Climate Change Adaptation

Third Round Report

September 2021

WALES&WEST UTILITIES

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1 Introduction

This report is Wales & West Utilities (WWU) third round of reporting to the Department for Environment Food and Rural Affairs (DEFRA) Climate Change Adaptation Reporting Power, as required under the Climate Change Act 2008.

The Climate Change Act 2008 provides the framework for ensuring the UK's ability to adapt to climate change. DEFRA established an 'Adapting to Climate Change Programme' and in November 2009 laid a strategy before Parliament for using the Adaptation Reporting Power (ARP) under the Act. The ARP provides for the Secretary of State to direct reporting organisations (those with functions of a public nature or statutory undertakers) to report on how they are addressing current and future climate impacts. Reports should detail:

- The current and future projected impacts of climate change on their organisation;
- Proposals for adapting to climate change; and
- An assessment of progress towards implementing the policies and proposals set out in previous reports.

WWU was launched as an independent gas distribution business in June 2005 following the sale of the gas network for Wales and the South West of England. With more than 35,000 km of mains, WWU transports gas to the homes and businesses of 2.5 million consumers across a geography covering 1/6th of the UK and serving a population of 7.4 million people.

WWU is a natural monopoly funded by gas consumers under the regulation of Ofgem and the Health and Safety Executive. WWU is committed to delivering a safe and reliable gas network whilst providing value for money to consumers. Assessing the risks associated with climate change against our commitments is a fundamental part of our wider business strategy. Financial allowances are agreed in funding cycles to deliver approved work streams. Future adaptation actions identified are also subjected to these funding mechanisms.

1.1 Objectives

This report builds on the risks WWU identified in the first round (ARP1 2011) and second round (ARP2 2015) reports. Using information drawn from the UK Climate Projection 2009 (UKCP09) and 2018 scenarios (UKCP18) and engagement with the Energy Network Association (ENA), the key risks and opportunities facing the WWU business will be assessed.

Innovative assessment work by WWU has also been undertaken since ARP2, applying quantitative modelling and emissions projections to clarify physical risks. These are used to determine worst case risk scenarios correlated against the lifetimes of existing assets.

Key objectives of the report include:

- Identify any material risk changes since previous reporting rounds in relation to the companies' functions;
- Describe how WWU have been addressing risks identified in the previous reporting round (ARP2) including innovative approaches;
- Describe WWU's preparedness for future impacts and risks, potential adaptation, and mitigation options;
- Outline barriers and interdependencies to climate change resilience for WWU; and
- Highlight any opportunities and benefits that may arise from the climate risks.

Note: UKCP18 data has not indicated there are any new hazards likely to impact energy network operations since previous reporting rounds (ENA 2021[1]). The risk categories assessed in ARP2 are therefore still applicable. This provides network operators, such as WWU, with the assurance that measures and approaches used in adaptation and protection will continue to support network operation as climate change impacts are realised.

[1] *Adaptation to Climate Change Task Group, Gas & Electricity Transmission and Distribution Network Companies 3rd Round Climate Change Adaptation Report March 2021*

2 First and Second Round ARP Reports

2.1 First Round

The WWU first round report (ARP1) was submitted in June 2011.

Using information drawn from UKCP09 and working alongside the Meteorological Office Hadley Research Centre, the Environment Agency (EA) and the Scottish Environmental Protection Agency (SEPA), the key risks and opportunities facing the businesses were identified. Emissions projections to 2050 were used to determine worst case scenarios.

Account was taken of expected increases in the number, frequency, and intensity of weather events. The main categories of weather events and environmental risks identified in the 1st report were as follows:

- Flooding and heavy rainfall (including saturated ground conditions);
- Snow and ice;
- Increases in temperature, heat waves and drought conditions;
- Coastal erosion from sea level rise;
- River erosion; and
- Storm events and high winds.

The risk methodology and categorisation identified several potentially vulnerable areas and highlighted the mitigation measures either in place or that needed to be developed further. The climate change risks to WWU requiring action in the short term were recognised as:

1. Riverbed and bank erosion exposing pipelines;
2. Flooding impacts to assets;
3. River water volumes damaging over-river crossings;
4. Impacts of climate change on WWU's supply chain; and
5. Mobilisation and migration of land contaminants.

ARP1 highlighted that network assets and processes may be vulnerable to certain aspects of climate change. However, the national and regional infrastructure was classed as having a significant degree of resilience to these impacts and none of the identified risks were high. The management of these risks was recognised as embedded within overall risk management processes to ensure that any appropriate actions are recorded and completed. Responsibility and

ownership of these action plans ensured their timely delivery, and climate change adaptation was subject to the same level of ongoing review and evaluation as other business risks.

It was noted the inherent resilience of the gas distribution infrastructure is largely due to most assets being located underground, with greater resilience built into the gas transmission network compared to the distribution network. Those assets most at risk from weather and climate were those found above ground; typically, large Pressure Reducing Installations (PRIs), critical sites such as data centres, and pipelines near watercourses. Impacts are usually localised to the asset and the process it supports and were unlikely to lead to a loss of supply or result in a risk to the system.

The report also recognised that prolonged periods of extreme weather could have a significant impact on the ability of the workforce to access and carry out their roles, particularly field-based engineers. They could also impact on the ability to conduct 'business as usual' activities because of the reliance on appropriate adaptation of other major infrastructure, such as telecommunications and transport. Impacts on the operation of supply chain businesses and the continued availability of equipment were also flagged as issues to be considered. The environmental impact of companies' assets could also be affected by the mobilisation and migration of land contaminants from flooding and ground saturation.

These interdependencies can be mitigated through the implementation of maintenance and inspection regimes, the development of flood defence measures, the availability of necessary equipment, up to date contingency measures and by ensuring Business Continuity Management Plans are in place.

2.2 Second Round

The second-round report (ARP2) was submitted in July 2015. It was structured to address the following key questions:

Understanding Climate Risk

UKCP09 was still the primary source of data with respect to assessing climate risks for ARP2. However, all the Gas Distribution Network operators (GDNs) experienced severe weather events between 2011 and 2015. This provided further insight into, and confidence in the resilience of the gas networks infrastructure.

A pilot mapping study (See Section 5.2) was instigated by WWU over a small area in mid-Wales containing a broad range of gas distribution assets linked to EU water framework directive catchments. The pilot study was initiated to close the gap between UKCP09 forecasts and actual physical impacts as a small-scale proof of concept study. The aim was to inform and enable reporting authorities and wider users to make justified investment decisions to adapt to climate change.

The pilot study led to the development of a mapping tool after ARP2 to analyse and query asset data against floodplain growth, increasing flood depth and escalating rates of riverbed and bank

erosion. The availability of such an asset management tool enables a significant shift in the assessment of impact likelihood and consequence. Presentation of the findings of the pilot study were well received by Defra, The Department of Energy and Climate Change (DECC), The Met Office and HM Treasury (Infrastructure UK).

For ARP2, there were limited changes to WWUs risk assessment with regards to overall risk categories. Those with minor changes in risk related largely to slight alterations to likelihood scoring (mainly revised down rather than up). These revisions were predominantly due to experiences up to 2015, existing controls, and that "notable changes in climate between 2015 and 2020 are unlikely".

Understanding Uncertainties

The overall level of uncertainty for gas networks was viewed as low, as the sector has a high level of inherent resilience due to the level of safety awareness and regulatory overview.

Barriers and Interdependencies

Details of fundamental interdependencies with transport, telecommunications and the local authority sectors were identified. Within the gas sector, it was recognised that high levels of cooperation exist between all the network operators to manage emergency situations, including major incident simulations. This, together with joint working via the ENA, helps to create an environment of cooperation to address climate risk.

Monitoring and Evaluating

In 2013 WWU introduced the concept of 'contaminated land and the risks faced by climate change' to DEFRA in London, with subsequent site visits by DEFRA, Natural Resources Wales (NRW), and the other GDNs to see the works in progress.

WWU won the Business in the Community 'Wales Environment Award' in 2013 for taking a dual approach to climate change, focussing on both mitigation and adaptation. This was in reference to WWUs world's first contaminated land remediation projects driven by climate change forecasts.

Through coaching and development, our frameworks of environmental consultants and contractors were the first to deliver climate change considerations in contaminated land projects. Our better-than-best practice approach was the subject of a national conference and workshop for the Construction Industry Research & Information Association (CIRIA), which was delivered to environmental regulators, other clients, and supply chain businesses in June 2015.

WWU identified that the availability of climate change impact mapping will allow detailed interrogation of assets which interact with projected flooding areas and rivers with significant erosion potential. Such predictive analytics will support the re-prioritisation and frequency of asset monitoring.

Opportunities and Benefits

Limited opportunities and benefits were identified during ARP2. Minimal financial benefits from implementing adaptation were identified by 2015, but there was an appreciation of the benefit of early adaptation response where necessary to help mitigate future costs.

3 Risk Assessment Approach: Third Round

The approach for this third-round report has built on ARP1 and ARP2, incorporating multiple information sources and the application of more current UKCP18 information.

3.1 UKCP18 vs UKCP09

The ARP1 and ARP2 reports used UKCP09 data to inform an understanding of potential climate risks. Since 2015 UKCP09 has been replaced with UKCP18. The differences between UKCP09 and UKCP18 are explained by the UK Met Office[2]. Key differences include:

- UKCP09 used the Special Report on Emissions Scenarios (SRES) which were reported on in the Intergovernmental Panel on Climate Change's 4th assessment report (IPCC 2007). UKCP18 uses new emissions scenarios called Representative Concentration Pathways (RCPs). RCPs are the emissions scenarios used in the 5th IPCC report (IPCC 2013);
- The use of multiple data products, observations and resolution has increased in UKCP18 e.g., regional projections; and
- UKCP18 reports use a different baseline period from UKCP09. UKCP18 uses a 20-year base line period of 1981-2000, as opposed to the 30-year (1961-1990) baseline period in UKCP09.

A summary comparison between UKCP09 and UKCP18 emissions scenarios is provided in Table 3-1. Key projections from UKCP18 are summarised in Section 4 where relevant.

[2] *https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-guidance-ukcp18-for-ukcp09-users.pdf*

Table 3-1 Comparison of UKCP09 and UKCP18 Emissions Scenarios - Source IPCC 2013

SRES Emissions Scenario UKCP09	RCP Emissions Scenarios UKCP18	Increase in global mean surface temperature 1850-1900 to 2081-2100 (°C)
None	RCP 2.6	1.6 (0.9-2.3)
Low	RCP4.5	2.4 (1.7-3.2)
Low to Medium	RCP6.0	2.8 (2.0-3.7)
High	RCP8.5	4.3 (3.2-5.4)

SRES - Special Report on Emissions Scenarios Applied for UKCP09

RCP - Representative Concentration Pathways Applied for UKCP18

Temperature values in brackets represent the projected range

3.2 Risk and Adaptation Workshop

Critical to the third-round assessment process was the WWU climate change risk and adaptation workshop, conducted on July 8th, 2021. Relevant WWU asset managers were in attendance to provide updates on risks and adaptation work that that has taken place since 2015. Where further information was required, questions were passed to senior managers and area experts within WWU whose departments will be affected by climate change. The workshop was prepared and facilitated by an external team of climate change adaption specialists.

The workshop had the following key objectives:

- Second-round risk categories and scores were systematically reviewed and updated for the third-round report;
- Knowledge of changing climate conditions, WWU operational changes, COVID-19 outcomes, WWU climate studies, and extreme climate events since 2015 were discussed and the results captured; and
- New relevant risks highlighted in the 2021 ENA report were raised and scored.

The updated risk scores are provided in Appendix A. A summary of the overall approach and key findings is presented below.

3.3 Assessment Period

Risks have been assessed for present day conditions and projected up to 2050. These dates fit with WWU's short and long-term analysis requirements. 2050 encompasses the operating life of the majority of WWU's assets and so fits well with long term adaptation plans and analysis.

3.4 Risk Scoring

Through research and discussion, the consequence and likelihood of the risks established in ARP1 and ARP2 have been re-scored in line with WWUs Business Risk Model (BRM), shown in Figure 3-1. The BRM sets out the severity and probability classes for consequence and likelihood as defined for WWUs operations. The BRM criteria used for consequence and likelihood are provided in Appendix A.

Figure 3-1 WWU BRM

	Consequence				
Likelihood	1 Insignificant	2 Minor	3 Moderate	4 Significant	5 Serious
5 Almost Certain					Very High Risk
4 Likely				HIGH	
3 Possible		MEDIUM			
2 Unlikely	LOW				
1 Rare					

All risks were given consequence scores based on manager feedback. Likelihood scores were also established by using climate change projections in line with each risk's impact threshold.

