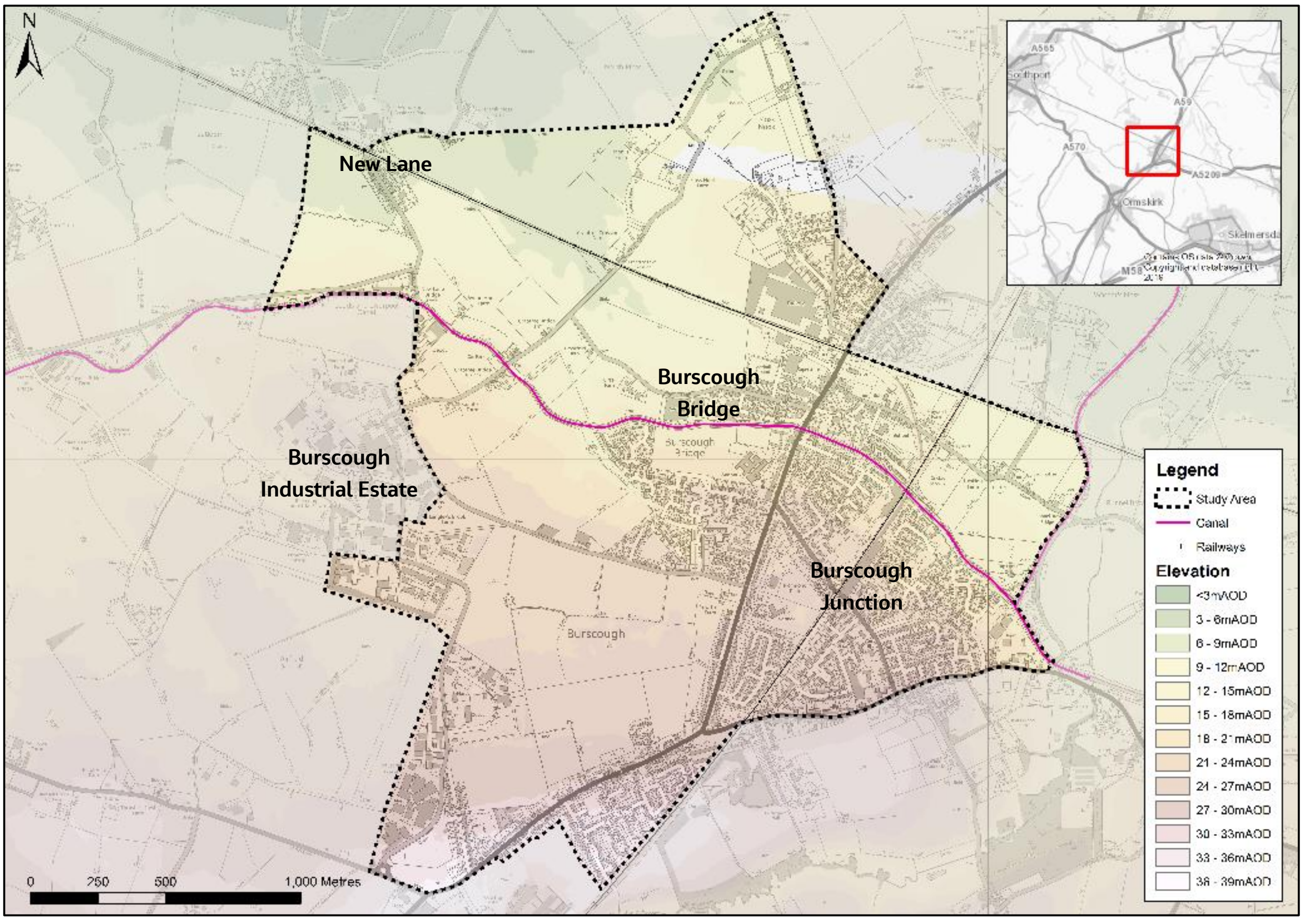
Development Site and a 10ha extension to the Burscough Industrial Estate along with development of Victoria Park football ground.

Burscough is also intersected by several networks including the Leeds and Liverpool Canal that passes through the northern part of the town and two railway networks including the Liverpool to Preston line and the Southport to Manchester line. There are also several local Ordinary Watercourses, but no Main Rivers within the study area. There are however three Main Rivers surrounding the study area: Boat House Sluice immediately north of New Lane adjacent to the Burscough Wastewater Treatment Works, Eller Brook to the east of the study area and Langley's Brook immediately west of the Burscough Industrial Estate.

According to flood incident reports, Burscough suffers regular extensive but shallow surface water flooding, but during more extreme rainfall events, flooding has been known to cause roads to become impassable and internal flooding to households and commercial properties. Notable events include 2004, 2012, December 2015 and 2016. The most significant event occurred on 26th December 2015 following Storm Eva, with 23 known incidents of internal property flooding.

According to the West Lancashire Level 1 SWMP (2013)[5], surface water flooding is primarily driven by the flat nature of the topography, local watercourses, and pinch points along open, culverted and pipped surface water drainage networks.

Figure 1-1: Burscough Study Area

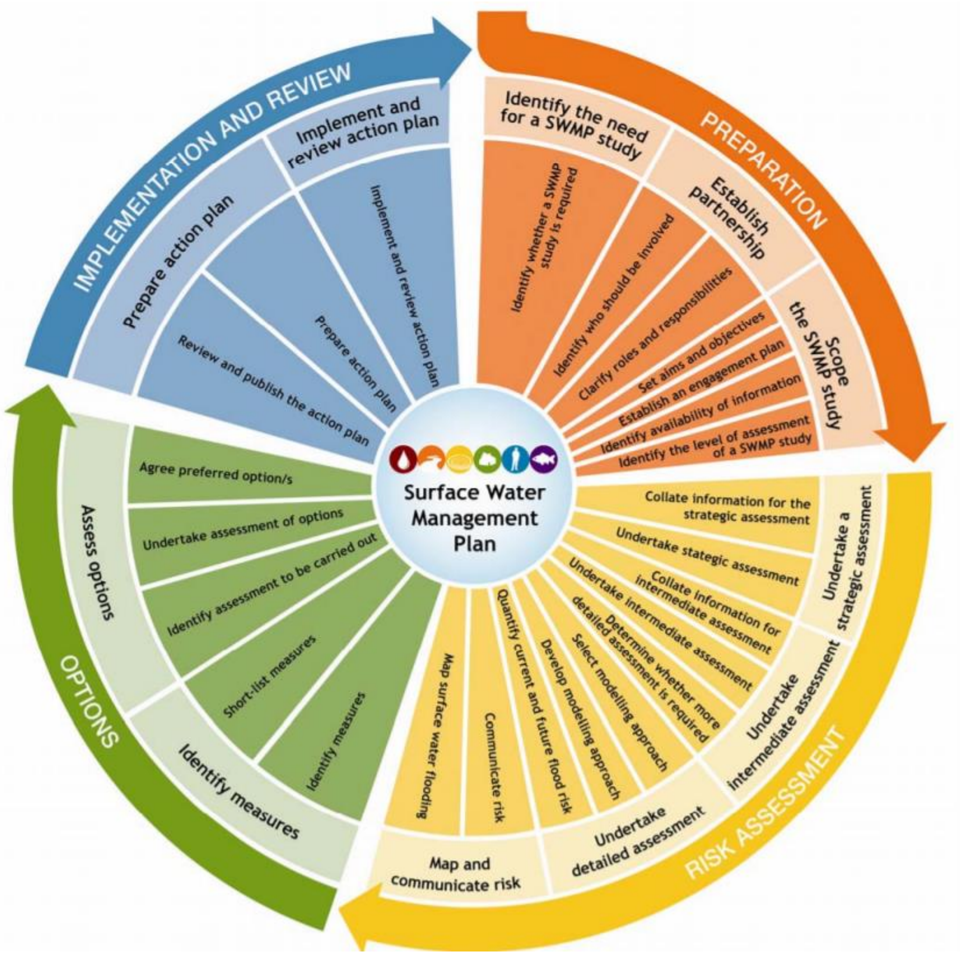


1.3 SWMP Framework

The Defra SWMP Technical Guidance (2010)[6] provides a framework for preparing SWMPs, which is illustrated in Figure 1-2. The Burscough Level 2 SWMP has been prepared and undertaken with this framework in mind, moving through the four principal stages of delivery:

1) **Preparation:** The first phase of a SWMP study focuses on preparing and scoping the requirements of the study. The aims and objectives of the study should be established, and an assessment should subsequently be undertaken to identify the availability of information (See Section 1.3 – this chapter).
2) **Risk Assessment:** Objectives and data help inform the level of risk assessment required. Given the need to understanding of the probability and consequences of surface water flooding and to test potential mitigation measures in high risk locations, a detailed assessment has been undertaken (see Section2).
3) **Options:** In this phase a range of options should be identified, through stakeholder engagement, which seek to alleviate the risk from surface water flooding in the study area. The type of form of options is very much dependent of the findings of the risk assessment (see Section 3).
4) **Implementation and Review:** Phase 4 is about preparing an implementation strategy (i.e. an action plan), delivering the agreed actions and monitoring implementation of these actions (see Section 4).

Figure 1-2: SWMP Framework (Defra, 2010)



1.4 Partnership Approach

Due to the complex mechanisms associated with local surface water flooding, a partnership approach is the most efficient way to co-ordinate flood risk management activities and is essential in achieving integrated and efficient mitigation where multiple organisations are involved.

1.4.1 Risk Management Authorities

There are several RMAs who have an influence and interest in this SWMP and will be responsible for helping to deliver the SWMP and its recommended actions. RMAs and their roles and responsibilities within flood risk management are set out in the Flood and Water Management Act (2010)[1]. Further details on this are also provided in Section 3.2 of this report.

RMAs engaged with as part of this SWMP include:

- Lancashire County Council (as Lead Local Flood Authority and Highway Authority);
- West Lancashire Borough Council (as District Council); and,
- United Utilities (as Water and Sewerage Company).

A project start-up meeting was held on the 6th December 2018 with key RMAs listed above to share local knowledge of flood history, define the aims and objectives of the SWMP, to develop the scope of the study including the sharing of critical data sets and key project deadlines.

Although the Environment Agency have a coordination and strategic overview role for all forms of flooding, there are no main rivers within the study area and therefore the Environment Agency were not involved in the scoping of this project. They will however, be kept informed of the project, its outputs and recommendations.

1.4.2 Other Stakeholders

There are other primary stakeholders who will benefit or be affected by this SWMP, including those who are responsible for 'at risk' land or property. Each of these groups or individuals have been engaged with at key stages of the SWMP development, these include:

- Network Rail;
- Canal and Rivers Trust;
- North West Regional Flood and Coastal Committee;
- West Lancashire Making Space for Water Group; and,
- Burscough Flooding Group (consisting of landowners, riparian owners and individual householders at risk of flooding).

Secondary stakeholders, such as Individual householders / businesses (not at risk of flooding) and developers who are indirectly impacted have not been engaged with as part of this SWMP process as their feedback is not necessarily required at this stage.

1.5 Aims and Objectives

As defined at the project start-up meeting, the aims and objectives of the SWMP are stated below.

1.5.1 Aims

The aim of the SWMP is to establish a long-term action plan to manage surface water. Its findings should also be used to influence future capital investment, drainage maintenance, public engagement and understanding, land-use planning, emergency planning and future developments.

1.5.2 Objectives

In collaboration with project partners, several objectives for the SWMP study were defined as listed below. These were set to address the flood risk situation and local priorities.

1) Develop a clear and common understanding of surface water drainage networks;
2) Understand the probability of flooding and principle flood mechanisms;
3) Quantify the consequences of flooding;
4) Map surface water flood risks;
5) Identify if designation of a Critical Drainage Area (CDA) is required;
6) Identify potential flood risk management measures (including quick win solutions);
7) Engage stakeholders with a role in local flood risk management including the community through the Burscough Flood Action Group; and,
8) Prepare an Action Plan and delivery strategy.

2. Risk Assessment

Given the history of frequent surface water flooding in Burscough, several plans, studies and investigations undertaken by varying authorities and flood groups, which have help to develop a broad understanding of flood sources and potential mechanisms.

In order to build upon the previous work, a detailed risk assessment has been undertaken as part of this SWMP to explore the complex drainage issues to identify and confirm the primary flood mechanisms and locations at risk of surface water flooding.

This detailed risk assessment is informed by existing datasets and information along with the development of a purpose-built 1D-2D integrated hydraulic model used to enhance the understanding of the cause, probability and consequence of surface water flooding.

The findings of the detailed risk assessment help to achieve the following objectives:

- Develop a clear and common understanding of surface water drainage networks;
- Understand the probability of flooding and principle flood mechanisms;
- Quantify the consequences of flooding; and,
- Map surface water flood risks.

2.1 Available Information

To begin any risk assessment, maximum use should be made of existing data and information including previous studies and investigations. Much of this data and information collected by RMAs as part of their specific roles and responsibilities. This was then supplemented by information provided by other stakeholders, including data on surface water drainage assets and local evidence of historical flooding incidents.

Table 4-1 in Appendix A contains a list of key datasets and outlining how these have been used to inform the risk assessment. Table 4-2, also in Appendix A, provides an overview of with key findings and recommendations from previous plans, studies and investigations, including:

- Environment Agency (2009) Alt-Crossens and River Douglas Catchment Flood Management Plans
- West Lancashire Borough Council (2010) Burscough Flood Studies Investigation
- West Lancashire Borough Council (2013) West Lancashire Local Plan 2012 – 2027 Development Plan Document
- Lancashire County Council (2013) West Lancashire Level 1 SWMP
- West Lancashire Borough Council (2015) Yew Tree Farm Final Masterplan Supplementary Planning Document
- Burscough Parish Council (2015) Drainage Assessment Review
- Lancashire County Council (2017) West Lancashire District Flood Report
- Burscough Flooding Group (2017) Burscough Flood Records Report
- United Utilities (2018) Integrated Drainage Areas Strategy Report: Burscough WwTW Drainage Area
- Burscough Parish Council (2019) Burscough Parish Neighbourhood Plan 2017 – 2027

2.1.1 Site Visit

Following the collection of information, a site visit was undertaken on the 22nd November 2018 to ground truth data as well as provide an opportunity to discuss known flooding issues and perceived flood mechanisms at key locations. The site visit was attended by representatives of Lancashire County Council and the Burscough Flood Action Group.

2.2 Flood History

According to several sources of information, Burscough suffers from surface water issues, which frequently result in the flooding of roads and agricultural land. In addition, the area has also experienced several larger rainfall events that have resulted widespread flooding to most vulnerable infrastructure and properties. Those known larger flood events include:

- **2004 –** Internal flooding to 16 properties on Mill Lane[7], with the primary mechanism being cited as surcharging of the public sewer. United Utilities also recorded two internal and six external instances of flooding to properties on Mill Lane.
- **2012 –** Internal flooding to residential property along Crabtree Lane, Moss Lane and New Lane. Seven properties reported internal flooding along Crabtree Lane[7]. The Burscough Flood Group reported that the key flooding mechanisms at Crabtree Lane and Moss Lane are associated with surface water runoff and culvert capacity issues. Whereas surcharging of the public sewer is perceived to be the cause of flooding at New Lane.
- **2015 –** Internal flooding of 23[8] properties resulting from the December 2015 storms with 75[7] properties throughout 2015. Key flooding mechanisms reported by the Burscough Flood Group are associated with surcharging of the public sewer, surface water runoff and culvert capacity issues.
- **2016 –** Reports[7] suggest this is the second most widespread flood event in Burscough with the Burscough Flood Group reporting flooding external flooding at 52 locations, however limited internal flooding is recorded with affected locations including Mill Lane and Gower Gardens. In addition to recording property flooding, the Burscough Flood Group has also provided information relating to highway flooding with Furnival Drive, Mill Lane, Lordsgate Lane, Liverpool Road South and School Lane all being cited as locations which have been subject to flooding.

Historical flood incident data must be taken with a level of caution as different authorities have different mechanisms (and reasons) for collecting and record incidents. Data also relies heavily on residents or business owners reporting incidents and providing quality data for the responsible authority to log and investigate. In some case residents or business owners may not want to report their property has flooded. As seen above, there are some discrepancies in the number of properties affected by internal flooding. This is likely the result of how the two reports have defined "internal"[1] property flooding as well as counting of properties that have flooded more than once (e.g. over a calendar year).

The historical flood data still provides a good overview of higher risk locations, with several instances of flooding occurring along Mill Lane, New Lane and Crabtree Lane reported by multiple data sources. This data is extremely useful when validating hydraulic modelling results as discussed later in this Chapter.

[1] Lancashire County Council define internal flooding as flooding to any habitable space inside a dwelling that is affected by flooding. Flooding garages, gardens, driveways and other are classified as external flooding. This should be taken as the true definition to avoid any ambiguity in the reporting of property flooding.

2.3 Surface Water Drainage Networks

As a key objective of the study, the sub-sections below aim to provide a clear and common understanding of surface water drainage networks and features that would influence surface water flooding in Burscough. This section is primarily driven by existing datasets and ground-truthing undertaken by Lancashire County Council. The understanding of these networks and their connectivity provides the backbone to the 1D-2D integrated hydraulic model discussed later.

Using this information, surface water drainage catchments have also been defined to help illustrate the how different urban and rural areas are connected and potentially interact during normal and flood scenarios. These catchments will also help in the reporting the the1D-2D integrated hydraulic model results and considering the effectiveness of possible interventions and actions.

2.3.1 Topography, geology and land use

As can be seen by the LIDAR data shown in

Figure 1-1, the topography in Burscough is relatively flat. From the junction of the A59 and the A5209 (26mAOD), land generally falls towards Burscough Wastewater Treatment Works (WwTW) to the north west (5mAOD) and School Lane in the north east (10mAOD).

According to Cranfield Soilscapes data[9], soils within Burscough are categorised as naturally wet very acid sandy and loamy that drain to shallow groundwater. The superficial geology is largely comprised of the Shirdley Hill Sand Formation and Till with areas of peat to the north west. According to Superficial Aquifer Designation map[10], the till within Burscough is ‘unproductive’ and the Shirdley Hill Sand is classified as a ‘Secondary A’ aquifer. Bedrock geology within Burscough is comprised of Singleton Mudstone Member and Helsby Sandstone Formation. According to Bedrock Aquifer Designation map[11], approximately 75% of Burscough is underlain by a ‘Principal’ bedrock aquifer and the remaining 25% underlain by a Secondary B aquifer.

Altogether, this data suggests that groundwater levels are likely to be shallow with limited capacity for infiltration and therefore during storm rainfall events, the percentage of surface water runoff from open green space and agricultural land through the central, norther and eastern areas of the catchment is likely to be high.

The urban areas of Burscough include Burscough Junction and Burscough Bridge, which are primarily residential estates. There are also much smaller residential areas of New Lane to the far north east of the study area. Historical OS mapping suggests there has been little change in land use since the 1960s with isolated areas of urban expansion within the centre of the town. The most change during this period was the development of the Burscough Industrial Estate in the 1980s.

