Final Project Report
Ecological Digital Twin
Anglian Water
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1) Executive Summary – Ecological Digital Twin

Overview

This project brought together Anglian Water and a partnership of organisations to explore how digital twin and AI technology could be extended to the natural world to address the problems we collectively face across the water sector and wider society in a way that could be scaled to all water companies across the

UK. This project aimed to deliver short and long-term outcomes aligned with Ofwat's strategic innovation themes. Firstly, to directly improve the health of our rivers, overall environment and the general public's perception of river water quality. The platform aimed to provide a novel way to engage all stakeholders in the health and ecological management of UK rivers, and to deliver directly or indirectly, against Ofwat's strategic innovation themes. The ecological digital twin aimed to help protect and enhance the future natural environment by providing a new capability to manage and model ecological health and the impact of the whole stakeholder community.

As part of Anglian Water's purpose to create social and environmental prosperity for the region, in 2022 Anglian Water joined forces with Severn Trent to Get River Positive by 2030. Working collaboratively, Get River Positive is driving real action and making the changes we all want to see for a better future for our rivers and environment through a wide variety of partnership-led projects, including this one, which aligned perfectly with the Get River Positive commitments.

Together, the partnership explored the problems we collectively face across the water sector and wider society; Only 14% of rivers in England are at Good Ecological Status, 10% of freshwater and wetland species are threatened with extinction in the UK, and we've lost 90% of our wetland habitats in the last 100 years. Healthy wetlands and rivers provide communities with protection from flooding, access and amenity and physical & mental health benefits. Many sectors impact river health and there are gaps in system thinking leading to sub-optimal outcomes. Our goal for the project was to accurately understand the health of the river system and the positive and negative impact of Anglian Water's and other operations to enable effective action

Partner	Role
Microsoft and Avanade	Technology partners
Norfolk Rivers Trust, National Trust and the Environment Agency	Environmental and social value partners
Country Land and Business Association (CLA)	Agriculture and landowner representatives
University of Suffolk	Research and academic partners
Severn Trent and Wessex Water	Wider water industry representatives

A Digital Twin is a digital model of a real-world entity, in this case, a river, which enables the digital application of different inputs and scenarios in order to view the impact of these within the safety of the digital environment. With our technology partners, we began to create ideas of how extending digital twin and AI technology to the natural world could address the problems we faced and achieve our goal. We settled on creating a world-first River Quality Digital Twin, initially focused on the River Stiffkey, one of Norfolk's iconic chalk streams, but to be built and developed in a way that it could be applicable and scalable to any water company and river system.

Our theory was to first 'understand' the complex system of a river by mapping it within a common framework. We captured this in a River Health Ontology, which we could recreate as a digital model in a Digital Twin. The ontology defines the categories and properties of a river and how they relate to each other. It is applicable to all river systems and can be widely shared. With this digital representation of a river system, we then collated disparate datasets, aligned to the River Health Ontology model, into a single digital twin environment and connected via Anglian Water's existing data platform. With the River Quality Digital Twin being fed by data, we have opportunities to carry out complex system modelling of assets, processes and resources, to provide machine-led diagnostics and embedded analytics engines. This will provide future opportunities to determine cause and effect. With this clarity, there is potential for different organisations to come together to work collaboratively to determine the best course of action to protect and improve river health.

Background - prototype

In January 2023, an initial prototype solution was jointly funded by Anglian Water, Microsoft and Avanade over a 3-month project. Using expert knowledge from across the partnership, the river system ontology was created in an Azure Digital Twin. The Microsoft Azure platform helped to accelerate this as it provided us the tools and technology in a completely connected stack to implement ideas and test them quickly, utilising technology already used by Anglian Water and widely across the sector.

Alongside this, data sources were reviewed with partners for input into the prototype. Twenty-eight data sources were identified ranging from discharge flows, to weather, to river geojson files, to cropping and soil data. A data ingestion pipeline was built to store data in a data lake, transform it and ingest it into the Azure Digital Twin (ADT). With the digital representation of the river system populated with existing data, a UI layer was created in PowerBI to show trending and a spatial map of the river Stiffkey.

Moving to Minimum Viable Product

In May 2023 Ofwat Innovation funding was secured to continue developing the River Quality Digital Twin and move our prototype to an MVP stage.

The goal of the Ofwat Innovation Funded Project was to focus on use cases for the digital twin and to create a data science model that would provide an option to 'look forward', as well as onboarding more data. Three products were created, with varying levels of maturity:

- A PowerBI dashboard called **RiverKeeper** that empowers operational users to make data driven decisions by combining internal and external data available and presenting them in several spatial and trending information points.
- A PowerBI **RiverPlanner** proof of concept. This would allow the modelling of interventions and to view their impacts on the health of the river, with a primary focus on Nitrates, Ammonia and Phosphorus. RiverPlanner allows users to create action plans to implement either nature-based solutions or adjust the permitted levels of discharges to see what combination of actions are needed to reach a given water quality target. This enables the benefits and costs of point-source and farming interventions to be balanced and created into action plans. The aim is that the tool would be used collaboratively between different teams in Anglian Water as well as by Anglian Water working alongside farmers and landowners to support decision making.
- A mobile and web app **RiverViewer proof of concept** experience, intended to engage the public in the health of their local river and educate on the range of factors that influence this. The app is presented as a tour across five locations down the River Stiffkey. QR codes at each of the five locations unlock audio, video and animation that explain the factors that feed into keeping rivers healthy. The experience is intended to give a holistic picture of activities that a number of actors, agencies and businesses are doing to improve the quality of the river. It displays data from the nutrient sensors placed into the river, using the data systems developed within this project.

These products are distinct in terms of their usage to meet varying objectives, but all use the underlying River Quality Digital Twin capability that had been developed during the prototype. The River Quality Digital Twin capability was enhanced by increasing the data and coverage of the ontology, including installing new IOT sensors into sections of the river system to gather more data. A Structural Equation Model (SEM) was created to capture the state of the river as a series of observed values and equations linking each of these values. Our SEM captures the relationships between different datapoints on the river. This enables a view of the downstream impacts on the river of making a given intervention.

Conclusion

We have developed a River Quality Digital Twin of one of Norfolk's iconic chalk streams, the River Stiffkey. Seamlessly integrating the digital twin with historical data and data science models has provided Digital Cognition capability to Anglian Water, bringing clarity to Stiffkey's complex system, providing insight which will turbo charge the response to river water quality to meet the evolving needs of customers, wider society and the environment. The solution can be scaled to positively affect customers and the

environment now and in the long term, enabling new ideas and ways of working with partners from a broad range of sectors and perspectives. Taking an open approach, our project will generate learning for the benefit of all. We have created a step-by-step guide to support other companies in adopting the River Quality Digital Twin, in the spirit of the Ofwat Innovation fund and supporting knowledge sharing across the industry.

2) Introduction

Name: Ecological Digital Twin

Funding Stream: Water Breakthrough Challenge 3 Catalyst stream

River water quality is one of the greatest challenges facing industry and society. Recent surveys indicate only 14% are in a state of ecological health that can be described as 'good' All rivers fail to meet current standards for chemicals. Of the rivers impacted, two thirds (2,296 river water bodies) are affected by agriculture and the water sector itself impacts nearly half of the river water bodies (2,032). Urban and transport sectors account for a quarter of the issue. Pollution itself isn't the sole problem and it is simplistic to think of it this way. Abstraction and habitat destruction also put rivers future health in jeopardy.

Anglian Water and the partners involved in this project believe that the innovative world's first ecological digital twin will aid the water sector in protecting our rivers. There is evidence that capturing and utilising river water quality data has a positive effect on river health. A UKCEH study funded by DEFRA for example was able to correlate the impact of activated sludge treatment on a steady increase in the diversity and abundance of freshwater invertebrates downstream. The aim of our project was to collate these data sources and more to build a dynamic digital twin model rather than just a series of output reports and analysis.

England's river network includes 85% of the world's chalk streams, widely regarded as critical environmental habitats. Around a third of England's chalk streams are here in the East of England. The project developed an innovative ecological digital twin of one of Norfolk's iconic chalk streams, the River Stiffkey. It offered the ability to scale solutions to a major issue affecting customers and the environment now and in the long term, enabling new ideas and ways of working with partners from a broad range of sectors and perspectives. We have developed a proof of concept that integrates the best of advanced technology to provide insights. This includes the development of a **Digital Twin** (a virtual replica of a complex system, using Internet of Things data to understand it's current state), integrating with **Data Platforms** (a store of historical and enriching data to understand the system's previous states) and developing **Data Science** models (identify system diagnostics leading to prescriptive analytics and actionable insights).

Through the partners involved in the project gone outside of the water industry to include a variety of voices, opinions and needs into the project. Our project as a whole was undertaken on the premise that without extending our reach to the entire external community, we would not be able to succeed in building a true digital twin of the river catchment at Stiffkey.

Background

Prior to this Ofwat project, there were a number of initiatives that aim to capture and record data on the health of UK water bodies. Led in the UK by the Rivers Trust, the Water Framework Directive is a European directive that monitors waterbodies for a range of issues, including pollution from chemicals and excess nutrients, as well as the health of ecology such as plants and fish. Rated as high, good, moderate, poor or bad, river health is then categorised. Rivers that are described as 'good' or 'high' are the only water bodies in a sustainable and healthy condition. In addition, the Environment Agency also maintain the catchment data explorer dataset.

The UK Centre for Ecology and Hydrology (UKCEH) also develop frameworks and systems for the assessment and monitoring of river health. The UKCEH focus on how management of water quality and quantity affects river ecology and biodiversity. The UKCEH utilise a range of capabilities to build qualitative and quantitative analysis to guide policy decision making in the public and private sectors. There is evidence that capturing and utilising river water quality data has a positive effect on river health. A UKCEH study funded by DEFRA for example was able to correlate the impact of activated sludge treatment on a steady increase in the diversity and abundance of freshwater invertebrates downstream.

The aim of our project is to collate these data sources and more to build a dynamic digital twin model rather than just a series of output reports and analysis.

