water NEW ZEALAND

The New Zealand Water & Wastes Association Waiora Aotearoa

A consistent approach across the 3 waters sector

NEW ZEALAND GRAVITY PIPE INSPECTION MANUAL

4TH EDITION

Prepared for Water New Zealand by
ProjectMax Ltd and Citycare Water 2019

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Contents

Foreword

The 4th edition of the New Zealand Gravity Pipe Inspection Manual incorporates the evolution of pipeline inspection and the changing requirements of the water industry since the publication of the 3rd Edition in 2006. The scope of the revision was identified in the report prepared for the 'Evidence Based Investment Decision Making for 3 Waters Pipe Network Programme' a joint initiative between WaterNZ, IPWEA, University of Canterbury Quake Centre titled "Recommendations for the Revision of the New Zealand Pipe Inspection Manual, December 2016" by ProjectMax. This included consideration of:

- Development of technology
- Increased sophistication of data analysis
- Increased emphasis on asset management as a key driver of service and efficiency
- The creation of other guidelines such as the "Meta-data Standards"
- Benchmarking and desire to align more closely with other international standards and practices
- A desire for more, and better, guidelines

This edition observes a change in title of the manual with the addition of 'Gravity' to differentiate this manual from pressure pipelines which are intended to be covered in separate publications such as "National Asbestos Cement Pressure Pipe Manual, February 2017".

The 4th edition makes comprehensive changes intended to improve the ability of the industry to scope the works required, undertake inspections to a consistent and high-quality standard and then interpret the outcomes in relation to the maintenance and/or renewal of the asset in accordance with best asset management practices. The manual has been completely revised and substantially extended to align with the industry's desire to incorporate more guidance and specific requirements. For the first-time this edition includes a process for the inspection of manholes, laterals and acceptance of new and lined pipes.

Some of the most significant changes have been made to the defect/feature classifications and pipe grading systems that improve the description of defects and more closely align the New Zealand classification system to other international classification standards such as the Australian WSA05: Conduit Inspection Manual and the European EN 13508-2:2003: Conditions of drain and sewer systems outside buildings Part 2: Visual inspection coding and Classification Systems. Care has been taken to ensure that any changes that have been made to the classification system maintain compatibility with the codes in the previous versions of the manual, ensuring that existing condition data captured under the previous editions can continue to be used. The upgraded defect scores provide condition grading that better aligns with assessed condition and enables more meaningful benchmarking.

The overarching intent of the manual remains, as it has since the first edition, to provide asset owners and contractors with a consistent and reliable basis for undertaking inspections of gravity pipeline and for assessing the condition the pipe for good asset management and renewal planning purposes.

This edition has been produced with the input and collaboration of the New Zealand Water industry, through industry surveys, nationwide workshops, review and feedback from steering committees and feedback from individual councils and industry groups.

This updated manual will provide a powerful tool for the systematic and effective inspection and management of gravity pipelines.

Chain of Custody Guide

This Manual is one of a suite of documents being generated by the New Zealand Water Services industry to assist asset owners to deliver robust and cost-effective water services.

The high level 'What and Why' of asset management is defined by generic international standards such as *'ISO 55000: 2014 Asset Management – Overview, principles and terminology'* and the more detailed infrastructure focussed *'International Infrastructure Management Manual (IIMM): 2015'*. These documents provide the overall context for asset management and broadly identify the approaches and systems that an organisation needs to adopt to reliably and efficiently deliver infrastructure services. However, they are intended to generically apply to all such services, e.g. from railways to nuclear power stations, and they do not include guidance on the tools required for specific industries and types of assets.

The 'How' of applying these asset management principles to the New Zealand Water Services industry is being addressed through the *'Evidence Based Investment Decision Making for 3 Waters Pipe Network Programme'*. This is a joint initiative of the University of Canterbury Quake Centre, IPWEA and WaterNZ. The intent is to develop guidance documents and tools to assist New Zealand water services providers to make nationally consistent, evidence-based decisions relating to the management and renewal of their 3 water pipe networks i.e. water supply, wastewater drainage and stormwater drainage. It comprises 47 discrete projects to be delivered over a period of several years.

These guidelines, together with other relevant documents, range from very specific standards referenced by legislation e.g. Drinking Water Standards for New Zealand to documents such as this one that are intended to provide a robust and consistent solution that can be applied across the country.

Broadly the various documents can be grouped into the following elements, albeit with significant interaction between them:

Element	Example of Relevant Documentation
Inventory of Network	Meta-data standards
Condition of Network	New Zealand Gravity Pipe Inspection Manual
Performance of Network	New Zealand Drinking Standards National Performance Review
Management of Network	Pipe Renewals Guidelines

In New Zealand the water services industry is dominated by Local Government. Legislation requires each council to generate an Infrastructure Strategy that identifies the requirements for maintaining, renewing and developing their water networks for at least the next 30 years. It is also expected that councils can justify the decisions they are making in relation to their water services in the short to medium term. The various documents referred to above, and this manual, are intended to provide a consistent and recognisable framework for asset managers to understand and manage their water services networks to provide the required/desired level of service, at an acceptable level of risk and at an optimised long-term cost.

Preface – Inspection and Condition Assessment as Part of Good Asset Management

Stormwater and wastewater pipelines comprise some of the most important assets in a community. They must be effectively managed to ensure they provide the services they are designed for, at an acceptable level of risk and at the lowest achievable long-term cost. A primary requirement for effective asset management is understanding the condition of the assets. Closed circuit television (CCTV) is the principal means for inspecting gravity pipelines and therefore plays an integral and essential part in infrastructure asset management.

CCTV inspections provide information to help Asset Owners gain an understanding of the condition, performance and connectivity of their gravity assets which can be used to:

- Determine the structural condition of pipes to enable planning and prioritisation of renewals.
- Maintain a check on the structural condition and rate of deterioration rates of pipes to enable forward budgeting for maintenance and renewal.
- Provide an overall inventory of the asset and a global picture of system problems.
- Acceptance of new or lined pipelines
- Provide a basis for reporting the condition of wastewater and stormwater networks for industry benchmarking, valuation and audit.

The standardisation of procedures for carrying out an inspection, and more particularly, for the recording of the results of that inspection, must therefore reflect the requirements and expectations of asset owners i.e.:

- Can the inspection records provide the information required for informed asset management?
- Can the information provided be relied upon to make timely and reliable decisions?

This manual details the standards, procedures and guidelines to enable Asset Owners to meet their objective of obtaining accurate, reliable, consistent records of gravity pipeline condition. The manual covers the various processes involved with undertaking inspections of gravity pipelines which broadly encompasses:

PART A: PLANNING FOR THE INSPECTION OF DRAINS AND SEWERS

- Planning which pipelines are to be inspected and how they are going to be inspected.
- Method of inspection and determining the right equipment for the intended purpose.
- Checking the information collected is to the right standard, accurate and complete.

PART B: INSPECTION OF PUBLIC DRAINS AND SEWERS

PART C: PRIVATE DRAINS & SEWERS

PART D: INSPECTION OF MANHOLES

- Preparing the pipes and manholes for inspections.
- Carrying out the inspections and condition reporting.

PART E: INTERPRETATION OF INSPECTION RESULTS

- Analysing the CCTV inspections.
- Generating the required outputs.

PART F: GROUND WATER INFILTRATION SOURCE DETECTION

- Infiltration Source Detection Investigations.

The need for accuracy and consistency is paramount. The information collected from inspections will be used to make decisions that will have significant short term and long-term impacts on budgets and the management of the system. Checks and balances throughout this manual have been designed to safeguard and enhance the quality of the information. If these are not effectively utilised the quality of the information can quickly deteriorate until its usefulness is significantly reduced and the value of the expenditure on inspections severely compromised. Consistent standards of accurate reporting will allow:

- Consistent specification of the required inspection and reporting leading to industry wide efficiencies and value generation.
- Valid comparisons of subsequent inspections of the same pipeline, probably by different inspectors using different equipment, to study progressive deterioration.
- Reliable use of district wide data (sampling) for maintenance and renewal planning and reporting purposes.
- Information to be used for more than one purpose if required.

CCTV Inspection of Stormwater Management Devices

Different types of Stormwater Management Devices are in use in New Zealand to control quantity and quality of Stormwater discharge to the receiving environment. Many of these devices are not suitable for man entry inspection and maintenance. As a result, CCTV cameras are needed to inspect the condition of these devices. The inspection processes, and the interpretation of their outcomes for stormwater devices are outside the scope of this Manual, however it is generally believed that same principles of this Manual are still applicable in many cases.

The preparation, inspection and interpretation of the inspection results shall be specified by the device suppliers, or designers within their operation and maintenance manuals submitted to the Asset Owner including, but not limiting to, the following:

- Pre-inspection preparation and points of camera entry
- Type and size of cameras appropriate for inspection of the device
- Any cleaning methodologies (pressure, flow rates) and equipment.
- Information on interpretation of the inspection results
- Limitation of the proposed CCTV inspection.

A1 Planning and Developing an Inspection Programme

A1.1 Introduction

There are a variety of reasons for undertaking inspections of pipes and manholes. The reason, or combination of reasons, will influence which assets are inspected, the technology to be used, how the inspection data is interpreted and utilised, who does the inspection and whether it is a one-off inspection, or part of a cyclic programme.

When determining how the inspection should be done consideration should be given to how the outcomes are to be used to support, and optimise, management of the assets.

A1.2 Asset Management Maturity

The asset owner's approach to asset inspection should reflect their desired level of 'Maturity' as described in IIMM 2.5 'Asset Performance and Condition'. Note that the targeted level of maturity does not need to be the same for all an asset owner's asset types, for all asset management considerations or for all assets within an asset type. For example, the targeted maturity level for critical wastewater pipe assets might be quite different to non-critical stormwater open-channel assets.

Table A1.1 – Interpretation of IIMM Table 2.1.2 Asset Management Maturity Index for Section 2.5 Asset Condition

Maturity Level	Description	Implications for Inspection Programme
Aware	*Condition and performance information understood but not quantified or documented.*	Inspections, if any, are reactive maintenance focussed with little value extracted for renewal planning purposes.
Basic	*Adequate data and information to confirm current performance against AM objectives.*	Focus is on achieving current Level of Service objectives and information required to achieve that.
Core	*Condition and performance information is suitable to be used to plan maintenance and renewals over the short term.*	Focus is on assets that are failing or considered to be close to failure. Limited understanding of rates of deterioration or how this varies between assets or across the network.
Intermediate	*Future condition and performance information is modelled to assess whether AM objectives can be met in the long term. Contextual information such as demand is used to estimate likely performance.*	Information is gathered that provides justification for short term maintenance and renewal responses and robust indications of longer-term requirements, i.e. supporting forecasts in Infrastructure Strategy.
Advanced	*The type, quality and amount of data are optimised to the decisions being made. The underlying data collection programme is adapted to reflect the assets' lifecycle stage.*	A sophisticated approach adopted with the inspection programme fine-tuned to the status of the asset, where it is in its whole of life journey and the intended use of the information obtained.

A1.3 Reasons for Undertaking Inspections

One, or more, of the following reasons will cover most pipe inspections that will be undertaken using this manual.

'Likely Funding' is intended to reflect the source of the budget used to undertake such inspections and is further discussed in A1.9 Funding of Inspections. 'OPEX' indicates operational funding and 'CAPEX' indicates capital

Table A1.2 – Reasons for undertaking pipe inspections

Type	Group	Description	Likely Funding
Planned Inspections (Able to be planned several months ahead)	Critical Assets	Regularly scheduled inspection of assets considered to be critical, to identify any performance issues where operational maintenance is required and to track their gradual deterioration and identify the appropriate time for renewal. May involve inspection of every relevant asset or a sampling approach.	OPEX
	Non-Critical Assets	Inspection of non-critical assets on a structured basis, to gain information on any performance issues requiring operational maintenance and the overall condition of pipes with particular attributes. This will be used to inform long term planning for renewals and for valuation purposes. Typically involves a sampling approach rather than inspection of every asset in a group.	OPEX
	Confirmation of Proposed Renewals	Inspection of assets that are being considered for repair or renewal to confirm their actual condition and the appropriateness of the planned works. This may require the use of several methodologies to confirm ovality, obstructions, displacements, dips, etc. This is different to the pre-rehabilitation inspection done by the rehabilitation contractor who is checking the location of laterals and for any obstructions that would inhibit their ability to undertake a successful relining.	CAPEX
	Pipe and Manhole Attributes	Inspection of specific assets, or groups of assets, to confirm key attributes such as material, diameter, location, connectivity, condition, accessibility, etc. The currently held information is either missing or has low confidence. This might be combined with survey information to determine gradients, ground and invert levels.	OPEX
	Specific Issue Driven	A particular issue might drive the need for asset inspections. This could be in response to surface flooding odours, accelerated deterioration, blockages, multiple overflows, etc. The intent is to investigate the issue with a view to resolving it. This may be a full, or specifically focussed, inspection in accordance with this manual.	OPEX
	Inflow and Infiltration (I/I)	Inspection of assets to identify sources of infiltration for planning of response to excessive I/I.	OPEX / CAPEX
Unplanned and As Required Inspections	Pipe and Manhole Acceptance	Inspection of newly constructed, rehabilitated or repaired assets to ensure that works have been completed to an acceptable standard.	CAPEX
	Build-overs	Pre and Post-work inspection of assets where there is an application to undertake works over, or in close proximity, to the pipe. This is done to assess current condition and risk before the proposal is approved and to check for any damage, or change in condition, after the works have been undertaken.	OPEX

continued on following page

Type	Group	Description	Likely Funding
	Opportunistic	Works being undertaken on assets or inspections occurring if other assets in the vicinity generate an opportunity to inspect an asset that might not have otherwise been surveyed.	OPEX
	Maintenance Related	Quick (informal) inspection to identify the cause of a fault, confirm fault has been removed and/or to find specific information. The focus of the inspection may be limited to a specific section of pipe and limited reference to this manual might be required. Inspection information (from planned or reactive approach) will also guide the choice of appropriate remedial works to avoid further damage to the pipe, creation of tomos, avoidance of blow-backs, etc May be supplemented by a follow-up full inspection if required by the asset owner.	OPEX

A1.4 Choosing the Right Assets to Inspect

The asset owner will not have unlimited resources for undertaking inspections and the overall planned inspection programme must therefore be structured to optimise the value of the information that is being collected, the change in risk profile that is achieved and the cost of obtaining, analysing and utilising the information.

For many of the planned inspections listed above, in table A1.2, they will require the selection of 'some' assets, rather than 'all' assets, in that category. Fundamental to choosing the right assets to inspect is an understanding of the relative criticality of the assets within the network. It is entirely appropriate that assets with an elevated criticality are managed quite differently to those that are not considered to be critical. Using criticality to determine how many, and when, inspections are undertaken to assess condition is a core asset management concept.

For inspections related to Critical Pipes, it is recommended that a high proportion of these assets are inspected to ensure the information is as robust as possible and tracks the gradual deterioration in condition that is occurring. This group of pipes would have the highest priority for inspection in relation to available budget. If a high inspection rate is not considered to be affordable, or justified, then It is recommended that any available inspection programme is weighted towards the assets that are expected to be exhibiting moderate to severe deterioration and/or the highest criticality i.e. highest overall risk or highest consequence of failure.

It should also be noted that inspections of an asset are often not a one-off activity. For example, assets with elevated criticality should be inspected on a regular cycle. The period between inspections would reflect the relative criticality of the asset and its condition at the last inspection. An example of how an inspection programme for assets with elevated criticality might be structured is given in figure A1.1 at the end of this section.

Inspections relating to Non-Critical assets, or to confirm asset attributes, would typically be undertaken on a sampling basis, as the intent is largely focussed on determining the general characteristics of asset cohorts e.g. by material, age, size, location, depth, etc. While condition information on relatively new assets is interesting, in relation to plotting overall long-term condition deterioration, it generally adds little value to the planning of renewals or identification of behaviour that is deviating from the expected trend. It is therefore recommended that inspections in this group are weighted towards the assets that are expected to be exhibiting moderate to severe deterioration, as this provides the most valuable information for renewal planning. Non-Critical assets that are less than 50% through their expected lives might not be inspected at all unless there are questions relating to their performance, or inspections undertaken for other purposes indicates that something unusual is occurring. While the reason for undertaking pipe inspections falls into different categories the information obtained is largely the same for all and is relevant to all pipes that have similar characteristics. Results that are unusual should trigger further investigation to determine if this is peculiar to a particular pipe or indicating an underlying trend with other similar pipes.

Inspections of assets for specific issues, inflow and infiltration programmes, or confirming proposed renewals, would typically involve inspecting all the assets within that identified group. For example, as part of an inflow and infiltration programme, all the wastewater assets within a mini-catchment would likely be selected for inspection. Sampling of these assets within these groups would not provide sufficient information to confirm the extent or the appropriate response to the specific identified issues.

Maintenance related inspections are typically focussed on identifying the cause of a problem as quickly and cheaply as possible. The approach used might only align with portions of this manual and would not usually generate a defect logsheet for the entire length of the pipe. Pipelines that have had a problem of some sort are ideal candidates for a full inspection if the cause of the problem has not been fully resolved. A case could be made for undertaking full inspections every time, rather than partial maintenance inspections, to minimise rework. This would largely depend on the availability of resource to undertake a full inspection at a reasonable cost, and in a reasonable timeframe. If this cannot be achieved, then the partial inspection is a useful tool to minimise the likelihood of a reoccurrence of the problem in a short time.

A useful consideration in relation to inspections that are focussed on reducing the likelihood of blockages and overflows is the use of acoustic devices such as Sewerbatt and SL-RAT described in section '2.4.4 Acoustic Testing for Service Lines to Prioritise Cleansing or Inspections'. These devices do not provide any useful information on the structural condition of the pipe but do provide a cheap, quick and effective means of determining if there is any obstruction in the line compared to any form of CCTV inspection. Where obstructions are detected and cleared there is merit in then considering a CCTV inspection to see if there is any particular reason for the obstruction to have occurred.

All unplanned inspections, including build-over and post construction inspections, occur on an ad-hoc basis. These are typically undertaken on demand and are dependent on the level of development or maintenance activity and the asset owner's need for information. By their nature the reasons for their inspection are reactive and cannot be realistically planned as part of a programme.

A1.5 Typical Range of Services Required

Services associated with undertaking asset inspections are listed in the following table and most inspections will involve many of the services listed.

Generally, a specialist inspection contractor would be able to provide a range of related services and operate largely autonomously. However, their focus is on inspecting assets as quickly and effectively as possible and if a lot of effort will be required to locate and access manholes, expose pipes, liaise with home-owners, etc then these ancillary activities might be better managed by the asset-owner's own forces or maintenance contractor. This will require careful management of the interface in relation to the inspection programme, responsiveness to urgent needs and allocation of responsibilities between the parties.

When planning an inspection programme the full range of services required should be identified and a clear understanding developed in relation to who will do each of the required tasks and what relationship management this will require. Consideration should be given to which party is best suited to do what roles. Tasks and expectations should be clearly outlined in the various contract specifications, including the maintenance contract if that resource is being utilised.

It is easy to under-estimate the extent of the supporting activities required, particularly resolving issues that may arise and the export and import of the inspection data/reports into the asset owner's Asset Management Information System.

Table A1.3 – Typical range of services required

Works and Services Typically Associated with Pipe Inspections
Enabling Works
Collation of asset information – Maps, attribute information (e.g. size, material, length, history)
Asset location and exposing of access points
Community liaison regarding access and works
Planning and Documentation. Depending on circumstances and contract requirements this may include consideration of: • Health and Safety Plan • Traffic Management, and Corridor Access, Plan • Quality Management Plan • Environmental Impact Management Plan • Communication strategy • Data Management Plan • Contingency Plan • Critical Path and Timeline Management • Logistics and Supply • Methodology
Pre-Cleaning
Water Supply
Temporary diversion of flows and over-pumping
Exposure of pipe to allow sampling or testing
Inspections
Walk and crawl through visual inspections of large pipe assets -having due regard for safety considerations
CCTV inspection of pipes (full inspection per this manual). This might be split by trunkmains, collection mains, public laterals and private pipework
Capture of asset attribute, connectivity and location information, particularly if different from existing
CCTV inspection of pipes (urgent maintenance related).
Works and Services Typically Associated with Pipe Inspections
Inspection of manholes and chambers
Location of 'live' and 'dead' lateral connections
Heavy cleaning of lines of debris, gravel, fats, roots to enable inspection completion and associated disposal
Removal of water from dips
Laser/sonar inspection of pipe
Extraction of pipe-wall samples
Non-destructive in-situ testing of pipe-wall

Associated with Inspection Activity (supporting Activities)
Urgent remedial works discovered by the inspection or required to allow the inspection to proceed
Independent auditing of the quality of the inspection
Resolution of issues associated with identification and location of assets to allow inspections to proceed and creation/ amendment of assets to align with reality
Import of information into Asset Management Information System
Updating of Asset Management Information System and/or GIS to reflect as-built information obtained during inspections
Contract administration, site supervision, property owner issues, dispute resolution
Follow-up Activities and Assessments
Laboratory testing of pipe-wall samples
Assessment of inspection outputs, allocation of condition 'score' and identification of remedial works required
Capital works planning for renewals and input of information into Asset Management Planning

A1.6 Procuring Inspection Services

How inspection services are procured will vary depending on the scale of the project and the reason it is being undertaken.

A1.6.1 General Overview of Procurement

In each case consideration needs to be given to the quantity and location of the assets, the types of issues that may be encountered, the information (type and quality) that is sought, and the logical geographic groupings of pipes. For example, planned inspections of pipelines for relatively straightforward and a small quantity of inspections, (<5km) may be simply undertaken by utilising the maintenance contractor, provided there is confidence on the contractor's competency to undertake the work to the requirements of this manual. Whereas programmes involving larger quantities of inspections, or that have more specialist services, may be better obtained through an alternative external arrangement.

There is no single preferred solution in relation to how the various works associated with asset inspections are provided. Generally speaking, a Specialist Inspection Contractor will prefer to focus on activities that are directly related to the inspection and being able to progress their programme with minimal interfaces and opportunities for delays to occur. The asset owner will typically seek to utilise resources that are already working on the drainage network to undertake support activities that are not regarded as specialist. This combination will work effectively in most circumstances providing the interfaces and expectations are adequately defined.

At any given time, the asset owner might simultaneously have contracts and relationships in place to cater for each of the 3 approaches described as follows.

A1.7 Particular Considerations for Procurement

The particular circumstances relating to the assets to be inspected, and the information that is sought, may significantly influence the procurement, documentation and contract management approach that is adopted.

The engagement of a competent and experienced contractor to undertake inspections of low criticality assets, in a low risk environment and utilising conventional equipment and methodologies should be relatively straight-forward and require a low level of oversight by the asset owner.

Conversely, if the required inspections involve elevated safety risk levels, time critical programming, contingency and response planning, involvement and co-ordination of multiple agencies/contractors, specific methodology approvals, very specific information outcomes, sourcing of specialist equipment and operators and/or high levels of contractor / asset owner interaction then a very different procurement and contract management approach would be justified.

Between these extremes may be a particular requirement that makes the inspection unusual and which requires consideration at the procurement stage to ensure that adequate contractual provision is included, a suitable contractor is selected and all parties of aware of what is required.

A1.7.1 Long Term Planned Approaches

Where the pipes to be inspected can be identified well in advance, these can be logically grouped and progressed as a project. Depending on the procurement preferences of the asset owner, this might extend to a 'whole of network' approach covering several years of inspections, or alternatively to contracts limited to discrete portions of the network, types of pipe, or limited durations.

This approach allows budgets requirements to be identified and allocated well into the future at rates that reflect ongoing continuity or work, and low risk, for inspection contractors.

These broader and longer-term approaches could logically apply to inspections of critical assets, non-critical assets sampled from across the network, and asset attribute inspection activity.

A1.7.2 Shorter Term and On-Demand Approaches

Inspections of specific pipes for proposed renewals, asset acceptance, build-overs and other on-demand, and as-required, inspections might logically be grouped into smaller contracts, an on-call relationship with a provider or undertaken by the asset owner's staff or maintenance contractor.

Unless otherwise specified it would be anticipated that inspections undertaken for the above purposes would fully comply with the requirements of this manual. The condition information generated would be suitable for storing in an Asset Management Information System and utilised for system planning.

A1.7.3 Maintenance Driven Approaches

Urgent, maintenance related inspections would typically be provided by the asset owner's operational staff, the maintenance contractor, or an on-call external provider. Such inspections are likely to be focussed on a particular problem rather than the overall condition of the pipe. These inspections might follow the general guidelines of this manual for camera operation but might not utilise the detailed defect identification and scoring procedures. The condition information that is generated might be entirely suitable for maintenance purposes, and quick and cheap to generate, but not suitable for storing in the Asset Management Information System, other than as a maintenance record.

A1.8 Managing the Quality of Inspections

Quality management is a fundamental requirement of any inspection programme planning. This is absolutely a case of 'Garbage in – garbage out' and the primary intent of utilising this manual is sabotaged if the inspections are not undertaken in accordance with the manual and to an acceptable quality.

Quality management needs to be comprehensively specified in any documentation relating to inspection activities irrespective of whether they are undertaken by own-staff or external contractors.

For further guidance on quality control and management refer to sections A3 and A4 of this manual.

A1.9 Funding of Inspections

The funding of pipe inspections can be from Operational or Capital expenditure budgets, depending on the circumstances.

Generally, inspections that are focussed on repairing the pipe and restoring service would be funded from operating expenditure. This would apply to most inspections undertaken for maintenance purposes.

An inspection that is undertaken to confirm that a pipe has deteriorated to the point where it needs renewal, and that renewal then proceeds, can be regarded as part of the renewal project and funded from capital budgets.

Inspections undertaken to build understanding of the overall condition of the network and to track the deterioration of critical assets, but without triggering an immediate renewal of those pipes, falls between the above extremes. How this activity is funded will depend on the accounting rules adopted by the organisation. This is a discussion that needs to occur between the asset planning and financial arms of the asset owner.

Funding may also be a consideration where unblocking or removal of large quantities of debris/roots may be identified as part of planned inspections. Unblocking and de-silting would generally be associated with operational expenditure. Where significant quantities of this type of work may be encountered (e.g. inspection of stormwater culverts) this may influence how these services are procured (e.g. this type of support services may be better undertaken by the maintenance contractor).

A1.10 How Much Is Enough?

In an ideal world, with unlimited funding, the asset owner would be able to inspect all assets on a regular basis. This would provide a large database of information that can be used to track the deterioration of pipes with common attributes, identify pipes approaching the end of their effective working lives and allow the use of this information to plan for the renewal of assets with high levels of certainty. This would allow the future funding requirements of the organisation, and the associated customer charges, to be estimated with confidence. In this ideal world the information would be gathered nationally on a consistent basis and pooled into a national data-base that provided even more robust estimates of useful life and identification of exceptions.

Conversely the asset owner can choose to do very little, if any, asset inspections and there is no current explicit statutory obligation to do so. Long term planning can be based on information relating to similar assets in other networks and renewals can be undertaken as they are required. However, without condition assessment and informed renewal planning the necessary funding might not have been budgeted.

Whether an asset is inspected or not, will not significantly influence when and how it will fail, or the cost of its renewal at that time. This is particularly true for non-critical pipes where there is an acceptance that failures can occur, and it may be difficult to justify the inspection of non-critical pipes from a purely economic perspective.

The difference between these two approaches essentially relates to consideration of the following:

Table A1.4 – Discussion on the approach to selecting pipes based on the purpose of the inspection

Consideration	Comment
Risk Management	This particularly relates to Critical Assets. The criticality of an asset is largely constant over its life but its likelihood of failure increases as it ages and deteriorates. Without inspections it is difficult to track the deterioration of these assets and to undertake renewals, or remedial works, before failure occurs.
Avoidance of Surprises	While industry wide data can be used for long term planning this may not be relevant to all the circumstances that apply to particular networks. If there are no inspections there will be no indication of renewal requirements until failures actually occur. This may be in a time frame quite different to that assumed.
Planned Procurement and Expenditure	With good quality information and an understanding of how the network will fail, plans can be put in place to provide for a steady flow of maintenance and renewals to be undertaken supported by a steady flow of funding.
Cost Avoidance	For critical assets, in particular, there may be significant avoidable costs associated with the failure of the asset. This may relate to damage associated with the failure and the additional cost associated with undertaking urgent remedial works. Undertaking inspections, with the intent of avoiding such a failure, might be justified on pure economic grounds.
Confidence	A primary outcome of robust Asset Management is the confidence it provides that the asset owner understands their assets, and the works and funding required to maintain the desired level of service.

An active and comprehensive inspection programme will provide the asset owner with confidence that all these considerations are being adequately addressed. However, such confidence comes at a cost and this is a debate that needs to occur within each asset owning organisation, particularly where the assets have the capacity to dramatically impact on the environment, health, safety, resilience and economic prosperity of the serviced communities.

Figure A1.1, below, illustrates a structured approach for determining the earliest inspection and reinspection interval for pipe assets pending on their criticality and current condition. The table is intended to be indicative and identify the factors that should be considered and what a response to this might look like.

The time to first inspection, frequency of re-inspection and response to various levels of condition are all influenced by the level of acceptable risk for the asset owner. If the asset owner has a very low risk tolerance the table will look quite different, the inspections more frequent, the renewal triggered at better condition grades and the cost of inspection and asset ownership higher – all compared to an asset owner with a high tolerance of risk associated with the performance of the asset.

Figure A1.1 – Illustration of Possible Structure for Initial and Periodic Inspection of Critical Pipe Assets

Criticality Rating (Using IIMM heading with typical description)	Timing of first post – acceptance inspection (% of expected life) for 'Normal' operating conditions	Time Interval Until Next Inspection				
		Condition at Last Inspection (per proposed Standards descriptions Refer to Section E1)				
		1: Very Good	2: Good – Superficial deterioration only	3: Adequate – Defects evident	4: Poor – Significant defects evident	5: Very Poor – Failure is imminent
Catastrophic Failure cannot be tolerated	25% but not more than 20 years	≤ 20 years	≤ 10 years	≤ 5 years	Consideration given to renewal or frequent inspection	Highest priority renewal
Major Failure should be avoided if possible	50% but not more than 30 years	≤ 20 years	≤ 20 years	≤ 5 years	≤ 2 years	High priority renewal
Severe Some failures can be tolerated but re-occurrence avoided	75% but not more than 50 years	≤ 20 years	≤ 20 years	≤ 10 years	≤ 5 years	Near term renewal
Minor Some consequences greater than Insignificant but not Severe	Inspection of sample of assets at 75% but not more than 50 year	No scheduled inspection unless selected as part of overall condition survey	No scheduled inspection unless selected as part of overall condition survey	≤ 20 years	≤ 10 years	Renewal should be programmed and undertaken
Insignificant (not critical at all) Service failures are acceptable within defined Level of Service	No scheduled inspection unless selected as part of overall condition survey	No scheduled inspection unless selected as part of overall condition survey	No scheduled inspection unless selected as part of overall condition survey	No scheduled inspection unless selected as part of overall condition survey	Renewal should be programmed but still subject to confirmation of need at that time	Renewal should be programmed and undertaken

EXAMPLE ONLY

Notes on the use of this example table Figure A1.1

- Time intervals used in this table are for assets with expected lives of 50 years or more
- Table assumes assets with elevated criticality have passed an 'Acceptance Test/Inspection' at creation and no reason to expect accelerated deterioration
- If operating conditions likely to accelerate deterioration, then consideration should be given to reducing the above guidelines. Such conditions might include geothermal, corrosive or unstable soils, presence of H2S, induced currents, traffic or vibrational loadings, etc.
- If an asset is required to have a high level of resilience, and ability to survive an extra-ordinary event, then this may require a minimum condition rating that is higher than a 4 or 5 that might otherwise be acceptable. The above guidelines would need to be modified for such an asset, but it is anticipated that there would be relatively few of these assets. The above table is intended to reflect the likelihood of failure under 'normal' conditions. Consideration of survivability under extreme conditions introduces additional factors that would influence the inspection programme.
- If the first inspection of an asset with elevated criticality detects a condition a 3, or more, this would indicate accelerated deterioration is occurring and this should trigger an investigation and a specific response
- Definitions of Criticality are nominal and asset owner's Criticality Framework will be utilised

A2 Inspection Methods, Equipment and Capability

A2.1 Introduction

Visual inspection of the inside of a pipe is the principal method of assessing the condition of gravity pipelines. Most gravity pipes are too small for person-entry inspection, and therefore Closed Circuit Television (CCTV) cameras are the primary visual inspection technique used.

The information that can be obtained from a CCTV camera inspection may be limited by how the equipment is operated, the capability of the camera and the quality of the presented image, but it is principally limited by the method itself, i.e. what information can be acquired from a 'camera'. As a result of these limitations, additional supplementary inspection methods may be required in addition to CCTV to attain the information required to complete the assessment.

This section covers the range of CCTV inspection equipment, supplementary inspection methods and their capability.

A2.2 Information that Cannot be Obtained from a CCTV Inspection

CCTV is a visual inspection method. The information available for assessment is captured by a video or still image camera and is therefore limited by the following:

1. It can only record what is available to see. Any defects or features that are hidden beyond the surface of the pipe wall, below the level of water flowing through the pipe, behind fat deposits, roots or silt will not be revealed by the CCTV camera. Similarly, if the camera operator does not take care to provide an adequate view of the pipe wall, detailed observations may be missed.
2. Relies on enough lighting and recording resolution to capture the features within the pipe clearly
3. The video and photographs are two-dimensional images of a three-dimensional object.
4. Accurate measurements are generally not able to be made (Digital scanning cameras are able to take measurements, but measuring very small dimensions such as crack widths, which are typically ≤1mm wide, is still not possible).
5. Cannot quantify flow within the pipe or any visible infiltration. Infiltration or exfiltration can only be quantified by visual evidence available, e.g. dripping water, discoloration of the pipe wall from ground water or build-up of encrustation deposits.

CCTV camera inspections cannot:

- Determine the (remaining) thickness of the pipe wall material
- Determine the condition of the pipe wall, beyond the surface of the pipe, or the joint sealant
- Measure pipe ovality
- Identify whether there are cavities (tomos) behind the pipe wall
- Quantify the build-up of debris below the flow
- Confirm sources of groundwater infiltration or inflow where there is not clear visual evidence of it occurring.

The assessment of pipe condition, serviceability or pipe attributes is limited where only CCTV camera inspections are undertaken. Supplementary inspection methods are used where required and covered further in A2.4 of this section.

A2.3 Types of CCTV Camera Equipment

There are different types of CCTV camera equipment available. The type to be used depends on the pipe dimensions, length, features of the pipe such as bends and the purpose of the inspection.

The CCTV equipment is made up of two components:

i. **Camera System** – the type of camera: Pan and Tilt, Fix Axial, Digital Scanning, Zoom and 'Action'.

ii. **Transportation System** – The method of carrying the Camera System through the pipe: Push Rod, Tractor/Crawler, Float System or Static Pole.

The CCTV equipment suitable for the inspection is chosen as a combination of the camera and transportation systems. *Refer to table A2.1 Types of CCTV Inspection Equipment.*

A2.3.1 Camera Systems

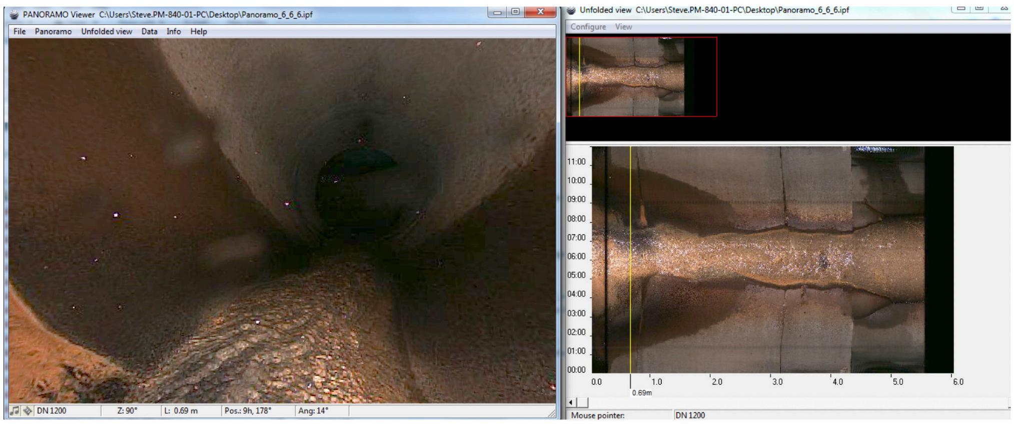
The following describes the different types of camera systems.

1. **Pan-Tilt-(Zoom) Camera.** These cameras have heads that can pan (generally 90o to horizontal axis of the pipe, but in many cases, this can be up to 115o) and tilt/rotate (up to 360o around the pipe circumference). This provides the ability to directly view the pipe wall and inside lateral connections. Many have either optical zoom (typically 10x but up to 36x) or optical and digital zoom (Optical zoom plus up to 12 – 16x digital zoom). This is the most common camera system for inspections of public Stormwater and Wastewater pipelines.

2. **Fixed Axial Camera.** The camera view is fixed along the horizontal axis of the pipe, (can only look forward). This camera system is mostly used in domestic/private laterals.

3. **Digital Scanning Camera.** High Resolution digital camera (or cameras, some have two or more) that take wide angle (>180o) digital photographs that when processed by software provide a continuous view of the pipeline. The digital scanned images can typically be presented in different views including the standard internal 'pipe' view, (as would be seen from a Pan-Tilt-Zoom or Fixed Axial cameras) or an 'unfolded' view, (the pipe circumference is laid flat, refer to Figure A2.1). The digital scanned images permits computer-aided measurement of the pipe and allows the person carrying out the assessment to self-navigate through the inspection and view all defects and features through a Virtual Pan-Tilt-Zoom function without the camera operator having to stop to capture the information.

Figure A2.1 – Digital Scanned images of a pipe, both showing a view of the same location within the pipe (IBAK Panoramo 3D Optoscanner)



Standard internal view *Unfolded view*

4. **Zoom (Pole) Camera.** These cameras capture video images of the pipe by utilising a 'zoom lens' to view the pipe from a stationary position within a manhole. This method is a version of what was previously referred to as 'lamping the line'. The technology does not provide the detailed visual information that traditional moving cameras provide but can identify some defects and identify potential issues that can be prioritised for further detailed investigation.

5. **Action Camera.** A compact camera capable of capturing photos and video. An example of an action camera is a 'Go-Pro' camera. When mounted on a pole with extra lighting can perform inspections of manholes or with enough lighted can be used to capture video as part of a person-entry inspection.

A2.3.2 Transportation System

The following describes the different systems used to carry/transport the camera systems described above.

1. **Push Rod**. Sometimes referred to as a 'push-cam'. This system consists of a semi-rigid cable that is used by the camera operators to push the camera through the pipeline and to withdraw it. The system is not powered by electrical motors. The semi-rigid cable and short camera connector/housing is flexible enough to navigate up to 90o bends in the pipe. This flexibility makes it ideal for domestic/private laterals which typically have a significant number of bends or restrictive drainage features such as gully traps. To accommodate a variety of pipe diameters a range of skids or brushes are selected used to centre the camera in the pipe.

2. **Tractor/Crawler.** A robotic system controlled from the CCTV operator's console is driven through the pipeline on either self-laying tracks or wheels. To accommodate the various pipe diameters, different sized wheels or components are used, or exchanged on the tractor/crawler unit. For pipes larger than 600mm the tractor/crawler systems typically use mechanical elevators to lift the camera up to the centre of the pipe, and up to a maximum of 900mm from the invert. The maximum length of the pipe that can be surveyed in a single pass is typically limited by the length of cable available.

3. **Floating Platform.** In larger diameter pipes where the depth of flow exceeds maximum acceptable levels for a tractor/crawler and cannot be controlled, (e.g. an interceptor sewer) a small boat can be used to transport the camera system. Typically, the boat is floated downstream or towed upstream.

4. **Pole Support.** An extendable pole or tripod that a zoom or action camera can be mounted to and lowered into a manhole *(refer to figure A2.2)*.

A combined Tractor/Crawler and Push Rod system has been developed by some camera manufacturers that enable inspection of both the public main and branch laterals as part of the same inspection. These are referred to as 'Lateral Launch' cameras. These systems operate using the tractor/crawler system for the public main inspection and then use a Push Rod system built into the unit to launch the camera head up the branch lateral.