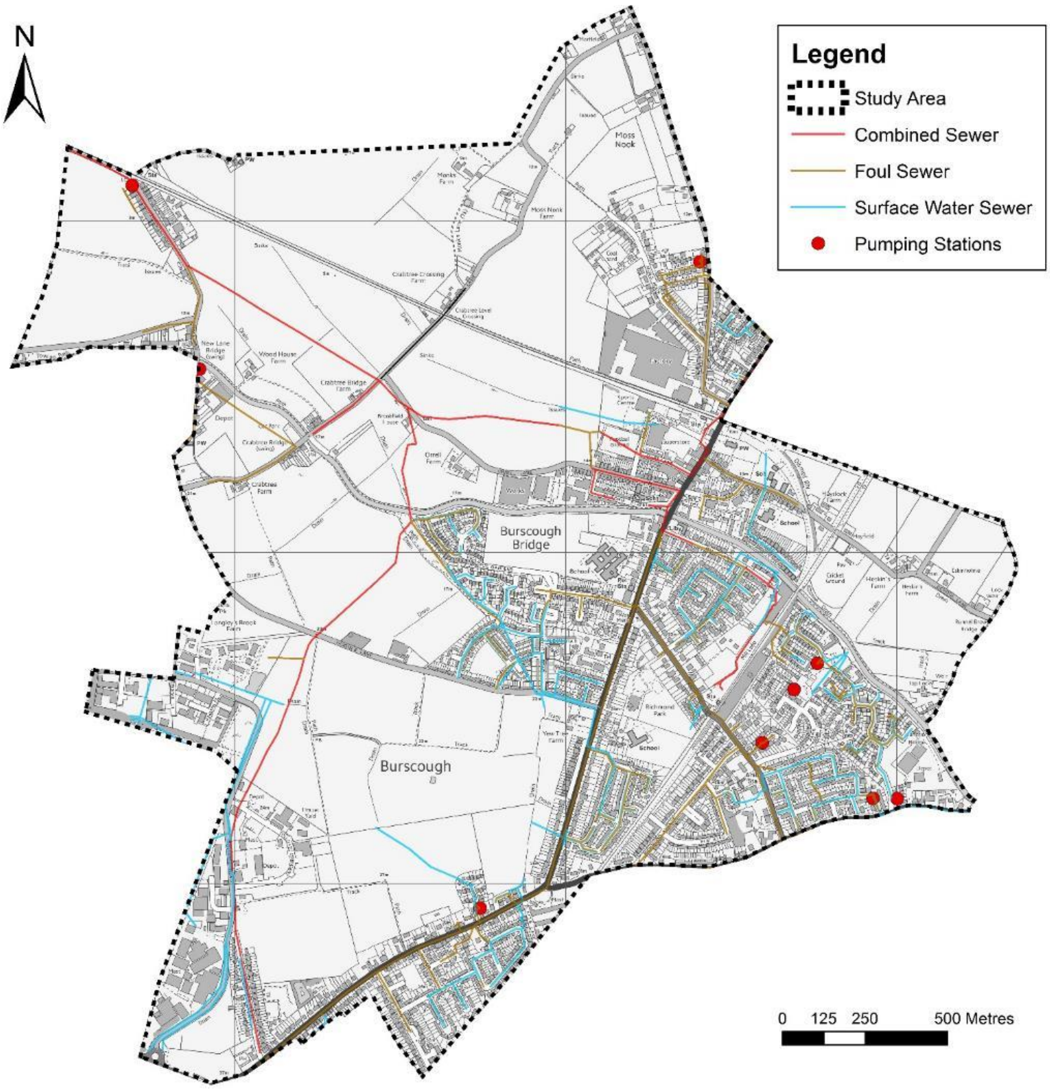
According to the West Lancashire Local Plan (2013)[4], there is new development proposed in Burscough, notably the Yew Tree Farm site. This is a 74-hectare site that lies to the south of Higgins Lane, between the Burscough Industrial Estate and the A59. Over the plan period (to 2027), this site will aim to deliver at least 500 homes and 11ha of new employment, along with roads, open space and community facilities. Some of the site will be safeguarded for future development needs beyond the plan period (2027).

According to the Yew Tree Farm Final Masterplan Supplementary Planning Document (2015)[12], *“Development of the Yew Tree Farm site will not result in surface water being discharged into the public sewerage system and will, in fact draw surface water off the public sewerage system to be attenuated to the local watercourse at greenfield runoff rates to at least the equivalent of foul water being discharged from the site into the public sewerage system.”*

2.3.2 Public sewer network

The urban areas of Burscough is served by a public sewer network owned and maintained by Untied Utilities as the local water and sewerage authority. The public sewer network itself comprises of separate (surface water and foul sewers) and combined sewers. Figure 2-1 illustrates the distribution of these networks across Burscough.

Figure 2-1: United Utilities sewer network assets



The foul and combined sewers ultimately flow towards the Burscough Wastewater Treatment Works (WwTW) located just outside of the study area boundary immediately north west of New Lane. The WwTW also drains the area of a further five separate towns and villages including, Ormskirk, Rufford, Bescar, Shirdley Hill and Hurlston Green.

According to the United Utilities Integrated Drainage Area Strategy (IDAS) report (2018)[13], *"The Burscough WwTW has one main gravity inlet, and a pumped rising main which also feeds into the inlet. The gravity main is connected to Burscough, Ormskirk, Bescar, Shirdley Hill and Hurlston Green and passes under the railway to connect to the treatment works. The pressurised main connects Rufford to the treatment works and pumps directly into the inlet at the works. Spills from the storm tanks drain to the Boathouse Sluice Drain which flows to* *the north of the treatment works. The wastewater network is a combination of both combined and separate systems."*

There are several interconnections with the public sewer network and local Ordinary Watercourses, specifically associated with surface water sewers serving the urban areas discharging to watercourse west of the A59. There are however, one or two instances where watercourses flow into culverts currently classified as surface water sewers. For example, the watercourse that runs through the Yew Tree Farm development and into culvert at Higgin's Lane.

Table 2-1 provides an overview of the primary cause of incidents investigated by United Utilities between 2010 and 2018 as provided by United Utilities. 86% of the incidents recorded were associated with blockages with common causes cited as fats, oils and greases, rags and root ingress. The remaining 14% of incidents were associated with hydraulic performance issues with the network. Of all 511 incidents, only 22 resulted in internal property flooding (20 of which were caused by blockages).

Table 2-1: United Utilities network incidents

Incident type	No. of instances
Blockages	439
causing external flooding	143
causing internal flooding	20
causing no flooding	276
External flooding due to hydraulic performance	70
Internal flooding due to hydraulic performance	2

2.3.3 Watercourses

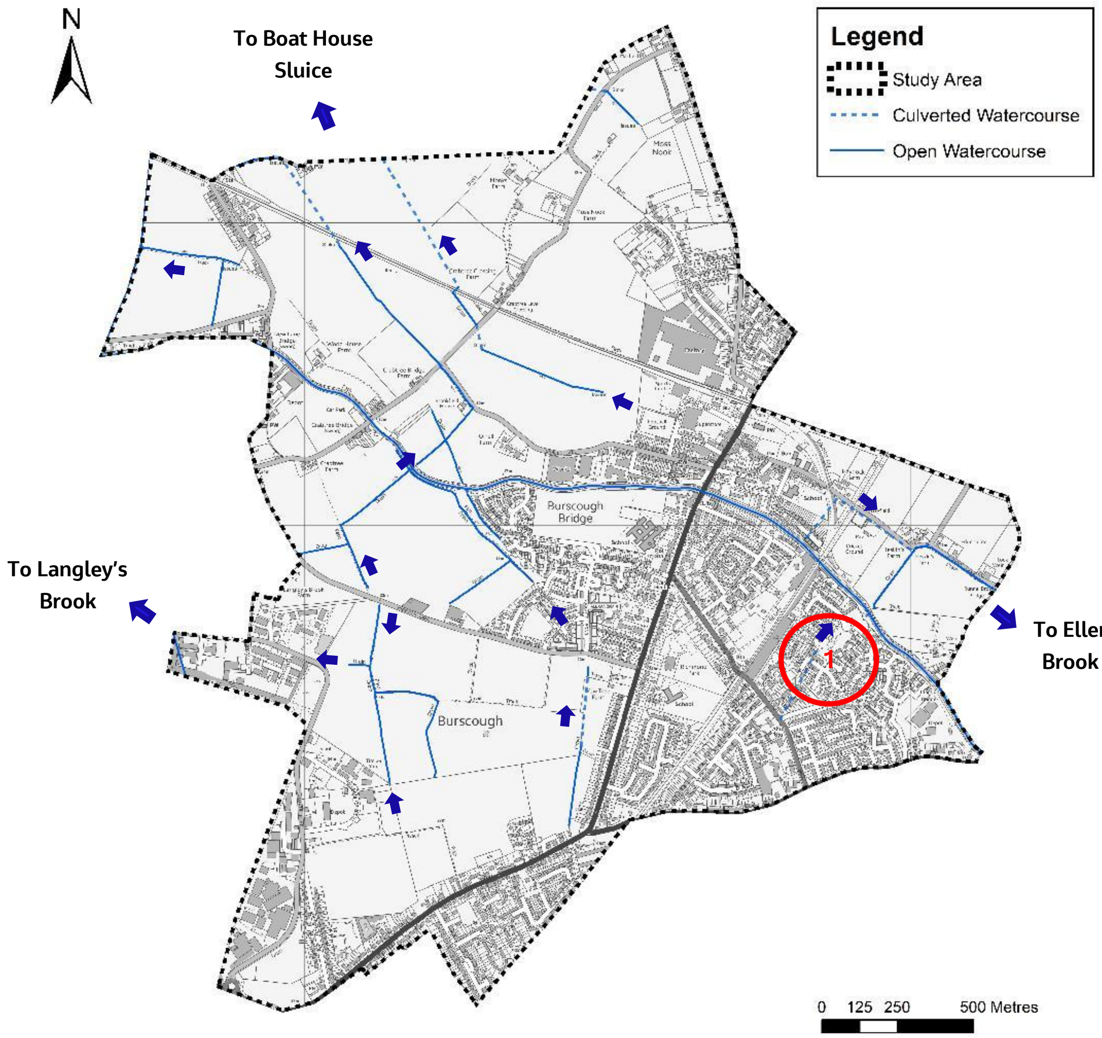
Burscough is situated in two natural catchments; the western half of the study area is located within the Alt-Crossens catchment, whilst much of the eastern half of the study area is located within the River Douglass catchment. Whilst there are no Main Rivers within Burscough, there are several Ordinary Watercourses as shown in Figure 2-2. Those located to the west of the A59 flow in a westerly direction towards Langley's Brook and in a north easterly direction towards Martin Mere. Both ultimately discharge into the Crossens system. Watercourses east of the A59 discharge to Eller Brook within the River Douglas catchment.

To Eller Brook

To the east of the A59, a single culverted Ordinary Watercourse is situated within the study area. This watercourse originates adjacent to School Lane and is fed by the surface water sewer network from the south and a culvert to the west. The watercourse is open until it is culverted beneath the Leeds and Liverpool Canal before flowing in open channel and discharging to Eller Brook east of the study area.

South, of the Leeds and Liverpool Canal, a second culverted watercourse is believed to be present between Alexander Close and Delph Drive (labelled (1) in Figure 2-2). Little information is available on its exact location or size, other than it runs in south west to north east and beneath the Leeds and Liverpool Canal before discharging into the watercourse adjacent to School Lane. Due to the lack of information, this culvert has not been included in the hydraulic model as discussed in Section 2.4.

Figure 2-2: Open watercourses and culverts



To Langley's Brook

Langley's Brook flow through the Burscough Industrial Estate, just outside of the study area. Within the study area, Ordinary Watercourses west of the Yew Tree Farm development site drain surrounding agricultural land and eventually flow west before entering a culvert (classified as a surface water sewer) and joining Langley's Brook underneath the estate. These watercourses are also fed by surface water sewers along the A59 and a small residential catchment surrounding Springfield Close.

It must be noted that the watercourse closest to Higgin's Lane does not flow underneath the road and join the watercourse on the north side of the road. It in fact flows south.

To Boat House Sluice

There are two main Ordinary Watercourses that flow through Burscough towards Martin Mere. The first watercourse originates west of the junction of the A59 and the A5209 immediately north of Platts Lane and is fed by the surface water sewer network serving the urban area surrounding Manor Avenue. As it travels north, the watercourse enters a culvert at Higgin's Lane (classified as surface water sewer), before re-emerging downstream of Hesketh Road. This watercourse eventually flows north west underneath the Leeds and Liverpool Canal, through agricultural land, underneath Crabtree Lane and then the Manchester to Southport Railway and discharges to Boat House Sluice adjacent to the Burscough WwTW on through Martin Mere. Maintenance of Boat House Sluice is the responsibility of the Environment Agency given its classification as a Main River.

The second watercourse originates west of Victoria Park football ground. This watercourse is also fed by surface water sewers serving the urban area around the football ground and the Tesco Superstore. This watercourse flows in a westerly direction and flows under Crabtree Lane. At the Manchester to Southport Railway, the watercourse enters a long culvert underneath agricultural land, before re-emerging downstream of Marsh Moss Lane and through Martin Mere, joining Boat House Sluice.

Alt-Crossens

Alt-Crossens is the name given to a large area of land between the Mersey and the Ribble estuaries, with a good proportion of the low-lying land sitting below sea level. The land is drained via a network of smaller drainage ditches and watercourses, which since the 1920s, has been pumped to sea via a series of pumping stations operated by the Environment Agency. These pumping stations are also used to prevent flooding and protect the large urban populations of North East Liverpool, Maghull, Knowsley, Southport, Formby and Ormskirk.

According to the Alt-Crossens CFMP, the catchment includes the sub-catchment of Martin Mere and the very western boundary of Burscough. Any changes to the management regime at Alt-Crossens is unlikely to impact on flood risk in Burscough due to the difference in elevation with land in Burscough. Two of the lowest elevation locations known to be at risk of flooding, Crabtree Lane level crossing and New Lane, have approximate elevations of 6.6mAOD and 8mAOD respectively, whereas elevation with the Crossens system downstream of the study area range between 0.1mAOD and 2.5mAOD.

2.3.4 Surface water catchments

Since Burscough is served by several interacting surface water drainage networks as introduced in the previous sections, it can be difficult to understand what part of the catchments drains where. This can lead to further misconceptions on the cause and mechanisms of surface water flooding.

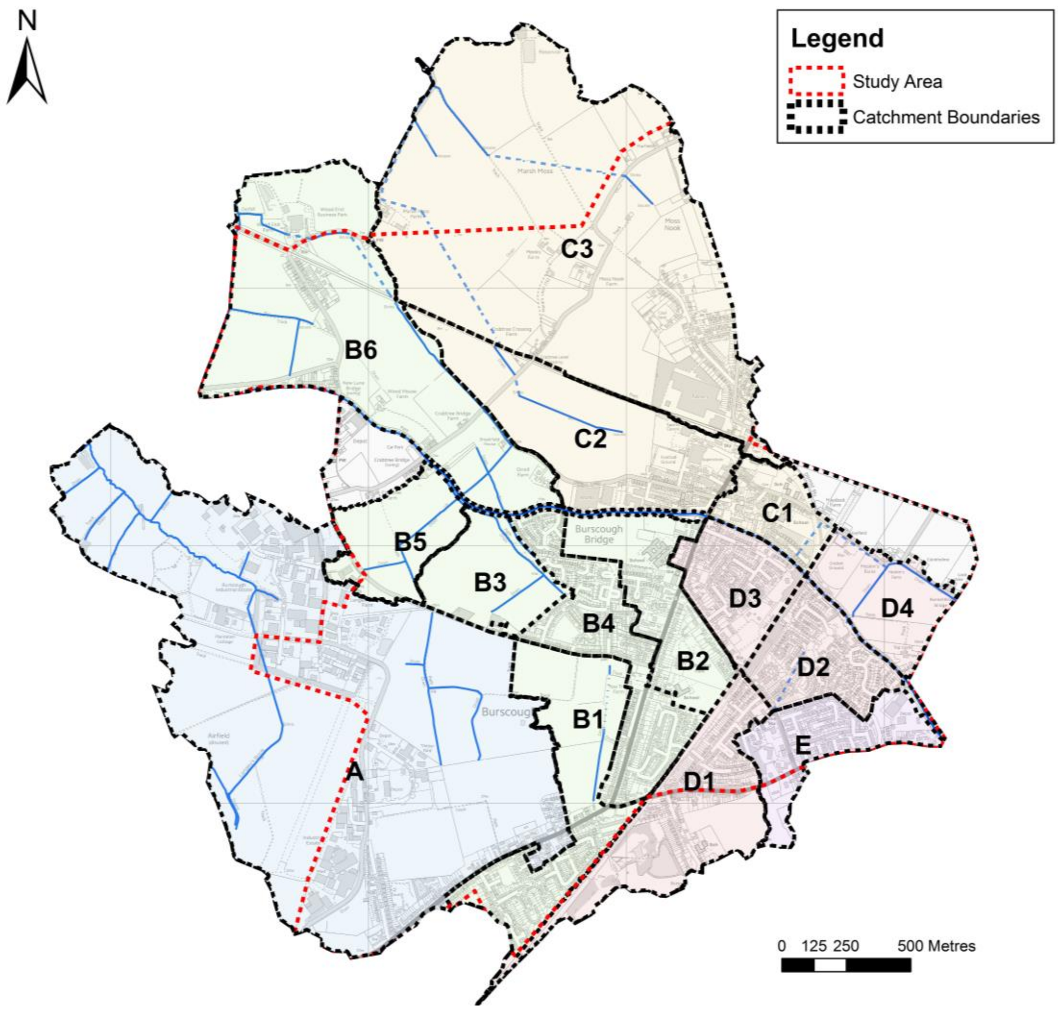
To help overcome this, surface water catchments have been defined as part of this SWMP. To delineate these boundaries, natural surface water runoff catchments were first created using a GIS tools and topographic LIDAR data before overlaying these with watercourses, sewers and other urban drainage networks to undertake manual edits. The final product is a set of distinct drainage catchments and sub-catchments as illustrated in Figure 2-3.

All together that are five principal catchments, Catchment A, B, C, D and E. These are then further sub-divided into several sub-catchments.

- **Catchment A:** This 2km^2 catchment predominantly drains the large rural area east of Tollgate Road but also includes the Burscough Industrial Estate to the west. Ordinary Watercourses in this catchment flow in a westerly direction through the estate before discharging into Langley's Brook.
- **Catchment B:** This catchment is one of the largest catchments (1.98km^2) and runs south to north through the centre of Burscough, essentially following an Ordinary Watercourse and sewers from Yew Tree Farm to the Burscough WwTW. It is however split into by the Leeds and Liverpool Canal.
- **Catchment C:** This 2.01km^2 catchment forms the most northern section of the study area. South of the railway line, the catchment is predominately centred around an Ordinary Watercourse fed by the urban surface water sewer network and flows east to west underneath the railway line near Crabtree Lane before discharging to Martin Mere. North of the railway line, the catchment is predominantly rural with few surface water drainage networks.