Innovative approach

Across our industry, water companies are making inroads into the application of machine learning and AI capabilities. As an industry we have recognised the significant opportunity to leverage these functions on top of our existing data and asset information to optimise performance. In addition to this, digital twin capabilities are becoming more and more prevalent across industries as we look to understand, model and test new hypotheses. Within the water industry this is

evidenced by the digital twin projects that are being used within projects like the SPA alliance with Anglian Water and the Beckton digital twin developed by Thames Water.

However, at this point most data and AI projects and digital twin initiatives are constrained to physical infrastructure. They are taking data feeds from service and physical devices to build machine learning powered models to optimise the delivery of water services to end consumers and businesses. Whilst water company efforts have been focused on transforming the use of data to optimise our infrastructure and services, our freshwater ecosystems are facing multiple pressures from a variety of pollutants, including chemicals, microplastics, pharmaceuticals, invasive species and land management practices. This results in the majority of UK rivers failing to have good ecological status, with only 14% of waterways in England, 46% in Wales, 50% in Scotland and 31% in Northern Ireland reaching what can be classed as the 'good' threshold.

This project identified the innovation potential of creating the world's first Ecological Digital Twin (EDT), around one of Norfolk's iconic chalk streams, the River Stiffkey. A Digital Twin is a capability that creates comprehensive models of an environment, allowing us to query data from a model of the environment, rather than from many disparate sensors or data speeds. Digital twins help us to build reusable, highly scalable, spatially aware experiences that link streaming data across the digital and physical world. An ecological digital twin will help to collate and provide insight that is enhanced by the uniquely relevant contextual features of a river system. The platform will deliver a shift from discrete reporting river water quality capabilities to the ability to query a live execution environment to extract machine learning insights from the twin graph. This ability to query historised environmental data and integrate with other data, analytics and AI services will allow us to track the impact on the river environment health and predict the future state.

Digital Cognition brings clarity to complex systems, providing new insights. Complex system mapping within a common framework provides clarity to whole systems, relationships & the impact of events. Complex system modelling of assets, processes & resources will provide machine-led diagnostics based on a number of key performance indicators (KPIs), and embedded analytics engines and nudging human behaviour will create automatic and autonomic prescriptions which can then be used to drive improvement.

Alongside the technical innovations inherent in the project, the collaborative nature of how the project was developed and the openness of approach have led to a wide range of contributions to be factored in to shape the outcomes throughout the agile management process. The project was designed with scalability and deployability in mind and contains a toolkit 'how to' guide to enable sharing.

Delivery team

The structure of key roles within the delivery team:

Project Lead : Carly Leonard (Anglian Water) : As Head of Environmental Strategy, Carly has worked in the sustainability field since 2008 and brings a wealth of experience of managing and delivering sustainability change programmes. Carly was the senior business stakeholder and overall lead for the project.

Data/business SME : Chris Gerrard (Anglian Water) : Chris is Head of Landscape Transformation at Anglian Water and has been delivering innovative projects for over 10 years in this role. Chris was

the primary Anglian Water Business and Data SME and lead the collation of wider data sets for ingestion into the ecological digital twin.

Programme Lead : Adam Dooley (Avanade) : As Group Manager, Digital Advisory at Avanade Adam has knowledge and experience of leading Product, Programme and Project management teams, Automation (RPA, Process re-engineering, Process mining), Mobile App, Enterprise Architecture, Capability Development and Systems Thinking. Adam has 15 years' experience working in a change and project environment within the Utilities sector and specialises in leading systems thinking, capability development and digital transformation. Adam was the Programme lead for the project and ensured that the agile methodology and scrum formats were adhered too and delivered on time.

Data and AI Consultant : Josie West (Avanade) : As Director, Josie led the strategy, performance and growth of the AI & IOT Offering for Avanade UK & Ireland. Josie is responsible for driving innovation, vision and development of Avanade's capability and works closely with Avanade Europe offering leadership, Microsoft and external partners to shape the offerings based on client centric demand and market pressures. Josie was the primary data and AI architect on the project and responsible for leading the development of the overall ontology.

CTO Data & AI : Simon Turner (Avanade) : Simon is CTIO for Data & AI for Avanade UK & I. He is a member of Avanade's Technology Leader Community, part of the Executive Leadership Council and also one of the four founding Avanade Distinguished Engineers. Simon is deeply passionate about the opportunities that innovation, technology and data can create, both at an enterprise and social level, whilst keeping people front and centre of the solution. Simon supported Josie and lead efforts on the development of data visualisations and interpretation**.**

Microsoft Lead : Lewis Richards : Lewis is the Microsoft CTO for the UK Water Industry and is the lead for sustainability initiatives within Microsoft. As part of the project Lewis was the pivot point into leveraging the Microsoft partnership.

Project Monitoring by Anglian Water's Innovation team:

Innovation Projects Manager : Denis Moran (until Q4 2023) & Jay Bullen (2024) : Denis was AW Research & Innovation's project manager with a specialisation in Water Quality. After departing AW, his role was filled by Jay Bullen.

Project Controls Manager: Sean Hoey (Project Phases 2-4) : Sean joined the OFWAT project to provide financial management and controls mechanisms to fulfil OFWAT's budgetary requirements. He provided oversight for the whole team over budgets, forecasts, actuals spends and scoping opportunities for how best to allocate the reserve funds.

Project Monitoring Officer : Phil Buckingham (Q3 2023 onwards) : Broader management of AW's Innovation portfolio, including Ofwat projects.

Project delivery support:

IS Project Manager: Darrell Froggart (Project Phases 1-4): Darrell was the Project Manager responsible for the delivery of all DDaT elements of the project, working with service lines to setup all new interfaces and data flows. Working with 3rd Party water sensor vendors to ensure

interfaces were setup to receive data and the solution was aligned with IT Cyber security standards. He was also the EDT project's link into the Information Services delivery vehicle of Anglian Water and worked closely with Avanade, he also provided gateway consultancy avenues with Azure and helped to map expected expenditure of a continuation of their work supported by EDT.

Anglian's catchment advisors:

Catchment Advisor: Rob Holland (Phase 2-4): Rob's work on EDT included liaising with Norfolk Rivers Trust regarding securing landowners/managers permissions to access and install the WATR monitoring equipment, securing appropriate licences/permissions from local authorities, IDB and EA. Rob was also involved with the App development, giving feedback and testing functionality. Testing and feedback on the dashboard was also part of his involvement. Finally, Rob was active in the delivery of video material for the river info app.

Catchment Advisor: Gary Hodgetts (Phase 2-4): Gary's work on EDT included liaising with Norfolk Rivers Trust regarding securing landowners/managers permissions to access and install the WATR monitoring equipment, securing appropriate licences/permissions from local authorities, IDB and EA. Gary was also involved with the App development, giving feedback and testing functionality. Testing and feedback on the dashboard was also part of his involvement.

Confidentiality

N/A

3) Project Methodology and Implementation

Project Approach

Avanade were the delivery partners for this project, using an agile delivery method based on the Scrum framework. The Scrum framework structures software development in cycles of work called Sprints, time boxes of work which are typically 1-4 weeks in length and take place one after the other without pause. For this project, we adopted a 2-week sprint period. This method was selected as being most appropriate for this project, with an agile approach providing continuous feedback to inform the development of the project, as the shared awareness of Anglian and Avanade developed and demonstratable progress was delivered each sprint.

Teams across Anglian Water were involved in shaping the focus and steering the project. This included catchment advisors, data teams, treatment leads, communications and community engagement colleagues and other potential users of the final products.

Phase 1 (Prototype)

The project began with an 8-week prototyping stage, to incorporate sensor data into an initial data visualisation dashboard, providing a baseline understanding of river health.

To do this, a data model was built within PowerBI to relate common data sources and provide visualisation of all relevant data within one platform. This data model uses the combined operational data within both Anglian Water and open-source data from various sources such as the Environment Agency. The data was designed to be filtered within PowerBI, with the aim of empowering users to find the most appropriate data to infer risks, and to make interventions as required.

A River Health model was also developed through multiple phases. Firstly, a paper-based ontology design was created in consultation with the project partners. The model aimed to understand where river health is good, by considering the following questions:

- What is the distribution of fish species in the river?
- Are there any sensitive flora/fauna in the river and what is their distribution?
- What is the concentration of nutrients/organics in the river?
- How natural is channel morphology (physical shape of the river?)
- Do physical modifications of the river impact the migration of aquatic species?
- How naturally functioning is the floodplain?
- What is the extent, condition and location of semi natural habitat (meadows, woodlands, wetlands) in the catchment?
- How many people use the river for recreation?
- What is the status of the bathing water?

The project delivery partner (Avanade) next worked with Anglian Water to understand and review the available data sources (both internal and external), helping to decide which parts of the ontology model to focus on during the early design stages (i.e. focusing on the data that was more readily available).

We then established the infrastructure for the Digital Twin: a scalable Azure data platform, designed to be future-proof ready and capable of integrating more data streams and enabling the sharing of intelligent insights. We used Serverless SWL Pool in the Serving layer for a comparatively smaller dataset.

Digital Twin functionality was built to collate disparate datasets and ingest additional data from sensors in the environment. This digital twin was built within the Azure Cloud environment, and integrated the paper-based ontology for the River Health model. We represented the Stiffkey and Binham Tributary rivers using geospatial data from the Environment Agency's Catchment Data Explorer. The core of the ontology used in the digital twin was the river and river segments, with a river being a single water body, made up from a multitude of straight-line segments, all of which connect to one another to form the shape of the river. The river segments were given relationships to denote the flow of the river, and physical modifications to the river, such as weirs, were connected to the relevant river segments, providing a higher-level division of the river. All river segments and physical modifications were given latitude and longitude coordinates, for geospatial calculations and for plotting them on a map.

We also stored river water data, sewage treatment works data, and fish observations within the Digital Twin. Most river segments did not have all associated measurements, for instance some segments did not have water quality measurements and were therefore used to provide structural information only (this is one motivation towards achieving greater coverage of the catchment using continuous monitoring sensors). Sewage treatment works were linked to the river section that they effect and contain the latest flow value for their final effluent and their storm overflow. Observations of fish during surveys were given their own twins, containing the count of the species of fish that was observed, linked to the river segment where they were observed.