Figure A2.2 – Zoom Camera attached to a pole is lowered into a Catchpit chamber to inspect the pipe (Envirosight Quickview airHD)

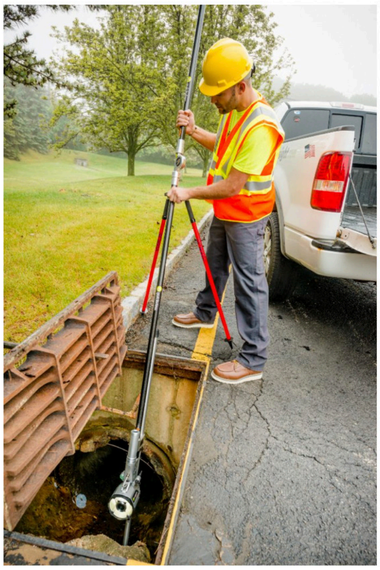


Figure A2.3 – Semi-rigid cable is used to push and pull the camera through the pipe

Figure A2.4 – Pipe Inspection float system, transporting in this example rear facing VPTZ camera, laser profiling and Sonar equipment below (MSI HD System, Photo Credit Red Zone Robotics)

Table A2.1 – Types of CCTV Inspection Equipment

Transportation Type	Camera System Options	Pipe Diameter Range
Push Rod	• Fixed Axial • Pan-Tilt-Zoom	Generally <300mm but can be used in larger pipes where restrictions such as bends prevent Tractor/crawler access. Flow depth ≤15% pipe diameter.
Tractor/crawler	• Pan-Tilt-Zoom • Digital Scanning	≤1800mm Flow depth ≤30% pipe diameter.
Combined (lateral launch)	• Pan-Tilt-Zoom	>200mm mainline, >90mm lateral Flow depth ≤30% pipe diameter (mainline), ≤5% pipe diameter (lateral)
Floating Platform (small boat)	• Pan-Tilt-Zoom • Digital Scanning	450mm to 3000mm Flow depth 25% to 75% pipe diameter.
Pole Support	• Zoom • Action	≥100mm Manhole Inspections

A2.4 Supplementary Inspection Methods

In circumstances where CCTV camera inspections cannot provide the required information, (refer to A2.2) supplementary inspection methods may need to be undertaken prior, to or in conjunction with, CCTV inspections.

Supplementary inspections fall into the following four groups:

1. **Measurement of pipe profile.** Includes quantifying wall loss, deformation/ovality, sediment volumes and grade/alignment.
2. **Leak Detection.** Includes locating sources of Inflow/Infiltration (I/I).
3. **Ground surrounding the pipe.** Includes location of cavities surrounding the pipe.
4. **Maintenance Prioritisation.** Using acoustic testing to rank pipe blockage to determine if maintenance or further investigation is required.

A2.4.1 Measuring pipe profile

Supplementary investigation equipment that can measure the pipe profile includes the following:

(i) **Laser Profiling**

A Laser Profiling system consists of a laser light projector and a laser spectrum sensitive CCTV camera. The laser projector creates a ring of laser light onto the pipe wall and is captured by the CCTV camera. The laser light is scattered or altered where the pipe wall surface varies, resulting in changes in shape, size, and intensity levels of the laser in the captured 2D video image. By analysing these changes with software, a 3D profile and accurate dimensions of the internal pipe wall surface can be generated.

The field procedure for laser profiling is similar to a regular CCTV inspection. The profiling is usually combined with the a CCTV inspection to also get visual records. The stored image is calibrated to remove the CCTV camera's distortion and fish-eye effects. Filters are applied to enhance the image by removing background noise and intensifying the laser ring edges. The image is digitalized by the accompanied software, which also carries out comparison with the original pipe dimension (reference).

Knowing the original pipe dimensions is necessary to enable comparison with the profiled section. If the original pipe diameter is not known, a portion of the surveyed pipe, with little apparent deterioration or corrosion, can be used as the reference. To calculate the remaining wall thickness, the original wall thickness also needs to be known.

Laser profiling can measure localised and general loss of wall thickness and also any ovality of the pipe.

(ii) Light Detection and Ranging (LIDAR)

Photons of light are bounced off an object and the time taken for the light to return to the LIDAR scanner is converted into a distance measurement. Measurements are taken at many different angles and are assembled into a full 3D model of the pipe surface. LIDAR is principally used for the same purposes as Laser profiling, but LIDAR does not require a CCTV camera as part of the process. In addition to pipe wall profiling, LIDAR is able to identify deviations in pipe alignment. LIDAR scanners are very sensitive to water splashes on the scanner lens which can significantly affect the data collection. As with Laser Profiling, LIDAR requires information on the original pipe dimensions and wall thickness to be able to determine quantum of wall loss. Accuracy of LIDAR measurements is ±20 – 30mm.

(iii) Pipe Proving

A rigid proving pig is pulled through the pipeline. The size of the prover is selected to match the minimum expected dimensions of the pipeline. Where the dimensions vary below the minimum expected, the prover will stop and not be able to travel further. This is a low cost, low tech traditional investigation method. For ovality testing the method and type of prover is specified in ASNZS 2566.2 Buried Flexible Pipelines: Installation, Appendix O2.

(iv) Sonar Profiling

Sonar is a pulse-echo ultrasonic method. It involves the emission of an acoustic pulse and the subsequent reception of the pulse echo reflected from the pipe surface below the water. The time delay from the time of transmission to the time of reception is used to determine the distance from the transducer to the pipe surface. The main use of sonar equipment in pipelines is to provide a profile of the pipe surface of submerged section of the pipes.

If there is hard debris in the invert of the pipe the sonar will detect this rather than the pipe wall and this can also be useful information.

Sonar is the only technology that can 'see' below the water surface but is typically less accurate with its measurements than laser.

(v) Gyroscopic Profiling

A mapping probe equipped with inertial sensors (gyroscopes, accelerometer, magnetometer, etc) that can position the X, Y and Z coordinate location of the pipe over its entire length at 100 samples per second. The probe is pulled through the pipeline on wheels at ±2m/second and provide an accuracy of 0.03% XY and 0.01% Z as a percentage of pipeline length surveyed. (e.g. a 100m long pipe the accuracy would be 3mm XY and 1mm Z). Prior to undertaking gyroscopic profiling, the pipeline must be clean with no debris or attached deposits in the pipe invert that may affect the pitch of the profiler

Figure A2.5 – Gyropscope based mapping tool developed for gravity pipelines (Reduct ABM-80)

(vi) Excavating and Extracting Pipe Coupons/Ultrasonics

This covers the excavation and visual inspection of the external pipe surface and testing of coupons cut or drilled from the pipe. This method enables the external pipe surface to be examined and exact measurement of the pipe wall thickness at that location. Coupons can be taken for tests such as crush tests, flexural tests, Phenolphthalein solution testing, or MRI scanning dependant on the material properties. The information from this method is only a representative sample and does not provide a continuous measurement of the full pipe length and therefore the selection of the locations for exhuming and collecting coupons must be carefully considered. Extracting pipe coupons can also be used after Laser Profiling/LIDAR to confirm competent wall thickness.

The need to measure the pipe profile may be determined from initial CCTV inspection results or where there are areas of known corrosion, deformation, dips. Table A2.2 identifies the suitability of the profiling equipment for the task based on the type of information that is required.

Removal of soft corroded concrete material using full/heavy cleaning is required prior to laser profiling or LIDAR to measure wall loss. This allows accurate measurement to the remaining structurally sound wall. Cleaning may also be required to remove any fat attached to the pipe wall or significant root intrusions for all laser or LIDAR based measurements.

Table A2.2 Pipe Profiling Equipment Suitability

Purpose	Laser Profiling	LIDAR	Pipe Proving	Sonar	Gryoscopic Profiling	Comments
Gyroscopic	✓	✓	✗	✓	✗	
Identifying changes in internal diameter	✓	✓	✓	✓	✗	Sonar is really only suited for this task when used in conjunction with laser/ LIDAR on floating platform or where the flow level in the pipe is ≥50%. Pipe Proving has limited application here as it will identify a reduction in the minimum expected diameter but will not identify if the diameter increases above the minimum expected diameter.
Measure pipe wall loss due to corrosion/erosion	✓	✓	✗	✓	✗	Laser Profiling or LIDAR can measure extent of erosion where the flow level can be reduced below average dry weather flow (ideally to ≤5%). Sonar can measure extent of erosion provided sediment deposits are removed prior to the survey.
Quantify deformation or ovality	✓	✓	✓	✓	✗	
Measure sediment volumes below flow	✗	✗	✗	✓	✗	
Pipe grade, alignment or dips	✗	✗	✗	✗	✓	

Table A2.3 outlines the profiling equipment methodology and suitable application ranges.

Table A2.3 – Application range of pipe profile measuring equipment

Method	Equipment/Type	Diameter Range	Flow Depth Range
Laser Profiling	Snap-on attachment to CCTV Tractor/Crawler	150mm to 2200mm	<30% pipe diameter
	Skid System (Similar to Push Rod)	150mm to 1050mm	<30% pipe diameter
Laser Profiling/LIDAR & Sonar	Floating Platform	400mm to 3000mm	25% to 75% pipe diameter
Pipe Proving	Rigid proving pig	<750mm	Pipe is out service during proving operation
Sonar	Fully Submersible system (Sub)	450mm to 2200mm	≥30% of pipe diameter
Gyroscopic Profiling	Pulled through by winch	90mm to 1500mm	0 – 100%

Some CCTV camera equipment has profile measurement tools built into the unit. This equipment includes:

- Laser calliper measurement (Laser dots) – the most commonly available measurement enabling tool for Pan-Tilt-Zoom cameras. Laser dots are projected on to the pipe surface which have a known fixed measurement that can then be used to calibrate and measure the width of joints or other smaller features (that can be viewed within the monitor). To use these laser measuring dots, the camera must be panned directly towards the pipe wall (90o to the pipe axis).
- Gyroscopes – enabling the tracking and plotting of the camera to map the position of pipelines.
- Laser profiling – this is limited to some digital scanning cameras

Figure A2.6 – Laser dots projected from the camera head panned towards to pipe wall either side of a joint

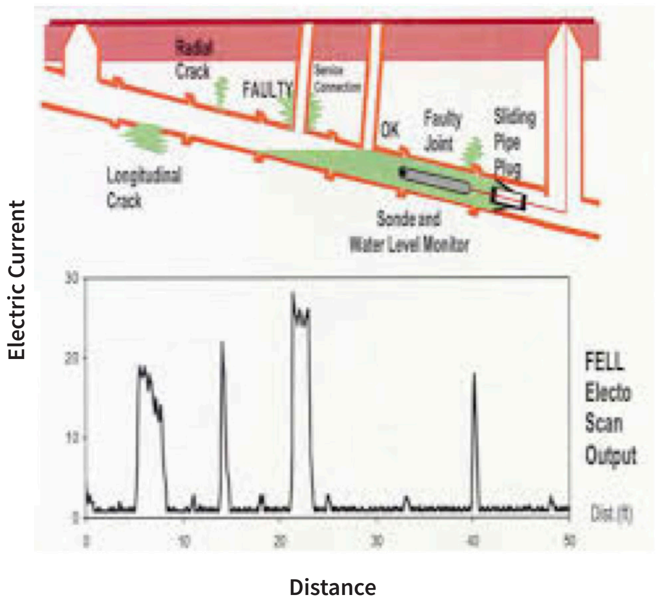
A2.4.2 Locating Sources of Inflow/Infiltration (I/I)

There are a number of methods used for detecting or quantifying I/I. These methods and how they can be used as part of I/I source detection are discussed in Section E4 Ground Water Infiltration Source Detection. The following supplementary investigation methods can be used with CCTV to locate the sources of I/I within the pipe. These methods are classified as Type 2 investigation methods in Section E4:

(i) Focused Electrode Leak Location (FELL)

FELL identifies defects that allow ground water infiltration into the pipe by measuring the size of an electric current that is able to flow from an electrode probe inside the pipe to a probe at the ground surface. The test is carried out by pushing a probe through a non-conducting (non -metallic) pipe and applying an electric potential of 9 to 11 volts rms with a frequency of 500Hz to 30 kHz between the internal probe and the surface electrode. The resistance of the pipe wall only allows a very small electrical current to flow to the surface electrode, but where there is a defect in the pipe wall that extends through to the outside of the pipe, allowing the current pass through, the strength of the electrical current is much higher. The greater the electric current flow, the larger the size of the leak. The data can be processed to grade the variations of electrode current values into those that represent small, medium or large potential pipe leaks, but do not measure the actual flow of ground water infiltration occurring through the pipe defect. The probe is pushed through the pipe in a similar fashion as a Push Rod Camera. The probe must be fully submerged in water throughout the inspections (either by flooding the whole pipe or just around the probe as it moves through the pipe). The type of soil surrounding the pipe does not affect the data. Some FELL equipment has built in fixed axial CCTV cameras.

Figure A2.7 FELL Electro Scan Output, locating leaks



(ii) Distributed Temperature Sensing (DTS)

DTS equipment measures the temperature inside the pipe, more particularly in the flow within pipes, by using optical fibre cables strung through the pipe. The 'optoelectronic' devices, (combination of the fibreoptic cable and a computer) provide a temperature profile along the length of the pipe that shows the location(s) of I/I or illicit cross-connections (into Stormwater). Inflow or ground water, (which is cooler than the wastewater flow) when it enters the wastewater stream causes a localised drop in temperature. Conversely wastewater entering a stormwater pipe, through an illicit connection, will raise the local temperature at that point. Following detection by the DTS equipment the sites can then be inspected using CCTV cameras to identify either the pipe defect or lateral connection. For DTS to work, there must be active infiltration or inflows occurring while the fibreoptic cable is in place. The DTS equipment can detect temperature changes of ±0.1 degree Celsius, but very low levels of infiltration, such as seeping or dripping, may not be detected with dry weather flow depths >10%.

(iii) Joint (isolation) Packer Test

Packer testing is a technique in which a joint is isolated from the rest of the pipe using inflatable packers and air test is undertaken. The packer ends are expanded so as to isolate the joint from the remainder of the pipe and create a void area between the packer and the pipe joint. The void around the joint is pressurised to 340 mbar (5 psi) held for 15 seconds. Failure to achieve the test pressure or a drop of ≥70 mbar (1 psi) over the test period indicates a failed test result. The size of the drop in pressure indicates the 'leakiness' of the joint. The testing could also be undertaken on defects such as circumferential cracks. CCTV cameras are used to position the packer(s) to isolate the joint. Some equipment has Pan and Tilt cameras built in.

Figure A2.8 combined testing and mechanical repair packer (with a repair sleeve shown) and CCTV camera (IDTEC QLP160, photo credit IDTEC USA)

Table A2.4 – Suitability of the I/I location equipment based on the type or source of I/I.

Capability	FELL	DTS	Packer Test	Comments
Locate sources of infiltration	✓	✓	✓	DTS requires active infiltration to be occurring sufficiently to reduce the localised temperature of the wastewater i.e. if the water table is lower than the pipe or very low flows, infiltration may not be detected.
Locate sources of inflow/illicit connections	✗	✓	✗	FELL and Packer tests cannot determine the source of a lateral connecting onto the pipe being inspected.
Identify pipe defects that extend through the pipe wall	✓	✓	✗	Can be used if the axial length/width of the pipe wall defect is less than the gap between the isolating bladders of the packer.
Quantify the volume of I/I	✗	✗	✗	Although the size of the electric current flow (FELL) or the amount of pressure loss (Packer test) can indicate the level of 'leakiness' or potential rate of infiltration they are not able to directly quantify the actual volume of infiltration occurring. Likewise, the temperature measurement (DTS) will be affected by the volume of inflow or infiltration, but a volume cannot be assessed.

A2.4.3 Locating Cavities Surrounding the Pipe

The location of sub-surface voids or rocks behind the pipe wall may be detected using Ground Penetrating Radar (GPR). There are two approaches for this type of investigation:

i. From the surface

Using similar equipment and methodology as used to locate underground services. Some soil types and ground water saturation can limit what can be determined. Dependant on the capability of the GPR equipment used, the maximum depth of the signal penetration is limited to around 2 to 3m.

ii. From inside the pipe

Pipe Penetrating Radar can be used in non-metallic pipes. The radar penetration through the pipe wall is best suited for brick, plastic, Earthenware or unreinforced concrete pipes. Pipe Penetrating Radar (PPR) can be used in reinforced concrete pipes but dependant on the spacing of reinforcing steel and whether the signal can sufficiently pass through it. As with the surface inspection methodology, the water saturation of the soil can attenuate the signal making identification of voids difficult if not possible. PPR surveys can be conducted with man-entry operations where it is safe to do so, using hand held units against the pipe wall, or by a remotely operated vehicle. In addition to void detection PPR may be used to see remaining wall thickness, rebar cover, or delamination in asbestos cement pipe. PPR, although not a new technology, is still emerging and developing capability. The size of pipe able to be inspected is dependant on how close the radar units can be placed to the pipe wall.

A2.4.4 Acoustic Testing for Service Issues to Prioritise Cleaning or Inspections

Two low cost methods for quickly assessing and prioritising pipelines that have blockages or service issues use acoustic (sound) sensing or detection technologies. These investigations enable utilities to implement targeted spending on cleaning of pipes or determine the need for further investigation. Acoustic tools detect obstructions to the airspace within a pipe by the amount of sound dissipation caused by roots, fat, dips, displacements etc. The two methods use a different method of acoustic analysis, but both are targeted at determining the same outcome.

Both methods provide limited information but provide a quick and low cost approach for determining if a line is clear or partially blocked. This information can then be used to determine the need for further investigation.

i. SewerBatt

SewerBatt is a portable acoustic sewer inspection tool that consists of an acoustic sensor head that is mounted on a pole (similar to a pole camera) which is lowered into the manhole and inserted into the pipe to be tested. The sensor head contains a sound source (speaker) that transmits an acoustic excitation signal into the pipe. Simultaneously, the acoustic signal response from the pipe is captured by an array of microphones that are also contained in the sensor head. The captured signal responses are used to assess the pipe service condition. An automated condition assessment module that reviews the acoustic signal response, makes allowance for the energy loss from the pipe-ends and lateral connections, and then grades the pipe. The final pipe service condition is simply in the form of a coloured traffic light indicator providing a red, amber (yellow), or green (RAG) grade. A red grade assessment indicates the need for further inspection or cleaning. An amber grade assessment is cautionary, indicating that there may be some blockage issues, but not enough to block the flow. A green assessment indicates the pipe is free of any significant blockages and no further evaluations are necessary.

Figure A2.9 – SewerBatt inserted into the pipe for rapid inspection (photo credit Lanes Group plc)

ii. SL-RAT

SL-RAT measures the dissipation of sound energy between a transmission speaker and a separate receiver, device. The transmission and receiver devices are set up in the upstream and downstream manholes at either end of the pipe to be tested. Any single service defect that completely obstructs the pipe will not allow the transmission of sound energy between the two devices. Additionally, defects such as roots, fat etc., increase the sound dissipation. The overall blockage assessment by SL-RAT is provided in the form of a numeric output value on a scale of 0 (completely obstructed) to 10 (completely unobstructed).

Figure A2.10 – SL-RAT device is positioned at each end of a pipe section to be tested (photo credit www.kci.com)

Table A2.5 – Comparative SL_RAT and Indicative of service condition

SL-RAT Assessment Range	Score Interpretation
10	No Significant obstructions within the pipe
7 – 9	Minor impediments
4 – 6	Impediments within the pipe
1 – 3	Significant impediments
0	Major impediments reaching near full flow or blocked

Both acoustic methodologies can identify defects that obstruct the flow through the pipeline but are not suited for identifying most structural defects.

A2.5 Inspection Equipment Classification

Table A2.6 classifies the different inspection equipment, CCTV cameras and supplementary inspection methods, by:

A. The quantum of information able to be collected expressed as 'Dimension':

- 1-Dimension - single outcome, e.g. x, y, z location of the pipe only
- 2-Dimensions – more than single outcome, e.g. visual assessment of structural and service condition.
- 3-Dimensions – Multiple outcomes, e.g. visual assessment, pipe dimensions, remaining wall thickness.

B. The quality of information able to be provided by the equipment, expressed as Inspection Resolution, a 6 point scale (i – vi):

- Lowest possible resolution, (i) provides indicative information without defining location.
- Highest possible resolution, (vi) provides through understanding of pipe condition and attributes.

The intent of the equipment classification is to provide an overview of all the inspection equipment covered in this section and compare them in terms of the information they individually provide towards a complete condition assessment. A combination of CCTV and supplementary inspections provides the greatest amount and quality of information. The required level of inspection will depend on the reason for undertaking the inspection and the intended outcome. These are discussed in many of the sections of this manual, in particular within Part E Interpretation of Inspection Results.

Table A2.6 – Inspection Equipment Classification

DIMENSION (QUANTUM OF INFORMATION)	INSPECTION RESOLUTION (QUALITY OF INFORMATION) i	ii	iii	iv	v	vi
3				• Laser Profiling	• Person Entry • Combination of Camera & Supplementary	• Multi-Sensor • Person Entry (with sample extraction)
2			• Fixed Axial Camera • Sample Extraction	• Pan-Tilt-Zoom Camera • Lateral Launch Camera • Sonar Profiling • FELL	an-Tilt-Zoom Camera (with laser measurement) • LIDAR	• Digital Scanning Camera
1	• Acoustic Testing	• GPR/PPR • Zoom Camera	• Packer Test • Pipe Proving	• DTS • Gyroscopic Profiling		

A3 CCTV Video Quality

A3.1 Introduction

The quality of the CCTV video provided by the contractor is dependent on a several factors which include the quality of the camera equipment used, and the decisions made by the asset owner, such as, how big the video files can be and what type of monitors they will be viewed on. In short there is no single correct definition of the right level of quality, but rather it is about the considerations that need to be made so that the videos generated are 'fit of purpose' and this can vary considerably. This section aims to provide guidance on what needs to be considered to achieve the required 'video quality'.

Reference should also be made to Appendix F which provides more detailed information and notes on specific factors relating to video quality.

A3.2 Key Considerations

The top three items that need to be considered by the asset owner when determining the required video output quality are:

1. **Intended Video Quality** – What is the intended video resolution? The maximum achievable resolution may be limited by the camera equipment suitable for the inspection or that is available in the market, how they will be viewed and overall cost.
2. **Video File Size** – How big the video files will be, or limited to, which may depend on how the files are going to be stored and/or transmitted.
3. **Video decoder compatibility** – What is the file going to be played back with?

All the above items interact, and the final quality of the video output will be dependent on achieving the right balance of all these items. This will differ from one organisation to another.

A3.3 Intended Video Quality

Ultimately the video generated must be 'fit for purpose'. The quality of the image needs to be clear and sharp enough to provide the level of information appropriate for the purpose of the inspection. However, consideration must then be given to the availability of CCTV camera equipment, how the video will actually be viewed by both the operator and the asset owner and the cost. Getting an appropriate balance of these considerations, which sometimes conflict with each other, is complex. These considerations are summarised in Table A3.1.

Table A3.1 Summary of Considerations Relating to Required Video Quality

Issues to Consider	Discussion
Purpose of the Inspection	A video generated for maintenance purposes might be primarily focussed on identifying the cause or location of a blockage and the video resolution required to do this does not need to be high. For this purpose, an approach that is fundamentally low-cost, quick and easy might be quite appropriate. If the purpose is to assess the effects of defects on structural condition and life expectancy, then a higher quality video that facilitates the accurate identification of all defects is important.
Availability of CCTV Camera Equipment	CCTV camera equipment has improved substantially over time. While High-Definition (or greater) digital CCTV cameras are available, most cameras in use in New Zealand, are Standard-Definition analogue cameras. Local availability of different resolution cameras will vary through out the country and where high definition outcomes are required, this may need to be specifically sourced from outside the district.

Issues to Consider	Discussion
Video Monitors	The resolution of the screen/monitor used to view the video will have an impact on the perceptible quality of the image. Typically, an LCD computer monitor will have a display resolution between 1388x768 and 1920x1080 pixels. If this exceeds the resolution of the video, then the screen will scale the display down to match and this may generate a 'grainy' full-screen image. If the monitor resolution is less than the video, it may not be able to fully utilise the higher quality of the file and this may negate much of the intended improvement. In some cases, a smaller screen may improve the perceived image sharpness.
Cost	The total cost of collecting and storing video is related to the video definition. High resolution cameras cost more than low resolution cameras and higher resolution video needs to be supported by much larger file sizes which must to be stored on servers or transmitted via the internet.

A3.4 Video File Size

The 'raw' video generated by the CCTV camera is too large for storage or sharing. To address this issue the video files are compressed for storage/transmission and then de-compressed for viewing. The software on the recording side and video player side that does this is called a CODEC (Coder – decoder) and conforms to a range of available compression standards (refer to appendix F). However, the process to compress the video file to a smaller file size results in some loss of video quality when it is decompressed for playback. The greater the compression, generally the greater the loss of perceptible quality.

The loss of quality affects both low and high resolution cameras. Higher resolution cameras will provide higher perceptible sharpness than lower resolution cameras, however, this needs to be supported by much larger file sizes. Starting with a high quality video and then applying a lot of compression to fit with file size requirements may not generate the desired outcome of using a high definition camera. What size of file is required for storage or transmission (i.e. is it over the internet?) is an important consideration and should be clearly specified if there is an upper limit.

The amount of compression is influenced by the data processing rate, called the bitrate, (refer to appendix F) expressed as Megabits per Second (Mbps). Low bitrates will generate smaller files, but as discussed above, can lead to lower picture quality when viewed. The choice of compression standard that the codec uses can influence the affect that lower bitrates have on the perceived video quality. Where smaller file sizes are necessary, then the use of alternative compression standards can enable the use of much lower bitrates without large reductions in video quality. Alternatively, a higher quality of video can be achieved using the same bitrate if another appropriate standard is used.

There are other factors that can influence the final video quality, (such as lens quality, and the sensitivity of the camera to colour and light). It is therefore necessary to experiment with bitrates and compression standards to achieve the intended video quality.

A3.5 Video Decoder Compatibility and File Types

The choice of CODEC used for the video compression must consider the compatibility of the encoded file to the decoder of the video playback software.

CODEC software that supports the common compression standards (examples in appendix F) will generally be able to be viewed using common video playback software such as Windows Media Player or VLC.

The following video file formats are suitable for the supply of CCTV video and compatible with common playback software:

- MPEG video (including .mpg, .mp4)
- AVI (.avi)

For playback over the internet with web video players, MP4 (MPEG video) is generally the best suited format.

A3.6 Overview

All of the factors discussed above will influence the quality of the final video playback and its usability to determine the nature and significance of defects, and decisions subsequently made about the pipe.

It may not be realistic to expect a high definition image for every inspection undertaken. The availability of equipment, and the cost, may not justify higher definition inspections each time an inspection is undertaken. For purely maintenance purposes a 'quick, cheap and easy' combination may be all that is required and a lower definition video maybe entirely acceptable. For detailed condition assessment an 'end to end' specification that requires higher quality components and systems that contribute to high quality outcomes throughout may be appropriate, but this will have implications in relation to how many contractors can provide that quality, the size of the files and ultimately the quality of the monitor that the video is viewed on by both the contractor or the asset owner.

It is difficult to assemble all the various options into specific combinations that are suited to particular purposes. A 'one size fits all' approach to acceptable video quality is not recommended. Ultimately it comes down to the quality of the viewed video and the file size required to provide that quality suitable for the intended purpose.

The asset owner needs to identify the outcomes the need to be achieved (i.e. intended use, outcomes, file size limits, storage and transmission, etc) and specify the appropriate CCTV Video Quality requirements to be provided by the contractor.

Requiring the inspection contractor to provide examples of the outputs generated by their proposed equipment and methodology, before the commencement of inspections, allows this to be reviewed and, if acceptable, used as a benchmark for the acceptability of subsequent inspection outcomes. This approach allows all the interactions described above to be collectively demonstrated and reduces the potential for disappointment and disputes to arise as the inspections get underway.

In most cases, poor CCTV Video Quality can be predicted from the capability of the various elements that impact on quality as described above. It cannot be assumed that 'fit for purpose' outcomes will be achieved by a poorly defined specification.

A4 Quality Control and Management

A4.1 Introduction

The quality and accuracy of inspections results and subsequent confidence in the data is reliant on the skill and experience of the personnel carrying out the inspection and the equipment used. Quality control procedures to monitor and ensure that the expected results are achieved are therefore a fundamental requirement of any planned inspection programme. Table A4.1 outlines the typical consequences of errors and inaccuracies reflective of poor quality.

Table A4.1 – Consequences of poor-quality CCTV Inspections

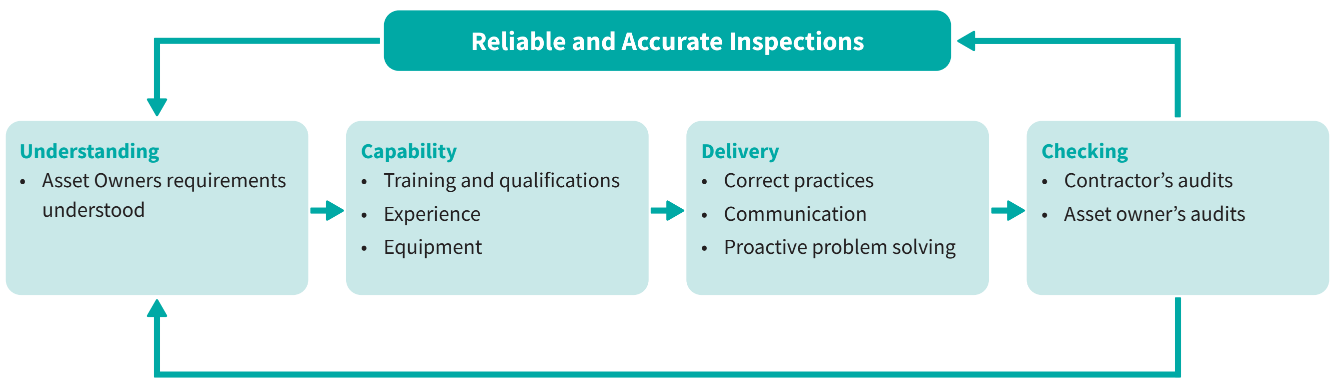
Item	Example Problems	Impact
Inspection Header	Asset or inspection information is missing or not correctly recorded.	Incorrect asset validation data recorded in the asset management database and/or GIS.
Camera Operation	Camera speed too fast, or does not stop and investigate defects, poor picture quality, pipe not cleaned to specification.	Defects in the pipe may be overlooked or incorrectly identified or quantified. May require additional inspections (re-inspection) to get more information or a better look.
Defect and Feature Classification	Incorrectly coded or missed.	Preliminary condition grade does not reflect condition and incorrect analysis of required renewals, repairs or maintenance.
Completeness of Inspection	The full length of the pipe is not inspected.	Defects maybe overlooked and full extent of pipe condition not understood.

Quality control procedures shall be established by both the CCTV Contractor and the Asset Owner to ensure that the intended quality and reliability of data and analysis is obtained. This section outlines the considerations and procedures necessary for effective quality control and management of planned inspections.

A4.2 Key Elements of Quality Management Process for Pipe Inspections

A quality control framework for pipe inspections involves several procedures that work together to deliver a quality outcome.

Figure A4.1 – Key Elements of a Quality Management Process



The following outlines the responsibility of both the Asset Owner and the Contractor in delivering quality outcomes:

The asset owner needs to ensure that:

1. The Asset Owners' requirements are clearly communicated to the Contractor, e.g. in the form of the contract specifications. These requirements will generally align with this manual, but particular requirements may include, but not limited to:
    - Specific purpose of the inspection and expectations of what information is intended to be discovered and reported.
    - Level of cleaning prior to inspection.
    - What shall happen if the inspection cannot be completed.
    - What 'optional' or additional information is required to be collected or supplied.
    - How data and video are to be conveyed to the Asset Owner and any specific limits to video sizes or types where this is applicable.
2. The Asset Owner is available to help solve any problems, e.g. difficulty in getting a property owner's permission to access a manhole, issues with flow control in high flow pipes, removal of obstructions and other issues that may unfairly impede the contractors progress.
3. The Asset Owner has adequate knowledge about CCTV inspection procedures, including what can and cannot be achieved and have appropriately qualified and experienced personnel involved.
4. They have appropriate measures in place to ensure that the inspections and outputs are meeting their requirements and advise the contractor of any areas needing improvement.

The Contractor needs to ensure that:

1. The Contractor understands the Asset Owners requirements and seeks clarification where this is not fully understood prior to undertaking the work.
2. The Contractor's personnel have the appropriate qualifications and experience to complete the work.
3. The Contractor has equipment that is suitable for the inspections specified.
4. The Contractor carries out the investigations in the correct manner.
5. The Contractor communicates to the Asset Owner any problems or issues as they arise, and proactively solves problems.
6. The Contractor has effective quality assurance processes in place and undertakes audits of their own work as it is being carried out.

A4.2.1 What Checks Shall the Asset Owner Undertake?

It is recommended that the Asset Owner undertakes the following checks before and during the inspections:

- Prior to award
    - **i.** The CCTV Contractor's experience, equipment and capability to carry out the work.
    - **ii.** The qualifications and competence of the proposed operators (refer to A4.3).
    - **iii.** Review a sample of the contractor's deliverables demonstrating experience of similar inspections, including a benchmark sample video (refer CCTV Video Quality, A3.6).
- Auditing of initial works – the initial works completed by the Contractor shall be checked to ensure that they are to the required standard (refer to A4.4.2).
- Ongoing auditing during the inspection programme – samples of the work shall be checked as the works are carried out to ensure that standards are maintained (refer to A4.4.3).

If audits have not been undertaken during the course of the inspections, then an audit shall be undertaken before contract sign-off and final payment. However, this is a very poor substitute for earlier audits which would highlight any issues in time for them to be corrected and avoid end of contract disputes.

A4.3 Qualifications and Competency

There are three NZQA unit standards established for CCTV inspections. The following recommendations identify how they can be utilised, together with other qualifications and competency assessments, to establish a robust "quality chain".

30094 Demonstrate knowledge of CCTV inspection of non-pressure water services assets

People credited with this unit standard can: describe the role of closed-circuit television (CCTV) in non-pressure water services asset management; describe the preparation of assets for survey by CCTV; and describe procedures for the survey of assets using CCTV and recording and/or coding pipe conditions.

30095 Carry out CCTV inspection of non-pressure water services assets

People credited with this unit standard can prepare to carry out closed circuit television (CCTV) inspection of non-pressure water services assets; select and set up CCTV and equipment for inspection of non-pressure water services assets; and carry out a CCTV inspection of non-pressure water services assets.

30096 Report on pipe condition for a CCTV inspection of non-pressure water services assets

People credited with this unit standard can complete closed circuit television (CCTV) inspection header information; and report pipe defects and features from a CCTV inspection of non-pressure water services assets.

Which unit standard is applicable to personnel is dependent on their role.

A4.3.1 Operators

Persons responsible for preparing and operating the CCTV Camera, and identifying and recording defects and features shall:

- Have attained NZQA Unit Standards 30094, 30095 and 30096.
- The Asset Owner may also require that the Operator can demonstrate current competency. Such competency would require that operators provide evidence that they can operate the CCTV equipment and carry out inspection reporting to the correct standard. Evidence of current competency is generally required to be provided every two years after accreditation of unit standards 30095 and 30096. Suitable evidence of competency may include a current Competency Certificate issued by the Asset Owners approved CCTV training providers or satisfactory quality audits (refer A4.4.4) undertaken within the two years prior.
- Operators undertaking workplace-based training who have not achieved the required unit standards or who have not maintained current competency shall be directly supervised by appropriately qualified and accredited personnel.
- In addition to the CCTV qualifications, Asset Owners may also require Operators to have attained qualifications relating to working in confined space, that may include some or all of NZQA Unit Standards 17599, 03058, 18426, 19207, 25510 and/or other specific recognised work place health and safety certifications.

A4.3.2 Coding Technician or Reviewer

Persons responsible for identifying, reporting or reviewing defects and features shall:

- Attained Unit Standards 30094 and 30096.
- The Asset Owner may also require the coding technician or reviewer to demonstrate current competency as per the role of Operator (excluding equipment operation, 30095).

A4.3.3 Asset Engineers and Contract Managers

Asset engineers and contract managers responsible for using the data from CCTV inspections or supervising or managing CCTV inspection contracts conducted in line with this manual are recommended to attain Unit Standard 30094.

Table A4.2 – Summary of Recommended NZQA CCTV Qualifications

Unit Standard	CCTV Operator Technician	Coding Technician / Auditor / Reviewer	Asset Engineer / Contract Manager
30094	Required	Required	Required
30095	Required	Not Required	Not Required
30096	Required	Not Required	Not Required

A4.4 Auditing Reporting Accuracy and Field Work

A4.4.1 Contractor's Quality Auditing Process

The Contractor shall implement and maintain a quality assurance system to ensure that the work undertaken complies with the Gravity Pipe Inspection Manual and the requirements of the Asset Owner's Particular Specification.

As part of the quality assurance system, the Contractor shall undertake their own audit on the quality of the CCTV footage and inspection data reporting prior to submitting this to the Asset Owner. The Contractor's audit methodology shall be submitted to the asset owner for approval prior to the commencement of inspections. The Audit methodology shall be based on audit procedures outlined in A4.4.4.

The Asset Owner may require the contractor to provide evidence of the audits being undertaken and the results generated.

A4.4.2 Asset Owner's Initial Audit Procedures

Within two working days of starting inspections the Contractor shall submit, to the Asset Owner, the first available video records, inspection reports and export data for review and auditing. This shall include a minimum of at least one complete inspection supplied in the format specified.

The Asset Owner shall check this work as soon as possible and advise the contractor of any deficiencies that need to be corrected. Items that shall be checked include:

- Level of cleaning meets the required standard.
- Video quality/resolution versus the benchmark sample supplied prior to award.
- CCTV Camera Operation.
- Accuracy of header and observation reporting.
- That the electronic data is able to be transferred into the Asset Owners system.

The Contractor shall immediately rectify any deficiencies or problems identified and if necessary re-inspect the pipelines.

A4.4.3 Asset Owner's Ongoing Auditing Procedures

As the CCTV inspections are carried out, it is recommended that the Asset Owner shall:

- Carry out regular audits as described in Clause A4.4.4. This shall consist of at least 5% of the CCTV inspections completed, with the audits completed progressively as the work is submitted by the CCTV contractor.
- Where the asset attribute data recorded on the inspection header, e.g. pipe diameter or pipe material, is different to that currently recorded in the Asset Owner's asset database system the records shall be checked to ensure that they are accurate before the asset management database is updated.
- Check that all of the required pipelines have been fully inspected. Where inspections have been abandoned, determine what additional works need to be completed to enable the inspection to be completed.
- Complete random field checks to confirm measurements such as pipe lengths, diameters and manhole depths are accurately recorded.

A4.4.4 Auditing Methodology

The audit consists of two parts

A. Assessing the accuracy of the reporting of Header and observation fields.

B. Checking conformance to correct camera operation practice and video quality.

For practicality reasons, Part A and Part B are usually undertaken at the same time.

An audit shall be undertaken on the inspections completed each week or for each ‘batch’ of inspection deliverables. The inspections are sorted and grouped by the name of the coder (CCTV Operator or Coding Technician). Individual inspections are then randomly selected for an initial sample size of 5% of the inspected length completed for each coder.

Part A: Audit on Reporting Accuracy

The process shall measure the accuracy of reporting of both header and observation information separately and count:

- The total number of entries that shall have been made
- The number of required entries not recorded (omissions)
- The number of errors occurring in the entries recorded

The audit could fail due to inaccuracies in either the header or data sections.

The Auditor classifies errors as either Grade 1 or Grade 2. The type of error and grade is provided in Table A4.3. Grade 1 errors are considered to have a more significant impact on the reporting than Grade 2.

During the audit, each error or omission shall be noted on the inspection report to identify the type and nature of the error that has occurred. This will enable the Contractor to make corrections to the inspection data and avoid similar errors or omissions in future inspections.

The equation used to calculate accuracy level (expressed as a %) is:

$$\text{Accuracy Level} = 100 \times \frac{RE - (G1 + (0.5 \times G2))}{RE} \%$$

Where

- RE is the required number of header or condition record field entries
- G1 is the total number of Grade 1 errors
- G2 is the total number of grade 2 errors

The level of accuracy that that the batch shall achieve is 95%. The calculated accuracy level is rounded to the nearest one decimal place.

Table A4.3 – Grading of errors noted during auditing of Accuracy Level

Reporting Requirement	Error Grade	Error
Inspection Header	1	Missing or incorrect Mandatory header information[1]
	2	Missing or incorrect Optional header information[2]
Inspection Observations	1	Missing defects (Score > 20)[3]
		Incorrect Classification (main code, Characterisation code or quantification code changing Score from ≤20 to >20 or >20 to ≤20)[4]
		Incorrect distance recorded to defect or features[5]
		Missing Continuity Code
	2	Missing defects (Score ≤20)
		Incorrect Classification (main code, Characterisation code or quantification code)[6]
		Clock reference missing or recorded incorrectly[7]
		Still images missing or not clear[8]
		Missing / incorrect required remarks[9]
		Missing features
		Missing or Incorrect 'Measured From' Code[10]

Notes:

1. Excludes missing mandatory fields where information cannot be captured, and comments have been provided.
2. Optional Header Information as specified in the Particular Specification
3. Missing defects which have a score >60 are considered gross omissions.
4. Incorrect Main Code or Characterisation Code, or Quantification Code (or all 3 are incorrect) that would change the score to from ≥20 to <20 or visa-versa.
5. Error is recorded where the incorrect distances are >±2D, where D = pipe diameter.
6. Incorrect Main Code or Characterisation Code, or Quantification Code (or all 3 are incorrect) but the error does not result in a change of score that would lift the score to >20 or drop it to ≤20.
7. Errors are counted as a single group of two clock references, regardless whether only one or both clock references are incorrect. Errors are only recorded where the error is greater than '15 minutes' or where the 'Position From' or 'Position To' is required but has been missed. Where two clock positions have been recorded, where only one is required, this shall be noted as incorrect on the inspection report but not recorded as an error in the audit.
8. Still images as required under B1.2.3.4 or as specified in the Particular Specification
9. Requirements for remarks are specified for each code in B2.3 Condition Classification Codes
10. Where applicable as some inspection reports do not include the Measured From field.