- **Catchment D:** This 0.87km^2 catchment serves the urban area east of Burscough between the A59 and the Leeds and Liverpool Canal, most surface water is drained by surface water sewers and a local Ordinary Watercourse that flows north east and discharges into Eller Brook.
- **Catchment E:** This catchment is one of the smallest catchments (0.20km^2), with a separate surface water sewer system serving the residential properties north of the A5209. Surface water is drained in a westerly direction before discharging into Eller Brook immediately south of the Leeds and Liverpool Canal.

Figure 2-3: Surface water drainage catchments



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2.4 Surface Water Flooding Mechanisms

2.4.1 Introduction

To develop a detailed understanding of surface water flooding mechanisms, a purpose-built 1D-2D integrated hydraulic model was developed. Appendix B provides an overview of the hydraulic modelling approach.

The hydraulic model itself uses data provided by United Utilities, Lancashire County Council, and West Lancashire Borough Council to represent the main 1D surface water drainage network (e.g. sewers, watercourses and culverts) and how these interact with the general 2D ground surface (e.g. via gullies, manholes and exceedance flows).

To simulate surface water flooding across the modeled catchment, a direct rainfall approach was adopted by applying a rainfall hyetograph representative of a range of design storm events directly to the 2D surface model.

During a simulated event, the hydraulic model computes the rainfall that would be absorbed through natural infiltration into the ground, the rainfall runoff that would be routed overland by topography and the runoff volume that would drain into and be conveyed through the surface water drainage networks. The overland flow routed through the built environment and the flow conveyed through the drainage systems are dynamically linked at each manhole.

Annual Exceedance Probability Event

This report uses the term annual exceedance probability (AEP) to express flood frequency. This is a better approach when presenting hydraulic model results in comparison to the annual maximum return period. This is due to the misconception that return periods are associated with a regular occurrence rather than an average recurrence interval e.g. the 100-year flood will not only occur every 100-years but has a 1% chance of being exceeded in any year. However, to aid the understanding of flood frequency, the table below provides a comparison of AEP to return periods.

AEP	20%	10%	5%	3.33%	1.33%	1%	0.5%
Return Period	5-year	10-year	20-year	30-year	75-year	100-year	200-year

Appendix C contains a suite of flood maps illustrating the results on the hydraulic model showing the geographical extent of surface water flooding along with flood depths and hazards across the AEP events modelled.

Both the 1D and 2D hydraulic model results were the interrogated to understand the complex flooding mechanisms, such as how each surface water drainage network interacts, the capacity of these networks, how surface water flows over land, and the location of at-risk receptors. Historical flood incident data was also used to validate the hydraulic model results.

The sections below provide a high-level narrative of the key flooding mechanisms through each of the sub-catchments.

2.4.2 Catchment A

Catchment A is a mixed-use catchment, which includes agricultural land to the east and the Burscough Industrial Estate to the west. Surface water sewers and watercourses within the catchment eventually discharge into Langley's Brook through the Burscough Industrial Estate. Hydraulic modelling suggests the key area at risk of flooding within this catchment is Burscough Industrial Estate.

Predictive flood mechanisms

Figure 2-4 shows the results of the hydraulic modelling covering Catchment A. It illustrates both the depth of surface water flooding predicted and the pipe full capacity of the public sewer network and culverted watercourses. It also identifies those manholes modelled where water is entering the network/no change and where water is leaving the network.

According to the hydraulic model results, the primary mechanism of surface water flooding within Catchment A is exceedance flows from Langley's Brook driven by flood flows exceeding the capacity of the culvert under the Burscough Industrial Estate. The capacity of the culvert is shown to be exceeded during the 20% AEP event onwards. Exceedance floodwater then flows at a rate of approximately 1. 43m^3/s through the Burscough Industrial Estate following the line of the culvert, with flood depths reaching approximately 0.55m during the 3.33% AEP event.

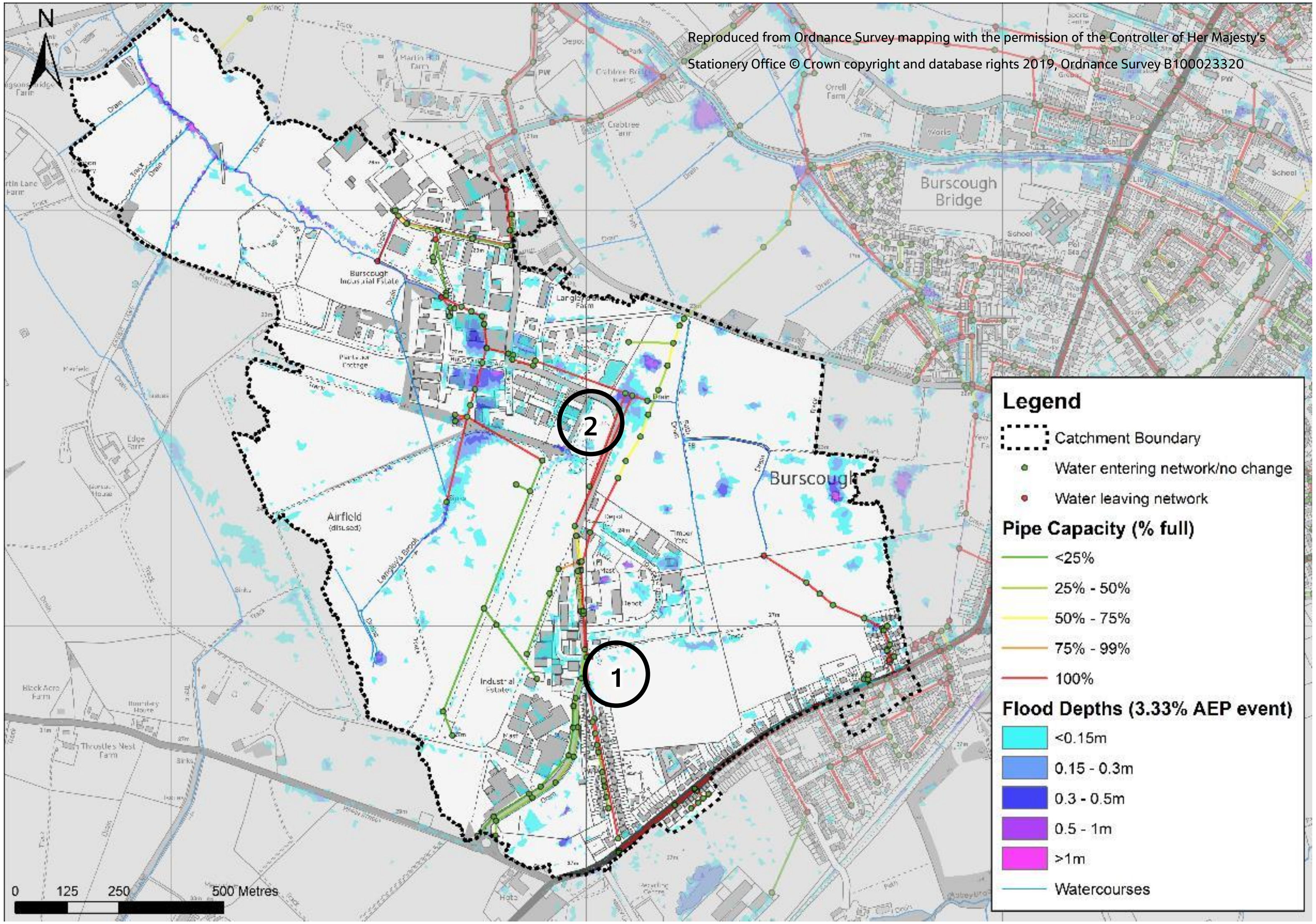
Highway flooding is also observed along Lordsgate Lane. Surface water flooding here is the result of the storm rainfall events exceeding the capacity of the combined sewer network. The model predicts this to occur from the 20% AEP event onwards. Peak overland flows along the highway reach approximately 0.3m^3/s during the 3.33% AEP event with depths reaching approximately 0.25m. Surface water flows along Lordsgate Lane flow north west and ultimately discharge to the most upstream reach of Langley's Brook. These are generally very shallow but can be observed in mapping during larger events.

During the larger 1% AEP event, the flood mechanisms detailed above remain with no new mechanisms identified but the severity of flooding is increased. Many of the surface water and combined sewers are at full capacity during this event but surcharging is limited to Lordsgate Road and two locations within the Burscough Industrial Estate. As can be seen in Appendix C, the Burscough Industrial Estate is the most sensitive location within this catchment to changes in rainfall, with flood extents increasing and affecting much of the industrial estate. However, peak flood depths during the 1% AEP event do not increase significantly when compared to the 3.33% AEP event with peak depths of 0.55m to 0.6m predicted during the 3.33% AEP and 1% AEP event respectively and with peak flows also increasing to 2.45m^3/s.

Historical flood incidents

There are no reported incidents of surface water flooding through the Burscough Industrial Estate to validate the flood mechanisms predicted by the hydraulic model. Incidents have however been recorded along Lordsgate Lane as can be seen in Figure 2-4. During discussions with Lancashire County Council on 14th August 2019, it was reported by the highways team that sewer capacity issues leading to flooding on Lordsgate Lane have been rectified following the recent separation of foul and surface water networks here.

Figure 2-4: Flood depths and sewer network capacity during 3.33% AEP design event



Lordsgate Road (1)

Tollgate Road (2)

2.4.3 Catchment B

Catchment B is divided into six sub-catchments, these predominantly cover agricultural land surrounding an Ordinary Watercourse that runs from Yew Tree Farm to the Burscough WwTW. The Leeds and Liverpool Canal splits the catchment in two. Hydraulic modelling identifies two key flooding areas including the Furnival Drive area and Crabtree Lane level crossing.

Predictive flood mechanisms

Figure 2-5 shows the results of the hydraulic modelling covering Catchment B. It illustrates both the depth of surface water flooding predicted and the pipe full capacity of the public sewer network and culverted watercourses. It also identifies those manholes modelled where water is entering the network/no change and where water is leaving the network.

Upstream of the Leeds and Liverpool Canal, the main areas at risk of surface water flooding to Furnival Drive and New Lane. According to the hydraulic model, the primary source of surface water flooding is the Ordinary Watercourse, which spills out of bank immediately upstream of the Higgin's Lane culvert inlet. Once floodwater leaves the watercourse, it is shown to overtop Higgin's Lane and flood Furnival Drive, with floodwater then following the line of the culvert before re-joining the watercourse downstream of Abbey Fold.

In the residential area surrounding Furnival Drive, the hydraulic model also predicts that the surface water sewer network would become surcharged during the 20% AEP event, with water also leaving the sewer network and spilling onto the road at the junction of Furnival Drive and Truscott Road, and Hesketh Road and Truscott Road, and contributing to the surface water flow path originating from the Ordinary Watercourse upstream Surcharging of the network is potentially driven by a pinch point in the sewer network, with three 225mm sewers coming together into one 225mm sewer at Truscott Road.

The capacity of the culverted watercourse (which the surface water sewers discharge to) is not believed to be an issue, with the hydraulic modelling showing that the culvert has enough capacity up to the 1% AEP rainfall event. During the larger 1% AEP event, these flood mechanisms are repeated; however, with greater flood depths and extents predicted around Furnival Drive with flood depths increasing from 0.34m to 0.46m.

The Ordinary Watercourse then flows underneath the Leeds and Liverpool Canal. According to the hydraulic model results, the culvert underneath the canal does not restrict flow during the 20% AEP event. the capacity of the culvert is exceeded from the 10% AEP event onwards resulting in ponding at the upstream face, this is not predicted to present a risk to property as it is constrained to an area of open green space. During the 20% AEP rainfall event, approximately 0.85m^3/s flows through the culvert. Downstream of the canal near to Brookfield House, the capacity of the channel is exceeded with approximately 0.62m^3/s spilling out of bank and entering the floodplain (Brookfield House is not affected).

According to the hydraulic model, the Ordinary Watercourse culvert, at the junction of Crabtree Lane and Orrell Lane, is a pinch point in the system. The capacity of the culvert is estimated to be approximately 0.74m^3/s. During both the 20% AEP and larger 1% AEP rainfall events, peak flows along the watercourses (0.86m^3/s and 2.08m/s^3 respectively) exceed the capacity of the culvert, resulting in floodwater overtopping Orrell Lane and flooding the highway and agricultural land to the north.

Downstream of Orrell Lane, the Ordinary Watercourse flows towards the Manchester to Southport railway. Before reaching the culvert, the watercourse is predicted to spill out of channel during the 20% AEP rainfall event and onto the floodplain. The topography of the floodplain falls towards the railway, with floodwater eventually pooling against the embankment. Flow at this culvert is restricted to 0.45m^3/s during the 20% AEP event. During the larger 1% AEP rainfall event, the same flood mechanisms occur; however, the floodplain becomes further inundated, with floodwater running back along the railway embankment and joining floodwater from a secondary Ordinary Watercourse in Catchment C (explained further in Section 2.4.4).

Further downstream, immediately west of the New Lane level crossing, the hydraulic model shows that the combined sewer begins to surcharge during the 20% AEP rainfall event. Floodwater also leaves the network here at a peak rate of 0.05m^3/s resulting in water ponding on the southern face of the railway embankment. Floodwater is not shown to affecting properties along New Lane. However, floodwater does extend to the new Lane level crossing with shallow flooding up to 0.09m predicted on the railway during the 20% AEP event. During the larger 1% AEP rainfall event, flooding to the New Lane level crossing increases with depths reaching up to 0.38m.

Burscough Wastewater Treatment Works

The downstream extent of the Ordinary Watercourse, which runs through Catchment B, passes the Burscough WwTW. There are local resident concerns that the condition of the watercourse and its banks in terms of "overgrown" vegetation could increase the risk of flooding further upstream. It should be noted that maintenance of Boathouse Sluice is the Environment Agency given its classification as a Main River.

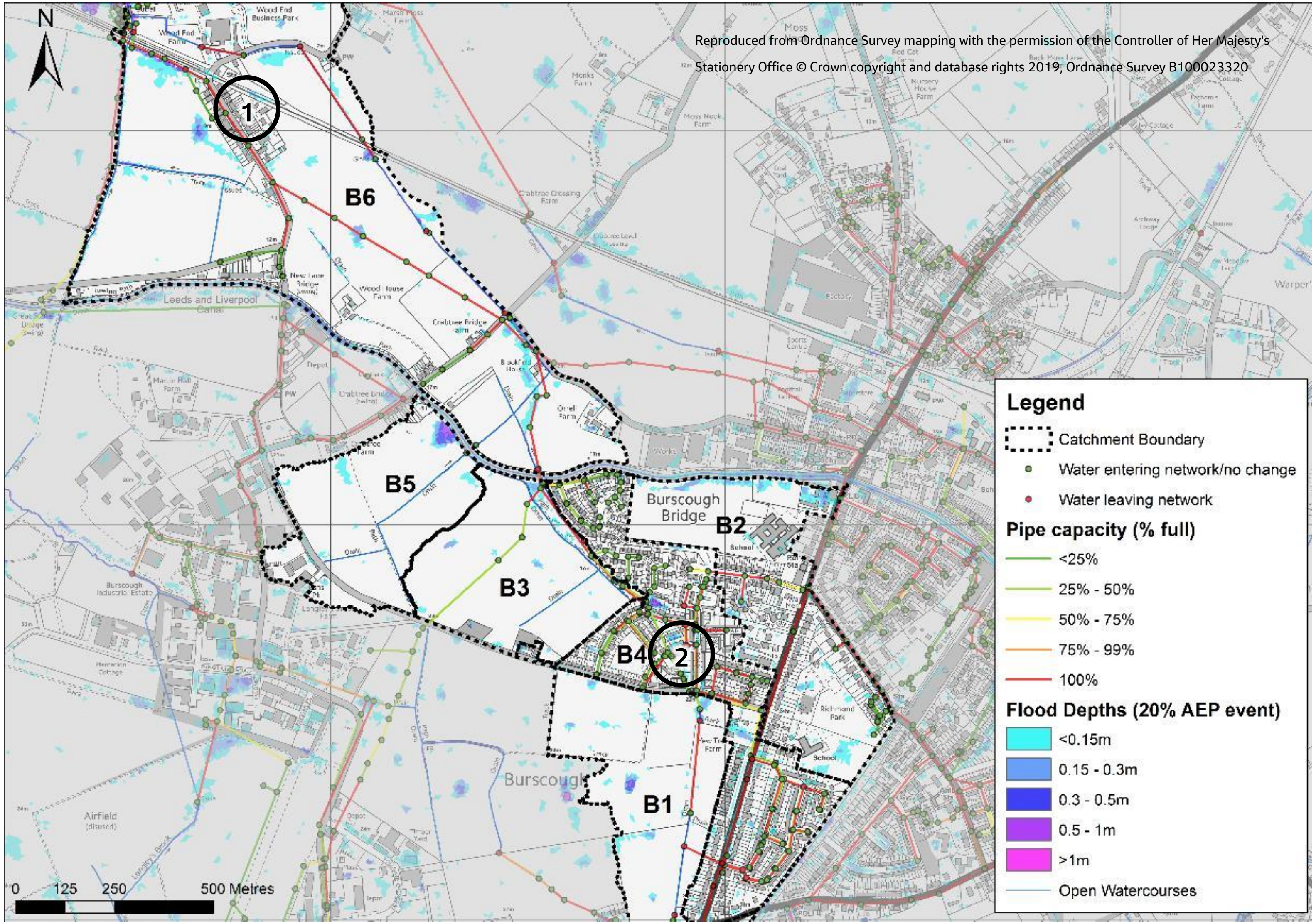
To understand the impact that this section of watercourse has on flood risk, additional hydraulic modelling has been undertaken by representing high levels of channel roughness in the watercourse to slow flood flows. The hydraulic modelling shows that in a worst-case scenario, during a large 1% AEP rainfall event, changes in flood risk is negligible across the study area. Any changes to flood depths are restricted to the land immediately south of the railway (to the west of New Lane). Here, flood extents increase significantly, and flood depths increase by approximately 0.05m. During an intense 1% AEP rainfall event an increase up to 0.21m is predicted. Here, floodwater is contained within the floodplain and does not affect neighbouring properties. Any increase in flood depth also dissipates approximately 100m upstream.

Historical flood incidents

In Catchment B, there is a good correlation between historical flood incident data and the predictive results of the hydraulic model, with internal property flooding recorded along Furnival Drive, Hesketh Road and Higgin's Lane/Truscott Road in 2015. However, during engagement with Lancashire County Council on 14th August 2019, it was reported by the highways team that flooding in this area has since been resolve following clearance work carried out by the highways team.

