TAKING ON A MOUNTAIN OF INSPECTION DATA – DEVELOPING A FLEXIBLE DATA MANAGEMENT SOLUTION

O.T. Modricker and C. De Silva (ProjectMax Ltd)

ABSTRACT

Most water utility managers would likely agree that embarking on any significant asset inspection programme is challenging and can seem like staring up to the top of a foreboding mountain that is in the way. It is a challenge that requires strategy, experience, and a clear process and place to collect and manage data collected from inspections and other information that will be required for analysis.

A complex inspection programme that covers multiple asset classes inherently generates a large amount of inspection data and other associated information. This can present several challenges. Is all of that information needed? What data format(s) are required to be compatible with adopted tools, formats, and processes? How is data collected and stored? How is data reviewed and validated to confirm it is in accordance with specified requirements for quality and completeness? What processes are needed to transition the data to become useful information on asset condition and performance? How can the data and other relevant information be efficiently and consistently integrated into an Asset Management Information System (AMIS)?

In 2020 Wellington Water engaged ProjectMax to assist them in carrying out a wide-ranging investigation and condition assessment programme on their Very High Critical Pipe Assets. This inspection programme covered stormwater, potable water, and wastewater pipes (including both gravity and pressure pipes), across the 6 'client' council water asset owners. The project involved close to 500km of VHCA pipes to inspect and assess, using multiple inspection technologies and more than one contractor. To support the project, an integrated data management solution was required to enable data to be collected, checked, assessed, and imported into Wellington Waters AMIS.

This paper will set out a strategy and processes for developing a data management solution to successfully collect, check, and assess the so-called 'foreboding mountain' of inspection data. The Wellington Water VHCA pipe inspection project will be used as a case study and will include the challenges that had to be overcome, the milestones that have been reached, and the lessons learnt that can be utilised for future similar inspection projects for water utility managers.

KEYWORDS

Data Management, Critical Pipe Inspection, Condition Assessment, Data portal

PRESENTER PROFILE

Oliver is a Senior Project Engineer for ProjectMax Ltd, a New Zealand-based strategic consulting firm specialising in potable water, wastewater, and stormwater infrastructure solutions. Oliver has 12 years of engineering experience throughout New Zealand performing project management, data analysis, quality assurance and condition assessment programme management.

1 INTRODUCTION

Most water utility managers would likely agree that embarking on any significant asset inspection programme is challenging and can seem like staring up to the top of a foreboding mountain that is in the way. It is a challenge that requires strategy, experience, and a clear process and place to collect and manage data collected from inspections and other information that will be required for analysis.

A complex inspection programme that covers multiple asset classes inherently comes with a large amount of inspection data. A large amount of inspection data raises multiple issues, such as what information do you actually need. How do you collect and store all of the data? How do you ensure the inspection data meets the specified requirements of quality and completeness? What processes do you need to transition the data to become useful information on asset condition and performance? And the big question is, how can all of the data be integrated into a Client's Asset Management Information System (AMIS)?

In response to the credibility and experience ProjectMax has across New Zealand with water, wastewater and stormwater asset condition assessment, Wellington Water approached Project Max to assist with the assessment of their most critical pipe assets.

In 2020 Wellington Water engaged ProjectMax to assist with a wide-ranging investigation and condition assessment programme on their pipes, identified as Very High Critical Asset (VHCA). This inspection programme covered stormwater, potable water, and wastewater pipes (including both gravity and pressure pipes), across the six 'client' council water asset owners. The project involved just under five hundred kilometres of pipes to inspect and assess, using multiple inspection technologies and more than one contractor. An integrated data management solution was required to ensure that all of the data could be collected, checked, assessed, and imported into Wellington Water's asset management information system (AMIS).

This paper details our journey to developing the Critical Network Inspection Tool for Assessment, 'CriNITA' data platform for Wellington Water's Very High Critical asset pipe inspection project.

2 PLANNING FOR A LARGE INSPECTION & CONDITION ASSESSMENT PROJECT

2.1 WHAT IS REQUIRED?

When commencing the VHCA project, the project team worked with Wellington Water to define and confirm project objectives, required outcomes, resource requirements and success factors.

The first question that is often asked is 'What is the client wanting to achieve?'. Closely followed by how we, as a consultant, can help them to achieve their objective. A large inspection and condition assessment project implies that the client is wanting to understand the condition of an asset. The important things to understand for us are what is needing inspection, what is the quantum of assets and what sort of inspection and condition assessment is required and appropriate for the asset under investigation. If a client is designating an asset's criticality as high, the level of confidence in the inspection and condition assessment information needs to provide greater certainty and have a greater level of accuracy.

The standard process for obtaining data for any inspection and assessment project is portrayed in the figure below.