The Auditor shall take into consideration that some elements of defect classification can be subjective. Where it is possible for the characterisation or quantification to be interpreted differently, then this shall be noted on the inspection report but not recorded as an error in the report. The following omissions would not generally be classified as errors:

- Joint Displaced (JDV/JDH) with "Small" quantification in concrete or earthenware pipelines
- Joint Open (JO/JOA) with "Small" quantification in concrete or earthenware pipelines

Accuracy levels are calculated for each inspection header and observation in the sample to monitor the accuracy of each section.

The Pass/Conditional Pass/Fail result for the audit is assessed by the calculation of the average specified accuracy over all the 5% sample results.

- If the average accuracy result is greater than or equal to 95% accuracy level, and all results within the audit are greater than or equal to 95% the sample Passes the accuracy audit.
- If the average accuracy result is greater than or equal to 95% accuracy level, but some of the results within the audit (either inspection header or observations) are less than 95% the sample Conditionally Passes the accuracy audit.
- If the average accuracy result is less than 95% accuracy level, the sample Fails the accuracy audit.

Where gross omissions are identified the accuracy audit shall automatically default to a Fail accuracy result.

Gross omissions can be defined as follows:

- Header Information – Missing Asset ID or Video volume Reference (Video file name)
- Observation Information – Missing defects with a weighted score >60 (e.g. PX, DX, PBL, DFVL, etc.)

The asset owner can set a different specified accuracy level for the header or observations (and these can be different) and the resulting average requirement. This shall be provided in the Particular Specification.

Different responses or actions are required based on the audit accuracy result and whether it is header or observation data inaccuracies.

Table A4.5 Actions resulting from accuracy audit results

Overall Accuracy Result	Section	Response
Pass – ≥ 95% Accuracy Level for all audits **(Pass)**	Header	• All errors identified in the inspection header regardless of the audit result will need to be corrected.
Conditional Pass – ≥ 95% average Accuracy Level achieved but some audits falling below this	Header	• All errors identified in the inspection header regardless of the audit result will need to be corrected. • If the header accuracy level for any coder is less than the specified header accuracy level, then all the inspection headers for that coder shall be checked by the contractor and corrected.
	Observations	• Any inspection that has an individual result less than the specified observation accuracy level will require corrections to the observation data. • Where there is more than one coder then for any coder where the observation accuracy is less than the specified observation accuracy level, then all the inspection observations for that coder within the batch shall be checked by the contractor and the errors corrected.
Fail – < 95% average Accuracy Level	Header and Observations	• A further 5% sample is selected and audited. If the average of accuracy result for 10% of total length of the batch (original 5% plus additional 5%) still falls below the specified accuracy level, then the entire batch will need to be checked by the contractor, corrected and re-submitted for further auditing until a Pass result can be achieved. • Where the audit fails due to a gross omission, then the additional 5% sample is not added. The entire batch is checked and corrected by the contractor then re-submitted for re-audit.

In addition to the above Pass/Conditional Pass/Fail criteria for auditing the on-going accuracy (the operator confidence level) of each operator, or coding technician, shall be calculated from the average of all batch results to date for each coder. Both the individual inspection accuracy results and the average results shall be entered onto the operator/coding technician's accuracy graph, refer to the example in Figure A4.3. The graph shall have two boundaries:

- Specified Accuracy Level – the minimum level of accuracy expected, i.e. 95%
- Specified Tolerance limit – the level to which the accuracy can fall before corrective action is required for the operator/coding technician.

Any Operator, or coding technician, whose quality control results fall below the specified tolerance limit on more than two occasions, within two batches, shall be deemed to have failed their control criteria and shall be subject to supervision and re-skilling before resuming unsupervised duties.

Figure A4.2 – Example Reporting Accuracy Audit, 5% of the inspected length per coder

Batch/Week Ref: 01		AssetID	1001011	1002115	1012300	Totals
		Name of Coder	B. Smith	J. Roger	T.J. McKay	
		Length (m)	86	61	85	232
Inspection Header	**Grade**	**Required Entries (No. of Fields)**	**27**	**27**	**27**	**81**
	1	Missing or incorrect Mandatory header information	1		2	3
	2	Missing or incorrect Optional header information				0
	Header Accuracy Results		**96.3%**	**100.0%**	**92.6%**	
Inspection Observation	**Grade**	**Required Entries (No. of Fields)**	**75**	**90**	**82**	**247**
	1	Missing defects (Score > 20)		7		7
		Incorrect Classification (main code, Characterisation code or quantification code changing Score from ≤20 to >20 / >20 to ≤20)	2			2
		Incorrect distance recorded to defect or features		1		1
		Missing Continuity Code		1		1
	Total Grade 1 Observation Errors		**2**	**9**	**0**	**11**
	2	Missing defects (Score > 20)				0
		Incorrect Classification (main code, Characterisation code or quantification code)		1		1
		Clock reference missing or recorded incorrectly	1			1
		Still images missing or not clear	1			1
		Missing / incorrect required remarks				0
		Missing features			2	2
		Missing or Incorrect 'Measured From' Code				0
	Total Observation Grade 2 Errors		**2**	**1**	**2**	**5**
	Observation Accuracy Results		**96.0%**	**89.4%**	**98.8%**	
	Overall Accuracy Results		**96.1%**	**91.9%**	**97.2%**	**95.0%**

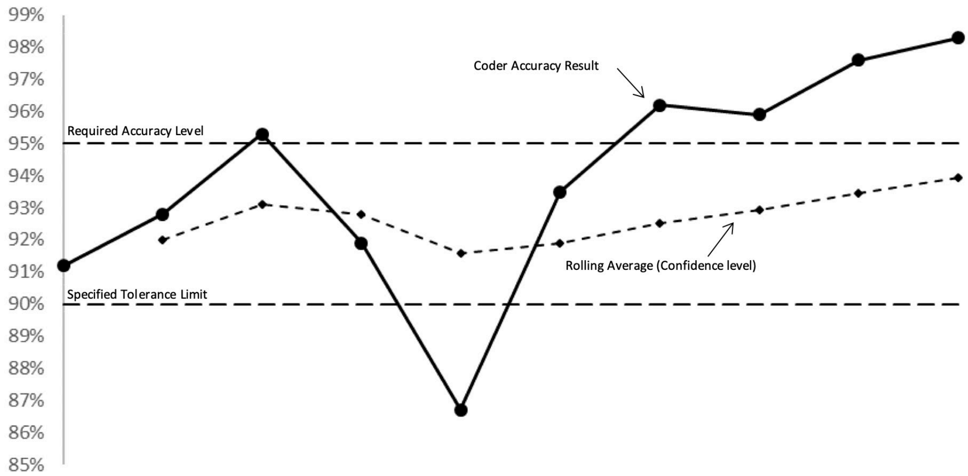
In the example on the previous page, the overall accuracy result for the Batch 01 is 95% but one of the Inspection Header, and one Inspection Observation audit outcomes are below 95%. The outcome is therefore a Conditional Pass and additional checking is required per the following observations:

- The overall accuracy is calculated using the accuracy level equation:

$$100 \times \frac{(81 + 247) - (3 + 11 + (0.5 \times (0 + 5))}{(81 + 247)} = 95.0\%$$

- As the header accuracy result for coder, TJ McKay, is less than 95%, (92.6%) the recommended action, in addition to correcting all identified header errors, shall be that all the inspection headers in Batch 01 coded by TJ McKay shall be checked for errors.
- The observation accuracy result for J. Roger, is less than 95%, (89.4%) and therefore the observation errors identified in the audit for that asset will need to be corrected, and all inspection observations coded by J. Roger in Batch 01 shall also be check for errors.

Figure A4.3 – Example Coder Accuracy Monitoring Graph with a Tolerance Limit of 90%



Part B Audit on Camera Operation Practice

CCTV inspection is a visual inspection and relies on the ability to be able to see the internal pipe wall to identify defects and features. Several factors influence the final quality of the image viewed by the assessor on their monitor including the quality of the camera, its operation, conditions within the pipe, file management and the resolution of the monitor.

The audit shall check the conformance of the operation of the camera to the requirements set out within this manual to achieve a quality outcome. The audit shall also check the conformance of the video file with the benchmark provided by the contractor

The audit is undertaken by observing the video, and identifying camera operation faults, and ranking them into different levels that relate to the impact they have on how much the faults have on the view of the internal pipe wall and therefore the video quality. While the overall aim is to achieve the best view of the pipe wall as possible, the different fault levels reflect situations where unintentional faults may arise that do not have an overall effect on the use of the video compared to poor operational practice or quality checking.

Table A4.6 describes the five camera operation fault levels, how that relates to the Pass or Fail of the audit and the actions necessary following the audit.

Table A4.6 – Description of Camera Operation Faults and Resulting Actions

Fault Level	Level Description	Audit Result	Actions resulting
L1	Major issues with the video quality that means that the video cannot be used for its intended purpose.	Fail	A new inspection shall be undertaken to replace the faulty inspection. All video inspections completed by the same camera operator within the batch shall be checked by the Contractor and re-inspected if L1 or L2 faults are found. The Asset Owner may undertake further audits to check compliance.
L1	Significant video quality issues that impact on the usability and reliability of the video for its intended purpose.	Fail	
L3	Moderate video quality issues that has some impact on the information available but does not significantly affect the usability of the video for its intended purpose.	Pass	The video can be accepted. Camera operator must take steps to avoid same faults occurring in subsequent inspections. All video inspections completed by the same camera operator within the batch shall be checked by the contractor to ensure no L1 or L2 errors exist. If errors continue to be observed in subsequent audits the asset owner may require the contractor to reinspect the affected asset.
L4	Minor video quality issues that have little effect on the information available and does not affect the usability of the video for its intended purpose.	Pass	The video can be accepted. Camera operator shall take steps to avoid these faults occurring in subsequent inspections.
L0	No camera operational practices observed that affect the video quality, the video can be used for its intended purpose.	Pass	The video can be accepted.

The different camera operation faults are separated into different categories:

- Faults relating to the quality of the video footage provided: i.e. image resolution or items affecting the resolution or playback.
- Faults relating to the effect of the environment inside the pipe: e.g. Water level, fog/mist, conformance to cleaning requirements.
- Faults relating to the operation of the equipment: e.g. Camera Stopping, Panning, camera setup.
- Faults relating to the information displayed: e.g. Screen information.

The audit items within those criteria and how they are assessed against the Fault Levels are described in Table A4.7 (Dots represent the fault level associated with that category).

Table A4.7 Camera Operation Faults Audit Category and Fault Level

Category	Level 1	Level 2	Level 3	Level 4	Reference
Video Quality					
Video File quality/resolution does not meet the Benchmark video standard[1]		●			Section A3.6 & A.2.1
Vision of the pipe is affected by grease, water drops, scratches etc on the lens or camera not in focus[2]		≤50% reduced vision in more than 10% of the pipe length	< 10% reduced vision in more than 10% of the pipe length	Any occurrence < 10% of pipe length	B1.2.1
Loss of Vision. No view of the pipe or substantial loss of view (more than 50% of the pipe circumference)	No vision over more than 10% of the pipe length	No vision or ≤ 50% of pipe circumference not able to be seen for up to 10% of the pipe length	Intermittent loss of vision but no length of pipe missed	Single occurrence of no vision but no length of pipe missed	B2.1, I6.4
Video File Not Working Due to Error[3]	●				
Environmental Issues					
Water level in the pipeline at the start of the inspection is more than the specified amount with no reason given[4]		●			B1.2.3.1
During inspection Water level increases to >40% for more than 10% of pipe length without reason given[4]		●			
Cob webs, Mist/fog or foam etc. in the pipe obstructing view of the pipe wall[2,5]		> 40% of pipe circumference obstructed in more than 10% of pipe length	≤ 40% of pipe circumference obstructed in more than 10% of pipe length	Any occurrence < 10% of pipe length	B1.2.1
Pipe cleaning not complying with specified and no reason given		≥ 10% of the pipe length	< 10% of the pipe length		Particular Specification & B1.1.2 (Table B1.1_1)
Operating Procedure Issues					
Camera speed too fast or too slow	> Maximum specified speed over more than 10% of the pipe length and multiple defects not able to be identified or quantified	> Maximum specified speed over more than 10% of the pipe length OR ≥ 1 defect not identified	> Maximum specified speed (not exceeding 10% of the pipe length)	Camera speed to slow	B1.2.3.2
Camera does not stop at a defect		Did not stop at > 10% of the defects	Did not stop at ≤ 10% of the defect	Incorrect stopping distance	B1.2.3.3
Inadequate or no panning of defects		Panning is not undertaken at all for >10% of the required locations	Does not correctly pan over area (some parts of area missed), OR Regular panning during continuous defects not undertaken	Panning speed too fast or pause too short	
There is not a clear view of the interface between pipe and manhole wall (at start manhole)			●		B1.2.2.4

Category	Level 1	Level 2	Level 3	Level 4	Reference
There is no view of the pipe entry (before the distance counter re-set)			●		B1.2.2.4
Camera height not aligned in the centre of the pipeline (with no reason given)			●		B1.2.2.3
Camera not facing along axis while moving forward[6]		≥ 10% of the pipe length	< 10% of the pipe length		B1.2.3.3
Pre-set Distance with Off-Set not entered[7]			●		B1.2.2.6 & B1.2.2.7
Inspection ends before the finish node without any explanation[8]		●			B1.2.4.3 & B1.2.2.8 (Table B1.2_1)
Display Information					
Screen header is incorrect or missing (start or end display)			●		B1.2.2.8
Continuous information displayed on the monitor incorrectly or missing					
No panning around or view of the start manhole and finish manhole			●		B1.2.2.4 & B1.2.4.1

Notes:

1. Benchmark video is the video provided by the contractor and accepted by the asset owner, prior to starting inspections, as the minimum acceptable video quality standard to be supplied. This test requires both a physical check of the video resolution, file size etc and a subjective assessment of the video clarity between the audited video and the benchmark video considering the intended monitor resolution.
2. Where view of the pipe wall reduces to ≤ 50% then the fault is recorded as a Loss of Vision.
3. Where the faulty video file can be quickly replaced by the contractor for one that can be played then this shall not be recorded as a fault.
4. Water level assessment shall include for ± 10% value. Reason for water level variation shall be clearly documented in the inspection report and is approved by the asset owner.
5. Does not consider fat, debris, roots, encrustation deposits obstructing the view that could not be removed by the specified level of cleaning. These are recorded as service defects. Where they obstruct the view to >40% of the pipe circumference, the asset owner shall consider whether they shall undertake heavy cleaning to remove these and then carry out another inspection of the pipe.
6. Does not include where camera moves forward or backward while panned to get a better view of a defect or confirming extent of defect. Shall not exceed a distance equivalent to one pipe diameter.
7. Not recorded as a fault where the camera cable is already taut, and the counter will start counting as soon as the camera moves from the centre of the start node.
8. Applies where the video ends unexpectedly or abruptly without an ending screen header or clear explanation in the inspection report.

A4.5 Checking of Field Measurement Testing

A4.5.1 Displayed Pipe Inspection Distances

The Accuracy of the distance counter shall be checked each month and/or at any change of cable or equipment. There are two methods that can be used:

1 Field Measurement

The distance between two known points (e.g. manholes) is measured with a tape and compared against the distance recorded during the CCTV inspection. The distance can be measured (i) above ground, from centre of manhole to centre of manhole, if there is a clear line of sight between the manholes without obstructions (e.g. in the berm or carriageway) or, (ii) a tape is attached to the back of the camera and pulled through the pipe – the measured distance is taken from a reference point after the cable distance counter has been pre-set with the Offset Distance (refer to Section B1.2, clause B1.2.2.6).

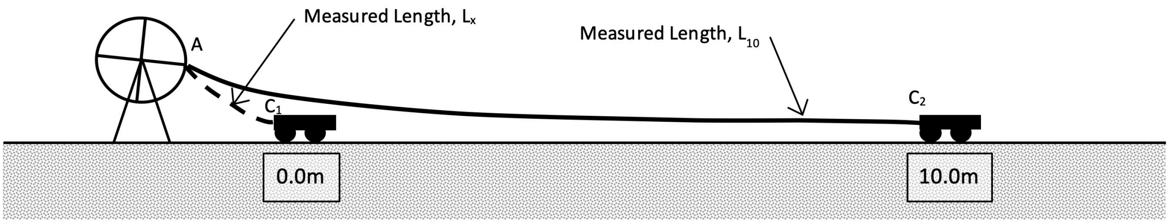
The difference between the counter distance and the measured distances shall not exceed 1%.

2 Cable Calibration Test

The test is carried out above ground and can be conducted with or without the camera attached, but utilising the control unit and monitor (refer to Figure A4.4):

1. The cable is fully wound on the cable drum ensuring that the cable is through the measuring wheel. The counter is set to zero.
2. If there is any length of cable that extends before the measuring wheel (A to C1) this is measured and recorded (Length Lx)
3. Pull off cable until the distance counter is reading 10.0m (C2)
4. Using a tape measure, measure the length of cable between the measuring wheel and the camera/connector (A to C2, measured length L10). Subtract Lx to record the length of cable than has been pulled off the cable drum.
5. Rewind the cable fully on to the cable drum and repeat step 2 to 4 each time increasing the distance by 10m until a length of 50m has been recorded.
6. Compare the differences between the counter distance and the measured distance for each 10m increment. The largest difference shall not exceed 0.2m.

Figure A4.4 – Cable Counter Calibration Test



Actual measured length of cable pulled off (A to ?)

Maximum allowable difference cable counter reading and measured length is 0.2m

If the variance in length in either method is greater than the maximum allowable the cable distance counter requires maintenance and recalibration.

A4.5.2 Verifying Manhole Depth Measurements

The depth from the top of the manhole cover frame to the depth of connecting pipes or defects shall be measured with a tape and compared against the depth measurement recorded on the inspection report or manhole diagram. The two depths shall be within the tolerances specified in Section D1.2, Table D1.2.1 Minimum required accuracy of measurements based on the method of inspection.

B1.1 Preparation of Drains and Sewers for Inspection

B1.1.1 Introduction

This section covers the preparation of Stormwater and Wastewater pipelines for inspection. This primarily involves the cleaning of the pipe by hydro-jetting. The aim is to provide guidance on when and what type of cleaning shall be undertaken, and how to minimise damage to the pipe or the surrounding ground and prevent overflows.

This section is not intended to specifically cover the unblocking or mechanical cleaning of pipes. Where blockages, large roots or obstructions are encountered, any unblocking or mechanical cleaning will require a pipe-specific methodology to be prepared by the Contractor that will consider the pipe material and condition.

Hydro-Jetting shall only be undertaken by trained personnel. For general guidance refer to the WRc Sewer Jetting code of Practice (2005) and EN 14564-1:2004 Management and Control of Operations in Drains and Sewers – Part 1: Sewer Cleaning.

B1.1.2 Recommended Pre-Inspection Cleaning

The requirements for cleaning prior to carrying out the CCTV inspection shall be provided by the Asset Owner in the Particular Specification.

Cleaning the pipe prior to CCTV inspection will provide the best view of the pipe wall, making it easier to identify defects and features in the pipe. However, cleaning adds to the cost of the CCTV inspection, it can damage the pipe and it may remove evidence that may allude to the pipe serviceability, or hydraulic performance, by flushing away defects such as roots, fat and debris. The requirement for pre-cleaning is dependent on the purpose of the inspection.

In some cases, it is necessary to clean the pipe to remove obstructions so that the camera can travel the full length of the pipeline.

B1.1.2.1 Pipes That Require Full (Heavy) Cleaning Prior to CCTV Inspection

Where the pipe is specified as requiring 'Heavy' cleaning prior to the CCTV inspection this means the removal of all foreign matter, including but not limited to silt, gravels, fats, most roots, encrustation deposits and scale. The level of root removal will be dependent on the thickness of the roots. Thick Tap roots or dense interwoven root beards may remain. Hard mineralised encrustations, grout or mortar bonded with the pipe wall might also not be removed by water jetting alone.

The cleaning work shall include manholes, dead end pipes and any other structure encountered in the sewer system. Cleaning of the manholes shall include channels, benches, and walls to the soffit level of the pipe being inspected.

The Contractor is responsible for selecting the most appropriate equipment and nozzles to ensure that pipes are fully cleaned. This may require multiple passes of the nozzle or the use of multiple specialist nozzles. This specification excludes rodding, flails, dredging or any other mechanical methods of cleaning. If such methods are required to obtain a clean pipe this would require a pipe specific methodology prepared by the Contractor and approval from the Asset Owner.

B1.1.2.2 Light Cleaning

Where a pipe is specified as requiring 'Light' cleaning prior to the CCTV inspection this means the removal of slime, light debris, some fat deposits and fine roots. The intent is to remove material that may limit the view of the pipe but not to remove all evidence of service defects. This provides the opportunity to better understand both the structural and service condition of the pipe, albeit that this is partially compromised by the removal of some service defects and some structural defects may be partially obscured.

Typically, this will be achieved with the same pressure and flow rate as heavy cleaning but with fewer, generally up to two, passes of the nozzle through the pipe.

B1.1.2.3 No Cleaning Prior to Inspection

The decision to 'Not Clean' prior to inspection may be due to the deteriorated condition of the pipe, or the desire to fully observe and quantify the service defects in the pipe. However, if there is a lot of debris, fats or roots in the pipe, then structural defects may not be seen.

Typically, Stormwater pipelines will only be cleaned when obstructions prevent the inspection equipment from travelling the full length of the pipeline.

Table B1.1.1 outlines the recommended level of pre-cleaning for Wastewater pipelines, based on the intended purpose of the inspection.

Table B1.1.1 – Recommended cleaning for Wastewater pipelines

Purpose of Inspection	Recommended Cleaning
Identify the general structural and service condition of the pipeline	Light cleaning to remove slime, light debris, some fat deposits and roots1.
Identify sources of infiltration	Light cleaning to removal of slime, light debris, some fat deposits and roots1.
To identify all structural faults, e.g. to determine a repair strategy	Full/heavy cleaning of the pipeline to remove all foreign material. For pipe ≥600mm diameter, removal of all fat and loose material above the normal dry weather flow level.
Laser profiling to determine ovality or extent of corrosion/ erosion	Full/heavy cleaning of the pipeline to remove all foreign material and soft surfaces.
Determine the cause of a blockage or surcharge/overflow	Do not clean prior to inspection. Only clean if the camera/scanner cannot clearly see the cause of the surcharge.
Inspection of pipes suspected to be in Poor Structural Condition	Carry out an initial inspection without cleaning, as cleaning may cause further damage and cause the pipe to fail.

Notes: 1. For wastewater pipes >600mm a light clean would not normally be undertaken prior to inspection.

Table B1.1.2, on the following page, provides a commentary on the expected results and methodology for the different types of cleaning.

Table B1.1.2 – Comparison of Light and Heavy Cleaning and expected outcomes

Type of Clean	Cleaning shall remove	Cleaning probably won't remove	Implications for CCTV Inspection	Typical methodology
None			All service defects will be visible. Some structural defects may not be visible. Cobwebs may obstruct the lens or service defects may prevent camera from passing all the way through the pipe. Least risk of causing damage to the pipe.	No cleaning undertaken
Light	Soft FOG (Fats, Oils, Grease), cobwebs, some debris and fine roots	Most roots, debris, hardened fats, and hardened encrustation deposits	Improved traction for the camera and removal of material that can obstruct the camera vision (e.g. slime, cob webs and foam). Evidence of pipe serviceability including fat deposits, root intrusion and leakage (staining and encrustation deposits) remains. Some structural defects may be concealed by remaining FOG. Possible that remaining debris, roots or fat could prevent the camera from passing all the way through the pipe. Some risk of causing damage to the pipe.	Two passes of the jetting nozzle through the pipe. *Refer Table **B1.1.3** & **B1.1.4** for recommended pressure and flow*
Heavy	All FOG, debris, fine to medium roots	Thick tap roots, some hard encrustation deposits and grout/ mortar	Pipe shall be free of all fat debris and roots to reveal all structural defects (above the flow in the pipe). No evidence of pipe serviceability will be available. Will Remove soft corrosion layer of concrete and AC pipes. Remaining material would require mechanical or robotic cleaning to remove. Most risk of causing damage to the pipe.	As many passes of the jetting nozzle through the pipe as required. *Refer Table **B1.1.3** & **B1.1.4** for recommended pressure and flow*

B1.1.3 Working Pressures and Flow Rates

Generally hydro-jetting can be classified as High Pressure/Low Volume or Low Pressure (under 130 Bar)/High Volume. Both approaches are applicable to pipeline maintenance and cleaning and have their respective benefits and limitations.

The ability of a pipe to withstand hydro-jetting without damage depends on the cleaning pressure, the pipe material and its condition. Excessive pressure may have significant implications for the asset owner. The pipe wall may be damaged, and/or the surrounding ground may be washed into the pipe through holes in the pipes or open joints. This can cause subsidence, increasing the risk of collapse or damage to other structures and surfaces. In some cases, surcharging of connected pipework and flooding may occur.

The inspection contractor shall obtain as much information as possible from the asset owner about the pipe material and known condition prior to undertaking any cleaning. Limits on the maximum pumping pressure to be applied will vary depending on what is known (or not known).

Although high pressure/low volume hydro-jetting has been common in New Zealand, particularly in unblocking or descaling, it is recognised that high-pressure jetting for general cleaning, in preparation of a pipe for inspection, risks causing damage to the pipeline.

Sewer cleaning differs from blockage removal as low pressure/high volume hydro-jetting is more effective for removing accumulated fats and debris, and significantly reduces the likelihood of damage to the pipe and other associated risks. Common cleaning tasks can usually be reliably accomplished with pressures under 130 Bar, (1900 psi).

Where blockages are found, roots or attached deposits cannot be removed using the maximum pressure recommended in this section, or a mechanical cleaning method is required, then site specific methodologies shall be determined by the contractor in consultation with the asset owner.

Where a pipeline is in very poor condition (Structural Grade 5) or suspected of being in very poor condition (i.e. there is visual evidence of poor condition, such as broken pipe material or pipe bedding material in the downstream manhole) the pipe shall not be cleaned prior to inspection. Cleaning would only ever be undertaken on very poor condition pipes under the direction of the asset owner using a specifically agreed methodology.

If the Contractor suspects that the pipe is being damaged during cleaning then the cleaning shall cease immediately, and the asset owner notified. Evidence of damage might include pieces of pipe or bedding material observed in the debris trap or collected material from any one collection location (i.e. access chamber or manhole) exceeding 10 kilograms/metre cleaned, as this potentially material from outside the pipe being washed into the pipe.

B1.1.3.1 Recommended Working Pressures

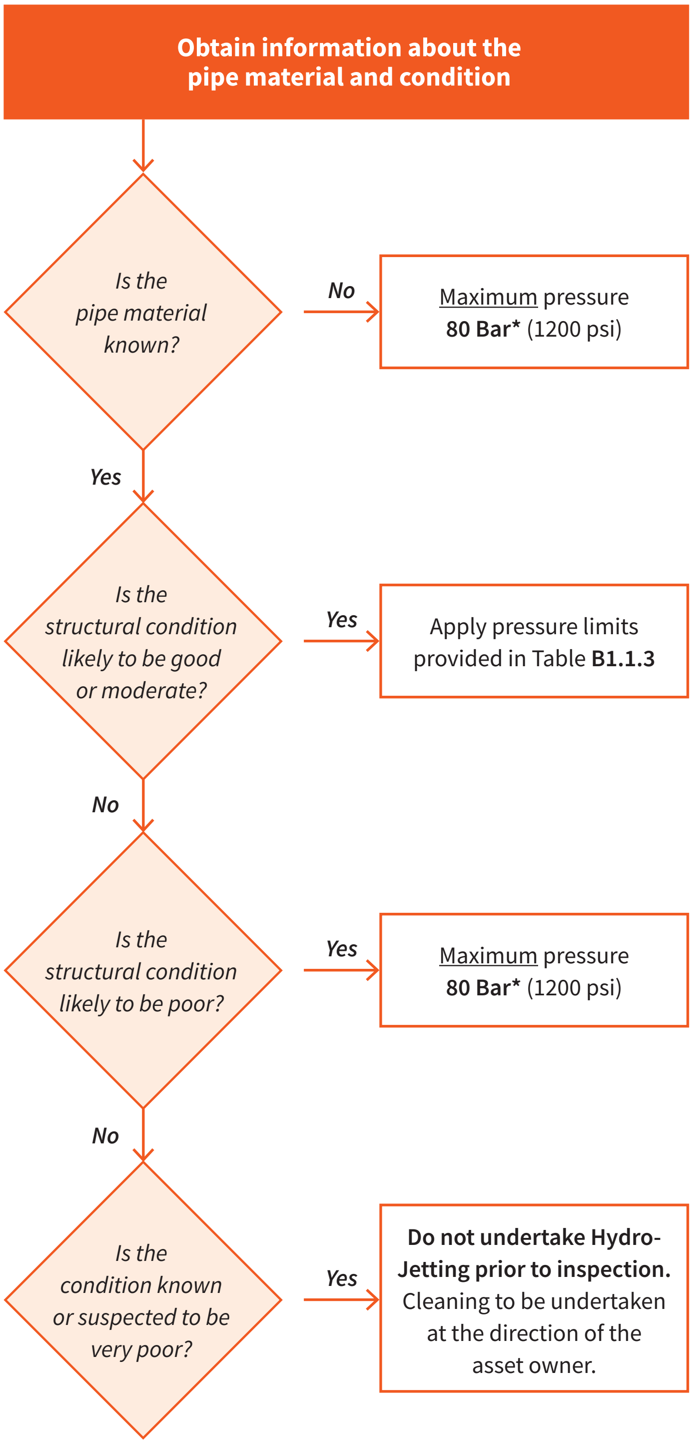
The procedure for determining the appropriate working pressure to apply is shown in Figure B1.1.1.

In this manual the basis for selecting the pressure to be used is categorised into three types:

1. Pipes where the material is known and likely to be in good to moderate structural condition.
2. Pipes where the details about the pipe material or condition are not known or could be in poor condition.
3. Pipes and manholes that are in very poor structural condition.

High pressure/low volume cleaning techniques shall be avoided for pre-inspection cleaning. The maximum pressure applied shall be 130 Bar (1900 psi).

Figure B1.1.1 – Procedure for applying Pressure Limits



** If trenchless repair patches have possibly been installed, then maximum pressure shall be reduced to 70 Bar/1000 psi (in line with Table B1.1.3)*

Table B1.1.3 – Recommended pressures for pipes in good to moderate condition

Pipe Material	Recommended Pressure for Pipes in Good to Moderate Condition)	
	Bar	psi
PVC-U, PVC-M, PE, PP[1]	120	1750
GRP[2]	80	1200
Concrete	120	1750
Clay	120	1750
Brick/Masonry	100	1500
Asbestos Cement (AC)	120	1750
PU Coated CIP Patch/Lateral Junction Repairs[3]	70	1000
PVC Coated CIP Patch/Lateral Junction Repairs[3]	120	1750

Notes:

1. Solid and structural wall plastic
2. Refer to Manufacturer for specific guideline
3. One or more Cured-In-Place (CIP) patches or Lateral Junction Repairs (LJR) within a pipeline

B1.1.3.2 Recommended Flow Rates

High volume flow, at low pressures, is good for transporting sediment to the downstream manhole for removal. The recommended flow rate based on the pipe diameter is provided in Table B1.1.4.

Table B1.1.4 – Recommended Flow Rates

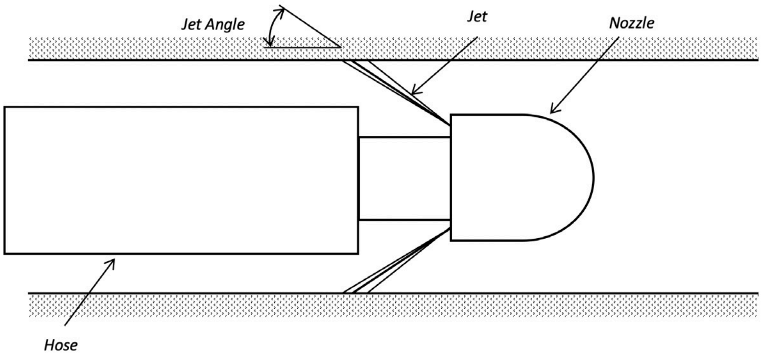
Pipe Diameter	Flow Rate (l/min)
≤ 100mm	30 – 60
150mm – 300mm	140 – 220
300mm – 600mm	240 – 350
600mm – 900mm	400 – 620
>900mm	>620

B1.1.4 Nozzle Type and Speed of Withdrawal

The selection of the type of nozzle to be used is one of the important variables (along with pressure and flow) that impacts on the efficiency of the pipe cleaning.

When selecting the size and type of nozzle consideration needs to be given to the jetting equipment, the nature of the material to be removed (silts, fats and roots) and the depth of the deposits.

Figure B1.1.2 – Sketch of a nozzle



Nozzle performance for removing non-cohesive debris (silts, sands and gravels) in small diameters (<600mm) is considerably affected by the Jet Angle (refer to Figure B1.1.2) and the depth of the sediment to be removed. Table B1.1.5 shows the optimum nozzle jet inclination for non-cohesive debris.

Table B1.1.5 – Nozzle Jet inclination for optimising cleaning performance in non-cohesive debris for pipes <600mm diameter

Depth of debris (% of pipe diameter)	Nozzle Jet Inclination for optimised cleaning (degrees)
>50%	<15°
15% to 50%	15° to 20°
<15%	Inclination has minimal effect on performance

In some cases, such as the removal of attached or cohesive deposits, (fats, oils, grease and encrustation deposits) or roots, the selection of a specialised nozzle such as a rotating (spinning) nozzle may be considered for maximum cleaning efficiency.

Where PU or PVC coated Cured-In-Place (CIP) Patches/Lateral Junction Repairs (LJR) have been installed, spinning/rotating nozzles shall not be used as these may lead to damage or failure of the installed repairs.

When the nozzle passes through sediment the rear jets push the loosened material downstream and the sediment may form into a dune. The speed of the nozzle withdrawal has an important effect on the efficiency of removal of the loosened material:

1. If the speed of the nozzle withdrawal is faster than the migration of the sediment, then the nozzle can pass through the sediment only partially removing the material, and more passes of the nozzle will be required.
2. If the velocity of the sediment movement is greater than the removal rate of the nozzle withdrawal, then the sediment can be completely removed.

To provide the most efficient removal of material from relatively flat grade pipes, the speed of the nozzle withdrawal shall not be more than 12m/min.

If the pipe has a thick layer of debris, it may be necessary to clean small sections of the pipe at a time, (5m long) to avoid burying the hose and making it difficult to retrieve.

The performance of lower pressure jetting is severely reduced when the nozzle is submerged below water, and it may be beneficial to reduce the flow in the pipe to avoid this occurring.

B1.1.5 Cleaning General Requirements

B1.1.5.1 Care

The Contractor, when using cleaning equipment or undertaking any of the associated cleaning activities, must take all necessary precautions to ensure that these activities do not:

- Damage or flood public property.
- Cause sewer overflows.
- Damage the sewer conduit being cleaned or any associated conduits or structures.

The asset owner shall provide the contractor with the following:

- Location plans for the pipe to be cleaned
- Structural condition of the pipe, if known
- Pipe material, if known
- Previous repairs/patches, if known
- Details of any connections, if known
- Blockage or blow-back history

Cleaning where possible shall be carried out from a downstream manhole, in an upstream direction.

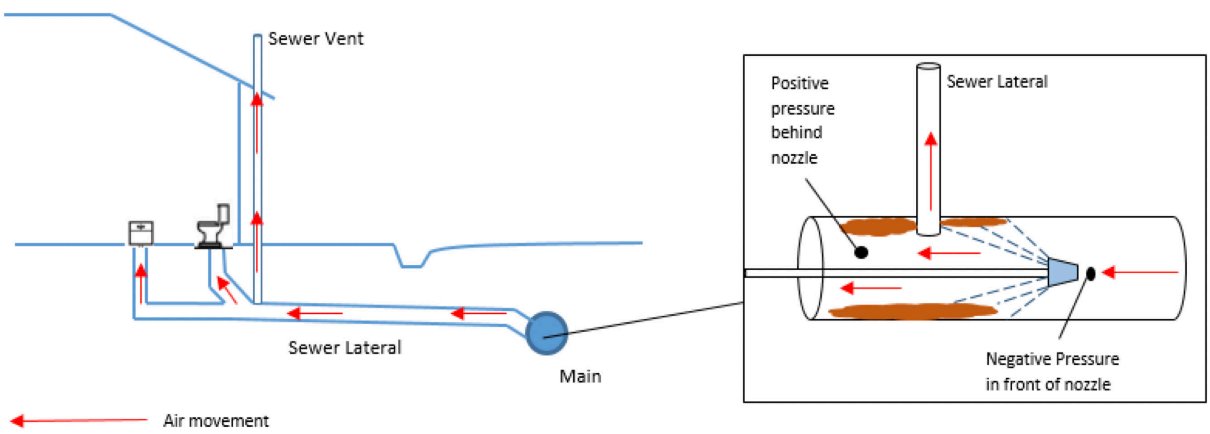
Downstream cleaning (from an upstream manhole) of wastewater pipelines shall only be carried out with the prior written approval of the asset owner, in which case special requirements may include

- On-site meetings with every property owner connected to the line and written confirmation that the property owners have been advised of the precautions required, such as sealing toilet seats down.
- Water removal upstream of the cleaning nozzle during cleaning
- A visual check of all gully traps on completion of cleaning.

B1.1.5.2 Blow-backs

Blowbacks may occur during cleaning of the wastewater pipelines, particularly if high pressure is used. During this cleaning process a negative pressure is created ahead of the nozzle while a positive pressure is created behind the nozzle due to the airflow associated with the spray. The amount of pressure created by the nozzle varies with the pump pressure and volume of water. As the nozzle moves through the line the positive pressure pushes into the sewer lateral lines. If there is nowhere for the positive pressure to go, (e.g. through a properly installed vent) air pressure may escape through a toilet water trap, floor drain or the nearest exit it can find (refer Figure B1.1.3). This undesired venting can result in the release of unpleasant odours and, on occasion, sewage/contaminated water from the u-bend and/or sewer into a home or business.

Figure B1.1.3 – Diagram showing how pressure causes blowbacks



The potential for blowbacks is almost impossible to predict and could be caused by a combination of different scenarios such as:

i) Shallow depth of main

ii) Type of lateral connection to the main (vertical dropper, ramp riser, constant grade)

iii) Angle of connection to main (45o or 90o)

iv) Distance from main to property

v) Number of bends in the lateral

vi) Position of vent stack

vii) Blockage in vent stack

The potential for blow-back is increased if cleaning in an upstream direction is used and this is another reason to avoid this if possible.

Where blow-backs have occurred, asset owners shall consider maintaining a blow-back register identifying susceptible properties.

For wastewater pipelines, the Contractor shall notify the residents of all the properties connected to the pipeline at least 24 hours prior to cleaning. The residents shall be provided with appropriate instructions on how they can minimise and contain any blow-back of the water seal shall it occur.

Advice would include:

- Lower the lid on toilet seat and place a weight (phone book) on it
- Provide contact number for questions or to report a problem
- Provide contact number if the resident is aware that there has been a problem in the past.

Additional measures to contact residents of properties known to be susceptible to blow-back and proactive measures to prevent internal discharges from occurring shall be taken.

B1.1.5.3 Hold time

Hydro-Jetting nozzles when stationary may cause damage to the pipe wall. It is essential that the nozzle is kept moving. The Contractor shall limit the stationary time of the nozzle to maximum of 60 seconds.

Care shall be taken when releasing the nozzle into the manhole as the equipment may damage the manhole wall, benching or channel. The pump shall not be turned on until the nozzle is inside the pipe.

B1.1.5.4 Snaking of the hose in the pipe

To prevent snaking or reverse travel of the hose in the pipe, a rigidizer/section of steel tube of a length greater than the pipe diameter shall be fitted between the hose and the nozzle. Snaking usually occurs in pipelines of 300mm in diameter and above and does not usually occur in smaller size pipes.

B1.1.5.5 Timing of the cleaning before the inspection

CCTV inspections shall be carried out as soon as possible but not longer than seven days after cleaning. Where heavy cleaning is required, any build-up of debris occurring between cleaning and inspection shall be removed before inspection.

B1.1.5.6 Removal and disposal of Materials

All sludge, silt, debris, grease, roots, scales and other materials resulting from cleaning operations shall be collected at the manhole immediately downstream of the section being cleaned. Passing material from manhole section to another manhole section shall be avoided. The type and size of equipment required to sufficiently remove the material will need to be able to manage the volume of flow from the nozzle, water flow through the pipe and the expected quantity of material to be removed or sufficient debris trap installed to prevent debris or fat passing downstream.

