NORTHUMBRIAN WATER living water | ESSEX&SUFFOLK WATER living water

Appendix 3.6

RESILIENCE ASSESSMENT FINAL REPORT

September 2018

NORTHUMBRIAN WATER *living water*

ARCADIS Design & Consultancy for natural and built assets

RESILIENCE ASSESSMENT FINAL REPORT

PR19 Too-Critical-To-Fail Sites

CONTENTS

ARCADIS CONTACTS

TO DISCUSS THIS REPORT AND THE RECOMMENDATIONS FURTHER

OLU ERIOLU
Principal Consultant | Business Advisory, Risk and Resilience Lead
M: +44 7900 703 636
E: olu.eriolu@arcadis.com

MIKE ROSE
Associate | Business Advisory, UK Head of Asset Management
M: +44 7881 854 935
E: michael.rose@arcadis.com

MARK HOWARD
Associate | Business Advisory, UK Water Sector Lead
M: +44 7818 525 995
E: mark.c.howard@arcadis.com

EXECUTIVE SUMMARY

Section 1

EXECUTIVE SUMMARY

PROJECT BACKGROUND AND SCOPE

Northumbrian Water (NWG) commissioned Arcadis to develop and deliver a Resilience Assessment of previously identified Too Critical To Fail (TCTF) sites, applying the methodology developed through application on other clean water supply areas.

Context

Your key challenges are to:

1. Identify key external hazards and options to raise resilience of TCTF sites;
2. Broaden your resilience focus to identify options beyond CAPEX
3. Develop a methodology that can be rolled out to other sites and allow you to incorporate external hazards into ongoing resilience work;
4. Develop a customer centric Business-As-Usual (BAU) resilience approach that enables engagement with customers.

Responding to these challenges

The Arcadis Resilience Assessment is a consequence-led approach that quantifies resilience by "customers at risk". Five hazards were evaluated for 62 sites and NWG controls were assessed for each of the 4 Rs of resilience.

Scope

62 Too Critical To Fail sites, including service & raw water reservoirs, pumping stations, key control points, and treatment works were considered and five hazards were defined; surface flooding, fire, loss of power, extreme weather, and malicious damage.

The objective was to quantify resilience and this was achieved through the assessment of 2 scenarios:

- Baseline
- 2030 assumptions

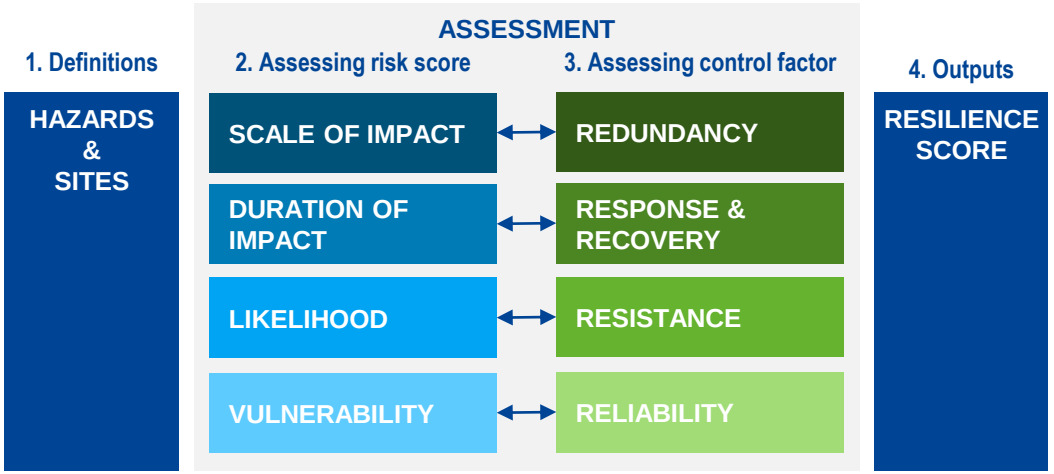
OFWAT Definition

Ofwat define Resilience as ***"ability to cope with, and recover from, disruption, and anticipate trends and variability in order to maintain services for people and protect the natural environment now and in the future".***

This definition for resilience has been applied throughout this assessment.

Four stage delivery approach

Assessment Structure



FINDINGS & RECOMMENDATIONS

Project

- The Resilience Assessment of NWG's 62 TCTF sites highlighted and validated where key vulnerabilities exist across each of the sites, and how this will improve by 2030 if assumed upgrades are carried out.
- Recommendations have been developed from the insights and findings obtained from the baseline and 2030 future assessment, this should provide a solid foundation for NWG to further investigate areas of high vulnerability.
- The project provided an opportunity to involve a number of NWG staff in resilience work (see Appendix 6).
- This work can also act as a foundation to build a wider approach to operational resilience and resilience in the round.

Findings

- 40% of the TCTF sites are at High or Moderate threat from at least one of the 5 hazards, with Hanningfield TWT still scoring High after assumed 2030 upgrades.
- Many sites that score low due to low likelihood of a hazard have very limited controls in place despite the large potential impact.
- Key hazards are Fire, Surface Flooding, & Malicious Damage.
- Best practice is not consistently embedded, with reliance on local "firefighting" and tactical responses.
- There is extensive evidence of siloed decision making.

Developing Capability

There are several opportunities to build on NWG's resilience capability to ensure the customer service and value is improved. The following focus areas have been identified:

- **Long term planning** – integration of assessments with wider planning including drainage, waste, WRMPs, & DWSPs; should consider process, organisation, systems, and information.
- **Asset Health** – working with IAM programme to focus on reliability & criticality; possible rollout of the SEAMS EDA solution.
- **Systems approach** – developing system level assessments that enable evaluation of resilience at zonal level and allow customer communications within different areas.

Recommendations

- **Treat data like an asset**
- **Build Response and Recovery capability**
- **Consider 'Environmental' Hazards**
- **Develop Enterprise Risk Management**

Next Steps

- Sharing with wider NWG teams. Enabling insight to be shared with relevant teams (e.g. Operations Management, Asset Planning and Regulation teams).
- Propose and embed integration with business as usual planning and wider resilience activities. There is a need for a wider business discussion and integration, further guidance is provided at the end of this summary.
- Develop approach and run Resilience Assessment of further sites.

FINDINGS & RECOMMENDATIONS

Key findings

1. Many sites have no controls in place where there is a low likelihood risk despite the large potential consequence.
2. The main hazards are Fire, Surface Flooding, & Malicious Damage, with resilience significantly improved by the assumed improvements by 2030.
3. Several of the good practices like ERPs or key maintenance are not consistently embedded and instead business continuity is reliant on local “firefighting”.
4. Varying incentives and processes limit both integrated decision making and the ability to access required information.

Key Recommendation Themes

1. **Treat data like an asset**
   Understand its condition, maintain it, and ensure it’s reliable and available. Focus on data access for decision making whilst planning, in operations, and during incidents. Enable a step change in decision making to impact performance and resilience.
2. **Build Response and Recovery capability**
   Develop detailed response plans for all key sites including step by step directions relevant to each hazard, and wider network contingency planning. Ensure these are developed with local operations experts. Future proof NWG in the face of uncertain and diverse hazards.
3. **Consider ‘Environmental’ Hazards**
   To be considered in future expansion of the assessment. Include Contamination & Pollution, both shock and incremental change. Build on existing approaches to add this hazard to an integrated resilience score.
4. **Develop Enterprise Risk Management**
   Can be embedded in wider processes within NWG to drive aligned decision making. Could join up wider resilience initiatives and allow consideration of high impact / low likelihood risks.

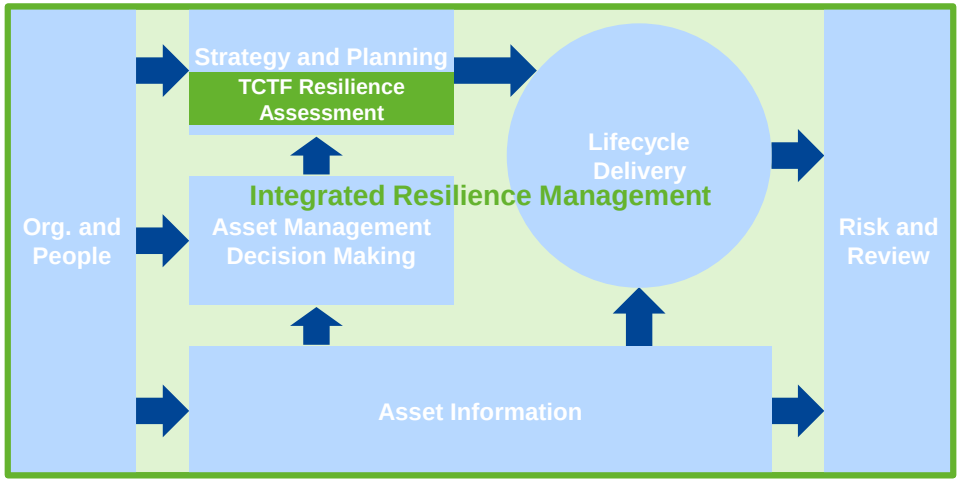
EXECUTIVE SUMMARY

HOW TO USE

Framework

The resilience assessment focuses on one element of “Resilience in the Round” as described in Ofwat’s PR19 methodology document; Operational Resilience. As described in the Arcadis publication “*Measuring Resilience in the water industry*”, the principles that support our methodology can also be extended to cover Corporate and Financial resilience – the other two elements of “Resilience in the Round”.

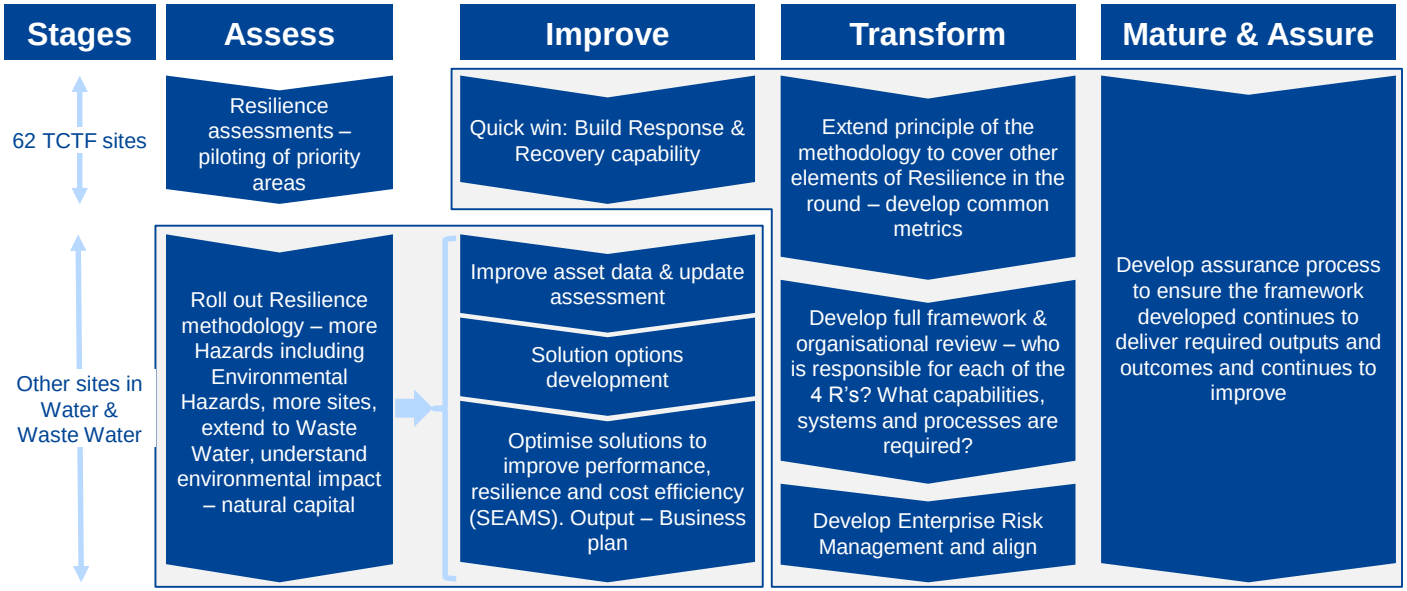
NWL are currently developing an updated view of their Asset Management Framework. To assist in understanding how the framework could integrate the toolset developed, we have considered against the IAM Conceptual Model, the current scope of the toolset and described where it sits within the conceptual model.



Implementation Stages

So what does this mean for NWG, how could you use this assessment as a basis for transforming your business planning approach and integrate it with Business As Usual (BAU)?

We have developed a high level approach to embed this approach to support your longer term business planning; creating a business planning framework that is consequence led and helps drive both short term and long term performance and efficiency.



Long term business planning to improve resilience, performance and cost efficiency → Embed process in the business so it becomes Business As usual

METHODOLOGY

Section 2

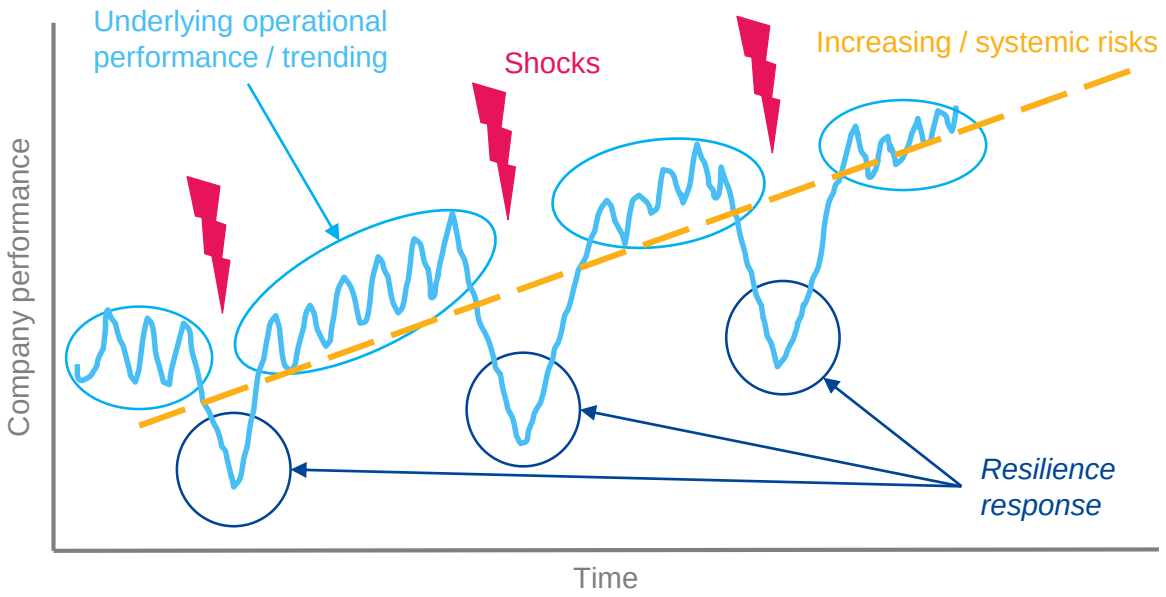
NATURE OF BUSINESS CHALLENGES

When responding to disruptions, organisations have to consider the differences in the nature of the challenge before determining how they would respond to the disruption. Within this methodology we classify three types of disruption, all of which must be managed by a resilient organisation, and directly assess resilience to shocks. This assessment does not consider financial or organisational resilience.