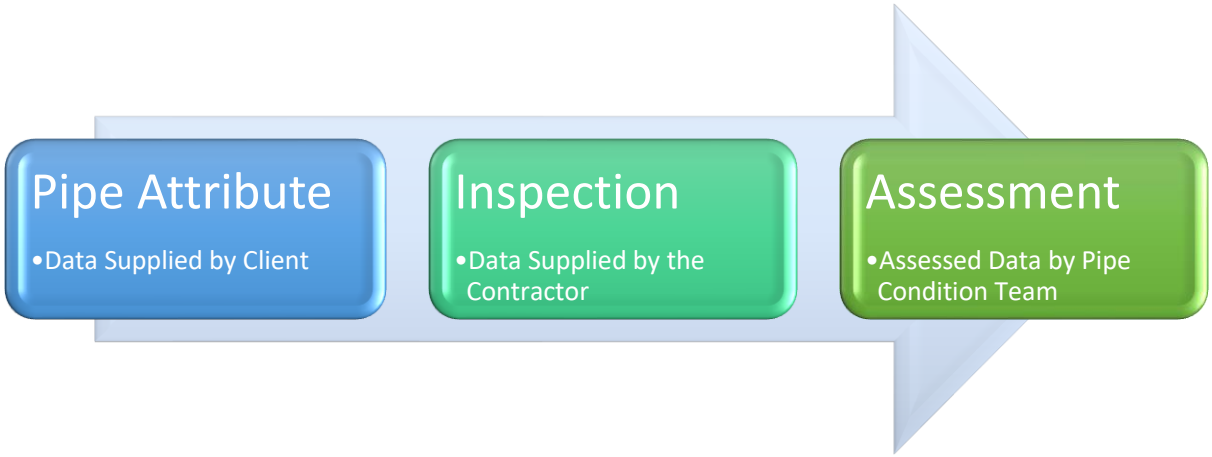

Figure 1: Standard data supply process for an inspection and assessment project

2.1.1 IDENTIFYING ASSETS FOR INSPECTION AND CONDITION ASSESSMENT

When commencing an inspection and condition assessment project it is important to understand the asset(s) to be inspected. This can involve the inspection of one asset with multiple sub-asset components, such as a pump station, or numerous individual primary assets with only a few sub-asset components, such as gravity pipes and pressure pipes with their node assets. In regard to the inspection and condition assessment of pipe assets, we should know the following critical bits of information:

- Historical inspection and condition assessment information
- Pipe and Node attribute information, such as pipe type, use, criticality, material, diameter, ownership etc.

- Pipe failures and repairs
- Scheduled maintenance activities (previous and ongoing)
- Future development work around the pipe or on the pipe network
- Access requirements for inspections
- Flow conveyance information

In many cases this information is not readily available and either we need to persevere with what information is provided or available or if possible, track it down by talking to the appropriate people within the water utility to obtain it.

2.1.2 IDENTIFYING APPROPRIATE INSPECTION TECHNIQUES AND CONDITION ASSESSMENT METHODS

There are well-utilised methods of inspection of gravity pipes that are used across the country, such as CCTV pipeline inspections and laser profiling. However, some types of pipes require different types of specialist versions of internal inspections such as boat cameras, also known as profiler cameras. In addition, an internal walkthrough inspection could be considered in the right circumstances. All of the inspection techniques can provide good information on the internal condition of the pipe. Any obvious significant defects or deterioration that can be identified internally can be condition assessed.

Pressure pipe inspections for condition assessment are starting to become more common in New Zealand and with the three waters reform, it is becoming increasingly more important to understand the condition of the pressure pipe assets. There is a good understanding worldwide of what is good practice pressure pipe inspection methods. From our knowledge, it is necessary to inspect the pipe for both the pressure that is being exerted on the pipe internally (hydrostatic) and externally (external loads). In addition, we want to inspect the pipes to determine its wall thickness. There are several internal inspection techniques for pressure pipes, which require gaining access to the pipe via the water column and can require shutdowns of service. There are, however, unobtrusive inspection techniques that utilise acoustic-induced wave monitoring and transient wave analysis to determine wall thickness. These inspection techniques only require connection points to be set up so that there is access to the water column and possibly access to an external feature of the pipe, such as a valve or literally the pipe surface.

The inspection techniques that show the condition of the pipe surface or provide a longitudinal analysis of the pipe's wall thickness are considered screening inspections. Where further inspections are considered necessary, we would look to undertake point inspections, either involving the traditional coupon/cut-out sample of the pipe or carrying out specialised point detailed inspections using external pipe wall scanning, such as ultrasonics.

The condition assessment of the pipes involves carrying out structural pipe condition assessments either by reviewing the internal pipe inspections or by carrying out calculations on the wall loss that is determined from the pressure pipe screening inspections. The assessment allows the remaining life assessment to be made and the associated grade outputs to be determined. The remaining life for pressure pipes is contingent on the design safety factor.

3 THE VERY HIGH CRITICAL ASSET PIPELINE INSPECTION PROJECT

In the second half of 2020, Wellington Water engaged ProjectMax to plan what an inspection and condition assessment project of a large selection of Wellington Water's highly critical pipe assets would require. These pipe assets were identified as the Very High Critical Asset (VHCA) pipelines. ProjectMax was provided with a data set of pipe assets from the three main asset classes, potable water, stormwater, and wastewater. Upon review of the VHCA pipe data, we found that the stormwater pipes were primarily all gravity pipes, with some having a dual function (i.e., they functioned as both gravity and pressurised pipes when required), while the wastewater pipes had gravity and pressure pipes.

Due to the inclusion of both gravity and pressure VHCA pipes, we began working on identifying the specific inspection techniques that would be most practical to use for the condition assessment purposes. This also involved making sure there were industry capabilities to carry out the inspection work required available either in New Zealand or close enough that it would not take long to procure. Prior to undertaking the VHCA inspection programme, Wellington Water prepared intervention guidance documents for their critical assets, with the help of several consulting firms. ProjectMax assisted in this work as well. The intervention guidance documents were modified into implementation documents by ProjectMax. These implementation documents formed the basis of how we would look to inspect, and condition assess the VHCA pipes.