Information continues to be collected upon which likelihood scores are based. As the knowledge and evidence base increases with new information, so do the associated confidence scores in the data. This refinement and understanding have been translated into a 'confidence' score to assist in the justification for any investment in adaptive measures.

3.5 Risk Owner

Climate change risks will be assigned to the relevant asset / business process owner, in line with the BRM. The owner will provide ongoing acknowledgement and consideration of asset or business process risks assigned to them. Ongoing assessment of climate risk is based on UKCP18 scenarios, direct experience of extreme weather events, and other climate change forecasting models and data sources.

3.6 Recommended Future Actions

Section 4 provides an assessment of current risks from each climate variable, and the adaptation work taken by WWU to date. It also provides recommended future actions that will improve WWU's resilience to climate change.

Currently, WWUs active management of climate risks is primarily embedded within day-to-day maintenance operations. Recommended future actions will need to consider future funding cycles for WWU and will require support as and when it becomes available.

3.7 Stakeholder Engagement

WWU have a history of engaging in stakeholder engagement relating to climate change adaptation. WWU have previously collaborated with organisations such as DEFRA, DECC, the Environment Agency, the Welsh Government, and the ENA.

Prior to developing this third-round report, WWU worked with the ENA, Electricity Distribution Network Operators (DNO) and other GDN members as part of the 'Adaptation to Climate Change Task Group'. A joint report was produced in March 2021. This collaborative approach is indicative of a more cohesive, interactive future energy network.

WWU will continue to engage with stakeholders and other operators to share knowledge and experiences to identify risks and opportunities from climate change.

4 Risk Assessment Summary

The key outcomes of the third-round risk assessment process are summarised in Sections 4.1 to 4.6.

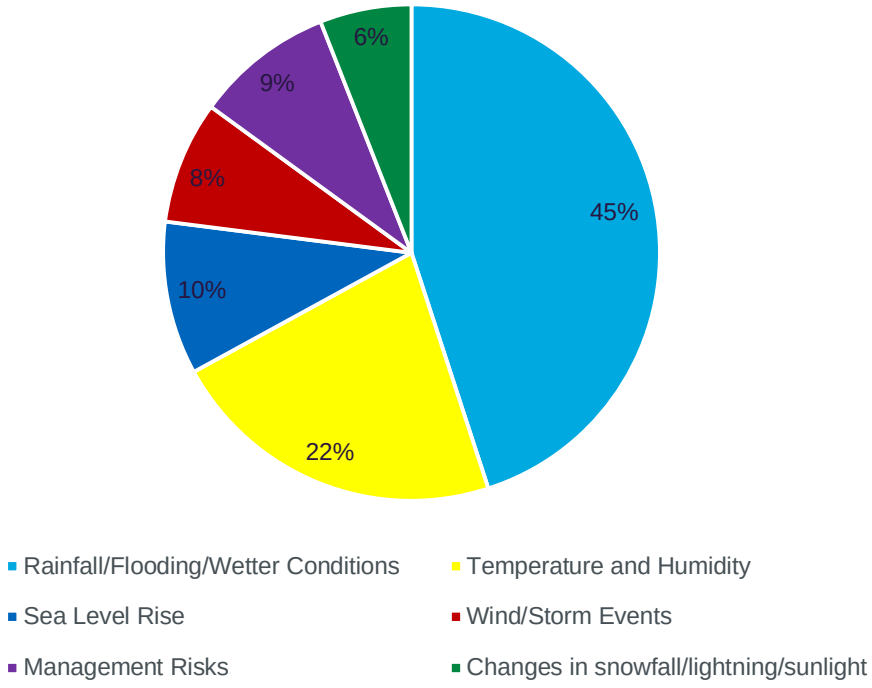
The risks have been grouped under the main climate risk categories (see Figure 4-1).

The two categories accounting for two thirds of all identified risks are:

- The effect of increased rainfall and flooding (Section 4.1) and
- Changing temperature (Section 4.2).

Sea Level Rise (SLR), the increasing frequency of strong winds and storm events, climate change management risks, and changes in snowfall, lightning and available sunlight are also considered.

Figure 4-1 Breakdown of Third Round Risks by Category



4.1 Rainfall/Flooding

"Recent UK observations show a high level of variability in precipitation from year to year, with a slight overall increase in UK winter precipitation in recent decades.

UKCP18 projections show a pattern of larger increases in winter precipitation over southern and central England and some coastal regions towards the end of the century. Summer rainfall reductions tend to be largest in the south of England….".

https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-factsheet-precipitation.pdf

4.1.1 Increase in Peak Water / Flooding

Multiple potential vulnerabilities for WWU arise from changes in rainfall and peak water flows, resulting in more frequent and more intense flooding by 2050. This applies to both pluvial and fluvial flooding, mainly driven by changes in winter rainfall. Pluvial and fluvial flooding is defined as:

- Pluvial flooding - occurs when an extreme rainfall event creates a flood independent of a flowing water body such as river or stream, for example pluvial overflow of an urban drainage system.
- Fluvial flooding - occurs when the water level in a river, lake or stream rises and overflows onto the surrounding banks, shores, and neighbouring land.

Assessed risks are provided in Table 4-1. 2050 risk scores are provided in Figure 4-2. Summary comments are provided in Table 4-2.

Table 4-1 Risks from Increased Rainfall, Peak Water Flows and Associated flooding

WWU Climate Change Risk Code[3]	Risk (Function / Services / Assets Affected)
09, 10	Access to place of work for critical and noncritical staff
17, 18 44, 45 50, 51 54, 55	Increase in both Pluvial and Fluvial flooding: • Difficult access to less than < and greater than > 7bar Pressure Reduction Installations (PRIs) in emergency situations • Operating difficulties due to loss of electrics on < and >7bar PRIs
19, 20, 21, 77	Increase in peak fluvial waters, riverbed, and bank erosion: • Under river pipes becoming exposed and damaged • Pipes parallel to rivers become exposed and damaged from meandering • Over River Pipes (ORP) impacted by debris contact, water volume and velocity
28, 46, 49	Loss of asset Integrity: • Water damage to data loggers • General deterioration of site assets • Impact on cathodic protection
29	PRIs are currently protected to current flood depths, not protected to future flood depths
36	Flooding due to insufficient depot drainage, operational impacts
37, 38 52, 53	Pluvial and fluvial flooding of National Transmission System (NTS) offtakes: • Difficult access in emergency situations • Operating difficulties due to loss of electrics

[3] *Further detail on individual risk codes is provided in Risk Assessment Table Appendix A.*

Figure 4-2 Increased Rainfall, Peak water, and Associated flooding - 2050 Risk Scores

	Consequence				
Likelihood	1 Insignificant	2 Minor	3 Moderate	4 Significant	5 Serious
5 Almost Certain					
4 Likely			19		
3 Possible		46 36, 77	20, 21		
2 Unlikely	28, 37, 38	09, 10, 53	17, 18, 50, 51, 29, 52, 54, 55		
1 Rare		44, 45, 49			

Low Risk	Medium Risk	High Risk	Very High Risk

Table 4-2 Increased Rainfall, Peak water, and Associated flooding - Summary of Risks, WWU Actions and Recommendations

Summary	
Hazard	Increased rainfall, flooding, riverbed, and bank erosion
Key risk areas	13 of the 23 risks assessed were scored as Medium for 2050. One risk was scored as High - 'Under river pipes become exposed and damaged'. Risks around changes in river flows affecting pipe integrity are a recognised concern. WWU have a considerable number of water crossings and lines running parallel to, under and over rivers. For example, incidents have occurred during 2020-2021 where ORPs have been impacted by debris from peak fluvial flows.

Changes in risk since ARP2	The single High risk from under river pipes becoming exposed and damaged is scored the same as during ARP2. However there has been an overall reduction in risk since ARP2 due to multiple management actions taken by WWU. For example, several risks have been reduced from Medium to Low due to assessment work clarifying asset vulnerabilities. The risk of loss of work site access following flooding, for critical and noncritical staff, has reduced since ARP2 from Medium to Low. Mapping and case study work showed key access routes were unlikely to be critically affected by flooding. Working from home directives during COVID has also changed understanding of risks for non-critical staff, who can now work remotely as required.
Adaptation and mitigation actions taken by WWU since ARP2	Flood risk assessment and case study work conducted since 2015 has allowed for a better understanding of the risks to WWU assets (See Section 5.1), acting as a tool to identify and manage vulnerabilities. Example actions that have been taken are: • All newly installed Electrical and Instrumentation (E&I) equipment is now elevated on plinths with raised electrics. • WWU are now avoiding the installation of ORPs where possible, limiting new vulnerable infrastructure. • Mapping data can be interrogated to identify risks to ORPs. No current plan exists to replace all existing ORPs so a degree of risk will remain for 2050. • Rivers crossings on the High Pressure (HP) network are visited on a risk-based frequency (1-5 years) with a depth of cover survey undertaken as part of the visit. • Each depot has its own water / drainage plan which allows review of the flood risk to be undertaken.
How these actions impact on risk level, and risk tolerability	WWU have an improved understanding of flood risks since ARP2. Flood risks are currently considered acceptable at a company level due to the limited number of facilities critically exposed and the ongoing monitoring/mitigation and adaptation actions taken by WWU.
Recommended further actions	The risks from flooding are to continue to be monitored and assessed. It is recommended that this third-round assessment should be challenged whenever extreme events occur. Dependent on funding, additional studies can be conducted at critical sites to mitigate damage to the most vulnerable assets/equipment such as ORPs. A specific replacement program for very high risk existing ORPs can be considered.

4.1.2 Increase in Ground Saturation / Wetter Conditions

It is likely that overall operating conditions will be wetter by 2050, presenting risks such as increased ground saturation and ground movement, changes in the water table and a wetter environment for workers. The climate change risks assessed are provided in Table 4-3. The overall level of risk for 2050 is provided in Figure 4-3.

Table 4-3 Risks Associated with Changes in Ground Saturation / Wetter Conditions

WWU Climate Change Risk Code	Risk (Function / Services / Assets Affected)
6, 24, 61	Increase in winter ground saturation: • Ground saturation leading to gas escapes • Increased water ingress to gasholders • Effect on cathodic protection
13, 16, 48	Increase in water table, pipes submerged in water: • Increased corrosion of pipes • Increased water ingress to pipes • Floatation risk to large diameter pipes
60	Increased movement of land contaminants, additional statutory liability, and risk to sensitive receptors.
14, 15, 59, 78	Increase in winter ground saturation and ground movement leading to increased pipe movements: • Pipes become exposed • Increased number and size of fractures on metallic mains • Gradual ground movement will increase the stress on gas assets • Intense one-off large-scale land movement resulting in loss of a pipeline
26, 27, 31, 32	Increase in winter mean precipitation, general wetter working conditions: • Reduction in reuse of excavated and recycled material • Increased time and difficulties with setting concrete • Difficulties with trench water
7	Decrease in summer ground saturation, ground saturation leading to gas escapes

Figure 4-3 Changes in ground saturation / wetter conditions - 2050 Risk Scores

	Consequence				
Likelihood	1 Insignificant	2 Minor	3 Moderate	4 Significant	5 Serious
5 Almost Certain					
4 Likely					
3 Possible	26	14, 15, 32			
2 Unlikely	31	6, 13, 16, 24, 27, 48, 61		78	
1 Rare		7, 59	60		

Table 4-4 Changes in ground saturation / wetter Conditions - Summary of Risks, WWU Actions and Recommendations

Summary	
Hazard	Changes in ground saturation, ground movement, raised water table, wetter conditions
Key risk areas	11 of the 16 risks associated with ground saturation and wetter conditions were scored as Low. The remaining 5 were scored as Medium, covering increased ground movement, pipes becoming exposed, moving and/ or fractured. Increased movement of land contaminants within a higher water table are also a risk. This risk is linked to associated increase in statutory liability under Part IIA of the Environment Act (1990). Currently, contaminated land risk assessment takes place as part of WWUs Contaminated Land Management Program (CLMP) for former gasworks sites.
Changes in risk since ARP2	In the ARP2 assessment, the potential for increased movement of ground contaminants was scored as High for 2050. This is now reduced to Medium, with the work of the CLMP reducing the likelihood. The risk of water ingress to pipes due to them being more frequently submerged and/or corroded has decreased from Medium to Low. This is due to the ongoing program to replace metal pipes with Polyethylene (PE) pipes.
Actions taken by WWU since ARP2	Since 2015 WWUs risk management of wetter conditions has improved and developed, for example: • Ongoing replacement of metal pipes with PE pipes.