The approach to Resilience Assessment is very much focused on ***external shocks*** and the ability of NWG to respond. It assesses the ability of individual sites to endure these shocks through the controls already in place, and highlights areas of focus for future improvement.

There are other pressures acting on NWG which impact company performance and ultimately customers. These are systemic or operational trends that are not covered in the Resilience Assessment. Examples could include leakage management or drought planning, for which robust measurement and organisational response already exist. We have also excluded shocks that are covered though other workstreams.

Highlighting the different nature of performance challenges



Types of disruptions

Shocks	Operational	Systemic
Organisations should have processes setup to respond to the different disruptions		
Disruption could be internally or externally driven and usually a top down approach to response.	Disruption, typically internal, performance or compliance related and usually bottom up approach to identification and response.	Performance related and usually bottom up, the nature of these risks is that they increase over time and are not always visible.

BRINGING THE METHODOLOGY TOGETHER IN FOUR STAGES

Our methodology frames resilience within a risk and controls environment and is implemented in four key stages, embedding the risk calculations to create a one to one relationship between the four risk elements and the corresponding control factors. It enables you to better understand the risk drivers, i.e. scale of impact, duration, likelihood or vulnerability, and target appropriate resilience response, i.e. redundancy, response & recovery, resistance or reliability.

1. Definitions

HAZARDS

- Surface Flooding
- Fire
- Loss of Power
- Extreme Weather
- Malicious Damage

SITE TYPES

- Raw Water Reservoirs
- Raw Water Pumps
- Water Treatment Works
- Pumping Stations
- Service Reservoirs
- Key Control Points

ASSESSMENT

2. Assessing risk score

SCALE OF IMPACT
Short and long term impact of the hazard, i.e. the number of households affected if the system were to fail

DURATION OF IMPACT
The length of time the system would be unavailable for if the hazard were to occur

LIKELIHOOD
The likelihood of the hazard occurring, irrespective of damage it causes, drawing on historical, geographical and other information

VULNERABILITY
The vulnerability of the system to that hazard, i.e. weakness in a system that can be exploited by an hazard leading to functional failure

3. Assessing control factor

REDUNDANCY
The service can be continued through other systems, reducing the impact

RESPONSE & RECOVERY
A plan to recover the system to full functionality more quickly, reducing duration

RESISTANCE
Protection in place or measures to reduce the likelihood of the hazard reaching the system

RELIABILITY
Measures in place to strengthen the system's ability to function when a hazard occurs, reducing vulnerability

4. Resilience Score

RESILIENCE SCORE

An overall site sample resilience score and individual site score will be calculated. The output is easily comparable across other site samples and is customer focused reporting estimated customers at risk.

Confidence levels are highlighted indicating where data gaps persist.

COMPONENTS OF OUR RESILIENCE APPROACH

A consequence-led approach which focuses on service continuity and is based on a definition of resilience aligned to Ofwat's thinking. It puts customers at the heart of investment decisions and enables consideration of interventions beyond capital expenditure. The risk calculation reflects this by building on the international J100 resilience framework developed by the US Department of Homeland Security and the UK Cabinet office 4 Rs.

Risk = C (consequence) x V (vulnerability) x T (threat likelihood) **Resilience = R (risk) x 4 Rs (control factor)**

Consequence

SCALE OF IMPACT

The measure for the scale of impact is determined by the number of customers impacted if the site were to fail.
This can include:

- The total population served by the site.
- The number of major institutions such as hospitals & prisons, that would be affected.

DURATION

Including duration of impact is particularly important. Whether a system is out of service for several hours, several days or several weeks is likely to have a major bearing on the scale of the impact on services to customers.

We have used industry standards to determine appropriate options for time taken to get the site back to full functionality. For the overall score boundaries, we have taken NWG's recommended boundaries of 10k & 20k properties (25k & 50k customers).

Likelihood and Vulnerability

When evaluating the "probability" of site failure due to a hazard, the assessment considers:

- The **LIKELIHOOD** of the hazard occurring, for example whether it is more or less likely to flood in a particular area. This is determined using historical data of previous occurrences, geographical locations and other forward looking questions.

- The **VULNERABILITY** of the site to the hazard, for example if all critical assets can function when the site is flooded, the site is not vulnerable to the hazard. This is judged by specific questions focused around the existence of single points of failure and the ability of these to survive during the hazard.

Questions have been created to be answered with industry standard data from open access sources like Environment Agency (EA) flood maps or internal systems and insight.

Control factor

To provide a true indication of resilience, it is also necessary to understand the controls. These are resilience activities that have been applied beyond the inherent design and operation of the site, to reduce the likelihood, vulnerability, or consequence of hazards.

This is achieved by defining questions in line with the 4 Rs of resilience. This method applies to a number of qualitative questions against each hazard to assess:

REDUNDANCY
The ability to supply via another route
RESPONSE AND RECOVERY
The ability to respond and recover from disruption.
RESISTANCE
The ability to resist a risk occurring, e.g. building flood defenses.
RELIABILITY
The capability of infrastructure to maintain operations under a range of conditions, e.g. electrical cabling is able to operate in extremes of heat and cold.

METHODOLOGY

QUESTIONS WE ASKED

To enable an accelerated assessment of the hazards and develop an understanding of the corresponding resilience response, standard question sets using multiple choice answers based on the defined scoring mechanism have been used. Simple questions have been designed to ensure a good level of common understanding and drive consistency and comparability.

Assessing the risk

SCALE OF IMPACT
As a consequence driven model, the question establishes the population served by the site. It can also take into account institutions such as prisons and hospitals.

DURATION OF IMPACT
The question is the same for all hazards and it assumes a minimum of 12 hours and a maximum of “more than 7 days” and the scoring applies an exponential curve to reflect the full range of potential outcomes.

LIKELIHOOD
The historical questions focus on critical assets within the site and their failure rates in the last 5 years, whilst the forward looking factors consider asset grade conditions.

VULNERABILITY
The questions focus on design, operational or conditional factors to understand the inherent vulnerability of the site. The questions would also address single points of failure challenges.

Assessing the control factor

REDUNDANCY
The question is focused on determining the level of operation that is possible over the given duration of the impact post-implementation of contingency plans. It enables the true level of redundancy to be understood by taking duration into account.

RESPONSE & RECOVERY
Key focus of this question is to understand the level to which the contingency plans/emergency response plans have been designed to and operated –by specific for each site and hazard or generic.

RESISTANCE
Tailored questions are designed for each hazard to understand the level of resistance, e.g. the availability of flood barriers, risk-based maintenance and control of catchment land improves the ability to resist potential hazards.

RELIABILITY
The questions focus on measures already in place to avoid known potential failures. The questions are designed to be asked in area(s) (design, operational or condition) that is most pertinent.

METHODOLOGY

TYPES OF SCORING

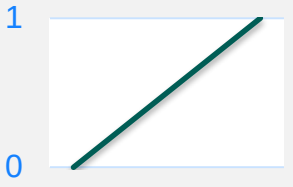
Each question results in a score between 0 and 1, depending upon the multiple choice option selected. In some cases the potential impact to customers vary more significantly between the options than in others. For example, the difference between a site flooding once versus never is substantial, whereas the difference between a site flooding four or five times is less significant.

This means that, depending upon the question, the scoring approach can be either linear, logarithmic, exponential, or a combination of these in order to provide an appropriate weighting for each response. Examples of these are set out below.

Linear scoring – equally proportioned

Does the site run on a continuous basis? Does the site experience significant variations in electrical load during routine operation?

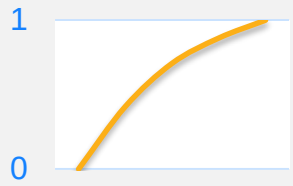
Smooth, continuous, low variation	Smooth, continuous, High variation	Disrupted, with low variation	Disrupted, with high variation	Don't know
0.25	**0.5**	**0.75**	**1.00**	**1.00**



Logarithmic scoring – decreasing difference between the scores

How many security incidents or malicious attacks have there been in the last 5 years?

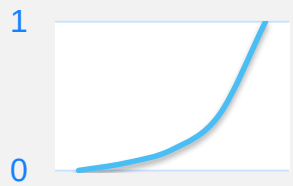
None	One	Two	Three or four over 5 years	At least one every year	Don’t know
0.00	**0.42**	**0.71**	**0.88**	**1.00**	**1.00**



Exponential scoring – increasing difference between the scores

In the event of a power loss limiting the ability to store, distribute or produce drinkable water, what is the expected duration the site would be out of service for?

Up to 12 hours	Up to 24 hours	Up to 72 hours	Up to 7 days	More than 7 days	Don't know
0.10	**0.14**	**0.23**	**0.50**	**1.00**	**1.00**



Where the answer is “Don’t know” the worst case scenario is assumed and a score of 1.00 is given.

DELIVERY APPROACH

Section 3

DELIVERY APPROACH

OUR APPROACH

We have tailored the industry leading Arcadis methodology with NWG to provide insights supporting PR19 decisions and a template to roll out across other areas. We defined a four stage approach to delivery of the TCTF assessment and, through a very collaborative approach in establishing the methodology early on, identified a need to maintain flexibility and regular contact throughout so some activities have been carried out in parallel.

	Resilience methodology	Resilience assessment - baseline	Solution review and future assessment	Develop final report and presentation
Outcomes	• Established methodology and stakeholder engagement plan • Focussed assessment on TCTF sites • Common understanding of hazards and scenarios • Knowledge of possible data sources and what is available • Agreed questions, scoring, and final outputs • Agreed project governance	• All available data and information gathered • Understanding of baseline resilience • Initial recommendations & guidance	• Agreement of assumed future state with relevant solutions • Understanding of priorities and focus areas to improve resilience	• Dashboard available for exploration • Final report aligned for use within NWG and to support customer acceptability research and solution costings. • Assessment tool and guidance document to support future use
Activities	• Establish the methodology and tailor to NWG (confirm hazards and relevant questions, scoring methodology, and final outputs) • Identify key stakeholders and sources of data and information • Develop governance, delivery, logistics, and stakeholder engagement plan.	• Workshops to build business intelligence – collecting data and people knowledge • Gather data from other sources and engage stakeholders • Carry out baseline assessment and analyse results • Develop draft dashboard • Begin drafting report	• Review baseline and highlight key focus areas • Review planned works and other solutions for each site • Define the 2030 scenario • Carry out 2030 assessment and analyse results • Analyse changes in scores • Develop draft report	• Final analysis and alignment of business intelligence • Collate assumptions • Develop final report with recommendations and next steps • Share draft outputs for review and align as needed • Develop guidance documents

This section of the report describes some elements of the approach that are specific to this project. Further detail can be found in the Appendices, in particular, Appendix 6 shows the stakeholders engaged in this project.

HAZARDS CONSIDERED

Working in close collaboration with the relevant stakeholders, a list of key hazards and sites were identified and agreed upon at the start of the project. The definitions of each of these hazards can be found below, with the table highlighting the applicability of these hazards to each site type.

Surface Flooding causing inundation of site/buildings
The effects of climate change increase the risk to sites from environmental flooding. Site locations are likely to be exposed to surface, fluvial and coastal flood risks. Sites that are located in EA Flood Risk Zone 3 have a 1 in 100 or greater annual probability of river flooding; or have a 1 in 200 or greater annual probability of sea flooding. This assessment is particularly concerned with localised surface flooding (eg as result of heavy precipitation) so the questions will be focussed on this so as to avoid overlap with existing climate change work.

Fire (damage to critical, Single Point of Failure asset on site)
This assesses the mitigations and warning systems in place to manage fire risks from electrical, mechanical and bulk chemical storage ignition sources. This considers fire damage to assets, systems, or processes that would reduce the site's capacity and the ability to provide safe, clean water to customers.

Loss of Power
This assesses the ability of the site to operate at full flow with no compromise to water quality in the event of a power failure. Typically, this will include aspects such as back-up generation, generator connection points, incomer supplies or nothing in place.

Extreme Weather (extremes of temperature)
Climate change is increasing the severity of temperature extremes. This assesses the sites capability to cope with both extreme high and low temperatures. The scenarios considered will include; ability to access site, operator experience of specific extreme weather instances and mechanical asset ventilation.

Malicious Damage
This assesses the expected risk from 3rd party malicious damage, including attacks to telemetry systems and other IT/OT infrastructure on site. Historically this work has largely been considered under the Security and Emergency Measures Directive (SEMD) programme. Wider cyber threats are not considered in this assessment and are assumed to be addressed by other projects (see Appendix 6).

DESCRIPTION OF SCENARIOS

Baseline Scenario	This scenario is intended to evaluate the current situation across the 62 TCTF sites. The results serve as the primary guidance out of this report, highlighting areas where further investigation or resilience work may be focussed. The assessment requires some assumptions as described below.

- Operations are assumed to be in steady state as per expert judgement at time of capture (see Appendix 6 for dates).
- This assessment is carried out for an average day and does not consider high demand scenarios.
- No special water quality considerations have been applied to this assessment.
- It is assumed that the given information on TCTF sites is accurate so no other sites or information is considered. (Ormesby is assessed as a single site instead of the two separate sites in the TCTF document. This is because the sites mentioned were not recognised by NWG staff).

2030 Scenario	This scenario is intended to demonstrate changes in resilience resulting from planned or predicted work over the next two AMPs. With a scenario representing a proposed future state for the TCTF sites, certain assertions have been required to complete the analysis. These are in addition to the assumptions made for the baseline scenario.

- Population & demand are assumed to be the same in 2030 as for the baseline.
- It is assumed that, as part of IAM work for all assets, there will be full maintenance across all sites, including for support systems. This is likely to be reactive, progressing towards proactive maintenance for all site types.
- Hazard specific Emergency Response Plans (ERPs) for each hazard are assumed to be under development and embedded by 2030.
- It is assumed that there will be flood defences in place to deal with 1 in 100 events for all sites regarded as high threat in the baseline & rapidly deployable defences for all moderate threat sites.
- The assessment assumes that, for all sites regarded as at high threat from fire in the baseline, any combustibles will be moved to ‘elsewhere on site’ in relation to critical assets, and there will be telemetry alarms and fire suppression systems in place, whilst combustibles will be moved to ‘other building, close proximity’ if for any moderate sites.
- It is assumed that no further changes to network structure or operation will take place beyond those described in the site specific assumptions in Appendix 8.