The Digital Twin and the River Health model products were fed into one another and presented to the user in a single environment using PowerBI. Both models were built such that the accuracy of both can be improved over time, as more data becomes available and hypotheses are validated.

We then reflected upon the delivery of Phase 1 and reviewed the planned work packages. Using the learnings from the prototype, we concluded that the remaining three phases would be better ran concurrently rather than sequentially and informed by a single 'product design workstream'. This was to allow us to add greater control and consistency across the three products that we are developing and also to ensure the continuity of critical resources.

Phases 2-4 (MVP)

During Phases 2-4 of the project, we moved from Prototype to minimum viable product (MVP). In the prototype phase, the work was focused on one branch of the ontology only. In phases 2-4, we acquired new data sets that we onboarded into the River Quality Digital Twin, to enable us to achieve wider coverage of the overall ontology design that we had established. Introducing sensor data helped to establish a better understanding of Water Quality, the missing piece to River Health in Phase 1's prototype. By expanding the Digital Twin's reach to further parts of the ontology, we aimed that the three products would provide a fuller and more accurate view of River Health by drawing on the River Quality Digital Twin.

We developed a River Quality Data Science Model. Here, we used a Structural Equation Model (SEM) to capture the state of the river as a series of observed values and equations linking each of these values. This was used to model the impact that upstream assets will have on water quality downstream. We included variables such as elevation, soil type, NVZ status, and the climate of each land parcel. We then combined this model with Farmscoper results to get the farming effluents for each given area of catchment. The Digital Twin was then developed to help us understand which farmland or water recycling centre impacts the water quality at each observation point. We developed this functionality to help us assess the downstream impacts on the river of a given upstream intervention, answering questions such as:

- How will implementing a permit change at a Water Recycling Centre (WRC) at point A change the water quality at point B?
- Would establishing wetlands upstream of point C have a stronger impact?
- What happens if we do both?

Phases 2-4 started with a 6-week design phase, aiming to bring to life the use cases aligned to the operational and strategic business context. Building on the learnings from the prototype and in preparation for a build phase across each of the three products, our product and Service Design Team:

- Created the overall picture of the service (people, processes, interactions – how it all fits together)
- Captured, documented and agreed details around how different types of users use the data and what their expectations are
- Designed the 'production' version of the digital twin (e.g. dashboard)
- Defined how we quantify the benefits for Anglian and external stakeholders and what translating use cases to other catchments might look like
- Defined how we will engage members of the public and how they will use the data.

After the Design phase for the three products, we moved to Refine & Validate the designs, turning wireframes into high fidelity design prototypes. Here, we built the overall blueprint for the service, capturing processes, users and opportunities.

The third stage was Testing & Handover, where the team ran testing sessions with users, captured and prioritised insights to inform the overall user-facing metrics, and prepared assets and guidelines.

Overall, we were able to develop three products from the Digital Twin: RiverKeeper, RiverPlanner, and RiverViewer. These were developed in line with User Stories mapped to various end user Persona, through consultation with our stakeholders. The features of these three products are described in the section of this report on Outcomes.

Risks

One of the main risks we were aware of at the commencement of the project was the difference in operations across UK water companies, which could affect scalability of the digital twin. Our mitigation was to use existing technology that is widely adopted across the sector (namely Microsoft Azure) and work with the advisory partners will help to make the digital twin guidance applicable to all UK water companies.

Another risk we faced was finding and consolidating datasets from various sources. Whilst we had identified a number of datasets, we might have encountered challenges in accessing a complete capability needed to fully model the river system as a complete entity. Our mitigation was to use the river Stiffkey catchment as a testbed, to test and correlate all datasets into the digital twin to prove the ontology is robust. We also explicitly addressed this risk through a distinct work package during Phase 1 (prototyping), identifying data availability, as related to the paper-based ontology. We were then able to identify the low hanging fruit data streams for the Phase 1 prototyping development of the Ecological Digital Twin, before scaling the model to incorporate more data streams in Phases 2-4 (MVP build).

Our adoption of the agile delivery approach allowed us to pivot around data that was available before onboarding the more challenging datasets later. We procured and deployed new sensors to collect data at the particular river sections where we had poor visibility on water quality using the existing Anglian Water data, open data or the wider partnership data. These units carry several sensors that allow for the real-time collection of data which was ingested into the Anglian Water data lake for storage and representation in the digital twin. These units worked well but we encountered challenges with the process of installation. Landowner permission, EA and IDB consent was more challenging than expected. This delayed the installation in some circumstances, as well as the redeployment of units. Whilst the selected sensors performed satisfactorily overall, continuous monitoring catchment sensors is an area of rapid development so we would want to explore other solutions as and when we scale up. We're planning a session with in-river and earth observation solution providers for the next phase.

An additional discussion of the Risk Register, as well as the RAG system used during identification and discussion of blockers and other secondary risks during Agile product delivery, is provided in the Project Monitoring section of this report.

Lessons learnt

A number of lessons were learnt during the course of the project. We have captured the lessons learnt in an ‘Ecological Digital Twin Toolkit’ that we have made available to Ofwat for sharing and dissemination across the Water Sector. Some of the areas that can drive improvement in further adoptions of this project include:

- Overall data identification and onboarding into data platforms was more challenging and took longer than anticipated. In future phases, more time should be made available for data exploration and analysis.

- Procuring and deploying additional sensors into the catchment took longer than expected due to the capacity of the supplier. In future phases, ordering sensors ahead of the project start date would ensure the sensor data was ready and available in the data platform when required
- A bigger challenge still, was securing permissions from landowners and controllers of waterbodies - EA and IDB. Early planning for sensor deployment in future could support mitigation of this risk
- It is essential for the water company to bring in their inhouse IT Project Delivery teams at the time of project conceptualisation, to ensure that the effort is properly costed, and to fully understand where capacity and infrastructure is and isn't already available for supporting products within a live environment.
- When working with International Partners, taking more care to understand the nuances of working with these as they operate and communicate in different ways to UK companies, additionally also taking the time to implement controls within the contracts when dealing with other currencies and exchange rates.
- Ensuring there is one individual implementing financial project controls throughout all Phases of the project: the Innovation Team's Project Controls Manager was only onboarded after Phase 1 had been completed. This led to a need to bring all recorded costs together in one location both for OFWAT Reporting purposes and within Anglian Water's Financial System. Therefore, it would have been better to have full oversight of how the budget was being mapped out.

Sponsorship and leadership

Sponsorship and leadership was high-contact and effective throughout, which was designed in line with the Agile delivery approach. Within a 2-week period, there would be a series of checkpoints:

- Daily standups with the delivery team to focus work for the day and remove blockers.
- Fortnightly steering group meetings to update on progress and set direction.
- Fortnightly project boards to review risks, issues etc
- Fortnightly project demos to showcase the work completed in that sprint.

This allowed fast decision making and removal of any blockers that might have otherwise slowed down the development.

Project partner choice

Anglian Water and Microsoft already had a strong working relationship (Microsoft are a technology partner to Anglian Water) and a shared desire to work together for environmental benefit. In discussions together it was decided that it would make a strong partnership to utilise Microsoft's latest secure, cloud-based capabilities and to leverage their investments into data modelling and sustainability alongside the world class practical expertise and data science capabilities from Microsoft's partner organisation Avanade.

In addition, as mentioned previously in this report, one of the risks we identified was that there is a difference in operations across UK water companies, which could affect scalability of the digital twin. Opting to work with Microsoft, using existing technology that is widely adopted across the sector (namely Microsoft Azure) helped to mitigate this risk.

Microsoft made an additional financial contribution of £79,274.00 reflecting their commitment to support the concept of an ecological digital twin for river health. Their motivations for their extensive engagement are summarised as thus: *Microsoft's technology is instrumental in digitising the modern world, particularly within the water industry where we've helped to enhance the efficiency of both the workforce and physical operations for clean and wastewater management. Recognising the impact on the natural world from*

various stakeholders, we partnered with Anglian Water and a collaborative ecosystem to digitise the Stiffkey river catchment. This initiative aims to provide a comprehensive view of our collective impact on nature. By understanding the entire process, we can drive positive change together. Microsoft's commitment to water extends to our pledge to replenish more than we consume. The ecological digital twin project exemplifies how our platform empowers customers to develop solutions with significant societal benefits.

The wider partner choice was key to the success of this project. Sector partners Severn Trent and Wessex Water have aligned ambitions to improve river health and explore innovative solutions to expedite this. Norfolk Rivers Trust are key experts with unique knowledge of the local area, the specific environment of the River Stiffkey and local landowners. The newly formed Sustainability Institue at the University of Suffolk are involved in a number of initiatives on similar subject areas and provided academic expertise into the project. Environment Agency involvement has been key to feeding into the project, particularly around building understanding of data availability and gaps. The National Trust hold vast experience and expertise on land management and community engagement activity that they were able to contribute. Lastly, the Country Land Association provided vital insights from the rural business perspective to ensure that the project was grounded in the reality for this sector.

Project Monitoring

There were a range of project meetings with a different focus including fortnightly Scrum meetings with Avanade to share the progress made after each two-week sprint, to identify blockers and solutions, and to set the direction for future sprints.

Additionally, there have been Project Steering Groups held on a regular basis to review and discuss all aspects of project delivery and finances attended by the key stakeholders of the project with at least one representative of each being part of the quorate.

Financial Monitoring

During Phase 1 of project delivery, the Anglian Water team did not have a dedicated Project Controls Manager. We realised that this limited our ability to provide the entire team with full, up-to-date oversight of budget spend. Consequently, we brought in a Project Controls Manager for Phases 2-4.

We then established weekly Project Controls Meetings to summarise delivery progress, current issues and budget availability that would influence decisions on future delivery options to achieve the required outcomes. This was all informed by the maintaining of a Financial Tracker document that details our forecasted spend, actual expenditure and remaining budget to ceiling.