The VHCA project involved all sorts of critical assets that Wellington Water had identified. These included critical facility assets, such as pump stations, reservoirs, and treatment plants, and critical pipeline assets. ProjectMax were responsible for initiating and planning the VHCA pipeline inspection and condition assessment project.

3.1 PREPARING THE PROJECT FOR TENDER

Due to the VHCA pipeline inspection project being funded via the Government stimulus funding there was an urgency to get the project out to tender. To do this work we teamed up with GHD to help us prepare the tender and manage the contract, while ProjectMax provided the technical oversite. We started preparing the tender specifications and the scope and schedule of work, while GHD was engaged to prepare the contract documents and manage the tender process.

The tender needed to be put out to the market to enable the Contractors to have as much time as possible to inspect the VHCA pipes. This meant that the planning work and data gathering exercises, which should normally come before had to be completed retrospectively during the tender phase.

3.1.1 VHCA PIPE DATA

VHCA pipeline inspection project originally consisted of inspecting a large number of pipes as follows:

- Potable Water: 653 potable water pipes consisting of ~ 77.4km
- Stormwater: 4497 stormwater pipes consisting of ~164.8km

- Wastewater: 3553 wastewater pipes consisting of ~230.5km
    - Gravity Wastewater Pipes – ~2538 pipes consisting of 79.4km
    - Pressure Wastewater Pipes - ~1015 pipes consisting of 151.1km

The initial review of the VHCA pipes identified all potable water pipes as pressure, all stormwater pipes could be treated as gravity pipes and inspected as such. For the wastewater pipes, there was a combination of both gravity and pressure pipes. These quantities included the VHCA pipes of Wellington Water's six 'client' councils and the asset owners, which are:

- Wellington City Council (WCC)
- Porirua City Council (PCC)
- Hutt City Council (HCC)
- Upper Hutt City Council (UHCC)
- South Wairarapa District Council (SWDC)
- Greater Wellington Regional Council (GWRC)

Although the quantities above, include all of the VHCA pipes from each of the Councils, initially SWDC's pipe assets weren't included. They were added eventually, by including them as a variation to the Contract at a later stage. Even so, the quantity of the SWDC pipes only notably raised the quantity of the potable water pipes, the additional SWDC wastewater and stormwater pipes were only a small increase. The overall pipe asset quantity was very large with only slight changes to the quantities throughout the project.

3.1.2 THE SCHEDULE AND SCOPE OF WORK

The ProjectMax team worked with Wellington Water's VHCA Project managers and the network engineering team to identify and propose the best-suited inspection techniques for the VHCA pipe inspections and condition assessments. The following inspection techniques were identified:

- CCTV Pipe & Laser Profiling Inspections
- Multi Sensor Boat Camera Inspections (incl. Laser and Sonar Profiling)
- Transient Pressure Monitoring
- ePulse Acoustic Inspections
- pCAT inspections

The chosen inspection techniques were the most practical options that could be identified to allow for the inspection of the pipes, as was identified in section 2.1.2 above. The techniques were also identified as being available in NZ or in Australia with an acceptable transit time.

The schedule included separate sections for gravity and pressure pipes and also separation between the different pipe classes (i.e., wastewater vs stormwater pipes). A multi-phased approach to the gravity pipe inspections was included to allow for the highest priority pipes to be focused on first. These pipes were identified as P1 pipes. The remaining lower priority pipes were identified as provisional items to be added once the Contractors add achieved a sufficient percentage of the P1 gravity pipes. These provisional lower priority pipes were identified as P2 and P3 pipes. The priority of the pipes was separated by the age range of the pipes.

For pressure pipes, all of the VHCA pipes were included for inspection in the first phase of the project, as it was considered to allow the Contractors to scope and identify any enabling work that would be required and provide inspection length continuity. The Contractors were expected to focus on the P1 pipes first, followed by the P2 pipes and then the P3 pipes.

Risk to contractor availability should be identified and assessed, particularly where loss or delay of assessment outcomes are highly consequential. In this case COVID-19-related restrictions and isolation disrupted the monitoring programme. Many lessons were learnt, and improvements have been identified in the scheduling and scoping of the work. This included the application of the chosen inspection techniques and the requirement to have more time to scope and carry out enabling work to access the pipes. Early Contractor engagement is considered a key factor in this phase.

The scope relied on the Contractors to work with ProjectMax, GHD and Wellington Water's Operations teams (COG and Bulkwater) to plan and enable the inspection work. This resulted in many inefficiencies in progressing the inspections, particular for the pressure pipes.

3.2 THE TENDER IS OUT, WHAT'S NEXT?

With the tender out to the market, we knew we had to get on with the preparation to tackle the expected mountain of inspection data. At this point, we understood what was going to be provided for this number of pipe assets, in the first phase of the inspection work. As a result, we had to come up with a data ingress and processing plan that would be able to be developed before the Contract commenced, it would need to function quickly and logically to be able to cater to the amount of inspection data expected.

At the same time, an information-gathering exercise was carried out on the VHCA pipes with Wellington Water to provide more of an understanding of what was already known about the VHCA pipes.

3.2.1 PREPARING A DATA INGRESS AND PROCESSING PLAN

Once the project was tendered, a data ingress and processing plan were needed to establish how data would be stored, managed, processed, and accessed by the project team and Wellington Water.