DELIVERY APPROACH

DATA QUALITY FRAMEWORK

The Resilience Assessment has provided a good opportunity to collate business knowledge from NWG systems and people into a meaningful evaluation framework. To understand the quality of the data used in the assessment we have developed a data quality framework using the quality measures defined in the Institute of Asset Management report, “an Anatomy”.

The following measures were considered when assessing the quality of the data provided to complete the resilience assessment:

Data source – how the data has been obtained

Accuracy - the data is a true reflection of the physical entity it represents

Completeness - a complete set of data is available for each asset data record and all assets are recorded

Consistency - data has been provided from a consistent understanding of the requirements

Timeliness - data is up to date and reflects the current state of an asset (not used for professional judgement)

Steps	Data quality score per question	Risk & control factor data quality scores	Overall hazard data quality score
Activities	• Score all of the questions against each of the quality measures to create a data quality score per question. • The score per question is calculated by taking a geometric mean* of all the quality scores.	• Link each question with their relevant risk and control factors in order to create risk and control factor scores. • If a risk or control factor has multiple questions, an arithmetic mean of the individual question scores is taken.	• Take an arithmetic mean from all the control and risk factor scores to create an overall hazard data quality score.

*The **geometric mean** is a type of average, which indicates the central tendency or typical value of a set of numbers by using the product of their values – it gives a meaningful average on which to compare whilst highlighting inconsistency.

DELIVERY APPROACH

RESILIENCE SCORES

The **Weighted Risk** is reported individually for each site and for each relevant hazard. This value represents a weighted estimate of customers at risk after the control factors have been applied.

Risk Boundaries indicate the threshold of risk by number of customers.

A **Total Weighted Score** sums site Maximum Weighted Risk after control factors have been applied.

No. Customers shows the sum of population counts for all sites.

The **Normalised Score** is a ratio between the Number of Customers and the Total Weighted Score (max = 1.0). It is a measure of Resilience and provides an easily comparable metric to future assessments. Higher score indicates better resilience.

SUMMARY

Northumbrian Water

62 'Too Critical to Fail' Sites

Risk Boundaries per Hazard
High: 50000
Mid: 25000

Assumptions
Data not available = max score
Hazard not relevant = 0

Total Weighted Score	No. of Customers	Normalised Score
716,300	10,882,827	0.93

Hazard	Flooding	Fire	Loss of Power	Extreme Weather	Malicious Damage	Max Weighted Risk Score	Risk Category	Max Uncontrolled Risk	Average Control Factor	Completeness
Overall Data Quality	58%	57%	58%	57%	58%					
Gosforth Park Control Total loss of supply	3,234	0	0	0	0	3,234	Low	6,468	0.10	100%
Rainton Control	0	0	0	0	2,531	2,531	Low	5,625	0.10	100%
Washington Control	0	0	0	0	0	0	Low	140,625	0.01	100%
Washington West Control Total Loss of Supply	0	0	0	0	0	0	Low	16,875	0.00	100%
Barsham final contact tank PS	13,198	0	234	0	5,449	13,198	Low	58,125	0.25	100%
Barsham PS1	11,541	2,911	732	626	4,269	11,541	Low	45,534	0.21	100%
Barsham PS2	1,185	2,893	202	31	1,180	2,893	Low	12,591	0.29	100%
Basildon PS	0	6,706	349	0	2,624	6,706	Low	23,322	0.14	100%
Birney Hill PS	17,325	10,872	1,031	0	1,465	17,325	Low	69,299	0.18	100%
Broken Scar PS	13,238	10,984	23,295	0	293	23,295	Low	169,417	0.19	100%
Chigwell Raw Water PS	17,700	16,026	0	0	2,820	17,700	Low	58,640	0.17	100%
Chigwell Treated Water PS	17,700	16,026	0	0	2,820	17,700	Low	58,640	0.17	100%
Durham Pumps (Mosswood - Castleside) PS	0	5,492	2,261	405	146	5,492	Low	21,928	0.11	100%
Gateshead PS	1,471	1,087	0	0	352	1,471	Low	5,883	0.12	98%
Hanniesfield PS 3A	0	31,442	0	0	2,353	31,442	Moderate	92,870	0.19	100%
Heaton Grange PS	0	6,766	1,093	0	9,276	9,276	Low	27,484	0.21	100%
Hedgeley WPS	588	435	0	0	211	588	Low	1,177	0.25	98%
Herongate PS	0	3,053	443	0	1,139	3,053	Low	9,018	0.16	100%
Hullbridge PS	0	17,626	2,193	1,474	1,411	17,626	Low	69,417	0.13	100%
Kirkleatham PS	0	2,053	0	0	316	2,053	Low	4,500	0.21	100%
Layer High Lift PS	39,197	25,952	8,631	0	2,589	39,197	Moderate	230,163	0.12	100%
Lower Hall PS	0	16,026	16,546	0	1,410	16,546	Low	142,305	0.15	100%
Ormesby PS	0	3,914	5,687	0	4,490	5,687	Low	41,358	0.24	100%
Skelton PS	0	1,232	0	0	190	1,232	Low	2,700	0.21	100%
Walpole PS	6,143	0	0	507	4,565	6,143	Low	13,527	0.30	100%
Warkworth North Pumps	0	0	0	0	0	0	Low	15,400	0.00	100%
Wylam PS	1,471	1,087	0	0	3,516	3,516	Low	15,625	0.23	100%
Yearby PS	0	2,053	0	0	316	2,053	Low	4,500	0.21	100%
Broken Scar River Intake Pumps	41,250	22,465	18,139	0	1,096	41,250	Moderate	165,000	0.21	100%
Ovingham River Intake Pumps	0	10,665	6,497	0	7,383	10,665	Low	31,500	0.23	100%
Burnhope RWR	0	0	0	0	0	0	Low	3,594	0.00	100%
Hury RWR	0	0	0	0	0	0	Low	8,594	0.00	100%
Whittle Dene Great Northern RWR	0	0	0	0	1,250	1,250	Low	2,500	0.11	100%
Beacon Lough SR	0	0	0	2,910	246	2,910	Low	9,313	0.16	100%
Bedfords Park SR	0	0	0	0	0	0	Low	1,163	0.00	100%
Castleside SR	0	0	0	0	1,055	1,055	Low	9,375	0.02	100%

Site List.

A **Data Completeness** score reports on amount of data gaps. This highlights sites where no data was available for any question and the experts "don't know".

Average Control Factor is given for each site. This gives an average of the sites controls across all hazards ranging from 1 (no controls) to 0 (fully resilient).

Each cell includes a **Traffic Light Coding** based on the prescribed Risk Boundaries.

A **Maximum Weighted Risk** value reports the maximum count from the relevant hazards for each site.

A **Max Uncontrolled Risk** score reports the maximum risk from the relevant hazard without any controls in place.

Principle Metrics: Normalised Score and Total Weighted Score

KEY FINDINGS

Section 4

SUMMARY OF RECOMMENDATIONS

This summary categorises recommendations for ease of communication with wider NWG teams and stakeholders. Further detail is available at the end of this section.

Indicative rising cost and time of implementation

	Response & Recovery	Reliability	Resistance	Redundancy
Organisational	• Develop approach to ERPs (Emergency Response Plans) • Explore opportunities for strategic stores of spares • Develop standardisation where possible	• Leverage IAM programme to improve maintenance of key assets and of relevant supporting systems • Develop approach to measure and ensure maintenance is completed as needed	• Include security in wider resilience plans to ensure plans align to overall needs • Review approach to standby generation and alternatives	• Improve network interconnectivity overall with particular focus on larger supply zones
Site Specific	• Review site power outage responses and SLAs • Investigate options for rapidly deployable defences for flooding, loss of power, and extreme temperatures	• Carry out reviews of sites identified as having high number of incidents linked to asset condition	• Relocate combustible materials away from critical assets • Explore ventilation options • Build on current security plans • Review power outages and accelerate plans to convert sites to LV • Carry out detailed key site flood risk & controls assessments	• Install bypasses where possible to provide value for money redundancy solutions (particularly for reservoirs)

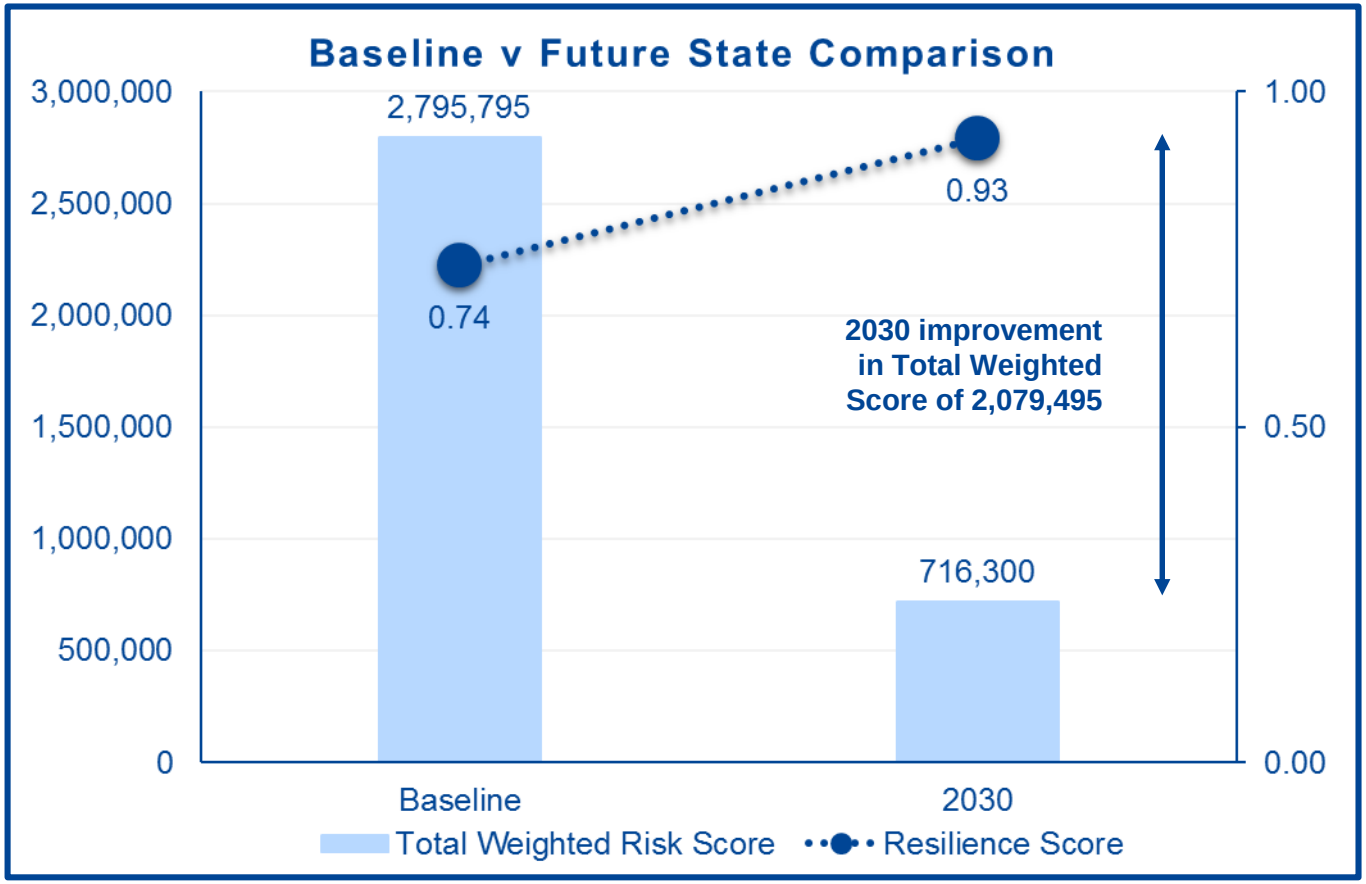
These recommendations are all linked to existing functions and roles, and could form part of a transformation plan with sponsors driving outcomes. While many of the recommendations captured through this project are related to assets specifically, the overall transformation should be focussed on people and developing the organisation, processes, technology, and skills to ensure long term resilience of water supply to NWG customers.

KEY FINDINGS

SUMMARY OF FINDINGS

Key Findings:

- 40% of the TCTF sites are at High or Moderate threat from at least one of the 5 hazards, with Hanningfield TWT still scoring High after all 2030 assumptions have been taken into account.
- While the remaining sites are not at high risk from most of the hazards, we observe that as a result limited controls are in place. This means that additional improvements in resilience could be obtained from adding controls for the unlikely but impactful hazards.
- Assessment of the 2030 scenario, taking NWG's assumptions forward has shown a major improvement in resilience across all 62 sites. This is mainly due to the threat from Fire, Flooding and Malicious Damage significantly decreasing as enhanced protections have been considered and hazard specific ERPs will be embedded.



The overall 2030 Site Normalised Score shows a 0.19 improvement on the baseline scenario.

Key assumptions for future scenario:

- There will be hazard specific ERPs embeded for all hazards for each site
- All assets on each site will have a maintenance regime embedded as part of the IAM work
- All sites with a high threat of fire will have combustibles moved elsewhere on site
- All sites with a high threat of surface flooding will have 1 in 100 event flood defences in place by 2030
- No site will have any open access points to critical systems by 2030

More details on assumptions can be found in Section 3 – Delivery Approach or in Appendix 8.

KEY FINDINGS

BASELINE SCENARIO

Key Findings:

- 40% of TCTF sites are at High or Moderate threat: 18 sites High, 7 sites Moderate, and 37 sites Low threat.
- Normalised Score = 0.74 and Total Weighted Score = 2,795,795.
- Hanningfield WTW alone accounts for 14% of the Total Weighted Score.
- The majority of risk is due to: 1. Fire (e.g. lack of protection and control where there has been historic events and also combustibles stored in the same area as critical parts of the system) 2. Surface Flooding (e.g. lack of protection and defence to deal with surface flooding, where there is history of surface flooding) 3. Malicious Damage (e.g. lack of security measures, open access points and no site barriers where there is a history of intrusion).