The Contractor shall be responsible for the disposable of the removed materials from the site at the end of each work day. The removed material shall not be allowed to accumulate, except in enclosed containers. All materials removed are to be disposed of in a safe and legal manner at an approved location appropriate to the degree of contamination of the removed material. Note that material removed from a stormwater line can contain a range of contaminants other than sewage.

Where a claim is to be made for disposal of material from cleaning operations, the Contractor must drain off excess water prior to weighing the load of material. Excess water shall only be drained back to an approved disposal point.

B1.2 CCTV Camera Operation

This section sets out the good practice principles for the operation of the CCTV camera.

B1.2.1 General

One of the most important elements of a gravity pipe inspection is the quality of the recorded inspection. To ensure that all defects and features are correctly and fully identified there must be a full and clear view of the pipeline, and information that is presented on the video recording needs to be as accurate as it possibly can be.

There are many factors that influence the view of the pipe. Principally these factors include the capability of the camera system, (including the suitability of the equipment for the job, the recording quality and the file media, refer to Sections A2 and A3) and equally the methods employed by the CCTV camera operator. The setup of the equipment in the pipe, the speed the camera equipment travels, and the steps taken to fully capture the information found during the inspection are all critical factors determining the standard of the CCTV footage.

The environment within the pipeline can also play a role in the quality of the view of the pipe. Examples of environmental issues that may detrimentally affect how much of the pipe can be clearly seen include:

a) Fats, oils and grease, (FOG) and debris in the pipe

b) Condensation, grease, debris or spider webs that may become attached, or scratches, to the camera lens

c) Steam or fog in the pipe

d) Temporary discharges of water down the pipe

e) Depth of base flow

Prior to commencing any work on site, the pipe inspection shall be planned. This shall include, but not be limited to:

- Understand the purpose of the inspection and any specific requirements the asset owner is requesting
- Collect information on the assets to be inspected, including GIS maps and attributes (e.g. pipe material, length and diameter)
- Determine if pre-cleaning of the pipe is required
- What node shall the inspection start from?
- What equipment is going to be needed given the pipe size, length and any limitations (e.g. bends).
- Is flow control required, and if yes, at what times and how will this be implemented to stop overflows?
- Are there any accessibility restrictions – where are the manholes located, are they buried, and does access to properties need to be arranged?
- What is the specific health and safety issues that will need to be eliminated or minimised (including traffic control, dogs, confined space entry, etc)?

In general, unless instructed by the Asset Owner, where less than 60% of the pipe surface can be seen, the CCTV inspection shall not commence unless efforts to reduce the flow or remove obstructions to the view of the pipe wall have been completed.

B1.2.2 Starting the CCTV Inspection

B1.2.2.1 Direction of Camera Travel

Where it is possible inspections shall start at the upstream manhole/node and proceed in a downstream direction. In some circumstances this may not be practicable and therefore it may be necessary to start or continue the inspection from the downstream manhole and travel upstream. Circumstances where this latter approach would be expected include:

- Where both upstream and downstream assets from the manhole are required to be inspected.
- Inspection of long pipelines where the CCTV camera equipment does not have enough cable to complete the inspection from the upstream end.
- Where the upstream manhole cannot be accessed, e.g. cannot be found, it is buried, or it is a buried junction.
- There is no manhole at the upstream end, e.g. there is a lamp hole (inspection point) at the upstream end.
- There are obstructions that prevent the CCTV camera travelling downstream for the full length of the pipeline.

B1.2.2.2 Lighting

The camera iris and/or light intensity shall be adjusted to get the best possible picture clarity. Care is needed to ensure that there is sufficient lighting when the pipe material may influence the amount of light either by light absorption or reflection, or where bright light from outside the pipe may make it difficult to see. For example:

a) Black PE pipe will absorb light and the picture will appear dark. A ‘charge’ of water sent down the pipe before the camera may assist with increasing the amount of light available by reflecting the camera lights off the beads of water on the pipe wall.

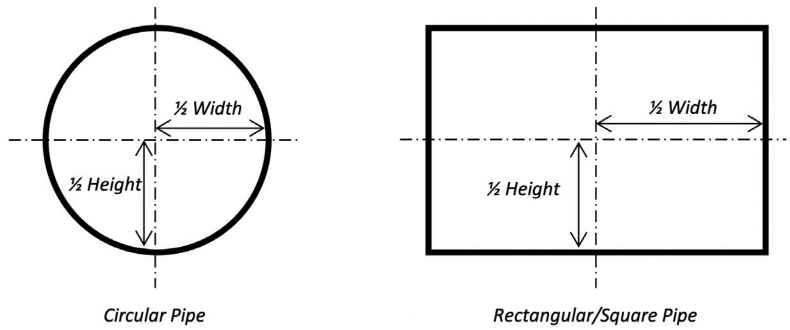
b) White PVC pipe may result in the camera lights being reflected from the pipe surface, making it difficult to see the pipe. Adjustment of the camera’s light sensitivity setting may be required to ensure adequate vision.

c) Sunlight entering through an access point, such as a stormwater inlet or outlet structure, may ‘blind’ the camera, in similar way as sun strike may blind a car driver. Placing a curtain over the structure entrance may be required to shade the pipe as the camera approaches.

B1.2.2.3 Centering the Camera

Most pipelines in New Zealand have a circular or rectangular shape. When inspecting these pipes, the camera equipment shall be selected and setup such that the view down the pipe is centred along the central axis of the pipeline. This shall be within 10% of the largest dimension.

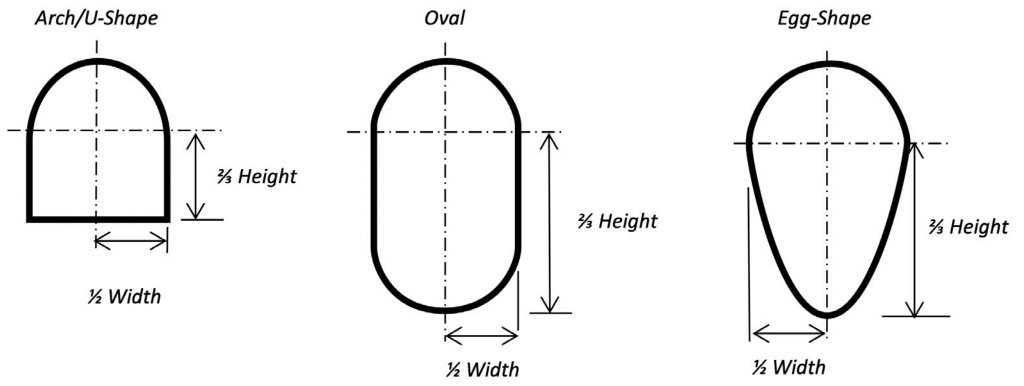
Figure E1.2.1 – Diagram indicating the position for the camera in a circular or rectangular/square pipe in the centre of the pipe



If a camera is set to high, or too low, in the pipe it can lead to a reduced view of the pipe walls, or picture distortion resulting in errors when quantifying defects.

For other pipe shapes the camera shall generally be aligned with the centre of the upper circle, normally approximately two thirds of the height of the pipe (refer to Figure B1.2.2). For egg-shape pipes, the steep angle of the lower pipe walls is inherently unstable for the camera, with the propensity for the camera to tip over. The likelihood of the camera tipping over is increased if the camera is high in the pipe. Therefore, the height of the camera in egg-shaped pipelines, or any pipe shape where there is a higher risk of instability, shall as close as possible to the ideal height whilst ensuring that the camera is as stable as possible.

Figure B1.2.2 – Diagrams indicating the preferred position of the camera in other pipe shapes



Where ever it is not possible for the camera to be set up at the specified height in the pipe, a note shall be provided in the inspection report comments describing the reason why it cannot be achieved.

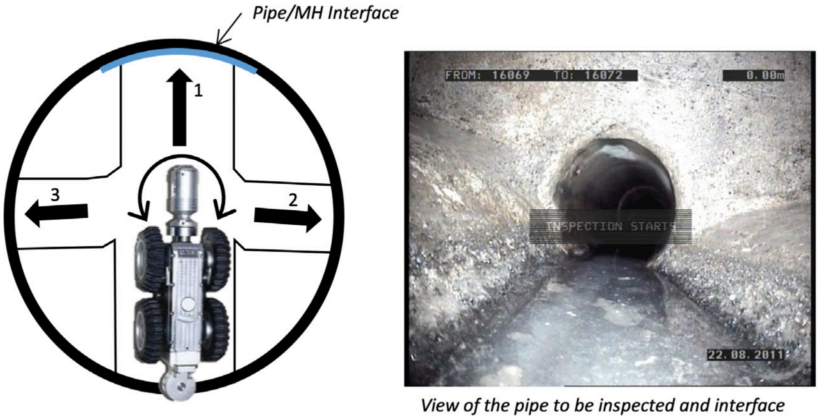
B1.2.2.4 Starting in a Manhole or Similar Structure

The inspection shall commence with the recording of a visual inspection of the starting manhole.

Where starting in the centre of the manhole (using a Pan and Tilt camera)

1. Once the camera has been lowered into the manhole channel, the camera shall be reversed so the camera head is as close to the centre of the manhole as possible and a good view can be obtained of the entry to the pipe and the manhole.
2. The distance counter is set to zero metres (0.0m). Note later requirement to reset the distance counter when the camera is in the pipe.
3. The video recording (or image capture) shall commence.
4. A screen header is displayed for 5 to 10 seconds notifying the start of the inspection (refer B1.2.2.8 Screen Displays).
5. The camera shall then focus on the interface seal between the manhole and pipeline to be inspected. If the entire circumference of the pipe/manhole interface cannot be seen within a single view, the camera shall be tilted and panned around the circumference to enable a view of the entire interface.
6. The camera is then panned, first in a clockwise direction as far as possible, stopping to identify any incoming or outgoing pipes, before returning to the start position. This is then repeated in an anti-clockwise direction.
7. The camera is then tilted upwards to record as much as possible of the manhole walls, lid and any high-level incoming pipes (Droppers). Where components are noted as defective or missing, these shall be noted in the inspection report comments.

Figure B1.2.2 – Diagrams indicating the preferred position of the camera in other pipe shapes



View of the pipe to be inspected and interface between the manhole wall and the pipe (interface seal).

Where unable to start in the centre of the manhole, or using a fixed head camera

1. Prior to lowering the camera into the manhole, a view looking down into the manhole from the ground surface shall be recorded, such that the manhole wall, benching and all the incoming and outgoing pipes can be seen on the video.
2. The distance counter is set to zero metres (0.0m). Note later requirement to reset the distance counter when the camera is in the pipe.
3. A screen header is displayed for 5 to 10 seconds notifying the start of the inspection (refer B1.2.2.8 Screen Displays).
4. The recording shall then continue as the camera is lowered into the entrance of the pipeline to be inspected, ensuring that the entire interface between the manhole wall and the pipe can be clearly seen as this is undertaken.

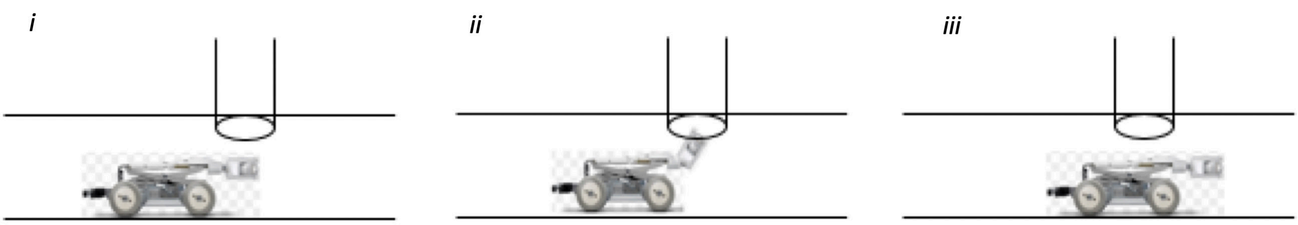
Figure B1.2.4 – Example of view looking down a manhole when the camera (pan and tilt or fixed head) cannot start in the manhole

B1.2.2.5 Starting at a lateral connection or Lamp hole (Inspection Point)

The inspection shall commence with the recording of a visual inspection of the lateral connection.

1. The inspection begins with the camera head positioned with a view down the axis of the pipeline to be inspected.
2. The distance counter is set to zero metres (0.0m).
3. The video recording (or image capture) shall commence.
4. A screen header is displayed for 5 to 10 seconds notifying the start of the inspection (refer B1.2.2.8 Screen Displays).
5. Where a pan and tilt camera is used, the camera shall be tilted and panned to view the inside of the lateral and the connection zone (refer to Section B2.1.6.6).
6. Before travelling down the pipeline, the camera head is returned to view along the pipe axis.

Figure B1.5 – Camera setup when starting in the pipeline at a lateral connection.
i) starting position of CCTV camera at a lateral connection.
ii) panning the inside of the lateral and connection zone.
iii) commencing inspection.



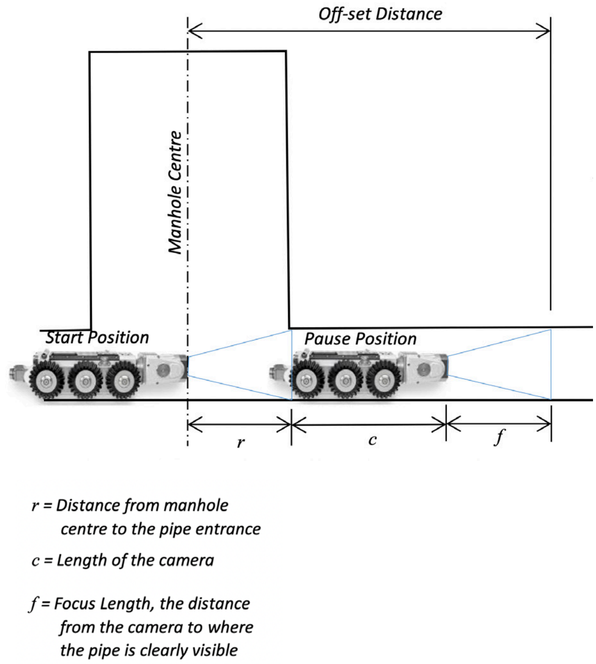
B1.2.2.6 Setting the Distance Counter

The distance to the defect or feature of interest is measured from the centre of the starting node. The distance counter, however, will not normally start to measure the distance until the cable behind the CCTV camera is taut. Typically, where the camera is starting from a manhole, the cable would not be pulled taut until the rear of the camera is level with the entrance to the pipe. This provides an easily recognised and predictable measurement. It is therefore important that the distance counter is adjusted to allow for any distance that may be travelled, from the camera starting position, before the distance counter begins to operate. This *'Offset Distance'* includes the distance from the centre of the manhole to the entrance of the pipe (r), the length of the camera (c) and the distance from the front of the camera to where the pipe can be clearly seen, referred to as the Focus Length (f). Note that this is a measurement and is not related to the optical focussing of the camera.

When starting at a manhole, or similar structure, the camera shall be temporarily paused (along with the video recording) once the camera has fully entered the pipe. At this point it shall be checked that the cable is taut and re-set the distance counter with the *Offset Distance*.

Where the camera is starting at a lateral connection, or similar, within a pipeline, the cable behind the camera shall already be taut, and the distance counter will start to measure as soon as the camera begins to move forward. In this situation an *Offset Distance* does not need to be set.

Figure B1.2.6 – Measuring the Off-set Distance



B1.2.2.7 Measuring the Focus Length (f)

The image shown on the monitor screen is a view of the pipe some distance in front of the camera. This distance varies with the size of the pipe and the type of camera used. As a rough guide, the Focus Length is generally similar to the pipe diameter.

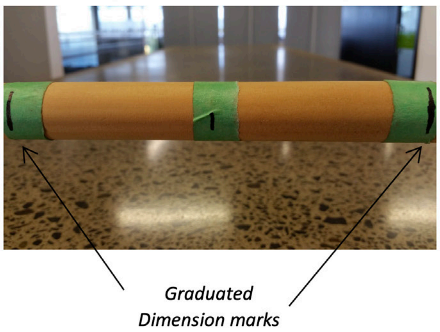
To be able to accurately enter the Offset Distance at the start of an inspection from a manhole, the operator needs to be able to know what the correct Focus Length is that must be used before commencing an inspection. A look-up reference table is recommended to be populated, by the CCTV contractor, for each camera type, by measuring the focus distance for every pipe diameter over the range of pipe sizes that the camera can inspect.

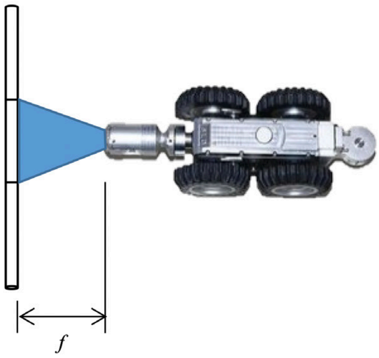
To measure the *Focus Length*, the following procedure is recommended:

1. Use a measuring tape, or a long pole (such as broom handle) that can be marked/graduated to match the largest dimension of the cross-section of the pipe. Where the pipe is circular, this is the pipe diameter.
2. The tape or pole is held horizontally in front of the camera. The graduated markings shall be centred on the camera.
3. Move the camera nearer to, or further away from the tape or pole, until the graduated dimension markings are just touching the left and right sides of the monitor screen (refer to Figure B1.2.7).
4. To determine the Focus Length, measure the distance from the front of the camera to the tape or pole.
5. Repeat this process for each pipe size.

The look-up table could include the length of the camera unit (c), such that the CCTV Camera Operator could use the combined values (c + f) as pre-set values, that only require the measurement of the manhole centre to the pipe entrance (r) to be able to establish the Off-set Distance.

Figure B1.2.6 – Measuring the Off-set Distance





Focus Length (f) is measured between the pole and the front of the camera

B1.2.2.8 Screen Displays

Screen Header Display (Start of Inspection)

A screen header shall be included at the start of the recording of each inspection. As a minimum the following information shall be displayed and recorded on the screen as follows:

- The unique Asset ID of the pipe that is being inspected
- Name of the Contractor and camera Operator
- Upstream and downstream manhole/node Asset ID's
- The set-up node (Upstream or downstream)
- Measured pipe diameter
- Inspection date and time
- Distance Counter (set to 0.0m)
- Purpose of the inspection (refer to Character codes for header field ABP, Section B2.2)
- Cleaning Status (refer to Character codes for header field ACM, Section B2.2)
- Use of the pipeline (refer to Character codes for header field ACK, Section B2.2)
- Laser measurement (calibration) dot spacing distance (Must be provided if used)

Additional information may also be requested by the asset owner to be displayed on screen which may include but not limited to:

- Client reference number
- Location
- Name of the Client
- Weather (refer to Character codes for header field ADA, Section B2.2)

Continuous Screen Display (Running Page)

During the inspection the following minimum information shall be visible and recorded:

- The measured distance the camera has travelled from the centre of the start manhole or node.
- Start and end manhole/node Asset ID's

Additional inspection information provided by the camera equipment may also be provided if the camera equipment used is able to provide them, examples include:

- Camera inclination
- Camera head position (diagram indicating the position of the camera head in relation to the pipe circumference)

Any information displayed shall be easily seen, but not adversely obstruct the view of the pipe. The displayed information shall be positioned in the corners of the recorded image and shall never be positioned in the centre of the screen. If necessary, the information shall be temporarily removed from the screen to enable a clear view of a defect.

End of Inspection Screen Display

At the end of the inspection a screen display shall be provided to confirm the end of the inspection and any relevant information. The information to be provided depends on the inspection completion status, the reason for the end of the inspection and whether there are any changes from what was expected when the inspection commenced.

Table B1.2.1 – End of inspection screen display information

Situation	Information to be displayed
Where the inspection is completed as expected (without changes)	• Statement "Inspection Complete" • The Asset ID of the end manhole/node
Where the inspection is completed but with changes (e.g. a new manhole has been found or the connectivity has changed, or an error in the start screen header is identified during the inspection)	• Statement "Inspection Complete" • Statement about the change identified • The confirmed Asset ID of the end manhole/node
Where the inspection is uncompleted (i.e. the inspection was unable to be completed and was abandoned)	• Statement "Inspection Abandoned" • Statement about the reason for the abandonment
Where the inspection completes a previously abandoned inspection	• Statement "Inspection Completed at previous point of abandonment"

B1.2.3 Carrying Out the Inspection

B1.2.3.1 Depth of Water Flow During an Inspection

The inspection shall be carried out in low flow conditions to maximise the perimeter of the pipe that can be seen. Unless specified or agreed with the asset owner, the maximum depth of flow values in Table B1.2.2 shall not be exceeded at the start of the inspection. Inspection of a new pipe, (as-built inspection) shall ideally be undertaken with no live flows, or a maximum depth of flow of 5% of the pipe diameter.

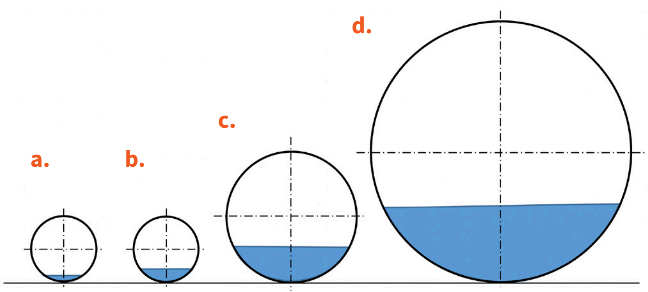
To reduce the depth of flow in the pipe, flow control measures may be required. This may involve the following:

- Returning at an off-peak time when the flow rates have reduced. Off-peak times vary according to location and use of the pipeline, but in general this would be between 10am – 3pm and after 9pm in residential areas. Industrial/ commercial areas will have unique profiles.
- Controlling (limiting) the flow, or by-pass pumping the water around the pipeline being inspected. A flow model or flow rates shall be sought from the asset owner for large diameter/high flow pipes or where a pressure sewer main discharges at a location upstream of the asset to be inspected.
- Flushing the water from the pipe by pulling a jetting nozzle through the line immediately in front of the CCTV camera or extraction of flow from a downstream manhole using a vacuum truck. It shall be noted that for inspections of new pipe (as-built inspections) removing water with Hydro-Jetters in front of the camera shall not be used as dips need to be revealed.

Table B1.2.2 – Maximum depth of flow at the start of the inspection

Pipe Diameter	Maximum Depth of Flow (% of pipe diameter)
<150mm	15%
150-299mm	20%
300-600mm	25%
>600mm	30%
New constructed, any size	5%

Figure B1.2.8 – Examples of maximum depths of water in various pipe sizes



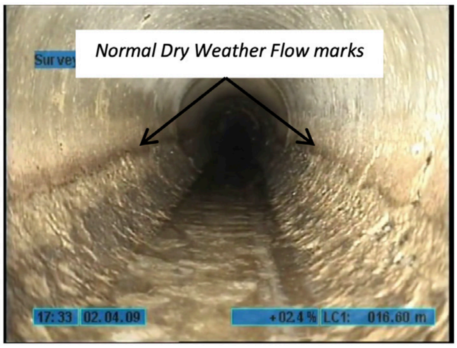
a. *5% in 150mmΦ*
b. *20% in 150mmΦ*
c. *25% in 300mmΦ*
d. *30% in 600mmΦ*

Many large trunk sewers or stormwater culverts will not conform with these values, as the flow never drops to below 30% of diameter at any time during the day. In such cases the inspection equipment may need to be floated down the pipeline to carry out the inspection (refer to Section A2). If available to the Contractor, sonar technology shall be fitted in these situations to the float to give an indication of debris levels in the large sewers.

If the inspection equipment is travelling in an upstream direction, then water may surge in front of the equipment. Therefore, the water level at the start of the inspection will need to be less than the maximum values in table B1.2.2 to ensure that the depth of flow, in front of the camera, does not exceed the maximum values. For example, the flow depth in a 150mm diameter pipe may need to be less than 10% of the pipe diameter to ensure that the water surge does not exceed 20% of pipe diameter. Actual adjustment for an upstream survey will vary, dependant on the pipe size and inspection equipment used.

If there is any sign of erosion or corrosion of the pipe material present, the inspection shall be carried out with the flow direction (setup at the upstream node) and where necessary, the water level must be controlled to a level of at least 10% of diameter below the normal dry weather flow level. The dry weather flow level maybe be indicated by the staining/discoloration of the pipe material from the flow in the pipe.

Figure B1.2.9 – Photo of concrete pipe with erosion and staining indicating the level of normal dry weather flows



If during the inspection the water level rises above 40% of the pipe diameter (for all pipe sizes), for more than 10% of the pipe length, including where the pipe is dipped, (or obstructed downstream) the inspection must be paused and continued in lower flows or with flow control measures in place. If the flow does not return to below 40% of the pipe diameter, or control measures cannot be implemented, then unless instructed by the asset owner to continue, the inspection shall be abandoned. Continuing inspections where the camera lens is below the water level is not acceptable, except in rare cases where the flow in the pipe is clear and defects and features can be clearly identified.

B1.2.3.2 Camera Speed

The camera shall travel through the pipeline as smoothly and consistently as possible, at a speed that enables the camera operator to identify potential defects and stop the camera before arrival at the defect. The required speed may be affected by the cleanliness of the pipe or the frequency of defects. The camera speed shall not exceed the range specified in table B1.2.3

The speed of travel is not relevant for digital scanning cameras (refer Section A2).

Progression through the pipe shall not be unnecessarily limited or delayed. Where the camera is stationary in the pipe for longer than 20 seconds, the video recording shall be paused until the camera recommences its travel through the pipe. Lack of traction, e.g. when travelling upstream on a pipe with a steep gradient, may cause the camera to consistently travel at low speeds. In these cases, it may be necessary to fit a tow line to the camera and pull it through the pipeline.

Table B1.2.3 – Maximum camera speeds

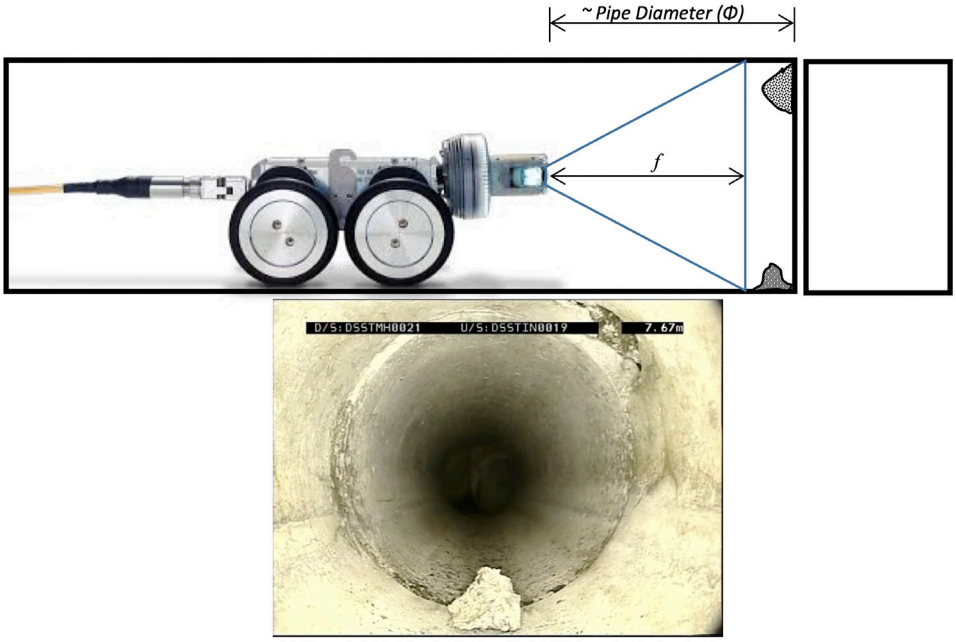
Pipe Diameter	Camera Speed (m/sec)	Camera Speed (m/min)
Up to 200 mm	0.05 to 0.10	3.0 to 6.0
225mm to 300mm	0.05 to 0.15	3.0 to 9.0
Over 300mm	0.10 to 0.20	6.0 to 12.0

B1.2.3.3 Observing Defects and Features

Stopping the Camera

The camera shall be stopped at all defects and features. The stopping position shall be before the camera reaches the defect or feature, where it can be clearly viewed, in focus, within the full circumference of the pipe. This position is approximately a pipe diameter from the defect or feature, and just beyond the Focus Length of the camera. Figure B1.2_10 shows an example of the ideal stopping distance and camera position. The camera shall remain stationary at this location, looking forward along the pipe axis, while continuing the image recording for 5 to 10 seconds.

Figure B1.2.10 – Camera stopping position at defects (and features) where it can be clearly seen in focus within the circumferential location



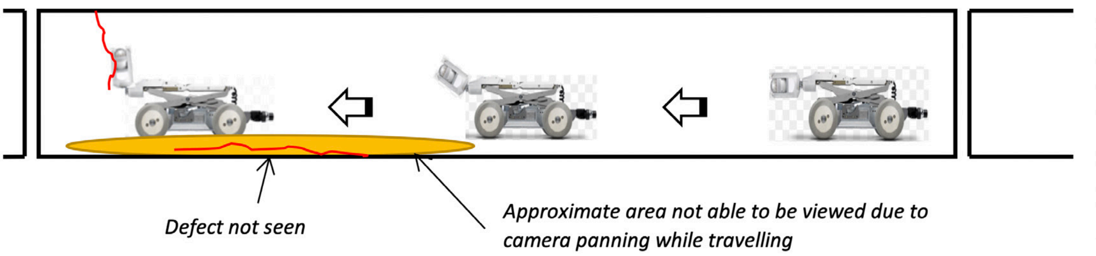
Tilt and Panning

The camera is then moved forward up to the defect or feature. To gain a clearer view of a defect, (that cannot be clearly seen looking down the pipe from the stopping distance) or confirm evidence, or determine the extent of a defect, the camera shall tilt and pan over the pipe surface, ensuring that the image is in focus throughout the panning operation. Where possible, the pan must be performed with the camera head tilted perpendicular (90o angle) to the direction of travel. The camera zoom during panning shall be set at a distance that enables enough detail to be seen, but not too close so that the camera needs to move forward or backwards to be able to observe the affected area. Where possible the full width of the defect shall be able to be viewed while the camera pans around the circumference. The speed of the panning operation shall be regulated, including pausing the panning where necessary, such that the operator or the observer of the inspection can always clearly identify features on the pipe surface. Adjusting the zoom setting while the camera head is stationary, is acceptable. Generally, the inspection of the defect or feature shall not exceed 20 seconds.

Before continuing the inspection, the camera head must be back in the normal position looking down the pipe axis. The camera head shall not be tilted while the camera is in motion. Tilting the camera head while the camera is travelling through the pipe will result in areas of the pipe wall that will not be able to be seen.

When the camera is travelling the image shall have a 'natural' alignment with any flowing water at the bottom of the screen and a horizontal horizon.

Figure B1.2.11 – As the camera begins to tilt up as it travels towards the upcoming defect, there is a loss of view of the pipe invert and any defects present in that location may not be seen.



Tilt and panning defects at a joint

The camera shall be located and tilted so that the view is positioned over the centre of the joint gap. The camera view shall be directly into the joint such that any defects that may be present inside the joint gap can be observed. The pan shall include a full rotation around the circumference, (360o) either as a single pan, in one direction, or completed in both a clockwise and anti-clockwise directions.

Where defects or potential defects are observed to occur within the Joint Zone, but cannot be clearly seen whilst the camera is tilted and centred on the joint gap, the camera shall be temporarily tilted at an angle to enable the extent of the defects to be viewed. The panning shall be paused while the camera head is tilted away from the view of the centre of the joint gap and resumed once the camera is restored to its central viewing position.

Tilt and panning defects at a lateral connection.

The camera shall be tilted so that it is looking into the lateral pipe along its longitudinal axis. Where the lateral connection is not a factory-made junction, or there are defects, or suspected defects within the Lateral Connection Zone, the camera shall be tilted and panned around the Lateral Connection Zone to enable the extent of the defects to be viewed

Tilt and panning defects in the pipe wall

The camera shall be tilted and panned over the affected area sufficiently to explore the extent of the circumferential position of the defect.

All continuous defects must be tracked over the distance they occur. For continuous defects listed in table B1.2.4, the camera must stop and tilt towards the defect, within the distances/frequency outlined, to confirm the severity has not changed or is still present.

Table B1.2.4 – Continuous defects that required regular observation to track

Type of Continuous Defect	Frequency of stopping and tilting
Longitudinal or Multiple Cracking (CL, CLC, CLB, CLD, CM, CMC, CMB, CMD)	1m intervals
Deformed Plastic Pipe (PFC)	1m intervals
Surface Damage (SS, SDL, SAE, SAP, SAM)	At least once every pipe unit or 2.5m intervals
Masonry defects (MM, MUS, DI, MMU)	1m intervals

Using Fixed Head Axial (Non-Pan and Tilt) Cameras

If the inspection is being carried out with a CCTV camera that does not have pan and tilt capabilities, then the camera shall be stopped and shall focus on the defect or feature for 5 to 10 seconds. To further improve the view of the defect, the camera shall then be moved past the defect and then pulled back slowly until the extent of defect has been viewed.

Stopping and panning over defects or features is not relevant when using digital scanning cameras (refer Section A2).

B1.2.3.4 Measurements Taken during the Inspection

Distance measurements need to be accurately recorded during CCTV inspections to enable the position of defects or features to be located.

To enable accurate measurements the camera cable shall be kept taut in front of the distance measurement unit. Camera cable shall not be coiled in front of the distance measurement unit except for the first metre or so at the start of the inspection, prior to setting the distance measure system with the Off-set Distance. If the camera is reversed more that 300mm the camera cable shall be pulled back through the distance measurement unit to ensure that the correct distance measurements are maintained.

The distance reading to defects and features are recorded using the Focal Length, this is the distance recording at the point where the defect or feature 'touches' or is in line with the sides of the monitor. Figure B1.2.12 demonstrates the distance measurement to a defect.

Figure B1.2.12 – Using focal length for distance measurement

Distance measurement recorded for the faulty Joint in this example is 39.2m, where the joint is in line with the

Figure B1.2.13 – Example of measurement to a lateral connection

Distance measurement recorded for the lateral connection in this example is 32.06m, where the centre of the branch lateral is in line with the side of the monitor (lateral visible in top left-hand side).

The distance measurement to features such as lateral connections are recorded when the centre of the lateral connection is in line with the edge of the monitor.

Some software systems automatically capture a photograph and the distance when an observation code is entered. This dictates the position of the camera when the observation code is entered (refer to clause B1.2.3.3) and therefore limits the need for separate distance recording. In this situation, it is acceptable for the distance to be recorded when the photograph is taken, provided the position of the camera is as specified in clause B1.2.3.3, (approximately a pipe diameter) for pipe sizes up to 300mm. Alternatively, the camera shall first be driven up to the defect/feature (after being stationary for 5 to 10 seconds) to display the distance measurement, then reverse the camera to the correct stopping distance without pulling the cable back through the distance measurement unit.

B1.2.3.5 Photos

The asset owner shall specify the need for photographs in the Particular specification.

Photographs are often taken to record the:

a) General condition

b) Condition where it changes significantly during the inspection

As a minimum, a photograph is taken whenever an inspection is abandoned and every time one of the following defects or features are encountered:

i. Collapse or blockage

ii. Soil visible or Tomo's

iii. Deformed pipe section (DF or PF)

iv. Pipe Broken

v. Pipe Hole

vi. Significant Corrosion or erosion (including SPM, SH)

vii. Intrusion of an external object (excluding lateral connections)

viii. Other defects with Medium or Large quantification

ix. Drop structures or bends

The first picture taken shall be a 'straight ahead view' looking down the pipe axis. The camera shall be positioned as described in clause B1.2.3.3.

The second, and any subsequent, photographs can be in a tilted position or zoomed to show detail or view of the defect or feature that cannot be seen in the first photograph. The second and subsequent photographs shall be added to the log sheet report using the General Photograph code (GP). Remarks shall be provided to describe the view perspective if the image has been zoomed.

Figure B1.14 – Example of first photograph and second/subsequent photograph showing defect detail without over zooming

First photograph taken looking 'straight ahead' down the pipe axis, with the camera stopping position as described in clause B1.2.3.3, where the defects (pipe hole and root intrusion) can be clearly seen within the pipe circumference.

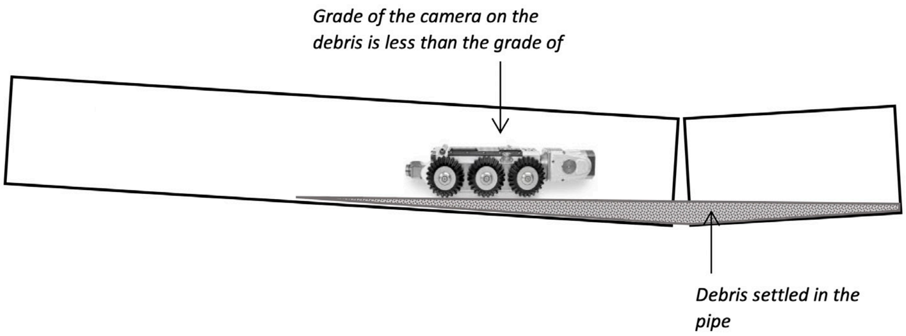
Second photograph taken with the camera tilted and panned towards the defect showing more information that cannot be clearly seen in the first photograph

B1.2.3.6 Measuring Pipe Inclination

Inclinometers built into CCTV cameras measure the change in the camera inclination and not the pipe inclination. However, if the camera is sitting still directly along the pipes longitudinal axis, with no debris in the pipe, the camera inclinometer reading would be expected to indicate the pipe inclination (grade) at that point. The accuracy of different inclinometers varies but are likely to be in the range of +/- 0.3% to 0.5%, for gradients ranging between approximately ±10%.

During camera movement, the camera inclinometer reading becomes less reliable for indicating the pipe inclination due to several factors. This includes variability in the pipe material ("waviness" or cosmetic "rippling" in PVC pipe, wall thickness variability in concrete pipe) minor deflection/deformation in PVC/PE pipe, camera speed, steering and passing over pipe joints. These factors will affect the way that the camera travels through the pipe and the resulting variable inclinometer reading. Because the inclinometer works in the same way as a spirit level, if the camera is not aligned directly along the pipes longitudinal axis, (as the camera will do at times as it moves and rotates through the pipe) then the inclinometer reading will fluctuate as the camera travels through the pipe. Even if stationary, with a constant actual grade, it could be expected that there may be some variability in the camera inclinometer readings at different points in the pipe. If there is any debris in the pipe, then this potentially makes the inclinometer readings of no value in terms of the pipe gradient.

Figure B1.2.15 – Inclinometer reading (grade) measures the grade of the camera not the pipe and can be affected by many factors



Although inclinometers are becoming more stable, the inherent issues mean that they are not intended to take the place of a survey tool, but rather to be used as a reference to identify potential problem areas during an inspection.

Using inclinometers to identify dips is fraught with issues. Because of the variability of the readings the dips would need to be sufficiently long enough (or significant enough) to identify a consistent increase in the inclinometer readings, followed by a consistent negative grade reading, that then returns to the consistent expected grade.

The best practice approach for identifying/quantifying dips with CCTV cameras is

a) Remove all debris from the pipe.

b) If the pipeline has live flows a plug shall be installed, where possible, to prevent debris from re-entering and to control the depth of flow.

c) Flush clean water through the line, introduced from the upstream access point (not using a Hydro-Jetter as this may remove water from dips). The volume of water introduced shall be sufficient that added water is witnessed entering the downstream manhole (this ensures that any dips are filled)

d) The extent and depth of any dips, or humps will be identified by the water ponding at those points.

Where flow control measures involve the use of a hydro-Jetter in front of the camera, which will evacuate any water from a dip, it may be possible to identify the change in height of staining/discoloration from the normal dry weather flow in the pipe to detect the presence of a dip. A great deal of care is required in these circumstances and staining/discoloration may not always be present. The severity of the dip, using this method, would be indicated by the amount of change in height of the normal dry weather flow stain lines.

B1.2.4 Ending a CCTV Inspection

B1.2.4.1 Ending at Manhole or Similar Structure

The inspection shall end with a visual inspection of the ending manhole.

Where the camera can enter the ending manhole

Where possible the inspection shall end at the centre of the ending manhole or structure.

1. Where a pan and tilt camera is used, the camera shall be panned, first in a clockwise direction as far as possible, ideally to obtain a view of the pipe/manhole interface of the pipe inspected (some camera models are unable to tilt backwards sufficiently to be able to view the seal). The camera shall be stopped during the panning operation to identify any incoming or outgoing pipes. This operation is then repeated in an anti-clockwise direction.
2. The camera is then tilted upwards to record as much as possible the manhole walls, lid and incoming pipes.
3. A screen header shall be displayed for 5 to 10 seconds to notify the end of the inspection (refer B1.2.2.8)

Where the camera is not able to enter the ending manhole

There several reasons why the camera may not be able to enter the ending manhole or structure. These include, but not limited to, where there is a drop or cascade into the manhole or a bend. Where the camera is prevented from entering the manhole or structure, the operator shall attempt, by panning and tilting the camera head and/or zoom, to record as much of a view as possible of the manhole or structure. Prior to ending the inspection, a screen header shall be displayed for 5 to 10 seconds to notify the end of the inspection (refer B1.2.2.8).