ProjectMax worked with our IT and software specialist team to develop a data management solution for the VHCA project. The solution needed to follow ProjectMax's established process for inspection data quality assurance and condition assessment. In addition, it needed to be a robust, dynamic, streamlined data portal able to be developed to enable all parties to access and manage the large amount of inspection data we expected to receive.

The team prepared an information flow map that enabled us to visualise and map out the data flow and choose what applications were best used to create a solution. In consultation with Wellington Water, it was agreed that the Microsoft suite of applications was the most appropriate solution as it was able to effectively achieve the project objectives.

It is important to note that when the process was developed, we did not anticipate the evolution and expansion of what the information flow and the data portal

required and could potentially provide as a solution. This revealed itself as the project progressed. The following section 4 provides further details of what applications were used and how.

3.2.2 INFORMATION GATHERING EXERCISE

At the same time as we were planning the data management platform, an information-gathering exercise was undertaken at Wellington Water's Petone office. This was my first trip down to Wellington in November 2020. This trip had several objectives, as follows:

1. To meet and introduce myself to the key Wellington Water personnel that were directly involved in the operation and management of the water assets, they also provided a really good understanding of the condition of particular high-profile VHCA pipes.
2. To collect/gain access to historical inspection data and condition assessment reports
3. To gather more pipe attribute data and any further information on pipe condition records as per section 2.1.1, which included:
    a. Pipe failures and repairs
    b. Scheduled maintenance activities (previous and ongoing)
    c. Future development work around the pipe or on the pipe network
    d. Access requirements for inspections
    e. Flow conveyance information

For objectives #2 & #3, interviews were carried out with the members of Wellington Water's Digital Products & Services (DPS) team, and the Network Engineering team to obtain a good amount of historical inspection data and other pipeline information that would help with the VHCA pipe inspection project. Due to the large number of VHCA pipes, the information on the pipes was not readily available for all or it took time to determine which pipes were applicable. The high-profile VHCA pipes were the pipes with the most information. These included the well-known critical pipes and the pipes that had, had failures and repairs carried out on them. It was the relatively lower-profile VHCA pipes that had limited information or were difficult to find information on. This first trip was only short and although it provided a good start to the information gathering, there was more needed.

4 THE DATA MANAGEMENT SOLUTION – UNDER THE HOOD

This section discusses the solution from an IT perspective including solution development and tools used.

To store, process and report on the large volume of data received and generated, an all-encompassing data management solution was required to be designed, built, and delivered in an iterative way to meet the requirements of the VHCA pipeline inspection project.

To determine the right solution, a series of workshops were held to define and map out the business requirements for the project. Based on these requirements, a technology assessment would be undertaken to decide the solution specifically, whether a single customised application or a series of applications. Finally, a

methodology would have to be used to allow for the solution to be deployed effectively given the constraints and dependencies for the project on time and resource availability.

4.1.1 BUSINESS REQUIREMENTS

The business requirements were captured and documented in a series of 5 workshops. The outcome of the requirements is summarised below:

1. Data Collection
    a. Capturing baseline data provided by Wellington Water
    b. Organising the data by asset class and inspection technique
    c. Providing a mechanism for contractors to submit and store inspected data records in information batch submissions
    d. Store historical inspection records
2. Data Validation
    a. Creating routines and workflows to perform cursory checks on the completeness and quality of the data submitted by the contractors
    b. Enforcing version control on submitted batches for resubmitted and reworked batches from the contractor
3. Data Processing
    a. Ensuring that batches can be processed in bulk through the quality assurance and auditing processes according to defined business rules
    b. Enable the creation of specific calculated measures based on criteria of the asset class, inspection technique, batch, and asset attributes
    c. Promote asset records from batches for the condition assessment with selective rules based on asset class and inspection technique.
4. Reporting
    a. Generate extraction points of current condition grade information
    b. Provide statistical information on the progress of the project

4.1.2 THE SOLUTION

After the requirements were captured and documented, a technology assessment was performed to assess viability. The criteria used were based on the functionality, amount of customisation required, the complexity of customisation, cost, and time to implement the solution.

Based on the technology assessment, a recommendation was made to leverage existing applications within the Microsoft ecosystem that could be easily integrated to form a uniform solution. This would minimise the amount of customisation and cost while allowing DS Consulting to deploy the solution within the time constraint.

The components of the solution are listed in the below table. The Microsoft Power Platform manages the integration of each component to define an end-to-end data management solution which is called CriNITA (Critical Network Inspection Tool for Assessment). The components of the solution are summarised in the following table:

Requirement	Solution Components
Data Collection	SharePoint to manage the submission of inspected data records OneDrive to store non-database records (CCTV files, Images and PDFs)
Data Validation	Power Automate to workflow and validate data between the subcontractor, GHD and ProjectMax
Data Processing	Dynamics 365 and PowerApps to perform complex data processing tasks and data generation
Reporting	Power BI to create paginated data extracts and statistical dashboards

Table 1: CriNITA Solution Sub-components

4.1.3 MAINTAINING THE SECURITY

There were security risks identified with the solution given that it is a cloud-based platform. To ensure that the risks were managed the following key features were employed:

- Used Microsoft Azure Active Directory to manage user security roles across the solution
- Used multi-factor authentication
- Continuous 30-day backup + on-premises backup of solution and data
    - We had 2 instances of having to roll back large changes and were able to do so within 1hr each time
- Federated Microsoft office accounts were utilized between the Contractors, GHD and ProjectMax.