SUMMARY

Northumbrian Water	Risk Boundaries per Hazard	Assumptions	Total Weighted Score	No. of Customers	Normalised Score
62 'Too Critical to Fail' Sites	High: 50000 Mid: 25000	Data not available = max score Hazard not relevant = 0	2,795,795	10,882,827	0.74

Hazard	Flooding	Fire	Loss of Power	Extreme Weather	Malicious Damage	Max Weighted Risk Score	Risk Category	Max Uncontrolled Risk	Average Control Factor	Completeness
Overall Data Quality	59%	58%	60%	59%	60%					
Gosforth Park Control Total loss of supply	5,174	0	0	0	0	5,174	Low	6,468	0.16	100%
Rainton Control	0	0	0	0	4,050	4,050	Low	5,625	0.22	100%
Washington Control	0	0	0	0	101,250	101,250	High	140,625	0.22	100%
Washington West Control Total Loss of Supply	0	0	0	0	0	0	Low	16,875	-	100%
Barsham final contact tank PS	52,793	0	467	0	10,898	52,793	High	58,125	0.67	100%
Barsham PS1	30,776	38,357	1,464	1,753	8,538	38,357	Moderate	45,534	0.55	100%
Barsham PS2	2,370	5,785	405	101	2,361	5,785	Low	12,591	0.66	100%
Basildon PS	0	13,411	698	0	5,247	13,411	Low	23,322	0.28	100%
Birney Hill PS	55,440	17,395	49,500	0	2,344	55,440	High	75,000	0.46	100%
Broken Scar PS	35,300	14,279	46,590	0	586	46,590	Moderate	169,417	0.42	100%
Chigwell Raw Water PS	47,199	108,559	0	0	5,641	108,559	High	120,337	0.43	100%
Chigwell Treated Water PS	47,199	199,024	0	0	5,641	199,024	High	220,618	0.43	100%
Durham Pumps (Mosswood - Castleside) PS	0	7,139	3,618	1,945	234	7,139	Low	21,928	0.19	100%
Gateshead PS	2,942	2,174	0	0	703	2,942	Low	5,883	0.23	98%
Hanningfield PS 3A	0	87,399	0	0	15,058	87,399	High	109,248	0.47	100%
Heaton Grange PS	0	13,532	2,186	0	18,552	18,552	Low	27,484	0.43	100%
Hedgeley WPS	1,177	870	0	0	422	1,177	Low	1,177	0.51	98%
Herongate PS	0	26,799	886	0	2,279	26,799	Moderate	29,707	0.36	100%
Hullbridge PS	0	46,967	4,386	4,127	2,821	46,967	Moderate	69,417	0.32	100%
Kirkleatham PS	0	4,106	0	0	633	4,106	Low	4,500	0.43	100%
Layer High Lift PS	156,787	69,151	17,262	0	5,179	156,787	High	230,163	0.35	100%
Lower Hall PS	0	98,029	33,093	0	2,820	98,029	High	142,305	0.33	100%
Ormesby PS	0	7,828	11,373	0	8,980	11,373	Low	41,358	0.47	100%
Skelton PS	0	2,464	0	0	380	2,464	Low	2,700	0.43	100%
Walpole PS	9,829	0	0	1,299	7,305	9,829	Low	13,527	0.53	100%
Warkworth North Pumps	0	0	0	0	0	0	Low	15,400	-	100%
Wylam PS	2,942	2,174	0	0	7,031	7,031	Low	15,625	0.46	100%
Yearby PS	0	4,106	0	0	633	4,106	Low	4,500	0.43	100%
Broken Scar River Intake Pumps	165,000	87,885	36,277	0	2,193	165,000	High	165,000	0.54	98%
Ovingham River Intake Pumps	0	31,500	12,994	0	14,766	31,500	Moderate	31,500	0.52	100%
Burnhope RWR	0	0	0	0	0	0	Low	5,750	-	100%

KEY FINDINGS

2030 SCENARIO

Key Findings:

- 1 site High, 9 sites Moderate and 42 sites Low threat.
- Resilience Score = 0.93 and Total Weighted Score = 716,300 (74% decrease on the baseline scenario).
- Only one site falls in to the high threat category overall for flooding and malicious damage – Hanningfield WTW, however both hazards have had a significant score improvement due to future controls.
- Improvements across the 62 sites is largely from embedded ERPs for each hazard for all sites and enhanced defences and protection where required (across Flooding, Fire and Malicious Damage).

SUMMARY

Northumbrian Water	Risk Boundaries per Hazard	Assumptions	Total Weighted Score	No. of Customers	Normalised Score
62 'Too Critical to Fail' Sites	High: 50000 Mid: 25000	Data not available = max score Hazard not relevant = 0	716,300	10,882,827	0.93

Hazard	Flooding	Fire	Loss of Power	Extreme Weather	Malicious Damage	Max Weighted Risk Score	Risk Category	Max Uncontrolled Risk	Average Control Factor	Completeness
Overall Data Quality	58%	57%	58%	57%	58%					
Chigwell Treated Water PS	17,700	16,026	0	0	2,820	17,700	Low	58,640	0.17	100%
Durham Pumps (Mosswood - Castleside) PS	0	5,492	2,261	405	146	5,492	Low	21,928	0.11	100%
Gateshead PS	1,471	1,087	0	0	352	1,471	Low	5,883	0.12	98%
Hanningfield PS 3A	0	31,442	0	0	2,353	31,442	Moderate	92,870	0.19	100%
Heaton Grange PS	0	6,766	1,093	0	9,276	9,276	Low	27,484	0.21	100%
Hedgeley WPS	588	435	0	0	211	588	Low	1,177	0.25	98%
Herongate PS	0	3,053	443	0	1,139	3,053	Low	9,018	0.16	100%
Hullbridge PS	0	17,626	2,193	1,474	1,411	17,626	Low	69,417	0.13	100%
Kirkleatham PS	0	2,053	0	0	316	2,053	Low	4,500	0.21	100%
Wylam PS	1,471	1,087	0	0	3,516	3,516	Low	15,625	0.23	100%
Yearby PS	0	2,053	0	0	316	2,053	Low	4,500	0.21	100%
Broken Scar River Intake Pumps	41,250	22,465	18,139	0	1,096	41,250	Moderate	165,000	0.21	100%
Ovingham River Intake Pumps	0	10,665	6,497	0	7,383	10,665	Low	31,500	0.23	100%
Downhill SR	0	0	0	0	0	0	Low	71,875	0.00	100%
Frosterley SR	0	0	0	0	0	0	Low	6,875	0.00	100%
Gunnerton CWT SR	0	0	0	0	172	172	Low	1,838	0.12	100%
Heaton Grange SR	0	0	0	0	42,638	42,638	Moderate	189,502	0.06	100%
Herongate SR	0	0	0	0	5,360	5,360	Low	15,881	0.08	100%
Hollingsworth Road Reservoir	0	0	0	0	6,115	6,115	Low	18,118	0.08	100%
Loud SR	0	0	0	0	0	0	Low	1,313	0.00	100%
Oakwood SR	0	0	0	0	5,980	5,980	Low	53,157	0.04	100%
Ormesby	27,667	6,255	2,225	0	23,344	27,667	Moderate	110,668	0.28	96%
Pelton SR	0	0	0	0	0	0	Low	2,188	0.00	100%
Sacriston SR	0	0	0	0	0	0	Low	2,500	0.00	100%
Stoneygate SR	0	0	0	0	0	0	Low	4,063	0.00	100%
Walpole TW reservoir	494	0	0	0	1,504	1,504	Low	4,456	0.29	100%
Broken Scar TW	0	11,986	23,295	0	293	23,295	Low	169,417	0.11	100%
Chigwell TW	4,744	32,395	0	0	2,424	32,395	Moderate	95,685	0.19	100%
Gunnerton TW	0	7,897	0	162	172	7,897	Low	16,500	0.12	100%
Hanningfield	77,736	21,884	0	0	77,029	77,736	High	342,349	0.18	100%
Honey Hill TW	0	19,896	1,547	486	352	19,896	Low	58,767	0.22	100%

RESILIENCE FINDINGS & RECOMMENDATIONS

These are key findings and recommendations that NWG should focus on addressing post assessment. Each recommendation highlights how this contributes to improved system resilience. Several recommendations include multiple levels of action that can be taken to improve resilience, and others are merely preliminary steps that will lead to further opportunities to improve resilience not just of the TCTF sites but of NWG sites overall.

Key Findings	Key Recommendations and Actions
Limited contingency planning Limited availability of ERPs, with those that exist seen as generic and not recognised as best practice by local operations. Essex and Suffolk have a number of outage plans at 'draft level' which are generally regarded as 'optimistic' and not detailed. Additionally, a number of sites are identified as 'operationally' possible to bypass, although have no plans in place or structured procedures to do so if required.	**Develop and embed best practice ERPs** Develop detailed ERPs for all key sites including step by step response & recovery directions relevant to each hazard, and wider network contingency planning. Ensure these are developed in collaboration with local operations experts and build on best practice from other sectors or the Business Continuity Institute.
Low redundancy for critical sites General redundancy across the network is low, with Flooding, Fire and Malicious Damage causing loss of over 50% of customers for over 40 sites. This not unexpected for these TCTF sites.	**Improve network interconnectivity** Explore options to increase redundancy. Focus in particular on those improvements that would also deliver operational benefits day to day. These don't always have to be large capital programmes but may be simple bypass projects.
Raw water contamination hazard Essex & Suffolk workshop highlighted contamination of raw water as a key risk. Langford & Ormesby highlighted as at risk from contamination and pesticides entering the water source. All drainage at Chigwell leads to the lagoon as there is no discharge licence creating key risks of contamination or prosecution.	**Expand range of hazards considered** Explore this hazard in future works. Can prioritised sites based on local knowledge. For example, other organisations have included a "Raw Water Loss" hazard in this assessment, exploring elements like the type of source, nearby sources of contamination, or early warning systems.
Threat from combustibles A number of sites with a history of fire have combustibles in the same or adjoining building.	**Relocate combustible materials** For all medium threat sites move combustibles to other building, away from critical system elements or elsewhere on site where there is a high threat.

RESILIENCE FINDINGS & RECOMMENDATIONS CONTINUED

Key Findings	Key Recommendations and Actions
Time to Fix Several sites have long impact durations due to difficulty of locating spares for critical equipment extending the Time to Fix estimates.	**Strategic spares & standardisation** Explore sub process/ asset criticality and consider a more strategic store of spares and standardisation of equipment (eg key process elements, pumps, motors, or generators). This can aid day to day operations, improve resilience, and reduce procurement costs and variance in capital works.
Future security measures A number of sites are identified as not having a perimeter fence, with no plans in place to install a fence.	**Include security in wider resilience plans** Refer back to the security programme to understand the level of protection being planned to reduce threat from malicious damage. Review these resistance measures as part of wider resilience planning rather than as standalone (eg smaller site with no redundancy may need better resistance than a larger but more redundant site).
Reservoir Bypasses Not all Service Reservoirs/ Contact Tanks are designed with, or retrofitted with bypass arrangements to enable rapid interventions and reconfiguration.	**Install Bypasses** As part of Emergency Response Planning consider the installation of bypass tap ins. Review design standards for new installations to ensure they make provision for bypass tap in points, particularly if no further downstream storage is provided. This will improve the redundancy of these sites.
Unmaintained assets Number of references and data points reveal that planned preventative maintenance is not completed in line with plan and activities aren't aligned to up to date criticality assessments or organisational priorities.	**Improve & measure maintenance** This should already be in action through the IAM programme. Ensure maintenance is fully covered. with regimes in place for all assets on site, including trace heaters and other support systems. Develop leading indicators to monitor compliance with PPMs. Ensure use of FMECA, RCM, CBM methods to develop deliverable PPM plans, which recognise the resources available.

RESILIENCE FINDINGS & RECOMMENDATIONS CONTINUED

Key Findings	Key Recommendations and Actions
Overheating at Barsham Barsham PS1 appears particularly vulnerable to overheating, with a number of system elements needing ventilation in hot weather.	**Explore ventilation options** Explore ventilation options, cost and benefit to prevent reoccurrence.
Malicious damage at Hanningfield Hanningfield has significant threat level from malicious damage.	**Build on current security plans** ERP development and planned security fence will provide a significant improvement in resilience. Consider wider options including protection of key assets and increasing redundancy within the site.
Power outage Several sites are recoded as having regular power outages but with limited detailed information. Rural sites are generally more vulnerable to regular power outages.	**Review power outages and accelerate plans** Accelerate plans to convert sites to LV, and include this in future resilience planning. Carry out power loss assessments at key sites, including opening discussions with suppliers and considering wider options for protections.
Generator requirements HV sites generally struggle for any kind of backup power due to power requirements and generator constraints, and overall level of certainty around getting back-up power to site in some instances was patchy. Multiple sites are recorded as having back-up generation but not able to support full site operation.	**Review approach to standby generation and alternatives** Including SLAs and other agreements with supply chain to understand agreed response times for back-up, and identifying back-up generators across NWG and sites they can serve. Also explore potential partnerships and joint planning with other organisations for both back up generation and additional defences.
Limited flood defences and understanding of risks Unknown causes of surface flooding at several sites. In addition there are often no flood defences in place for sites to deal with surface flooding, although sites are identified as having low capability sump pumps and there are several sites with equipment placed in sumps. All drainage at Chigwell leads to the lagoon as there is no discharge licence creating key risks of contamination or prosecution.	**Carry out detailed flood risk & controls assessments** Further investigation in to the cause of surface flooding (prioritise high and moderate sites: Layer High Lift PS, Broken Scar River Intake Pumps, Ormesby, Hanningfield, & Layer WTW). Include review of site drainage (eg to understand contamination risk). Focus on preventing water ingress by reviewing all high threat sites and apply defences to as per risk appetite. Additionally explore requirements and options for rapidly deployable defences and response equipment.

NORTHUMBRIAN WATER living water

ARCADIS Design & Consultancy for natural and built assets

BUSINESS INTELLIGENCE

Section 5

FINDINGS & RECOMMENDATIONS

Completing the resilience assessment of Too Critical To Fail sites has provided a great opportunity to assess the availability and quality of data at NWG. The quality of data for all hazards is very similar, meeting a minimum quality level due to the completeness of SME answers, with significant improvements possible with the recommendations below. These are the key findings and recommendations that NWG should focus on in order to improve data quality from the current 57/100 score, which in turn will help improve the ability to plan for future resilience.