	• High-Pressure and Low-Pressure (LP) lines are now being actively route walked. Inspection for ground movement is now included as part of the regular general route surveys. Depth to cover surveys on HP lines are undertaken every five years. • Use of innovative techniques for surveys such as the use of drones is being actively investigated by WWU to monitor and prevent third party impacts. • A sustained CLMP for former gasworks sites has reduced the overall presence of contaminants and the potential for them to mobilise. • Use of any weed killing herbicides is controlled to manage contaminants to below established thresholds.
How these actions impact on risk level, and risk tolerability	The continuous review and innovative improvement in WWU's monitoring and maintenance program will limit any increase in overall risks as conditions become wetter and ground saturation increases. The potential for contaminants to be introduced and subsequently transported through groundwater has been reduced since ARP2 and will be decreased further by 2050.
Recommended further actions	WWUs CLMP to continue to assess statutory contaminated land risks.

4.2 Temperature

"Observations show an overall annual warming in the UK during recent decades.

Over land the general trend of climate change in the 21st century projected by UKCP18 is similar to UKCP09, with a move towards warmer, wetter winters and hotter, drier summers. However, natural variations mean that some cold winters, some dry winters, some cool summers, and some wet summers will still occur. In summer there is a pronounced north/south contrast, with greater increases in maximum summer temperatures over the southern UK compared to northern Scotland."

https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-fact-sheet-temperature.pdf

Changes in temperature and humidity also present a wide of range of direct and indirect risks to WWU operations see Table 4-5. The overall level of risk for 2050 is provided in Figure 4-4.

Table 4-5 Risks associated with Changes in Temperature and Humidity

WWU CC Risk Code	Risk - Function, Services Assets Affected
1, 56, 57, 58, 76	Increase in peak temperatures: • Increased demand on WWU air conditioning units • Increased demand for cooling at IT server data centres • Requirement for dehumidifiers at IT server data centres • Potential overheating of PC's • Overheating of vehicles
11, 30, 35	Warmer working conditions: • Heat exhaustion of engineers • Effects on engineer's welfare • Changing requirements of Personal Protective Equipment (PPE)
22, 25	Annual mean humidity increase: • Additional sweat on pipes causing corrosion and associated maintenance increase • Increase moisture in atmosphere, affecting PE fusion creating issues with bonding of pipe joints
23, 39, 62, 71, 81	Increase in temperature, operational issues: • Change in pipe thermal conductivity • Change to the specific gravity of gas, difficulties meeting regulatory requirements • Warmer temperatures impacting compressor efficiencies, lower gas pressure supplied to offtakes from national gas transmission pipelines • Increase in storeroom temperatures impacting on chemical storage • Change in vegetation growth
66, 69, 80, 85	Drought: • Limited water supply, creating, difficulties in performing hydrostatic testing • Drought, wildfire, leading to damage of WWU assets • Ground movement due to drought conditions and dry ground

Figure 4-4 Changes in Temperature and Humidity - 2050 Risk Scores

	Consequence				
Likelihood	1 Insignificant	2 Minor	3 Moderate	4 Significant	5 Serious
5 Almost Certain					
4 Likely					
3 Possible	1, 56, 57, 58	11, 80			
2 Unlikely	66, 81	22, 25, 30, 39, 62, 71	35, 69, 85		
1 Rare	81	76			

Table 4-6 Temperature and Humidity - Summary of Risks, WWU Actions and Recommendations

Summary	
Hazard	Increased Temperature and Humidity
Key Risk Areas	14 of the 19 risks associated with temperature and humidity were scored as Low. The remaining 5 scored as Medium are focussed on HSE risks associated with higher temperatures, such as heat exhaustion for workers and changing requirements of PPE. Ground movement due to drier conditions was also considered a Medium Risk, as was potential impacts from drought related wildfires.
Changes in risk since ARP2	No risk scores associated with changing temperature or humidity have increased since ARP2. Risks from increased demand on services such as air conditioning and cooling at IT centres have reduced from Medium to Low, due to actions taken by WWU (see below). The Wellbeing and Future Generations Act came into force in April 2016, '*requiring public bodies to do things in pursuit of the economic, social, environmental and cultural well-being of Wales in a way that accords with the sustainable development principle'* The well-being goals are wide ranging, including reference to low carbon strategies and people's physical and mental wellbeing. WWU's HSE standards for working conditions, subject to rising temperatures, is required to align with the act.

Actions taken by WWU since ARP2	Air conditioning systems in the main office have been upgraded. WWU have a fully automated building management system fed from boilers and a chiller which controls the temperature, set to auto switch off during evenings, weekends and bank holidays. Annually serviced in line with manufacturers guidelines. With regards to working conditions, ongoing review of HSE protocols acknowledges the effects of warmer temperatures for field engineers. Provision of water and amenities are provided as required and defined working temperature thresholds agreed for field operations.
How these actions impact on risk level, and risk tolerability	The overall robustness of services infrastructure potentially affected by higher temperatures has improved. Awareness of the effect of heat on workers welfare and its integration into standard HSE practices will ensure any increase in risks are managed up to 2050.
Recommended further actions	Future upgrades to other air conditioning systems to be considered. WWU will conduct a regular review of working conditions guidance for high temperatures, aligned with the Wellbeing and Future Generations Act.

4.3 Sea Level Rise

"UK tide gauge records show substantial year-to-year changes in coastal water levels (typically several centimetres)[1].

The UKCP18 sea level projections are consistently larger than in UKCP09 for similar emissions scenarios. However, UKCP18 also includes a lower emissions scenario that assumes more mitigation. UKCP18 shows the amount of sea level rise depends on the location around the UK and increases with higher emissions scenarios. No evidence shows significant changes in future storm surges. Extreme sea levels will increase due to the rise in mean sea level."

https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-fact-sheet-sea-level-rise-and-storm-surge.pdf

Compared to changes in rainfall and temperature, sea level rise (SLR) presents a lower risk to WWU due to the limited number of assets close to the coast. However, SLR risks still need to be considered with respect to tidal flooding (See Table 4-7). The overall level of risk for 2050 is provided in Figure 4-5. Discussion is provided in Table 4-8.

Table 4-7 Risks associated with Sea Level Rise, Flooding

WWU CC Risk Code	Risk - Function, Services Assets Affected
2, 42 3, 43	• Difficult access to < and > 7bar PRIs in emergency situations following tidal flooding • Operating difficulties due to loss of electrics on < and > 7bar PRIs following tidal flooding
4, 5, 47	• Increased corrosion of pipes following tidal flooding • Pipes submerged in water with low pressure pipelines floating • Pipes submerged in water with large diameter pipelines floating
40, 41	• Difficult access to NTS Offtakes in emergency situations • Operating difficulties due to loss of electrics on NTS Offtakes

Figure 4-5 Sea Level Rise and Coastal Flooding of Assets 2050 Risk Scores

	Consequence				
Likelihood	1 Insignificant	2 Minor	3 Moderate	4 Significant	5 Serious
5 Almost Certain					
4 Likely					
3 Possible					
2 Unlikely		2, 3, 4, 5, 40, 41, 42, 43, 47			
1 Rare					

Table 4-8 Sea Level Rise - Summary of Risks, WWU Actions and Recommendations

Summary	
Hazard	Tidal flooding of assets due to SLR.
Key risk areas	All risks associated with SLR were scored as Low. Key considerations included access and operation of PRIs and NTS offtakes following tidal flooding, and the increased risk of corroded and submerged pipes. With respect to submerged pipes, protective coatings are currently used. Seawater corrosion incidents are historically rare with cathodic protection in place. Most of WWUs HP pipelines do not run close to the coast, although the HP line through the Menai straights is an example where SLR could have an impact. It is noted that PE pipes are at higher risk from floating compared to steel, so risks from floating are likely to rise as PE pipes become more prevalent.
Changes in risk since the second round	Due to an improved understanding of vulnerabilities: • Difficult access to NTS offtakes in emergency situations was rescored as Low in this third round • Access and operating difficulties to >7bar PRIs after flooding is also now scored as Low.
Actions taken by WWU since the second round	Case study work (see Section 5.2.1) by WWU clarified the risks associated with tidal flooding. Flood Risk Assessments (FRAs) are now undertaken for new infrastructure, flood defences have been/are being actioned/investigated. Risks from corroded and submerged pipes are regularly mitigated by the maintenance schedule.
How these actions impact on risk level, and risk tolerability	Mapping and case study work by WWU has improved understanding of the risks from SLR, reduced the uncertainties and enabled the prioritisation of management actions.
Recommended further actions	The risks from SLR and extreme events such as storm surge are to be monitored. This round 3 assessment should be challenged whenever extreme events occur. WWU has a remit to increase engagement with Natural Resources Wales and the Environment Agency to improve understanding on how their strategy for flood defences affects WWU assets. Subject to funding support, additional studies can be conducted at critical sites to mitigate damage to the most vulnerable equipment e.g., to ensure critical equipment remains above predicted worst case scenario tidal flood depths.

4.4 Wind

> *"There are no compelling trends in storminess, as determined by maximum gust speeds, from the UK wind network over the last four decades.*
>
> *The global projections over the UK show an increase in near surface wind speeds for the second half of the 21st century for the winter season when more significant impacts of wind are experienced. This is accompanied by an increase in frequency of winter storms over the UK. However, the increase in wind speeds is modest compared to interannual variability for some models."*
>
> https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/factsheets

Changes in the likelihood and frequency of extreme winds present several operational and safety risks (See Table 4-9). The overall level of risk for 2050 is provided in Figure 4-6.

Table 4-9 Risks associated with Increased Frequency of Strong Wind

WWU CC Risk Code	Risk - Function, Services Assets Affected
65, 67, 68, 72, 73, 74, 75	Increased frequency of strong winds: • Material blown off site • Issues with remaining gasholder inspections • Working at height • Damage to telemetry masts • Damage to WWU assets and staff from material / uprooted tree • Dust migration increase • Movement of signs providing operational guidance to WWU staff

Figure 4-6 Increased Frequency of Strong Wind 2050 Risk Scores

	Consequence				
Likelihood	1 Insignificant	2 Minor	3 Moderate	4 Significant	5 Serious
5 Almost Certain					
4 Likely					
3 Possible	65	68, 72, 73, 74 75			
2 Unlikely					
1 Rare		67			

Table 4-10 Wind - Summary of Risks, WWU Actions and Recommendations

Summary	
Hazard	Increased chance of high winds
Key risk areas	Five of seven risks were scored as Medium. These cover potential damage to communications equipment and support infrastructure and working at height in high winds. Risks to gasholders were scored as Low due to WWUs ongoing removal program.
Changes in risk since the second round	Risks from wind were not scored in the ARP2 assessment due to low confidence and limited available data on how changing wind patterns may affect WWU's operations. Confidence has improved to a degree that it has now been formally assessed.
Actions taken by WWU since ARP2	No specific actions taken with respect to risk from wind on communications equipment and support infrastructure. Working at height is to be managed through HSE policy implementation and monitoring.
How these actions impact on risk level, and risk tolerability	Uncertainty remains regarding the level of risk from high winds to support infrastructure e.g., telemetry masts. Maximum operating design thresholds need to be compared against UKCP18 wind speed scenarios.
Recommended further actions	Subject to available funding, a review of key services and infrastructure potentially at risk from extreme winds could take place. A program can be developed to ensure equipment is sufficiently robust.

4.5 Others – Snowfall/Sunlight/Lightning

"Widespread and substantial snow events have occurred in 2018, 2013, 2010 and 2009, but their number and severity have generally declined since the 1960s

For the period 2061-2080, under a high emissions scenario (RCP8.5), projections show a decrease in both falling and lying snow across the UK relative to 1981-2000. Decreases are smaller in mountainous regions (e.g., Scottish Highlands) than in low-lying regions (e.g., southern England)."

https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18_factsheet_snow_jul-2021.pdf

Projections for lightning and cloud cover are not provided under UKCP18. However, the potential for changes were still assessed in line with the ARP2 assessment (see Table 4-11). The overall level of risk for 2050 is provided in Figure 4-7.