4.1.4 THE BUILD AND DEPLOYMENT OF THE SOLUTION

After completing the business requirements and designing an integrated solution, only a short amount of time was available to build and deploy CriNITA. Our IT team decided the best approach was to take an iterative 'build, test, deploy' approach to each system component to ensure that the solution could be delivered without causing project disruption and compromising data quality.

The key external facing components, SharePoint and PowerAutomate were built and deployed first. This allowed the contractors to make their submissions and GHD to perform their validation tasks. This allowed the IT Team to configure security roles for the solution at the same time.

The next component deployed was the rollout of the Dynamics 365 Power App to enable the management and processing of large data sets in an organised way by ProjectMax. This part required the most amount of customisation but was able to be achieved relatively quickly due to the flexibility of the Microsoft Power Platform.

Power BI reports were the last component to be configured and were able to be done so based on an efficient way of utilising Microsoft Azure data management services. Additional measures, master data and metadata were able to be created and appended back to the main Dynamics 365 Power App.

Undertaking the iterative approach allowed the solution to be fully operational from 4 months after the business requirements were completed. The solution was implemented by our IT team which are made up by Microsoft-certified functional consultants and ProjectMax.

5 DEVELOPING CRINITA AS A PRACTICAL APPLICATION

In developing CriNITA, we started off planning a storage and data transfer portal for the Contractors to submit their inspection data.

This data portal needed to be able to accommodate the size and scope covering multiple pipe assets and the multiple inspection techniques planned. We also needed to have a secure place to compare pipe attribute data obtained from Wellington Water with the inspection data from the Contractors.

Initially, the pipe attribute data we obtained was from a snapshot in time and only focused on the VHCA pipes that we were looking into. However, it was understood and expected as is the case in most inspections, that other pipe assets that are not under the scope of work are often inspected in addition. The reasons are primarily to access the pipes that are within scope when direct access is difficult or not possible. Other reasons were that it may be to allow continuity for a contractor's pipe inspection or an inspection of a VHCA pipe may also allow for the opportunistic inspection of a non-VHCA pipe. In any case, the need to have the attribute information of other pipe assets within the adjacent pipe network around the VHCA pipes was identified early on in the development.

5.1 OBTAINING THE ATTRIBUTE DATA

We were originally provided with the VHCA pipe shapefiles and utilised the data set included, however, the data set needed to be expanded. This was due to the following:

- Data fields were limited and came from different Council sources of information.
- All pipe assets were required
- Full pipe metadata set was required

A full metadata set was obtained from the Wellington Water DPS team for each of the three pipe water types. This allowed us to select the fields that were applicable to the inspection and condition assessment of the pipes and then be able to reference and link them, whenever an inspection outside of the VHCA scope was inspected. Due to there being hundreds of data fields from the 6 'client' Councils we had to cut down the number to only the necessary fields that provided good information for the inspection and the assessment. There was a bit of learning over the project time to understand what information some of the customised fields provided. There were different uses by the 6 client councils. The DPS team were very helpful in providing us with information in this space. The pipe data fields were able to be brought into the CriNITA Dynamics database.

5.2 CREATING THE CONTRACTOR UPLOAD PORTAL

The Contractor upload section required an access portal for the Contractors to securely store their inspection data. We understood that the Contractors would use their own data capture software for their inspections, but once they were

ready to submit the inspection data it needed to be submitted to a centralised location for storage and data transfer through the CriNITA system. The inspection data also needed to have a unique CSV form filled in to allow for the batch inspection data to flow through to the quality assurance and condition assessment sections. The initial forms used were a simple selection of potential inspection data fields that were considered possible for the Contractor to retrieve onsite. We either worked with existing export spreadsheets from inspection data software or we worked directly with the Contractors to refine these forms over the project duration.

At the early stages of Contractor engagement, we requested the Contractors nominate two people responsible for the data uploads. They would become their primary and secondary points of contact. They were also included in the automated emailing notifications to receive confirmations about uploaded data or notifications on quality assurance checks and corrections required.

The upload portal needed to have separate upload sections for each pipe water type and separate inspection techniques. This was designed to enable the most efficient way of processing inspection data and ensuring that the inspection data identified in each uploaded batch would be assigned to the correct pipe asset ID.

5.3 TRANSFERRING THE DATA THROUGH THE CRINITA STAGES

The first step in the flow of inspection data following the Contractor batch upload is the Data Completion Check. GHD were responsible for the Completion check section of the quality assurance. The purpose was to allow GHD to have oversight of the pipe inspection data and be able to track the inspection completion from a contractual completion perspective. This section was designed to allow GHD access to the data portal, to carry out a review of the batch inspection data from the Contractors and have a platform to pass through batch status confirmations, i.e., was the batch acceptable or were there corrections the Contractor needed to carry out. If there were issues identified, an email notification was sent to the Contractor to rectify the issues, and if necessary, the Contractor was required to re-upload a new version of the batch. However, if the batch had no missing files or obvious data errors, the batch is sent through to the ProjectMax Dynamics section of CriNITA. The ProjectMax Dynamics section is where the batches are prepared for condition assessment in tables that allow a further quality assurance check.

To carry out the completion check the GHD project engineers were given a tutorial on what to look for, for each inspection technique. There was also further support provided as necessary when any technical questions on inspection data or IT issues arose.