Key Findings	Key Recommendations and Actions
Source of data There was an overarching reliance on Subject Matter Experts (SMEs) and unsecured data sources (eg. spreadsheets based on SME) to complete the assessment. This highlights a lack of structured data stored in corporate databases available to support business decisions and puts NWG at significant risks from staff turnover.	**Review asset data management** Develop a programme to capture the information areas not currently in secured / structured databases and business management systems. This will help support future business decisions and ensure knowledge longevity. Having multiple data sources will build integrity in the data through further validation to improve overall accuracy.
Accuracy of Scale values Population figures were taken from several places with sometimes conflicting data. The conflicts, age of the data, and SME feedback suggest accuracy concerns. For most sites numbers are based on estimations fed into the 2011-13 work whilst for others there is a mix of data from Netbase and draft outage plans. There was no data provided on institutions or key customers.	**Carry out population/customer calculations** Undertake full review to understand population served from each site including identifying institutions/key customers and defining parameters to be used. These should be stored centrally and easy to use for works including criticality, response planning and operations, and stakeholder engagement.
System Analysis There is limited evidence of use of system level analysis. This significantly impacts the quality of redundancy and response planning in particular. Strategic Network planning have completed ‘optimistic’ outage plans, these are in draft format and subject to significant scrutiny from various operational teams. Water supply in Suffolk and Essex is further complicated by supply agreements with Anglian.	**Develop system analysis at multiple levels** Initially review system assumptions and outage planning with operational teams. The long term aim should be to develop dynamic systems modelling with key logic included. This should be easily used to develop response plans and to understand site redundancy.

FINDINGS & RECOMMENDATIONS CONTINUED

Key Findings	Key Recommendations and Actions
Barsham & Ormesby The assessment of Barsham stands out as an outlier with multiple condition and completeness issues flagged. Ormesby also stands out as the SMEs involved had lower confidence in answers supplied for this site. This highlights a wider issue with reliance on localised knowledge and human capital.	**Review data for key sites** Initially complete reviews for the two sites in question. Further investigate options to prioritise investment in data capture and management for key sites.
Records and registers Data, when available, is often stored in ad-hoc documents and not structured for ease of interrogation, with existing structures not always contributing to ease of use.	**Review asset data structuring** Consider reviewing data structures such as the asset hierarchy to ensure ease of use and interrogation. This will facilitate integration of data from disparate systems and records.
Short term focus Company scorecard information is focused on understanding in month and lagging performance, in respect of asset management and operation.	**Consider leading indicators in scorecards** Consider as part of Asset Health metrics the inclusion of leading measures of asset performance (eg. current financial ratio, PPMs compliance, asset productivity, and asset data records updated).
Desire for objectivity There is clear desire within NWG to become a more data led organisation, with frequent reference in workshops to data available to SMEs, but regular reliance on estimates or data from unclear sources.	**Promote integrated knowledge management & data skills** Review use of systems and databases across the group with an aim to promote connectivity and reduce siloed or ‘offline’ data. Leverage clear interest in data to develop skills in knowledge management, data quality management and evaluation, and analytics within NWG.

SURFACE FLOODING – 58/100 DATA QUALITY

Scale	39	• Population figures were taken from several places with sometimes conflicting data. • The main source was the 2011-2013 resilience work– assumed properties served were multiplied by 2.54 for a population estimate (2.54 persons per property is an estimated average for unmeasured properties for the timeframe 2011/12 – 2025/26 from official figures documented in the NWG 2015-2020 WRMP). • Other sources included draft outage plans and Netbase.
Duration	56	• Working with various SMEs through a number of assessment focused workshops, durations were given from expert judgement. • There were no significant past incidents that could be used for guidance. • Some durations were taken from the DEFRA Flooding Assessment 2017 – also based on expert judgement.
Likelihood	69	• Working with various SMEs through a number of assessment focused workshops, surface flooding history was recorded for most sites (no confident judgement for some). • Environment Agency Flood Map website was interrogated to assess the flood zone for each site.
Vulnerability	56	• Working with various SMEs through a number of assessment focused workshops, anticipated vulnerability was recorded from expert judgement as estimates for different types of site.
Redundancy	62	• Working with various SMEs through a number of assessment focused workshops, site redundancy was recorded via understanding outage duration, downstream storage capacity, and alternative feeds to locations to understand population likely to lose supply. For some sites this was based on the existing outage plans though this was not consistent.
Response & Recovery	62	• Working with various SMEs through a number of assessment focused workshops, existing ERPs were recorded & evaluated. • Further outage plans emerged for a number of sites (WTW only). • The outage plans were widely regarded as too generic and often “optimistic”, with no hazard specific comments.
Resistance	62	• Working with various SMEs through a number of assessment focused workshops, the absence of flood barriers and defences was recorded for all but 1 site (Lower Hall PS) which has defences designed to 1 in 100 event.
Reliability	56	• Working with various SMEs through a number of assessment focused workshops, design elements and the sites’ ability to continue functioning was recorded from expert judgment.

FIRE – 56/100 DATA QUALITY

Scale	39	• Population figures were taken from several places with sometimes conflicting data. • The main source was the 2011-2013 resilience work– assumed properties served were multiplied by 2.54 for a population estimate (2.54 persons per property is an estimated average for unmeasured properties for the timeframe 2011/12 – 2025/26 from official figures documented in the NWG 2015-2020 WRMP). • Other sources included draft outage plans and Netbase.	Redundancy	62	• Working with various SMEs through a number of assessment focused workshops, site redundancy was recorded via understanding outage duration, downstream storage capacity, and alternative feeds to locations to understand population likely to lose supply. For some sites this was based on the existing outage plans though this was not consistent.
Duration	56	• Working with various SMEs through a number of assessment focused workshops, durations were given from expert judgement. • There were no significant past incidents that could be used for guidance.	Response & Recovery	62	• Working with various SMEs through a number of assessment focused workshops, existing ERPs were recorded & evaluated. • Further outage plans emerged for a number of sites (WTW only). • The outage plans were widely regarded as too generic and often “optimistic”, with no hazard specific comments.
Likelihood	62	• Working with various SMEs through a number of assessment focused workshops, fire history was recorded, along side whether there were any combustibles near critical parts of the system. Some assumptions by type of site. • Some incident reports available but limited scope and quality so not used.	Resistance	60	• Working with various SMEs through a number of assessment focused workshops, fire protection, suppression and alarm was recorded from expert judgement.
Vulnerability	56	• Working with various SMEs through a number of assessment focused workshops, anticipated vulnerability was recorded from expert judgement as estimates for different types of site.	Reliability	56	• Working with various SMEs through a number of assessment focused workshops, design elements and the sites’ ability to continue functioning was recorded from expert judgment.

LOSS OF POWER – 58/100 DATA QUALITY

Scale	39	• Population figures were taken from several places with sometimes conflicting data. • The main source was the 2011-2013 resilience work– assumed properties served were multiplied by 2.54 for a population estimate (2.54 persons per property is an estimated average for unmeasured properties for the timeframe 2011/12 – 2025/26 from official figures documented in the NWG 2015-2020 WRMP). • Other sources included draft outage plans and Netbase.
Duration	56	• Working with various SMEs through a number of assessment focused workshops, durations were given from expert judgement. • There were no significant past incidents that could be used for guidance.
Likelihood	68	• Working with various SMEs through a number of assessment focused workshops, power loss history and power supply / site draw was recorded from expert judgement. • Further outage logs were obtained covering a very small number of Northern sites, with little clarity around source of failure, resulting in these not being used.
Vulnerability	56	• Working with various SMEs through a number of assessment focused workshops, anticipated vulnerability was recorded from expert judgement as estimates for different types of site.
Redundancy	62	• Working with various SMEs through a number of assessment focused workshops, site redundancy was recorded via understanding outage duration, downstream storage capacity, and alternative feeds to locations to understand population likely to lose supply. For some sites this was based on the existing outage plans though this was not consistent.
Response & Recovery	62	• Working with various SMEs through a number of assessment focused workshops, existing ERPs were recorded & evaluated. • Further outage plans emerged for a number of sites (WTW only). • The outage plans were widely regarded as too generic and often “optimistic”, with no hazard specific comments.
Resistance	62	• Working with various SMEs through a number of assessment focused workshops, power loss protections were recorded from expert judgement.
Reliability	62	• Working with various SMEs through a number of assessment focused workshops, design elements and the sites’ ability to continue functioning was recorded from expert judgment. • It was decided through these workshops that SRs and RWRs should be assumed to be able to function without power.

EXTREME WEATHER – 57/100 DATA QUALITY

Scale	39	• Population figures were taken from several places with sometimes conflicting data. • The main source was the 2011-2013 resilience work– assumed properties served were multiplied by 2.54 for a population estimate (2.54 persons per property is an estimated average for unmeasured properties for the timeframe 2011/12 – 2025/26 from official figures documented in the NWG 2015-2020 WRMP). • Other sources included draft outage plans and Netbase.	Redundancy	62	• Working with various SMEs through a number of assessment focused workshops, site redundancy was recorded via understanding outage duration, downstream storage capacity, and alternative feeds to locations to understand population likely to lose supply. For some sites this was based on the existing outage plans though this was not consistent.
Duration	56	• Working with various SMEs through a number of assessment focused workshops, durations were given from expert judgement. • There were no significant past incidents that could be used for guidance.	Response & Recovery	62	• Working with various SMEs through a number of assessment focused workshops, existing ERPs were recorded & evaluated. • Further outage plans emerged for a number of sites (WTW only). • The outage plans were widely regarded as too generic and often “optimistic”, with no hazard specific comments.
Likelihood	56	• Working with various SMEs through a number of assessment focused workshops, instances of extreme weather impacting site were recorded from expert judgement. • It was often challenging to differentiate between operational issues and shocks.	Resistance	62	• Working with various SMEs through a number of assessment focused workshops, the presence of temperature protections to key assets was recorded from expert judgement.
Vulnerability	56	• Working with various SMEs through a number of assessment focused workshops, anticipated vulnerability was recorded from expert judgement as estimates for different types of site.	Reliability	62	• Working with various SMEs through a number of assessment focused workshops, design elements and the sites’ ability to continue functioning was recorded from expert judgment. • Whilst various records of PPMs were provided, no insight was drawn from these due to the difficulty of identifying relevant assets. SME estimates of maintenance compliance were used instead.

MALICIOUS DAMAGE – 58/100 DATA QUALITY

Scale	39	• Population figures were taken from several places with sometimes conflicting data. • The main source was the 2011-2013 resilience work– assumed properties served were multiplied by 2.54 for a population estimate (2.54 persons per property is an estimated average for unmeasured properties for the timeframe 2011/12 – 2025/26 from official figures documented in the NWG 2015-2020 WRMP). • Other sources included draft outage plans and Netbase.	Redundancy	62	• Working with various SMEs through a number of assessment focused workshops, site redundancy was recorded via understanding outage duration, downstream storage capacity, and alternative feeds to locations to understand population likely to lose supply. For some sites this was based on the existing outage plans though this was not consistent.
Duration	53	• Working with various SMEs through a number of assessment focused workshops, durations were given from expert judgement. • Some durations were judged to be too abstract to estimate. • There were no significant past incidents that could be used for guidance.	Response & Recovery	62	• Working with various SMEs through a number of assessment focused workshops, existing ERPs were recorded & evaluated. • Further outage plans emerged for a number of sites (WTW only). • The outage plans were widely regarded as too generic and often “optimistic”, with no hazard specific comments.
Likelihood	66	• Working with various SMEs through a number of assessment focused workshops, malicious damage incidents were recorded from expert judgement. • Further incident records were provided and used to verify expert judgement. • Sites were assigned a morphological category using Office for National Statistics Rural-Urban Classification maps.	Resistance	62	• Working with various SMEs through a number of assessment focused workshops, information covering fencing provision was given. • It may be appropriate to review what is assessed in future. • Security highlight that all water supply and distribution sites will comply with Water UK Security Specifications by the end of AMP 6, and provided very little current data.
Vulnerability	62	• Working with various SMEs through a number of assessment focused workshops, anticipated vulnerability was recorded from expert judgement regarding open access points and whether critical points of the system could be impacted.	Reliability	62	• Working with various SMEs through a number of assessment focused workshops, design elements and the sites’ ability to continue functioning were recorded from expert judgment. • Security highlight that all water supply and distribution sites will comply with Water UK Security Specifications by the end of AMP 6.

APPENDICES

APPENDIX 1 – GLOSSARY

GLOSSARY

Acronym	Description
AMP7	Asset Management Plan 7 – The next regulatory period running 2020-2025
BAU	Business As Usual – The normal day-to-day running of the organisation that resilience should be part of
Capex	Capital Expenditure – Often large sums sometimes erroneously seen as the only way of improving resilience
CBM	Condition Based Maintenance – Monitoring actual asset condition to determine triggers for maintenance to be carried out
DEFRA	Department for Environment, Food and Rural Affairs – Urging water companies to demonstrate they are managing critical risks
DO	Deployed Output – Average amount of water supplied from a site per day
DWSP	Drinking Water Safety Plan – Risk based approach to each water supply chain to ensure safe supply of water to customers
EA	Environment Agency – Provides open access data used for flooding assessments
ERP	Emergency Response Plan – Often generic but best practice is collaborative and multi-layered with specific guidance
FMECA	Failure Mode, Effects, and Criticality Analysis – Bottom-up approach to identifying most impactful opportunity for intervention
HV	High Voltage – Electrical supply for specific sites or equipment which often requires additional on-site infrastructure and specialist equipment and skills
IAM	Intelligent Asset Management – NWG programme to improve understanding and maintenance of assets launching in 2020
IT/OT	Information & Operational Technology – All software & hardware on site, also teams within NWG who look after this equipment and cyber threats
LV	Low Voltage – Most common type of electrical supply to site (with plans to expand) and relatively easy to work with
MSOA	Middle-Layer Super Output Area – Mapping layer produced by the Office for National Statistics and used to understand type of location for each site
NWG	Northumbrian Water Group – Used to refer to both Northumbrian Water and Essex & Suffolk Water together
Ofwat	Office of the Water Regulator – Economic regulator for the water industry with mandate to ensure resilience of water supply
PPMs	Planned Preventive Maintenance – Activities scheduled in advance to address potential failures before they occur