Table 4-11 Risks associated with snowfall, sunlight, and lightning

WWU CC Risk Code	Risk - Function, Services Assets Affected (CC Risk Code)
8, 12	Increase in winter cloud cover, decrease in sunlight: • Reduction in energy from WWU solar panels that operate in combination with power from the grid. Solar currently provides power to telemetry and cathodic protection systems • Seasonal affected disorder (SAD) increases
63, 64	Increase instances of lightning: • Damage and loss of control to gas sites following lightning strike • Lightning strike to hilltop radio towers, loss of data transmission to multiple sites
79	Asset impact from snow/ice falls and accumulation

Figure 4-7 Others (Snowfall, sunlight, and lightning) - 2050 Risk Scores

	Consequence				
Likelihood	1 Insignificant	2 Minor	3 Moderate	4 Significant	5 Serious
5 Almost Certain					
4 Likely					
3 Possible		8			
2 Unlikely	12	63, 64, 79			
1 Rare					

Table 4-12 Snowfall/Sunlight/Lightning - Summary of Risks, WWU Actions and Recommendations

Summary	
Hazard	Changes in snowfall, decreased sunlight, higher chance of lightning strikes
Key risk areas	Changes in snowfall are considered of lesser relevance to WWU than to more northern operators. Four out of five risks were scored as Low. The single Medium risk referred to the decrease in received sunlight, reducing energy generated through solar power.
Changes in risk since ARP2	None
Actions taken by WWU since ARP2	No specific actions with respect to snowfall and lightning. Since 2015 there has been an increased focus on mental health issues within WWU e.g., mental health charter and first aiders, reach out and discussion, employee assistance schemes that incorporate SAD.
How these actions impact on risk level, and risk tolerability	The likelihood of unrecognised poor mental health issues for WWU staff has decreased overall.
Recommended further actions	Subject to available funding, a review of key services and infrastructure potentially at risk from increased lighting strikes can take place e.g., telemetry masts.

	Further mitigation can be introduced as required to control damage from direct strikes, with redundancy in place for critical equipment to maintain operations. Assessment for solar installations is based on current sunlight intensity. Projected solar changes will likely affect this modelling, and bigger panels may be required in the future, but it is currently uncertain. This could be an area for further analysis.

4.6 Climate Change Management Risks

The 2021 ENA report highlighted several overarching risks associated with management policies and procedures to address climate change risks. WWU identified potential supply chain and purchasing strategy issues in the second-round assessment. Other new management related risks have now been included in this third-round assessment (see Table 4-13). The overall level of risk for 2050 is provided in Figure 4-8.

Table 4-13 Management Risks

WWU CC Risk Code	Risk - Function, Services Assets Affected
33	Supply chain costs increase due to environmental impact focus
34	Change in purchasing strategy for environmental focus
70	Impact on suppliers from other countries effecting supply of materials
82, 83	Lack of climate change management procedure Lack of specific policies and procedures governing risk assessment process on climate change
84	Risk and action owners not identified at senior leadership team level
86	Business Continuity Management (BCM) plans affected due to severe travel difficulties resulting from extreme weather events
87	Knock on effect on GDN operations from variable electricity supply due to impact on DNOs

Figure 4-8 Management Risks 2050 Risk Scores

	Consequence				
Likelihood	1 Insignificant	2 Minor	3 Moderate	4 Significant	5 Serious
5 Almost Certain					
4 Likely		33	70		
3 Possible		34			
2 Unlikely	86				
1 Rare		82, 83, 84, 87			

Table 4-14 Climate Change Management - Summary of Risks, WWU Actions and Recommendations

Summary	
Hazard	Climate change management protocols within WWU do not adequately manage risks
Key risk areas	The two Medium risks are an increase in supply chain costs and a change in purchasing strategy due to a revised environmental impact focus. The risk scored as High is related to impacts on suppliers from other countries effecting supply of materials to WWU, e.g., operating fuels, supply of steel pipe, supply of plastic pipes. No significant climate related supply issues for WWU have occurred to date. However, risks are likely to increase by 2050, e.g., phasing out of coal affecting steel production and local UK industries, such as the steel industry coming under cost pressure.
Changes in risk since ARP2	There is no increase in risks from those scored in ARP2. To align with the 2021 ENA report[4], five new climate change management risks were introduced, all are scored as Low.
Actions taken by WWU since ARP2	Currently WWU undertake separate internal reporting on climate change management issues. For example, assessment of WWU operations against

[4] *Adaptation to Climate Change Task Group, Gas & Electricity Transmission and Distribution Network Companies 3rd Round Climate Change Adaptation Report March 2021*

	sustainability development goals (SDGs), environmental action planning and Green House Gas (GHG) emissions. Innovation projects have been introduced to reduce WWUs carbon footprint.
How these actions impact on risk level, and risk tolerability	Understanding of overall climate change vulnerabilities and their management within WWU has improved since 2015, with the development and application of multiple actions to clarify, manage and reduce risks. The impact from international suppliers affecting the availability of materials remains High with multiple drivers and potentially significant consequences to WWUs operations.
Recommended further actions	Subject to available funding, a consolidated WWU climate change management/adaptation strategy should be developed and implemented as a key management system (see Section 9). This would include a review of WWUs Business Continuity Plans to ensure supply chain disruptions due to climate issues are managed e.g., alternative suppliers and routes. Collaborative investigation with other GDNs will help better understand and manage risks from international suppliers.

5 Preparedness for Future Impacts and Risks

5.1 Actions against Key Risks

The use of updated UKCP18 guidance on key climate change scenarios, combined with state-of-the-art modelling and field-based verification has increased our understanding of the thresholds for critical climate impacts. This has allowed WWU to prioritise vulnerabilities and focus management and monitoring actions where they are needed most.

Almost half of all identified risks are related to changes in rainfall, and the associated increase in the frequency and intensity of flooding, ground saturation and river erosion. The main work undertaken by WWU since ARP2 has therefore focussed on assessing risks related to these scenarios.

The first-round report identified five areas that required immediate action, predominantly to address the effects of increased rainfall, flooding, and wetter conditions. Between the second reporting round and his third-round significant steps have been taken to address these key risks, reducing the immediate risk profile.

The two risks scored as 'High' in this third-round assessment are:

- 'Under river pipes becoming exposed and damaged'; and
- 'Impact on suppliers from other countries effecting supply of materials.'

As stated in Table 4-2, several actions have been taken by WWU since ARP2 to manage and monitor for increased river erosion and its risks to pipeline integrity.

The impacts of climate change on WWU's supply chain are a complex global issue. It requires collaborative investigation to quantify the risks and to fully understand potential adaptation actions.

5.2 Innovative Approaches

5.2.1 Flood Risk Case Studies

In partnership with data specialist Landmark Information and flood modelling experts Ambiental Risk Analytics, WWU launched Great Britain's first national flood map. This incorporated current and future predictive flood scenarios for the 2020s, 2050s and 2080s, i.e., accounting for the potential effects of climate change.

Delivered via a new Climate Change Adaptation Reporting service, it provides asset managers, infrastructure owners, landowners, their advisors, and reporting organisations with the ability to understand future flood risks on existing assets and infrastructure, and create a plan to adapt in a phased, responsible, and appropriate manner, removing the need to create manual estimations.

The datasets incorporate the latest river flow, rainfall, sea level rise and climate change projections available, and allows the creation of unique, innovative new layers, providing insight into flood hazards and the resulting impacts on property, riverbanks, transport networks and bridges.

Several field-based assessments were undertaken to verify the various mapping datasets around five risk themes:

- Transport Infrastructure;
- Tidal Flooding;
- River Erosion;
- Fluvial and Pluvial Flooding; and
- Bridge Heights.

The results of these assessments were presented in case studies (see example in Appendix B). These case studies demonstrate that critical access routes can be queried against the mapping to deliver high resolution predictive analysis of flooding and erosion risks over time. This desk-based assessment, when used in conjunction with field-based verification, enables the justification of the proactive and adaptive investments required to intervene on future risks.

5.2.2 Emissions Reduction

With respect to addressing the primary cause of climate change, various innovation projects and programs have been introduced to reduce WWUs carbon footprint and GHG emissions.

'Shrinkage' (gas emissions through WWU operations) represents 97% of the businesses carbon footprint. Addressing the various shrinkage emissions sources provides WWU with the greatest opportunity to directly affect carbon emissions. For example, the replacement of ageing metallic mains with plastic pipelines.

In addition, the increased use of renewable energy within WWUs operations, such as internally and externally sourced solar energy power, will be adopted to a significant extent by 2030.

As industry becomes more and more engaged with low carbon solutions, e.g., hydrogen pipelines and hydrogen heating[5], future net zero options are being acknowledged and considered by WWUs Future Energy Team. For example, blending hydrogen into natural gas pipeline networks has been proposed as a means of delivering pure hydrogen to markets, using separation and purification technologies downstream to extract hydrogen from the natural gas blend close to the point of end use[6]. Increased use of plastic piping is also repositioning WWU for a hydrogen future.

Operating protocols, such as pipe temperatures, may also be revised due to carbon neutral commitments, subject to vendor standards.

[5] *https://wwutilities.co.uk/news-and-events/our-response-to-the-hydrogen-strategy/*
[6] *https://www.energynetworks.org/creating-tomorrows-networks/gas-goes-green*

5.3 Monitoring and Evaluation

WWU have put in place several monitoring and evaluation actions to inform immediate and future climate change planning. When developing and implementing actions such as these, where possible they are embedded into existing maintenance programs, providing efficiencies in time, personnel, and budget.

Current examples include:

- Regular preventative monitoring route walks for HP and LP pipelines to ensure the riverbanks are not eroding towards the pipeline;
- Inspection for ground movement now included as part of the regular general route surveys.
- Depth to cover surveys on HP lines undertaken every five years;
- Review of innovative monitoring techniques e.g., use of drones;
- Regular review of HSE protocols to ensure fit for purpose with respect to changing climate conditions e.g., warmer working conditions, mental health awareness;
- Flood risk assessments now undertaken for new infrastructure; and
- Contaminated land remediation program, reduction in risk of mobile contaminants from these redundant sites.

5.4 WWU Adaptation and the UN Sustainable Development Goals

WWU are committed to aligning the business priorities to the United Nations Sustainable Development Goals (SDGs). As a responsible business, alignment to the SDGs shows WWU are committed to increasing the positive and minimising the negative impact we have on communities, the economy and environment. Business ambition and priorities are complementary to these goals while embracing the aspirations of the 'Well-being of Future Generations (Wales) Act' 2015.

Acting as a key economic sector and service, WWUs responsible approach to climate change adaptation directly supports this alignment[7], as we reduce our GHG emissions and work towards carbon neutrality.

We believe the adoption of the UN SDGs by the business will help to drive change and transparency, encouraging more sustainable practices within the utilities sector, and amongst all industries and partners that WWU connects with.

[7] *https://sdgs.un.org/goals/goal13*

6 Understanding Uncertainties

ARP1 and ARP2 viewed the overall level of uncertainty for gas networks as Low, as the sector has a high level of inherent resilience due to the level of safety awareness and regulatory overview. There is no change for this third-round assessment. Levels of uncertainty have remained Low overall.

Progress has been made since the last reporting round to reduce uncertainty in specific critical areas. For example:

- The understanding of threats from flooding has been significantly improved by the mapping project and associated case studies (Section 5.1);
- Information gaps have been/are being closed or reduced through various monitoring and evaluation actions. For example, data is now available on pipeline river locations most susceptible to risks from flooding;
- Maintenance work and route walks are now providing regular information on erosion risks; and
- Flood Risk Assessments are now undertaken for new infrastructure projects.

Certain areas require improved data collection and monitoring to reduce uncertainty, e.g., a defined groundwater monitoring program outside the contaminated land management program is not yet in place to assess for levels and movement of contaminants. Uncertainty is higher for those risks related to WWU's supply chain and certain interdependencies (Section 0). Further work is required to provide greater understanding of these risks' likelihood and consequence.

7 Interdependencies

Interdependencies when assessing climate change risks have not fundamentally changed since the first and second round assessments.

Within the gas sector, high levels of cooperation exist between all the network operators to manage emergency situations including major incident simulations. This, together with joint working via the ENA, helps to create an environment of cooperation to address climate risk.

Interdependencies with transport, telecommunications and the local authority sectors are still applicable to WWU, increasing certain operational risks to the organisation. As stated in the previous assessments, establishing these sectors as co-reporting authorities for climate change would improve overall management and planning.

7.1 Power

A critical interdependency for WWU is with power operators. If climate change results in more frequent disruptions to supply, then operational risks are increased.

The electricity networks are also aware that other infrastructure operators, and society in general are reliant on having a reliable and resilient supply. Network operators and the National Grid Electricity System Operator (NGESO) continue to work to ensure that the UK electricity network remains one of the most reliable networks in the world, and climate change is one of the impacts considered when developing and reinforcing those networks.

The 2021 ENA report[8] identified multiple risks to electricity networks like those for gas networks, for example pluvial, fluvial and tidal flooding, higher temperatures, and ground movement.

WWU have a degree of inbuilt redundancy to mitigate this interdependency with power providers. For example, WWUs NTS offtakes have either gas fired generators or back-up diesel generators. Several of the more critical PRI's with preheating also have back-up generators. Back-up batteries are also in place at all Offtakes / PRI's to maintain telemetry and visibility to system operations in the event of a power outage.