There were also separate quarterly calls held to discuss and complete the Quarterly Monitoring Reports where the financial data was presented, along with the updates on project delivery progress and the narrative of what events had occurred.

Equity, Diversity and Inclusion (EDI)

In line with the original aspirations in the bid, the project team and lead partners from all organisations showed a commitment to creating a positive working environment in which the project team, and everyone they dealt with, were treated fairly and with dignity and respect.

4) Project Outputs

Primary Project Outputs

- A world first Ecological Digital Twin, providing a virtual replica of a complex river system, integrating various data streams (water quality, ecological quality, physical/structural properties, weather) and a River Quality ontology map, with associated Data Science Model.

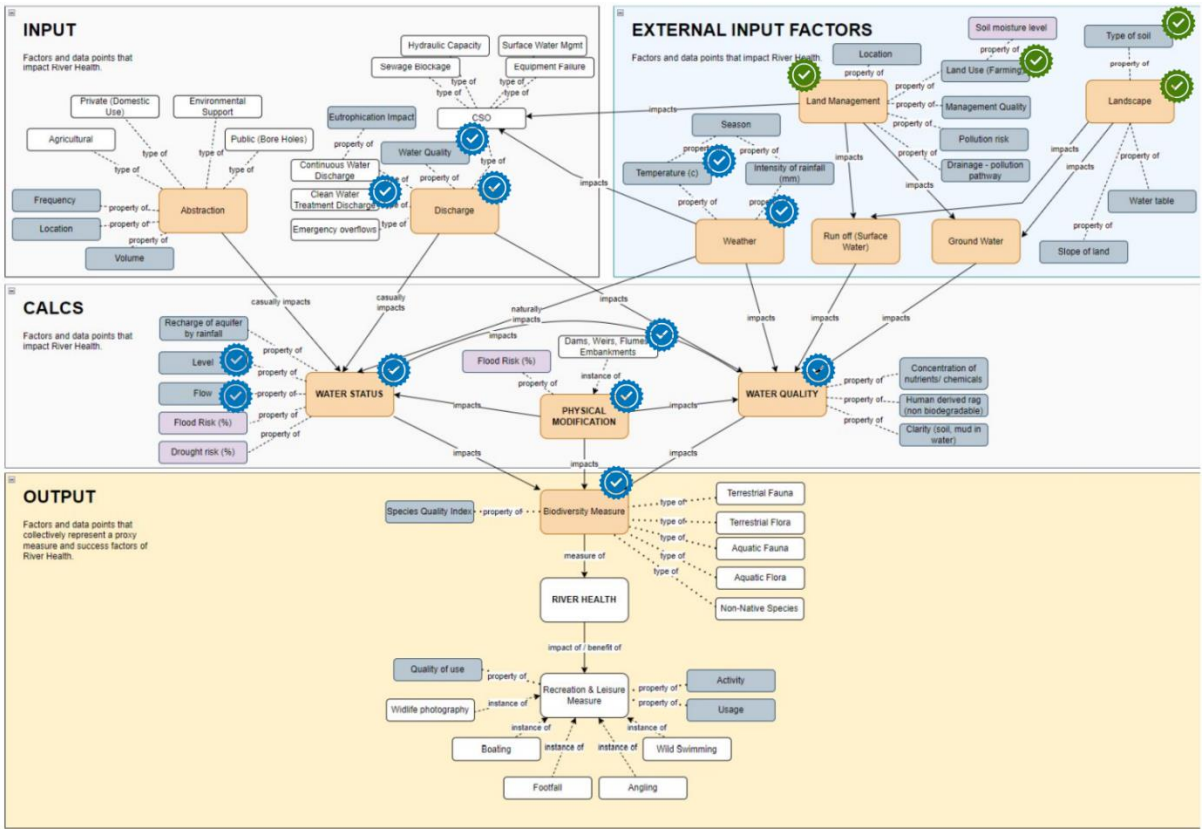
- Three distinct products, leveraging the Ecological Digital Twin model, to provide tailored experiences to different user groups:

  (1) **RiverKeeper:** An MVP PowerBI dashboard that empowers operational users to make data driven decisions by combining internal and external data available and presenting them in a number of spatial and trending information points.

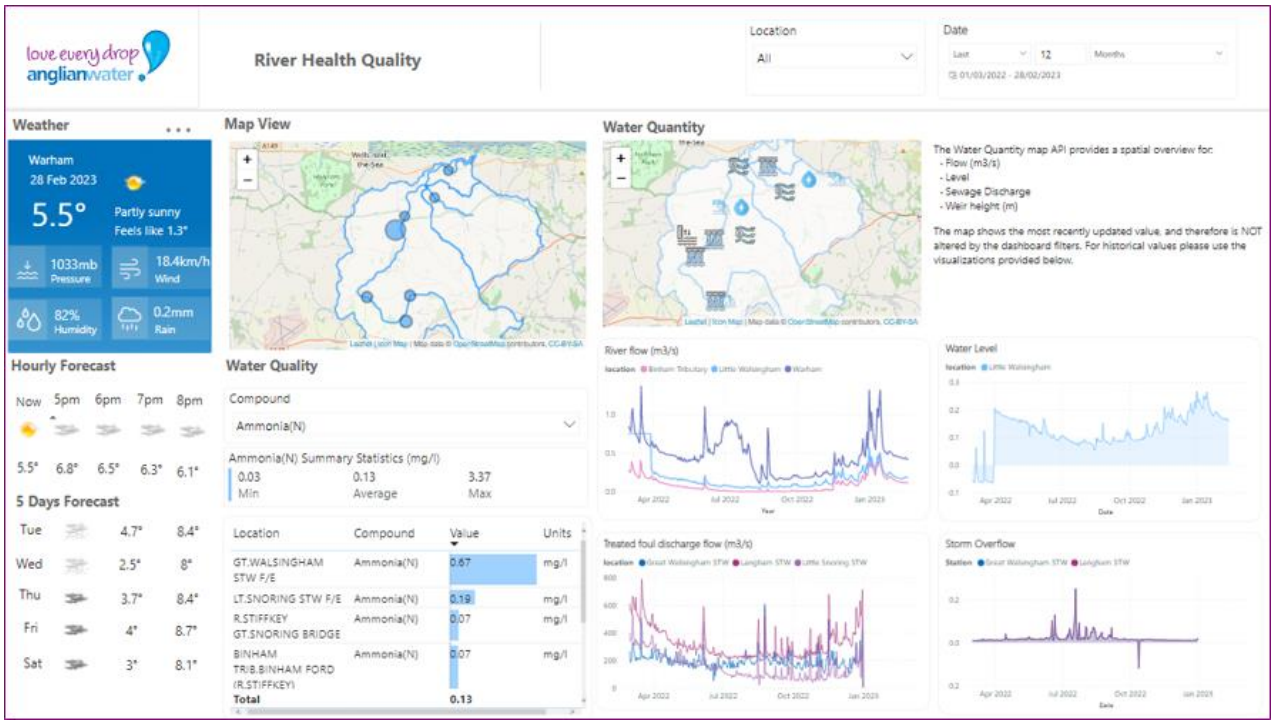
  (2) **RiverPlanner:** A proof-of-concept app that allows the modelling of interventions and to view their impacts on the health of the river, with a primary focus on Nitrates, Ammonia and Phosphorus as a means of measuring this. It allows users to create action plans to implement either nature-based solutions or adjust the permitting levels of discharges to see what combination of actions are needed to reach a given water quality target. This enables the benefits and costs of permitting and farming interventions to be balanced and created into action plans. The aim is that the tool would be used collaboratively between different groups such as Anglian Water alongside farmers and landowners to support decision making.

  (3) **RiverViewer:** A proof-of-concept mobile and web app experience, intended to engage the public in the health of their local river and educate on the range of factors that influence this. The app is presented as a tour across five locations down the River Stiffkey. QR codes at each of the five locations unlock audio, video and animation that explain the factors that feed into keeping rivers healthy. The experience is intended to give a holistic picture of activities that a number of actors, agencies and businesses are doing to improve the quality of the river. It displays real time data from the nutrient sensors placed into the river, via the ecological digital twin.

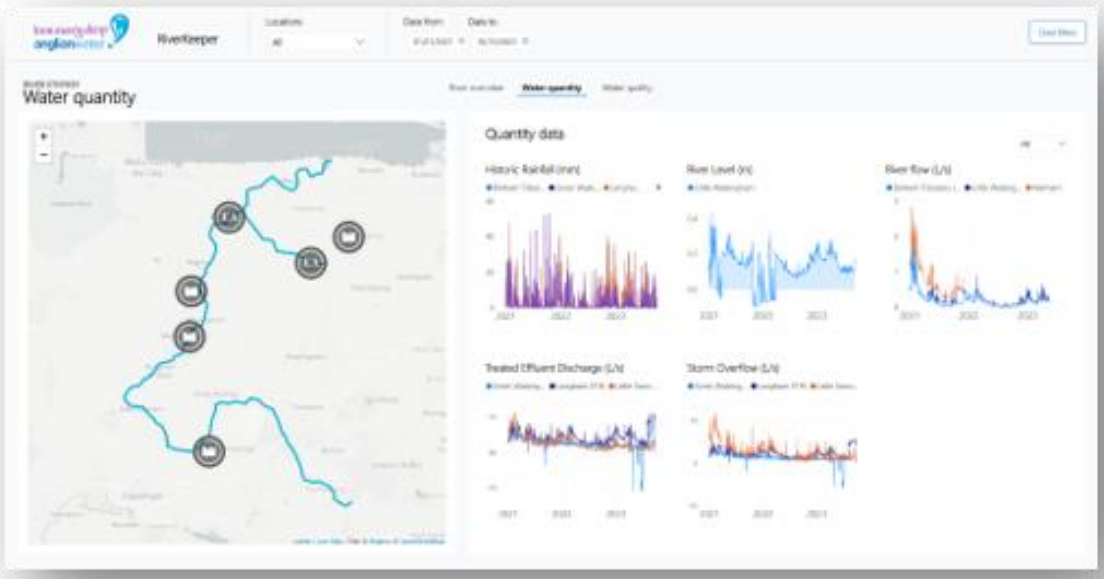
These products are distinct in terms of how each functions to fulfil its unique objective, but all use the underlying River Quality Digital Twin capability that was developed during the prototyping phase (Phase 1). The River Quality Digital Twin capability was enhanced by increasing the data and coverage of the ontology, including installing new IOT sensors into sections of the river system to gather more data. A Structural Equation Model (SEM) was created to capture the state of the river as a series of observed values and equations linking each of these values. Our SEM captures the relationships between different datapoints on the river. This enables a view of the downstream impacts on the river of making a given intervention.