B1.2.4.2 Finishing at a Lateral Connection or Lamp Hole (Inspection Point)

An inspection ending at a lateral connection shall follow the same process as starting at a lateral connection, (refer to B1.2.2.5). The camera shall be in line with the centre of the lateral connection. Before ending the inspection, a screen header shall be displayed for 5 to 10 seconds notifying the end of the inspection (refer B1.2.2.8).

B1.2.4.3 Abandoned Inspections

The inspection shall be abandoned when the camera is prevented from proceeding further in the same direction. There could be many reasons that may prevent the camera from proceeding such as:

- Obstructions or protruding laterals
- Roots or fat that the camera cannot passing
- Large dip or high flows
- Where there is a risk that the camera may become 'stuck' or damaged if it were to continue e.g. missing invert

Abandoned inspections shall be recorded in the inspection report as per Section B2.1 Coding Principles, clauses B2.1.4.1, Multiple Inspections from both ends of a single asset, and B2.1.6.4C Inspection Abandoned.

Where an inspection is abandoned an attempt must be made to complete the inspection from the opposite node and reach the point where the abandoned survey was stopped. If a reverse survey is not possible, the reasons for this shall be noted in the inspection report comments.

When a reverse survey is undertaken the following precautions shall be taken to prevent the inspections over lapping. i.e. if the reverse inspection can reach the previous point of abandonment, it must stop at that point, and not continue past the previous point of abandonment. The following steps could be taken before the camera is withdrawn from the point of abandonment:

a) Take note of any obvious features that could be identified when coming from the opposite direction, and/or

b) Take note of any camera wheel or skid tracks left in the invert of the pipe that may be seen from the opposite direction, and/or

c) Locate the camera using the sonde locator. Deduct the surveyed length from the GIS length to indicate the expected length of the reverse survey. As the reverse survey approaches the calculated required distance, locate the position of the camera and measure the remaining distance that needs to be travelled to complete the inspection.

If only steps a) or b) are used, the completed reverse survey distance shall be checked against the expected GIS length to check or confirm inspection is complete.

B1.2.5 Changes to the Asset Being Inspected

The location, length or general layout of the asset may be identified as different from that shown in the asset owners GIS. In these cases, the Contractor must:

a) Carry out reporting and asset identification as per Section B2.1 Coding Principles, clause B2.1.5.2 New Asset Identification

b) Provide a marked-up drawing showing manhole locations and pipe network layout and how they differ from the GIS.

Marked-Up Drawings shall where possible be based on the asset owners GIS maps, using aerial maps as the base. New assets shall be highlighted in red, and abandoned or non-existent assets marked in yellow. These types of drawings are sometimes referred to as Red-line Drawings.

GIS drawings or supplied construction drawings (for new developments) shall be the most up to date versions. Where construction drawings are used, these shall include the node and pipe reference names (and road names) used on the approved design/construction drawings.

Marked-up measurements shall have an accuracy of +/- 0.3m. Measurements must be made from permanent features such as buildings, existing manholes, site boundaries or the outside kerb face. Offset measurements are preferred, but intersecting arc measurements may also be made, with a minimum of two measurements in each case, being made as close as possible to perpendicular to each other. A minimum of two measurements shall be made to a manhole cover.

The marked-up drawings must clearly indicate the address of the properties in which the manholes or pipeline are located, or the nearest adjacent property where the assets are in the road reserve or a park. At least one adjacent property shall also be identified to facilitate later location by other personnel.

Where Coordinates have been specified as a required (optional) header fields by the Asset Owner (Header Fields AAE and AAG) these shall be referenced on the marked-up drawings.

B1.2.6 Reporting of Hazards and Significant Defects

There are situations that may be found during the inspection of a pipeline which require urgent attention by the asset owner to avoid blockages, causing overflows and environmental damage.

Significant structural defects found in the sewer could indicate that a failure of the pipe is imminent and urgent action is needed to prevent the failure. Where the following structural defects are found during an inspection, the CCTV Contractor shall notify the asset owner as soon as possible:

- Pipe Collapsed (PX, MX)
- Deformed pipe, Large severity (PFVL/PFHL & DFVL/DFHL)
- Pipe Broken, Large severity (PBL)
- Pipe Holed, Large Severity (PHL)
- Pipe Missing (SPM)
- Missing Masonry Units, Large severity (MMNVL)
- Tomo (TM)

All obstructions, deposits (DG, DE and ED) and tree root intrusions of more than 50% of the diameter (refer to Clause B2.1.6.3C Quantification Sub-Codes, method 2 in section B2.1 Coding Principles, coded as 'B' Blocked Pipe) are defined as significant flow capacity hazards, with high risk of blockage and an overflow occurring. Where these defects are found, the CCTV Contractor shall notify the asset owner as soon as possible. If these hazards are removed with cleaning or root cutting as part of the CCTV inspection, the hazard shall still be notified, but communicated that the hazard has been removed.

B2.1 Coding Principles

B2.1.1 Introduction

This section covers the principles used to record and interpret the information that is collected as part of a visual, internal inspection, of a gravity pipeline. The following procedures for recording information are designed to define the attributes of the pipeline and classify the defects that describe the pipe condition.

There are several field data capture and reporting software systems available to pipeline inspection contractors. Likewise, there are a variety of different Asset Management Information Systems (AMIS) used by asset owners. The method of recording, storing and reporting inspection information will not be the same for each system. This manual does not set out to specify the specific layout of the inspection reports or how the information is stored by software systems. This manual does set out a minimum standard for the type of information to be collected and how it is to be classified. It also sets out what information is to be provided in the gravity pipeline inspection reports within New Zealand.

B2.1.2 The Coding System

The coding system for gravity pipe comprises a series of codes that describe the defects and features observed, as well as attribute data collected during the inspection. Each asset must be treated separately, with a separate report produced for each. Each report contains two sections as follows:

a) Header information—this is information relating to the pipe and contains information about the inspection undertaken and about the pipe. This information is described in sub-section B2.1.4 and the codes are described in Section B2.2 Header Classification Codes.

b) Information about defects and features encountered within the pipe - the process for recording observation information is described in sub-section B2.1.6 and the condition classification codes are described in Section B2.3 Condition Classification Codes.

B2.1.3 Transfer of Encoded Data

While it is acceptable under this code to generate handwritten or typed pipe inspection reports, most asset owners want the information in an electronic format to provide for information transfer and automatic uploading into their AMIS. Data transfer protocols will normally be established to enable the exchange of data between different inspection and AMIS software systems.

Asset owners need to ensure that protocols for the transfer of data into their specific AMIS are specified in tender documents. It is then the contractor's responsibility to ensure that the required encoded inspection reports can be transferred from their field data capture software system into the asset owner's AMIS.

Data transfer may also be undertaken for benchmarking pipe condition and defects with other regions outside of New Zealand. The European Committee for Standardisation published the European Standard EN 13508-2 "Investigation and assessment of drain and sewer systems outside buildings – Visual inspection coding system" which provides a process for transfer of pipe condition data for this purpose.

EN 13508-2 is the basis for condition classification within European countries, and the United Kingdom, through the WRc Manual for Sewer Condition Classification (BS EN13508-2:2003+A1:2011). It also extends, via license to the WRc, to North America's National Association of Sewer Service Companies, (NASCO) Pipeline Assessment Certification Program (PACP). This standard specifies an agreed set of descriptions to classify defects and features, and permits each country to use friendly mnemonic codes as classifiers, but imposes a universally compatible process for the transfer of data. Australia's conduit reporting code, WSA05, generally aligns with the standard, although WSA05 has many Australia specific codes that do not match the European Standard and would be lost in the data transfer process. The New Zealand condition classification system (header and observation field codes) set out within this manual are also based on the EN 13508-2 standard, but, like the Australian WSA05, there are many New Zealand specific codes that are not directly transferable into the EN 13508-2 standard without either loss of data or requiring data manipulation/conversion before the transfer process. This is explained further in B2.1.6.2 and Section B2.2. The format for the electronic transfer of coded data is provided in Appendix A.

B2.1.4 Header Information

The header is used to record information about the inspection and the asset that has been inspected. Some of the information is necessary to ensure that the data can be matched with existing assets and easily retrieved from an AMIS. Other types of information in the header record data can be used to update or confirm information already known about the asset. Being able to asset-match and locate the inspection data is a critical requirement and therefore the header information to be recorded is categorised as either mandatory, or optional, information. Which category the type of header information belongs to is identified in Section B2.2 Header Classification Codes.

A Mandatory Header Information

Mandatory header information is required to ensure the asset being inspected is uniquely identified and records the circumstances of the inspection. It identifies:

- The asset inspected (sufficient to uniquely identify the asset)
- Origin of the inspection (purpose, contractor, personnel involved)
- Video records relating to the inspection (video file name)
- Status of the inspection (Inspection completion status, pre-cleaning status and when the inspection was carried out)

B Optional Header Information

Optional header information will generally relate to the asset attributes. They are not necessarily required to assess the asset condition or identify the inspection, but can be used:

- To supply new attribute information in the AMIS database;
- To check existing attribute information in the AMIS database;

The attribute information can be used to compare field observations with existing database records. If there are significant discrepancies (e.g. in the recorded and observed line length) it can mean that either the contractor has wrongly identified the asset or manhole position, or the existing AMIS database record is incorrect.

The term “optional”, does not imply a choice for the Contractor. The extent of the information to be recorded can vary depending on the purpose of the inspection. The optional header information to be captured and supplied by the contractor is specified by the asset owner.

B2.1.4.1 Multiple Inspections from both ends of a single Pipe Asset

Where multiple inspections are required to be carried out on a single asset, those inspections shall be recorded against a single header so that defects and features are related to a single inspection reference. All the measurements need to be related to a single origin (the upstream manhole), but the distances will be displayed from both the upstream and downstream manholes using a camera setup, or direction, code (based on the “Measured From”, refer to B2.1.6.3E) against each condition code.

Multiple inspections require close attention to ensure that:

- The full extent of defects such as dips are recorded, i.e. the start and end of continuous defects and features that span across the two inspections are recorded.
- Overlapping of inspections does not occur and defects or features are not recorded twice.

Header details such as identification and attribute information shall not alter. If inspection dates are different the inspection dates shall be recorded as a “Remark” against the start of the second inspection.

B2.1.5 Encoding of Headers

A full description of the Header Information Codes is detailed in Section B2.2 Header Codes. The following provides guidance on the collection and interpretation of header field information.

B2.1.5.1 Recording of Information

Header information shall be entered at the start of each asset inspection.

Any changes to header information identified during an inspection shall be recorded, or edited, as they arise.

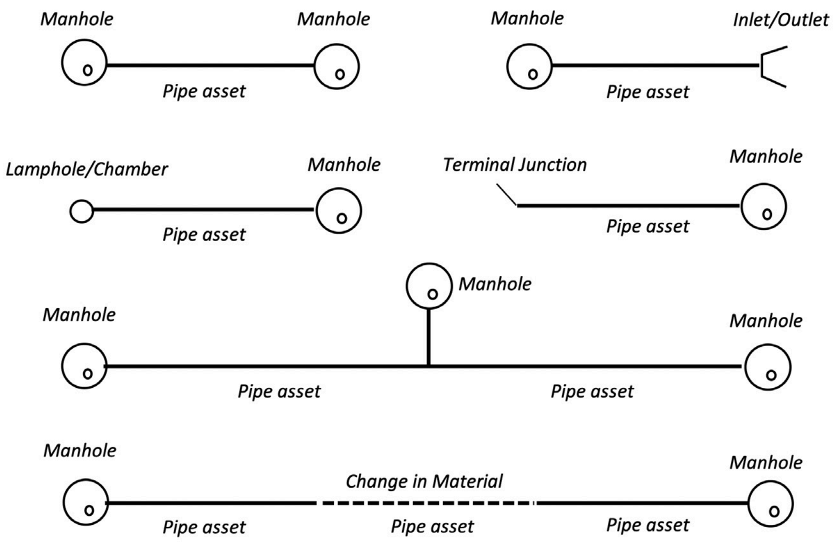
B2.1.5.2 Asset Identification

Pipeline assets are usually defined in the asset owner's AMIS. Typically, a pipe asset will consist of a single pipe section between an upstream and a downstream manhole. Some databases may identify several separate pipeline assets between manholes because of pipe material changes, or other situations. In these cases, the start or end point of the asset is a Node. Where the asset owner has identified a node between manholes, irrespective of whether there is an identifiable feature at that point or not, it shall be treated as a start/end point of an inspection. In this case a node will normally be identified by the distance from the start upstream or downstream manhole/node. In any case, a separate inspection header must be completed for each asset inspected.

If the inspection reveals a significant change in the asset (e.g. material, diameter) without a node being specifically identified by the asset owner, then this would be recorded as a 'feature' unless the asset owner has nominated that such changes be identified as a node point to separate assets.

As the description of a pipeline asset is not consistently defined between asset owners, it is important that prior to inspection, the extent of the asset to be inspected is correctly identified, and the rules that an asset owner uses to define start and end nodes are understood.

Figure B2.1.1 – Examples of 'typical' pipe asset definitions



Assets are typically identified by their Asset Identification Number (AssetID). The AssetID is a unique reference number allocated by the asset owner within the asset owner's AMIS to link the asset location, attributes, maintenance records, inspection records and any other asset specific information. There will not be two assets in an asset owner's AMIS (within the same network and asset type) with the same Asset ID. The accurate entry of the Asset ID by the contractor in the inspection header field is crucial to avoid the results of an inspection being allocated to the wrong asset, or not being allocated to an asset at all.

Some AMIS may identify pipeline assets by utilising the manhole/node Asset IDs at each end of the pipeline asset. In this case the pipeline Asset ID field would be populated as the concatenation (combining) of both manhole/node Asset ID's.

The asset owner shall provide to the contractor a list of Asset IDs for all the assets to be inspected.

B2.1.5.3 New Asset Identification

In some cases, inspections will be required of new assets that do not have a AMIS AssetID. These inspections will generally be post-construction surveys of newly created assets, that are not yet included in the asset owner's database, or due to locating unrecorded manholes or changes to the pipeline layout or connectivity. There are several issues involved:

- Where a previously unrecorded manhole or node is found during an inspection of an existing asset, a new inspection report is started.
- The contractor must allocate a unique 'temporary' identification number to any new manhole or node so that the asset owner can add them to the AMIS.
- The portion of pipe inspection beyond the newly discovered manhole or node, or where the pipe layout differs from the Asset Owners GIS, will also be allocated a unique 'temporary' identification number as this will also need to be changed in the AMIS.
- Where pipe and node identification numbers (and road names etc.) have already been allocated by a developer, these shall be provided to and used by the CCTV contractor to identify the assets.

The method of allocating temporary identification numbers for new assets shall be outlined by the asset owner in the contract specification.

B2.1.5.4 Inspection Status

The 'inspection status' provides information on the completeness of the survey, when the inspection was done and whether the inspection was carried out before or after cleaning or root cutting. The combination of this information may identify a specific inspection, or inform the asset owner that several inspections of a single asset have occurred.

The inspection status is described by the combination of five separate mandatory header fields; Inspection Completion Status, Inspection Date, Time of Inspection, Purpose of the Inspection and Cleaning Status:

A Inspection Completion Status

The inspection is "Complete" when the entire asset has been inspected from either one end or from both ends of the asset. There are several circumstances that describe a complete inspection:

i. The inspection equipment completely passes through the asset from, and to, the centre of the start and end nodes from a single direction

ii. The inspection of the pipe is abandoned from one direction, but the inspection equipment reached the same point in the pipeline from the other end of the pipe.

iii. The inspection of the pipe is otherwise complete but:

  a) The inspection equipment could not start at the centre of the start manhole for any reason, but a clear view of the start of the pipe can be seen at the commencement of the inspection, including the pipe connection with the manhole wall.

  b) The inspection equipment cannot be taken to the centre of the finish node for any reason, but the condition of the remainder of the asset is clearly visible

An inspection is Uncompleted if the entire asset could not be inspected (i, ii or iii above not achieved) and the inspection has been abandoned.

The Inspection Completion Status is entered in the Header Field ABS.

B Inspection Date and Time

The date and time the field inspection was carried out (not the date and time the inspection coding was completed).

Where the inspection is completed from both ends under a single header, and the second, reverse inspection, is not carried out straight after the first inspection, the time (and date if not on the same day) shall be noted in the remarks against the second Inspection Starts (IS) code.

C Purpose of the Inspection

There are many reasons why an inspection may be required. This field records the intended purpose of the inspection. The operator enters a code in this field which best describes the purpose of the inspection. The codes for this field are provided in Section B2.2, field ABP.

D Cleaning Status

Identifies if any pre-cleaning or root removal has been undertaken prior to the inspection. The operator enters a code, provided in Section B2.2 Field ACM, that confirms one of the following cleaning statuses:

- The pipe was not cleaned prior to the inspection
- The pipe was light cleaned prior to the inspection
- The pipe was heavy cleaned prior to the inspection
- The pipe was root cut prior to the inspection

The following are examples of how the inspection status fields can be used to describe the status of the Inspection Status:

1. Uncompleted, operational exam, carried out on 18/04/18 at 9:30am, not cleaned
2. Complete inspection of an earlier abandoned inspection, carried out on 18/04/18 at 1:00pm, after cleaning

In the two examples above, both inspections were carried out on the 18 March, but with combination of the other four fields we can quickly determine that inspection #1 was carried out first, and inspection number 2 was completed later in the day after cleaning of the pipeline had been undertaken. The order of the fields is not important, if the interpretation is clear.

B1.2.5.5 Confirming Pipe Asset Attributes

A Measuring Length

There are three length measurements that could be recorded as part of the pipe inspection:

Pipe Length

The pipe length is the measured length of the pipe asset. The measurement is from the centre of the upstream node to the centre of the downstream node, (refer to Figure B2.2). Where the inspection is complete, both the Pipe Length and Survey Length will be the same. Where the inspection is not able to be completed, or the inspection equipment is not able to traverse the full length, the value to be recorded in the Pipe Length field shall be, (in the following order):

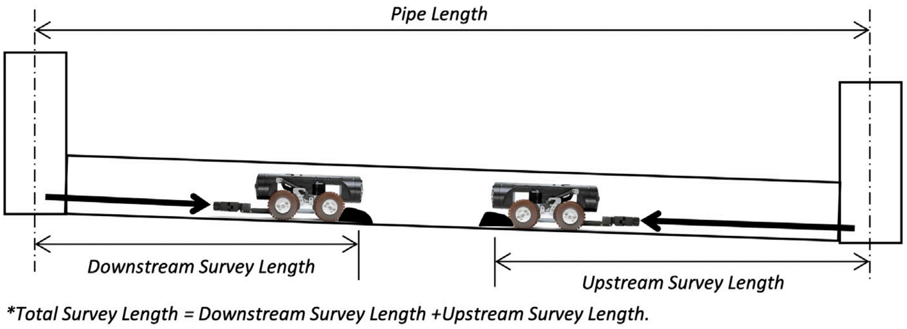
1. The pipe length measured above ground, (e.g. using a measuring tape).
2. The GIS length, if physical measurement is not possible
3. Left blank, if the GIS length is not available

The measured line length will differ from the GIS length where the pipeline is on a significant gradient. At a gradient of 20% or more, (1:5) the slope distance will exceed the plan distance by over 6%. The measured line length may also differ from the GIS length due to errors or inaccuracy of the GIS information. Attribute information collected as part of the inspection enables existing asset attribute data to be checked and updated where appropriate.

Surveyed Length

The Surveyed Length is the length of pipe asset surveyed. The Surveyed length is recorded from the video display. Where an inspection is completed from both ends under a single header, the Surveyed Length is the sum of the two survey lengths. The Surveyed Length may be less than the Pipe Length if the inspection is not able to be completed.

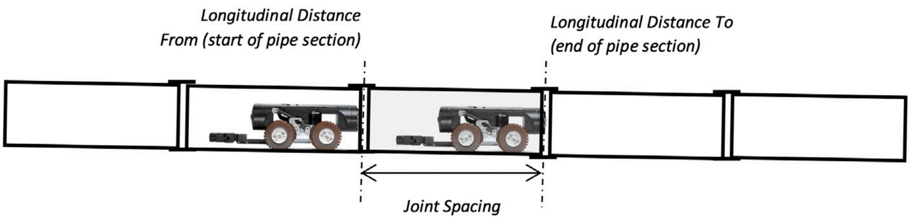
Figure B2.1.2 – Example of the different measurements where the inspection is uncompleted.



Joint Spacing (Pipe Segment Length)

The length of the pipe segment between pipe joints, is referred to as the Joint Spacing. This is measured by observing the difference in the distance shown on the distance video display as the video camera passes each joint. The Joint Spacing is confirmed by measuring serval consecutive pipe segments (excluding the manhole shorts, or sometimes referred to as rocker pipes at the start and end nodes).

Figure B2.3 – Measuring the pipe segment length to determine the Joint Spacing.



B2.1.5.6 Identifying Pipe Materials

The "Material" field may be used to confirm the accuracy of, or update, the information in the asset owner's AMIS. The data in this field is therefore based on the Operator's observation and is not taken from supplied information. Refer to Table B1 in Appendix B for a list of the pipe material codes and descriptions.

The material can often be identified based on visual evidence (e.g. colour, surface texture, type of joint or visible stone aggregates) and the Joint Spacing. Typical joint spacings for common pipe materials are:

Table B2.1.1 – Typical material joint spacings

Material	Typical Joint Spacing
Asbestos Cement	4.0m
Cement lined steel	6.0 to 12.0m
Non-Reinforced Concrete,	0.6 to 1.2m
Steel Reinforced Concrete,	1.8m to 2.5m
Earthenware/Stoneware	0.6 to 1.0m
Polyvinyl chloride	3.0 to 6.0m
Vitrified clay	1.2 to 1.8m
Polyethylene	12m identified by internal weld bead (if not removed)

Where the Operator is unable to determine what the pipe material is, the Material field shall be left blank and relevant comments provided in the "Comments" header field.

B2.1.5.7 Recording Pipe Size

Pipelines come in different shapes and sizes. Although most pipelines have a circular profile, some are rectangular, arch-shaped, oval or egg-shaped. Recording the pipe size requires different ways of expressing the pipe dimensions and describing the shape.

The size of circular pipes is described by the pipe diameter. Rectangular or Square shape pipe are described by two-dimension measurements, i.e. "Height" and "Width".

Other shapes, as mentioned above, have a combination of a circular and rectangular elements. These shapes are also described by height and width. In these cases, the width is the widest horizontal point in the shape, which is commonly the diameter of the circular component. The term Width and Diameter are therefore interchangeable in those circumstances.

The following header fields are used for recording the pipe size:

A Width/Diameter

This field is used for recoding the diameter of circular pipes, or the maximum horizontal dimension of the other shapes.

B Height

For non-circular shapes, the measured Height (vertical), measurement is recorded. Where the shape is circular, this field is left blank.

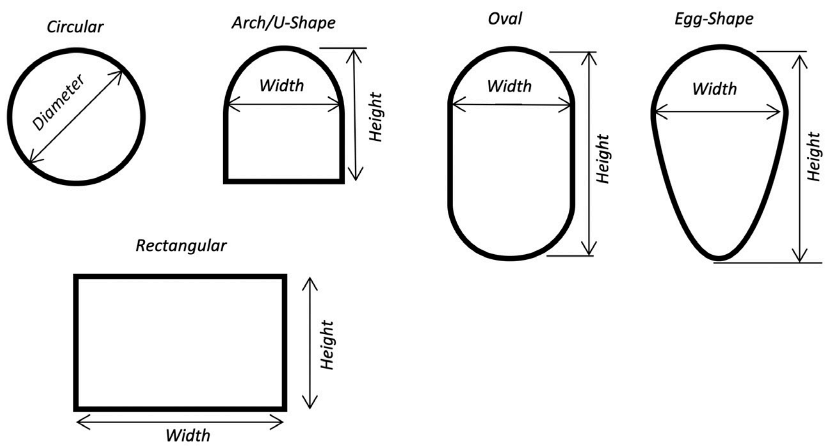
C Shape

Shape describes the pipe section profile and clarifies the recording of the dimension fields. A code is entered that describes the shape. The codes for this field are provided in Section B2.2, Header codes.

The pipe size must be measured by the Operator (refer to the example diagrams in Figure B2.4 below) and not taken from existing attribute information (plans or GIS). Where the pipe dimensions cannot be measured, dimension fields shall be left blank and relevant comments shall be provided in the "Comments" header field.

Where it is identified during the inspection that the dimensions have changed from the initial "tape" measurements at the start manhole, the change in dimensions shall be noted in the observations using the Dimension Change code, "DC", at the longitudinal distance they occur.

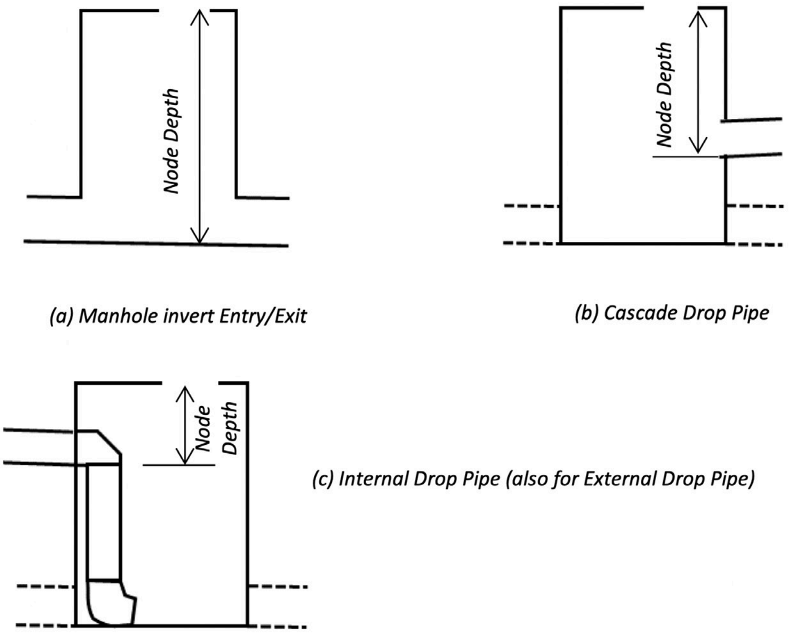
Figure B2.1.4 – Examples of typical pipe shapes and the dimensions used to record the pipe size



B2.1.5.8 Measuring Node Depth (Depth to pipeline)

The node depth is measured from the ground surface (top of manhole cover) to the invert of the pipeline inspected.

Figure B2.1_5, examples of typical situations and the measurements for the depth of node (depth of pipe)



(a) Manhole invert Entry/Exit

(b) Cascade Drop Pipe

(c) Internal Drop Pipe (also for External Drop Pipe)

B2.1.6 Observation Information

A full description of the condition classification codes is detailed in Section B2.3 Condition Classification Codes. The following specifies the observation information fields to be completed, and provides guidance on the collection and interpretation of the information.

B2.1.6.1 General

Observations within a pipeline are defined as either defects or features. Defects can be described as faults in the pipeline that deteriorate the strength, durability, water tightness or hydraulic performance of the pipeline. Furthermore, defects can be classified as either structural, (strength related) or service (performance related in terms of effects on the conveyance of water through the pipe). Features are attributes or components of the pipe or information related to the inspection being undertaken that are not defects. Significantly, defects require quantification and attract weighted scores used in the process of analysis of the preliminary condition grades, (refer to Section E3.1) whereas features do not.

Each observation of a defect or feature is described by one or more main observation codes, each of which shall be accompanied, as appropriate, by other supporting information sub-codes and fields.

Defects and features are encoded using the data fields, (described in table B2.2) in the order that they are observed in the inspection. Some of these data fields provide essential information required to fully classify the observations. Others provide additional information that may be required for some software applications or for reporting. For this reason, the observation data fields are categorised as either mandatory or optional.

B2.1.6.2 Observation Information Data Fields

The observation data fields used in New Zealand are listed in Table B2_2. These fields are based on those used in the European Standard, EN 13508-2 "Investigation and assessment of drain and sewer systems outside buildings – Visual inspection coding system", and WSA 05 Conduit Inspection Code of Australia. The EN 13508-2 and WSA 05 data fields are identified with a code (A-O as described in Appendix A). Not all the EN 13508-2 or WSA 05 observation data fields are used in New Zealand, and an additional code "P", Measurement From, has been added to cover New Zealand specific requirements that are not covered by the other standards. The observation field codes are generally not included in the naming of the observation fields, but are intended to be used as a reference for the format for the electronic transfer of data (refer to Appendix A).

The Main Observation Codes and Characterisation codes are specific to New Zealand, although some are based on the Australian WSA05 codes where practicable. The intent is that where practicable the codes, Characterisation and quantification have been established so that they can be directly converted for benchmarking with other countries, if required. There are, however, many Main Codes that are unique to New Zealand, either because of the need to maintain historic data records, or to ensure relevant means of determining pipe condition that is meaningful in the New Zealand Context. In virtually all cases, as the same types of defects are common everywhere in the world, these unique codes could, with some manipulation, be converted/translated if it is required to report in the EN 13508-2 or WSA 05 format.

Table B2.1.2 – Observation Data Fields

Observation Field for Reporting	Description
Main Code	Principal defect or feature code
Characterisation	Additional codes that describes a defect or feature in more detail.
Quantification	Additional code that quantifies the severity of the defect.
Longitudinal Distance	The distance measured from the start node to a defect, or feature.
Measurement From	A single code, (U/D) identifying the node that the longitudinal distance to the defect or feature is measure from (i.e. the Upstream or Downstream node).
Circumferential location, Position From	One or two clock face references that locate the position of a defect or feature around the circumference.
Circumferential location, Position To	
Continuous Observation Code	Denotes a defect or feature that continues for a distance greater than one metre length, or is a repeated feature that occurs in at least three out of four adjoining pipe segments.
Photograph Reference (Optional)	A reference to identify any still photographs
Remarks	Text that describes aspects of the observation that cannot be described any other way.
Video Reference (Optional)	A video recording timer reference to locate a defect or feature within the continuous video record of the inspection.

B2.1.6.3 Encoding Observations

The following information describes the information to be captured in the observation data fields and their interpretation.

A Main Code

The main observation codes, which are used to describe the defect or features, are set out in Section B2.3 Condition Classification Codes. Observations shall only be recorded using these codes.

Where necessary two or more main codes shall be used to describe a complex observation of different structural and service defects and features, at a single location, that cannot be addressed by a single code.

To simplify their reference, these codes have been formed into related groups based on their similarities, either in terms of the components they relate to, (e.g. Joints or laterals) or by the type of information they are providing. This grouping shall not be used to interpret or otherwise restrict the meaning of their terms. Coders shall use whichever of the codes of Section B2.3 that best describes the situation. Also refer to B2.1.6.7 for encoding defects within a single metre of pipe.

Groups include:

- **a)** Codes relating to the strength or durability of pipe walls.
- **b)** Codes specific to masonry pipelines (pipelines constructed of brick, stone, or masonry block).
- **c)** Codes relating to pipe joints (includes some aspects in common with pipe walls).
- **d)** Codes relating to lateral connections (also includes some aspects in common with pipe walls and joints).

e) Codes relating to linings and repairs.

f) Codes relating to blocking and leakage of the conduit.

g) Codes describing miscellaneous observations concerning the construction of the pipeline and administration of the inspection, including codes for changing header information.

B Characterisation sub-codes

Characterisation sub-codes further describe the defect or feature. Meaningful names have been assigned to the Characterisation data field in many cases to assist comprehension.

Not all main observation codes have Characterisation codes, some Main Observation codes do not, and the Characterisation data field is left blank for those codes.

Any other relevant information that cannot be communicated using the prescribed Characterisation codes, or do not have a Characterisation code, shall be the covered using a General Comment, code GC, (Code Reference I6.2).

C Quantification sub-codes

Quantification provides an indication to the size or extent of the defect. This is commonly referred to as the Severity Rating. Some defects do not require a Quantification code, in which case this field is left blank.

Quantification codes express a range of values that fit within a band. There are three quantification codes that cover the bands of values. These codes are:

S – Small Severity

M – Medium Severity

L – Large Severity

The method for quantifying defects is not the same for every defect. Some defects require the measurement or estimate of a dimension, (e.g. width of a joint gap) or percentage of an affected diameter or circumference. In other cases, the operator may be required to assess severity based on available visual evidence.

To assist with the application and comprehension of the different requirements for quantifying the relevant defects, the different methods have been formed into related method groups. Most of the methods fit within three groups, with a small number that have unrelated, unique, outlier methods of quantification.

The three main groups, and six Outlier groups are:

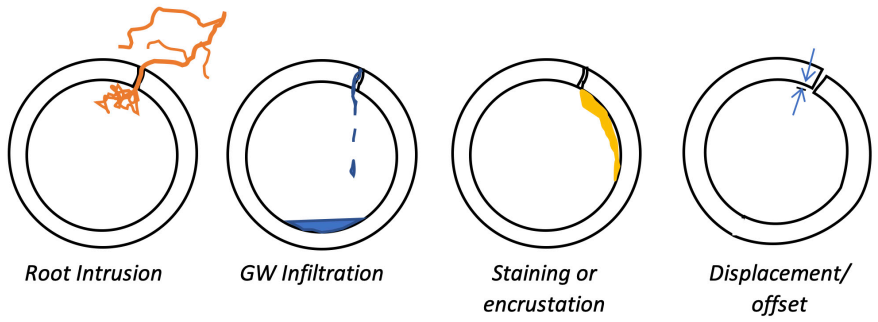
Method 1 – Evidence of a pathway to the outside of the pipe

This method requires the assessment of the visual information, or evidence, available to assess if there is a pathway through the defect to the outside of the pipe. Evidence of a pathway would include the following:

1. A vertical displacement/offset of the pipe wall either side of a crack
2. Active Infiltration entering the pipe through the defect
3. Ground water stain on the internal pipe wall surface originating from the defect
4. Build-up of encrustation deposits on the pipe wall originating from the defect
5. Roots entering the pipe through the defect
6. Visual confirmation of soil or cavity outside of the pipe

The presence of any of these evidence types would result in a L (Large) code for the defect. The scale of the evidence does not matter e.g. large tap roots Vs fine roots – only their presence. If the type of defect is apparent, but there is no evidence of a pathway, then a S (Small) or M (Medium) code will be recorded.

Figure B2.1.6 – Examples of visual evidence of a pathway to the outside of the pipe through a crack



The quantification code is banded as follows:

S Small, the defect is visible but there is no evidence that the defect extends all the way through the pipe wall

M Medium, there is some visual indication that there may be a pathway through the pipe wall, but there is no clear evidence that is present.

L Large, there is clear visual evidence that the defect extends all the way through the pipe wall.

Method 1 – Applies to the following Main Codes:

- Cracks (CC, CL, CM)
- Joint Faulty (JF) (but not used where the Characterisation code B (broken) is applies)
- Lateral Faulty (LF)

Method 2 – Reduction in the pipe diameter

This method requires the measurement, or estimation, of the reduction in the pipe diameter that is available for flow. In some cases, where the cause of the reduction in diameter is distributed around the pipe circumference, the total reduction in diameter is based on the accumulated reduction effect of the defect (e.g. fat or encrustation deposits on the pipe wall, refer to the example in Figure B2.7.

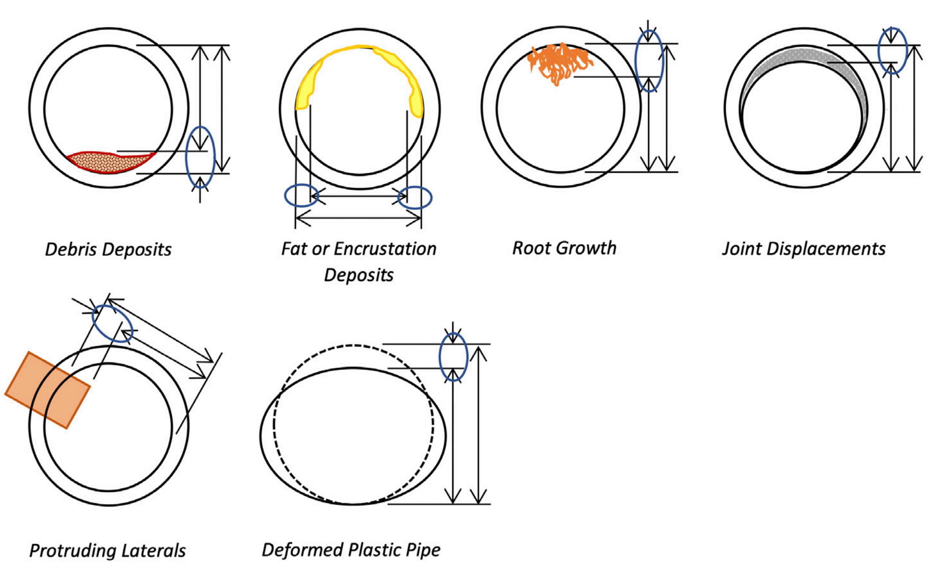
The quantification code is banded as follows:

S Small, the defect reduces the diameter up to 10%.

M Medium, the defect reduces the diameter between 10% – 25%.

L Large, the defect reduces the diameter greater than 25%.

Figure B2.1.7 – Examples of defects that result in reductions in diameter



Method 2 applies to the following Main Codes:

- Joint Displaced (JD)
- Lateral Protruding (LP)
- Deformed Plastic Pipe (PF)
- Surface Damage - Tuberculation (ST)
- Protective Lining Defective – Wrinkling (PLW, PLWC, PLWL), Blistering (PLB), Bulged (PLBU)
- Debris Silty (DE)
- Debris Greasy (DG)
- Encrustation Deposits (ED)
- Root Intrusion (RI)
- Obstruction (O)

Method 3 – Portion of the pipe circumference affected

This method requires the measurement, or estimation, of the portion of the pipe circumference that the defect affects.

The quantification code is banded as follows:

S Small, the defect covers up to 10% of the pipe circumference.

M Medium, the defect covers between 10% – 25% of the pipe circumference.

L Large, the defect covers greater than 25% of the pipe circumference.

Figure B2.1.8 – Quantifying Pipe Circumference. The figure shows the proportion of the circumference of a pipe for 10% and 25% bands. 25% is equal to one quarter of the 'circle'.

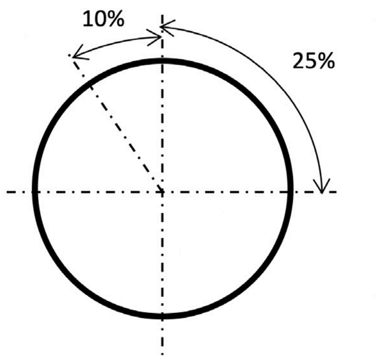
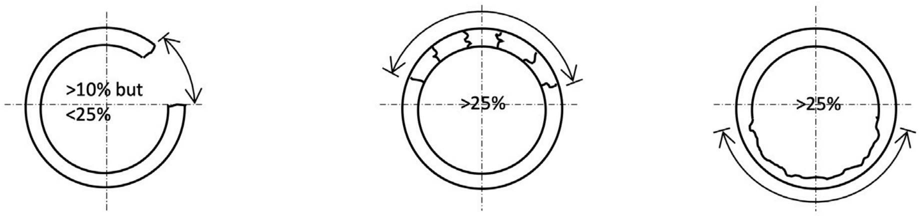


Figure B2.1.9 – Some examples with defects that are quantified by their circumferential measurements.



Method 3 applies to the following Main Codes:

- Missing Masonry Unit (MMU)
- Displaced Masonry Unit (DMU)
- Missing Mortar (MM)
- Surface Damage – Aggregate Exposed (SAE), Aggregate Projecting (SAP), Aggregate Missing (SAM), Reinforcement Corroded (SRC), Reinforcement Visible (SRV), Reinforcement Visible Projecting (SRVP), Corrosion Products (SCP), Mechanical Damage (SMD), Holed (SH), Wall Staining (SWS)

The following defects generally utilise Method 3, but have the following variation:

- Pipe Broken (PB) and Joint Broken (JFB) – These defect codes use method 3, but in addition the amount that the pieces of broken pipe wall are displaced is also considered. Where the broken pieces are displaced from their position by more than half the pipe wall thickness, the defect quantification band is Large.
- Pipe Holed (PH) – Small band is used where the hole, (regardless of % of circumference affected) has been covered or filled and is not open to the outside of the pipe. The medium band range covers all other holes from less than 10% up to 25% of the pipe circumference.

Outliers to the general method groups

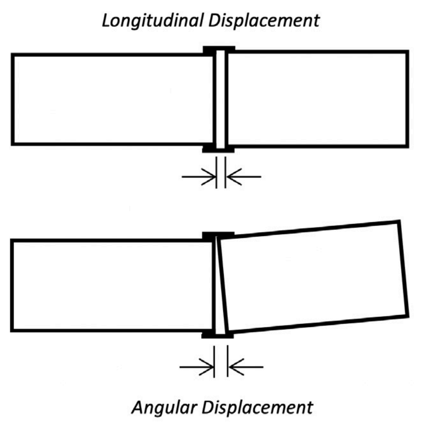
The following identifies the quantification methods associated with single defects that do not fit within one of the 3 quantification methods described above.