7.2 Gas Demand

An indirect interdependency for WWU is the potential effect on overall gas demand from changing electricity use due to climate change. Gas fired power stations are expected to remain a key component of the UK's future energy mix.

Warmer conditions will likely lead to increased use of air-conditioning systems, both within the organisation itself and in external commercial and domestic environments, particularly in urban

[8] *Adaptation to Climate Change Task Group, Gas & Electricity Transmission and Distribution Network Companies 3rd Round Climate Change Adaptation Report March 2021*

areas. Increased use of air conditioning will lead to a higher drawdown of gas reserves to generate power, impacting domestic supplies.

In contrast, the increased use of renewables such as solar and wind to heat and power homes and business will likely result in a fall in overall gas demand.

7.3 Supply Chain

Only two risks in total were scored as High for the third-round assessment. One of these was the impact on suppliers from other countries affecting the supply of materials. This is considered a High interdependent risk due to the current high level of uncertainty, multiple potential issues, and potentially significant consequences to WWUs operations. Further clarification on the key issues should be considered, potentially as a collaborative process with the ENA and other GDNs.

8 Opportunities and Benefits

Financial benefits from implementing adaptation have not yet been systematically identified and quantified, with no change since ARP2.

The benefits assessment in ARP1 details the very limited potential benefits posed by UKCP09 forecasts. This has not been updated for UKCP18, however due to the limited changes in overall risks between UKCP09 and UKCP18 no significant differences are expected.

The WWU organisation retains a strong awareness and understanding of the potential benefits of correctly timed adaptation responses to optimise future costs.

An updated detailed financial assessment of climate change risks against the cost of adaptation responses should be considered as part of developing a consolidated WWU climate change management strategy.

9 Future Work: Adaptation Pathways

Multiple WWU management and monitoring actions for known climate change risks are discussed in Sections 4 and 5. Post third round reporting, the aim will be to continue to consolidate these separate actions under the WWU climate change adaptation management and reporting program.

Several recognised approaches can be incorporated in the ongoing development of this program. The development of Adaptation Pathways (AP) to address climate risks is a recognised tool in planning for the uncertainties of climate change. The AP approach allows for the consideration of multiple possible futures, while assessing the strength and flexibility of various options across those multiple futures. For example, the UKs long-term planning in flood risk management shows that the AP approach can raise awareness about uncertainties and has been effective in keeping decision processes moving forward.

Adaptation Pathway measures contribute to:

- **Building Adaptive Capacity**: helping to understand and respond to climate change challenges. This includes measures to create new information (e.g., data collection, research, monitoring, and awareness raising); to support governance and organizational structures; and to help build resilience and recovery after events. These are low cost, no/low regret adaptation measures and it is recommended that they should start to be implemented as soon as possible as in many cases they can help in delivering adaptation actions.
- **Delivering Adaptation Actions**: implementing actions that help reduce climate change risks or take advantage of opportunities. To assist in prioritisation and implementation these can be divided into four sub-categories:
    - Operational: changes in processes and procedures, low cost, quick to develop and implement e.g., inclusion of erosion monitoring in pipeline route walks.
    - Grey measures: engineered/hard structural solutions such as coastal flood defences. These tend to address a single issue well, but with limited flexibility. Typically, these are higher cost with longer lead times for implementation compared to operational changes. In addition, negative secondary effects need to be managed e.g., coastal dynamics.
    - Green measures: ecosystem-based adaptation. These can have more positive additional benefits, but can be complex, and typically not as effective as engineered options at reducing risk; and
    - Hybrid: a combination of green and grey measures.

Moving forward, WWU will continue to build adaptive capacity, developing and implementing innovative approaches to assessing key risks, such as improving and expanding the flood mapping project. Current ongoing and proposed future actions will be maintained, implemented, and monitored.

A formal AP approach will be also developed, aligned with ENA and other GDN strategies. This typically includes a costs/benefit assessment for key adaptation implementation scenarios e.g., immediate, step by step, 5-year delay, 10-year delay.

9.1 IPCC 6th Assessment Report

It is acknowledged the IPCC is now in its sixth assessment cycle. The working group for the Climate Change 2021 Physical Science Basis released their report in August 2021. The working group report on Climate Change Impacts, Adaptation and Vulnerability will be available in February 2022.

The August 2021 report states that observed increases in GHG concentrations are unequivocally caused by human activities. That each of the last four decades have been successively warmer than any decade that preceded it since 1850. Globally averaged precipitation over land has likely

increased since 1950, with a faster rate of increase since the 1980s (medium confidence). Other climate parameters such as sea level rise show similar future changes.,.

It is acknowledged that climate change risks to WWU are likely to increase in the next decades, as GHG concentrations have continued to increase in the atmosphere since ARP1 in 2011. This is requiring ongoing and increased focus, assessment, and adaptation. WWU's climate change management strategy will review and incorporate any new guidance on approaches and timelines for adaptation, once the AR6 February 2022 report is released.

10 Concluding Comments

The third-round assessment demonstrates a significant amount of work has been undertaken by WWU between 2015 and 2021:

- Innovative and robust approaches have been applied to achieve greater understanding of key climate change risks.
- Management of climate change risks has been embedded within established management and monitoring strategies, ensuring any required actions are taken in an appropriate and timely manner.
- Responsibility and ownership of climate change risks is now well established within senior management, subject to the same level of ongoing review and evaluation as other business risks.
- No risks have been scored higher than in ARP2. The overall risk profile has been reduced through an improved understanding of asset vulnerabilities and active implementation of management and monitoring processes.
- Areas for improvement remain. A more consolidated approach to managing the various climate risks and a formal adaptation plan will provide more efficient, targeted results. Certain risks require further investigation to understand potential outcomes.
- Proactive assessment of the various options and timelines for required adaptation will improve confidence in the degree of resilience by WWU to potential impacts.

APPENDIX A

WWU CLIMATE RISK ASSESSMENT TABLE 2021

WWU CLIMATE CHANGE ADAPTATION RISK ASSESSMENT JULY 2021

Risk Assessment Matrix

			Consequence				
Likelihood			1 Insignificant	2 Minor	3 Moderate	4 Significant	5 Serious
5 Almost Certain	More likely to occur than not, one or more a year	> 90% chance	5	10	15	20	25
4 Likely	Significant chance of occurring, < once in 5 yrs	> 60% & < 90% chance	4	8	12	16	20
3 Possible	Will probably occur < once in 10 yrs	> 40% & < 60% chance	3	6	9	12	15
2 Unlikely	Unlikely to occur< once in 15 yrs	> 10% & < 40% chance	2	4	6	8	10
1 Rare	May occur in exceptional circumstances< once in 20 yrs	< 10 % chance	1	2	3	4	5
Financial Measured in terms of impact on 'operating profit'			<£500k	£500k - £1m	£1m - £10m	£10m - £20m	>£20m
Safety			Minor injury / Near miss / Negligible	Lost time injury / HSE Letter of Concern	Major injury e.g., RIDDOR reportable	Fatality / HSE Enforcement notice	Multiple fatality / HSE Enforcement notice
Reputation			Negligible	Local press, low running order. Actions criticised in forums	Industry press. Negative reaction in national forums, supported by Regulator	Local TV (terrestrial) or low running order in tabloid press. Reputation impacted, minor reduction in value of company	National media, TV / newspapers. Failure to address breach of license. Company reputation impacted, significant drop in value of company
Environment			Negligible environmental impact	Minor impact e.g., localised spillage	Major environmental incident e.g., contamination of water courses/EA letter of concern	EA enforcement notice / improvement notice	EA Prohibition Notice
Security of Supply				Interruptible supplies disrupted / negligible disruption	Tariff customers in Distribution Networks disrupted (multiple I&C &/or >250 domestics)/ Short term system failure.	Distribution Networks disrupted / major outage for significant period of time	NTS disrupted / total system outage for a lengthy period of time

Risk Assessment Matrices Results

Risk Code	Climate Variable	Risk	Function, Services, Assets	Location	Risk owner	Confidence Level (0 Low to 3 High)	2021 Risk classification	2050 Risk classification
CC1	Summer mean temperature increase	Increase in peak temperatures, Warmer working conditions	Increased demand on air conditioning	National	Facilities	2	Low	Low
CC2	Sea level increase	Rise in sea level, Flooding	Difficult access to <7bar PRIs in emergency situations	Coastal	Asset Integrity	3	Low	Low
CC3	Sea level increase	Rise in sea level, Flooding	Operating difficulties due to loss of electrics on <7bar PRIs	Coastal	Asset Integrity	3	Low	Low
CC4	Sea level increase	Rise in sea level, Flooding	Increased corrosion of pipes	Coastal	Asset Integrity	1	Low	Low
CC5	Sea level increase	Rise in sea level, Flooding	Low pressure pipes floating (Just pipelines floating)	Coastal	Asset Integrity	1	Low	Low
CC6	Winter mean precipitation increase	Increase in winter ground saturation	Understanding the relationship between ground saturation and gas escapes	National	Asset Strategy	1	Low	Low
CC7	Summer mean precipitation decrease	Decrease in summer ground saturation	Understanding the relationship between ground saturation and gas escapes	National	Asset Strategy	1	Low	Low
CC8	Winter cloud amount increase	Decrease in sunlight	Lower efficiency solar panels	National	Asset Integrity	2	Low	Medium
CC9	Wettest day in winter increase	Increase in peak water, Flooding,	Access to place of work for critical staff	National	Process Safety Standards Assurance (EP)	3	Low	Low
CC10	Wettest day in winter increase	Increase in peak water, Flooding	Access to place of work for non-critical staff	National	Process Safety Standards Assurance (EP)	3	Low	Low
CC11	Summer mean temperature increase	Increase in peak temperatures, Warmer working conditions	Heat exhaustion of engineers	National	HSE	2	Low	Medium
CC12	Winter cloud amount increase	Decrease in sunlight	Seasonal affected disorder (SAD) increases	National	HSE	3	Low	Low
CC13	Wettest day in winter increase	Increase in water table, Pipes submerged in water	Increased water ingress to pipes	National	Asset Strategy	2	Low	Low
CC14	Wettest day in winter increase	Increase in winter ground saturation, Ground movement	Pipes become exposed	National	Asset Integrity	1	Low	Medium
CC15	Wettest day in winter increase	Increase in ground movement, Pipe movement will increase	Increased number and size of fractures on metallic mains	National	Asset Integrity	2	Low	Medium
CC16	Winter mean precipitation increase	Increase in water table, Pipes submerged in water, Increased corrosion of pipes	Increased corrosion of pipes	National	Asset Strategy	2	Low	Low
CC17	Wettest day in winter increase	Increase in peak water (Pluvial), Flooding	Difficult access to >7bar Pressure Reduction Installations in emergency situations	National	Asset Integrity	3	Medium	Medium
CC18	Wettest day in winter increase	Increase in peak water (Pluvial), Flooding	Operating difficulties due to loss of electrics on >7bar Pressure Reduction Installations	National	Asset Integrity	3	Medium	Medium