Ontology design: *Paper-based and digital-based ontology representation of the Stiffkey river catchment, as developed in consultation between our project experts with Avanade project delivery partner. After evaluation of the data streams available, prioritised for importance and ease of access, subsection of the ontology was then chosen for focusing in on, during development of the prototype digital twin (Phase 1). These parameters are highlighted with blue ticks. During Phases 2-4, the ontology within the Ecological Digital Twin was expanded to incorporate additional data streams (green ticks). The digital twin was designed to have the flexibility and scalability to incorporate the remaining ontology inputs at a later date.*



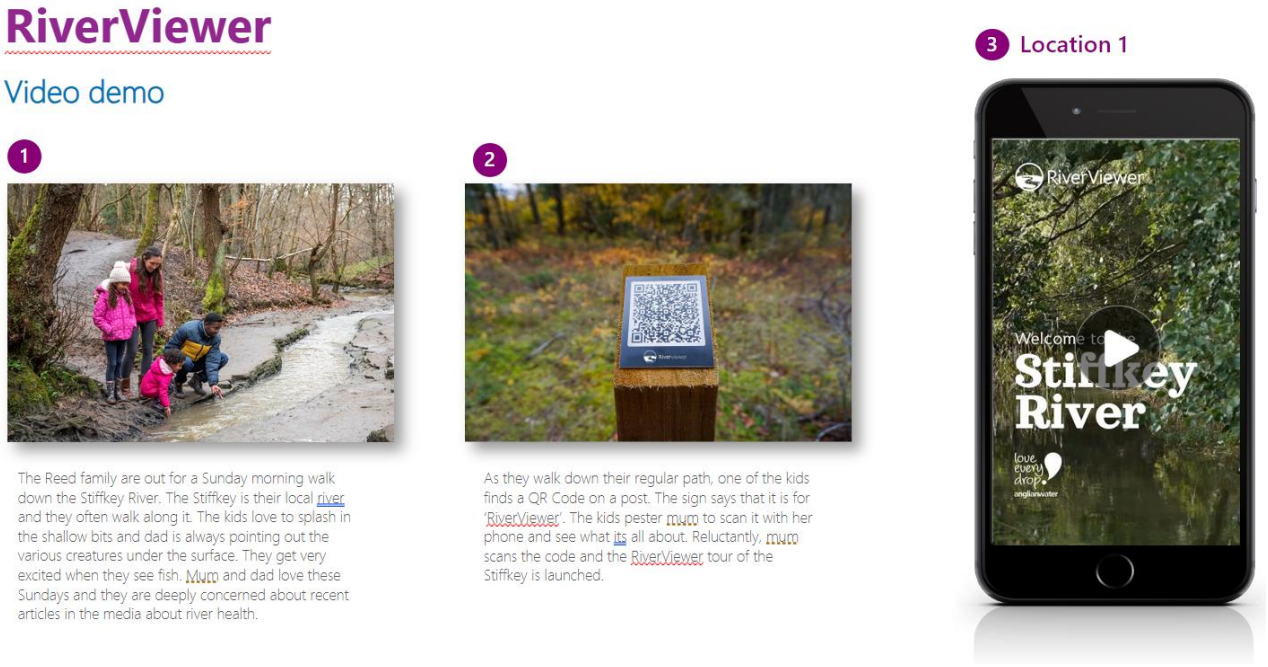
Initial Ecological Digital Twin data dashboard: *Operations dashboard using live data. From an operational perspective, the focus is on understanding sewage impact, as well as water overflow, in relation to water recycling centres. Shared features like weather patterns and a visual overview (map) of the catchment are available.*



RiverKeeper: *Following on from the initial prototype built in early 2023, this productionised solution of the RiverKeeper provides users with three tabs:* ***River overview:*** *to view the overall health of the Stiffkey river with the help of water quality data from the WATR sensors against the five Water Framework Directive (WFD) measures – temperature, pH level, dissolved oxygen, phosphates/phosphorous and ammonia.* ***Water***

quantity: *to view the river flow, river level, weather conditions, discharge data (storm overflow and treated effluent discharge) from both internal and publicly available data.* ***Water quality:*** *to view the water quality of the river at different locations of the river and comparing against the WFD measures.*

RiverPlanner: *The RiverPlanner app allows the modelling of interventions and view their impacts on the health of the river, with a primary focus on Nitrates, Ammonia and Phosphorus as a means of measuring this.*



RiverViewer app: *Highlighting the user experience as customers/members of the public can understand and engage with the ecological quality of the river via the Ecological Digital Twin, with location-specific water quality results presented based on local QW codes. The app also presents interviews with Anglian Water employees providing additional information about the catchment.*

Secondary project outputs

In addition to the Ecological Digital Twin and the three associated products, this project produced a number of Toolkit Items that can be re-used in future work, e.g. the development of digital twins for other catchments and other ecological systems.

Toolkit Item 1: Reusable River Health Ontology

- With partners, we created a re-usable Ontology Design that defines the River Health System and relationships. This ontology is used to understand if the river health is good by answering a number of questions (listed earlier within this report).

Toolkit Item 2: Product Design Recommendations

- We started phase 2-4 with a 6-week design phase. The objective was to bring to life the use cases aligned to the operational and strategic business context. This design phase produced a "design recommendation report" that can be used in future works developing digital twin-type modelling-visualisation systems and tools across the Sector.

Toolkit Item 3: Technology Blueprint

- We established a scalable Azure data platform that is future-proof, ready and capable of integrating more data and enable sharing intelligent insights. The technology blueprint is documented and available for re-use in future projects.

Toolkit Item 4: Catchment Assessment Tool

- We developed a Catchment Assessment Tool to help identify and determine which catchments would most benefit from the River Quality Digital Twin

Toolkit Item 5: Building Instructions

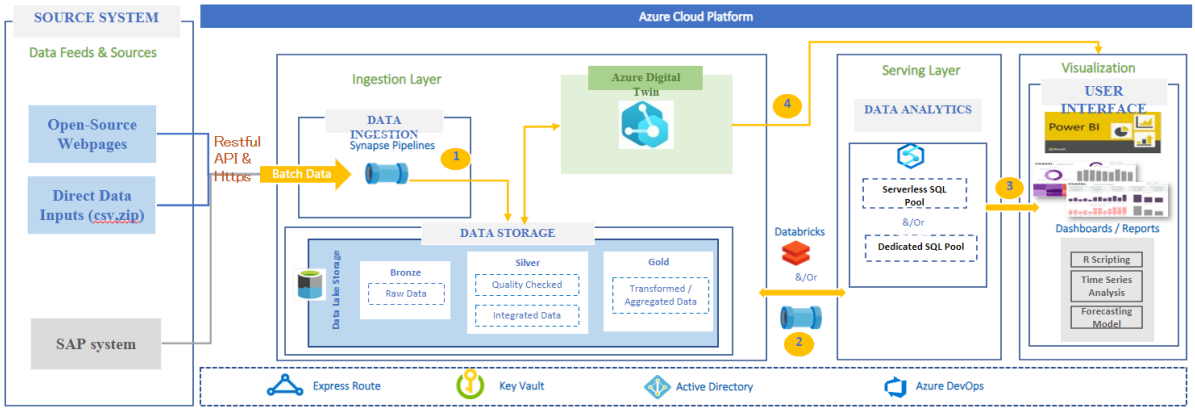
- We created a step-by-step guide to support other companies adopting the River Quality Digital Twin, in the spirit of the Ofwat Innovation fund and supporting knowledge sharing across the industry.

Toolkit Item 6: Lessons Learnt

- Summary provided within this report

Toolkit Item 7: Reusable Communications

- A variety of digital assets



Toolkit Item 3: Re-usable technology Blueprint

Key findings

- We set out to test three use cases, a real time view of river health (RiverKeeper); an investment decision-support toll (RiverPlanner) and a public engagement tool (RiverViewer). We found each of these had merits and value propositions, but each had different levels of feasibility for scaling up.
- RiverKeeper enabled colleagues to view existing AW data alongside 3rd party data, including live data, which was presented in a geographic format. This showed our assets in relation to each other and the catchment. It was felt that the greatest use of this was actually to enable us to look back in time to diagnose root causes of problems, taking account of things like existing river flow and recent weather.
- RiverPlanner, even as a proof of concept, was enthusiastically received. This tool enables different teams in AW to collaborate to find optimal solutions for investing to improve river health, taking account of permit requirements, cost and wider six capitals metrics. We found this tool could become the means by which asset planning and catchment management colleagues could collaborate, filling a current gap. With further investment the tool could be applied by stakeholders who could enable or deliver catchment interventions across the farmed environment.
- RiverViewer. This public engagement tool could be a valuable means to communicate information about river health in an honest, transparent and comprehensive way. However, as is would have to be bespoke to each river system to which it is applied, this would come with significant cost to create and maintain.
- Across the three tools, a number of insights emerged:
    - People have different views about what a digital twin is for, so it is necessary to clarify what is, and isn't, planned to be achieved with a digital twin
    - Live data about the state of the natural environment is still scant. It is costly and time consuming to generate. This is especially so for data that directly senses biodiversity, with very few sensors available. With eDNA and bioacoustics for example, this is changing.
    - Installing sensors in the river is not without its challenges, and maintaining these over the long-term requires planning and resourcing.
    - Harnessing earth observation technology to accurately assess land use in real time is necessary to build upon the accuracy of tools such as Farmscoper, by replacing assumptions about landuse.
    - Machine learning and AI could make the tool more efficient, for example by running scenarios to create viable solutions to meet a need, which could then be appraised by decision-makers.