In the case of the CCTV pipe inspection data, these batches are pushed through an auditing process. The coding and operation performance audit is as per the auditing methodology in the 4th edition of the NZ Pipe Inspection Manual (NZPIM). If the CCTV pipe inspection data passes the audit, the batch can be processed through to the condition assessment phase. However, if there are any issues with the batch, that batch may require corrections and an updated version of the batch to be submitted. The batch can be put on hold and the status and result of the audit identify that a new version of the batch is required. Once the Contractor provides the updated version of the batch, we may re-audit the batch or just

review the corrections made as necessary and then process it through to the condition assessment section.

In the case of any other inspection technique, quality assurance is only a pre-assessment check. This check determines if there are any clarifications required regarding the inspection data provided. The clarifications primarily relate to which pipe asset the inspection represents. For several of the inspection techniques, this question was difficult to answer, particularly for the pressure pipes. However, we needed to know the pipe assets that each inspection was applicable to, to ensure we could attribute the inspection data and subsequently assess the correct pipe assets. There have been many learnings as to how the pressure pipe inspections are assigned to pipe assets, and these will be utilised for future pressure pipe inspection projects.

5.4 CRINITA CONDITION ASSESSMENT

Each of the pipe water types had a thorough review of the flow of information through to the condition assessment section. The condition assessment section needed to encompass all pipe attributes and condition data checks. To do this we needed to enable the transfer of the appropriate data fields to be obtained from the pipe attribute data and the inspection data to allow for a comprehensive assessment of the pipe data and condition. This needed to be carried out for all pipe assets that had an inspection that could be assessed.

In addition to the transfer of data fields, we arranged for the setup of automated rules to reduce the large amount of data entry. The separate assessment table where pipe assets are displayed in. The condition assessment tables provide distinct sections for the pipe assessors to carry out the reviews on the pipe data.

5.4.1 PIPE ATTRIBUTE AND INSPECTION DATA REVIEW

The first section of the assessment is the comparison between the pipe attribute fields and the inspection data fields identified on-site by the Contractor. The assessor has the ability to provide a confirmation of any changes to pipe attribute fields. The assessor may also disregard if the changes identified by the Contractor are found to be an error or are not reliable. The assessor can provide comments on the changes identified. These help with identifying if any further work is required, such as GPS surveying to confirm uncertainty around MH positions and connectivity. Additionally, the comments will summarise what the changes are to the pipe attributes so that the Wellington Water data team can have verified the assessed pipe attribute data.

It is important to note that the pipe data is clustered under the water type. However, for assessment purposes, we found the pipe data was more aligned when we looked at the pipe use first and then the water type. By looking at the pipe use first, we could identify and separate all gravity pipes from pressure pipes (specifically for the wastewater VHCA pipes). The pressure pipes had similar data fields even if they were different pipe water types and the inspection techniques used on them were similar too. This was the same for gravity pipes. Therefore, the pressure wastewater pipes were clustered in an overarching table with the potable water pipes and conversely, the gravity wastewater pipes were clustered together in an overarching table with gravity stormwater.

5.4.2 CONDITION ASSESSMENT STAGES

Each of the water pipe type tables has three primary sections of assessment:

1. Preliminary Condition Assessment
2. Detailed Condition Assessment (as required)
3. Final Condition Assessment

The preliminary condition assessment is based on the screening inspection techniques. The preliminary condition assessment is the first level of condition assessment. We then have an internal review process of the preliminary assessment and recommendations, which allows for the assessment to be either passed through to the final assessment stage or if necessary, passed through to our intermediate detailed condition assessment stage. The detailed condition assessment is an in-depth look into the pipe assets' original structure and compares that with any deterioration identified from the inspections. This allows us to confirm safety factors and provide an accurate estimate of the remaining life. The final condition assessment is the section where we confirm all of the condition assessment grades, confidence grades and assessment recommendations.

5.5 ADDITIONAL CONSIDERATIONS & REQUIREMENTS

CriNITA had several additional considerations that were made. These included but were not limited to:

- Enabling all parties with an understanding of the data submission requirements and contract specifications
- Integration of other software already in use, e.g., pipe inspection coding software (WinCan) and other applications the Contractors were using for their own data capture.

5.5.1 WORKSHOPS WITH THE CONTRACTORS – DATA SUBMISSION

To make sure all parties understood the data submission requirements, live demonstration workshops were carried out to run through the data submissions with the Contractors and GHD. This was a really critical task as the best way to communicate the data submission requirements was to go through it with them. I spent an hour with each Contractor going through the upload process. There were delays between the workshop time and the first batch of inspection data uploaded by the Contractors and so there was some guidance on the first data submissions made for each of the inspection techniques. We also provided ad-hoc guidance on any issues and IT support when there were any issues made with the uploads.

The data submission process was refined at various points through the Contract, and these were made in collaboration with the Contractors and then confirmed with an NTC variation.

5.5.2 WORKSHOPS WITH THE CONTRACTORS – CONTRACT REQUIREMENTS

In addition to the data submission workshop, I also carried out workshops with the contractors and their Operators to go over the requirements for gravity pipe inspections. This was a good opportunity to redress some critical sections of the 4th edition of the NZPIM and then also identify and confirm understanding of

contract requirements identified in the applicable specifications. The workshops enabled me to raise awareness of the difference between a reactive inspection vs a proactive condition assessment inspection. The local Operators were new to proactive condition assessment inspections and so it was a good opportunity to review the data collection and inspection requirements with them and improve their understanding.