CC19	Winter mean precipitation increase	Increase in peak water in rivers (Fluvial), River changes	Under river pipes become exposed and damaged	National	Asset Integrity	3	Medium	High
CC20	Winter mean precipitation increase	Increase in peak water in rivers (Fluvial), River changes	Pipes parallel to rivers become exposed and damaged from meandering	National	Asset Integrity	3	Medium	Medium
CC21	Winter mean precipitation increase	Increase in peak water in rivers (Fluvial), River changes	Over river pipes attached to 3rd party structures impacted by debris contact and water volume and velocity	National	Asset Integrity	3	Medium	Medium
CC22	Annual mean humidity increase	Increase moisture in atmosphere, Sweating of pipes	Additional sweat on pipes causing corrosion and associated maintenance increase	National	Asset Integrity	1	Low	Low
CC23	Annual mean temperature increase	Increase in temperatures, Warmer working conditions	Change in pipe thermal conductivity	National	Asset Integrity	0	Low	Low
CC24	Winter mean precipitation increase	Increase in winter ground saturation, Water in gasholders	Increase volumes via discharge consents	National	Asset Integrity	3	Low	Low
CC25	Annual mean humidity increase	Increase moisture in atmosphere, PE fusion	Issues with bonding of joints	National	PSSA Process Safety Standards Assurance (EP)	2	Low	Low
CC26	Winter mean precipitation increase	Increase in water, Wetter working conditions	Reduction in reuse of excavated material	National	Operations	2	Low	Low
CC27	Winter mean precipitation increase	Increase in water, Wetter working conditions	Reduction in reuse of recycled material	National	Operations	2	Low	Low
CC28	Wettest day in winter increase	Increase in peak water, Flooding	Damage to data loggers	National	Operations	3	Low	Low
CC29	Wettest day in winter increase	Increase in peak water, Flooding,	Impact on PRI's protected to current flood depth - not protected to forecast future flood depth	National	Asset Integrity	3	Medium	Medium
CC30	Summer mean temperature increase	Increase in temperatures, Warmer working conditions	Effects on engineer's welfare	National	HSE	2	Low	Low
CC31	Winter mean precipitation increase	Increase in water, Wetter working conditions	Increased time and difficulties with setting concrete	National	Operations	1	Low	Low
CC32	Winter mean precipitation increase	Increase in water, Wetter working conditions	Difficulties with trench water	National	Operations	1	Low	Medium
CC33	General	Increased focus on environmental impacts	Supply chain costs increase	National	Procurement/ Environment	2	Medium	Medium
CC34	General	Increased focus on environmental impacts	Change in purchasing strategy	National	Procurement/ Environment	2	Low	Medium
CC35	Summer mean temperature increase	Increase in temperatures, Warmer working conditions	Changing requirements of PPE	National	HSE	2	Medium	Medium
CC36	Winter mean precipitation increase	Increase in water, Flooding	Depot drainage issues	National	Facilities	3	Low	Medium
CC37	Wettest day in winter increase	Increase in peak water (Pluvial), Flooding	Difficult access to NTS Offtakes in emergency situations	National	Asset Integrity/PSSA	3	Low	Low
CC38	Wettest day in winter increase	Increase in peak water (Pluvial), Flooding	Operating difficulties due to loss of electrics on NTS Offtakes	National	Asset Integrity	3	Low	Low
CC39	Annual mean temperature increase	Increase in temperatures, Change to the specific gravity of gas	Difficulties meeting regulatory requirements	National	Operations	1	Low	Low

CC40	Sea level increase	Rise in sea level, Flooding	Difficult access to NTS Offtakes in emergency situations	Coastal	Asset Integrity/PSSA	3	Low	Low
CC41	Sea level increase	Rise in sea level, Flooding	Operating difficulties due to loss of electrics on NTS Offtakes	Coastal	Asset Integrity	3	Low	Low
CC42	Sea level increase	Rise in sea level, Flooding	Difficult access to >7bar PRIs in emergency situations	Coastal	Asset Integrity	3	Low	Low
CC43	Sea level increase	Rise in sea level, Flooding	Operating difficulties due to loss of electrics on >7bar PRIs	Coastal	Asset Integrity	3	Low	Low
CC44	Wettest day in winter increase	Increase in peak water (Pluvial), Flooding	Difficult access to <7bar PRIs in emergency situations	National	Asset Integrity	3	Low	Low
CC45	Wettest day in winter increase	Increase in peak water (Pluvial), Flooding	Operating difficulties due to loss of electrics on <7bar PRIs	National	Asset Integrity	3	Low	Low
CC46	Wettest day in winter increase	Increase in peak water, Flooding	Deterioration of site assets	National	Asset Integrity	3	Medium	Medium
CC49	Wettest day in winter increase	Increase in peak water, Flooding	Impact on cathodic protection	National	Asset Integrity	3	Low	Low
CC50	Wettest day in winter increase	Increase in peak water in rivers (Fluvial), Flooding	Difficult access to >7bar PRIs in emergency situations	National	Asset Integrity	3	Medium	Medium
CC51	Wettest day in winter increase	Increase in peak water in rivers (Fluvial), Flooding	Operating difficulties due to loss of electrics on >7bar PRIs	National	Asset Integrity	3	Medium	Medium
CC52	Wettest day in winter increase	Increase in peak water in rivers (Fluvial), Flooding	Difficult access to NTS Offtakes in emergency situations	National	Asset Integrity/PSSA	3	Medium	Medium
CC53	Wettest day in winter increase	Increase in peak water in rivers (Fluvial), Flooding	Operating difficulties due to loss of electrics on NTS Offtakes	National	Asset Integrity	3	Medium	Low
CC54	Wettest day in winter increase	Increase in peak water in rivers (Fluvial), Flooding	Difficult access to <7bar PRIs in emergency situations	National	Asset Integrity	3	Low	Low
CC55	Wettest day in winter increase	Increase in peak water in rivers (Fluvial), Flooding	Operating difficulties due to loss of electrics on <7bar PRIs	National	Asset Integrity	3	Low	Low
CC56	Annual mean temperature increase	Increase in temperatures, Warmer working conditions	Increased demand for cooling at IT server data centre	National	Facilities	1	Low	Low
CC57	Annual mean humidity increase	Increase moisture in atmosphere, Humidity increase at data centres	Requirement for dehumidifiers at IT server data centre	National	Facilities	1	Low	Low
CC58	Annual mean temperature increase	Increase in temperatures, Warmer working conditions	Potential overheating of PC's	National	Facilities	1	Low	Low
CC59	Wettest day in winter increase	Increase in ground movement, Pipe movement will increase	Gradual ground movement will increase the stress on gas assets	National	Asset Integrity	2	Low	Medium
CC60	Wettest day in winter increase	Increase in winter ground saturation, Movement of land contaminants increase	Increase in statutory liability and risk to sensitive receptors	National	Asset Integrity	3	Low	Medium
CC61	Wettest day in winter increase	Increase in winter ground saturation, Corrosion increase to pipes	Effect on cathodic protection	National	Asset Integrity	0	Low	Low
CC62	Annual mean temperature increase	Increase in temperatures, Warmer temperatures impacting compressor efficiencies	Lower gas pressure supplied to offtakes from national gas transmission pipelines	National	System Operations	1	Low	Low

CC63	General	Increase instances of lightning, Lightning strike to gas sites	Damage and loss of control to gas sites	National	Asset Integrity	0	Low	Low
CC64	General	Increase instances of lightening, Lightning strike to hilltop radio towers	Loss of data transmission to multiple sites	National	Operations	0	Low	Low
CC65	Wind	Increased frequency of strong winds, Material blown off site		National	Operations	0	Low	Low
CC66	Summer mean temperature increase	Drought, Limited water supply	Difficulties in performing hydrostatic testing	National	Asset Integrity	1	Low	Low
CC67	Wind	Increased frequency of strong winds	Issues with gasholder operation	National	Operations	0	Low	Medium
CC68	Wind	Increased frequency of strong winds	Working at heights associated issues	National	Operations	0	Low	Medium
CC69	Summer mean temperature increase	Drought, Wildfires	Damage to WWU assets	National	Asset Integrity	1	Medium	Medium
CC70	General	Impact on suppliers from other countries effecting supply of materials	Supply of materials	National	Procurement/ Environment	1	Medium	High
CC71	Summer mean temperature increase	Increase in temperatures, Store temperatures increased	Impact on chemical storage	National	Operations	0	Low	Low
CC72	Wind	Increased frequency of strong winds, Damage to telemetry masts	Loss of data transmission to multiple sites	National	Operations	0	Low	Medium
CC73	Wind	Increased frequency of strong winds	Damage to WWU assets and staff from material / uprooted trees	National	Operations	0	Low	Medium
CC74	Wind	Increased frequency of strong winds	Dust migration increase	National	Operations	0	Low	Medium
CC75	Wind	Increased frequency of strong winds	Operations sign movement	National	Operations	0	Low	Medium
CC76	Summer mean temperature increase	Increase in temperatures, Warmer working conditions	Overheating of vehicles	National	Operations	1	Low	Low
CC77	Winter mean precipitation increase	Increase in peak water in rivers (Fluvial), River changes	Stand-alone over river pipes impacted by debris contact and water volume and velocity	National	Asset Integrity	1	Medium	Medium
CC78	Wettest day in winter increase	Increase in ground movement, Pipe movement will increase	Intense one-off large-scale land movement resulting in loss of a pipeline	National	Asset Integrity	2	Medium	Medium

NEW RISKS NOT PREVIOUSLY REFERENCED IN 1st and 2nd Round Reports.

Gas Networks								
Risk ID	**Climate Variable**	**Risk**	**Function, Services, Assets**	**Location**	**Risk owner**	**Confidence Level (0 Low to 3 High)**	**2021 Risk classification**	**2050 Risk classification**
CC79	Precipitation	Asset impact from snow/ice falls and accumulation	General	National	Asset Integrity	2	Low	Low
CC80	Temperature	Ground movement due to drought conditions and dry ground	Pipes become exposed, Increased number and size of fractures on metallic mains	National	Asset Integrity	1	Low	Low
CC81	Temperature and Precipitation	Vegetation growth	Various e.g., maintenance access, solar efficiency, asset integrity	National	Asset Integrity	2	Low	Low
Management								
CC82	All	Lack of climate change management procedure	General	National	Environmental Team	3	Low	Low
CC83	All	Lack of specific policies and procedures governing risk assessment process on climate change	General	National	Environmental Team	3	Low	Low
CC84	All	Risk and action owners not identified at senior leadership team level	General	National	Environmental Team	3	Low	Low
CC85	Temperature	Wildfire impacts	General	National	Asset Integrity	2	Medium	Medium
CC86	All	Business Continuity Management (BCM) plans affected due to severe travel difficulties resulting from extreme weather events	General	National	Environmental Team	2	Low	Low
CC87	All	Knock on effect on GDN operations from variable electricity supply due to impact on distribution network operator	General	National	System Operations	1	Low	Low

APPENDIX B

EXAMPLE CASE STUDY – FLUVIAL AND PLUVIAL FLOODING

Climate Change Impacts Mapping

Fluvial and Pluvial
Case Studies

WALES&WEST UTILITIES

Landmark INFORMATION

AMBIENTAL RISK ANALYTICS

Advisian
WorleyParsons Group

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2	Mapping Data	3
3	Fluvial Flooding	4
4	Pluvial Flooding	11
5	Summary	13

1 Introduction

Wales & West Utilities, in partnership with data specialist Landmark Information and flood modelling experts Ambiental Risk Analytics, has launched Great Britain's first national flood map that incorporates current and future predictive flood scenarios for the 2020s, 2050s and 2080s, i.e. accounting for the potential effects of climate change.

Delivered via a new Climate Change Adaptation Reporting service, it provides asset managers, infrastructure owners, land owners, their advisors and reporting organisations with the ability to understand future flood risks on existing assets and infrastructure, and create a plan to adapt in a phased, responsible and appropriate manner, removing the need to create manual estimations.

The dataset incorporates the latest river flow, rainfall, sea level rise and climate change projections available, and allows the creation of unique, innovative new layers, providing insight into flood hazards and the resulting impacts on property, river banks, transport networks and bridges.

Field based assessments to verify the fluvial and pluvial flood mapping datasets have been undertaken and the results of these assessments are presented in the following case studies.

2 Mapping Data

Ambiental's 2-D hydraulic modelling software, Flowroute-i™, was used to simulate fluvial (river) and pluvial (surface water / flash) flooding at a national scale for the present day (2017) and three future climate change scenarios based on UKCP09 climate projections. Flow input data from the Centre for Ecology and Hydrology for the 1 in 100 year flood return period were uplifted using the UKCP09 Medium Emissions Scenario to establish the baseline (2017) scenario. The data were then further uplifted to account for any time passed since the baseline was established. To produce data for the 2020s, 2050s and 2080s, the baseline data were proportionally increased, or in some cases decreased, by using the relative changes as described in the UKCP09 data. The uplifts applied to the fluvial data were based on Environment Agency Guidance (2016), whilst the uplifts applied to the pluvial data were based on UKWIR Guidance (2015). Both sets of guidance are provided for planning purposes.

Fluvial Climate Change Scenario Uplifts

Climate Change Catchment	2017 Baseline	2020s			2050s			2080s		
		Low	Medium	High	Low	Medium	High	Low	Medium	High
Dee	8%	5%	10%	20%	5%	15%	30%	5%	20%	45%
North West	12%	10%	15%	20%	10%	25%	35%	10%	30%	70%
Severn	8%	0%	10%	25%	5%	20%	40%	5%	25%	70%
South East	8%	-5%	10%	25%	0%	20%	50%	5%	35%	105%
South West	8%	5%	10%	25%	5%	20%	40%	10%	30%	85%
Thames	8%	-5%	10%	25%	5%	20%	40%	5%	25%	70%
West Wales	12%	5%	15%	25%	10%	25%	40%	15%	39%	75%

Pluvial Climate Change Scenario Uplifts for Wales & West Utilities Catchments

Climate Change Catchment	2017 Baseline	2020s			2050s			2080s		
		Low	Medium	High	Low	Medium	High	Low	Medium	High
All Catchments	4%	4%	5%	65%	4%	20%	100%	4%	35%	135%

The flood hydrographs for the nine future projected scenarios were produced and used as input files for the fluvial and pluvial models. Flood depth and extents were modelled at a 5 m cell resolution for 1 in 100 year fluvial and pluvial flood return periods assuming an undefended flood event. In an "undefended" flood event, not all flood defences are included in the hydraulic model, meaning that areas normally protected by flood defences will be shown to be

inundated. This presents the worst-case flood hazard which is independent of current or future flood defence infrastructure decisions.