Modelled flood mechanisms, such as the exceedance of culverts at Crabtree lane and subsequent overland flows through the floodplain towards the railway line have also been reported by the Burscough Flood Group with photographic evidence provided. There is also photographic evidence of New Lane level crossing from the combined network, with manholes running adjacent to the line popping their lids. United Utilities have confirmed this is a result of hydraulic capacity issues at this section on sewer.

Figure 2-5: Flood depths and sewer network capacity during 20% AEP design event



New Lane (1)

Furnival Drive (2)

2.4.4 Catchment C

Catchment C is divided into three sub-catchments including Burscough Bridge, the floodplain south of the railway line and the agricultural land north of the railway line surrounding Marsh Moss.

The primary surface water drainage network in this catchment is an Ordinary Watercourse that flows in a north westerly direction underneath Crabtree Lane and then the railway line before flowing to Martin Mere. The watercourse is fed by surface water sewers serving the urban area of Burscough Bridge. There is also a smaller Ordinary Watercourse flowing in a north westerly direction draining the agricultural land of Marsh Moss.

The hydraulic modelling results identifies Crabtree Lane as the key flood risk location in this catchment.

Predictive flood mechanisms

Figure 2-6 shows the results of the hydraulic modelling covering Catchment C. It illustrates both the depth of surface water flooding predicted and the pipe full capacity of the public sewer network and culverted watercourses. It also identifies those manholes modelled where water is entering the network/no change and where water is leaving the network.

South of the railway line, surface water flooding of Crabtree Lane originates from two flood sources include the Ordinary Watercourse running through Catchment C2 and during extreme rainfall events, exceedance flows from the Ordinary Watercourse that flows through Catchment B6 (as described in Section 2.4.3).

During the 20% AEP rainfall event, peak flows along the Ordinary Watercourse through Catchment C2 reach approximately 0.25m^3/s upstream of the Crabtree Lane. During this event, the hydraulic modelling shows that the Crabtree Lane culvert has a capacity of 0.21m^3/s, resulting in water backing up, pooling at the culvert entrance and eventually overtops Crabtree Lane. Floodwater is then conveyed along the highway to the Crabtree Lane level crossing as well as overtopping the road and entering the floodplain downstream.

Downstream of Crabtree Lane, flood flows are again restricted by the capacity of the culvert under the railway (0.2m^3/s), resulting in the banks of the watercourse overtopping, with floodwater inundating the eastern floodplain between Crabtree Lane and the railway line. As previously discussed in Section 2.4.3, during extreme rainfall events greater than the 20% AEP event, the Ordinary Watercourse running through Catchment B6 also begins to interact with this catchment, with floodwater inundating the floodplain and flowing towards the railway line. Here floodwater from both watercourses inundate the floodplain. Once flood depths exceed 1.01m during the 1.33% AEP rainfall event, a nearby residential property becomes at risk of flooding.

North of the railway line, surface water flooding of Crabtree Lane originates from direct runoff originating within agricultural land between Crabtree Lane and Moss Nook/Red Cat Lane. As can be seen in Figure 2-6, an overland flow path emerges on the north side of the railway embankment. During the 20% AEP rainfall event, approximately 0.26m^3/s of flow is recorded by the hydraulic model, which flows towards Crabtree Lane, overtopping the road and flooding properties. Flood depths reach approximately 0.27m adjacent to property. During the large 1% AEP rainfall event, peak flood depths marginally increase to 0.34m as a result of overland flows increasing to approximately 0.77m^3/s.

Outside of the main flood risk area, the hydraulic modelling also identifies surface water flooding to Red Cat Lane. This is due to runoff from the agricultural fields to the east running onto the highway during larger rainfall events. Floodwater is shown to remain largely within the highway, with flood depths reaching approximately 0.15m during the 20% AEP rainfall event, increasing to approximately 0.31m during the 1% AEP event. Surface water flooding is also predicted around Burscough Bridge, with surface water ponding along School Lane underneath the disused rail line with flood depths reaching up to 0.36m during the 20% AEP rainfall event, increasing to 0.44m during the 1% AEP event.

Ordinary Watercourse Culverts

The hydraulic modelling has identified two Ordinary Watercourse culverts at Crabtree Lane and at the railway embankment crossing immediately west of Crabtree Lane, which during storm rainfall events restrict peak flood flows. The resulting inundation of the floodplain is not a problem until depths reach over 1m (expected from the 1.33% AEP event onwards) and place a nearby residential property at risk.

To understand the potential future benefits of upsizing both these culverts, further hydraulic modelling has been undertaken. By increasing the size of the culverts, flood depths along Crabtree Lane could be reduced from 0.93m to 0.51m adjacent to the residential property at risk

Hydraulic modelling suggests that if the capacity of these two culverts was increased, the onset of flooding to property south of the Crabtree Lane level crossing would be reduced to the 1% AEP event. Flooding to the west of Crabtree Lane would also be far less significant, with peak flood depths decreasing from 0.93m to 0.51m adjacent to the property at risk. At the property itself, peak flood depths during the 1% AEP event are predicted to decrease from 0.21m to 0.002m. The same reduction is not reflected to the east of Crabtree Lane with peak flood depths decreasing from 0.82m to 0.78m during the 1% AEP event.

Further hydraulic modelling has also been undertaken to assess the impacts of culvert blockages. A scenario in which there is a 75% blockage of all culverts, results in a reduction in flood depths during the 1% AEP event with depths decreasing from 0.93m to 0.82m. East of Crabtree Lane, again this is not reflected with peak flood depths decreasing from 0.82m to 0.81m. The reduction in flood depth when all culverts across the study have a blockage of 75% is likely due to flow being held upstream of the canal leading to a reduction in flood depths within the floodplain around Crabtree Lane.

Historical flood incidents

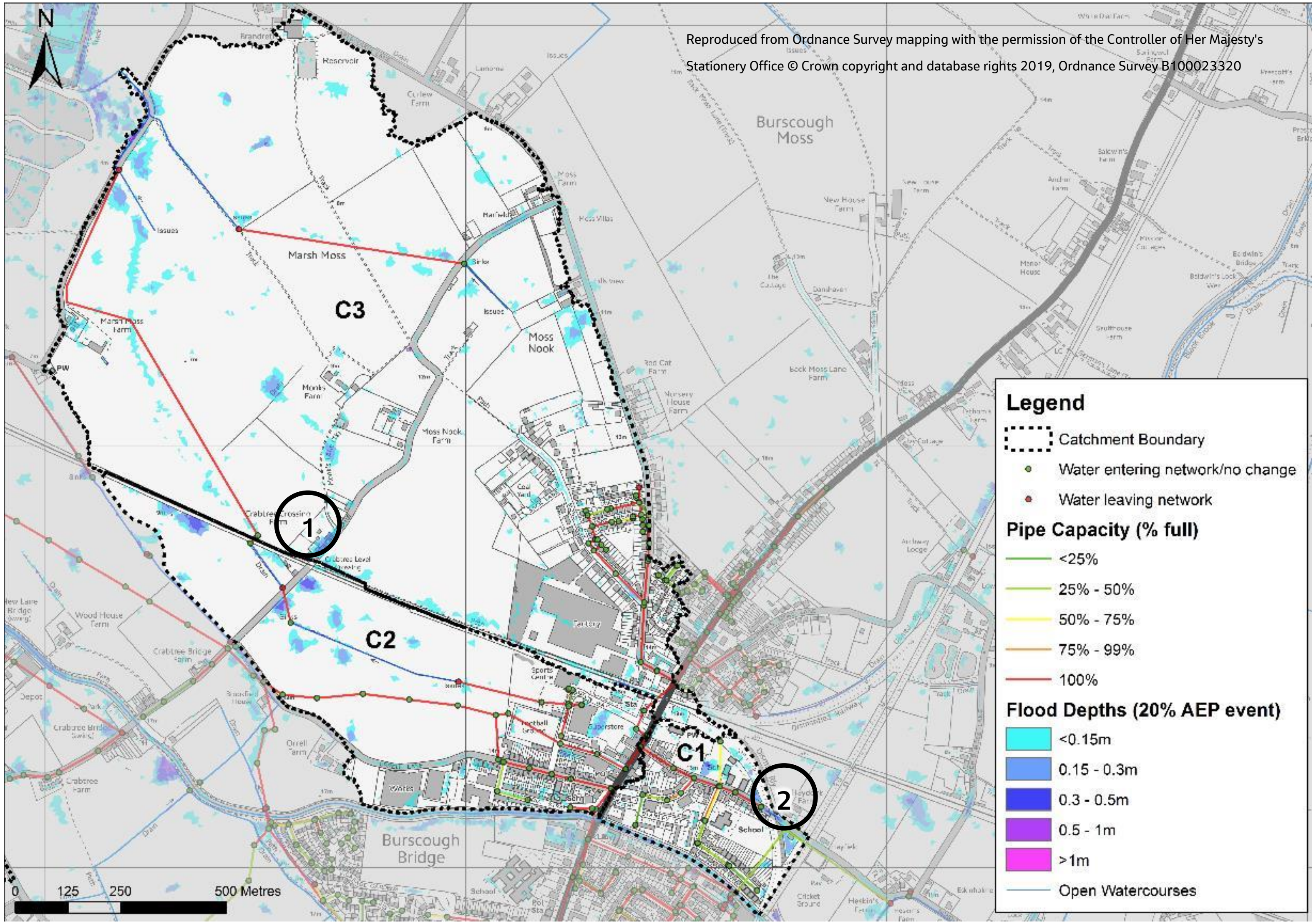
The hydraulic modelling results are well supported by recorded historical incidents of flooding in this catchment, with residential properties along Crabtree Lane (north of the railway line) suffering from frequent flooding. Many of the properties flooded have experienced internal flooding more than once over the past 7 years. External flooding of the properties has however occurred yearly since 2008.

The hydraulic modelling suggests that the main surface water flood mechanism north of the railway is runoff from agricultural land rather than exceedance flows from the Ordinary Watercourse (and culvert restrictions) south of the railway line.

However, it must be noted that the local highway drainage along Crabtree Lane, linking the north with the south sections of the road, has not been represented within the hydraulic model due to lack of survey data required to represent the piped system. Whilst this network could provide an ingress route from south to north of the railway line, it’s not believed to be the primary mechanism of flooding. There are known condition issues relating to this highway drainage network.

In addition, there is a known history of surface water flooding on School Lane with one instance of internal flooding reported by the Flood Action Group. This is noted by the Flood Action Group to be driven by surcharging of the sewer network at School Lane. However, surcharging of the sewer is not identified in the model (Figure 2-6).

Figure 2-6: Flood depths and sewer network capacity during the 20% AEP design event



Crabtree Lane (1)

School Lane (2)

2.4.5 Catchment D and E

Both Catchment D and Catchment E cover the largely urban area of Burscough Bridge. Catchment D is predominantly served by a separated sewer system, with surface water sewers discharging into a culverted watercourse, which eventually discharged to Eller Brook. Catchment E is also served by a separated sewer system, with surface water sewers flowing in a westerly direction before discharging to Eller Brook.

Predictive flood mechanisms

Figure 2.7 shows the results of the hydraulic modelling covering Catchments D and E. It illustrates both the depth of surface water flooding predicted and the pipe full capacity of the public sewer network and culverted watercourses. It also identifies those manholes modelled where water is entering the network/no change and where water is leaving the network.

The primary mechanism of surface water flooding in Catchment D and Catchment E is storm rainfall events overloading the capacity of the urban drainage network, resulting in surcharging manholes and minor overland flows paths and ponding of floodwater in topographic depressions.

According to the hydraulic modelling results across both catchments, the sewers become overloaded during the 5% AEP rainfall event. However, some networks are shown to become overloaded during the more frequent 20% AEP rainfall event, including surface water sewers serving Glenroyd Drive, combined and foul sewers along Mill Lane (Catchment D3) and surface water sewers along Abbey Dale and Ellerbrook Drive (Catchment E). Surface water sewers within the Delph Drive area have enough capacity to take on further water through all events modelled.

During the 20% AEP rainfall event, overland flows paths being to emerge along Mill Lane and Glenroyd Drive, reaching approximately 0.1m^3/s and 0.23m^3/s respectively. During the 5% AEP rainfall event, these can increase to 0.18m^3/s and 0.44m^3/s respectively. Surface water then begins to pond at the corner of Mill Lane adjacent to Ainscough Mill, placing surrounding properties at risk of flooding.

The hydraulic modelling also predicts a noticeable overland flow path emerging from Junction Lane, behind properties of Alexander Close and through the open green space toward the roundabout on Delph Drive. Peak overland flows are shown to reach 0.59m^3/s during the 5% AEP rainfall event. As mentioned in Section 2.3.3, there remains a data gaps regarding the exact location and size of a culverted watercourse at this located. Therefore, there is a potential that the hydraulic model maybe overpredicted the amount of surface water flooding shown, which would support the lack of historical flood incidents in this location.

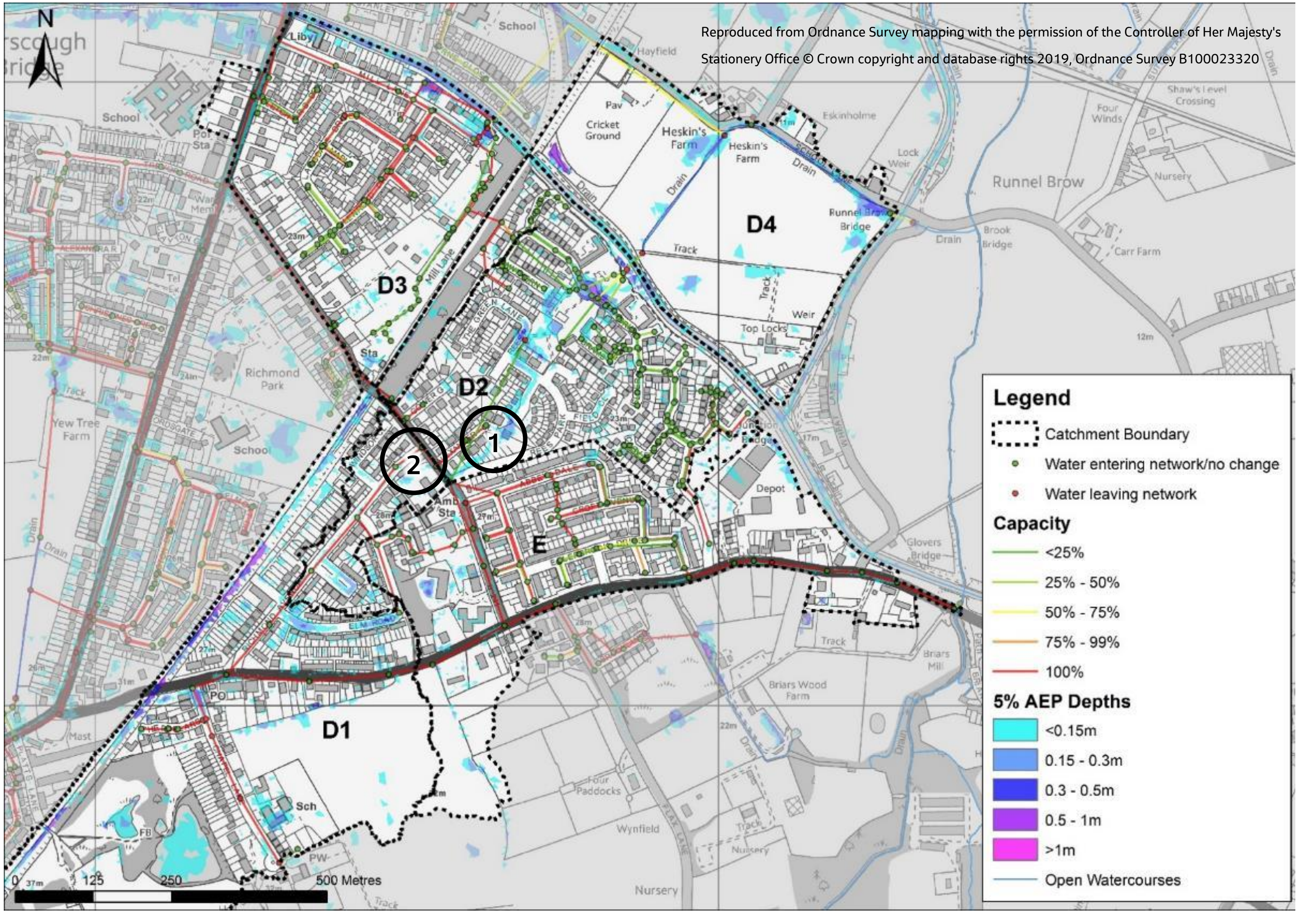
During the 1% AEP rainfall event, there is no significant changes in flood risk predicted. The sewers which are overloaded, largely remain the same as during the 5% AEP event and flood depths and extents largely remain consistent. Peak flood depths at the key risk area at the bottom of Mill Lane increase from 0.52m in the 5% AEP event to 0.56m in the 1% AEP event reflecting the general trend in this catchment that little change in risk occurs during greater magnitude rainfall events.

Historical flood incidents

Historical flood incident data supports the hydraulic model results in Catchment D3 around Mill Lane, with properties suffering from internal flooding adjacent to Ainscough Mill. United Utilities have reported that the cause of flooding from the combined and foul sewers in this area has been investigated and property level protection has been provided to those properties identified as being most at risk.

The sewer network on Alexander Close is known to surcharge and result in flooding to the highway. Whilst hydraulic modelling supports this, photographic evidence (see picture 1 accompanying Figure 2-8) shows potentially greater flooding than the model.

Figure 2.7: Flood depths and sewer network capacity during the 5% AEP design event



Alexander Close (1)

Junction Lane (2)

2.4.6 Climate Change

According to the latest climate change projections (UKCP18[14]), the UK's weather is expected to become hotter and dryer in Summer and warmer and wetter in Winter. Whilst rainfall patterns across the UK are not uniform and vary on seasonal and regional scales and will continue to vary in the future, extreme events, such as storm rainfall events investigated as part of this SWMP, could become more frequent and extreme during both Summer and Winter.

To assess the potential impacts of climate change on surface water flooding, further hydraulic modelling has been undertaken across a range of design rainfall events and in line with the current Environment Agency's climate change guidance[15], peak rainfall has been uplifted by 30% to represent this potential change in extreme rainfall. The 30% uplift has been chosen to best reflect Environment Agency Guidance[16] which recommends both a 'Central' (20%) and 'Upper end' (40%) allowance is applied, this goes beyond the scope of this study and so the centre of this range has been chosen to represent what change in rainfall might be expected to be seen in Burscough.

Appendix C contains a suite of flood maps illustrating the difference in extent of surface water flooding during these climate change scenarios. As can be seen from analysing these maps, there are several locations within Burscough where flood extents are predicated to increase due to climate change, particularly within the floodplain on the south side of the railway embankment at Crabtree Lane level crossing. Here, peak flood depths are also predicated to increase from 0.4m to 0.68m during the 3.33% AEP rainfall event.