APPENDIX 1 – GLOSSARY

GLOSSARY

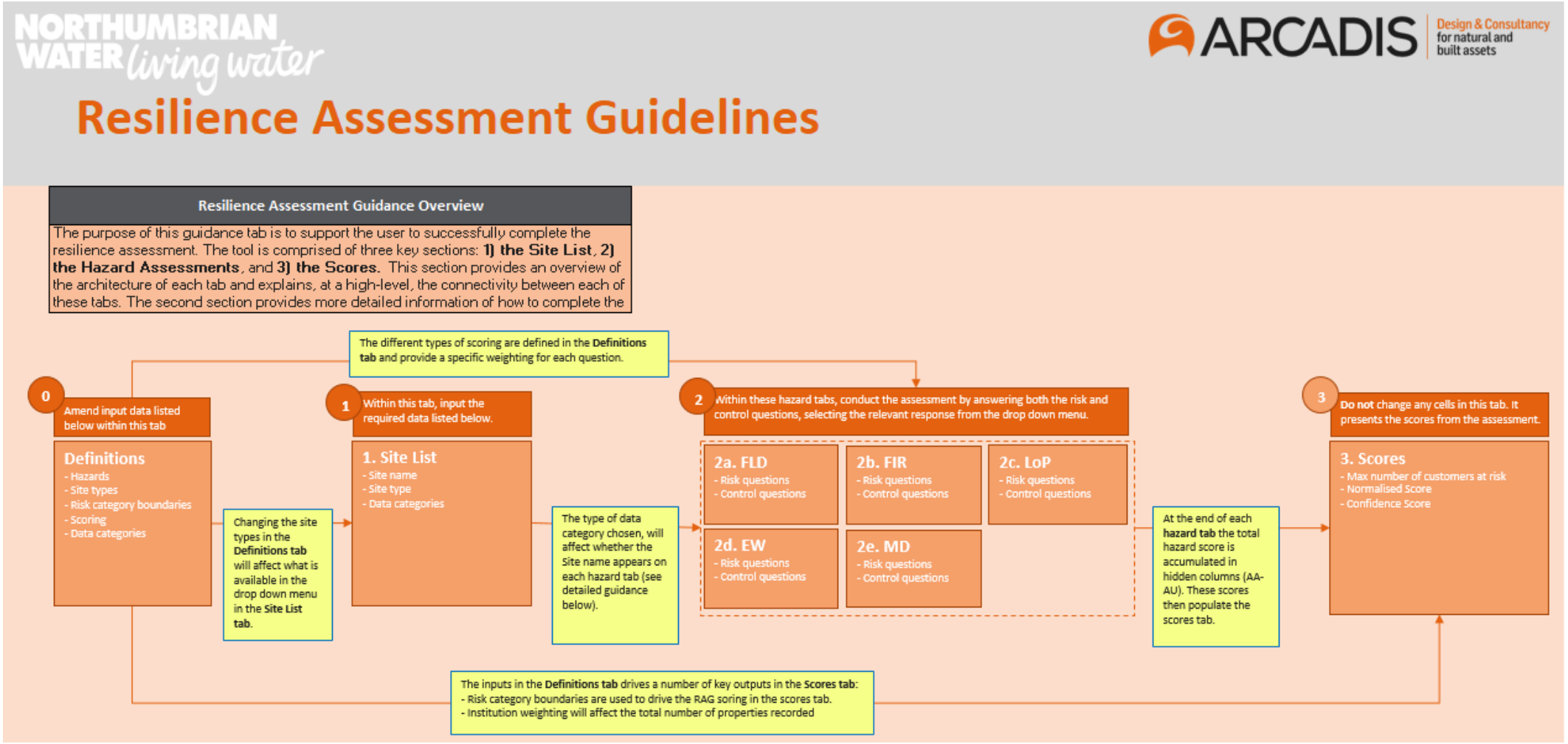
Acronym	Description
PR19	Price Review 2019 – Process for setting maximum water prices & asset investment for AMP7 which will include demonstration of resilience consideration
PS	Pumping Station – Array of pumps used to raise water so that most of the network is gravity fed
RCM	Reliability Centred Maintenance – Approach to designing maintenance interventions to ensure reliability of assets or key parts originally developed in the aviation sector
RWR	Raw Water Reservoir – Storage of untreated water often acting as large scale strategic reserves
EDA	Enterprise Decision Analytics – A set of analytics, modelling, & optimisation tools provided by SEAMS to support Asset Management and investment processes in order to provide maximum value for customers and stakeholders
SEMD	Security & Emergency Measures Direction – Used to define target level of security for all sites
SLAs	Service Level Agreements – Contracts with suppliers that may highlight response times, conditions of service, etc…
SMEs	Subject Matter Experts – Individuals within the organisation with specific knowledge and experience of a topic
SR	Service Reservoir – Storage of treated water providing buffer to supply loss
TCTF	Too Critical To Fail – Sites selected for this assessment based on previous work highlighting that consequence of interruption would be greater than organisational response capabilities
WRMP	Water Resources Management Plan – Plan for maintaining balance of water supply and demand submitted to Defra every five years
WTW	Water Treatment Works – Site designed for processing of Raw Water to produce clean, safe drinking water for supply to customers

APPENDIX 2 – GUIDANCE DOCUMENTS

ASSESSMENT SPREADSHEET GUIDANCE

The resilience assessment guidelines are located at the start of each excel workbook to provide the user with guidance on how to complete the assessment. The guidelines contain two sections:

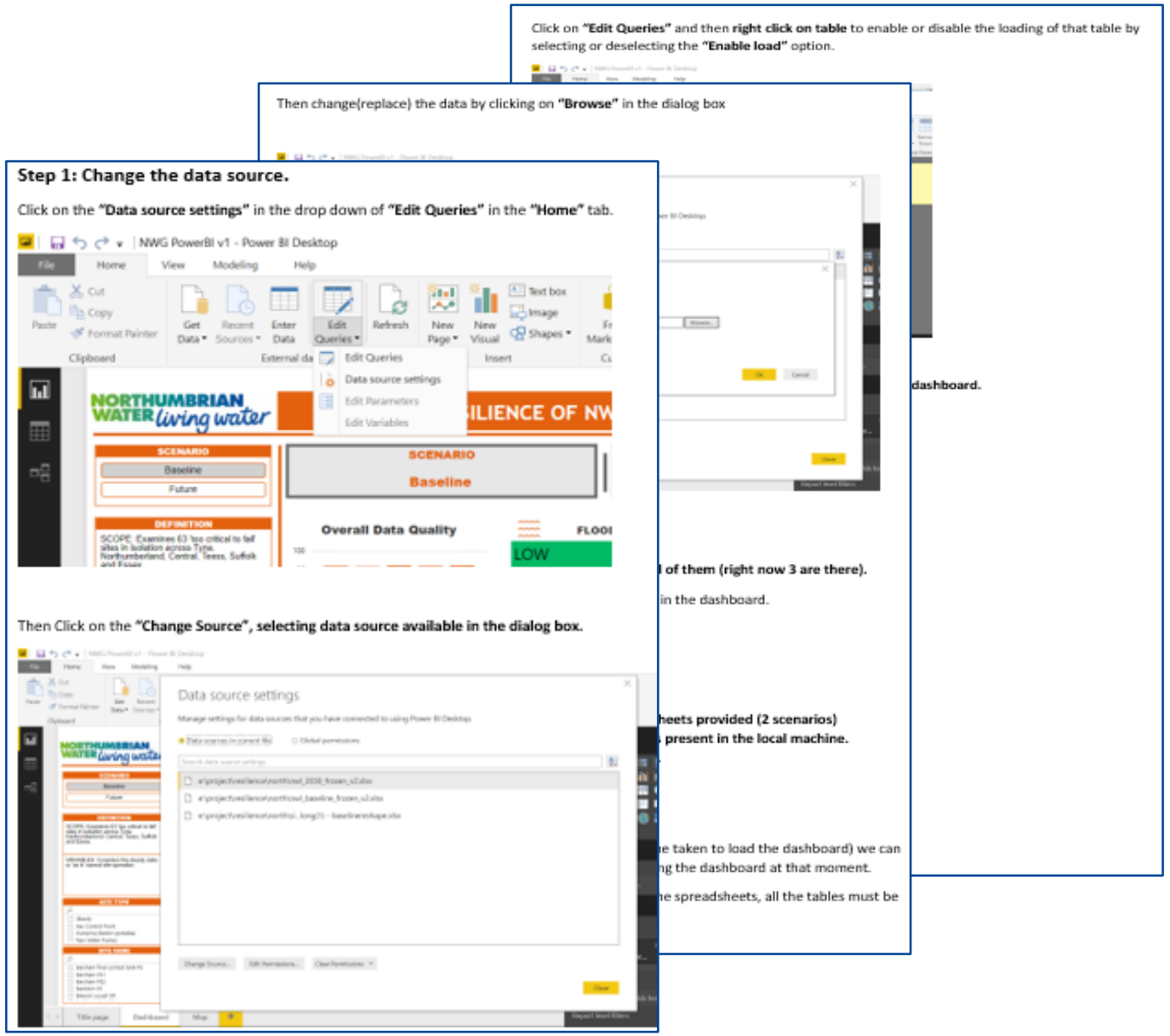
- Guidance overview – this highlights the architecture of the tool and indicates how all the sheets are connected (see figure below)
- Detailed guidance – this provides step by step guidance on how to complete the assessment (see assessment tool for example)



APPENDIX 2 – GUIDANCE DOCUMENTS

DASHBOARD GUIDANCE

As more sites are assessed and different scenarios are considered there will be a requirement to change, amend or update the data presented. The dashboard guidance document contains a step by step walk through of how to change the data source.



APPENDIX 3 – DATA

BASELINE DATA AVAILABILITY

Most data received has covered some sites or areas only so there has been heavy reliance on expert judgement. Positive engagement from local stakeholders (see Appendix 6) to gain this expert judgement means >99% of questions have been answered. This high level of completeness provides a very consistent level of scoring and has captured tacit knowledge from across NWG but should not be mistaken for high quality of data.

	a. Surface Flooding	b. Fire	c. Power Loss	d. Extreme Weather	e. Malicious Damage
1. Consequence - Scale					
2. Consequence - Duration					
3. Likelihood					
4. Vulnerability					
A. Reliability					
B. Resistance					
C. Response and Recovery					
D. Redundancy					

Key
All data present and validated
Expert judgement (primarily)
Some data received but not fully validated
Awaiting data
Awaiting response
Data not available

APPENDIX 3 – DATA

DATA QUALITY CRITERIA

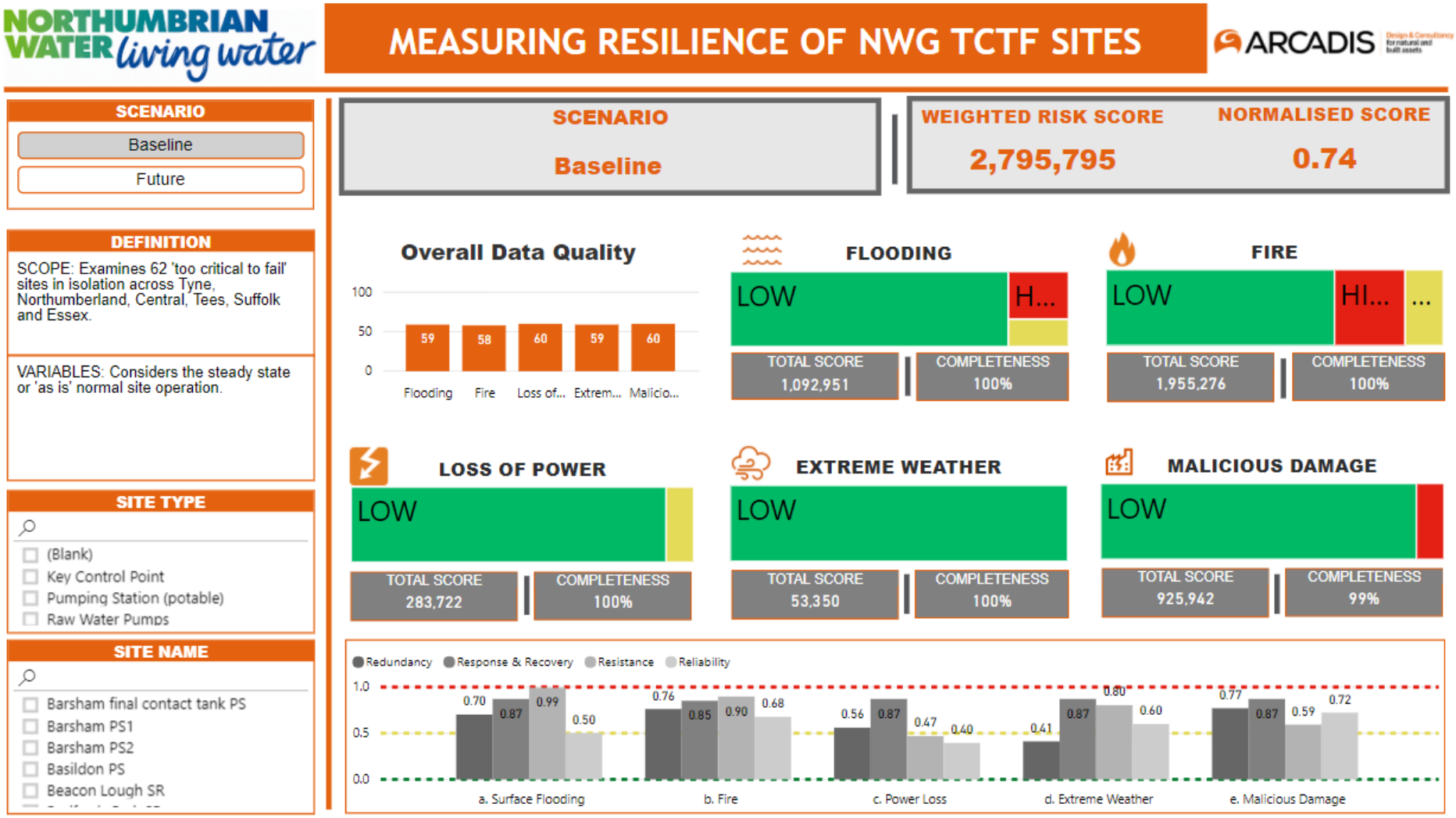
The following chart highlights the defined criteria used in the data quality framework.