Flooding at Wales & West Utilities' assets to depths greater than 0.5 m presents access issues at the site, with potential damage to equipment if flood depths exceed 1.0 m. Therefore, to identify assets that could be at risk of fluvial flooding, the mapping data was queried to identify assets located within 2 m of 0.5 m depth of flooding.

To identify assets that could be at risk of pluvial flooding, the mapping was queried to identify assets located within 2 m of 0.5 m depth of flooding.

This case study presents the baseline and medium emissions scenario mapping data.

3 Fluvial Flooding

Querying of the fluvial mapping data identified several Wales & West Utilities asset locations that are predicted to be at risk of fluvial flooding to depths in excess of 0.5 m. Of these, five locations were selected for further assessment: one above ground installation (AGI) and five pressure reduction stations (PRS).

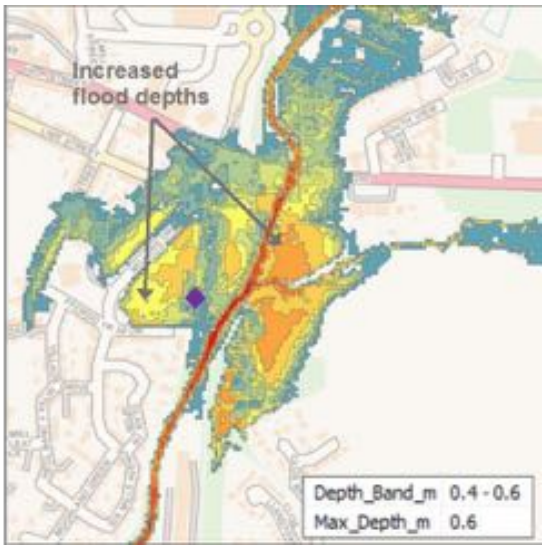
3.1 Location A - PRS

Location A is in a built-up area in South Wales with residential, commercial and light industrial properties nearby. A small river flows north to south to the east of the site in a man-made channel that is approximately 6 m wide. A main road crosses the river 250 m upstream of the site and a disused railway line runs north-west to south-east, crossing the river immediately to the east of the site.

The fluvial mapping for the PRS at Location A indicates that under the baseline scenario and all medium emissions climate change scenarios, the site is at risk from fluvial flooding from the river up to a maximum depth of 0.6 m. Under the 2080s high emissions scenario the site is predicted to be flooded to a maximum depth of 0.8 m. The impact of climate change on flooding at the site is limited as it sits at a higher elevation than the surrounding land. The flood mapping indicates that under the medium emissions climate change scenarios, the land adjacent to and west of the site, and the land on the left bank of the river will experience an increase in flood depths.

2017 Baseline

2080s Medium Emissions



◆ Location A - PRS

The field-based assessment confirmed that the site is at risk of flooding when considering an undefended scenario. It identifed that the PRS sits at a higher elevation than the adjacent plot to the west, confirming that future climate change is likely to have a limited impact on flooding at the site. The site assessment also identified the presence of a flood wall on the left bank of the river immediately downstream of the road bridge and three removable flood barriers on the right bank of the river along this stretch. These flood protection measures were installed by the Environment Agency and provided that they are appropriately maintained by Natural Resources Wales, it is assumed that they should protect the site from flooding during a 1 in 100 year flood event.

Removable flood barrier on right bank of river near Location A

Under the undefended fluvial flooding scenario, there will likely be difficulties in accessing the site, with both the main road and the site entrance experiencing fluvial flooding. However, as this is an unmanned site, the presence of flood protection measures upstream of the site, and the fact that critical equipment on site should remain above any flood waters under the medium emissions scenario, no further intervention options are considered necessary at this site.

Location A - Modelled Maximum Flood Depths

Scenario	*2017 Baseline*	*2020s*	*2050s*	*2080s*
Medium	0.6 m	0.6 m	0.6 m	0.6 m
High		0.6 m	0.6 m	0.8 m

3.2 Location B - AGI

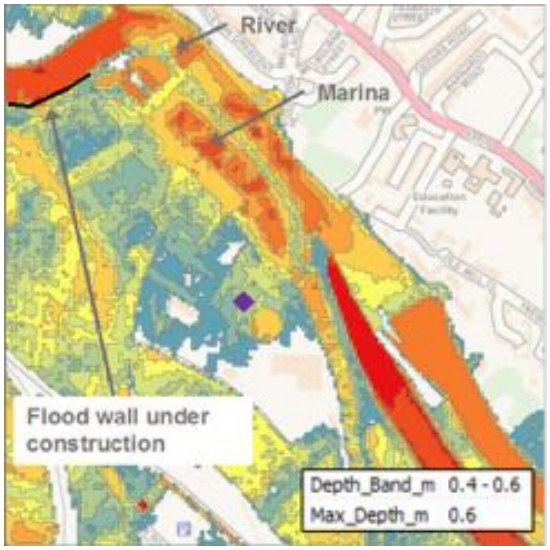
This AGI in a city in the south west of England is located in a light industrial area approximately 150 m to the west of a major river that flows north-east to south-west past the site. A marina sits in between the river and the site, with flow into and out of the marina controlled by a weir and a lock.

The site comprises several buildings surrounded by hardstanding and gravel and enclosed by palisade fencing. Raised curbs are present around the perimeter of the site, except at the entrance gate where the curbs are lowered to allow access. Steps up into the buildings on the site indicate that the floors are raised, placing the equipment at an elevated level. The site is flat with the surrounding ground sloping gently away from the site in an easterly direction towards the river.

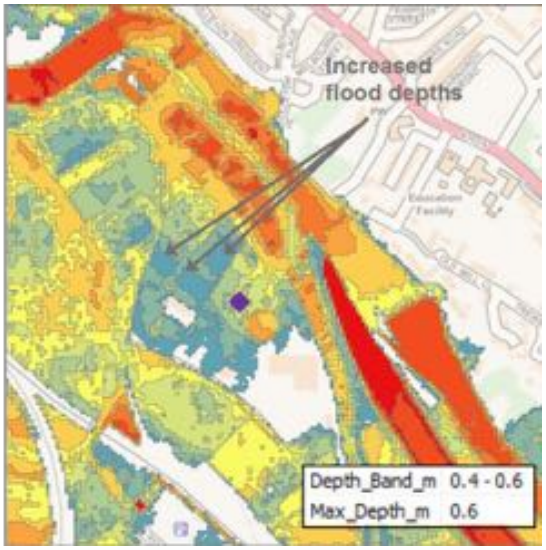
Location B - AGI

As with Location A, the fluvial flood mapping indicates that under the baseline scenario and all medium emissions climate change scenarios, the site is at risk from fluvial flooding up to a maximum depth of 0.6 m. Under the climate change scenarios, land to the north-east of site is predicted to accommodate the increased flood waters resulting in the maximum depth of flooding at the site remaining unchanged under the medium emissions scenario and only increasing to 0.8 m under the 2080s high emissions scenario.

2017 Baseline



2080s Medium Emissions



◆ Location B - AGI

The field-based assessment confirmed that the site is at risk of flooding from the main river. 400 m to the north of the site, a flood defence wall is being constructed on the right bank of the river. This forms part of the Environment Agency, city council and county council's flood defence scheme which aims to protect 3,200 homes from flooding. It is not known whether this flood wall will provide protection to the site, but as discussed previously a scenario in which the site is undefended should be considered for planning purposes.

Environment Agency flood wall construction

With maximum flood depths of 0.6 m predicted at the site, equipment should not be affected. However, access to the site will likely be restricted with the access road flooding to depths in excess of 0.6 m. As this is an unmanned site, the presence of flood protection measures upstream of the site, and the fact that critical equipment on site should remain above any flood waters under the all future climate change scenarios, no further intervention options are considered necessary at this site.

Location B - Modelled Maximum Flood Depths

Scenario	*2017 Baseline*	*2020s*	*2050s*	*2080s*
Medium	0.6 m	0.6 m	0.6 m	0.6 m
High		0.6 m	0.6 m	0.8 m

3.3 Location C PRS

Location C is in a light industrial area of a city in South Wales. It is located at the back of a timber yard and adjacent to a plant hire yard on the left bank of a major river that flows north east to south west past the site. A canal lies between the site and the river. The site is approximately 5 m higher than the river and is at the same elevation of the canal which was full at the time of the site visit.

The site contains two buildings each sitting on 0.2 m high concrete platforms. Doors into the buildings have air vents both in the top and the bottom. The remainder of the plot is covered by gravel and is enclosed by palisade fencing and a raised curb. The timber yard and plant hire yard adjacent to the site are both covered by poorly maintained hardstanding with no evidence of installed drainage.

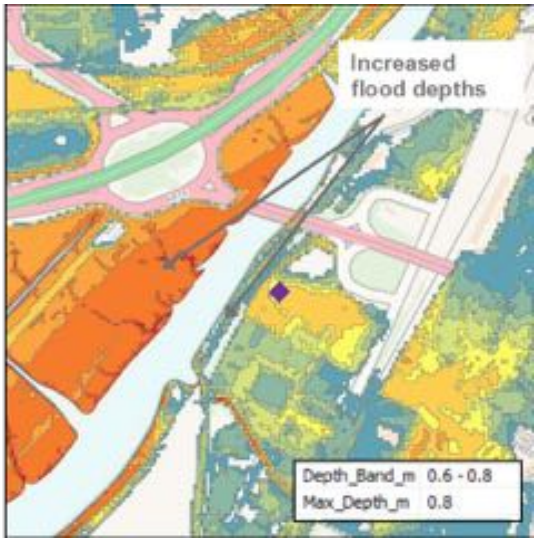
The climate change impact mapping for Location C indicates that under the baseline and medium emissions scenarios, the site is at risk from fluvial flooding to a maximum depth of 0.8 m. Under the high emissions scenario, the maximum predicted flood depth at the site is 1.5 m in the 2080s. The majority of floodwaters from the river overtop its right bank, submerging the fields beyond.

The site-based assessment confirmed that the site is liable to fluvial flooding, most likely attributable to the canal.

Location C PRS compound (top) and air vents on doors of bulding (bottom)

2017 Baseline

2080s Medium Emissions



◆ Location C - PRS

Under the baseline and medium emissions scenarios, access to the site will be restricted by the floodwaters but equipment should not be affected. To prevent the ingress of floodwaters to the building housing the equipment, water tight vent covers could be fitted to the lower vents on the doors. More significant flood protection measures would be required to protect the site from flooding under the high emissions 2080s scenario, such as the construction of a water tight flood wall to a minimum of 1.8 m (allowing for 0.3 m freeboard) or the raising of plant and equipment. Given the costs associated with these measures, it is recommended that a more detailed assessment of the site topography and flood behaviour be undertaken should the high emissions 2080s scenario be adopted as the design standard.

Location C - Modelled Maximum Flood Depths

Scenario	*2017 Baseline*	*2020s*	*2050s*	*2080s*
Medium	0.8 m	0.8 m	0.8 m	0.8 m
High		0.8 m	1.0 m	1.5 m

3.4 Location D - PRS

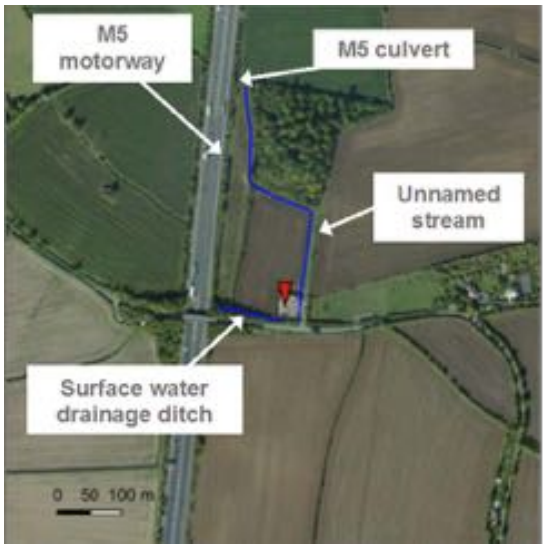
Location D is in a rural setting in the west of England. It is surrounded by agricultural fields with the M5 motorway running north to south on a raised embankment 150 m to the west. A small, heavily vegetated unnamed stream flows north along the eastern boundary of the site and a surface water drainage ditch flows west towards the M5 motorway embankment along the unnamed road that borders the site to the south. The terrain at the site slopes gently downwards to the north west towards the M5 motorway. The nearest significant watercourse to the site is a brook that flows from east to west 1 km to the north of the site, passing through a large culvert under the M5 motorway before discharging a tributary of the River Avon downstream of the M5.