In comparison, in higher risk urban areas such as Furnival Drive, peak flood depths are only predicted to increase from 0.19m to 0.23m as a result of climate change during the 3.33% AEP rainfall event and Mill Lane increase from 0.51m to 0.54m.

During larger magnitude events this trend remains the same with changes in flood depths and extents being more significant with rural catchments and floodplain than within the urban upstream locations. Depths within the floodplain such as at and around Crabtree Lane sees an increase from 0.78m to 1.03m whereas Furnival Drive sees and increase in flood depth from 0.37m to 0.42m.

The general trend in Burscough is that the urban catchments are not sensitive to the impacts of climate change of peak flood depths and extents; however, greater extents and depths are predicted within the floodplain.

2.5 Surface Water Flooding Consequence

2.5.1 Quantifying flood risk

To quantify the consequence of surface water flooding, it is possible to estimate the number of residential and non-residential properties at risk, as well as the resulting economic damages incurred should those properties flood internally. Appendix D contains information on the methodology adopted to estimate properties at risk and resulting economic damages, with detailed results provided at sub-catchment level. An overview of the results ae provided below.

2.5.2 Receptors at Risk

Table 2-2 contains the total number of residential and non-residential properties at risk of internal surface water flooding during a range of storm rainfall events simulated using the hydraulic model.

As per Lancashire County Council's Flood Investigation Policy, internal flooding is defined as *"any habitable space inside a dwelling that is affected by flooding"*. Without detailed property level information such as property thresholds and those properties with habitable basements, it is assumed that internal flooding of residential properties will only occur once flood depths exceed 0.15m. As non-residential properties generally don't have a raised threshold, a lower flood depth threshold on 0.00m has been assumed, so floodwater of any depth is assumed can enter shops and other businesses.

Table 2-2: Number of properties at risk of internal flooding by onset (and total per event)

Storm Rainfall Event	Residential	Non-Residential
20% AEP	13 (13)	23 (23)
10% AEP	3 (16)	3 (26)
5% AEP	5 (21)	4 (30)
3.33% AEP	4 (25)	6 (36)
1.33% AEP	12 (37)	8 (44)
1% AEP	3 (40)	4 (48)
0.5% AEP	9 (49)	2 (50)
Total	**49**	**50**

As shown in Table 2-2, 49 residential and 50 non-residential properties are identified as being at risk of internal flooding from surface water. The hydraulic modelling has however identified an additional 239 properties, both residential and non-residential, to be at risk of external flooding.

2.5.3 Infrastructure at risk

In addition to properties at risk, the hydraulic modelling results can be used to identify infrastructure at risk of surface water flooding. At risk infrastructure includes:

- **Electricity Substations:** three electrical substations are identified at risk of flooding during 20% AEP rainfall event, at the A59 Lordsgate Lane and Green Lane. A further substation is found to be at risk during the larger 1% AEP rainfall event located off Ringtail Road;
- **Roads:** whilst shallow surface water flooding of the road network in Burscough is frequent, roads at greatest risk include the A59, Furnival Drive, Delph Drive and School Lane. According to the hydraulic modelling, flood depths can reach between 0.1m on the A59 and 0.37m on School Lane during the 20% AEP rainfall event; and
- **Railways:** sections of the Manchester to Southport railway line are at risk of surface water flooding including New Lane level crossing and Burscough Bridge and the track adjacent to Richmond Park. According to the hydraulic modelling results, flood depths can reach up to 0.12m, 0.5m and 0.67m respectively during the 20% AEP rainfall event. This is supported by historical flood incident data provided.

2.5.4 Economic Flood Damages

The consequence of flooding in monetary terms is estimated through the calculation of Present Value (PV) Damages. Total PV Damages cover:

- Direct damages resulting from floodwater inundation into properties;
- Indirect damages, such as the cost of the emergency response, providing temporary accommodation, and the loss of personal items; and
- Intangible damages including the health impacts of flooding.

The calculation of total PV Damages has been undertaken over a 100-year appraisal period using standardised guidelines and figures, provided in the Environment Agency's Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG)[17], and the Middlesex University's Flood Hazard Research Centre's Multi-Coloured Manual (MCM)[18].

Table 2-3 contains the total PV damages calculated, whilst Figure 2.8 illustrates the distribution of the total PV Damages across the study area. Appendix D provides a full breakdown of PV damages across each sub-catchment.

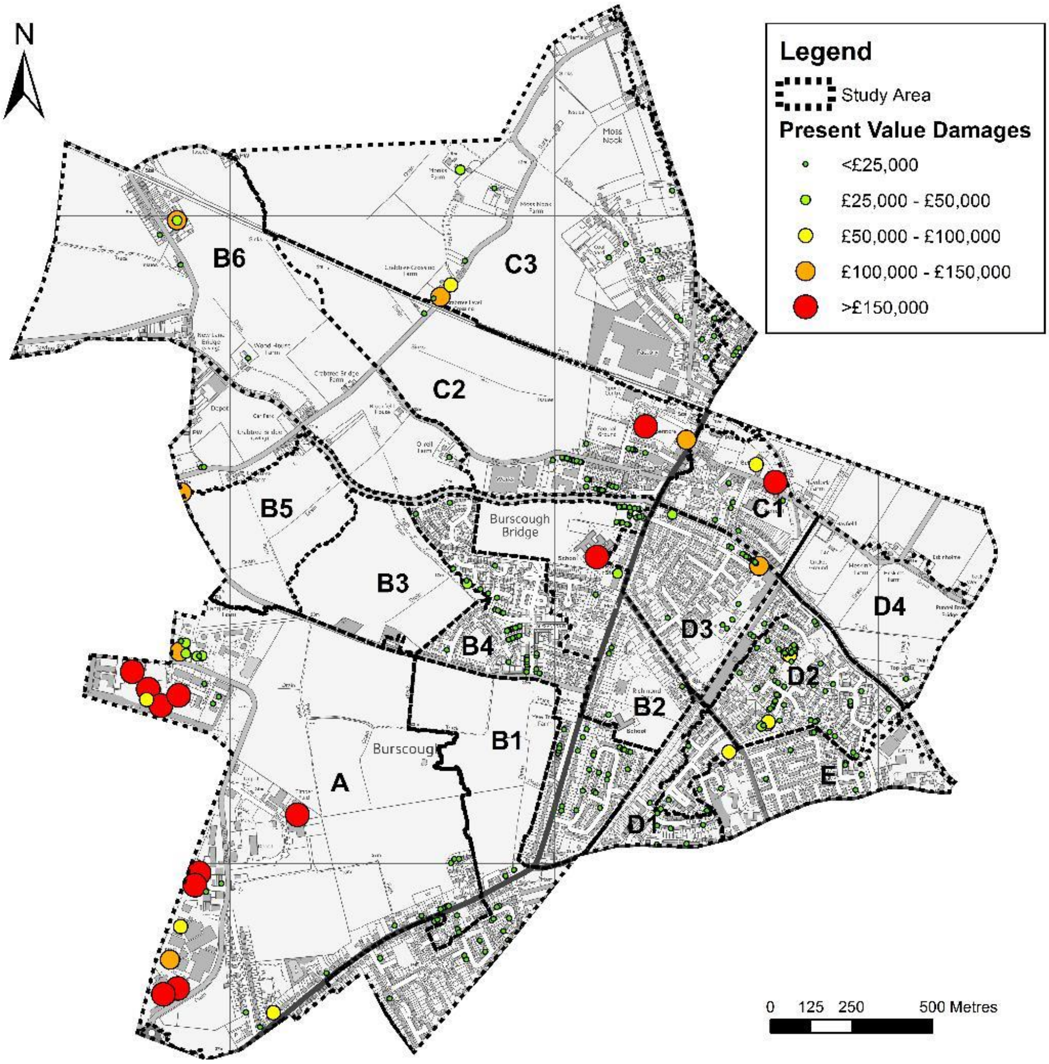
Table 2-3: Breakdown of PV damages

Property Type	Internally Flooded Property	Externally Flooded Property	Total
Residential PV damages			
Direct residential damages (capped)	£1,268	£1,890k	£3,158k
Vehicle damages	£11k	-	£11k
Emergency services costs	£88	£125k	£213k
Evacuation/ temporary accommodation costs	£203k	£3k	£206k
Total	**£1,570k**	**£2,018k**	**£3,588k**
Average	£32k	£9k	£13k
Non-residential PV damages			
Direct non-residential damages (capped)	£5,664k	£15k	£5,679k
Indirect damages	£186k	£0.4k	£186k
Emergency services costs	£347k	£0.4k	£347k
Total	**£6,197k**	**£16k**	**£6,212k**
Average	£124k	£15k	£124
Grand Total	**£7,767k**	**£2,034**	**£9,801**

On further inspection of the economic PV damage analysis, it can be found that:

- Properties at risk are well distributed across the study area (see Figure 2.8). This is generally a result of widespread, but shallow surface water flooding, with limited number of properties at risk of internal flooding.
- Of the residential properties at risk, ten properties account for approximately £1,013k of the PV damages, generally located along Crabtree Lane, Mill Lane and Alexander Close. This is driven by the high frequency and depth of flooded predicted. In total, five residential properties incur PV damages greater than £100k, with two flats on Mill Lane having damages capped at the assumed value of the property.
- Properties at risk of external flooding have also been shown to incur damages. This is associated with the direct damage of £2,034k along with indirect damages and costs associated with emergency services. The average PV damages of these properties is extremely low, but due to the total number of properties at risk of external flooding (239), cumulatively, the total PV damages are high.
- Properties at risk within the Burscough Industrial Estate contribute to approximately 43% of total PV damages. However, no historical flood incident data has been provided to validate the hydraulic modelling results in this area.

Figure 2.8: Distribution of economic damages



2.5.5 Flood hazards

In addition to economic flood damages, the consequence of surface water flooding can also be considered in the risk (or hazard) posed to people. According to the Defra Flood Risks to People Guidance Document[19], flood hazard *"describes the flood conditions in which people are likely to be swept over or drown in a flood, and is the combination of flood depths, velocity and the presence of debris"*. The consideration of flood hazards within the urban environments can be important in truly understand the level of risk posed by storm rainfall events.

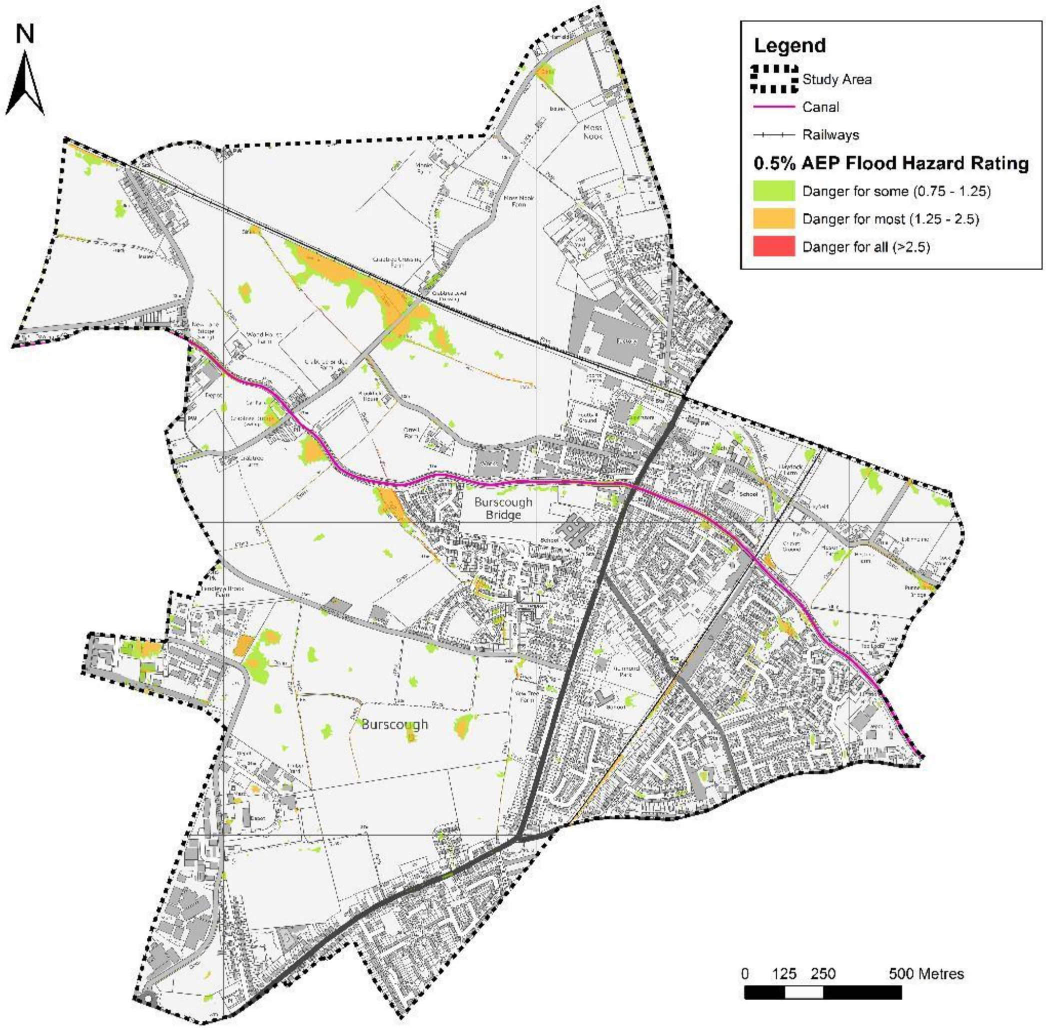
The Defra guidance documents classify four hazard classifications[20] as outlined in Table 2-4. Figure 2-9 illustrates the distribution of flood hazard during the 0.5% AEP rainfall event. On further inspection of the flood hazard analysis, it can be found that:

- Due to the flat nature of the local topography, flood velocities are generally low, resulting in a greater risk of shallow flowing water or deep standing water.
- Flood hazard is greatest where floodwater becomes obstructed by transport infrastructure embankments such as the floodplain south of the railway at Crabtree Lane level crossing and as Ordinary Watercourse travel underneath the canal.

Table 2-4: Flood hazard classification

Degree of Flood Hazard	Description
Low	Caution – *"Flood zone with shallow flowing water or deep standing water"*
Moderate	Danger for some (i.e. children) – *"Danger: Flood zone with deep or fast flowing water"*
Significant	Danger for most – *"Danger: flood zone with deep and fast flowing water"*
Extreme	Danger for all – *"Extreme danger: flood zone with deep fast flowing water"*

Figure 2-9: Flood hazard during a 0.5% AEP rainfall event



2.6 Summary

The hydraulic modelling shows that across a range of storm rainfall (AEP) events, Burscough is susceptible to widespread, but shallow surface water flooding. However, there are several locations where both the frequency, depth or velocity of flooding can be significant.

There are five main surface water sub-catchments. During a storm rainfall event, the urban surface water drainage networks become overloaded due to amount of rainfall and relatively flat topography. Through residential sub-catchments east of the A59, such as Catchments D2 (Junction Lane), D3 (Mill Lane) and E (Ellerbrook Drive), surface water sewers begin to surcharge during the 5% AEP rainfall event, primarily resulting in shallow flooding to the highway, with properties off Mill Lane at greatest risk of deeper internal flooding.

Surface water flooding in Catchment B and C are associated with local Ordinary Watercourses, which drain the residential areas of Catchments B1 (Rivington Drive), B4 (Furnival Drive) and C1 (Burscough Bridge), and agricultural land surrounding the Yew Tree Farm development site and land east of Crabtree Lane.

During a storm rainfall event, key culverts (Crabtree Lane and the railway culvert) are shown to surcharge during the 20% AEP event, causing water to backup and inundate the natural floodplain. Whilst the floodplain provides necessary flood storage downstream of the main urban catchment, residential properties located in or adjacent to the floodplain along Crabtree Lane are at greatest risk of frequent flooding. Enlarging these culverts has been shown to only benefit those properties along Crabtree Lane, with little to no benefit further upstream.

Properties along Crabtree Lane north of the railway line are at greatest risk of surface water flooding in Burscough. This is due surface water runoff from agricultural producing a major surface water flow path running along the northern embankment of the railway and flooding Crabtree Lane. Hydraulic modelling shows that Ordinary Watercourses south of the railway have little impact north of the railway.

239 properties are at risk of external surface water flooding in Burscough. This supports the conclusions made above that there is generally a widespread risk of shallow surface water flooding. There are however, 99 properties (49 residential and 50 non-residential) at risk of internal flooding resulting in total PV damages of £7,767k over a 100-year appraisal period. £1,570k of which is associated with 49 residential properties.

3. Options

3.1 Introduction

This section of the report discusses how surface water flooding within Burscough could be managed in the future, with those suitable and deliverable measures taken forward into the SWMP Action Plan found in Appendix E.

The measures identified have been informed by local knowledge of the catchment, the perceived understanding of flooding mechanism, historical flood records and the location of at-risk properties. Their suitability and deliverability have also been informed by other social, political and economic factors such as costs, funding, landownership, environmental constraints etc. These measures were also discussed at a SWMP Workshop with key RMAs with a role and responsibility in managing flood risk within Burscough.

3.2 RMA Roles and Responsibilities

To understand the measures that have been considered, it is important to understand firstly the roles and responsibilities of the various RMAs. The Flood and Water Management Act 2010[1] defines the role of each RMA and their responsibilities for managing flooding in the UK. RMAs have powers and duties to manage the different forms for flooding that can occur. Those relevant to Burscough are discussed in further detail below.

3.2.1 Lancashire County Council

Lead Local Flood Authority

As LLFA, the Council has several duties and powers as laid out under the Act. They lead in managing local flood risks (i.e. risks of flooding from surface water, groundwater and Ordinary Watercourses). This includes ensuring co-operation between the RMAs in their area. Under the Act, LLFAs are required to:

- Develop, maintain, apply and monitor a strategy for local flood risk management in its area;
- Investigate significant local flooding incidents and publish the results of such investigations;
- Develop and maintain a register of structures or features that might impact on flood risk; and
- Manage the consenting process for works that are likely to affect the flow characteristics of Ordinary Watercourses.

LLFAs also have powers to:

- Undertake works for managing flood risk from surface run-off or groundwater;
- Designate structures and features that affect flooding or coastal erosion; and
- Take enforcement action where there is an obstruction to an Ordinary Watercourse.

Highways Authority

The Council also holds the position as the local highway authority and under the Highways Act 1980 has a duty to maintain highways that are maintainable at public expense. This includes responsibility for highway drainage, as well as for the condition and safety of all highway assets including bridges and culverts.

3.2.2 West Lancashire Borough Council

West Lancashire Borough Council as RMA is a key partner in planning local flood risk management. They have a duty to:

- Exercise their flood risk management functions in a manner consistent with local and national strategies, and to have regard to those strategies in their other functions; and

- To co-operate with other relevant authorities in the exercise of flood risk management functions, which may include the sharing of information with other relevant authorities.

They also have powers to:

- Designate structures and features that affect flooding or coastal erosion; and
- Do works on Ordinary Watercourses.