Completeness - a complete set of data is available for each asset data record and all assets are recorded	Score
100%	5
≥90%	4
≥75%	3
≥50%	2
≥25%	1
<25%	0
Data Source - how the data was obtained	**Score**
Corporate databases or generated information available for the specific question being posed.	5
Trusted external data, e.g. Environment Agency websites for flood zone limits.	4
Structured data from unsecured source (eg spreadsheets on desktop) or trusted expert opinion	3
Professional judgement provided based on generic assumptions or partial information	2
Generic estimate provided	1
Accuracy - the data is a true reflection of the physical entity it represents	**Score**
All answers verified by multiple sources	5
Answers supported by robust evidence & SME	4
Answers validated by SME	3
Answers only partially validated by SME	2
Answers not validated	1
Consistency - data is provided from a consistent understanding of the requirements (consistency is less than or equal to completeness)	**Score**
All answers provided by the same consistent source(s) based on clearly defined parameters	5
Majority (90%+) of the answers provided by the same consistent source(s)	4
75%+ of answers coming from the same consistent source(s)	3
More than 50 % of the answers coming from the same source(s)	2
Answers from multiple conflicting source(s)	1
Timeliness - data is up to date and reflects the current state of an asset	**Score**
<1 month	5
<1 year	4
1-5 years	3
5-10 years	2
10+ years	1

APPENDIX 4 – DASHBOARDS

INTERACTIVE ASSESSMENT DASHBOARD

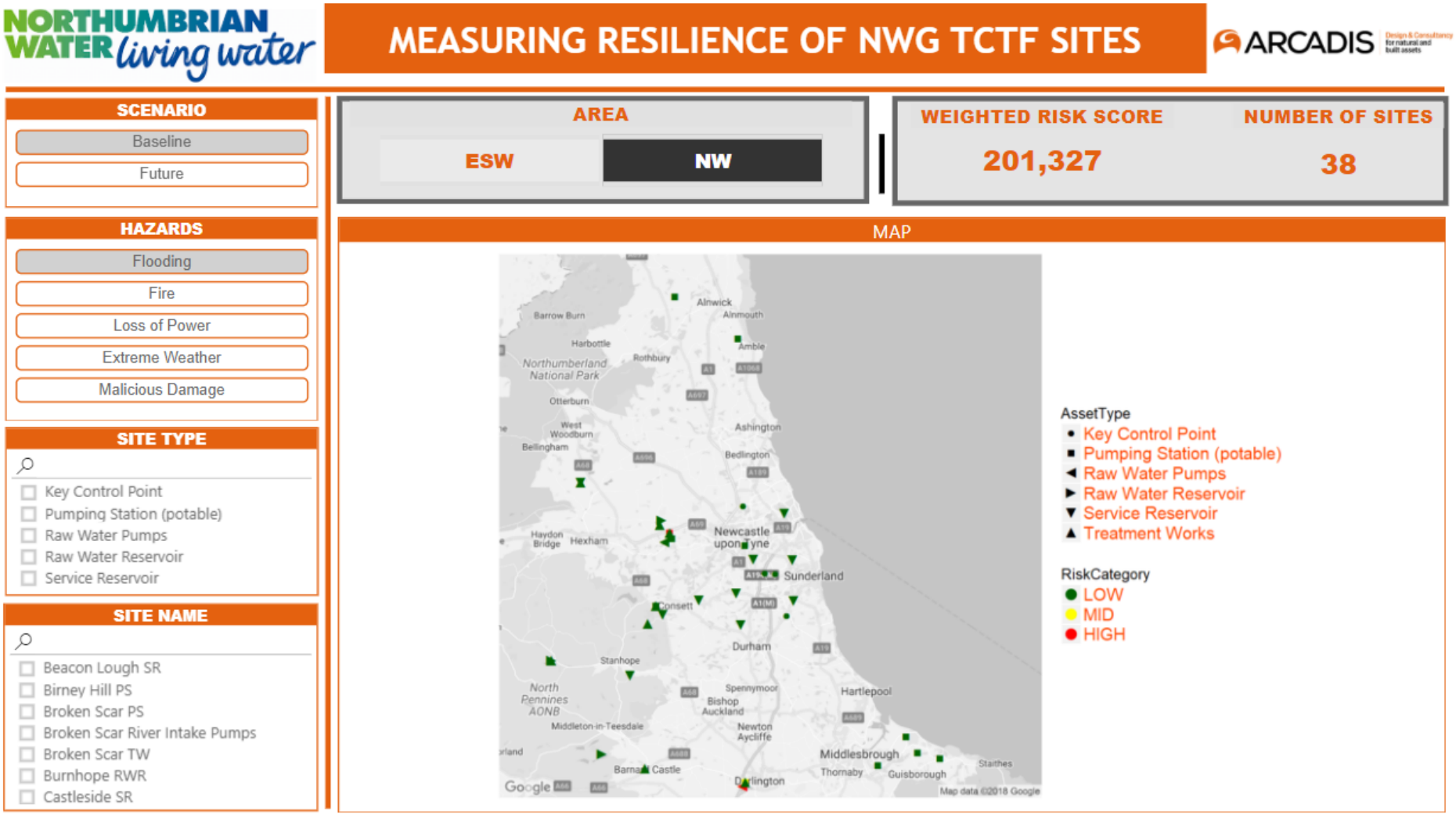
This is an interactive dashboard which allows the interrogation of resilience down to site level. It demonstrates which hazards are most prominent, whilst also highlighting the level of controls that are in place. The dashboard provides a visualisation of the weighted risk score from the assessment, detailing the overall hazard score, specific site type scores and site specific scores, all which are taken from the weighted scores in the assessment.



APPENDIX 4 – DASHBOARDS

SITE LOCATION MAPS

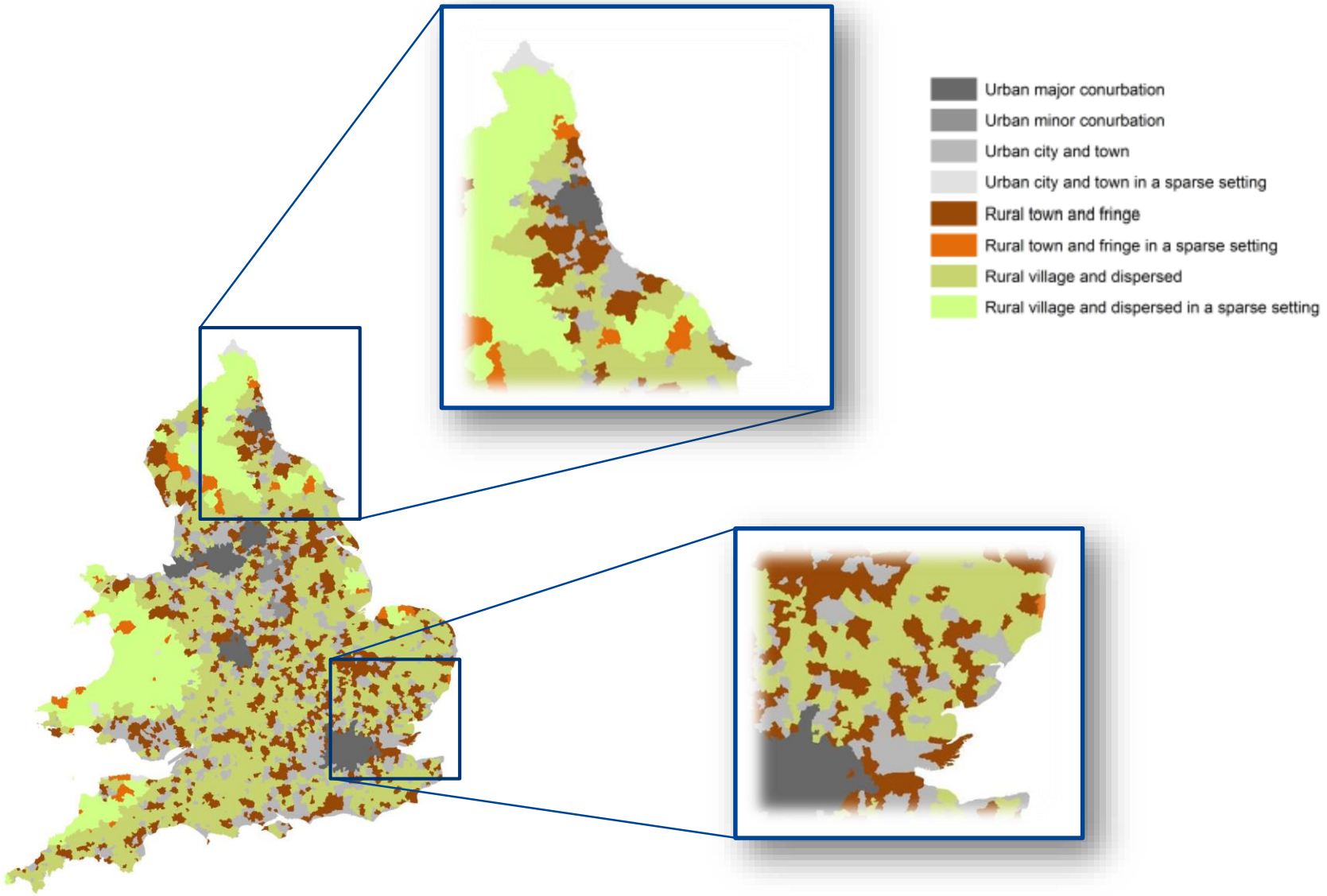
The “Resilience Site Map” highlights the level of resilience across the geographical spread of sites, whilst providing insight to threat levels at each site broken down by hazard. The map displays the weighted risk score for each of the hazards by site. Further filtering can be done to single out the weighted risk score for each site type or individual site score by hazard.



APPENDIX 5 – EXTERNAL DATA METHODOLOGIES

MSOAS, RURAL-URBAN CLASSIFICATION METHODOLOGY

Rural – Urban Classification for Output Areas (OAs), 2011



2011 Rural Urban Classification - Methodology

PDF, 3.83MB, 36 pages

This file may not be suitable for users of assistive technology. Request an accessible format.

APPENDIX 5 – EXTERNAL DATA METHODOLOGIES

EA FLOOD ZONES METHODOLOGY

To complete the flood zone question for the resilience assessment go to…

https://flood-map-for-planning.service.gov.uk/

... **and complete the three following steps:**

- Provide a postcode, place or National Grid Reference (NGR) where your development will take place
- Confirm the location using a map
- View a map showing the probability of flooding in the area

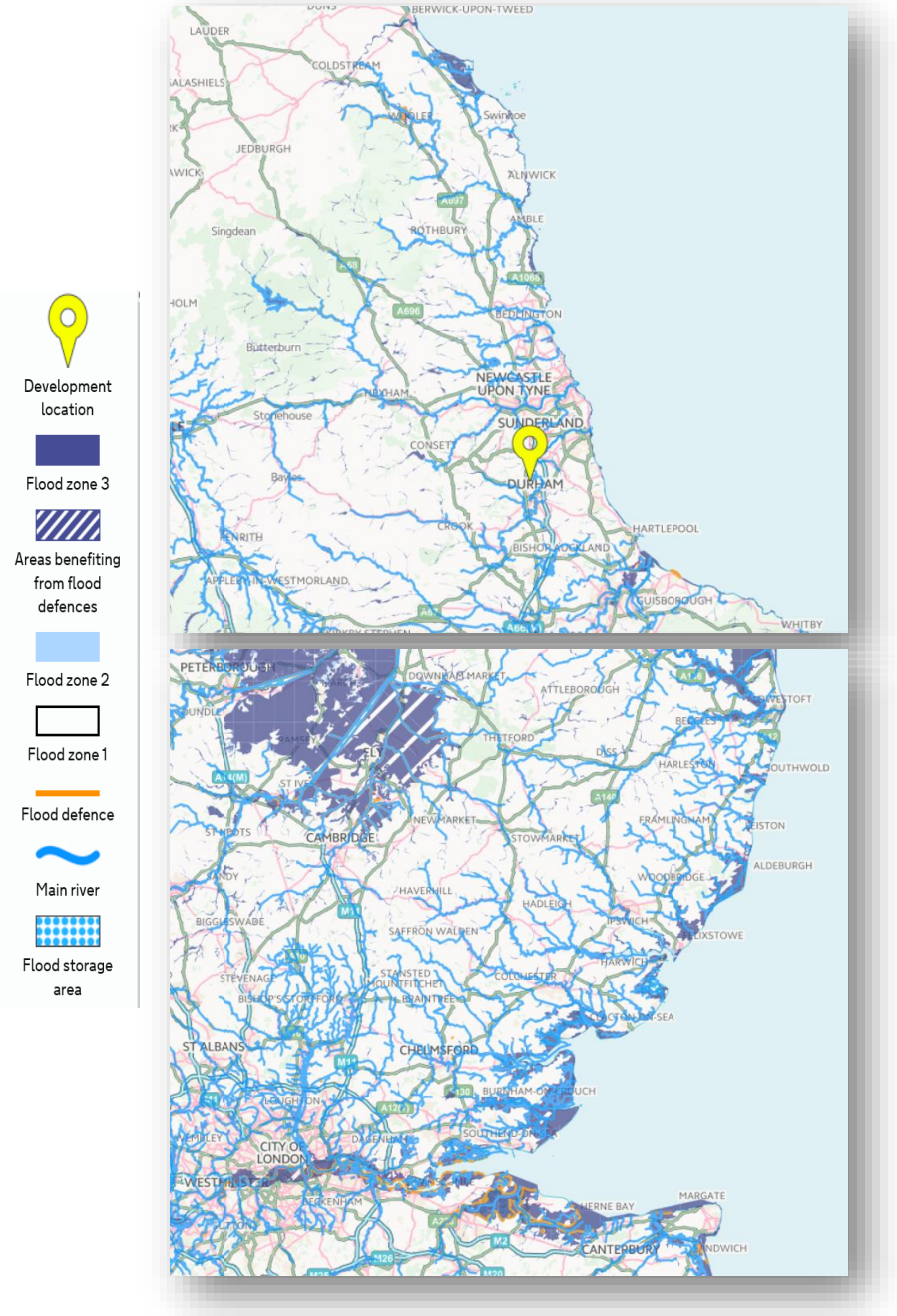
The location will be categorized into:

Zone 1: Low probability
Land having a less than 1 in 1,000 annual probability of river or sea flooding.
(Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3)

Zone 2: Medium probability
Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or
Land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding.
(Land shown in light blue on the Flood Map)

Zone 3a: High probability
Land having a 1 in 100 or greater annual probability of river flooding; or
Land having a 1 in 200 or greater annual probability of sea flooding.
(Land shown in dark blue on the Flood Map)

Zone 3b: The functional floodplain
This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency.