Outlier Method 1 – Measurement of the Joint Gap

This quantification method applies to Open Joints (Code Reference J3.2, Section B2.3). The method requires the measurement of the width of the widest part of the gap between two pipe segments.

Where there is a straight longitudinal displacement, the width of the gap will be consistent around the joint. If the next pipe segment is deflected, relative to the other, (vertically or horizontally) the joint will have an angular displacement and the width of the joint gap will vary around the joint. Figure B2.10 shows example of the two scenarios, and the gap to be measured.

Figure B2.1.10 – Examples of two types of Open Joint



The quantification code is banded as follows:

S Small, longitudinal/angular displacement up to 20mm.

M Medium, longitudinal/angular displacement between 20mm and 40mm.

L Large, longitudinal/angular displacement greater than 40mm.

Measurement using standard CCTV equipment may not be possible, and the width of the joint gap would need to be estimated. Where possible, the use of equipment that can measure the gap is preferred.

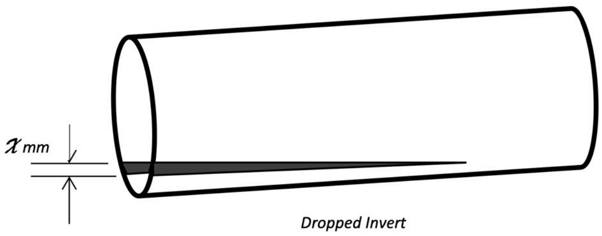
Outlier Method 2 – Measurement of the Brick Separation

This quantification method applies to the following masonry pipe defects

- Masonry unit separation (MUS)
- Dropped Invert (DI)

The method of quantification requires the measurement of the width of the separation gap between the bricks. Code applies when there is a minimum separation of 2x standard mortar joint width (or 20mm, whichever is the smaller)

Figure B2.1.11 – Dropped Invert with measurement of the horizontal gap separation on both sides of the pipe.



The quantification code is banded as follows:

S Small, longitudinal displacement up to 20mm.

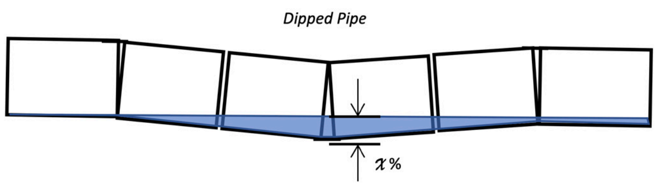
M Medium, longitudinal displacement between 21mm and 50mm.

L Large, longitudinal displacement greater than 50mm.

Outlier Method 3 – Dipped Pipe

This quantification method applies to Dipped pipes, or where the pipe grade deflects downward, before returning the original grade There is not a continuous fall in the pipe and water, and solids, will pool. (Code Reference S5.7, Section B2.3). The method of quantification is the depth of the dip, (depth that water will pool before being able to flow down the pipe) at the deepest point, expressed as a % of the pipe diameter.

Figure B2.1.12 – Dipped Pipe with maximum depth estimated as a % of diameter



The quantification code is banded as follows:

S Small, depth of dip up to 25% of the pipe diameter.

M Medium, depth of dip between 25% and up to 50%

L Large, depth of dip 50% or greater.

Outlier Method 4 – Deformed (Rigid) Pipe

This quantification method applies to rigid pipes where deformation is occurring, (Code Reference PW1.6, Section B2.3) identified by parallel longitudinal cracking through the pipe segment, (between joints). typically occurring at points: 12 O'clock, 3 O'clock, 6 O'clock and 9 O'clock.

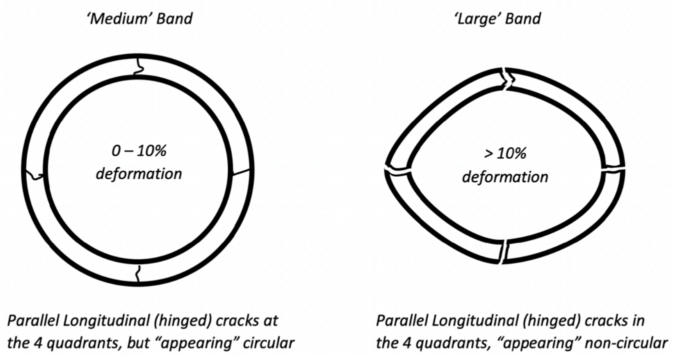
The quantification code is banded as follows:

S Not Used.

M Medium, deformation resulting in a reduction in diameter of up to 10%.

L Large, deformation resulting in a reduction in diameter of greater than 10%.

Figure B2.1.13 – Deformed (Rigid) Pipe



Outlier Method 5 – Delamination (AC Pipe)

This quantification method applies to the deterioration of asbestos cement (AC) pipes through the separation of the fabric of the pipe wall, (Code Reference PW1.8, Surface Damage, Characterisation Code D, Section B2.3).

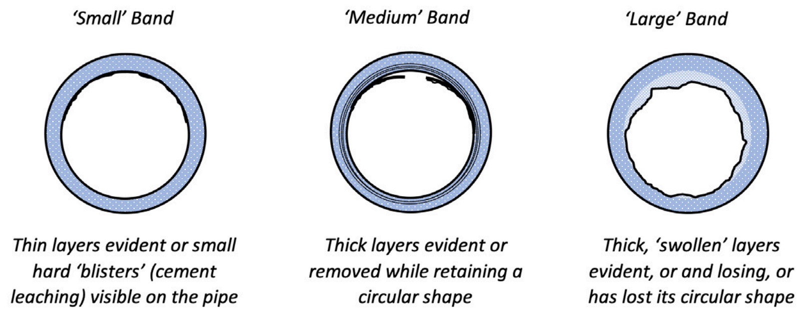
The quantification code is banded as follows:

S Small, delamination of thin (one or more) layers of pipe wall is evident and/or have been removed from the pipe surface, or evidence of cement leaching present on the pipe surface.

M Medium, delamination of thick layers of pipe wall is evident and/or have been removed from the pipe surface without evidence of the pipe losing its (circular) shape.

L Large, delamination of thick layers of pipe wall is evident and/or have been removed from the pipe surface such that the pipe is losing/lost its (circular) shape.

Figure B2.1.14 – Delamination at different levels in AC pipe



Outlier Method 6 – Infiltration Present

This quantification method applies to ground water infiltration into the pipe through defective components (Code Reference S5.9, Section B2.3).

S Seeping/sweating (wet) or dripping flow.

M Running (visibly moving) flow.

L Large, gushing or jetting (pressure flow).

D Longitudinal Distance

The location of each defect or feature is described by the Longitudinal Distance that is measured, in metres, from the centre of the start node to the defect or feature. This is also referred to as relative distance – the distance measurement relative to the starting location as indicated by the 'Measurement From' field.

E Measurement From

The location of the start node from which the Longitudinal Distance is being measured. The location, or Measured From point is identified using a single code as follows:

U The start node is the centre of the upstream node and the camera is travelling downstream.

D The start node is the centre of the downstream node and the camera is travelling upstream.

Where inspections are required to be undertaken from both ends of the pipeline, both codes will be used, and are important for clarifying where each of the Longitudinal Distances are measured from to correctly locate the position of the defects and features.

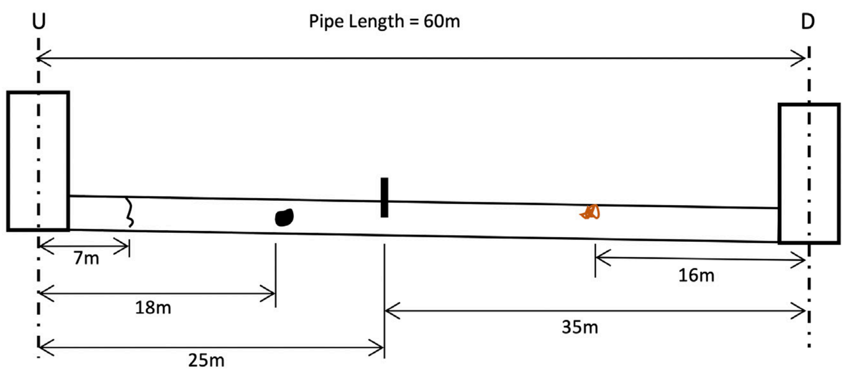


Figure B2.1.15 – Example of showing the location of defects where an inspection has been completed by inspecting from both ends. The combination of the "Longitudinal Distance" and "Measured From" fields, makes the reporting of the location of the defects and features within the pipe clear.

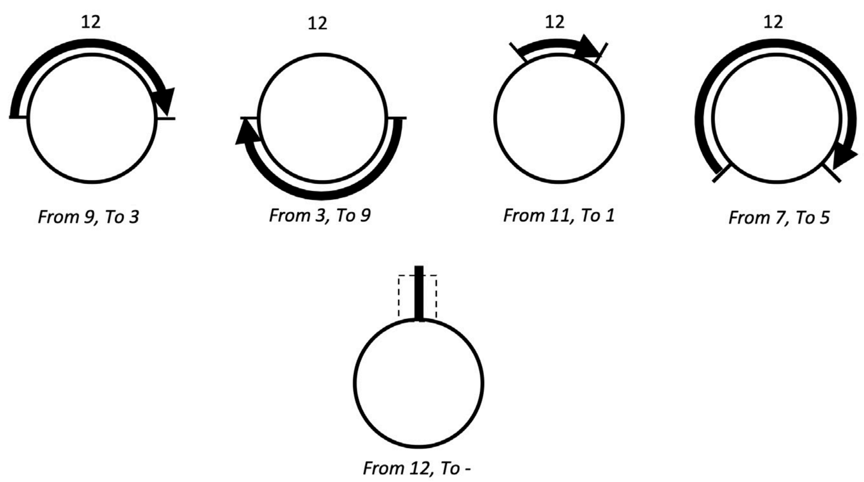
Longitudinal Distance	Measured From	Main Code	Characterisation Sub-Code	Quantification Sub-Code	Position From	Position To	Remarks
0	U	IS					Centre of upstream manhole
7	U	CC		M	12	5	
18	U	PH		M	2	4	
25	U	LP		L	12		
25	U	IA					Stopped by protruding lateral
0	D	IS					Re-Start at centre of Downstream MH
16	D	CF			12		Lifting eye
16	D	RI	F	M	10	2	
35	D	IE					Ends at previous abandonment

F Circumferential Location, "Position From" and "Position To"

The position of a defect or feature relative to the circumference of the pipe are described using the hours of an imaginary clock face, with 12 o'clock being the soffit (top) of the pipe and 6 o'clock the invert. The circumferential position is defined between a starting "Position From" data field, and the ending "Position To" data field. For coding purposes any single clock reference shall occupy the first clock reference position and shall relate to the centre/mid - point of the feature. The circumstances in which a single clock reference or two clock references are used are described in Section B2.3. Clock references shall be given to the nearest hour, as shown in examples given in Figure B2.16.

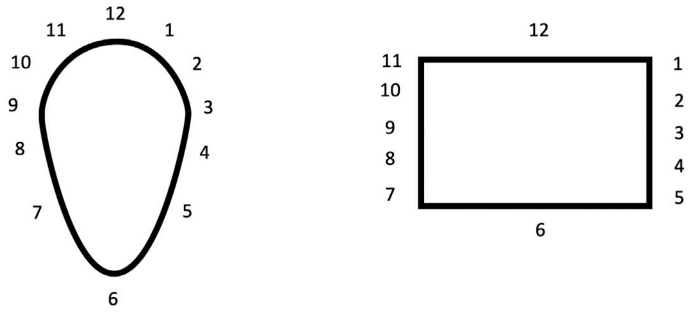
Where the start and finish clock face references are required, these shall be recorded in the clockwise direction. The circumferential location of a defect or feature occupying the entire periphery shall be recorded as "from 12 o'clock to 12 o'clock".

Figure B2.1.16 – Examples of Clock References



For non-circular pipes the hour clock reference positions are adjusted to maintain the traditional clock arrangement as best possible. In egg-shaped and oval pipes, the imaginary reference clock shall be centered around the circular portion of the pipe shape. For box or rectangular shaped pipes, the Roof and base of the pipe are defined as 12o'clock and 6 o'clock respectfully, with the rest of the positions distributed along the vertical sides.

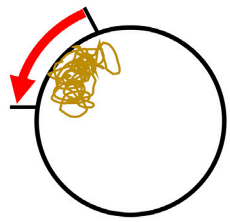
Figure B2.1.17 – Example clock positions for non-circular pipe shapes



The "Position From/To" (or "clock order") entries are always recorded according to what would be seen if the camera was travelling down the pipe from the upstream starting point. If the inspection is being completed from the downstream manhole (i.e. the camera is facing upstream) the recorded clock order positions need to be reversed from the observed positions. This requirement ensures that when multiple inspections are undertaken (inspection from both ends of the pipe under a single header) the clock references remain consistent.

For example, if the inspection started at the downstream manhole, a defect might be observed on the centre left hand side of the pipe. Rather than record the defect as being at 9 o'clock it would be recorded as being at 3 o'clock, as this is the position that would have been observed had the inspection been completed from the upstream manhole. In some cases, the software used for recording the CCTV observations will automatically translate the clock position.

Figure B2.1.18 – Example of 'reversed' clock references where a root intrusion is observed coming from the downstream end, (travelling in upstream direction



*Clock References **as viewed** are from 9, To 11 - **but are recorded** from 1, To 3 (note the arrow is reversed, in an anti-clockwise direction to represent the observation as it would appear from the upstream)*

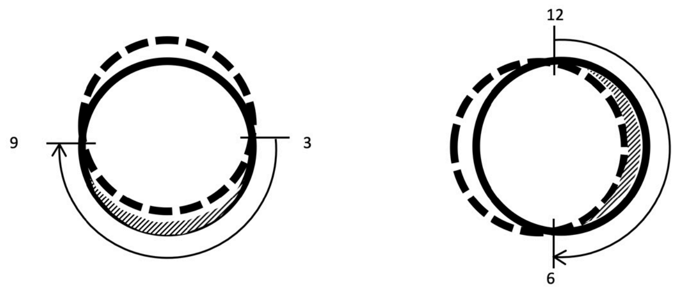
G Recording the clock positions for Displaced Joints (JD) and Open Joints with Angular Displacements (JOA)

The 'Position From' and 'Position To' clock reference values for vertical or horizontally displaced joints and open joints with an angular displacement have specific requirements as follows:

Displaced Joints (JD)

Position From and Position To are represented by a pair of clock references at the points at which the two pipe segments appear to intersect each other, in the clockwise direction of the exposed joint face.

Figure B2.1.19 – Examples of clock positions using vertical and horizontal joint displacements



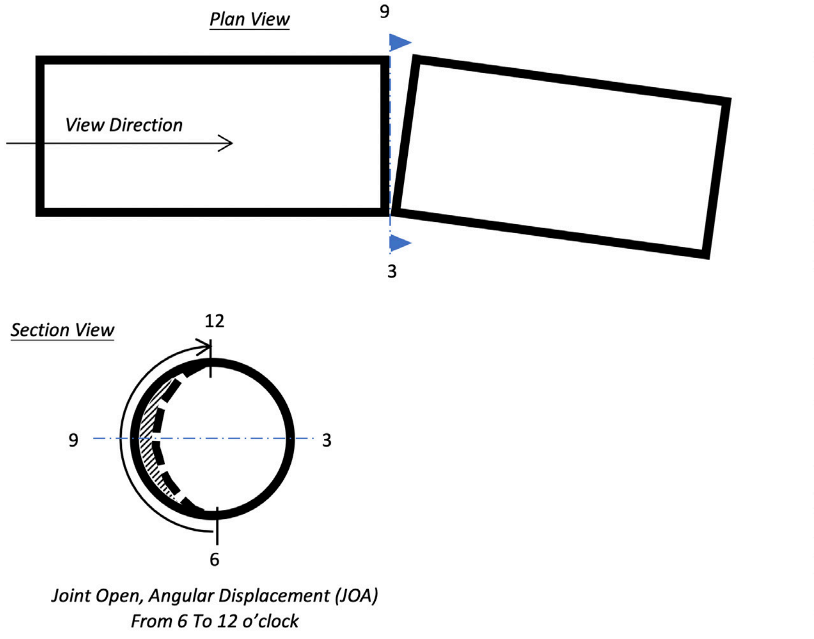
Vertical Joint Displacement (JDV)
From 3 To 9 o'clock

Horizontal Joint Displacement (JDH)
From 12 To 6 o'clock

Open Joints with Angular Displacements (JOA)

'Position From' and 'Position To' are represented by a pair of clock references at the points at which the two pipe segments appear to intersect each other, in the clockwise direction of the open joint gap.

Figure B2.1.20 – Example of clock positions for an open joint with an angular displacement



H Continuous Observations

Section B2.3, Condition Classification Codes, identifies if a defect or feature code can be recorded as continuous observations (continuous defect or continuous feature). A continuous defect or feature is any applicable observation that extends, or repeats, beyond a single point in the pipeline. Nominally a point defect is considered to affect 1m length of pipe. For a defect or feature to be considered continuous it would need to have a longitudinal length greater than one metre. Where the longitudinal length of a defect is ≤1m it shall not be recorded as a continuous observation, (that would be a coding error if it was so) it would only be recorded as a point defect.

Continuous Observations fall into one of two categories:

A. "Truly" continuous defects which extend along the pipeline without interruption over more than one metre. Examples include Longitudinal Cracks, Dips, Surface Damage.

B. "Point" features which are repeated at regular intervals along a pipeline, in at least three out of four adjoining pipe segments. An example would be Lifting Eyes.

For a continuous defect, or feature, of either type, the start and finish of the continuous observation shall be recorded as separate Main Code entries and labelling the start and finish of the continuity, adjacent to the Main code, in the Continuous Observation Field.

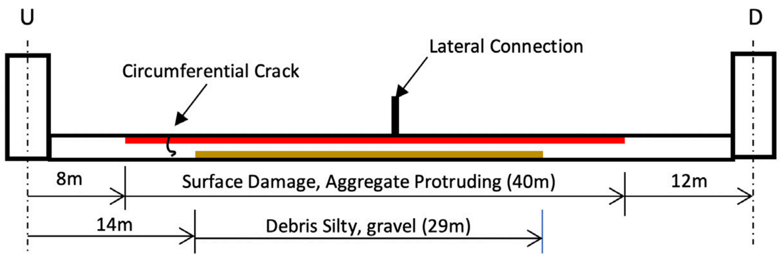
Any inspection may identify one or many continuous defects or features. Each continuous observation is recorded separately and identified using a sequential numbering system.

The start and end labelling is encoded as follows:

- The “Start” label is entered as Sn, where n is a sequential number 01 to 99.
- The “Finish” label is entered as Fn, where n is the number of the corresponding Start label

Some software systems denote the Finish label with En, where E translates to mean “End”. Either term is acceptable provided the asset owners AMIS can accommodate the translation.

Figure B2.1.21 – Example of encoding continuous defects



Continuous Obs.	Long. Distance	Measured From	Main Code	Char. Sub-Code	Quant. Sub-Code	Position From	Position To	Remarks
	0	U	IS					Centre of upstream manhole
S1	8	U	S	AP	M	10	2	Start of exposed aggregate
	11	U	CC		M	12	6	
S2	14	U	DE		S			Start of Gravel Deposits
	30	U	LO			12		100mm
F2	43	U	DE		S			End of gravel Deposits
F1	48	U	S	AP	M	10	2	End of exposed aggregate
	60	U	IE					Centre of downstream MH

If a continuous defect facility is being applied (e.g. SAV) and at an isolated point a more significant defect occurs, or the quantification increases, (e.g. SAP) this point occurrence is recorded in full, without the need to finish and restart the continuous defect already in place. However, if the more significant observation extends beyond one metre, then the original continuous defect shall be finished, and new continuous defect started. In this situation, the distance entered for the start of the new continuous defect (with the new quantification code) shall be one metre further down the pipe (i.e. distance to Fn + 1m) to avoid problems with the calculation of the Peak and Total Scores (refer to Section E1).

Some pipe inspection software uses a ‘C’ marker (in addition to markers S and F) to identify a change in a continuous defect. This may be used for a change in quantification of a continuous defect only. Where a C marker is applied, this would be considered the same as though the continuous defect has ended and a new continuous defect with a different quantification code had begun. As there can be more than one ‘change’ during a continuous defect a sequential numbering system is also used. The change marker is encoded as Cn, where n is a sequential number 01 to 99.

A continuous feature that "wanders" i.e. changes its circumferential location along the pipeline shall be noted by adding a remark using General Comment code, GC.

What affect do continuous defects have on the condition of the pipeline?

The effect that a continuous defect has on the condition evaluation of the pipeline depends on the type of defect.

Table B2.3 describes the two different types of continuous defect and which codes are relevant.

Table B2.1.3 – Continuous Defects

Method Used to Describe Continuity	Description	Relevant Main Codes
Per Metre	A single condition record is used to describe the full extent of the defect, but the Condition Weighted Score increases proportionally to the length of the defect.	CL, CM, DF, PB, PF, S, MUS, DI, MMU, DMU, MM, PH, PL
Per Defect	A single condition record is used to describe the full extent of the defect, and a single Condition Weighted Score applies the defect regardless of length.	DE, DG, DP, ED, RI, O, SV, TM

Why are there different approaches?

These different approaches reflect the impact that the different defects or features have on the condition of the pipe. In general, structural faults, which are typically recorded on a 'per metre' basis, have a more significant impact on the integrity of the pipeline than serviceability defects, which are typically recorded on a 'per defect' basis.

Refer to Section E1, Preliminary Condition Grading for further information on the continuous observations and their impact on the analysis of the preliminary condition grade.

I Photograph Reference

A reference to identify any still photographs or still computer images shall be recorded against a defect or feature whenever a photograph is taken. If the photograph is of a "general" nature, not directly related to a defect or feature, the General Photograph code, GP, shall be used with an appropriate remark.

J Specific Remarks

Where a feature cannot be fully described by a code, or where specified under Section B2.3, further information shall be recorded in the Remarks field for that observation. The remark shall be as short, but descriptive, as possible. Where additional explanation or description of the feature is necessary, the General Comment code (GC) shall also be used.

A General Comment alone shall not be used to describe a defect that can be described by a code.

K Video Location Reference

The video recorder run-time reading at the location of each defect or feature.

B2.1.6.4 Logging Procedures

A Start of inspection

Before the logging of observations can proceed, the following shall be encoded at longitudinal distance 0.0 to denote the start of every inspection:

1. Inspection Start code (IS), and its details to record and confirm the details of the start node.
2. Flow (Water) level code (WL).

B Finish of inspection

If the inspection is complete, either by a single pass through the pipe, or a multiple inspection that finishes at the previous point of abandonment, the Inspection Ends code, (IE) shall be encoded to record and detail the location of the end of the inspection.

C Inspection abandoned

Inspection (Survey) abandoned code, (IA) and the reason, shall be encoded at the abandonment of an inspection. Enter the appropriate defect or feature code before entering the IA code.

A General Comments, code (GC) shall be used to indicate the actions, if any, to be taken to complete the inspection.

If completion of the inspection can be attempted from the other end, this shall be undertaken under the same header (as the abandoned inspection) and the procedures for the start of the inspection shall again apply, i.e. encoded with the appropriate Measured From code (refer sub-section B2.1.6.3E, measured from).

Where an inspection has been abandoned due to debris or blockage and the pipeline has been subsequently cleaned along its entire length, the reinspection shall be undertaken from the beginning to ensure that all observations are recorded. When the inspection is recommenced, a new header shall be completed and the header code ABP, reason 'C' shall be used to show that this is the resumption of a previously discontinued inspection, (refer to Section B2.2, Header Codes).

B2.1.6.5 Encoding Defects at a Joint

Defects at a joint are recorded in a special manner. Where there is a faulty sealing mechanism, or structural defects occurring only within 100mm either side of the joint gap (200mm length centered on the joint), the defects are coded using the Joint Faulty code, JF (refer code reference J3.1, Section B2.3 Condition Classification Codes) for all defects occurring within that 200mm band. Defects outside of the Joint Zone, or that start within the Joint Zone, but extend beyond it, are recorded as discrete defects.

The joint zone is intended to encapsulate the parts of the pipe involved in the joining of the two pipe segments. Defects occurring within the joint zone are related to the jointing mechanism. Defects may have occurred because of displacement of the sealing ring, damage during construction (jointing the pipe segments), excessive loading or movement at the joint.

The Joint zone dimensions remain the same regardless of pipe diameter, type of joint or material. There is no marking to indicate the extent of the joint zone on the inside of the pipe, and therefore the 100mm length upstream and downstream must be estimated (within reasonable tolerance) or measured if the inspection equipment provides this functionality (e.g. laser measurement).

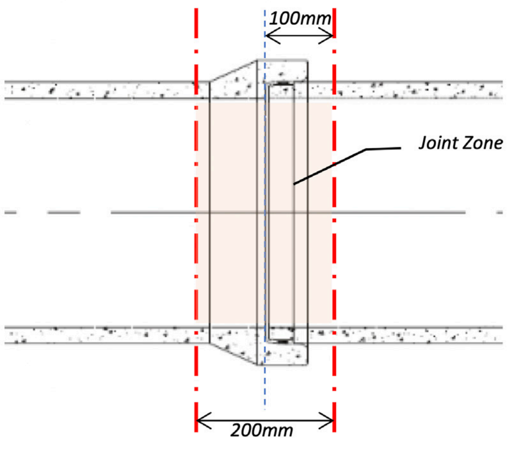


Figure B2.1.22 – Illustration of the Joint Zone

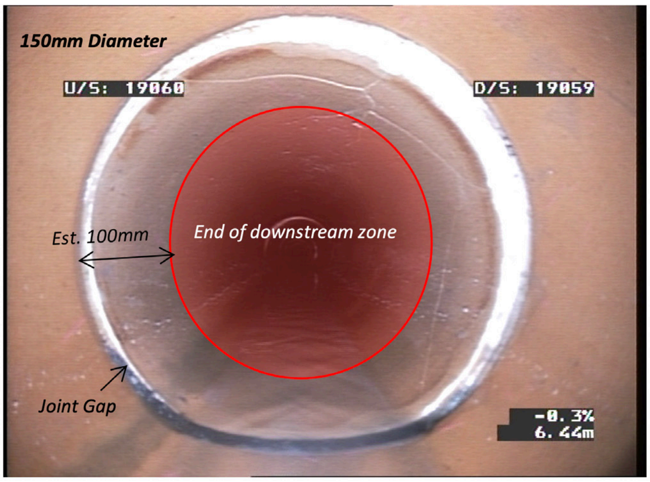
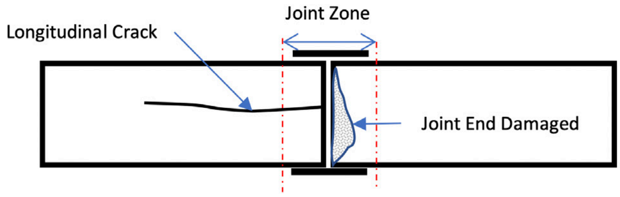


Figure B2.1.23 – Photograph and illustration of the extent of the downstream limit of a Joint Zone, as can be estimated (100mm distant from the Joint Gap).

Open and displaced joints are not covered under the Joint Faulty Code. Where these occur, they are coded under their own respective codes. It is possible that a defective joint may have a sealing/structural fault, be open and displaced and would require the coding of all three Joint defect codes separately at the same distance (i.e. JF and JO and JD)

Figure B2.1.24 – Example of encoding defects within and outside the Joint Zone



Main Code	Char. Sub-Code	Quant. Sub-Code	Position From	Position To	Remarks
CL		M	9		Crosses through Joint zone
JF	D	M	12	6	Joint damaged/Chipped limited to only within the Joint Zone

B2.1.6.6 Encoding Defects at a Lateral Connection

As with defects at joints, defects occurring at a lateral connection are recorded in a special manner. Where structural damage or faulty sealing of the connection occurs within 50mm of the internal face of the lateral connection pipe, and up to the first joint inside the lateral, the defects are coded using the Lateral Faulty code, LF (refer to code reference L4.2, Section B2.3 Condition Classification Codes).

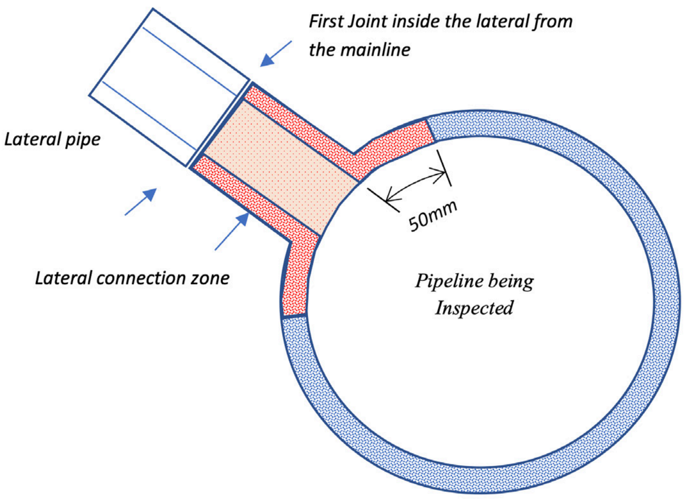


Figure B2.1.25 – Illustration of the Lateral Connection Zone (Cross-Section through the inspected pipe)

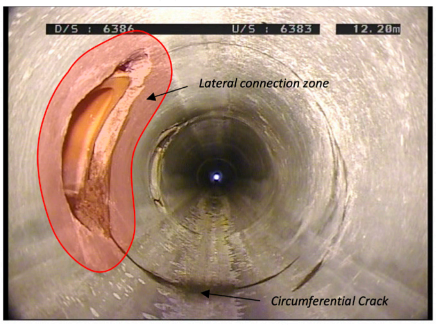


Figure B2.1.26 – Photograph and illustration of the extent of a Lateral Connection Zone, inside the pipe, as can be estimated (50mm perimeter around the lateral pipe, shown within red area). Observation reporting example also provided.

Long. Distance	Measured From	Main Code	Char. Sub-Code	Quant. Sub-Code	Position From	Position To	Remarks
12.4	U	LF	X	M	9		No internal seal, possible pathway to the outside
12.4	U	CC		M	10	8	Crosses through lateral connection zone

B2.1.6.7 Encoding Defects within a Metre of Pipe – Hierarchy of Defects

All defects observed within any one metre of pipe are recorded separately, but only one from each 'type' of defect, e.g. if there is more than one type of surface damage observed within a metre of pipe, only one surface damage code is recorded. To determine which defect from a group of defects is recorded, a hierarchy, or ranking, process for different defect types is used to decide. Only the most severe defect out of each of the listed defect hierarchy groups, below, shall be recorded for each 1m section of the pipeline. The exception to this rule is where continuous defects cross through the 1m section of pipe, as they may have started before that local defect and so could continue after the local defect.

Important notes:

1. This rule only applies to the defects within the same hierarchy group. If other structural defects are present within the same 1m section, that are not part of the same group, they are recorded in full.
2. The Quantification of the defect is not considered as part of the ranking. i.e. a large severity lower ranked defect does not become higher than a small severity higher ranked defect.
3. The Circumferential Location recorded for the most severe structural defect, must extend to cover the full extent of the other, less severe, defects within the same group that are present at that distance, but not coded.
4. A suitable note shall be made in the remarks about the types of defect present but not coded.

Structural Defect Hierarchy Groups:

A. Surface damage (corrosion and damage on pipe surfaces)
B. Cracked pipes (includes cracks, broken pipe, Pipe Holes, Deformed Pipe and collapses in rigid pipes)
C. Deformation in flexible pipes
D. Protective lining defective
E. Masonry pipes
F. Roots
G. Joint Faulty
H. Lateral Faulty

B2.1.6.8 Detailed Ranking of Codes in Individual Defect Groups

Hierarchy Group A – Surface Damage:

Only the most severe (Highest Ranked, 1 = Overall Highest) of the local or continuous defects shall be coded for any 1m section of the pipe. The ranking for surface damage in the different materials is outlined below:

Asbestos Cement

1. Hole (SH)
2. Delamination (SDL)
3. Mechanical Damage (SMD)
4. Wall Staining (SWS)

Concrete/Other Pipe Materials

1. Pipe Missing (SPM)
2. Hole (SH)
3. Reinforcement is visible and projecting (SRVP)
4. Reinforcement exposed and corroded (SRC)
5. Reinforcement is visible but not corroded
6. Aggregate removed (SAM)
7. Spalling of fabric (SS)
8. Wall Staining (SWS)
9. Aggregate projecting (SAP)

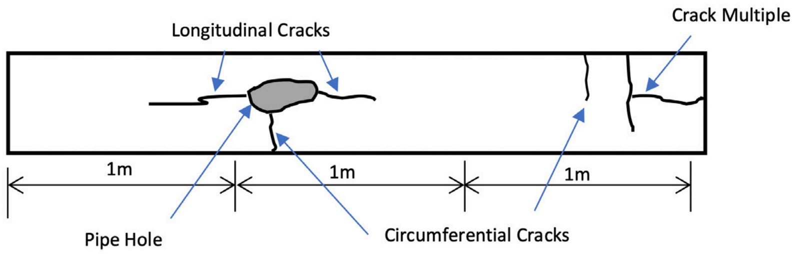
10. Aggregate Exposed (SAE)
11. Mechanical Damage (SMD)
12. Rough wall surface (SW)

Hierarchy Group B – Cracked Pipes:

Only the most severe (Highest Ranked, 1 = Overall Highest) of the local or continuous defects shall be coded for each 1m section of the pipe:

1. Pipe Collapsed (PX)
2. Deformed Pipe (DF)
3. Pipe Broken (PB)
4. Pipe Holed (PH)
5. Cracks; Multiple (CM), Longitudinal (CL), Circumferential (CC)

Figure B2.27 – Example of application of the structural defect Hierarchy rule for multiple defects included in the Cracked Pipes Group occurring within any 1m



Long. Distance	Measured From	Main Code	Char. Sub-Code	Quant. Sub-Code	Position From	Position To	Remarks
0.5	U	PH		M	2	3	Pipe hole with CC and 2x CL's
2.5	U	CC		S	12	3	
2.8	U	CM		M	12	5	

In the example given in Figure B2-27 above, only PH is coded between 0.5m to 1.5m, as it ranks higher than the CL's/CC within the same Hierarchy Group B within the same metre of pipe. Both CC & CM are each coded in between 2.5m to 3m, because they are beyond 1m from the Pipe Hole and are equally ranked within the same Hierarchy Group B.

Hierarchy Group C – Deformation in flexible pipes

Flexible pipes include plastic pipes, (e.g. PVC, PE) GRP and Steel. Only the most severe (Highest Ranked, 1 = Overall Highest) of the local or continuous defects shall be coded for each 1m section of the pipe:

1. Cracking (PFC)
2. Buckling (PFB) and Inverse Curvature (PFIC)
3. Vertical or Horizontal Deformation (PFV or PFH)
4. Corrugation Growth (PFG)

Hierarchy Group D – Protective Lining Defective:

Only the most severe (Highest Ranked, 1 = Overall Highest) of the local or continuous defects shall be coded for each 1m section of the pipe:

1. Rendered Mortar Missing (HPLRM)
2. Detached (HPLD), Bulged (HPLBU), Leak (HPLL), Weld Defective (HPLWD), Wrinkling – Vertical/Circumferential/Multiple (HPLWV, HPLWC, HPLW)
3. Dis-Colouration (HPLC), Blistered (HPLB)

Excluded from the hierarchy for Group D is Re-establishment of Connection Done Improperly (HPLRC), which is always coded when present.

Hierarchy Group E – Masonry Pipes:

Masonry refers to pipes constructed from bricks, concrete (masonry) blocks or stone. The units would typically be joined by mortar.

Only the most severe (Highest Ranked, 1 = Overall Highest) of the local or continuous defects shall be coded for each 1m section of the pipe:

4. Masonry - Conduit Collapsed (MX)
5. Missing Masonry Units (MMU)
6. Displaced Masonry Units (DMU)
7. Dropped Invert (DI)
8. Masonry Unit Separation (MUS)
9. Missing Mortar (MM)

Hierarchy Group F – Roots

Only the most severe (Highest Ranked, 1 = Overall Highest) of the local or continuous defects shall be coded for each 1m section of the pipe:

1. Tap roots (RIT) or Recently cut tap roots (RIRT)
2. A mass of mostly fine roots (RIM) or Recently cut root beard (RIRB)
3. Fine roots (RIF) or Recently cut fine roots (RIRF)

Hierarchy Group G – Joint Faulty

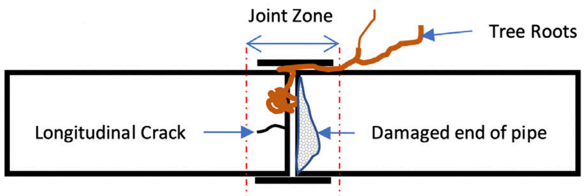
The rules for the joint faulty and lateral faulty hierarchy groups are applied differently to the other groups (A – E). For the Joint Faulty Hierarchy Group, the hierarchy rule *applies only to individual joints*, and *not* the '1m pipe section', i.e. if there is more than one faulty joint occurring within 1m, then the highest ranking joint fault at *each* joint would be recorded.

The Rule does not apply to Joint Open (JO), or Joint Displaced (JD) codes, and these are both recorded in full if present.

Only the most severe (Highest Ranked, 1 = Overall Highest) of the joint faults, within each 'Joint Zone' shall be coded:

1. Broken Pipe (JFB)
2. Damaged Pipe (JFD)
3. Cracked (JFC)
4. Defective Seal (JFX)

Figure B2.28 – Example of application of the structural defect Hierarchy rule for multiple defects included in the Joint Faulty Group occurring within a Joint Zone



Main Code	Char. Sub-Code	Quant. Sub-Code	Position From	Position To	Remarks
JF	D	L	12	12	Pipe end damaged (Chipped). Also 1x CL and root intrusion through the defect seal
RI	T	M	12	2	Tap root through faulty joint seal

In the example given in figure B2-28, above, the Characterisation code “D” (Damaged) was used and not “C” (Cracked) or “X” (Sealing fault) because Damaged Pipe present within a Joint Zone ranks higher than either Cracks or Defective Seals. The other Joint Faulty defects present are added as remarks. The tree root intrusion is coded separately because it is not part of the Joint Faulty Group, and service defects are always coded in addition to structural defects.

Hierarchy Group H – Lateral Faulty

The rules for the joint faulty and lateral faulty hierarchy groups are also applied differently to the other groups (A – E). For the Lateral Faulty Hierarchy Group, the hierarchy rule *applies to individual lateral connections*, and *not* the ‘1m pipe section’, i.e. if there is more than one faulty lateral occurring within 1m, then the highest ranking lateral fault at each lateral connection would be recorded.

The rule does not apply to Lateral Protruding (LP), or Lateral Problem (LX), these are both recorded in full if present.

Only the most severe (Highest Ranked, 1 = Overall Highest) of the lateral faults, within each ‘Lateral Connection Zone’ shall be coded:

1. Lateral Broken (LFB)
2. Lateral Damaged (LFD)
3. Lateral Cracked (LFC)

B2.2 Header Classification Codes

These codes are used to describe information relating to the pipe asset being inspected. They contain information about the inspection including asset identification, location, pipe attributes and its condition.

The codes are described within the following four tables. Each table groups the data into different types/purpose of information i.e.

B2.2.1 Header codes to describe the location of the inspection

B2.2.2 Header codes for reporting inspection details

B2.2.3 Header codes for recording conduit details

B2.2.4 Header codes for recording miscellaneous information

The main reporting codes for the inspection header are based on those specified in the European Standard, EN 13508 "Investigation and assessment of drain and sewer systems outside buildings - Visual inspection coding system" and WSA 05, "Conduit Reporting code of Australia". The exception is 15 codes AAR to AAU, ABQ, ABR to ABU and ACP to ACU. These additional codes have been provided to cover New Zealand specific information fields that are not covered by the EN13508-2 and WSA 05. The header reporting codes are generally not included in the naming of the header fields, but are intended to be used as a reference for the format for the electronic transfer of data (refer to Appendix A). Some header code fields are not used in New Zealand, and these are denoted in the header code tables (retained in the tables for completeness of information).

The sub-codes (described in the "Data to be recorded" column in the tables) are New Zealand specific but some are based on the Australian WSA05 sub-codes where applicable. These sub-codes are mnemonic and would need to be converted if it is required to report in EN 13508 format.