This project has confirmed to us and project partners that there is certainly a benefit in developing digital twins of river catchments. It is necessary to be clear about the use case for which the twin is being developed. For example:

- Is it for viewing what is happening in real time?
- Is it for scenario testing?
- Is it to provide more comprehensive data to improve transparency?

A digital twin of a river catchment, which includes the location and performance of water industry assets, drives recognition of the fact that we depend upon, and impact the natural environment.

Further innovation notwithstanding, digital twins for river catchments can:

- Support decision making to driver more sustainable solutions
- Provide real time information on river health, including parameters that are used for Water Framework Directive classification
- Enable root cause analysis of past events
- Identify catchment risks as they happen for quick response
- Provide trustworthy data in a more engaging way to customers and communities.

Changes in outputs

All originally-defined objectives were achieved (1: Identify and source appropriate data sets to incorporate into the digital twin platform prototype. 2: Development of a complete ontology data model by end of phase 3. 3: Identify and source appropriate data sets to incorporate into the digital twin platform prototype. 4. Creation of Power BI dashboard and visualisation capability started in phase 1 and iterated through 4 phases. 5: Production of a communications strategy, to ensure outputs and learning are actively shared to key stakeholders throughout the project. 6: Development of robust machine learning models on top of aggregated datasets).

The only change in output was how often the data apps refreshed datasets. The RiverViewer app was built with all functionality to pull data and process data from the diverse array of data sources in real-time, however the app is not currently supported within Anglian Water for automated real-time refreshing. Similarly, the proof-of-concept RiverKeeper app has all functionality provided by the Microsoft Azure digital twin environment, but is not continuously updating from real-time data sets.

Innovation maturity

Prior to this Ofwat-funded project, we were not aware of any virtual model (i.e. digital twin) that provided a representation of a complex ecological stream river system, such as the Stiffkey. It was not well understood

(i) which data streams would be needed in an ecological digital twin,

(ii) which data streams could be readily accessed and integrated into this digital twin, and

(iii) whether meaningful tools built upon a digital twin model could actually be developed for an ecological system such as the Stiffkey river catchment.

In addition, we embedded the twin with geospatial data from Catchment Data Explorer (CDE), enabling future versions of the twin to work back-to-back with CDE and comparing live river health data with CDE's ecological health status.

From this project, we have been able to answer our innovation questions, developing the concept from idea, to prototype, and all the way to MVP. By consulting our experts, we were able to

(i) develop the paper-based ontological model that provided a theoretical framework by which relationships within the river could be understood (Phase 1),

(ii) evaluate the data streams within this model, identifying priority data streams for incorporation (i.e. based on relevance and accessibility), and develop the ontology to focus on these key parameters (Phase 1),

(iii) scale the digital twin model to include a wider ontology (Phases 2-4) and generate 3 different products based upon this MVP, where we have developed the use cases based around the insights provided by the PowerBI products.

Having advanced all the way from idea to MVP, we are now in an excellent place to provide expert advice to the River Deep Mountain AI team – a subsequent Ofwat-funded innovation project focused around digital twins for better understanding complex environmental systems.

IPR

The project was designed with sector wide sharing in mind, and partners worked in an open and collaborative way to ensure that learning is easily transferable within the sector.

Background IP included:

- Primarily trade know-how of the Azure Digital Twin platform. The Azure Digital Twin platform is a Platform as a Service capability from Microsoft. Most UK water companies already utilise Azure for cloud workloads and have agreements in place with Microsoft.

Foreground IP includes:

- A toolkit of all project elements was created and will be shared across the sector by Anglian and hosted by Ofwat. Accelerators to aid adoption of the ecological digital twin will be made freely available to water companies, as per the Winner's Agreement.
    - These learnings are already being shared forwards to the Ofwat River Deep Mountain AI project.
- Video demos of the three proof-of-concept apps, which we are sharing during our dissemination activities.

Prior to project commencement, Anglian Water had already developed a bespoke Collaboration Agreement template and Collateral Agreement templates (to deal with service and works delivery elements) which have been used for the various projects we are currently leading through the Ofwat Innovation Fund. These are multi-lateral agreements that partners sign and within these we have transposed the required terms and conditions relating to foreground IPR and background IPR (both general and specific).

It was our intention to share all learnings, insight, and know-how from this project to ensure that this approach can be adopted across the water sector to benefit the environment and as many customers as possible.

5) Project Outcomes

Outcomes for the project team and the Water Sector

- **Initial prototyping phase (Phase 1)**
    - The prototyping phase, culminating in the first dashboard, allowed us to understand the complex system of the Stiffkey river catchment area (as documented in the paper-based and digital-based ontologies).
    - Understanding how different users can use the digital twin to drive increased value through better decision making.
    - Through data discovery activities, we identified gaps and opportunities for additional data in future phases (e.g. evidence to inform the purchasing and geolocating of subsequent water quality sensors).
    - This Phase culminated in an operational user dashboard, as an example of what a water sector catchment-focused dashboard can look like.
- **Product development phases (Phases 2-4)**
    - We gained practical experience in the end-to-end development of an Ecological Digital Twin, from idea through to MVP. This included developing an understanding of how best to map out the network of relations between different river segments and different parameters (water quality, flow, physical parameters, flora and fauna etc) to develop the River Health Ontology model. We also developed our knowledge over how to prioritise growth and expansion of the digital twin model, incorporating new data streams prioritised based on ease and utility.
    - The Anglian Water team are now well placed to scale the concept of Ecological Digital Twin to (a) more catchments, (b) a wider variety of data sources, (c) stronger and more powerful products with improved user experiences. We will leverage this knowledge base to support our colleagues on the Ofwat-funded River Deep Mountain AI project.
    - This project was successful in bringing together Microsoft and Anglian, introducing Anglian's new catchment sensors to the state-of-the-art Microsoft digital twin environment.

Outcomes for customers and the environment

- This project aimed to develop prototype and MVP digital twin dashboards, to inform further development towards ecological digital twins with operational outcomes. Consequently, the direct benefit to customers and the environment will only be realised by follow on projects.

Lessons Learnt during project delivery

- We found that whilst the selected catchment sensors satisfactorily monitored a range of relevant parameters, the major challenge was instead in installation of the sensors. Obtaining permission from landowners, EA and IDB was more challenging than anticipated, and this can lead to delays in delivery.
- We also identified the importance in developing Water Sector capacity and infrastructure to supporting the new data streams from catchment sensors, where there isn't currently the support to integrate into pre-existing telemetry systems.
- The project would have benefitted from bringing in Anglian Water's inhouse Programme Delivery sooner. The late engagement resulted in several impacts.

    - Without including Programme Delivery in the initial contract discussions, inhouse IT development (e.g. considerable work on the data infrastructure for the input data streams) was not accurately costed for, and consequently the budget had to be reworked.
    - Additionally, warranties and Early Life Support (ELS) to support and maintain the developed systems for a limited time after release, were not agreed between the business and supplier.
    - RiverKeeper was the only one of the three products planned to be taken into a production environment. This was installed into Azure, but not into Azure Digital Twin. This solution works for the Stiffkey, but as and when we scale up, we will need to use Azure Digital Twin. This requires support capabilities that neither Anglian Water, nor its supply chain partners currently have and will need to be planned in as part of any further expansion of digital twin activity. The substantial work for the Programme Delivery team on this high priority project caused delays to some projects elsewhere
- These findings are particularly important given large-scale programmes of work planned to deploy large fleets of catchment sensors, and the data infrastructure necessary to support the delivery of this programme.

Innovation capacity within the team

- The project has built innovation capacity and capability in terms of the specific technology developed as well as the success of the agile project management approach in terms of working at pace and giving the ability to build in insights along the way.

6) Impact

This project developed three outputs, one production tool and two proofs of concept, which we hope will have a positive impact across the sector through the following pathways:

The production tool ingested AW and third-party datasets into the AW data lake, and represented them through PowerBI to give a view of river health. This was built on the River Health Ontology, which systematises catchment attributes and activities to show how river health is affected by human and natural factors. The ontology is a key enabling feature of the digital twin, allowing a digital representation of the river to be created. This IP will be shared with the sector, for example to support the River Deep Mountain AI innovation project, and we aim to develop and refine the model in our digital twin work going forward. A single ontology to describe river health as a basis for all river digital twins would enable standardisation and comparability, as well as efficiency. We have also shared this work with the Environment Agency, to discuss how we can better create and share data for the benefit of customers and the environment. This platform capability has the potential to have a significant long-term benefit for England and Wales and could be extended in partnership to Scottish Water through Hydro Nation and SEPA engagement

Being proofs-of-concept, the impacts of RiverPlanner and RiverViewer will mostly be felt as they are developed into production. The RiverPlanner PoC was shared with colleagues and was recognised as a tool that would enable rapid, and increasingly automated, scenario development to aid decision-making. In addition, it enables parts of our business to collaborate in a way that is not currently easy to do, bringing together asset planners with catchment advisors to devise cost and carbon-effective schemes to tackle water quality problems at a catchment level.

RiverViewer tested how we might provide information about river health to local communities in a way that is more engaging and more informative, such that they can make better decisions about how they

interact with their local environment. RiverViewer would enable all aspects of river health, positive and negative, to be presented in a transparent way, restoring trust in the sector.

These impacts align with those anticipated and set forth at the commencement of the project. At the beginning of the project, we hoped that we would achieve a dynamic modelling capability to provide insights into changes in river biodiversity and health to understand, diagnose and then prescribe the best course of action to protect, restore and enhance river health. The developed technology was to be scalable (platform technology) to provide long-term benefits for England and Wales, and to provide an effective visualisation engine to display a rich data set. The final technology, from paper-based ontology through to digital ontology, through to the proof-of-concept apps and the RiverViewer MVP app are all scalable, using platform services, building in a diverse array of data streams into a single interactive dashboard for viewing river health status (RiverViewer), and exploring semi-quantitatively the likely impact of investment proposals (the PoC RiverPlanner). Through our dissemination activities, the Water Sector will now have a significantly greater understanding in the capabilities, challenges, and design principles around ecological digital twins. Our understanding of time scales, costs, the minimum scope of input data, and likely use cases, allows the sector to better develop business cases for digital twins for a BAU use case. We also better understand how pricing models would function, for instance based on the number of server requests, where apps are to be made usable by the public.