APPENDIX 6 – STAKEHOLDER ENGAGEMENT

MEETING AND WORKSHOP TRACKER

Attendees	Date	Purpose	Agreements/actions
NWG Michael Baker, Paul Richardson, Matthew Summers **Arcadis** Olu Eriolu, Sam Critchley, Federico Amorosi	08/01/2018	Kick-off – Boldon House	• Agreed Matthew Summers would be primary point of contact to assist with data collection • Scope discussion around the potential inclusion of more than 63 sites • Discussed each of the 6 hazards • Set-up SharePoint for shared access to all data and documents • Agreed dates for the 6 workshops and locations • Agreed the two scenarios, (Baseline and Future 2030)
NWG Michael Baker, Matthew Summers **Arcadis** Michael Rose, Sam Critchley	11/01/2018	NWG Network Overview Session – Boldon House	• General network overview from Mick and Matt, no specific NWG actions following the session • Update Federico Amorosi on session detail
NWG Michael Baker, Paul Richardson, Matthew Summers **Arcadis** Michael Rose, Sam Critchley, Federico Amorosi	16/01/2018	Weekly Update Call - Skype	• Agreed hazards • Agreed scenarios to be assessed • Reviewed and agreed the project charter *Update packs used for Weekly Calls available for details on the content covered

APPENDIX 6 – STAKEHOLDER ENGAGEMENT

MEETING AND WORKSHOP TRACKER

Attendees	Date	Purpose	Agreements/actions
NWG Michael Baker, Paul Richardson, Matthew Summers, Andrew Charleton, John Gibson, Michael Walsh **Arcadis** Michael Rose, Sam Critchley, Federico Amorosi	22/01/2018 (am)	Northumberland and Tyne Workshop, Networks – Northumbria House	• Review responses • Identify any further data gaps • Score quality of responses based on further data received • Complete assessment
NWG Michael Baker, Paul Richardson, Matthew Summers **Arcadis** Michael Rose, Sam Critchley, Federico Amorosi	22/01/2018	Weekly Update – Northumbria House	• General catch-up, discussion focused on the flow and further thoughts from the first Northumberland and Tyne workshop
NWG Michael Baker, Paul Richardson, Matthew Summers, Ken Robinson, Victoria Erickson, David McDermott, Stuart Tilley **Arcadis** Michael Rose, Sam Critchley, Federico Amorosi	22/01/2018 (pm)	Northumberland and Tyne Workshop, Supply – Northumbria House	• Review responses • Identify any further data gaps • Score quality of responses based on further data received • Complete assessment

APPENDIX 6 – STAKEHOLDER ENGAGEMENT

MEETING AND WORKSHOP TRACKER

Attendees	Date	Purpose	Agreements/actions
NWG Michael Baker, Matthew Summers, Jerry Trowbridge, Antony Smith **Arcadis** Sam Critchley, Federico Amorosi	23/01/2018	IT / OT Telemetry Overview – Northumbria House	• Agreed to review telemetry hazard and explore options for alternative approaches given the work that is being undertaken by the IT / OT team in the cyber space
NWG Michael Baker, Paul Richardson, Matthew Summers, Ivan Morpeth, Gary Hebron **Arcadis** Michael Rose, Sam Critchley, Federico Amorosi	24/01/2018 (am)	Central and Tees Workshop, Supply – Broken Scar	• Review responses • Identify any further data gaps • Score quality of responses based on further data received • Complete assessment
NWG Michael Baker, Paul Richardson, Matthew Summers **Arcadis** Michael Rose, Sam Critchley, Federico Amorosi	24/01/2018 (pm)	Central and Tees Workshop, Networks – Broken Scar	• Review responses • Identify any further data gaps • Score quality of responses based on further data received • Complete assessment
NWG Michael Baker, Matthew Summers **Arcadis** Michael Rose, Sam Critchley, Federico Amorosi	30/01/2018	Weekly Update - Skype	• Agreed report structure • Discussed and agreed to omit the telemetry hazard and enhance the Malicious Damage hazard

APPENDIX 6 – STAKEHOLDER ENGAGEMENT

MEETING AND WORKSHOP TRACKER

Attendees	Date	Purpose	Agreements/actions
NWG Michael Baker, Paul Richardson, Matthew Summers, Katie Davis, Tom Nichols, Louise Gell, Paul Barker, Lee Neal, Adrian Cross, Jon Burton, Mike Walker **Arcadis** Michael Rose, Sam Critchley, Federico Amorosi	06/02/2018 (am)	Essex and Suffolk Workshop, Supply - Hanningfield	• Review responses • Confirm the responses around fire, likelihood and risk are consistently identified as negligible for reservoirs • Clarify monitoring regime at Hanningfield • Identify any further data gaps • Score quality of responses based on further data received • Complete assessment • Combine Ormesby sites into one for assessment meaning only 62 sites included
NWG Michael Baker, Paul Richardson, Matthew Summers, Malcolm Huggins, Bernard Bray, David Sayer **Arcadis** Michael Rose, Sam Critchley, Federico Amorosi	06/02/2018 (pm)	Essex and Suffolk Workshop, Networks - Hanningfield	• Review responses • Review frequency of power outages – are they consistent across the region • Explore assuming a minimum duration for power outages • Identify any further data gaps • Score quality of responses based on further data received • Complete assessment
NWG Michael Baker, Paul Richardson, Matthew Summers **Arcadis** Michael Rose, Sam Critchley, Federico Amorosi	06/02/2018	Weekly Update Call – Hanningfield	• General catch-up, discussion focused on the flow and further thoughts from the Essex and Suffolk workshops • Confirmed we are using EA flood zone analysis for Surface Flooding hazard
NWG Michael Baker, Matthew Summers **Arcadis** Michael Rose, Sam Critchley, Federico Amorosi	13/02/2018	Weekly Update - Skype	• Finalised data availability • Discussed baseline assessment outcomes • Overview of the draft dashboard *Update packs used for Weekly Calls available for details on the content covered

APPENDIX 6 – STAKEHOLDER ENGAGEMENT

MEETING AND WORKSHOP TRACKER

Attendees	Date	Purpose	Agreements/actions
NWG Michael Baker, Matthew Summers **Arcadis** Michael Rose, Sam Critchley, Federico Amorosi	14/02/2018	Future State Assumptions Workshop – Boldon House	• Update assessment responses to reflect the assumptions gained • Complete the future state assessment
NWG Michael Baker, Matthew Summers **Arcadis** Michael Rose, Sam Critchley, Federico Amorosi	21/02/2018	Weekly Update - Skype	• Further amendments to the dashboard, change the language used for score output • Align language in assessment to match dashboard language *Update packs used for Weekly Calls available for details on the content covered
NWG Michael Baker, Paul Richardson, Matthew Summers **Arcadis** Sam Critchley, Federico Amorosi	27/02/2018	Weekly Update Call - Skype	• Agreement around final deliverable handover • Agreement on stakeholder presentation content • Agreement on what is to be sent to stakeholders ahead of Friday
NWG Michael Baker, Matthew Summers, Paul Saynor **Arcadis** Michael Rose, Sam Critchley, Federico Amorosi	02/03/2018	Presentation of Final Report, Findings and Recommendations	• No specific actions following the session *Presentation available for further detail

APPENDIX 7 – PROJECT GOVERNANCE

PROJECT CHARTER

Deliverables

	When
a) Baseline Assessment	a) 09/02
b) Future Assessment	b) 16/02
c) Resilience Dashboard	c) 02/03
d) Resilience Assessment Report	d) 02/03

Critical Success Factors

- Results and recommendations are recognised & understood by stakeholders.

Activities

- Gather and understand data
- Identify data gaps
- Carry out workshops for further data gather and to address gaps
- Complete baseline assessment
- Define future state and assumptions
- Complete future state assessment
- Analyse change between baseline and future
- Final analysis and alignment of business intelligence
- Develop and deliver final report

Objectives

- Establish an understanding of resilience of key Water sites through the application of a customer consequence led assessment.
- Enable NWG to respond to Ofwat's long term resilience themes as part of PR19, evidencing consideration of impact of mitigation and intervention.
- Strengthen understanding and ability to quantify and articulate resilience and how it will improve.

In Scope

- 62 high criticality sites across all zones (2 merged)
- Baseline & 2030 Scenarios
- Flood, extreme temperatures, fire, power loss, malicious damage (including telemetry) hazards only.

Out of Scope

- Asset level assessment
- Network analysis
- Multiple failures analysis
- Technical cyber assessment for 3rd party malicious damage to telemetry

Risks

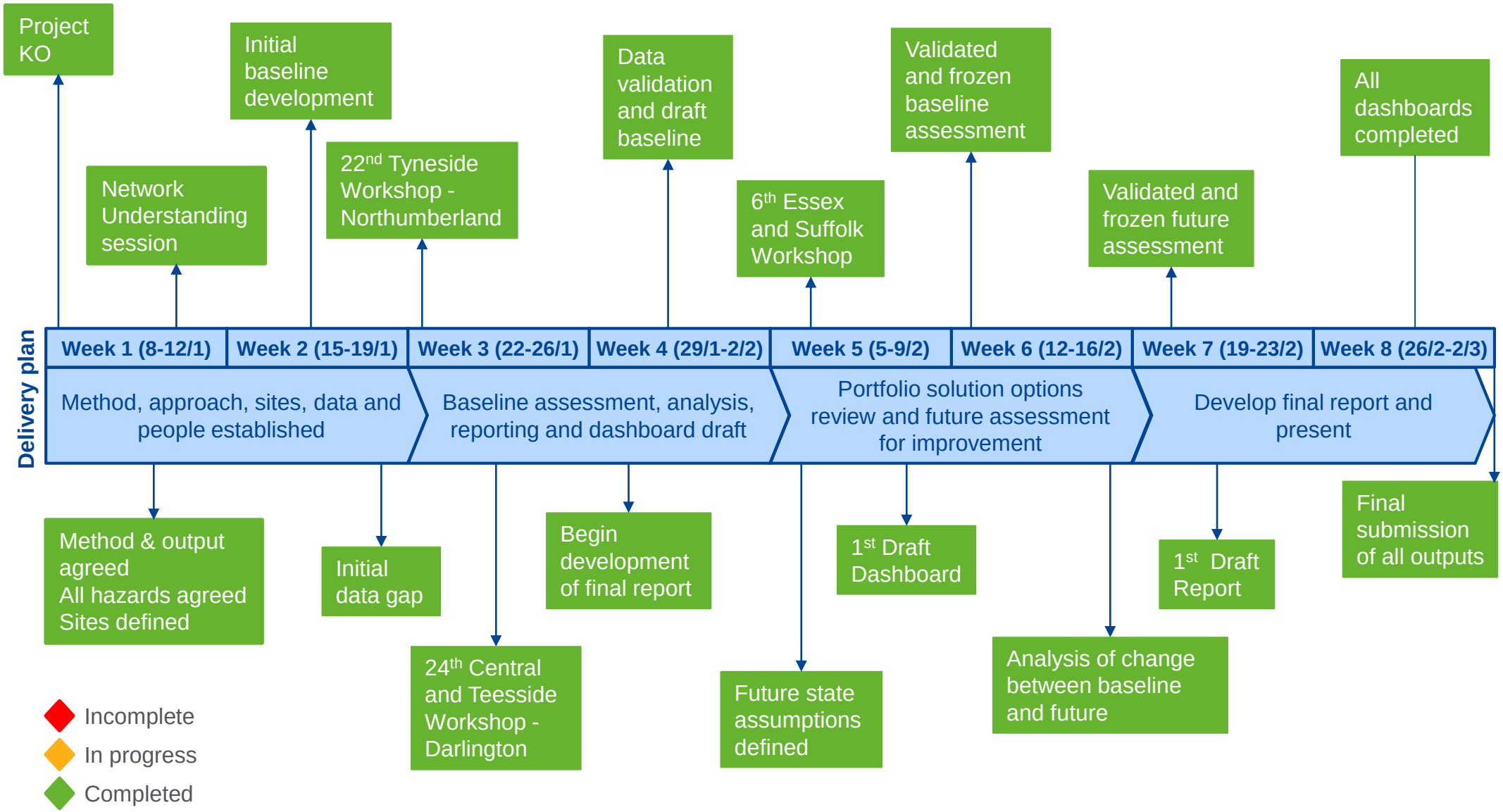
Risk	Mitigation
• Project may not deliver expected outcomes without alignment on objectives, deliverables, assessments, and inputs. • Late/not freezing assessments may lead to an inconclusive report. • Incomplete or late data would result in worse scores than reality. • Business intelligence from stakeholders is critical to assessment accuracy and relevance of recommendations.	• Agree Charter up front. • Set up weekly stakeholder briefing and regularly review draft outputs. • Develop assessment and report together and create plans for unfrozen outputs. • Early and ongoing engagement on data and stakeholder availability. • Carry out data based assessments where possible and provide multiple opportunities for stakeholder input.

Resources

Role	FTE
Sam Critchley – Assessment project delivery	100%
Fed Amorosi – Assessment project delivery	100%
Matt Summers – Primary NWG contact and stakeholder introductions	40%
Mike Rose – Project lead and industry insight	20%
Olu Eriolu – Best practice and wider Arcadis	10%

APPENDIX 7 – PROJECT GOVERNANCE

EIGHT WEEK MILESTONE PLAN



APPENDIX 8 – ASSUMPTIONS & ASSERTIONS

2030 SCENARIO SITE SPECIFIC ASSUMPTIONS

- **Gunnerton:** There are specific plans in place to improve fire suppression
- **Broken Scar** (all site types across all hazards): There are plans in AMP7 to utilise Larthington by 2025 to provide support – still likely to be 30ML short of 60ML changing redundancy to <50% loss
- **Washington Control:** Plans for AMP7 for new reservoir in the area and additional connectivity to make the site 100% redundant
- **Birney Hill:** new PS being built which will be LV with a fixed generator on site
- **Hanningfield PS 3A:** switching to LV will have full security fence
- **Layer:** Expanded Abotton to increase raw water quantity, Plan to install pipe between Abotton and Hanningfield to move water from Abotton, Hanningfield has DO of 250, so Layer may be able to be fed from Hanningfield (Hanningfield at full DO and further network flexibility to support Layer) – See added details to Hanningfield
- **Ormesby:** By 2020 there will be a new main connecting Ormesby to Loud, with further improvements planned at Barsham, redundancy will improve although not enough to alter population loosing supply
- **Horsley:** Plans to improve water treatment capacity
- **Hanningfield** (comments from further redundancy investigation, email from Bernard Bray):
  Between Nth Essex (Langham and Layer works) and Danbury (Chelmsford) we have approx. 40 to 50 ml/d of demand which in the event of Layer falling over we can support that area from Langham just – this assumes Langham can do the flow if required, no guarantees it could. We do this by affectively separating the Essex supply zone into two parts with the boundary being Slough House valves. Hanningfield supply is down stream of the Slough House valve cluster so we could not support a long term outage of Layer from Hanningfield easily. We have in the past closed in valves further downstream such that Hanningfield can push water back to Danbury but this is fraught with risk and would not be sustainable for any long duration.
  However in writing this Email there is one possibility that could stand a chance of working long term. It would require the Network to be configured in a way that it never has previously and ultimately, may not be possible, but certainly worth investigation. If my idea is workable then I think we could support a long term Layer outage. That said not for all Demand conditions, if it was peak summer on total volume grounds it would prove very difficult if not impossible.
  At this time I would say no it could not – but necessity is the mother of invention.....