3.2.3 United Utilities

Under Section 94 of the Water Industry Act 1991, United Utilities as the water and sewerage company serving Burscough, have a duty as sewage undertaker, to provide and maintain sewers for the drainage of buildings and associated paved areas within property boundaries. They are also responsible for transferred sewers under the 'Transfer of Private Sewer Regulations 2011' and lateral drains, which communicate with the public sewers.

With regards to local flood risk management, under the Flood and Water Management Act 2010[1], they have a duty to manage the risk of flooding to water supply and sewerage facilities and flooding which is directly caused by its assets (i.e. water or sewerage pipes). They also must maintain a register of properties that have flooded due to hydraulic incapacity of the sewerage network.

3.2.4 Riparian landowners

The legal term riparian is applied to landowners who own land adjoining or containing a river or watercourse. They have certain rights to use the water flowing across their land for their own purposes, and regarding flood risk management they also have several responsibilities, including the following:

- To maintain the bed and banks of the watercourse, and the trees and shrubs growing on the banks;
- To clear any debris (natural or man-made), even if it did not originate from their land; and
- To keep any structures (culverts, trash screens, weirs and mill gates) within their ownership clear of debris.

3.3 Existing Flood Risk Management Activities

In order to inform any future flood risk management measures considered as part of this SWMP, it is firstly important to understand those activities each RMA may already be undertaking in Burscough as they look to deliver their flood risk management roles and responsibilities. The sections below provide an overview of planned activities. It does not include details of activities or works already undertaken.

Table 3-1: Existing RMA activities

RMA	Capital Programme	Operation and Maintenance Activities
Lancashire County Council (as LLFA)	Lancashire County Council currently maintain a capital programme of works. These are works that have been identified as necessary and prioritised, for example the need for flood defence or asset improvement. The list of works is reviewed annually (April-March) with the purpose of those with greater need being prioritised as well as any new projects added. No capital works are currently planned by Lancashire County Council in relation to their role as the LLFA within Burscough. The outcomes of this SWMP will inform planned future capital works within Burscough.	Lancashire County Council hold a maintenance schedule for their assets relating to flood risk. This includes works such as culvert or Ordinary Watercourse maintenance. Although for some assets, Lancashire County Council will have a regular maintenance schedule programmed, works are largely reactive meaning action will only be taken once a problem is reported. Lancashire County Council currently do not have any programmed maintenance activities within Burscough in their capacity as LLFA.

RMA	Capital Programme	Operation and Maintenance Activities
Lancashire County Council (as Highways Authority)	Lancashire County Council currently maintain a capital programme of works. These are works that have been identified as required and prioritised, for example the need for highway drainage works or culvert improvement. The list of works is reviewed annually (April-March) with the purpose of those with greater need being prioritised as well as any new projects added. The Lancashire County Council Highways team currently have three projects in their capital works programme in Burscough: 1) Highway drainage improvements on Red Cat Lane to Crabtree Lane; 2) Highway drainage lining on Crabtree Lane; and, 3) Removal of telegraph post within highway drainage on Crabtree Lane.	Lancashire County Council hold a maintenance schedule for their highway assets. In terms of flood risk, this generally comprises works such as gully clearance or culvert maintenance. Although for some assets, Lancashire County Council will have a regular maintenance schedule programmed, works are largely reactive meaning action will only be taken once a problem is reported. As the local highway authority, Lancashire County Council currently hold a gully clearance programme in Burscough. Gullies included will be based upon previous clearance schedules as well as blockage history. These fall under two categories, P1 and P2 gullies that are cleared every 12 and 24 months respectively. Maintenance beyond the clearance programme is largely reactive.
West Lancashire Borough Council	West Lancashire Borough Council have confirmed that they do not have a capital works programme and do not have anything planned in Burscough.	West Lancashire Borough Council have confirmed that it does not have a scheduled maintenance programme in its capacity as riparian landowner. However, it does provide guidance to developers on flood risk and drainage issues, including guidance on runoff rates, discharges and mitigative measures such as Sustainable Drainage Systems (SuDS).
United Utilities	United Utilities works in 5-year asset management planning (AMP) periods. At the time of writing this report, United Utilities are in AMP 6 that runs until 31st March 2020, which does not include any capital works programmed in Burscough. However, a review of the recently produced IDAS report is currently being undertaken, which may inform future works which may be included in AMP 7 that will run from 1st April 2020 to 31st March 2025. The outcomes of this SWMP should also inform this review.	United Utilities do not have a programmed maintenance schedule within Burscough. Works are largely reactive following the reporting of issues. United Utilities reported that 76% of flood incidents associated with the sewer network in Burscough are as a result of blockage and not the hydraulic capacity of the pipes. The primary cause of these blockages is rag and wipes with the secondary cause being ingress of tree roots.
Riparian Landowners	It is currently believed that there are no capital works planned by riparian owners.	It is not currently understood what, if any, maintenance activities are currently undertaken by riparian landowners.
At Risk Residents	It is currently believed that there are no capital works planned by residents at risk of surface water flooding. It is however known that residents have previously constructed small earth mounds to protect their property from flooding and implemented property level protection measures.	Several residents deploy pumps during high rainfall events to divert floodwater away from properties and onto adjacent agricultural land in agreement with the landowner.

3.4 Flood Risk Management Measures

3.4.1 Source-pathway-receptor model

In line with the Defra SWMP Technical Guidance[6], a wide range of structural, non-structural and adaptation measures have been considered, which provide different levels of protection from surface water flooding and have a range of benefits and costs associated with them. Following the source-pathway-receptor model:

- **Source control** measures aim to reduce the rate and volume to surface water runoff through infiltration or storage reducing the impact on receiving drainage catchments. Within an urban environment, source control of surface water runoff can be achieved using the Sustainable Drainage Systems (SUDS) approach to drainage. Within rural upper catchments, these could include Natural Flood Management (NFM) techniques.
- **Pathway measures** seek to manage overland and underground flow pathways of water. Within an urban environment, they include traditional hard engineering solutions to increase pipe capacities to remove pinch points or provide additional storage or measures along roads to contain or redirect overland flows. Measures along more natural watercourses could include enhance maintenance or reconnecting the floodplain; and
- **Receptor measures** which can help reduce the impact (consequence) of flooding on receptors such as people, property and the environment. Measures such property level resilience is often considered last resort but can be beneficial when focusing on individual high-risk properties, especially where no other measures or scheme is viable.

3.4.2 Structural, non-structural and adaptation measures

Given the findings of the risk assessment (Section 2), use professional judgement and experience, a longlist of measures has been qualitatively assessed in terms of their suitability and deliverability to manage or reduce flood risk in Burscough. Table 3-2 contains a list of these measures. Each measure across the five main surface water sub-catchments in Burscough has been assessed using the following criteria:

✓✓ Given the understanding of surface water flooding mechanisms, these measures on their own will help to reduce the number of properties flooded, or a reduction in the depth of flooding (or duration) to a length of road. These measures can be delivered (and funded) by one or a combination of the RMAs.

✓ These measures can help reduce the overall level of risk but may form part of a wider option or strategy across the study area as whole. They may require buy-in from landowners and require partnership funding to deliver. They may be best delivered through other planning and infrastructure investment programmes.

✗ These measures are unlikely to be cost beneficial or may be difficult to deliver due to one or several social, political, economic or environmental barriers and constraints.

✗✗ These measures are not applicable given the understanding of surface water flooding mechanisms and the location of properties at risk.

Table 3-2: Structural, non-structural and adaptation measures

Measure		Likely suitability and deliverability / Catchments			
		A	B	C	D/E
Source	Green roofs	✗✗	✓✓	✗✗	✗✗
	Soakaways	✗✗	✓	✗✗	✗✗
	Swales	✗✗	✓✓	✓	✗✗
	Permeable paving	✗✗	✓	✗✗	✓
	Rainwater harvesting	✗✗	✓	✗✗	✓
	Detention basins	✗✗	✓✓	✗✗	✗✗
	Underground attenuation tanks	✗✗	✗✗	✗✗	✗✗
	Natural Flood Management	✓	✗✗	✓	✗✗
Pathway	Increasing capacity in highway drainage systems	✗	✗	✓	✗
	Separation of foul and surface water sewers	✗✗	✗✗	✗✗	✗✗
	Offline storage	✗✗	✗✗	✗✗	✗✗
	Increased channel capacity	✗	✓	✗	✗
	Increased culvert capacity	✗	✗✗	✓	✗✗
	Reviewed maintenance regimes	✓✓	✓✓	✓✓	✓✓
	Debris screens	✗✗	✗✗	✗✗	✗✗
	Managing overland flows	✓	✗✗	✓✓	✗✗
	Floodwalls or embankments	✗✗	✗✗	✗✗	✗✗
	Land management practices	✓	✗✗	✓✓	✗✗
Receptor	Improved weather warning	✗✗	✗✗	✗✗	✗✗
	Temporary flood defences (inc. Pumps)	✗✗	✓	✗✗	✗✗
	Social change, education and awareness	✓	✓	✓	✓
	Improved resilience and resistance measures	✓✓	✓✓	✓✓	✓✓
	Flood plan	✓	✓	✓	✓
Strategic Policies	Strategic planning	✓✓	✓✓	✓✓	✓✓
	Development control	✓✓	✓✓	✓✓	✓✓
	Critical drainage area classification	✗✗	✗✗	✗✗	✗✗

3.4.3 Discussion

Source control measures

Across the urban sub-catchments, the retro-fitting of SuDS is generally not considered to be suitable or deliverable. Unless implemented catchment wide, these individual retro-fitted solutions are likely to be relatively expensive and will offer little benefit in reducing flood risk downstream. Due to multiple land ownerships and low permeability drift geology underlying the area, certain techniques (e.g. infiltration based) will not be considered viable. Property level solutions such as rainwater harvesting would only be beneficial if implement at scale.

Retro-fitting of SuDS is best targeted on large development sites (as seen at the Yew tree Farm development) or around larger properties such as schools (e.g. Burscough Priory Academy and Lordsgate Township C.E. Primary School) located in sub-catchment B2 where land might be available, and measures such as green roofs, swales and detention basins can reduce the amount of surface water entering the urban drainage network. SuDS on these sites could also offer wider environmental and educational benefits as well as potentially reduce surface water charges.

Pathway measures

Increasing the capacity of the surface water drainage network (e.g. enlarging surface water sewers or providing offline storage) will not likely be cost beneficial given the high capital costs and distribution of properties at risk that would limit potential benefits at a local level.

Whilst key culverts at Crabtree Lane and the railway line restrict flood flows along the two Ordinary Watercourses, these pinch points help to ensure the floodplain is utilised for flood storage. The issue being when the capacity of the floodplain is exceeded, placing neighbouring properties at risk. Enlarging the culvert underneath Crabtree Lane could provide minor benefits reducing the probability of flooding to these properties; the limiting factor would be the culvert underneath the railway line which would be very expensive to enlarge. Land downstream of the railway line is also higher potentially making it difficult (and expensive) to add further culverts underneath the railway linking to two floodplains.

Solutions to manage the overland flow path that runs along the northern railway embankment towards properties on Crabtree Lane should be technically viable. This could include water catchment land management practices (such as changes in cultivation techniques or improved agricultural drainage) but also the construction of SuDS (such as swales and storage ponds) or bunding. Works to improve the local highway drainage network (which is known to suffer from condition issues) might also provide local benefits during more frequent rainfall events but would still likely to become overloaded during extreme rainfall events, as they will not be designed to drain the runoff from the agricultural land.

Focused or enhanced maintenance along surface water drainage networks with known issues which could provide local benefits. These measures could include a review of gully maintenance schedules. Riparian owners of Ordinary Watercourses should understand their responsibilities to ensure pathways are maintained and blockages are removed. However, the hydraulic modelling shows that any condition issues are likely to result in local impacts only and will not cause flooding further upstream through the urban area.

Receptors

Given the distribution of properties at risk and the limited benefits available through alternative solutions, property level resilience and resistance measures will be more beneficial and cost effective for high-risk properties. The results of this SWMP will also help to address any misconceptions regarding the source and mechanism of flooding, to allow RMAs and residents to focus attention where greatest benefits can be found. This could include for example, the preparation of a local flood plan setting out proactive actions to be taken once extreme rainfall events are forecasted.

Strategic policies

Critical Drainage Areas

A Critical Drainage Area (CDA) is an area within Flood Zone 1 that has known critical drainage problems, and which has been notified to the local planning authority by the Environment Agency. CDAs are a useful tool in the planning process to help ensure development in areas at risk of surface water flooding is designed appropriately and offer an opportunity to impose stricter runoff controls especially where there a significant capacity issues on receiving networks downstream of the development footprint.

According to the Environment Agency, there are currently no CDAs covering the area of Burscough.

Consideration has been given to the creation of CDAs as part of the Burscough SWMP in partnership with Lancashire County Council. However, they are not considered to be beneficial in this area because:

1. There are already strong surface water drainage policies within the West Lancashire Local Plan and the Burscough Parish Neighbourhood Plan. This includes ensuring developments demonstrate that the current natural discharge rate is at least mimicked on greenfield sites and that opportunities to remove surface water from the existing sewers are explored.
2. All major development proposed e.g. Yew Tree Farm, already have planning consent or are in development and have implemented SuDS.

4. Implementation & Review

4.1 Action Plan

Preparation

As part of this SWMP, an optioneering workshop was undertaken with attendance from relevant RMAs including Lancashire County Council, West Lancashire Borough Council and United Utilities. During this workshop, the following topics were discussed:

- An overview of the surface water flooding mechanism;
- Flood risk management activities undertaken and planned; and
- Potential flood risk management measures.

The aim of the workshop was to take a collaborative approach to developing the Action Plan and seeking agreement from all RMAs as early as possible.

Action Plan

Appendix E contains the final SWMP Action Plan. The action plan itself contains several actions to be delivered by relevant RMAs over the short, medium and long-term, with the aim of managing or reducing surface water flood risk in Burscough.

The actions themselves will be led by one of the RMAs linking to their role and responsibilities as set out in Section 3.2. Some of these actions will be a continuation of activities already undertaken or planned, whilst others challenge the RMAs to improve existing process or procedures.

Whilst the actions have been reviewed and agreed upon by the RMAs, timing and deliverability is still dependent on other factors, such as the capital budgets and other local or regional priorities.

4.2 Review

The actions outlined within the Action Plan have been agreed to by all parties, it is therefore the responsibility of the various authorities to ensure these are undertaken.

Lancashire County Council, as LLFA, should undertake regular reviews of the Action Plan to check whether the proposed actions are being undertaken by relevant partners and stakeholders. This may be best undertaken through existing forums such as Making Space for Water Groups.

As a minimum, the SWMP Technical Guidance recommends that the Action Plan should be reviewed and updated once every six years, but there are circumstances which might trigger a review and/or an update of the Action Plan in the interim or in some cases annually:

- Occurrence of flood incident (an event that might trigger a Section 19 Investigation);
- Additional data or modelling becoming available, which may alter the understanding of risk within the study area;
- Outcome of investment decisions by partners is different to the preferred approach, which may require a revision to the action plan; and
- Additional development or other changes in the catchment which affect the surface water flood risk.

Appendix A. Existing Datasets

Table 4-1: Existing datasets

Dataset	Data Owner	Description	Use in SWMP Study
Flood Map for Planning	Environment Agency	National dataset identifying locations at risk from fluvial and tidal flooding along Main Rivers.	Used to identify locations at risk from fluvial flooding from Main Rivers in Burscough.
Flood Map for Surface Water	Environment Agency	National dataset identifying locations at risk from surface water flooding.	Used to attain an understanding of surface water flood risk to Burscough prior to detailed hydraulic modelling.
Historical flood maps	Environment Agency and Lancashire County Council	Datasets detailing reported incidents of flooding.	Used to support anecdotal evidence and validate detail hydraulic modelling results.
Main Rivers	Environment Agency	National dataset showing locations of watercourses designated as Main Rivers.	Used to identify Main Rivers surrounding Burscough.
Detailed Rivers Network	Environment Agency	National dataset showing locations of all watercourses.	Used to understand surface water networks and the identification on Ordinary Watercourses, as well as define surface water drainage catchments.
Flood Risk Asset Register	Lancashire County Council	Locations of all Lancashire County Council Flood Risk assets.	Used to understand what assets Lancashire County Council currently hold in Burscough.
Drainage Plans	West Lancashire Borough Council	Drainage designs for sewers at several locations across Burscough.	Used to verify and fill data gaps within the United Utilities sewer network dataset.
Sewerage Asset Data	United Utilities	United Utilities GIS assets database showing public sewer network, pumping stations and wastewater treatment works.	Used to understand the surface water networks, define drainage catchments and inform the detailed hydraulic model.
Network Model	United Utilities	United Utilities network model.	Used to develop the SWMP integrated hydraulic model.
DG5 Register	United Utilities	A register of properties which have experienced sewer flooding (both internal and external) due to hydraulic overload, or properties which are 'at risk' of sewer flooding more frequent than once in 20 years.	Used to develop an understanding of flood history.
Canal Asset Data	Canal & Rivers Trust	Details of Canal & Rivers Trust assets including canal locations, embankments, locks and culverts	Used to identify assets owned by the Canal & Rivers Trust.
Gully Locations	Lancashire County Council	GIS dataset detailing the location of highway gullies.	Used to inform the detailed hydraulic model.
Soilscapes	Cranfield University	Provides information on soil type as well as soil drainage e.g. infiltration.	Used to understand infiltration potential of land within surrounding Burscough.
Superficial and bedrock geology	British Geological Survey	Details the composition of superficial and bedrock geology.	Used to understand local geology to aid in assessing the potential for groundwater emergence at the surface as well as the potential for infiltration.
Superficial and bedrock aquifer designation	Environment Agency	Provides information on superficial and bedrock aquifer designations.	Used to understand local aquifers to aid in assessing the potential for groundwater emergence at the surface.

Dataset	Data Owner	Description	Use in SWMP Study
West Lancashire Borough Council Burscough Flood Studies Investigation Data	West Lancashire Borough Council	Study undertaken by Entec investigating flooding issues and surface water networks in Burscough.	Used to develop an understanding of issues as well as providing data on watercourses and culverts to inform the hydraulic model.
Environmental Designations	Environment Agency	Location of sites with specific environmental designations.	Used to understand environmental opportunities and constrains as part of option identification.
National Receptor Dataset (NRD)	Lancashire County Council	National property dataset detailing property specific information and locations.	Used to calculate present value economic flood damages.
Local Development documents	West Lancashire Borough Council	Information regarding future development plans within the study area and planning policy.	Used to understand proposed developments.
OS and Historic Mapping	Lancashire County Council	Mapping for Burscough at various scales and from various dates.	Used to understand changes in land use, networks and watercourses, e.g. culverting over time.
LiDAR (1m)	Environment Agency	Digital Terrain Model detailing topography.	Used to understand topography within Burscough informing the development of drainage catchments and the detailed hydraulic model.
Resident Information	Burscough Flood Group	Historical flooding information, collected and provided by the Burscough Flood Group.	Used validate the results of the detailed hydraulic model.