7) Dissemination, information sharing and wider implementation

Dissemination completed to date

During the prototype phase in late 2022, Carly Leonard of AW and Lewis Richards of Microsoft attended the water sector CTO visit to Microsoft's global head office in Seattle. Carly and Lewis shared information on the project and the intended outcomes with the group. Microsoft UK CEO Clare Barclay CEO has been the lead sponsor for water and champion for this project and Peter Simpson (AW CEO) has championed the project within the sector and externally with partners. Clare and Peter have met to discuss the project and took part in a field visit to the river Stiffkey to see the site of the proposed Digital Twin.

We had the support of the global Corporate Vice President for Sustainability at Microsoft, Elisabeth Brinton and the UK head of sustainability, Musidora Jorgensen. Elisabeth met with Carly Leonard to discuss the ecological digital twin and was invested in ensuring the success of the project.

On 18th October 2023, Robin Price, Director of Quality and Environment, and Chris Gerrard, Head of Landscape Transformation met with Satya Nadella, CEO of Microsoft, to showcase the digital twin. The meeting took place at Microsoft Envision in London, Microsoft's flagship technology conference for showcasing their latest innovations focused on how AI can help address global challenges. Robin and Chris demonstrated the work done and the potential it has for accelerating action to improve river health. The project was one of just three projects chosen to be highlighted on the day. On the same day there was a round table to discuss the potential of digital twins for the natural environment with other senior representatives from Microsoft and Avanade.

Carly and Lewis presented the project at an Anglian Water Supply Chain event as part of a fireside chat with Dr Robin Price, Director of Quality and Environment at Anglian Water. The event was designed to engage

suppliers ahead of AMP 8. Through Avanade, Carly was introduced to SSE Nuclear team and shared our learning from this project. As a result, a digital twin was undertaken of a nuclear power plant.

Toolkit for sharing

As described, we created a Toolkit to facilitate the dissemination of our Lessons Learnt amongst our water sector colleagues. We provide tools, frameworks, and recommended design practices for building and scaling ecological digital twin models. The items are summarised in the section on Outcomes, and summarised below:

Scaling across the industry

Industry Toolkit Items

We have packaged reusable assets into a toolkit that can be shared with the wider water industry to support them in adopting the innovative River Quality Digital Twin.

Toolkit #	Title
1	River Health Ontology (v2)
2	Product Design Recommendations
3	Technology Blueprint
4	Catchment Assessment Tool
5	Building Instructions
6	Lessons Learnt
7	Reusable Communications

Future dissemination activities

Future communications and dissemination include Carly Leonard of AW speaking and part of a panel discussion on the Smart Utilities stage. Harnessing digital twins at Utility week in May 2024. The title of the presentation was 'Embracing digitalisation to protect the environment – ecological digital twin'.

A project team meeting took place 4th June to reconvene the key partners to review outcomes and collaboratively plan a range of next steps. This includes Wessex Water and Severn Trent. The project team are keen to plan the next phase of the project.

The project is also being showcased as part of the Ofwat-funded River Deep Mountain AI Project, which AW are a partner on. Carly Leonard will support River Deep Mountain AI by contributing to the project's Steering Group, whilst Chris Gerrard will support the project by contributing to the Technical Working Group. The team are also actively exploring additional avenues for continuing Anglian's work with digital twins for catchment solutions. A sector wide session with CTO's is planned to further disseminate learning.

IPR

- During the bidding process, we declared our intention to share all learnings, insight, and know-how from this project to ensure that this approach can be adopted across the water sector to benefit the environment and as many customers as possible.

- We are sharing our key learnings through the ToolKit items, available to the sector from Anglian and to be made available also via Ofwat.
- We are also sharing our lessons learnt through our dissemination activities, which include video demos of the three proof-of-concept apps.

8) Out-turn monitoring data

Budget, Forecast and Actual Figures to Date (Overall and by Partner)

The budget spend available for Ecological Digital Twin is £1,479,274.00, this was incorrectly stated as £1,500,000.00 on the bid/collaboration agreement documents.

It was assumed Microsoft would be contributing £100,000 but in reality this was $100,000 therefore the exchange rate upon discovery was applied to set their contribution at £79,274.00. OFWAT were made fully aware of this through emails, quarterly reports and monitoring calls.

The budget has been allocated to each partner as follows:

- Anglian Water: £1,300,000.00 (£105,399.47 was used to fund EDT Phase 1)
- Avanade: £100,000.00 (Contribution was used to fund EDT Phase 1)
- Microsoft: £79,274.00 (Contribution was used to fund EDT Phase 1)

The Forecast Project Expenditure total at FY 23/24 End is £1,478,824.37 and the breakdown between partners can be seen below:

- Anglian Water: £1,291,897.51
- Avanade: £100,000.00
- Microsoft: £79,274.00

The Actual Project Expenditure total at FY 23/24 End is £1,419,448.44 and has been allocated to partners as follows:

- Anglian Water: £1,240,174.44
- Avanade: £100,000.00
- Microsoft: £79,274.00

Variations

Whilst the main project delivery of the Digital Twin is complete, Anglian Water are using remaining contingency funds to support ongoing work by our Information Services team through Azure's Data Platform, we are also looking to fund the acquisition and installation of a Weather Station and additional sensors for monitoring and data collection. Finally, we will be funding various dissemination activities (beyond previous online webinars/presentations) such as talks at Utility Week Live and entry into/participation Innovation and Supplier Awards Ceremonies. This should bring us up to spending our full budget allocation.

Specific variations:

- Anglian Water's Labour resource requirements to date have been less than originally anticipated, however, this is likely to catch up during the additional work on the project.
- Microsoft's contribution was significantly less than stated on the bid due to exchange rates not being favourable as pound sterling is weak compared to the US dollar in recent times.
- Azure Data Platform IS Support running from October 2023 to October 2024, beyond the length of the original project timescale but not associated to the original scope.

Managing Cost Uncertainty

We have managed cost uncertainty by holding regular weekly and an additional monthly Project Controls Meeting to talk through the latest financial issues and find resolutions.

All of the details of Bid, Forecast and Actual Expenditure has been maintained on a Financial Tracker sheet that allows clear visibility of the Budget totals, Forecasted Spend on each cost item and then comparison of Actual Spend. This gets updated on a regular basis to be able to advise the project delivery team of availability of remaining funds so they can consider options to continue work on the project.

Additionally, the bid included provisions of contingency values to cover off any unexpected expenditure items, this was particularly crucial in being able to protect against the loss of around £21,000 of budget due to the Microsoft Contribution issues and still have funding to spare to be able to use on building upon the deliverables.

At this time, we do not expect to have significant underspend on this project however we will work with Ofwat in identifying where the project can exceed expectations in the event of the forecasted underspend being maintained to drive maximum value out of the funding we received.

Non-Financial Contributions

Severn Trent Water and Wessex Water are non-financial contributory partners. They provided their time and expertise to decide the outputs at the start, and, as part of the steering group and by joining technical meetings, helped guide the project.

National Trust, The Country Land & Business Association, Suffolk Sustainability – University of Suffolk and Norfolk Rivers Trust are non-financial, steering group advisory board members.

AW have raised awareness of this project at a number of key events such as the CIO forum and, Robin Price our Director of Quality and Environment attending Microsoft Envision in London, Microsoft's flagship technology conference alongside Chris Gerrard (part of the project team).

Risk Management and Risk Register

There were 5 primary risks identified at the beginning of the project. For each, a risk level before and after mitigation was determined using a Likelihood x Severity = Risk approach, with likelihood and severity graded between 1-5. Without mitigations, there were 4 medium risks and 1 low risk. After mitigating measures, the residual risk was 1 medium and 4 low.

Risk 1: There is a risk that historical and live data is of poor quality. To mitigate this risk, we discussed and explored the available data sets as early as possible, and actually created a deliverable focused around the identification and evaluation of available data sets, which were mapped onto the paper-based ontology, to create the structure of inputs for the digital-based ontology that was implemented within the final Ecological Digital Twin (discussed in earlier sections). Consequently, we were able to develop an approach that worked with available resources (whilst sourcing additional sensors to fill in data gaps), and we have included these learnings within a Toolkit item for future dissemination. Overall, the risk was successfully managed.

Risk 2: We might not be able to deliver the complete mechanism for digitising the selected river catchment. The mitigation measure was to build a project plan with phase gate reviews, allowing the work

packages to evolve in a more agile manner. After completion of the prototype digital twin (Phase 1), our progress review identified opportunities to increase productivity and streamline processes by running Phases 2-4 concurrently, streamlining the workflow, whilst still producing the three app products that form the MVP. This mitigation measure allowed for successful product delivery.

Risk 3: Selected catchment for proof-of-concept trial is no longer suitable after project initialisation. Whilst we held the options of using alternative catchments, this risk (identified as low risk) never materialised.

Risk 4: Costs to deliver the full Programme exceed the estimated costs. The mitigation measure was to use phase gates to control spending of the budget. The phase gate reviews helped us identify the need for a dedicated Project Controls Manager to provide greater oversight of the budget, especially where the contribution from one project partner was less than initially anticipated. We successfully kept our spend within budget, despite this being the greatest risk post-mitigation measures.

Risk 5: Technology selected for project becomes obsolete before the end of the deliverables. Our mitigation measure was to work with well-established tools, with robust product support, e.g. the infrastructure was built using the Azure Digital Twin Platform. The risk never materialised.