B2.2.1 Header codes to describe the location of the inspection

Header Code	Header Field	Data to be recorded	Format
AAA	AssetID	Unique asset identification number as supplied by the asset owner, or generated by the Contractor if the inspected pipe is a new asset.	Short Text
AAB	Not Used		
AAC	Not Used		
AAD	Up node reference	The asset ID of the upstream node	Short Text
AAE	Up node coordinate (Optional)	The grid reference (coordinates) of the upstream node	Short Text
AAF	Down node reference	The asset ID of the downstream node	Short Text
AAG	Down node coordinate (Optional)	The grid reference (coordinates) of the downstream node	Short Text
AAH	Not Used		
AAI	Not Used		
AAJ	Location (Optional)	A description of the location of the pipe e.g. street name.	Short Text
AAK	Camera Setup Location	Record the Setup node in which the camera is starting the inspection as follows:	Char
		U: The camera is starting at the upstream node—travelling in the same direction as the flow	
		D: The camera is starting at the downstream node—travelling opposite the direction of flow	
		UD: Camera travels from both ends Starting at the upstream node then restarting at the downstream node	
		DU: Camera travels from both ends starting at the downstream node then restarting at the upstream node	
AAL	Location type (Optional)	Record the type of location of the pipe as follows:	Char
		B: Within Bushland/parkland	
		BO: Under a permanent building (Built over)	
		C: Under a waterway (Creek)	
		D: Under property with buildings (Developed)	
		DA: Difficult access e.g. motorway or operational railway land	
		F: Under a footway beside road	
		G: Beneath Gardens	
		M: Under other pedestrian area (Mall)	
		NS: Under a berm beside a road (Nature Strip)	
		P: Under a field (Paddock)	
		R: Under a road	
		W: Water foreshore	
		Z: Other—further details shall be stated in remarks	

Header Code	Header Field	Data to be recorded	Format
AAM	Asset owner (Optional)	The name of the asset owner	Short Text
AAN	Town or suburb (Optional)	The name of the town or suburb as specified by the asset owner	Short Text
AAO	District/Catchment (Optional)	The name of the district or catchment as specified by the asset owner	Short Text
AAP	Name of pipe system (Optional)	The name of the pipe system, or a pipe system reference as specified by the asset owner	Short Text
AAQ	Land ownership (Optional)	Record the ownership of the land denoted as: C – Public land (Council or Crown land) Q – Not known (Query) T – Private land	Char
AAR	Parallel Line	Record the line number where there is more than one direct line between two manholes. The line number is supplied by the asset owner.	Short Text
AAS	Drawing Number (Optional)	The drawing reference number on which the pipeline is shown, if applicable	
AAT	Upstream node Location	The address of the upstream node	Short Text
AAU	Downstream node location	The address of the downstream node	Short Text

B2.2.2 Header codes for reporting inspection details

Header Code	Header Field	Data to be recorded		Format
ABA	Standard	The version of the standard used to record the data. This shall be in the form NZPIM (Gravity)—4th Edition 2019		Short Text
ABB	Original coding system (Optional)	Where the coding has been translated from an earlier version or from another system, the name of the original coding system.		Short Text
ABC	Not Used			
ABD	Not used			
ABE	Method of inspection (Optional)	Record the method used to inspect the pipeline as follows:		Char
		FZ	Inspection by means of a fixed position zoom pipeline camera	
		LP	Inspection by means of a remotely controlled laser profiler passed through the conduit	
		M	Direct inspection of a conduit by a person walking through the conduit (Manned)	
		PS	Inspection by means of a remotely controlled 3D optical pipeline scanner passed through the conduit	
		S	Inspection from the access structure only	
		SS	Inspection by means of a remotely controlled sonar scanner passed through the conduit	
		TVPT	Inspection by means of Pan-Tilt CCTV camera passed through the conduit	
		TVFA	Inspection by means of Fixed Axial CCTV camera passed through the conduit	
ABF	Date of inspection	Record the short date of the inspection using the DD/MM/YYYY format, e.g. 01/09/2017 means 1 September 2018. Leading zeros shall be included where necessary		Short Date (DD/MM/YYYY)
ABG	Time of inspection	The time as specified in ISO 8601 using the 24-hour hh:mm format. e.g. 14:41 means 2.41 pm local time. Leading zeros shall be included where necessary		Time (hh:mm)
ABH	Name of Operator	Record the name of the inspection equipment operator.		Short Text
ABI	Operators Reference (Optional)	The reference code or name for the inspection supplied by the operator or the operator's company		Short Text
ABJ	Asset owner's Reference (Optional)	The reference code or name for the inspection supplied by the asset owner		Short Text
ABK	Storage medium for video (optional)	Record the type of media used for storing moving images as follows:		Char
		CD	Video CD. Details of format shall be recorded in remark	
		DVD	Digital versatile disc. Details of format shall be recorded in remark	
		PHD	Portable Hard Drive. Details of format shall be recorded in remark	
		USB	Universal Serial Bus. Details of format shall be recorded in remark	
		Z	Other—full details shall be recorded in a general header comment (code ADE) immediately following	
ABL	Not Used			
ABM	Not Used			
ABN	Not used			

Header Code	Header Field	Data to be recorded		Format
ABO	Video volume reference	Where ABK is recorded as PHD or USB or Z, record the file name for the video file. The file name must be unique, and where applicable conform to the asset owners specified file naming convention. Where ABK is recorded as CD or DVD, record the storage media reference name. This media name must be unique.		Short Text
ABP	Purpose of inspection	Record the purpose of the inspection as follows:		Char
		C	Completion of an earlier abandoned inspection	
		IE	Suspected infiltration problem (Infiltration exam)	
		IP	Investment planning	
		L	Locating a pipe, connection or a manhole structure	
		NC	Final inspection of a new construction	
		OE	Suspected operational problem (Operational exam)	
		R	Routine inspection of condition	
		RC	Final inspection of renovation or repair (Renovation/repair control)	
		S	Sample inspection	
		SE	Suspected structural problem (Structural exam)	
		T	Transfer of ownership	
		W	End of warranty period	
		Z	Other—the reason shall be recorded as a header remark (code ADE) immediately following	
ABQ	Pipe Length	Record the measured length of the pipe asset. The measurement is from the centre of the upstream node to the centre of the downstream node. The pipe length will be the same value as the Surveyed Length (ARB) where the inspection is complete. Where the pipe length cannot be measured, (i.e. inspection is not able to be completed) the value to be recorded in the Pipe Length field shall be, (in the following order): 1. The pipe length measured above ground, (e.g. using a measuring tape. 2. The GIS length, if physical measurement is not possible 3. Left blank, if the GIS length is not available		Number (#.#)
ABR	Survey Length	Record the measured Length is the length of pipe that has been surveyed.		Number (#.#)
ABS	Inspection Completion Status	Record the completion status of the inspection as follows:		Char
		IC	Inspection Complete	
		UI	Uncompleted Inspection	
ABT	Name of Coder	Record the name of the person who encoded the pipe condition.		Short Text
ABU	Date of Data Entry (Optional)	The date of the data entry (coding is undertaken) if different to the date of inspection.		Short Date (DD/MM/YYYY

B2.2.3 Header codes for recording conduit details

Header Code	Header Field	Data to be recorded		Format
ACA	Shape	Record the shape of the cross section of the pipe as follows:		Char
		A	Arch shaped—circular soffit and flat invert with parallel sides	
		C	Circular	
		E	Oviform (egg shaped)	
		O	Oval—circular invert and soffit (of equal diameter) with parallel sides	
		R	Rectangular or Square	
		U	U shape—circular invert and flat top with parallel sides	
		Z	Other—a description shall be included as a general header comment (code ADE) immediately following	
ACB	Height	The height of the section in mm - —not required where both dimensions are the same e.g. circular		Number (##)
ACC	Width	The width or diameter of the section in mm		Number (##)
ACD	Material	The material of the fabric of the pipe, under the coding of Table B1 of Appendix B. Where the pipe has been lined the Material field shall be left blank.		Short Text
ACE	Lining type	Where a pipe has been lined, record the method of lining as follows:		Char
		CFL	Close fit lining	
		CIP	Cured in place lining	
		LCP	Lining with a continuous conduit (pipeline) e.g. a pipe string welded on the surface prior to insertion	
		LDP	Lining with discrete pipes i.e. short pipes jointed underground	
		MFL	Lining inserted during manufacture (Manufacturer's lining)	
		SEG	Segmental lining	
		SPL	Sprayed lining	
		SWL	Spirally wound lining	
		Z	Other	
ACF	Lining material	Where a pipe has been lined, record the lining material using the coding of Table B2 of Appendix B		Short Text
ACG	Joint Spacing	Record the length (m) of the individual pipe units that comprise the pipeline, (refer B2.1, H4.4.1). Where the pipe is continuous e.g. masonry, or PE, this field is left blank, and a remark made in ADE.		Number (#.#)
ACH	Depth at upstream node (Optional)	Record the depth of the invert of the pipe below cover level at the upstream node in m, (refer B2.1, H4.7).		Number (#.#)
ACI	Depth at downstream node (Optional)	Record the depth of the invert of the pipe below cover level at the downstream node in m, (refer B2.1, H4.7).		Number (#.#)
ACJ	Operation of Pipeline	Record the operational mode of the pipeline as follows:		Char
		G	Gravity (*Default)	
		P	Pressure	

Header Code	Header Field	Data to be recorded		Format
ACK	Use of Pipeline	Record the use of the pipeline system as follows:		Char
		COM	Combined system (Sewage and Stormwater combined)	
		CUL	Culverted watercourse e.g. a short, buried section for a road crossing or similar	
		S	A drain designed to carry only surface water (Stormwater).	
		F	The installation is designed to carry only sewage (Foul).	
		TW	Trade effluent sewer (Trade waste)	
		Z	Other—further information shall be included as a general header remark (code ADE) immediately following	
ACL	Not Used			
ACM	Cleaning Status	Record whether the pipeline was cleaned prior to the inspection as follows:		Char
		LC	The pipe was light cleaned prior to the inspection	
		HC	The pipe was heavy cleaned prior to the inspection	
		NC	The pipe was not cleaned prior to the inspection	
		RC	The pipe was root cut prior to inspection	
ACN	Not Used			
ACO	Jointing method (Optional)	Record the pipe jointing method as follows:		Char
		A	pipe sections abutted with no jointing elements or material	
		BF	Butt fusion welded e.g. steel and PE	
		BFD	Butt fusion welded with ground weld reinforcement(steel) or debeading (PE)	
		CMJ	Cement mortar jointed e.g. concrete	
		EF	Electrofusion coupling weld (PE only)	
		F	Flange jointed	
		L	Lap fillet weld (steel only)	
		MC	Mechanical coupling	
		RRJ	Rubber ring (elastomeric seal) jointed (socket and spigot or joint coupling/collar)	
		SCJ	Solvent cement jointed e.g. PVC, ABS	
ACP	Up Node Type (Optional)	Record the type of node at the upstream as follows:		Char
		SND	Sewer node – includes: Buried Junctions, material change, bend/ deviation, diameter change	
		SMH	Sewer Manhole	
		SPS	Sewer pump station	
		SIP	Sewer Inspection Point	
		SMS	Sewer Miscellaneous	
		STND	Stormwater node – includes: Buried Junctions, material change, bend/deviation, diameter change	

Header Code	Header Field	Data to be recorded		Format
ACP *continued*	Up Node Type (Optional)	STMH	Stormwater manhole	Char
		STI	Stormwater Inlet	
		STO	Stormwater Outlet	
		STCP	Stormwater Catchpit	
		STMS	Stormwater Miscellaneous	
ACQ	Down Node Type (Optional)	Record the type of downstream node as per ACP		Short Text
ACR	Total Structural Score	Calculated total structural score		Number (##)
ACS	Structural Peak Score	Calculated peak structural score		Number (##)
ACT	Structural Mean Score	Calculated mean structural score		Number (##)
ACU	Total Service Score	Calculated total service score		Number (##)
ACV	Service Peak Score	Calculated peak service score		Number (##)
ACW	Service Mean Score	Calculated mean service score		Number (##)
ACX	Preliminary Structural Peak Grade	Calculated peak structural condition grade		Integer (1 – 5)
ACY	Preliminary Service Peak Grade	Calculated peak service condition grade		Integer (1 – 5)

B2.2.4 Header codes for recording miscellaneous information

Header Code	Header Field	Data to be recorded		Format
ADA	Precipitation (Optional)	Record the precipitation as follows:		Char
		N	No precipitation	
		R	Precipitation (rain)	
		S	Melting snow or ice	
ADB	Temperature (Optional)	Record the ambient temperature either in Celsius or coded as follows:		Char
		C	Below freezing (Cold)	
		W	Above freezing (Warm)	
ADC	Flow control measures (Optional)	Record the measures taken to deal with the flow at the time of the inspection as follows:		Char
		B	Flows have been blocked or diverted upstream	
		N	No measures taken	
		P	Flows partially blocked or diverted upstream	
		Z	Other—record further details in remarks	
ADD	Tidal influence (Optional)	Record tidal influence as follows:		Char
		A	At or above high tide level	
		B	Below high tide level	
ADE	General comment	Record any information that cannot be included in any other way		Long Text

B2.3 Condition Classification Codes

The condition classification codes and their definitions are described within this section, along with examples. A summary of the Main Codes and Characterisation codes (Char.) are provided in Table B2.3.1.

Table B2.3.1 – Summary of Main and Characterisation Codes

Groups	Main Code	Main Description	Char.	Quant. (Method)	Characterisation Description	Clause	Page
Pipe Wall Codes	CC	Cracking Circumferential		1		PW1.1	111
			C	-	Crack edge Chipped		
			D	-	Crack faces are Displaced		
	CL	Cracking Longitudinal		1		PW1.2	
			C	-	Crack edge Chipped		
			B	-	Slabbing		
			D	-	Crack faces are Displaced		
	CM	Cracking Multiple		1		PW1.3	
			C	-	Crack edge Chipped		
			B	-	Slabbing		
			D	-	Crack faces are Displaced		
	PB	Pipe Broken		3v		PW1.4	
	PF	Deformed Plastic Pipe	C	-	Cracking	PW1.5	
			G	-	Corrugation Growth		
			B	2	Buckling		
			IC	2	Inverse Curvature		
			DV	2	Vertical Deformation		
			DH	2	Horizontal Deformation		
	DF	Deformed Pipe	V	O4	Vertical deformation	PW1.6	
			H	O4	Horizontal deformation		
	PH	Pipe Holed		3v		PW1.7	
	S	Surface Damage	W	-	Wall roughened	PW1.8	
			S	-	Spalling		
			PM	-	Pipe Missing		
			AE	3	Aggregate Exposed		
			AP	3	Aggregate Projecting		
			AM	3	Aggregate Missing		
			RC	3	Reinforcement Corroded		
			RV	3	Reinforcement Visible		
			RVP	3	Reinforcement Visible Projecting		
			CP	3	Corrosion Products visible		
			MD	3	Mechanical Damage		
			H	3	Holed		

Groups	Main Code	Main Description	Char.	Quant. (Method)	Characterisation Description	Clause	Page
Pipe Wall Codes *continued*			WS	3	Wall Staining		
			DL	O5	Delamination		
			T	2	Tuberculation		
			D	3	Damage (Other)		
	PL	Protective Lining Defective	WL	2	Wrinkling - Longitudinal	PW1.9	
			WC	2	Wrinkling - Circumferential		
			W	2	Wrinkling - multiple patterns		
			B	2	Blistered		
			BU	2	Bulged		
			D	2	Detached		
			E	-	End or edge of the patch repair lining is defective or irregular		
			C	-	Discolouration		
			WD	-	Weld Defective		
			RC	-	Re-establishment of Connection done improperly		
			L	-	Leak		
			H	-	Holed		
			RM	-	Rendered mortar Missing		
			SJ	-	Spiral Joints separated		
	PR	Point Repair	L	-	Localised Lining (patch repair)	PW1.10	
			I	-	Injected mortar/sealant		
			IC	-	Internal 'Clip' seal		
			Z	-	Other		
	LC	Lining Change		-		PW1.11	
	SV	Soil Visible through defect		-		PW1.12	
	TM	Tomo		-		PW1.13	
	PX	Pipe collapsed		-		PW1.14	
	DC	Dimension Change		-		PW1.15	
	MC	Material Change		-		PW1.16	
	PC	Pipe length Change		-		PW1.17	
Masonry Codes (For brick, blockwork and stone construction)	MM	Missing Mortar		3		M2.1	
	MUS	Masonry Unit Separation		O2		M2.2	
	DI	Dropped Invert		O2		M2.3	
	DMU	Displaced Masonry Units	I	3	Moving Inwards	M2.4	
			O	3	Moving Outwards		
	MMU	Missing Masonry Units	V	3	More Masonry Visible	M2.5	
			NV	3	No more masonry Visible		
	MX	Masonry Pipe Collapsed		-		M2.6	
Joint Codes	JF	Joint Faulty	C	1	Cracked	J3.1	
			D	1	Damaged		
			X	1	Seal		
			B	3v	Broken		

Groups	Main Code	Main Description	Char.	Quant. (Method)	Characterisation Description	Clause	Page
Joint Codes *continued*	JO	Joint Open		O1		J3.2	
			A	O1	Angular displacement		
	JD	Joint Displaced	V	2	Vertical offset	J3.3	
			H	2	Horizontal offset		
	W	Weld Defect	C	-	Weld is Cracked	J3.4	
			X	-	Weld is defective		
			LF	-	Weld exhibits a lack of Fusion		
			D	-	Displacement (butt weld)		
			AA	-	Angular misalignment (butt weld)		
			A	-	Misalignment (electrofusion)		
			I	-	Incorrect Insertion (electrofusion)		
			M	-	Electrofusion coupler (PE welding only) has partially Melted		
			O	-	Ovality and "flat areas" (electrofusion)		
			U	-	Weld exhibits undercut at the toe of weld (steel welding only)		
			Z	-	Other weld defect		
	MHJ	Manhole (or Chamber) Joint Faulty		-		J3.5	
Lateral Codes	L	Lateral	O	-	Open	L4.1	
			B	-	Blank		
	LF	Lateral Sealing Faulty	C	1	Cracked	L4.2	
			B	1	Broken		
			D	1	Damaged		
			X	1	Seal		
	LP	Lateral Protruding		2		L4.3	
	LX	Lateral problem (Defective)	B	-	Blocked	L4.4	
			C	-	Branch Cracked		
			R	-	Some Roots		
			SE	-	Soil Entering		
			Z	-	Other		
Service Related Codes	DE	Debris Silty		2		S5.1	
	DG	Debris Greasy		2		S5.2	
	ED	Encrustation Deposit		2		S5.3	
	RI	Root Intrusion	F	2	Fine Roots	S5.4	
			M	2	Mass of mostly fine roots interwoven into a clump		
			T	2	Tap roots		
			RF	2	Recently cut Fine roots		

Groups	Main Code	Main Description	Char.	Quant. (Method)	Characterisation Description	Clause	Page
Service Related Codes *continued*	RI	Root Intrusion	RB	2	Recently cut interwoven roots leaving a Beard	S5.4	
			RT	2	Recently cut Tap roots		
	O	Obstruction	P	2	Permanent	S5.5	
			T	2	Temporary		
			S	2	Service crossing through the pipe		
	B	Pipe Blocked	RI	-	Root Blockage	S5.6	
			DE	-	Silty Debris Blockage		
			DG	-	Fat Blockage		
			Z	-	Other		
	DP	Dipped Pipe		O3		S5.7	
	EX	Exfiltration		-		S5.8	
	IP	Infiltration Present		O6		S5.9	
	WL	Flow (Water) Level	C	-	Clear	S5.10	
			T	-	Turbid or Discoloured		
	LD	Line Deviates	D	-	Down	S5.11	
			L	-	Left		
			R	-	Right		
			U	-	Up		
Inspection Information Codes	CF	Construction Feature		-		I6.1	
	GC	General Comment		-		I6.2	
	GP	General Photograph	L	-	Pointing Left	I6.3	
			R	-	Pointing Right		
			F	-	Pointing Forward		
			B	-	Pointing Backward		
	LOV	Loss of Vision	UW	-	Under Water	I6.4	
			G	-	Grease on lens		
			S	-	Steam		
			EF	-	Equipment Failure		
			Z	-	Other/Unknown		
	TC	Change in video volume reference		-		I6.5	
	IS	Inspection Starts		-		I6.6	
	IE	Inspection Ends		-		I6.7	
	IA	Inspection Abandoned		-		I6.8	

PW1 – Pipe Wall Codes

PW1.1 – Cracking Circumferential

Code	Description	
CC	Cracking – Circumferential. Cracking occurring at right angles to the pipeline axis[1,2,3].	
	Additional Information	
	Characterisation – additional code to describe specific structural features associated with the cracking. Used <u>when they are present</u>	
	C	Chipping/splintering of the wall fabric along the crack edge
	D	Vertical Displacement (shearing) of the crack edges resulting in an off-set or step in crack.
	Quantification[5] – Evidence of a pathway through the pipe wall (Method 1). Record using additional code to describe the observations as follows:	
	S	Small, crack is visible but looks closed and there is no evidence that the crack extends all the way through the pipe wall
	M	Medium, crack is open but there is no clear evidence that the crack extends all the way through the pipe wall
	L	Large, there is clear visual evidence that the crack extends all the way through the pipe wall[4]
Circumferential location: Record the extent of the crack as a pair of clock references[6]		
Continuous Defect: Not Applicable[7]		

Notes:
1. Maximum longitudinal length that the crack may extend down the pipe is 100mm.
2. Single cracks may branch and re-enter the main crack before stopping. If the extent of the branching extends further than 100mm along the pipe, then use code CM or PB (if the branching crack re-joins the main crack).
3. Use code JF if cracking occurs only within 100mm of a joint
4. Describe the evidence for the Large severity band in the remarks
5. Quantification is not required when C or D Characterisation codes are used
6. Cracking may be present around the full circumference or only a portion of it. The extent of the cracking visible shall be recorded to reflect how much of the circumference the crack is visible.
7. Circumferential cracks are coded as individual defects and cannot be recorded as a set of continuous defects.

Examples:

PW1.1 – Cracking Circumferential

Dist.	Cont.	Code	Char.	Quant.	From	To
4		CC		S	1	11

Remarks: Autogenous (self-healed) crack

PW1.1.1 – Branch Cracking

Dist.	Cont.	Code	Char.	Quant.	From	To
22.6		CC		M	12	12

Remarks: Small branching crack extending < 100mm between 3 and 9 o'clock

PW1.1.2 – Chipping of Crack Edges (C)

Dist.	Cont.	Code	Char.	Quant.	From	To
3		CC	C		7	5
Remarks: Chipped edges along the crack circumference, particularly obvious from 7 to 11 o'clock						
2.9		*WL*	*T*			
Remarks: *Flow depth 10% (camera is sitting low in the pipe)*						

PW1.1.3 – Vertical Displacement of the crack (D)

Dist.	Cont.	Code	Char.	Quant.	From	To
12.5		CC	D		12	12
Remarks: Crack is open and has a slight displacement (left)						
12.3		*LP*		*S*	*9*	
12.3	*S1*	*GC*			*5*	*7*
Remarks: *Pipe stained from the wastewater flow*						

PW1.2 – Cracking Longitudinal

Code	Description	
CL	Cracking – Longitudinal. Cracking parallel to the pipeline axis[1,2,3,4].	
	Additional Information	
	Characterisation – additional code to describe specific structural features associated with the cracking. Used when they are present	
	C	Chipping/splintering of the wall fabric along the crack edge
	B	Slabbing[8] of the pipe wall fabric
	D	Vertical Displacement (shearing) of the crack edges resulting in an off-set or step in crack.
	Quantification[6] – Evidence of a pathway through the pipe wall (Method 1). Record using additional code to describe the observations as follows:	
	S	Small, crack is visible but looks closed and there is no evidence that the crack extends all the way through the pipe wall
	M	Medium, crack is open but there is no clear evidence that the crack extends all the way through the pipe wall
	L	Large, there is clear visual evidence that the crack extends all the way through the pipe wall[5]
Circumferential location: Record the position of the crack as a single clock reference[7]		
Continuous Defect: Where the length of cracking exceeds 1 metre, the crack shall be recorded as a Continuous Defect[9]		

Notes:

1. Single cracks may branch and re-enter the main crack, or change clock position before stopping. If the extent of the branching extends more than 100mm perpendicular from the main crack, then use code CM or PB (if the branching crack re-joins the main crack).
2. Where there are other longitudinal cracks present, these are coded as separate entries
3. Use code DF if more than 3 parallel longitudinal cracks are present occurring at 12, 3, 6, or 9 o'clock.
4. Use code JF if cracking occurs only within 100mm of a joint
5. Describe the evidence for the Large severity band in the remarks
6. Quantification is not required when C, D or B characterisation codes are used
7. If crack branches, or varies in clock position, use the median clock reference and describe the position of the crack using a pair of clock references in the remarks
8. The terms slabbing, shear slabbing, or slab shear refers to a radial shear failure of the concrete which occurs from the yielding of the structural reinforcement steel due to excessive tension. Slabbing is characterized by slabs of concrete "peeling" or delaminating from the reinforcing steel as it straightens. B characterisation is not used for non-circular pipe shapes.
9. Longitudinal cracking must be truly continuous for greater than one metre.

Examples:

PW1.2.1 – More than one longitudinal crack present

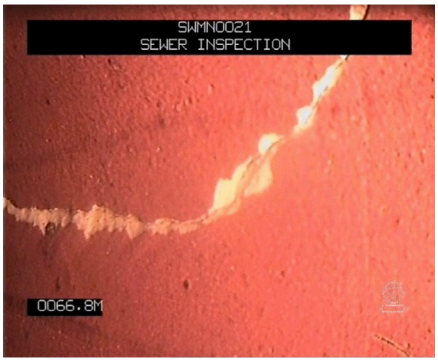
Dist.	Cont.	Code	Char.	Quant.	From	To
15	S1	CL		L	9	
Remarks: Encrustation Deposits on pipe wall from leakage through the crack						
15	*S2*	*CL*		*L*	*3*	
Remarks: *Encrustation Deposits on pipe wall from leakage through the crack*						
15		*JF*	*X*	*L*	*7*	*5*
Remarks: *Encrustation deposits on the joint due to leakage through joint*						
15	*S3*	*ED*		*S*	*7*	*5*
Remarks: *On Joint and below cracks*						

Although the longitudinal crack at 3 o'clock intersects the lateral connection, LF is not recorded as the crack extends (through) beyond the lateral connection zone.

PW1.2.2 – Chipping/Splintering (C)

Small splinters along the crack

Dist.	Cont.	Code	Char.	Quant.	From	To
4.5		CL	C		12	
Remarks: Small splinters along crack edges						



Dist.	Cont.	Code	Char.	Quant.	From	To
66.8		CL	C		3	
Remarks: Chipping evident along the visible length of the crack.						

PW1.2.3 – Vertical Displacement (D)

Dist.	Cont.	Code	Char.	Quant.	From	To
32.3		CL	D		6	
Remarks: Vertical displacement of crack face. Crack wanders between 5 – 6 o'clock						
32.3		*CL*		*M*	*11*	
Remarks: *Open but no clear evidence the crack extends through the pipe wall*						

PW1.2.4 –Slabbing (B)

Slabbing

Dist.	Cont.	Code	Char.	Quant.	From	To
29.8		CL	B		6	
Remarks: Slabbing in the pipe invert						
32.3	*S1*	*CL*		*M*	*6*	
Remarks: *CL extends after slabbing. Crack faces wet/damp due to flow*						

PW1.3 – Cracking Multiple

Code	Description	
CM	Cracking – Multiple. Cracking in both circumferential and longitudinal (multiple) directions. The connected crack branches extend longer than 100mm, but do not form 'blocks' of broken pipe[1,2].	
	Additional Information	
	Characterisation – additional code to describe specific structural features associated with the cracking used when present	
	C	Chipping/splintering of the wall fabric along the crack edge
	B	Slabbing[5] of the pipe wall fabric
	D	Vertical Displacement (shearing) of the crack edges resulting in an off-set or step in crack.
	Quantification[4] – Evidence of a pathway through the pipe wall (Method 1). Record using additional code to describe the observations as follows:	
	S	Small, crack is visible but looks closed and there is no evidence that the crack extends all the way through the pipe wall
	M	Medium, crack is open but there is no clear evidence that the crack extends all the way through the pipe wall
	L	Large, there is clear visual evidence that the crack extends all the way through the pipe wall[3]
Circumferential location: Record the extent of the cracking as a pair of clock references		
Continuous Defect: Where the length of cracking exceeds 1 metre, the crack shall be recorded as a Continuous Defect[6]		

Notes:
1. Use code PB if crack branches form 'blocks' of pipe
2. Use code JF if cracking occurs only within 100mm of a joint
3. Describe the evidence for the large severity band in the remarks
4. Quantification is not required when C, D or B characterisation codes are used
5. The terms slabbing, shear slabbing, or slab shear refers to a radial shear failure of the concrete which occurs from the yielding of the structural reinforcement steel due to excessive tension. Slabbing is characterized by slabs of concrete "peeling" or delaminating from the reinforcing steel as it straightens. B characterisation is not used for non-circular pipe shapes.
6. Multiple cracking must be truly continuous for greater than one metre.

Examples:

Dist.	Cont.	Code	Char.	Quant.	From	To
5	S1	CM		M	7	3
Remarks: Simple CM with CL & CC intersecting. Crack appears to be damp (would need to confirm if Infiltration was present)						
5		*JF*	*X*	*L*	*6*	*12*
Remarks: *Joint seal faulty with joint stained from infiltration*						

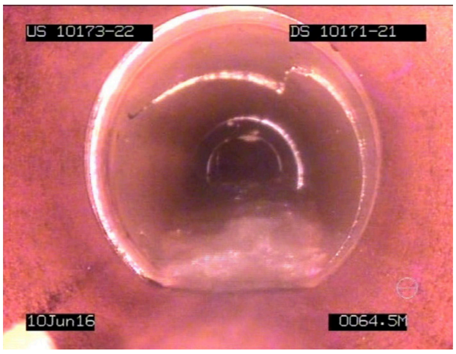
PW1.3.1 – Chipping/Splintering (C)

Dist.	Cont.	Code	Char.	Quant.	From	To
7.7		CM	C		6	9

Remarks: Edges of crack chipped.

This example shows a portion of the multiple crack. The cracking extends beyond the joint zone (edge of joint visible in immediate foreground) and the branching(circumferential) cracks do not connect back with the joint to form a 'block(s)'. If they do this defect would be coded PB.

PW1.3.2 – Vertical Displacement (D)



Dist.	Cont.	Code	Char.	Quant.	From	To
65		CM	D		10	5

Remarks: Displaced crack faces extending beyond joint zone with both circumferential and longitudinal directions.

For this example, additional investigation would be required by panning and tilting the camera at the joint to check if the cracks, extending towards the joint, at 10 o'clock and 5 o'clock, do not connect back with the joint to form a 'block'. If they do, then this defect would be coded PB.

PW1.4 – Pipe Broken

Code	Description	
PB	Pipe Broken. Pieces[1] or 'blocks' of pipe formed by cracks, (and branching cracks) connecting in a mosaic arrangement, including those made with cracks starting and ending at a joint face or lateral connection. The pieces have fallen out or are displaced from one another or are still in place but could become displaced.	
	Additional Information	
	Characterisation – Not required.	
	Quantification – The extent of the pipe circumference with broken pieces of pipe and the extent to which they have become displaced. (*Method 3 variation*). Record using additional codes to describe the observations as follows:	
	S	Small, broken pieces are up to 10% of the pipe circumference <u>and</u> not displaced by more than half the pipe wall thickness.
	M	Medium, broken pieces are up to 25% of the pipe circumference <u>and</u> not displaced by more than half the pipe wall thickness
	L	Large, broken pieces are more than 25% of the pipe circumference <u>or</u> pieces are displaced by more than half the pipe wall thickness or have fallen out/in[3]
Circumferential location: Record the extent of the broken as a pair of clock references		
Continuous Defect: Where the length of cracking exceeds 1 metre, the crack shall be recorded as a Continuous Defect[4]		

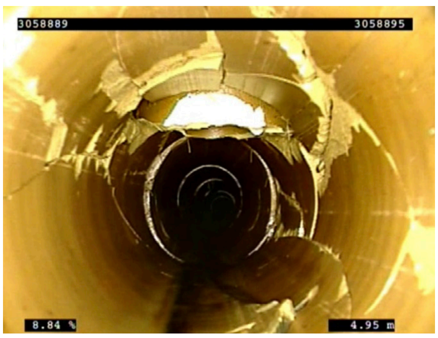
Notes:

1. Not used when the blocks are formed by branching cracks that extend less than 100mm and re-join the main circumferential or longitudinal crack.
2. Where pieces of broken pipe have fallen out of position (missing) this should be noted in the remarks
3. Pipe Broken (including all associated cracked) must be truly continuous for greater than one metre.

Examples:

Dist.	Cont.	Code	Char.	Quant.	From	To
57.4		PB		L	9	4
Remarks: Cracks extending beyond the joint zone have formed 'blocks' (> 25% of the pipe circumference) with the joint						
57.2		*WL*	*T*			
Remarks: *10%*						

Dist.	Cont.	Code	Char.	Quant.	From	To
0.5		PB		L	3	9
Remarks: Broken pipe pieces have displaced more than half the pipe wall thickness and some have fallen out						
0.5		*RI*		*S*	*12*	*12*
Remarks: *Fine roots, reduction <10% of pipe diameter*						
0.5		*EX*			*3*	*9*
Remarks: *Flow exfiltrating from the pipe through the broken pipe*						



Dist.	Cont.	Code	Char.	Quant.	From	To
8.8		PB		L	9	6
Remarks: Broken pipe pieces >25% of circumference and have displaced more than half the pipe wall thickness						
9		*LP*		*M*	*12*	
Remarks: *Lateral protruding 15 – 20%*						

PW1.5 – Deformed Plastic Pipe

Code	Description	
PF	Deformed Plastic Pipe. Refers to flexible pipe (e.g. PVC, PE, GRP, Steel) that has been deformed due to external pressure or loading	
	Additional Information	
	Characterisation – additional code to describe the type or orientation of the deformation	
	V	Vertical (elliptical) deformation – the vertical dimension has been reduced
	H	Horizontal (elliptical) deformation – the horizontal dimension has been reduced
	C	Cracking – cracks, fractures, rips or ruptures that can occur in circumferential, longitudinal or multiple directions
	G	Corrugation Growth – refers to plastic profiled pipes (with smooth internal walls) where corrugations have developed in the pipe's interior liner due to the transfer of stress from the outer layer to the inner wall
	B	Buckling – longitudinal or radial wavy deformation of the pipe wall due to large circumferential stresses
	IC	Inverse Curvature – buckling that results in an inwards buckling of the pipe wall (pipe all curves into the pipe) due to excessive loading
	Quantification[1,2] – Amount of deformation that has occurred expressed as a % of the reduction in pipe diameter (Method 2). Record using additional code to describe the observations as follows:	
	S	Small, deformation resulting in a reduction in diameter of up to 10%
	M	Medium, deformation resulting in a reduction in diameter between 10% - 25%.
	L	Large, deformation resulting in a reduction in diameter of greater than 25%
Circumferential location: No clock references are required		
Continuous Defect: Where the length of deformation exceeds 1 metre, the crack shall be recorded as a Continuous Defect[3]		

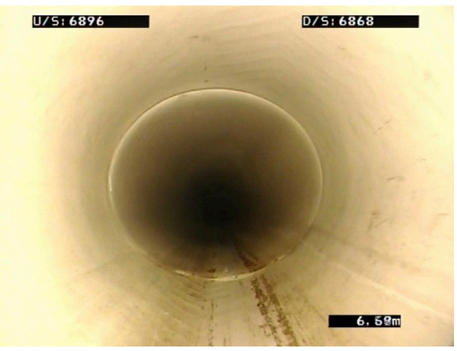
Notes:
1. Identifying plastic deformation up to 10% can be very difficult by visual inspection alone. Quantification of pipe deformation may require additional investigations (e.g. laser profiling).
2. Not required when C or G characterisation code is used
3. Plastic deformation must be truly continuous for greater than one metre.

BossPipe Twin wall drainage pipe

Regarding characterisation code G, corrugation growth, it should be noted that some types of profile walled pipes are manufactured with corrugated internal pipe walls, e.g. BossPipe twin wall drainage pipe, and the corrugations in these pipes should not be recorded as a defect.

Examples:

PW1.5.1 – Vertical/Horizontal Deformation (V/H)



Dist.	Cont.	Code	Char.	Quant.	From	To
6.6	S1	PF	V	M		

Remarks: PVC pipe with vertical deformation resulting in approx. 10% reduction in pipe diameter

Dist.	Cont.	Code	Char.	Quant.	From	To
77.8	S1	PF	V	M		

Remarks: Corrugated steel pipe with vertical deformation resulting in > 10% reduction in pipe diameter

PW1.5.2 – Cracking (C)

Dist.	Cont.	Code	Char.	Quant.	From	To
33.1		PF	C		12	4

Remarks: Rupture of the PVC pipe wall

Dist.	Cont.	Code	Char.	Quant.	From	To
33.3		LD	D			

Remarks: PVC pipe bends down approx. 5°

PW1.5.3 – Corrugation Growth (G)

Dist.	Cont.	Code	Char.	Quant.	From	To
X	S1	PF	G			

Remarks: Profile section HDPE pipe with corrugation growth failure

PW1.5.4 – Buckling (B)

Dist.	Cont.	Code	Char.	Quant.	From	To
X		PF	B		1	5

Remarks: Buckling in HDPE profile pipe wall (Corrugation Growth also evident)

PW1.5.5 – Inverse Curvature (IC)

Dist.	Cont.	Code	Char.	Quant.	From	To
X		PF	IC		8	10

Remarks: Bulge (inverse curvature)in the PP pipe wall

Dist.	Cont.	Code	Char.	Quant.	From	To
X	S1	PF	G			

Remarks: Corrugation growth failure (Coded as it is continuous, passing through the location of the IC, refer B2.1.6.7)

Dist.	Cont.	Code	Char.	Quant.	From	To
23.4		PF	IC	M	10	2
Remarks: Bulge in the soffit of the PVC pipe						

PW1.6 – Deformed Pipe

Code	Description	
DF	Deformed Pipe, or hinged cracked pipe, refers to rigid pipe, such as earthenware, asbestos cement or concrete pipe, that has been deformed due to pressure loaded on to the pipe. Identified by parallel longitudinal cracking through the pipe segment (between joints). typically occurring at points: 12 O'clock, 3 O'clock, 6 O'clock and 9 O'clock. The longitudinal cracking associated with the deformation is included in the DF code.[1,2]	
	Additional Information	
	Characterisation – additional code to describe the orientation of the deformation	
	V	Vertical deformation – the vertical dimension has been reduced
	H	Horizontal deformation – the horizontal dimension has been reduced
	Quantification[4] – Amount of deformation that has occurred expressed as a % of the reduction in pipe diameter (*Outlier Method 4*). Record using additional code to describe the observations as follows:	
	S	Small, **Not Applicable**
	M	Medium, deformation resulting in a reduction in diameter of up to 10%.
	L	Large, deformation resulting in a reduction in diameter of greater than 10%
Circumferential location: No clock references are required		
Continuous Defect: Where the length of cracking exceeds 1 metre, the crack shall be recorded as a Continuous Defect[3]		

Notes:

1. This is code is used if at least 3 parallel longitudinal cracks are visible in their typical arrangements above the flow in the invert (often continuous cracks that are expected at 6 O'clock are obscured by the flow or debris in the pipe).
2. The longitudinal cracks are not coded separately. Branching cracks, including those perpendicular to the longitudinal cracks, or broken pipe, are not coded, but should be noted in the remarks field.
3. Pipe deformation (including all associated cracked) must be truly continuous for greater than one metre.
4. Record the value of the reduction in diameter in the remarks.

Examples:

Dist.	Cont.	Code	Char.	Quant.	From	To
24.6	S1	DF	V	M		
Remarks: 3 longitudinal cracks are visible at 12, 3 and 9 o'clock. Expect 4th crack is hidden beneath the deposits in the invert. Reduction in diameter (due to deformation) <10%						
24.6	*S2*	*GC*			*3*	*9*
Remarks: *Pipe wall below the longitudinal cracks is stained from leakage*						
24.6	*S3*	*DE*		*S*		
Remarks: *Silty deposits*						

Dist.	Cont.	Code	Char.	Quant.	From	To
119.9	S1	DF	V	L		

Remarks: 4 longitudinal cracks are visible at 12, 3, 6 and 9 o'clock. Reduction in diameter 25%

Dist.	Cont.	Code	Char.	Quant.	From	To
1.3		DF	V	L		

Remarks: EW pipe has deformed to an extent that the pipe has moved out of place >25% (but <50%)

PW1.7 – Pipe Holed

Code	Description
PH	Pipe – Holed. A hole has been cut or 'punched' into the pipe, either to gain access to the pipe, (for example to remove a blockage) or through unintentional 3rd party damage to the pipe[1,2,3,4,5,7].
	Additional Information
	Characterisation – Not required.
	Quantification – The extent of the pipe circumference that has been holed by the impact and whether there has been any repair (*Method 3 variation*). Record using additional codes to describe the observations as follows:

S	Small, hole (any size) that has been repaired by covering or filling the hole, with no evidence that it is open to the outside of the pipe
M	Medium, pipe hole up to 25% of the pipe circumference
L	Large, pipe hole greater than 25% of the pipe circumference

Circumferential location: Record the extent of the hole as a pair of clock references

Continuous Defect: Where the longitudinal length of the hole(s) exceeds 1 metre, the defect shall be recorded as a Continuous Defect[7]

Notes:

1. A hole in the pipes as a result of a Piece(s) or 'blocks' of pipe, formed by a mosaic of cracks, falling out of position should be coded using defect code PB.
2. Lifting Eyes, lateral openings, or other 'holes' associated with the construction of the pipe or its features should not be coded PH but instead should use the appropriate feature code.
3. The surmised reason for the hole and evidence or otherwise of its repair is noted in the "Remarks" field.
4. Where an object is protruding through the pipe hole, this shall be coded separately and in addition to the PH
5. Where more than one hole occurs within one metre, they are entered as one hole. The quantification takes into account the combined loss of circumference.
6. If steel reinforcement is visible within the hole this is coded separately using code RV
7. Either a single hole or where multiple holes spaced less than a metre apart.