Table 4-2: Previous plans, studies and investigations

Study	Purpose	Main Findings	Recommendations
Environment Agency (2009) Alt Crossens and River Douglas Catchment Flood Management Plans	The CFMP looks to establish flood risk management policies which deliver sustainable flood risk management for the long term. This CFMP identifies flood risk management polices to assist all key decision makers in the catchment.	The CFMP found that there is a risk of flooding in built up areas from surface water run-off, drains and sewers. In built up areas there will be an increase in flood risk in the future associated with urban run-off and channel restrictions which may not be able to cope with the intense rainfall events which are expected to become more frequent. Surface water ponding and insufficient capacities of the satellite pumping stations during periods of heavy rainfall could also contribute to the main source of flood risk across the Alt Crossens catchment.	Policy 6 - Areas of low to moderate flood risk where we will take action with others to store water or manage run-off in locations that provide overall flood risk reduction or environmental benefits. Policy 4 - Areas of low, moderate or high flood risk where we are already managing the flood risk effectively but where we may need to take further actions to keep pace with climate change.
West Lancashire Borough Council (2010) Burscough Flood Studies Investigation	This report produced with the purpose of investigating the flooding issues that have occurred at number of locations in Burscough (period 2000 to 2010) and to make recommendations to improve the hydraulic capacity and/or understand the key areas.	Details the locations, sizes and condition of watercourses and culverts in Burscough. Identifies where maintenance works are required due to poor condition or blockage of sewers and pipes as well as were known issues have been rectified. It also confirms connectively of pipes as well as highlighting where connectivity cannot be confirmed.	Works required to inform any long-term mitigation solutions: ▪ Alexander Close: CCTV survey to complete un-surveyed section between MH2 and MH4 in report. ▪ Crabtree Lane/Red Cat Lane: verification of historic culvert routes. ▪ School Lane: verification of culvert route. ▪ Station Approach/Red Cat Lane: confirm connectivity of all inlets and outlets in chamber MH SA2.
West Lancashire Borough Council (2013) West Lancashire Local Plan 2012 – 2027 Development Plan Document	The West Lancashire Local Plan 2012 – 2027 contains a vision and strategy that sets out how West Lancashire Borough Council wants West Lancashire to develop over the period to 2027. It ensures that new homes, jobs and services required by communities are in the most sustainable places, but also provides the framework for delivering the necessary infrastructure, facilities and other development to make this possible.	In order to meet the needs of West Lancashire's population, including affordable housing and specialist accommodation, for the period 2017 – 2027 there will be a need for 4,860 new dwellings as a minimum to meet current requirements of strategic planning policy, this includes 850 new dwellings in Burscough. To meet this development need, the Yew Tree Farm site was identified as an opportunity to deliver much of the housing and employment land in a single, large development, providing both housing, employment and community benefits. The development will not result in surface water being discharged to the public sewer network. In order to ensure development in Burscough is sustainable with regards to flood risk, two policies have been implemented.	GN3 – "The Council will ensure development does not result in unacceptable flood risk or drainage problems by requiring development to… Demonstrate that sustainable drainage systems have been explored alongside opportunities to remove surface water from existing sewers. Robust justification will be required for any development seeking to connect surface water to the public sewer network. In addition, any surface water connection must be at an agreed attenuated rate". SP3 – "Development of the Yew Tree Farm site will not result in surface water being discharged into the public sewer system and will, in fact, draw surface water off the public sewerage system to be attenuated to the local watercourse at greenfield run-off rates to at least the equivalent quantity of foul water being discharged from the site into the public sewerage system"

Study	Purpose	Main Findings	Recommendations
Lancashire County Council (2013) West Lancashire Level 1 SWMP	Using national surface water flood zone mapping and other readily available datasets, a strategic risk assessment of local flooding sources was undertaken to identify 'Key Risk Area Hotspots' that warrant further detail investigations.	Burscough could be vulnerable to extensive but shallow surface water flooding, with deeper flooding likely to be limited to localised rural areas. There are also potential issues around the flat nature of the topography, local watercourses, and pinch points along surface water drainage routes. This, together with several instances of sewer flooding, suggested wider issues associated with the surface water and sewerage system.	The SWMP recommended that flood risk management options should focus on pro-active and reactive non-structural measures. But further engagement with United Utilities is required to determine what works are planned to investigate potential capacity issues along the sewer network.
West Lancashire Borough Council (2015) Yew Tree Farm Final Masterplan Supplementary Planning Document	The purpose of the Masterplan is to provide a useful framework to guide developers on the planning and design requirements when bringing the site forward for development.	The surface and foul water drainage network in Burscough suffers from capacity issues, as does the waste water treatment works at New Lane which serves Burscough, most of Ormskirk and some of the outlying areas towards Scarisbrick and Rufford. Land drainage within and around Burscough is also unsatisfactory in parts as a result of unmanaged local culverts and pinch points in the drainage network where physical barriers, such as the rail line and canal, cause obstruction in the flow of water to the outfall (Martin Mere / Boat House Sluice).	The use of Sustainable Drainage System (SuDS) should be used to ensure that none of the surface water from the development can be discharged into the public network and that it must be discharged into the natural drainage network at an appropriate existing greenfield rate to ensure no additional flood risk results from the newly developed site. In respect of the condition and capacity of the natural drainage network, this will ultimately be the responsibility of the riparian owner i.e. the land owner adjacent to or beneath the watercourse.
Burscough Parish Council (2015) Drainage Assessment Review	Study prepared by SCP on behalf of Burscough Parish Council in response to queries raised regarding the drainage proposals for the development at Yew Tree Farm.	Topographic undulations create areas of ponding during heavy rainfall, potentially misidentified by Burscough Flood Group as groundwater flooding. Surface water flooding within the site boundary is generally within the vicinity of watercourses, hedge ditches and topographic low points, and is generally associated with low permeability soils impeding infiltration. United Utilities acknowledges insufficient capacity of the foul and surface water networks however it is unable to refuse sewer connection applications due to the capacity issues	Farm development site to determine if the development will impact on the ability of flows to drain from the attenuation features (this goes beyond the scope of this study). Separation of the surface water and foul sewer networks on Lordsgate Lane with the surface water network incorporated into the attenuated on-site drainage systems. Pre and post development modelling to determine if additional foul flows discharging to the combined network on Lordsgate Lane would impact the drainage network.
Lancashire County Council (2017) West Lancashire District Flood Report	Investigation following the December 2015 flooding as required under Section 19 of the Flood and Water Management Act. The report identifies areas that experienced flooding and provides recommendation on potential further work or action by RMAs.	The investigation found that 23 properties within Burscough reported internal flooding on the 26th December 2015. Sewer related flooding has been identified by United Utilities on Junction Lane and Mill lane, whilst the Environment Agency investigation discounted groundwater as a potential source of flooding.	RMAs determined that a detailed study of surface water in Burscough is required and this should be programmed and delivered by Lancashire County Council as the LLFA. Lancashire County Council also encouraged concerned residents to consider installing property level flood resilience measures to further reduce the risk of flood water entering their property in the future.

Study	Purpose	Main Findings	Recommendations
Burscough Flooding Group (2017) Burscough Flood Records Report	Report developed by the local flood action group to document evidence of flooding incidents collected from Burscough residents. This includes anecdotal evidence as well as pictures of flooding.	Widespread flooding across Burscough with internal flooding reported in 2004, 2008, 2010, 2011, 2012, 2013, 2014, 2015, 2016 and 2017. the most significant of these being in 2015, with 75 properties reporting internal flooding. The report suggested issues with United Utilities networks to be the principal mechanism for flooding. The report also suggests that groundwater flooding has occurred at Moss Lane and that Yew Tree Farm is susceptible to groundwater flooding.	No recommendations put forward.
United Utilities (2018) Integrated Drainage Areas Strategy (IDAS) Report: Burscough WwTW Drainage Area	The IDAS studies use detailed risk assessment and forecasting tools to identify cost beneficial solutions across the region, adopting a holistic, catchment wide approach which looks beyond their own network assets. This report covers the Burscough drainage area and is based on reported incidents aligned to United Utilities current output delivery incentive mechanisms, resulting in risk values.	The IDAS report found that 16 risk areas within the Burscough WwTW Drainage Area be reviewed for potential operational improvements; predominantly risk of blockages, external/internal flooding from other causes. Enhancements to the existing network models in collaboration with local stakeholders to aid the quantification of hydraulic risk from runoff (e.g. agricultural land) into the network and impact of future development should be considered.	The IDAS process has identified a clear need for an integrated study to be undertaken to investigate and fully assess the various interactions between UU and third-party assets throughout the Burscough catchment area. This includes recommendations to: ▪ Construct and verify a new integrated hydraulic model, to include all UU assets, as well as receiving watercourses. ▪ Undertake conditional surveys on watercourses and drainage ditches. If watercourses under riparian ownership are found to be causing issues, the relevant authorities should liaise with land owners to remedy the issues. ▪ Investigate the reported land runoff from fields and assess inflow points to the UU drainage networks. ▪ Once the various drainage systems (and their interactions) in Burscough are fully understood, a catchment wide intervention plan should be undertaken to address the widespread issues within the catchment. Utilities Operational Team to evolve the IDAS plans for the area and promote prioritised schemes for investment planning to ensure network resilience

Study	Purpose	Main Findings	Recommendations
Burscough Parish Council (2019) Burscough Parish Neighbourhood Plan 2017 - 2027	The Burscough Parish Neighbourhood Plan is a planning document which must be taken into consideration, alongside the West Lancashire Local Plan, when making decisions on planning applications in Burscough. The neighbourhood plan process enables communities to better shape their area, inform how development takes place and helps influence the type, quality and location of that development, ensuring that change brings with it local benefit.	One of the objectives relating to infrastructure objectives is "Improvements in the existing infrastructure and utilities, particularly in respect of drainage and sewerage systems leading to a marked reduction in extent and occurrences of flooding in the area.", which closely relates to responses from a community survey undertaken in which "The majority of respondents considered that there was insufficient capacity within the existing infrastructure to cope with current demand" including surface water and sewerage.	Policy BPI2 aims to ensure that development does not have any adverse impact on existing issues within Burscough with a focus on the capacity of surface water sewer networks, address resident concerns and ensure that development is sustainable. In doing so, it sets out a surface water discharge hierarchy which should be adhered to. The policy puts an emphasis on management of surface water at source and every option should be investigated before discharging surface water to an existing public sewer network. Evidence will need to be provided if the developer wishes to discharge to public sewers as to why no alternative option is available. Where development is located on greenfield sites, BPI2 dictates that developers must provide evidence that attenuation will be provided to at least the existing runoff rates. BPI2 also states that on greenfield sites, developers will be expected to demonstrate that the current natural discharge rate is at least mimicked.

Appendix B. Hydraulic Modelling Approach

B.1 Hydrology

Objectives

The objective of this hydrological analysis is to provide the direct rainfall hyetographs required as input to the surface water hydraulic model for the following storm durations, for both summer and winter rainfall profiles: 0.5hr; 1hr; 1.5hr; 2hr; 3hr; 4hr; 6hr; 8hr; 10hr; and, 12hrs. The rainfall hyetographs are required for the Annual Exceedance Probability (AEP) events, listed in Table B-1.

Table B-1: Annual Exceedance Probabilities

Return Period	Annual Exceedance Probability (AEP)
1 in 2 year	50%
1 in 5 year	20%
1 in 10 year	10%
1 in 20 year	5%
1 in 30 year	3.33%
1 in 50 year	2%
1 in 75 year	1.33%
1 in 100 year	1%
1 in 200 year	0.5%

Data and model used

Catchment FEH-13 rainfall DDF (Depth Duration Frequency) curve has been purchased from the FEH Web Service for the model extent centroid (Northing: 343725, Easting: 412144). Dimensionless hyetographs were extracted from ReFH2.2 software package using the FEH13 rainfall data for the above storm durations and frequencies.

B.1.1 Methods

In order to derive rainfall profiles as specified in the objectives, the following steps were undertaken:

- Rainfall data was purchased for the study area;
- The total rainfall depths for each storm duration and required AEPs were manually extracted from the FEH Web Service;
- Dimensionless hyetographs were extracted from ReFH2.2 for both summer and winter storm profiles, in which case areal reduction factor and seasonal correction factor were considered as unity; and
- The required rainfall hyetographs were obtained from the total rainfall depths and dimensionless hyetographs for the required storm durations, and profiles (summer/winter) for each of the AEPs.

B.1.2 Results

Typical rainfall hyetographs for the 1% AEP 4-hour events are presented in Figure B.1 (summer profile) and Figure B.2 (winter profile).

Figure B.1: 1% AEP (100-year return period) event – 4-hour duration summer rainfall hyetograph

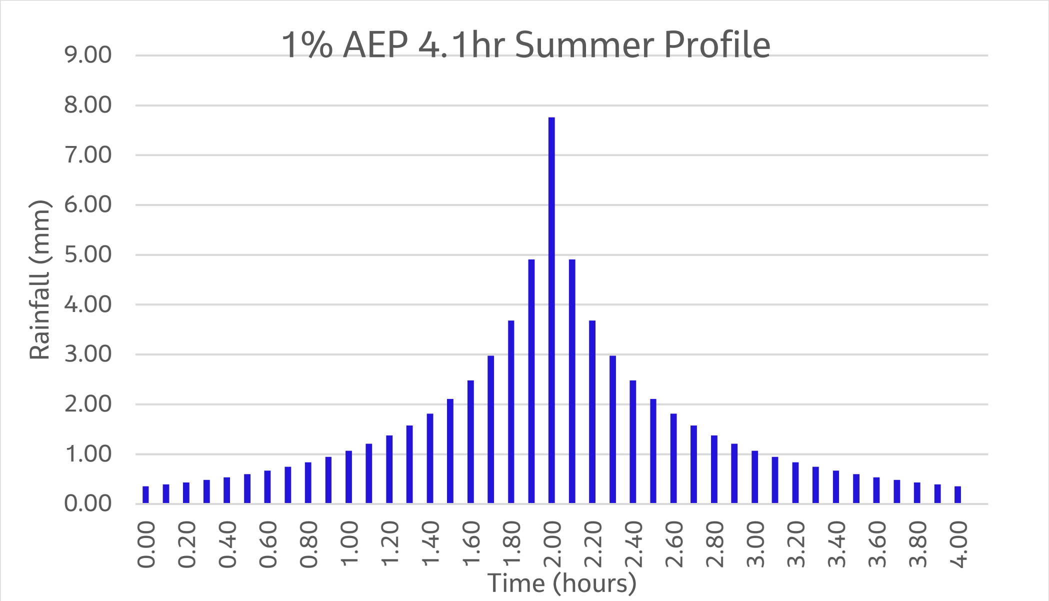
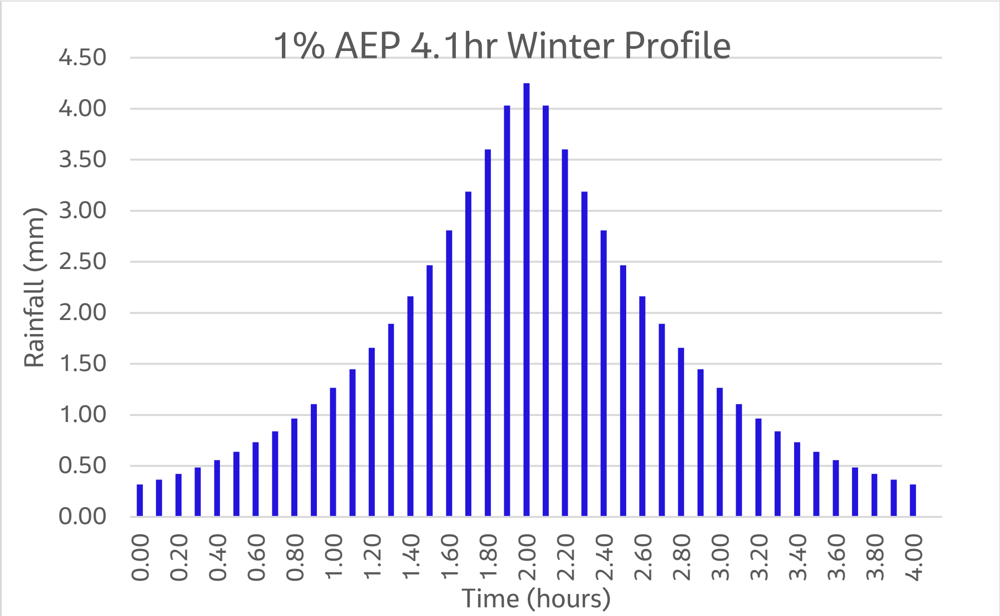


Figure B.2: 1% AEP (100-year return period) event – 4-hour duration winter rainfall hyetograph



B.1.3 Limitations

- The FEH13 rainfall statistics on which the analysis is based are not validated for storm durations of less than 1 hour. Therefore, the user must be mindful that the rainfall profiles for the shorter duration storms (0.5hr) are of lesser reliability.
- Only one set of rainfall data was purchased, namely at the catchment centroid; this assumes that the entire modelled catchment experiences the same total rainfall depths, i.e., the rainfall is uniformly distributed over the catchment.

B.2 Hydraulic Modelling

B.2.1 Introduction

The hydraulic modelling for Burscough was done by integrated modelling of two components; the drainage network and overland flow paths. The entire storm water drainage network and overland flow areas within catchments contributing to the Burscough and surroundings are part of the model domain. The model domain was applied with direct rainfall in InfoWorks ICM. The foul water network was applied with flows from sub-catchments as received from the incoming model.

B.2.2 Model Development

The drainage network was developed based on United Utilities network data from the ICMT file containing the existing network model for the Burscough Wastewater Treatment Works drainage area. The drainage network includes surface water, foul water and combined system pipes.

The culverts were added beneath the roads and railways to have a continuous flow path in the model using information available from the site visit and existing data from the client. Also, there were few culverts which were added in the model based on the flow in watercourses. The invert levels adopted for culverts are based on engineering judgment using elevation information from LiDAR data.

The storm water and combined water network were applied with four number of gullies with head-discharge applied to it based on shaft areas. For the combined water network through grassland, head-discharge was applied in such a way that water could flow to overland flow areas but not vice-versa. Similarly, foul water had similar head-discharge curve based on shaft area. The manhole elevations had been inspected from LiDAR elevation data.

The downstream boundaries of all network outlets were either applied with Outfall or Outfall 2D in case of watercourses.

The elevation data for representing the overland catchment of Burscough is based on LiDAR data of 1m spatial resolution stamped on 2m LiDAR data downloaded from the UK government data portal[21] for additional areas not covered by 1m LiDAR data.

The rainfall hyetographs provided by hydrologists were applied to the model domain directly. The runoff coefficients and roughness parameters are based on different land use polygons. The model domain (2D zone) was applied with normal condition as downstream boundary to allow the flow to leave the domain.