5.5.3 INTEGRATION OF OTHER SOFTWARE ALREADY IN USE

CriNITA is not intended to be a data storage system. The focus of CriNITA is to facilitate the collection and transfer of the summary inspection data between well-defined sections of the upload, quality assurance and condition assessment process. However, several inspection techniques had simple outputs that could easily be stored and then assigned to the appropriate pipe asset ID(s). Due to this, we ensured there was a data storage portal.

We also understood that there is well-used industry software, particularly gravity pipe inspection data capture software. This project was one of the first across the country to require the 4th edition NZPIM to cover such a large inspection project. Due to this, we worked with the Contractors to ensure their inspection software WinCan VX, was working in conjunction with the NZPIM. WinCan VX is the first pipe inspection data capture software to enable the 4th edition of the NZPIM. It is becoming more widely used now across the country. However, the first half year of use had several teething issues and required some updated versions to ensure the pipe coding was matching to the NZPIM.

The WinCan VX software is able to export a data summary file of each inspection batch that can be passed through the CriNITA system. The WinCan VX software can also be used to store and retain the CCTV video files and logsheet data so that it does not need to be stored in the CriNITA system. Wellington Water purchased their own license of WinCan VX, and the intention is to link the Contractors Wincan systems to Wellington Water's to ensure the data is transferred and available or quality assurance accessed directly from Wellington Water's WinCan VX system. This shows that the CriNITA system has a collaborative and flexible integration with existing pipe data capture software and that we can enable both data storage via Wincan and the quality assurance and condition assessment via Wincan.

5.5.4 DOCUMENTING THE PROCESS AND UPDATING SPECIFICATIONS

We have had requests from all parties including Wellington Water to document the data submission process. It is understood that documenting the process will provide better guidance for the data submission process and so that is a key objective for the next inspection and condition assessment phase working with the Wellington Water DPS and Network teams.

6 REPORTING AND ANALYTICS

Throughout the VHCA pipeline project, the Wellington Water Programme Managers were responsible for reporting to the Wellington Water Senior Leadership teams and the Client Councils. It was a difficult task to report on such a varied amount of data, i.e., different pipe water types and uses, different inspection techniques and statuses. ProjectMax utilised PowerBI analytics to provide status dashboards that informed the reporting provided by the Wellington Water Programme Manager.

6.1 THE CRITICAL STAGES OF REPORTING

There were several critical stages of the project which had different but important data capture points. These are identified in the next sections.

6.1.1 ORIGINAL PIPE DATA SET

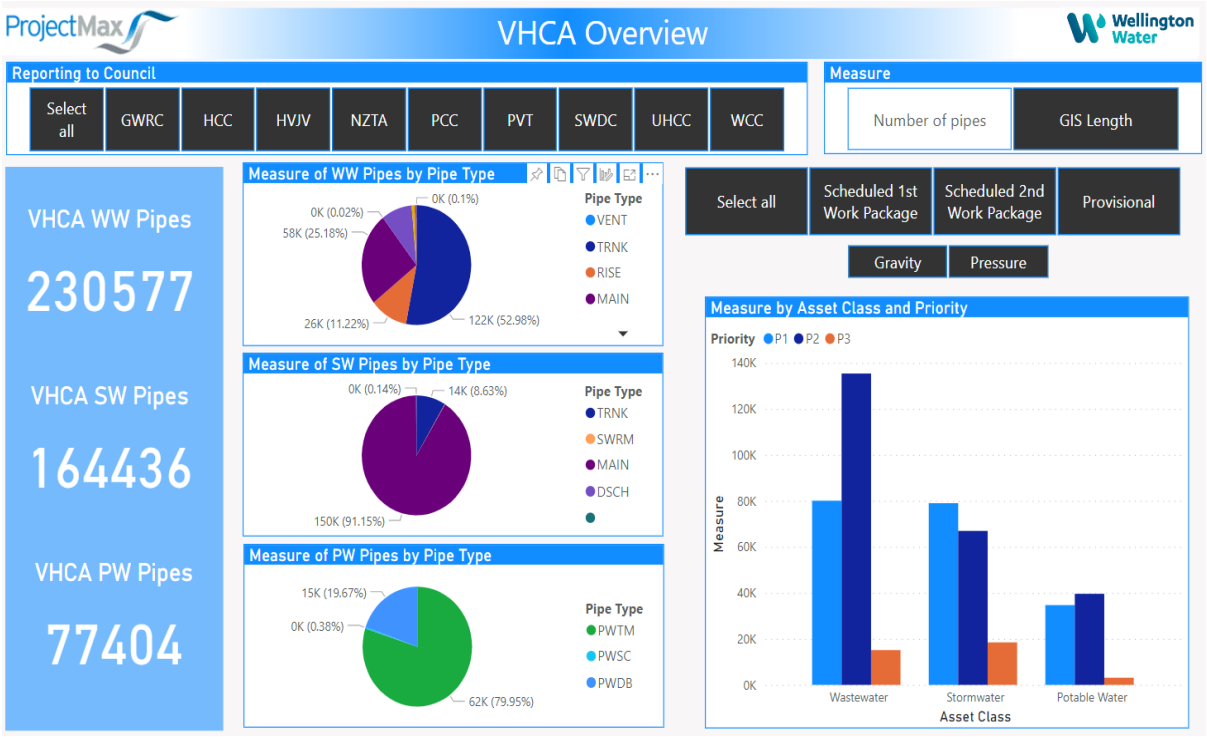

Figure 1: VHCA Overview PowerBI Dashboard from CriNITA

The first capture point was around the original data set and how this was managed and utilised through the project with the Contractors. ProjectMax managed the overarching original pipe data set and the high-level tracking of the pipe inspection requirements. GHD managed the pipes that required inspection by keeping track of which Contractor was responsible for which pipes. GHD also liaised with ProjectMax and the Contractors to identify which pipes were having difficulties to inspect or could not be inspected. If any pipes were put on hold or were removed from the Contractor's scope these would be recorded accordingly.