Initial risk register from the submission bid:

Risk category	Risk number	Risk description	Likelihood (L) (1-5)	Impact (I) (1-5)	Risk factor (LxI)	Phase(s) of project	Interdependencies	Mitigation	Residual risk after mitigation (H-L)
T	1	There is a risk that historical and live data is of poor quality	2	3	M	Phase 1	None	Initial data discussion upfront and early as focal point for deliverable. Data discovery task aimed at providing appropriate data usability and access.	L
T	2	We might not be able to deliver the complete mechanism for digitising the selected river catchment	2	5	M	All	None	We will use a gated process that allows us to plan and assess each development stage before progressing to the next. If issues arise that require the project to end we will make our data and lessons learnt available in the water sector.	L
E	3	Selected catchment for proof-of-concept trial is no longer suitable after project initialisation	1	5	L	Phase 1	None	Alternative catchment and data can be utilised If appropriate and the project outcome are still achieved.	L
P	4	Costs to deliver the full Programme exceed the estimated costs	2	3	M	All	None	We will use a gated process that allows us to plan and assess each development stage before progressing to the next. If issues arise that require the project to end, we will make our data and lessons learnt available to the water sector.	M
T	5	Technology selected for project becomes obsolete before	2	3	M	All	None	The Azure Digital Twin Platform as a Service capability is a strategic capability from Microsoft and is part of their future	L,

		the end of the deliverables						strategy to enable IOT and Edge capabilities.	

Anglian Water and the delivery partner Avanade collaborated through an agile/Scrum-based process, with regular touch points within each Phase. This agile way-of-working allowed the team to identify secondary risks, arising outside of the primary risks identified within the Risk Register. A traffic light system (RAG) was used, facilitating discussion of risks and blockers during these touch point meetings. As indicated in following screenshots from these meetings, the risks were more granular in detail/specific and helped identify blockers, that the team could then quickly respond to.

Example slide from Steering Committee update:

Status Report 25th July 2023

Summary update
We have made a good start mobilizing and establishing the project. All governance and delivery tools and ceremonies are in place. Product design across all three products has progressed as planned and technical alignment between AW and Avanade is established, with key design decisions being made. Input from across the partnership has been good.

Top risks and issues		
WS	**Type**	**Description**
All	Risk	There is a risk that, as we co-develop the product designs, we do not align to the Ofwat objectives. Mitigation: refer to mission at each governance session. Track design decisions against outcomes.
RiverPlanner & RiverViewer	Risk	There is a risk that key SMEs from the partnership are not available to contribute and input into the solution design or contribute key information to the two products. Mitigation: Avanade to utilize the Steerco sessions effectively and give as much notice as possible when information is needed. Project Sponsor empowered to make executive decisions at Steerco on behalf of the partnership.

RAG	Workstream	Work completed since last week	Work planned for the next week
	Project Management	- Project board, end of sprint demo, sprint retrospective and sprint planning for Sprint 2 all complete - Governance and delivery tools/ceremonies established	- Begin strategy planning - Begin communication planning - Continue to manage governance and develop tools
	River Keeper (ODT)	- User stories defined and validated - Wireframing has begun - Architecture designed with AW	- Wireframes continued and clickable prototype - User testing - Work with UDAP and OTP teams to start bringing in data
	RiverPlanner (SDT)	- Circulated paper-based ontology for SteerCo visibility - Spoke to Farmscoper and SAGIS experts with Denis and Chris to understand tools and capabilities - Analyzed outputs from Farmscoper and SAGIS tools and understand how those outputs feed into RiverPlanner - Created first draft of scenarios to be used for modelling - Development of user stories with catchment advisors	- Refine scenarios for data modelling with SteerCo input - Synthesize outputs according to ontology and support model design - Start build of RiverPlanner - Wireframes and clickable prototype
	RiverViewer (PET)	- Ideas generated within Avanade team through two workshops - Top 3 ideas selected to be taken through to concepting	- Ideas to be built out into concepts that can be reviewed by SteerCo

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August 23 Fortnightly Board meeting RAID report:

RAIDS – Open Items Pg1

Type	Description	Owner	Due Date	Status	Comments
Risk	There is a risk that there are new work items, additional effort and/or delayed decision making as the project navigates through the AW IS Governance Gateways. Impact: There is a risk of a delay to delivering the plan. There is a risk of blocking the project team.	Adam Dooley	13/11/23	Open – in progress	Mitigation controls in place: • Avanade technical team to work with Anglian's IS teams to ensure appropriate actions are completed in an appropriate timescale. • All actions will be recorded in the single action log and tracked at the daily standup. Any specific risks will be documents as a separate risk to this one and, if needed, escalated to project board. • A project RACI to be documented and managed. • Anglian Water to confirm suitable prioritization for the project against their full portfolio of work.
Risk	There is a risk that the steering group availability impacts the project timelines and/or rework is requested: Impact: This could delay the project. This could result in a sub-optimum output, with partners input missed	Adam Dooley	13/11/23	Open – in progress	Mitigation controls in place: • Regular reoccurring Steering Group Meetings established • Document steering group ToR, with decision process and sponsor exec decision making • Regular reoccurring End of Sprint Demos
Risk	There is a risk that, as we co-develop the product designs, we do not align to the Ofwat objectives. Impact: We do not achieve the project goals and Ofwat do not release innovation funding.	Adam Dooley	13/11/23	Open – in progress	Mitigation controls in place: • Refer to mission at each governance session. • Track design against outcomes in outcome tracker
Risk	There is a risk related to Digital Twin capability at AW in order to support the operational digital twin after this goes live. Impact: AW are not able to support the product post go live and therefore programme goals are unachieved	Dan Benitah / Darrell Froggatt	08/08/23	Open – in progress	Darrell is currently looking at what team will be able to support post go live. UDAP cannot support the Digital Twin part for now.
Risk	Data sources need to be accessible from source systems to the Digital Twin in order for the build of the ODT to start. The data connections need to be live to ensure the digital twin is continually updated once live. Impact: Delay in starting technical build of ODT	Dan Benitah / Darrell Froggatt	08/08/23	Open – in progress	Onboarded AW UDAP Dev (Sarah Greenwood) to complete this work

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Lessons on project management approach:

As already discussed, when preparing the Ofwat bid, we underestimated the challenge in establishing sufficient data streams to run a digital twin model for river catchment health.

Firstly, we learnt the importance of bringing in Anglian Water's IT Project Delivery colleagues earlier, during initial project planning. This is important to properly cost the work necessary to prepare the data infrastructure to push data from the catchment sensors to the Anglian data lake and from there, into the Microsoft Azure digital twin environment. Bringing in our project delivery colleagues early is also important to ensure that we set out the path for Early Life Support (ELS), i.e. understanding how the products will be supported beyond the scope of the innovation project.

Secondly, we now better understand the challenges associated with catchment sensor installation. To a lesser extent, procurement was a challenge, due to supplier capacity and product lead times. But to a greater extent, achieving land access permissions from land-owners and the EA to install catchment sensors was a major challenge, slowing down the pace of project delivery. Using local stakeholders such as the Rivers Trust is critical to securing landowner permission. Next time this will be done ahead of time, ideally to have sensors in place before the project starts. As mentioned earlier, we are also looking at earth observation solutions to replace in-river sensors to overcome these challenges.

In relation to the financials, being clear that what is stated on the bid is accurate. The EDT specific example being where £100,000 is stated as a contribution and where International Corporations/Businesses are involved in supporting the project delivery, checking that the contribution isn't being made for the equivalent amount in their domestic currency. This ended up impacting the budget availability for the project although we were able to deliver all of our deliverables/outputs despite this, it may have a more significant impact on future OFWAT projects if not addressed. Therefore, going forwards it is imperative to be clear with all partners the amount should be reflective of what they will be paying in Pound Sterling and making this a condition of the bid/collaboration agreement that needs to be signed up to.

During the project, we trialled an approach to record labour hours and cost data that hadn't been used on any other project. This was as part of a wider piece of work to find the best way to capture this data across the OFWAT Innovation Fund portfolio so we could then roll this out across the board. The data input sheet we used was lifted from our Financial Tracker document and placed into a new excel file to prevent multiple parties editing the Tracker sheet and potentially making unsolicited changes that either wouldn't be noticed or couldn't easily be fixed.

Although after a few months, we determined that it was difficult for the end user to find the correct location to enter the figures in for each week so consequently completion was not as high as we hoped. It was also difficult to copy the data from the Timesheet Capture file into the Financial Tracker especially when using a laptop screen as with both sheets being identical it was easy to get lost.

Therefore we changed approach to a system that we had trialled and had worked better on another one of our projects, whereby we set up a Microsoft Form that asks the end user straight forward questions to capture the data in a specific order. This can then be downloaded into an excel sheet in a format that can be copied across to the Finance Tracker easier and uploaded into our financial system more efficiently.

- One individual with financial controls oversight throughout all Phases of the project to allow a constant view and approach of managing this area. As opposed to our Information Services Team overseeing Phase 1 and Innovation Team Phase 2.

9) Reflection and Conclusion

In conclusion, the Ecological Digital Twin project represents an advancement in the understanding of how to effectively use data to enable the management and protection of river ecosystems. By integrating digital twin and AI technology, the project has provided Anglian Water with a powerful tool to understand and the health of the River Stiffkey. The collaborative effort has resulted in a scalable solution that can be applied to other water companies and river systems, promoting a broader impact across the industry.

The project's success lies in its ability to combine historical data with data science models, creating a Digital Cognition capability that offers clear insights into the complex river system. This clarity enables a proactive approach to addressing river water quality issues, aligning with the needs of customers, society, and the environment. Furthermore, the open approach adopted by the project encourages knowledge sharing and learning, which is essential for the continuous improvement of ecological management practices. The step-by-step guide developed for the adoption of the River Quality Digital Twin serves as a testament to the project's commitment to industry-wide innovation and progress.

Overall, the Ecological Digital Twin project demonstrates the potential of technology and collaboration in driving positive environmental change. It stands as a model for future initiatives aimed at protecting our natural resources and ensuring the prosperity of our ecosystems for generations to come.

10) References, appendices, links

Anglian Water are keen that Ofwat will host our ToolBox kit items, as well as the final project output deck.