Location D - PRS

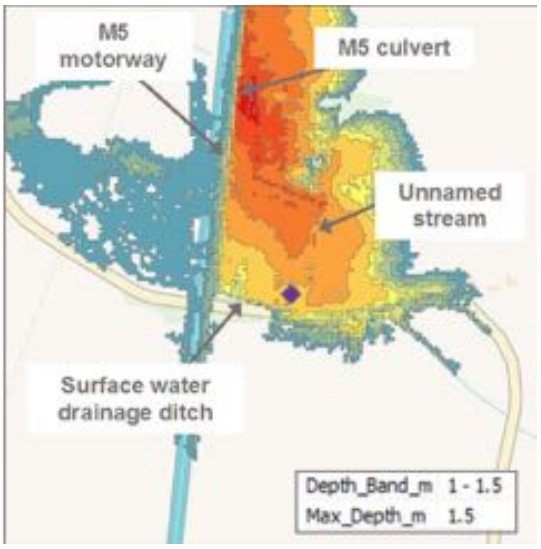
The site comprises three buildings in the west of the plot and pipework in the east of the plot. The plot is covered by gravel and is enclosed by a raised curb and palisade fencing. The raised curb is lowered at the entrance gate to allow access.

The climate change impact mapping for Location D indicates that under the baseline, medium and high emissions scenarios, the site is at risk of fluvial flooding to a maximum depth of 1.5 m. The source of the predicted flooding is the stream on the eastern boundary of the site, with flows from this channel predicted to back up at the M5 motorway approximately 350m to the north east of the site. The ground elevation at this culvert is approximately 3 m lower than at the site.

Location plan



2017 Baseline



Location D - PRS

The field-based assessment identified that the watercourse on the eastern boundary of the site is a small stream with limited capacity for large flood flows. Whilst it is anticipated that the channel capacity will be exceeded during an extreme fluvial flood event, the extent and depths of the flooding predicted by the climate change impact mapping are questionable. It appears from the mapping that the culvert that carries the watercourse under the M5 some 350 m downstream of the site is not represented in the model and, therefore, there is no outlet for the flows, which have backed up behind the embankment. In reality, fluvial flooding may be caused by the backing up of flows at the M5 culvert but as this is at an elevation some 3 m lower than the site, it is considered that 1.5 m of fluvial flooding at the site during a 1 in 100 year event is unlikely, although not impossible.

Unnamed stream along eastern boundary of the site

It is, therefore, concluded that that the climate change impact mapping provides a useful screening tool for fluvial flooding at this location, but that further detailed assessment should be undertaken to refine the potential flood risk at this site prior to flood protection measures being implemented, which could be overdesigned and costly if designed to protect from a 1.5 m depth of flooding. Potential flood protection measures at this site could include the raising of plant and equipment, flood proofing of the buildings housing the plant and equipment or the construction of a flood wall around the site (either temporary or permanent).

Location D - Modelled Maximum Flood Depths

Scenario	*2017 Baseline*	*2020s*	*2050s*	*2080s*
Medium	1.5 m	1.5 m	1.5 m	1.5 m
High		1.5 m	1.5 m	1.5 m

3.5 Location E - PRS

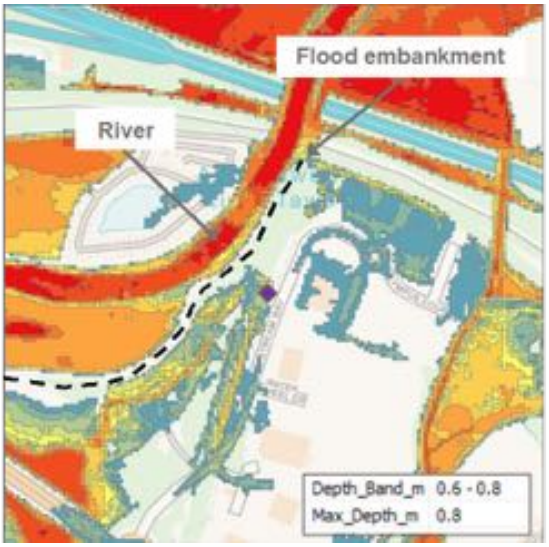
Location E is in a light industrial area of a city in South Wales. It is bounded by densely vegetated land to the north, south and west, and by a road to the east. A major river flows nortth to sourth 100 m to the west of the site and the M4 motorway runs east to west on a viaduct 300 m to the north of the site. The Great Western main line railway also runs east to west on a viaduct 250 m north of the site.

Location E - PRS

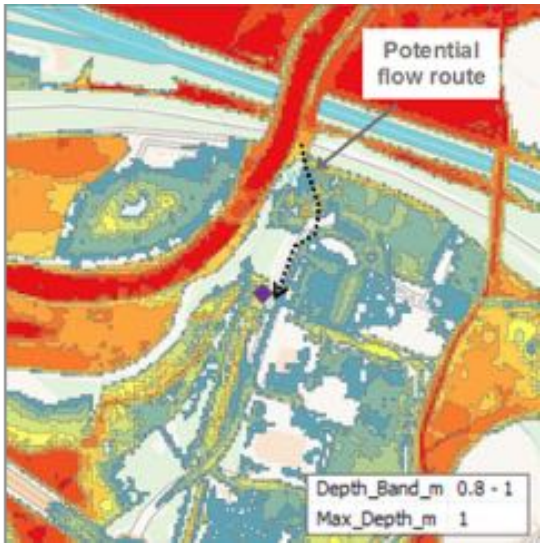
The site contains two brickwork buildings and pipework. It is covered by gravel and enclosed by palisade fencing. The site is located in an area of dense vegetation and trees in a dip between the road to the east and a flood embankment on the left bank of the river to the west.

The climate change impact mapping indicates that under the baseline 2017 scenario and medium emissions scenarios, the site is at risk from fluvial flooding from the river. The maximum flood depth at the site is 0.8 m under the baseline 2017 scenario, increasing to 1.0 m under 2080 medium emissions scenario. Under the high emissions scenario, the predicted flood depth at the site is 1.5 m. The route of the flood waters from the river to the site is not clear from the mapping.

2017 Baseline



2080s Medium Emissions



◆ Location E - PRS

The field-based assessment identified a possible flow route from the river to the site from just downstream of the railway viaduct where the flood embankment tapers down to ground level across the heavily vegetated area to the north of the site onto the road and down to the site. A more detailed assessment of this flow route and the source of

the potential flooding at the site would be required to determine the requirement for, and scale of any flood protection measures at the site. Potential flood protection measures at this site could include the raising of plant and equipment, flood proofing of the buildings housing the plant and equipment or the construction of a flood wall around the site (either temporary or permanent). If the design standard for flood protection measures is taken as the 2080s medium emissions scenario, then only limited flood protection measures would be required as the plant and equipment are expected to remain operable at depths of 1.0 m. Access to the site would be restricted but as the site is unmanned, this should not present an issue.

Flood embankment looking south west

River viewed from the flood embankment looking upsteam towards the railway viaduct

Location E - Estimated Maximum Flood Depths

Scenario	2017 Baseline	2020s	2050s	2080s
Medium	0.8 m	0.8 m	0.8 m	1.0 m
High		0.8 m	1.0 m	1.5 m

4 Pluvial Flooding

Querying of the pluvial mapping data indicated that Wales & West Utilities' assets are less susceptible to this form of flooding than fluvial flooding. Relatively few locations were identified as being at risk of pluvial flooding to depths in excess of 0.5 m. Of the sites identified, one was selected for further investigation.

4.1 Location F - PRS

Location F is a small site in a rural setting in mid-Wales. The field in which the PRS is located is used for pasture and is bordered by a major river to the west, fields to the north and east and by a main road to the south.

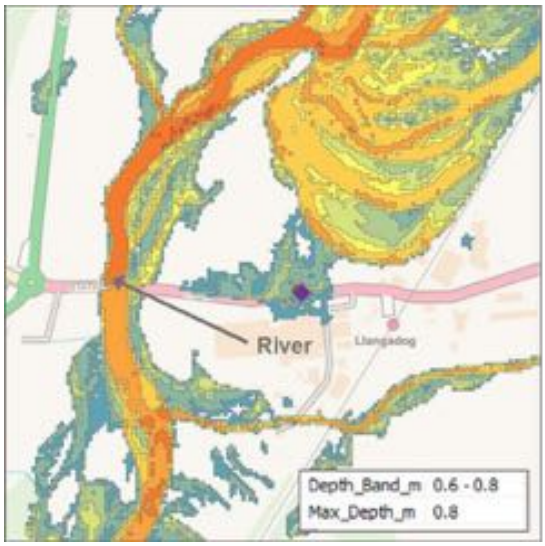
The site contains a single metalwork building that sits on a concrete platform approximately 0.5 m above ground level. The plot is covered by gravel and is enclosed by palisade fencing. Vents are present in the bottom left and right corners of the front and back of the building.

The climate change impact mapping indicates that the site is at risk from both fluvial and pluvial flooding under baseline 2017 and medium emissions scenarios. The maximum pluvial flood depth at the site is 0.6 m under the baseline 2017 scenario, increasing to

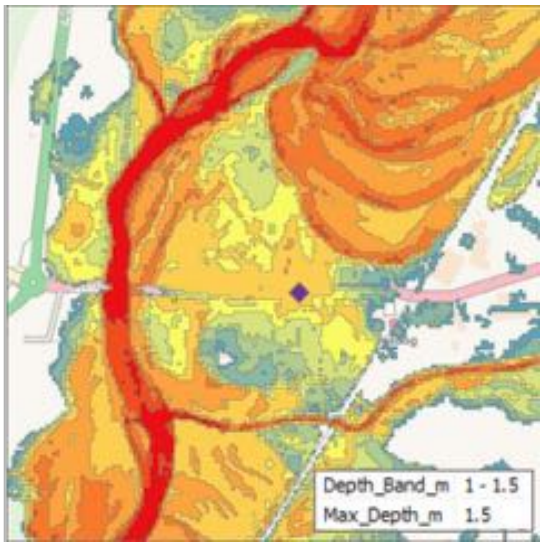
Location F - PRS

1.5 m under the 2050 and 2080 medium emissions scenarios. The proximity of the site to the river means that pluvial flooding is exacerbated at this location. Flash flooding from surface water runoff will cause an increase in river levels which, when combined with the surface water runoff will result in significant flooding at the site. During the site visit, it was noted that exposed soils in the field adjacent to the site had a high clay content which will promote surface water runoff over infiltration.

2017 Baseline



2080s Medium Emissions



◆ Location F - PRS

Looking upstream at the river. Location F PRS is located isome 300 m away in the field to the right

At flood depths of 0.8 m to 1.5 m, the vents on the outside of the building on site will be submerged. The vents were not flood proof on the outside and it is assumed that this is also the case on the inside (access to the building was not possible), meaning that during periods of flooding, flood waters will penetrate the building and could cause damage to the equipment and plant housed inside.

The floor of the building on site is already raised to approximately 0.5 m above ground level, affording the equipment and plant housed within the building a certain level of protection from flooding. Depending on the elevation of the critical equipment, it may be necessary to provide further flood protection measures at the site to ensure that it remains operable during a pluvial flood event. Such measures could include further raising of critical equipment and/or flood proofing the building by sealing the vents and fitting removable flood barriers to the doors.

Location F - Estimated Maximum Flood Depths

Scenario	*2017 Baseline*	*2020s*	*2050s*	*2080s*
Medium	0.6 m	0.8 m	1.5 m	1.5 m
High		1.5 m	2.5 m	2.5 m

5 Summary

The climate change impacts mapping presents fluvial and pluvial flood risk at a national scale. It can be interrogated and used as a high level screening tool to identify assets and infrastructure that may be at risk of fluvial and pluvial flooding in order to inform decision making.

These case studies demonstrate that assets can be queried against the climate change impacts mapping to deliver high resolution predictive analysis that enables the examination of fluvial and pluvial flood risk over time. The desk-based assessment, when used in conjunction with field-based verification, enables the justification of the proactive and adaptive investments required to intervene on future risks in order to ensure the resilience of our critical infrastructure and to maintain a reliable network that our customers can rely on to keep them safe and warm, to power industry and to keep the lights on.