The mesh level zones were used to represent the watercourse to align with the edges of the mesh. It was also used to fill the ditch around the development area by using the neighbouring ground elevations. The mesh zones were used for buildings, property gardens, roads, footpaths and watercourses to define finer mesh. They were also used in areas of openings through embankments to represent the flow paths with a finer mesh.

B.2.3 Simulations

The critical storm analysis was carried out for 5% AEP and 1.33% AEP events to finalise the storm duration that produces maximum flood depth and extent in the study area as a result of pluvial flooding. The simulations were done for 5% and 1.33% AEP events for summer profile storm durations of 0.5hr, 1hr, 1.5hr, 2hr, 3hr, 4hr and 6hr. Based on the analysis of the maximum depth, flow, velocity and flood extent, the storm duration of 1hr was finalised as critical storm duration. The model was also run for winter profile of 1hr to compare with summer profile. The summer profile was critical.

The final model was run for seven AEP events (20%, 10%, 5%, 3.33%, 1.33%, 1% and 0.5% AEP events) with the critical storm duration.

Blockage scenarios were simulated for all seven AEP events. For this scenario, the roughness of drains was increased to 0.05, manholes (storm and combined) were blocked by 75%, and culverts were blocked by 75%.

A Climate Change scenario was also simulated for all seven AEP events. The rainfall hyetographs were increased by 30%, representing the Central Climate Change estimate for period 2015-2039 (Epoch 1, 2020s).

Two sensitivity tests were simulated for all seven AEP events to assess the impact of upsizing the culverts under road and railway to 3m diameter and increasing the roughness of drain alongside the waste water treatment plant to 1 representing lack of maintenance. The runs were done for 10% and 0.5% AEP events.

B.2.4 Assumptions and Limitations

The model is a fair representation of the study area; however, it contains few limitations and necessary assumptions have been made. These include:

- 2D Zone uses coarse mesh outside urban area.
- Mesh is different for each scenario investigated making it difficult to do exact comparisons.
- The buildings in the study area are represented using a high roughness parameter rather than raising them up to plinth levels. This was done to improve model stability with appropriate representation of impact of buildings on the flooding.
- Watercourses are not surveyed, and levels are based on LiDAR elevation data.
- OS Mastermap data at far West of study area was not available. This is represented using a default values for runoff coefficient and roughness.
- The sizes of a number of the culverted sections have not been verified. The invert levels are estimated based on available LiDAR elevation data.

Appendix C. Surface Water Flood Mapping

Table 4-3: Surface water flood maps

File Name	Title
JUK-ZZ-BU-DR-Z-1301-P01	Flood Depths – 20% AEP Rainfall Event
JUK-ZZ-BU-DR-Z-1302-P01	Flood Depths – 5% AEP Rainfall Event
JUK-ZZ-BU-DR-Z-1303-P01	Flood Depths – 3.33% AEP Rainfall Event
JUK-ZZ-BU-DR-Z-1304-P01	Flood Depths – 1.33% AEP Rainfall Event
JUK-ZZ-BU-DR-Z-1305-P01	Climate Change Impact – 20% AEP Rainfall Event
JUK-ZZ-BU-DR-Z-1306-P01	Climate Change Impact – 5% AEP Rainfall Event
JUK-ZZ-BU-DR-Z-1307-P01	Climate Change Impact – 3.33% AEP Rainfall Event
JUK-ZZ-BU-DR-Z-1308-P01	Climate Change Impact – 1.33% AEP Rainfall Event
JUK-ZZ-BU-DR-Z-1309-P01	Flood Hazard – 20% AEP Rainfall Event
JUK-ZZ-BU-DR-Z-1310-P01	Flood Hazard – 5% AEP Rainfall Event
JUK-ZZ-BU-DR-Z-1311-P01	Flood Hazard – 3.33% AEP Rainfall Event
JUK-ZZ-BU-DR-Z-1312-P01	Flood Hazard – 1.33% AEP Rainfall Event
JUK-ZZ-BU-DR-Z-1313-P01	Burscough Sewers, Culverts and Watercourses
JUK-ZZ-BU-DR-Z-1314-P01	Sewer Network Capacity – 20% AEP Rainfall Event
JUK-ZZ-BU-DR-Z-1315-P01	Sewer Network Capacity – 5% AEP Rainfall Event
JUK-ZZ-BU-DR-Z-1316-P01	Sewer Network Capacity – 3.33% AEP Rainfall Event
JUK-ZZ-BU-DR-Z-1317-P01	Sewer Network Capacity – 1.33% AEP Rainfall Event

Appendix D. Economic Assessment

D.1 Properties at Risk

Prior to calculating flood damages, it is first necessary to identify those properties at risk of flooding. A GIS methodology has been adopted to count the number of properties (extracted from the National Receptor Dataset, NRD) that fall within the estimated flood extents.

Flood depths and extents produced through hydraulic modelling have been used to estimate properties at risk within Burscough. A methodology known as the 'property point' approach was then adopted to count properties where the NRD point intersects with the modelled flood extents.

Once individual properties were identified as at risk, the depth of flooding to the property was extracted from each flood event modelled. Only residential properties flooding to a depth of above 150mm (assumed threshold level) were counted (wetted). Non-residential properties were also included where flood depths exceeded 0mm.

Table 4-4 provides a breakdown of the total number of properties predicted to be at risk of flooding across the study area for all modelled flood return periods for the Baseline scenario.

Table 4-4: Number of properties at risk of internal flooding per catchment

Property Type	AEP/Number of properties at risk						
	20%	10%	5%	3.33%	1.33%	1%	0.5%
Catchment A							
Residential	0	0	0	0	0	0	0
Non-residential	20	2	4	4	8	3	3
Catchment B1							
Residential	0	0	0	0	0	0	0
Non-residential	1	0	1	1	0	0	0
Catchment B2							
Residential	0	0	1	0	0	0	1
Non-residential	3	2	1	3	2	1	0
Catchment B3							
Residential	0	0	0	0	0	0	0
Non-residential	0	0	0	0	0	0	0
Catchment B4							
Residential	0	2	1	0	4	2	1
Non-residential	2	0	0	0	1	1	1
Catchment B5							
Residential	0	0	0	0	0	0	0
Non-residential	0	0	0	0	0	0	0
Catchment B6							
Residential	0	0	0	0	0	0	0
Non-residential	4	0	0	0	1	0	0
Catchment C1							

Property Type	AEP/Number of properties at risk						
	20%	10%	5%	3.33%	1.33%	1%	0.5%
Residential	1	0	0	0	0	0	0
Non-residential	0	1	0	0	0	0	0
Catchment C2							
Residential	0	0	0	3	1	0	4
Non-residential	1	0	1	3	1	0	2
Catchment C3							
Residential	2	0	0	0	0	0	1
Non-residential	5	1	2	0	1	0	0
Catchment D1							
Residential	1	0	0	0	1	0	0
Non-residential	0	0	0	0	0	0	0
Catchment D2							
Residential	4	3	2	1	2	2	3
Non-residential	5	0	0	0	1	0	0
Catchment D3							
Residential	2	0	0	1	3	0	1
Non-residential	4	1	0	1	1	0	0
Catchment D4							
Residential	0	0	0	0	0	0	0
Non-residential	0	0	0	0	0	0	0
Catchment E							
Residential	0	0	0	0	0	0	1
Non-residential	0	1	0	1	0	0	1

D.2 Economic Damages

The calculation of economic Present Value (PV) damages has been undertaken using standardised guidelines and figures, provided in the Environment Agency's Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG), and the Middlesex University's Flood Hazard Research Centre's 'Multi-Coloured Manual' (MCM). The calculation has been undertaken over a 100-year appraisal period.

Flood Modeller Damage Calculator has been used to determine the PV damages within the study area, which estimates the direct economic damages resulting from flooding to properties as well as the value of indirect and intangible damages. Indirect and intangible damages represent loss of personal items, evacuation and ongoing costs such as temporary accommodation. Emergency services costs are also estimated as 5.6% of PV damages per property.

Average market valuations of residential properties are assigned to each property based on regional averages for West Lancashire from May 2019[22]:

- Detached £287,592
- Semi-Detached £175,710
- Terrace £130,253
- Flat £105,505

Damages for each individual property are capped at these values to avoid un-realistic damages; a property cannot accrue direct damages greater than its market value.

Damages for non-residential properties are based on 'Non-domestic rating: business floorspace' for West Lancashire from March 2016[23]. This provides rateable values per m^2. This value is uplifted by 1.077% based on Consumer Price Index (CPI) from May 2019 (107.9). This value is then multiplied by the individual property's floor area and the Equivalent Yield value divided by 100. Uplifted non-residential rateable values can be seen in Table 4-5.

Table 4-5: Uplifted non-residential rateable values and equivalent yields for West Lancashire

Property Type	Uplifted rateable value per m^2 (2019)	Equivalent Yield
Retail	128.14	6.67
Office	73.23	7.78
Warehouse	32.31	5.5
Leisure and public	52.77	7.78
Industry	32.31	7.13
Other	52.77	6.97

The above values have been used to calculate consequence of flooding in monetary terms. The calculation of flood damages has been undertaken using a standard methodology outlined in the MCM, which considers:

- Residential and non-residential direct damages resulting from flood water inundating a property;
- Vehicle damages;
- Indirect non-residential damages;
- Emergency service costs; and,
- Costs associated with evacuation and providing temporary accommodation.

A breakdown of PV damages can be seen in Table 4-6.

Table 4-6: PVd (£k) for Burscough

Property Type	Internally Flooded Property	Externally Flooded Property	Total
Residential PV damages			
Direct residential damages (capped)	£1,268	£1,890k	£3,158k
Vehicle damages	£11k	-	£11k
Emergency services costs	£88	£125k	£213k
Evacuation/ temporary accommodation costs	£203k	£3k	£206k
Total	**£1,570k**	**£2,018k**	**£3,588k**
Non-residential PV damages			
Direct non-residential damages (capped)	£5,664k	£15k	£5,679k
Indirect damages	£186k	£0.4k	£186k
Emergency services costs	£347k	£0.4k	£347k
Total	**£6,197k**	**£16k**	**£6,212k**

D.3 Damages per sub-catchment

Present Value damages (PVd) have then been broken down on a sub-catchment by sub-catchment basis to understand if there are any sub-catchments which are more at risk of flooding and provide damages which may justify capital works. Table 4-7 shows the economic damages on a sub-catchment basis.

Table 4-7: Breakdown of total PV damages per sub-catchment

Sub-catchment	Residential	Non-Residential	% of total damages
A1	£96k	£4,138k	43.2%
B1	£195k	£0k	2%
B2	£152k	£738k	9.1%
B3	£0k	£0k	0%
B4	£688k	£0k	7%
B5	£0k	£0k	0%
B6	£61k	£151k	2.2%
C1	£247k	£71k	3.2%
C2	£307k	£980k	13.1%
C3	£359k	£0k	3.7%
D1	£206k	£0k	2.1%
D2	£829k	£11k	8.6%
D3	£349k	£106k	4.6%
D4	£0k	£15k	0.2%
E1	£103k	£0k	1.1%

Appendix E. SWMP Action Plan

Table 4-8: SWMP Action Plan

Ref	Action	Action Type	Output / Benefits	Priority	Target Start Date	Target End Date	Action Owner / Lead Partner	Budget / Funding	Stakeholder Support
1	Red Cat Lane Drainage Improvement Works (Phase 1)	Capital & Maintenance	Investigate and finalise the scope of highway drainage improvement works to reduce surface water flooding along Red Cat Lane.	High	FY19	FY19	Highways Authority	Highway Capital Programme FY19	LLFA
2	Red Cat Lane Drainage Improvement Works (Phase 2)	Capital & Maintenance	Works to deliver scheme highway drainage improvements at Red Cat Lane	High	FY20	FY20	Highways Authority	Highway Capital Programme FY20	None
3	Crabtree Lane Drainage Improvement Works (Phase 1)	Capital & Maintenance	Works to remove blockage caused by telegraph post and to reline culvert. This will ensure design capacity is maintained whilst additional measures are explored.	High	FY19	FY19	Lancashire County Council	Highway Capital Programme FY19	None
4	Crabtree Lane Drainage Improvement Works (Phase 2a)	Financial / Resourcing	Feasibility / design of scheme to reduce the risk of surface water flooding to properties along Crabtree Lane north of the railway line. Feasibility to identify funding sources along with engagement with residents and landowners.	High	FY20	FY20	LLFA	Highway Capital Programme FY20	Residents and Property / Land Owners
5	Property Level Protection to Properties along Crabtree Lane (Phase 2b)	Capital & Maintenance	Consider implementing property level protection measures to properties along Crabtree Lane prior to capital works (Action 4). This will require engagement with property owners, property surveys, identification of funding and implementation.	High	FY19	FY19	Lancashire County Council	Need to explore funding sources	Property Owners
6	Crabtree Lane Drainage Improvement Works (Phase 3)	Capital & Maintenance	Works to deliver scheme to reduce the risk of surface water flooding to properties along Crabtree Lane north of the railway line.	High	FY21	FY21	Lancashire County Council	Highway Capital Programme FY21	Residents and Property / Land Owners
7	Crabtree Lane culvert improvement	Communication / Partnerships	Engage with Network Rail to understand if upsizing of the culvert beneath the railway line at Crabtree lane is viable	High	FY19	FY19	Lancashire County Council	Officer resources	Network Rail
8	Community Engagement and source control at property	Communication / Partnerships	Continue to engage with the community via the Burscough Flood Group. Provide support during and after surface water flood events, help and support the development of Flood Action Plans to help the community become more prepared and resilient. This should include sharing the outcomes of this SWMP investigation. In addition, work with the Action Group and RMA's to promote the use of source control measures at a property level to provide attenuation in heavily urbanised upstream catchments. Engagement and investigation into provision of SuDS at schools within B2.	Medium	Ongoing	Ongoing	LLFA	Officer resources	United Utilities and West Lancashire Borough Council
9	Update asset register	Communication / Partnership	GIS asset data and information contained within this SWMP should be used to update the Lancashire County Council asset register. This currently includes information on Ordinary Watercourses, culverts, sewers, ownership. Share asset register with RMAs.	Medium	FY19	FY19	LLFA	Officer resources	All RMAs
10	Report Flood Incidents	Communication / Partnerships	Continue to report flooding incidents to the relevant organisations via customers services and websites: **Highway flooding:** report to Lancashire County Council via: https://www.lancashire.gov.uk/roads-parking-and-travel/report-it/flooding-and-drainage/ **Surface water flooding, groundwater flooding and potential issues with Ordinary Watercourses:** report to Lancashire County Council via: https://www.lancashire.gov.uk/roads-parking-and-travel/report-it/flooding-and-drainage/ **Foul flooding:** report to United Utilities via: https://www.unitedutilities.com/emergencies/got-a-problem/flooding/sewage-flooding-your-home-or-garden/	Medium	Ongoing	Ongoing	Residents and Property / Land Owners	N/A	Burscough Flood Group
11	Flood Incident Reporting System	Communication / Partnerships	Explore opportunities to improve existing flood incident report system to allow residents and property / land owners to report incidents efficiently. This should consider the type and form of data to be collected to aid future investigations and studies. This should also consider the sharing of flood incident data between RMAs.	Medium	Ongoing	Ongoing	Lancashire County Council	Council Resources	West Lancashire Borough Council, United Utilities, Environment Agency
12	Investigating Flood Incidents	Communication / Partnerships	Investigate surface water flooding incidents as required under Section 19 of the Flood and Water Management Act and in line with the Lancashire Local Flood Risk Management Strategy. Produce and publish Section 19 Investigation as required.	Low	Ongoing	Ongoing	LLFA	Officer resources	All Risk Management Authorities
13	Highway Capital and Maintenance	Capital & Maintenance	Continue to maintain highway drainage network and investigate incidents. Undertake relevant action such as gully clearing, adding chambers, minor drainage repairs etc. Identify need for capital works and include on Highway Capital Programme.	Medium	Ongoing	Ongoing	Highways Authority	Highway Drainage Maintenance Programme	None

Ref	Action	Action Type	Output / Benefits	Priority	Target Start Date	Target End Date	Action Owner / Lead Partner	Budget / Funding	Stakeholder Support
14	Review Gully Maintenance Regime	Capital & Maintenance	Potential opportunity to review the existing gully maintenance regime using information contained in this SWMP. This could include reprioritising gullies on P1 (12 month) and P2 (24 months) frequencies. There is also a wider opportunity to explore benefits of data collection and analytics in developing smarter asset maintenance plan.	Low	FY19	FY20	Highways Authority	Council Resources	None
15	Implement Outstanding Recommendations of IDAS Study	Follow-up	Recommendations taken from IDAS: Construct and verify a new integrated hydraulic model, to include all UU assets, as well as receiving watercourses. Undertake conditional surveys on watercourses and drainage ditches. If watercourses under riparian ownership are found to be causing issues, the relevant authorities should liaise with land owners to remedy the issues. Investigate the reported land runoff from fields and assess inflow points to the UU drainage networks. Once the various drainage systems (and their interactions) in Burscough are fully understood, a catchment wide intervention plan should be undertaken to address the widespread issues within the catchment.	Low	Ongoing	Ongoing	United Utilities	TBC	None
16	Burscough Flood Plan	Communication / Partnership	Burscough Parish Council to use findings of this SWMP study and guidance from the Environment Agency and Lancashire County Council to develop a Flood Plan for Burscough. Due to the amount and frequency of highway flooding it is recommended that a plan also included illustrating likely road closure locations and recommended diversion routes to be implemented during time of flooding.	Medium	FY19	FY20	Burscough Parish Council	Council Resources	Burscough Flood Group, Environment Agency and Lancashire County Council
17	Review Planning Guidance	Policy Action	Review and update Planning Applications - Drainage, Flood Risk and Sustainability guidance available to developers, residents and property / land owners.	Low	FY20	FY20	West Lancashire Borough Council	Council Resources	None
18	Strategic Flood Risk Assessment	Policy Action	Use the findings of this SWMP to update the West Lancashire Strategic Flood Risk Assessment and application of the Sequential and Exception Tests. The Local Plan was until recently being reviewed but has now been put on hold. The SFRAs are normally updated when the Local Plan is being updated. As things stand now the current Plan runs until 2027, so when the SWMP can be used to update the SFRA Level 1 and 2 is not known at this time.	High	FY25	FY27	West Lancashire Borough Council	Council Resources	None
19	Update Development Control Data	Follow-up	Flood risk GIS data produced in SWMP should be uploaded to Council internal GIS systems to inform future planning applications. WLBC is currently undertaking an extensive review of how it currently operates. The current GIS internal system is likely to change and until an alternative has been found the uploading of the SWMP flood risk data will be delayed.	Medium	FY21	FY21	West Lancashire Borough Council	Council Resources	None
20	Update S.W Flooding Maps	Follow-up	Use the data from this SWMP to inform changes to National Surface Water Flooding Maps	Medium	FY20	FY20	LLFA	Council resources	EA

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