6.1.2 CONTRACTOR INSPECTION STATUSES

The Contractor's inspection statuses were another critical data capture stage. GHD was keeping track of the inspection status and ProjectMax provided technical reviews and confirmation on the applicability of the various inspections. All inspections submitted were reviewed and then quantified as the Contract progressed.

6.1.3 PIPELINE CONDITION ASSESSMENT STATUSES

ProjectMax were responsible for the condition assessment status and grading of the pipes. The status of the pipeline condition assessments is dependent on all of the necessary inspections being completed. Due to that when reporting on assessment status it was always requiring the inspection status confirmation.

6.2 REPORTING ASSESSMENT AND GRADING DATA TO WELLINGTON WATER

The condition assessment and grading information was passed through to Wellington Water's internal dashboard prepared by the DPS team. This dashboard provides an overview of all of the VHCA assets that were inspected and assessed, including facilities and pipes.

6.3 SOLUTION SUMMARY – DATA METRICS

Reviewing the CriNITA Data Management Solution at the end of the project we identified the following metric outcomes. These are summarised in the table below:

Metrics	Quantities Identified
Total database records in the core application	1.8 million records
Total Contractor Inspection Data Uploaded	1.8 terabytes
No. of User interactions in the Sharepoint Portals	just under 10,000
Contractor Batch Submission Uploads	772 Inspection data batches

Table 2: Summary of CriNITA Data Metrics

These metrics show the critical position that the data management solution CriNITA played in managing the data transfer and interactions by the Contractors and Consultants under this VHCA pipe inspection project.

7 NEXT STEPS - DEVELOPMENT OPPORTUNITIES

7.1 SOLUTION LIMITATIONS

While CriNITA was able to be fully operational in a short period of time, there were some limitations in what was initially deployed.

The initial sizing of the solution was based on a finite project VHCA scope. Any future use would require development to expand capacity and manage additional asset classifications and assessment version comparisons.

Full two-way integration with Wellington Water's information management system was not achieved but this was mainly due to timing and resource availability.

7.2 THE FUTURE STATE OF CRINITA

Fortunately, the limitations are easily addressed with some necessary development stages. Following the completion of the VHCA project, a workshop was held to address the required development for future use on an ongoing basis. Further leveraging Microsoft Azure-managed services to expand storage and enable two-way data integration would allow CriNITA to be used as part of a wider programme of work with Wellington Water.

There are additional development opportunities for CriNITA to improve the collaboration with external data capture software and also the processes utilised in CriNITA. Some of the opportunities are listed below:

- Incorporating a timeline of inspection and assessment records
- Quality assurance auditing database
- Expanding the inspection techniques application
- Integrating the data summary files with an existing export functionality from the Contractors data capture software.
- Improving the assessment and contractor uploading user experiences

8 CONCLUSIONS

The CriNITA data management solution enables the collection and transfer of inspection data to be checked through the quality assurance and condition assessment process and assigned to the appropriate pipe asset IDs. The platform was able to provide a solution that was developed prior to the commencement of the VHCA pipeline inspection project and then refined through the duration of the project. It is flexible in being able to work with existing data capture applications and software that Contractors use. The solution summary data metrics show that CriNITA was able to

It was not expected that the initial data ingress plan would be a simple solution to develop the platform quickly. It required extensive, logic-based programming and flexible development that we were constantly refining throughout the project. There were a lot of spontaneous requirements that needed to be worked on during the contract period. Due to this, the development was a true journey of discovery It is understood that many IT development projects can be this way. It was not ideal, but we persevered and gained a lot of insights into how things could have been and could still be developed better.

Due to the VHCA pipeline inspection project being the first project to use CriNITA, we have understood the development possibilities and identified critical areas for additional refinement. Two-way integration of the pipe inspection data between the Wellington Water DPS team and the CriNITA system is critical to an efficient and productive transfer of the data. We are also aware of developments to improve the processes and user interface around the data uploading, quality assurance and condition assessment. Power BI data analytics is also an area that has been identified as a significant area for development. We have obtained a lot of data that is important to be able to share in internal project dashboards via Power BI.

The solution summary data metrics show that CriNITA was and is able to provide processes for data management to successfully collect, check, and assess the so-called ‘foreboding mountain’ of inspection data. The Wellington Water VHCA pipe inspection project brought with it challenges that had to be overcome, CriNITA provided the platform to do this. We are sure that the CriNITA tool will be a good addition to any future similar inspection projects for water utility managers.

9 ACKNOWLEDGEMENTS

I would like to thank my co-author Chris De Silva and his team for providing software development expertise, without which the CriNITA solution would not have come to fruition.

To the Wellington Water teams, we would like to acknowledge and thank Dylan Hopkins and the Digital Products and Services team, the Network Engineering team and the VHCA Project Management team, including Aidan Crimp, John Scott, and Rob Blakemore.

To the Network Engineering team and the wider Project team, including (GHD and the Contractors), thank you for the support, patience, and involvement in the development of CriNITA.

To the ProjectMax team I would like to acknowledge the support and assistance throughout the project.