Examples:

Dist.	Cont.	Code	Char.	Quant.	From	To
33.9		PH		S	10	2

Remarks: 'Impact' pipe hole has been covered and there is no evidence of a pathway to the outside of the pipe. Cracks not coded separately (refer to B2.1.6.7)

Dist.	Cont.	Code	Char.	Quant.	From	To
28.2		PH		M	10	1

Remarks: Pipe hole up to 25% of the pipe circumference, the cause of the hole is not known

Dist.	Cont.	Code	Char.	Quant.	From	To
28.2		*TM*				

Remarks: *Cavity visible through the pipe hole*

PW1.8 – Surface Damage

Code	Description	
S	Surface Damage. The inside surface of the pipe has been damaged. This includes abrasive erosion, chemical/bacterial corrosion, spalling, delamination, chips and mechanical damage	
	Additional Information	
	Characterisation – additional code to describe the type/extent of damage that has occurred	
	W	Wall Roughened – light surface damage where the surface of the pipe is slightly worn
	S	Spalling of concrete pipe surface, including localized chipping or where layers or small fragments have broken from the pipe surface due to the expansion action of corroded reinforcement
	PM	Pipe Missing – A section of the pipe has completely corroded/eroded away
	DL	Delamination – refers to layers of pipe wall (typically AC) are visible or have been removed from the pipe surface and may have lost its circular shape
	AE	Aggregate Exposed – concrete aggregate is visible
	AP	Aggregate Projecting – coarse concrete aggregate is projecting from the surface of the pipe
	AM	Aggregate Missing – coarse concrete aggregate is projecting from the surface and the damage has extended sufficiently that individual pieces of aggregate have become removed.
	RV	Reinforcement Visible[5] – Steel reinforcement is visible with or without corrosion evident
	RC	Reinforcement Corrosion – The concrete cover to the steel reinforcement has been removed due to corrosion/ erosion/spalling/other and the reinforcement steel is corroded and may have extended sufficiently that the steel has been removed4.
	RVP	Steel Reinforcement is visible and projecting into the pipe
	WS	Wall Staining[3] – staining/discoloration of the pipe wall
	CP	Corrosion Products from the corrosion or chemical attack are visible as a build-up on the pipe surface
	H	Holed – damage has extended right through the pipe wall in localized areas
	MD	Mechanical Damage – surface of the pipe has been damaged by equipment e.g. cleaning equipment (jetters, root cutters, drainage rods) or other equipment such as weld de-beaders etc.
	D	Other Surface Damage
	Quantification[1] – The extent of the pipe circumference with surface damage evident. (*Method 3 and Outlier Method 5*[2]). Record using additional code to describe the observations as follows:	
	S	Small, (i) damage covering up to 10% of the pipe circumference, or (ii) Thin (one or more) layers of pipe wall are evident and/or have been removed from the pipe surface, or evidence of cement leaching present on the pipe surface[2]
	M	Medium, (i) damage covering between 10% to 25% of the pipe circumference, or (ii) Thick layers of pipe wall are evident and/or have been removed from the pipe surface without evidence of the pipe losing its (circular) shape[2]
	L	Large, (i) damage covering greater than 25% of the pipe circumference, or (ii) Thick layers of pipe wall are evident and/or have been removed from the pipe surface such that the pipe is losing/lost its (circular) shape[2]
Circumferential location: Record the extent of the surface damage as a pair of clock references		
Continuous Defect: Where the length of surface damage exceeds 1 metre, the defect shall be recorded as a Continuous Defect[6]		

Notes:
1. Not required when W, S and PM characterisation codes are used
2. Only applies when DL characterisation code is used
3. Wall staining is often due to the corrosion of the underlying steel reinforcement. Staining may also be due to non-corrosion related influences such as staining by agents within the stormwater or wastewater flow or groundwater infiltration. WS should only be used for corrosion related activity.
4. If reinforcement is completely corroded away, this shall be noted in the remarks field
5. Used where reinforcement is visible due to pipe holes or other situations (excluding lifting eyes) not related to corrosion of the pipe surface
6. Surface Damage must be truly continuous for greater than one metre.

Examples:

PW1.8.1 – Wall Roughened (W)

Dist.	Cont.	Code	Char.	Quant.	From	To
89.9	S1	S	W		12	12

Dist.	Cont.	Code	Char.	Quant.	From	To
26.7	S1	S	W		5	7

PW1.8.2 – Spalling (S)

Dist.	Cont.	Code	Char.	Quant.	From	To
23.2		S	S		8	10

Remarks: No reinforcement visible

Dist.	Cont.	Code	Char.	Quant.	From	To
8.6		S	S		7	9

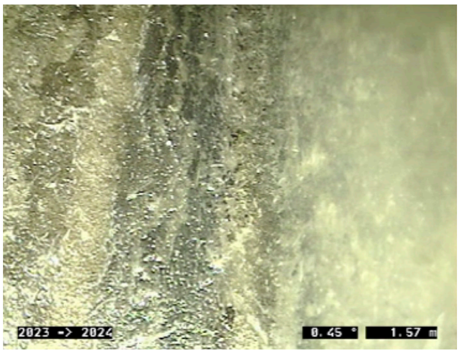
Remarks: Cement surface spalling. Reinforcement corrosion staining at the base of spalling area

PW1.8.3 – Pipe Missing (PM)

Dist.	Cont.	Code	Char.	Quant.	From	To
0.12	S1	S	PM		8	4

Remarks: Corrosion beyond the reinforcement with only a paper-thin veneer of pipe wall remaining

PW1.8.4 – Delamination (DL)



Dist.	Cont.	Code	Char.	Quant.	From	To
1.6	S1	S	DL	S	3	9

Remarks: Thin layers of AC pipe wall delamination

Dist.	Cont.	Code	Char.	Quant.	From	To
1.6	S1	S	DL	S	3	9

Remarks: Thin layers of AC pipe wall delamination

Dist.	Cont.	Code	Char.	Quant.	From	To
37.2	S1	S	DL	S	9	3

Remarks: Cement deposits on the pipe surface that have leached from the AC pipe wall

Dist.	Cont.	Code	Char.	Quant.	From	To
91.9	S1	S	DL	M	9	2

Remarks: Thick layers of AC pipe wall are delaminating but the pipe still retained it circular shape

Dist.	Cont.	Code	Char.	Quant.	From	To
2.9	S1	S	DL	L	9	3

Remarks: Thick layers of AC pipe wall are delaminating and the pipe is losing its circular shape

PW1.8.5 – Aggregate Exposed (AE)

Dist.	Cont.	Code	Char.	Quant.	From	To
2.6	S1	S	AE	M	5	7

Remarks: Aggregate exposed in the invert (up to 25% of pipe circumference) because of erosion from the flow in the pipe.

PW1.8.6 – Aggregate Projecting (AP)

Dist.	Cont.	Code	Char.	Quant.	From	To
19.4	S1	S	AP	L	8	4

Remarks: Coarse aggregate protruding above the pipe surface over >25% of the pipe circumference

PW1.8.7 – Aggregate Missing (AM)

Lost aggregate

Dist.	Cont.	Code	Char.	Quant.	From	To
0.77	S1	S	AM	L	4	7

Remarks: Coarse aggregate protruding with evidence that some aggregate has been lost (>25% of the pipe circumference)

PW1.8.8 – Reinforcement Visible (RV)

Dist.	Cont.	Code	Char.	Quant.	From	To
7.8		S	RV	S	3	5

Remarks: Circumferential reinforcement exposed

Dist.	Cont.	Code	Char.	Quant.	From	To
70.2		S	RV	S	9	10

Remarks: Circumferential reinforcement exposed where saddle connection has been installed

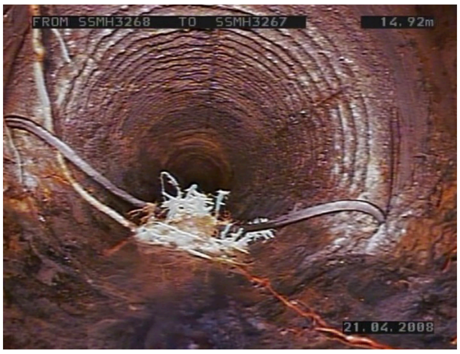
Dist.	Cont.	Code	Char.	Quant.	From	To
70.2		*LF*	*X*	*M*	*9*	

Remarks: *Internal mortar seal missing*

PW1.8.9 – Reinforcement Corrosion (RC)

Dist.	Cont.	Code	Char.	Quant.	From	To
38.5	S1	S	RC		6	12

Remarks: Wall loss due to corrosion exposing reinforcement steel (which is corroded)



Dist.	Cont.	Code	Char.	Quant.	From	To
15	S1	S	RC		8	4

Remarks: Wall corrosion starting to pass reinforcing steel leaving the corroded reinforcement protruding from the surface

Dist.	Cont.	Code	Char.	Quant.	From	To
15		*O*	*P*	*S*	*4*	*8*

Remarks: *Rubber ring displaced catching material*

PW1.8.10 – Steel Reinforcement is Visible and Projecting into the Pipe (RVP)

Dist.	Cont.	Code	Char.	Quant.	From	To
58.4		S	RVP	M	9	11

Remarks: Reinforcement projecting above the pipe surface due to manufacturing defect (up to 25% of the pipe circumference)

PW1.8.11 – Wall Staining (WS)

Dist.	Cont.	Code	Char.	Quant.	From	To
54.7		S	WS	S	9	11

Remarks: Staining on the pipe wall from steel reinforcement corrosion

Dist.	Cont.	Code	Char.	Quant.	From	To
54.7	*S1*	*S*	*AE*	*M*	*10*	*2*

Remarks: *Aggregate visible up to 25% of the pipe circumference (Coded as it is continuous, passing through the location of the WS)*

PW1.8.12 – Corrosion Products (CP)

Dist.	Cont.	Code	Char.	Quant.	From	To
54.3	S1	S	CP	L	10	2

Remarks: Calcium Carbonate buildup on the pipe surface (some has been removed) >25% of the pipe circumference

Dist.	Cont.	Code	Char.	Quant.	From	To
25.8		S	CP	L	12	5

Remarks: Steel corrosion products on the pipe wall

PW1.8.13 – Holed (H)

Dist.	Cont.	Code	Char.	Quant.	From	To	Remarks
33.2		S	H	L	4	8	Hole(s) eroded through cast-insitu pipe wall.
33.2		*SV*					

Dist.	Cont.	Code	Char.	Quant.	From	To
26.7	S1	S	H	L	4	8

Remarks: Erosion of the AC pipe wall in the invert causing a 'slot' to open to the outside

Dist.	Cont.	Code	Char.	Quant.	From	To
6.1		S	H	M	5	7
6.1		*EX*			*5*	*7*

Remarks: Rusting of the steel in the invert of this corrugated steel pipe causing a hole to open to the outside

PW1.8.14 – Mechanical Damage (MD)

Dist.	Cont.	Code	Char.	Quant.	From	To
37.6		S	MD	S	2	3

Remarks: Scratch at 3 o'clock peeling a thin layer of PE

PW1.8 – Surface Damage – Tuberculation

Code	Description	
S	Surface Damage. Tuberculation corrosion of steel pipes leads to the growth of tubercles on the inside surface of the steel pipe. Tuberculation falls under the general surface damage code, but the quantification requires fits under Method 2, and is describe separately here.	
	Additional Information	
	Characterisation – additional code to describe the type/extent of damage that has occurred	
	T	Tuberculation corrosion products are visible on the side of the steel or other ferrous pipes
	Quantification – Percentage reduction in the pipe diameter (*Method 2*). Record using additional code to describe the observations as follows:	
	S	Small, corrosion resulting in a reduction in diameter of up to 10%
	M	Medium, corrosion resulting in a reduction in diameter between 10% - 25%
	L	Large, corrosion resulting in a reduction in diameter of greater than 25%
Circumferential location: Record the extent of the corrosion as a pair of clock references		
Continuous Defect: Where the length of Tuberculation exceeds 1 metre, the defect shall be recorded as a Continuous Defect[1]		

Notes:
1. Tuberculation must be truly continuous for greater than one metre.

Examples:

Dist.	Cont.	Code	Char.	Quant.	From	To
X	S1	S	T	M	12	12

Remarks: Steel tubercles buildup on the pipe wall reducing the pipe diameter >10%

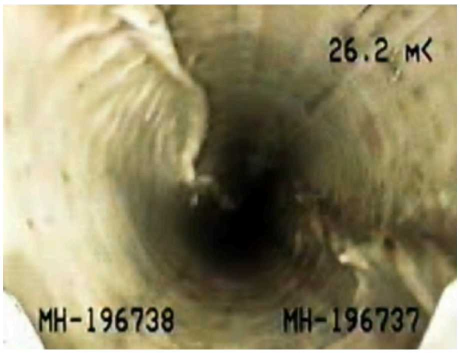
PW1.9 – Protective Lining Defective

Code	Description	
PL	Lining Defective. The lining of a pipe is defective. This relates to liners installed within a pipe conduit for protection, sealing or rehabilitation.	
	Additional Information	
	Characterisation – additional code to describe the nature of the defect	
	WL	Wrinkling Longitudinal
	WC	Wrinkling Circumferential
	W	Wrinkling – multiple patterns
	B	The lining is blistered
	BU	The liner is Bulged or deformed
	D	Detached – The lining has become detached from the host pipe wall
	E	End or edge of the patch repair lining is defective or irregular e.g. Excessive resin or end of patch is lifted (but the patch has not detached from the pipe wall)
	C	Discoloration – the lining material has localized staining or discoloured pigmentation2
	WD	Weld Defective – A weld in the lining is defective3
	L	Leak – Water is observed seeping or leaking through or from behind the liner wall4
	H	Holes or perforations are evident in the liner
	RC	Re-establishment of Connection done improperly
	RM	Rendered Mortar Missing
	SJ	Spiral Joints Separated
	Quantification[1] – Percentage reduction in the pipe diameter (*Method 2*). Record using additional code to describe the observations as follows:	
	S	Small, reduction in pipe diameter of up to 10%
	M	Medium, reduction in diameter between 10% and 25%
	L	Large, reduction in diameter greater than 25%
Circumferential location: - Record the extent of the surface damage as a pair of clock references		
Continuous Defect: Where the length of Tuberculation exceeds 1 metre, the defect shall be recorded as a Continuous Defect[5]		

Notes:
1. Only required when WL, WC, W, B, BU and D Characterisation codes are used
2. Not used when staining/discoloration is from agents within the stormwater or wastewater flow, or lubricants or resins used in the lining. Reason for the staining is noted in the remarks field
3. Not used for defect joint welds in PVC, PE or Steel pipes
4. Only used when no holes (H) or separated spiral joints (SJ) are evident
5. Defect must be truly continuous for greater than one metre.

Examples:

PW1.9.1 – Wrinkling Longitudinal (WL)



Dist.	Cont.	Code	Char.	Quant.	From	To
26.2	S1	PL	WL	M	4	10

Remarks: Two longitudinal wrinkles

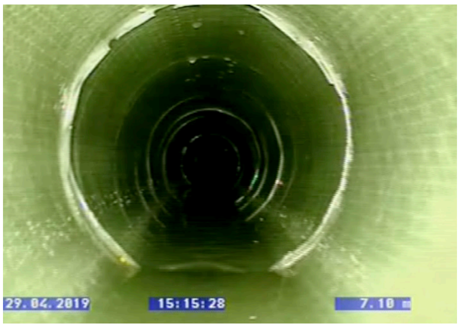
Dist.	Cont.	Code	Char.	Quant.	From	To
8	S1	PL	WL	S	5	6

Remarks: Thin Longitudinal (fin) wrinkle @ 5 o'clock

PW1.9.2 – Wrinkling Circumferential (WC)

Dist.	Cont.	Code	Char.	Quant.	From	To
23.2	S1	PL	WC	S	8	4

Dist.	Cont.	Code	Char.	Quant.	From	To
9.7	S1	PL	WC	S	1	10



Dist.	Cont.	Code	Char.	Quant.	From	To
7.2		PL	WC	S	12	12

Remarks: Residual Polyester Resing

PW1.9.3 – Bulged or Deformed liner (BU)

Dist.	Cont.	Code	Char.	Quant.	From	To
72		PL	B	L	1	6

Remarks: Bulge in fold & form liner

Dist.	Cont.	Code	Char.	Quant.	From	To
63.8	S1	PL	BU	L		
Remarks: Liner is deformed						
66		*WL*	*T*			
Remarks: *Water level reduces to <5%*						

PW1.9.4 – Detached (D)

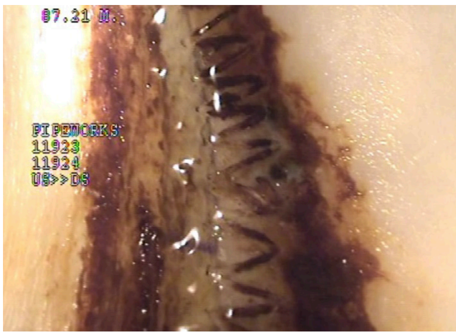
Dist.	Cont.	Code	Char.	Quant.	From	To
38.6		PL	D	M	7	9
Remarks: LJR Patch has become detached and lifted from the liner wall						
38.6		*PR*	*L*			
Remarks: *Liner Junction Repair (LJR)*						

PW1.9.5 – Discoloration (C)

Dist.	Cont.	Code	Char.	Quant.	From	To
31.5		PL	C		6	12
Remarks: Staining of the liner wall due to leaking seam						

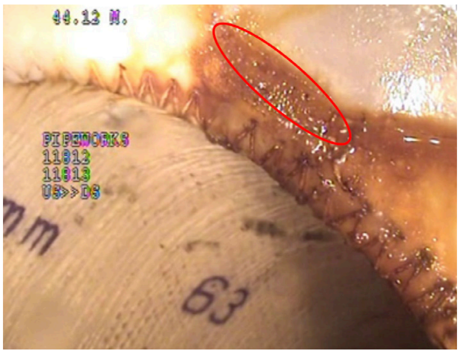
Dist.	Cont.	Code	Char.	Quant.	From	To
31.6		PL	C		8	5
Remarks: Staining of the liner wall due to Ground water infiltration through unsealed lateral connection						
31.6		*LF*	*X*	*L*	*2*	
Remarks: *Lateral junction seal not re-established post liner opening*						

PW1.9.7 – Leak (L)



Dist.	Cont.	Code	Char.	Quant.	From	To
87.2		PL	L		2	4
Remarks: Laminar (water sheen) flow over stitching and normal beading on LJR – Leakage through the stitching						
87.2		*IP*		*S*	*2*	*4*
Remarks: *Seeping infiltration through stitching*						

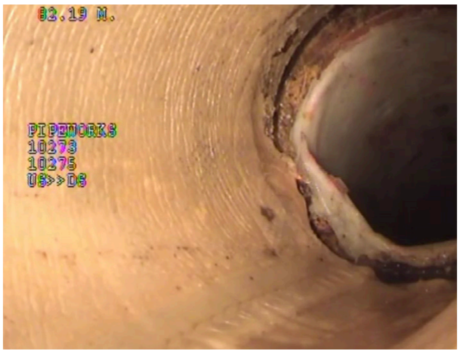
PW1.9.8 – Holes or Perforations are evident in the liner (H)



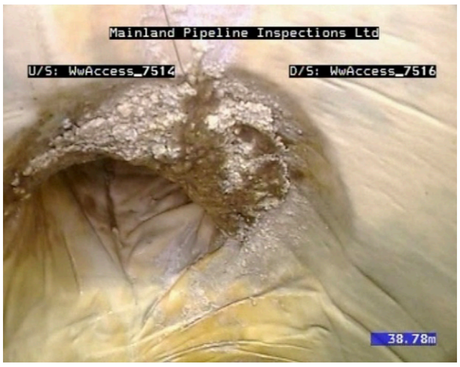
Dist.	Cont.	Code	Char.	Quant.	From	To
44.1		PLH	H		2	
Remarks: Split or tear in the LJR						
44.1		*IP*		*S*	*2*	*4*
Remarks: *Seeping infiltration*						

Dist.	Cont.	Code	Char.	Quant.	From	To
20.7		PL	H		2	
Remarks: Small hole/perforation in the liner.						
20.7		*PL*	*C*		*2*	*6*
Remarks: *Staining of the liner wall due to groundwater infiltration through the hole*						

PW1.9.9 – Re-establishment of Connection done improperly (RC)



Dist.	Cont.	Code	Char.	Quant.	From	To
82.2		PL	RC		3	
Remarks: LJR leg does not extend to cover the first joint inside the lateral						



Dist.	Cont.	Code	Char.	Quant.	From	To
38.8		PL	RC		12	
Remarks: Only just beyond the point of connection. Appears that an incorrect size LJR/LCR used, with excess resin, obstructing/blocking the lateral						

PW1.9.10 – Spiral Joints Separated (SJ)

Dist.	Cont.	Code	Char.	Quant.	From	To	Remarks
		PL	SJ				

PW1.10 – Point Repair

Code	Description	
PR	Point Repair – A short section of pipe (≤2m) has been repaired with an internal sleeve or injected sealing material	
	Additional Information	
	Characterisation – additional codes to describe the type of repair	
	L	Localised Lining (Patch Repair)
	I	Injected Mortar/Sealant
	IC	Internal ‘Clip” Seal
	Z	Other
	Quantification – No additional quantification required.	

Circumferential location: Where the repair affects only a portion of the circumference, record the location or extent of the repair as one or two clock references

Continuous Feature: Not Applicable

Notes:

1. Provide a description of the repair in the Remarks field.

Examples:

PW1.10.1 – Localised Lining (Patch Repair) (L)

Dist.	Cont.	Code	Char.	Quant.	From	To
16.4		PR	L			
Remarks: CIPP Patch Repair						
16.2		*GC*			*4*	*8*
Remarks: *Marks (lines) on the pipe wall*						

PW1.01.2 – Internal ‘Clip” Seal (IC)

Dist.	Cont.	Code	Char.	Quant.	From	To	Remarks
2.4		PR	IC				Internal sealing repair band

PW1.11 – Lining Change

Code	Description
LC	Lining Change – The lining of the original pipe has changed1. A description of the change is provided in the Remarks field.
	Additional Information
	Characterisation – additional codes to describe the Lining Change are not required.
	Quantification – No additional quantification required.

Circumferential location: No clock references are required

Continuous Feature: Not Applicable

Notes:
1. Not used for where a point repair has been installed (i.e. a CIPP patch or LJR)

PW1.12 – Soil Visible

Code	Description
SV	Soil Visible[1,2] – the soil or trench material outside the pipe is visible through a defect
	Additional Information
	Characterisation – additional codes are not required.
	Quantification – No additional quantification required.

Circumferential location: Record the extent of the visible soil as a pair of clock references

Continuous Defect: Where the longitudinal length of visible soil, through a defect exceeds 1 metre the soil visible shall be recorded as a Continuous Defect[3]

Notes:
1. Where a Tomo, (cavity/void) is visible the defect code TM should be used, even if some soil is still visible
2. Where more than one defect through which soil is visible occurring within one metre, they are entered as one entry.
3. Either a single defect or where multiple defects spaced less than a metre apart.

Example:

Dist.	Cont.	Code	Char.	Quant.	From	To
11.2		SV				
Remarks: Soil visible through pipe hole						
11.2		*PH*		*M*	*9*	*11*
11.2		*S*	*RV*		*9*	*11*

PW1.13 – Tomo

Code	Description
TM	Tomo – a cavity or void outside the pipe is visible through a defect
	Additional Information
	Characterisation – additional codes are not required.
	Quantification – No additional quantification required.

Circumferential location: Record the extent of the visible soil as a pair of clock references

Continuous Defect: Where the longitudinal length of the Tomo, through a defect exceeds 1 metre the Tomo shall be recorded as a Continuous Defect[2]

Notes:

1. Where more than one defect through which Tomo is visible occurring within one metre, they are entered as one entry.
2. Either a single defect or where multiple defects spaced less than a metre apart.

Examples:

Dist.	Cont.	Code	Char.	Quant.	From	To
1.2		TM				
Remarks: Tomo (Cavity) visible through pipe hole						
1.2		*PH*		*M*	*12*	*1*

Dist.	Cont.	Code	Char.	Quant.	From	To
16		TM				
Remarks: Tomo (Cavity) visible missing piece of broken pipe						
16		*PB*		*L*	*12*	*12*
16		*GC*				
Remarks: *Broken section of pipe is a junction and the water entering is flow from the lateral pipe (obscured)*						

PW1.14 – Pipe Collapsed

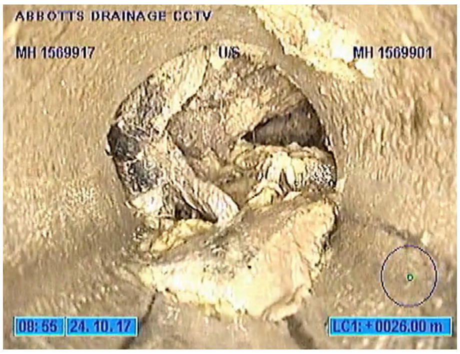
Code	Description
PX	Pipe Collapsed[1] – full structural failure and the pipe no longer functions as a free-flowing conduit, although water may still flow through the rubble of the collapsed pipe
	Additional Information
	Characterisation – additional codes are not required.
	Quantification – No additional quantification required.

Circumferential location: No clock references are required

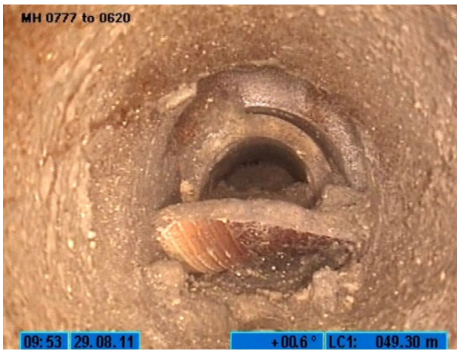
Continuous Defect: Not Applicable

Notes:
1. Code also applies when 50% or more of the diameter is obstructed by the collapsed pipe and other material.

Examples:



Dist.	Cont.	Code	Char.	Quant.	From	To
26.3		PX				



Dist.	Cont.	Code	Char.	Quant.	From	To
49.5		PX				

Remarks: Pipe roof collapsed in with broken pipe and debris reducing pipe diameter >50% and pipe no longer functioning as a free flowing conduit.

PW1.15 – Dimension Change

Code	Description
DC	Dimension Change[1] – changes in diameter/dimensions of the pipe during the inspection. Can also be used for changes in shape.
	Additional Information
	Characterisation – additional codes are not required.
	Quantification – No additional quantification required.

Circumferential location: No clock references are required

Continuous Defect: Not Applicable

Notes:
1. Record the previous and new dimensions in the Remarks field
2. Dimension change is coded as an individual feature and is not covered under a continuous feature, i.e. where a change in dimension is only is short portion of the pipe before it returns to the original dimensions, the start and end are coded as separate entries and not as a continuous feature.

Example:

Dist.	Cont.	Code	Char.	Quant.	From	To
18.2		DC				
Remarks: Change in pipe shape from Circular to Arch						

PW1.16 – Material Change

Code	Description
MC	Material Change – The pipe material has changed. A description of the previous and new pipe material and the joint spacing for the new pipe material, if it is longer than one pipe length, are noted in the Remarks field.
	Additional Information
	Characterisation – additional codes are not required.
	Quantification – No additional quantification required.
Circumferential location: No clock references are required	
Continuous Feature: Where the length of the material change exceeds one metre, the MC shall be recorded as a Continuous Feature	

Example:

Dist.	Cont.	Code	Char.	Quant.	From	To
29.1		MC				
Remarks: Concrete to PVC						
29.1		*JF*	*X*	*L*	*10*	*2*
Remarks: Root intrusion through gasket (end of concrete has been poorly cut)						
29.1		*JD*	*V*	*S*	*8*	*2*
29.1		*RI*		*S*	*10*	*2*
Remarks: *Fine roots growing through faulty joint seal*						

PW1.17 – Pipe Length Change

Code	Description
PC	Pipe Length Change[1] – the typical joint spacing has changed. The new joint spacing length is recorded in the Remarks field.
	Additional Information
	Characterisation – additional codes are not required.
	Quantification – No additional quantification required.
Circumferential location: No clock references are required	
Continuous Feature: Not Applicable	

Notes:
1. This code is used where the joint spacing length has changed without the material (or lining) changing.

M2 – Masonry Codes

M2.1 – Missing Mortar

Code	Description	
MM	Missing Mortar[1,2] – All or part of the mortar from between the masonry units are missing	
	Additional Information	
	Characterisation – additional codes are not required to describe the Missing Mortar	
	Quantification – extent of the pipe circumference where the mortar is missing (*Method 3*). Record using additional code to describe the observations as follows:	
	S	Small, mortar missing up to 10% of the pipe circumference
	M	Medium, mortar missing between 10% and 25% of the pipe circumference
	L	Large, mortar missing from 25% or greater of the pipe circumference

Circumferential location: Where only one or a few masonry units are affected, record the location as a single clock entry. Where the extent of the missing masonry units is more extensive, use a pair of clock references to describe the location.

Continuous Defect: Where the length of pipe with missing mortar exceeds 1 metre, the defect shall be recorded as a Continuous Defect[3]

Notes:
1. Code does not refer to missing mortar render. Where this occurs the defect code RM should be used
2. Where infiltration (IP), root intrusion (RI) or exfiltration (EX) is apparent through the mortar course, this is evidence of mortar loss and this code should be used. The IP, RI or EX is coded in separately and in addition to this code.
3. Defect must be truly continuous for greater than one metre.

Examples:

Dist.	Cont.	Code	Char.	Quant.	From	To
22.4	S1	MM		M	4	7

Remarks: Part or all the mortar is missing between bricks in the pipe invert

Dist.	Cont.	Code	Char.	Quant.	From	To
98.4		MM		S	7	8

Remarks: Part or all the mortar is missing between basalt block

Dist.	Cont.	Code	Char.	Quant.	From	To
21.7		MM		S	7	10

Remarks: Part or all the mortar is missing between basalt block

Dist.	Cont.	Code	Char.	Quant.	From	To
3.35	S1	MM		L	10	3
Remarks: Roots growing through the mortar joints indicating that some or all of the mortar is missing where the roots are present.						
3.35	*S2*	*RI*	*F*	*S*	*10*	*3*
Remarks: *Mostly fine Roots entering through mortar joints*						

Dist.	Cont.	Code	Char.	Quant.	From	To
74.5	S1	MM		L	2	6
Remarks: Leakage through mortar joints indicating that some or all of the mortar is missing						
74.5	*S2*	*ED*		*M*	*2*	*6*
Remarks: *Because distance between the individual deposits is less than 1m this is recorded as continuous*						
77.5	*F2*	*ED*		*M*	*2*	*6*

M2.2 – Masonry Unit Separation

Code	Description	
MUS	Masonry Unit Separation[1] – the regularity of the original bond pattern has been disturbed with masonry courses separating along mortar joints	
	Additional Information	
	Characterisation – additional codes are not required to describe masonry separation.	
	Quantification – the width of the gap separation (*Outlier Method 2*). Record using additional code to describe the observations as follows:	
	S	Small, gap separation width 20mm
	M	Medium, gap separation width between 21mm and 50mm
	L	Large, gap separation greater than 50mm

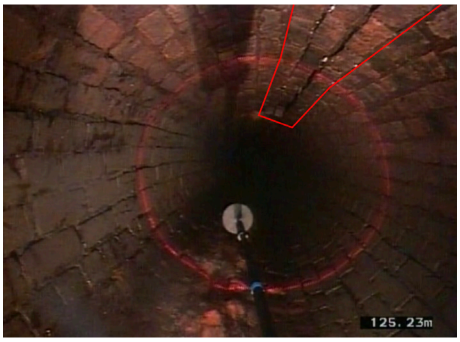
Circumferential location: Where there is only one separation, record the location as a single clock entry. Where the extent of the separation is more extensive, use a pair of clock references to describe the location.

Continuous Defect: Where the length of pipe with separation exceeds 1 metre, the defect shall be recorded as a Continuous Defect[3]

Notes:
1. Code applies when there is a minimum separation of 2x standard mortar joint width (or 20mm)
2. Cracking of masonry units where present shall be coded separately and in addition using defect codes CC or CL
3. Defect must be truly continuous for greater than one metre.

Examples:

Dist.	Cont.	Code	Char.	Quant.	From	To
33.4	S1	MUS		S	11	
Remarks: Single continuous separation						



Dist.	Cont.	Code	Char.	Quant.	From	To
125.2	S1	MUS		S	1	2

M2.3 – Dropped Invert

Code	Description	
DI	Dropped Invert[1,2] – A section of brickwork in the invert has dropped relative to the grade of the pipe forming a horizontal gap between the bricks near the invert of the pipe. The dropped invert may be evident on one side or both.	
	Additional Information	
	Characterisation – additional codes are not required to describe dropped inverts.	
	Quantification – the width of the gap separation (*Outlier Method 2*). Record using additional code to describe the observations as follows:	
	S	Small, gap separation width 20mm
	M	Medium, gap separation width between 21mm and 50mm
	L	Large, gap separation greater than 50mm
Circumferential location: Record the location of the wall separation using one or a pair of clock references[3]		
Continuous Defect: Where the length of pipe with separation exceeds 1 metre, the defect shall be recorded as a Continuous Defect[4]		

Notes:

1. Code applies when there is a minimum separation of 2x standard mortar joint width (or 20mm)
2. Cracking of masonry units where present shall be coded separately and in addition using defect codes CC or CL
3. A single clock position is adequate where there is only a single gap evident, otherwise a pair of clock references are used to define the drop area
4. Defect must be truly continuous for greater than one metre.

Examples:

Dist.	Cont.	Code	Char.	Quant.	From	To
X	S1	DI		M	5	7
Remarks: 2 clear gaps between masonry units near the invert indicating a dropped invert						
X		DE		S		
Remarks: Debris in pipe invert						

Dist.	Cont.	Code	Char.	Quant.	From	To
10	S1	DI		M	5	7
Remarks: 2 clear gaps between masonry units near the invert indicating a dropped invert						

M2.4 – Displaced Masonry Unit

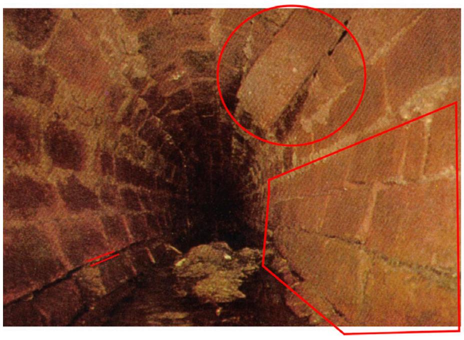
Code	Description	
DMU	Displaced Masonry Unit. One or more masonry units moved from their original position (but not fallen out)	
	Additional Information	
	Characterisation – additional code to describing the direction of movement	
	I	Moved Inwards
	O	Moved Outwards
	Quantification – extent of the pipe circumference where the masonry units are observed as displaced (*Method 3*). Record using additional code to describe the observations as follows:	
	S	Small, displaced masonry units are up to 10% of the circumference
	M	Medium, displaced masonry units are between 10% and 25% of the circumference
	L	Large, displaced masonry units are greater than 25% of the circumference

Circumferential location: Where only one or a few masonry units are displaced, record the location as a single clock entry. Where the extent of the displaced masonry units is more extensive, use a pair of clock references to describe the location.

Continuous Defect: Where the longitudinal length of pipe with displaced masonry units exceeds 1 metre, the defect shall be recorded as a Continuous Defect[1]

Notes:
1. Defect must be truly continuous for greater than one metre.

Examples:



Dist.	Cont.	Code	Char.	Quant.	From	To
X		DMU	I	L	1	7

Remarks: 1 brick has moved out of position (1 o'clock) close to falling out. At least 2 other courses between 3 and 5 o'clock appear to be moving inwards.

Dist.	Cont.	Code	Char.	Quant.	From	To
X	*S1*	*DI*		*S*	*5*	*7*

Remarks: *2 longitudinal gaps near the invert indicating the invert has dropped relative to the grade of the pipe (coded as defect is continuous passing through the location of the displaced bricks)*

Dist.	Cont.	Code	Char.	Quant.	From	To
0.0	S1	DMU	O	S	5	7

Remarks: Bricks in the invert of the pipe have displaced down (outwards)

M2.5 – Missing Masonry Unit

Code	Description	
MMU	Missing Masonry Unit. One or more masonry units are missing i.e. have fallen out	
	Additional Information	
	Characterisation – additional code to describing the extent of further brick layers	
	V	Another layer of masonry is visible through the hole left by the missing masonry unit(s)
	NV	No more masonry units are visible through the hole left by the missing masonry unit(s)[1]
	Quantification – extent of the pipe circumference where the missing masonry units are observed (*Method 3*). Record using additional code to describe the observations as follows:	
	S	Small, missing masonry units are up to 10% of the circumference
	M	Medium, missing masonry units are between 10% and 25% of the circumference
	L	Large, missing masonry units are greater than 25% of the circumference

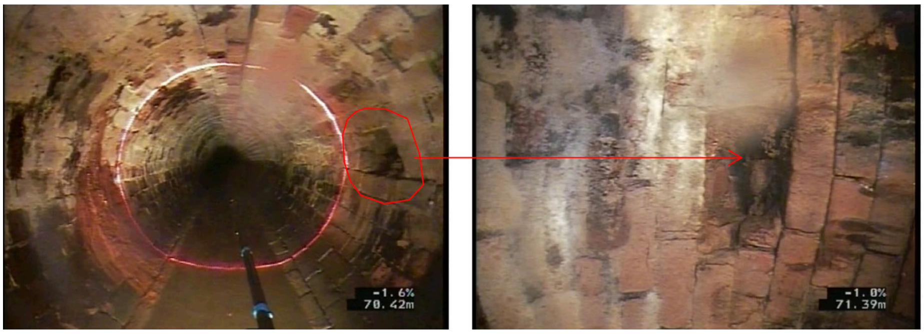
Circumferential location: Where only one or a few masonry units are missing, record the location as a single clock entry. Where the extent of the missing masonry units is more extensive, use a pair of clock references to describe the location.

Continuous Defect: Where the longitudinal length of pipe with displaced missing masonry units exceeds 1 metre, the defect shall be recorded as a Continuous Defect[2]

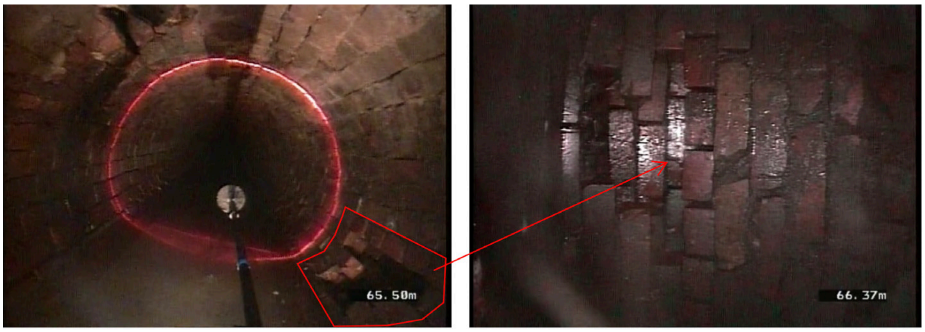
Notes:

1. Soil or earth visible shall be coded separately and in addition using the defect code SV. TM should be used if a Tomo (cavity/void) is visible
2. Defect must be truly continuous for greater than one metre.

Examples:



Dist.	Cont.	Code	Char.	Quant.	From	To	Remarks
70.9		MMU	NV	S	2	3	2 brick courses missing. Leakage through mortar joints evident by ED
70.9		*ED*		*S*	*7*	*10*	
70.4	*S1*	*GC*			*5*	*7*	Possible that invert is beginning to drop but gap is not wide enough to record as such.



Dist.	Cont.	Code	Char.	Quant.	From	To	Remarks
65.6		MMU	V	S	4	5	At least 3 brick courses missing (more visible behind)

Dist.	Cont.	Code	Char.	Quant.	From	To
38.9		MM	NV	M	3	5
Remarks: Bricks below the lateral are missing (2 courses)						
38.9		*TM*				
Remarks: *Cavity visible*						

Dist.	Cont.	Code	Char.	Quant.	From	To
38.9		MM	NV	M	5	7
Remarks: Bricks in the invert are missing (camera is tilted)						
38.9		*SV*				
Remarks: *Bedding visible*						
38.9		*EX*			*5*	*7*

M2.6 – Masonry Pipe Collapsed

Code	Description
MX	Masonry Pipe Collapsed[1] – full structural failure and the masonry pipe no longer functions as a free-flowing conduit, although water may still flow through the rubble of the collapsed pipe
	Additional Information
	Characterisation – additional codes are not required.
	Quantification – No additional quantification required.
Circumferential location: No clock references are required.	
Continuous Defect: Not Applicable.	

Notes:

1. Code applies when 50% or more of the diameter is obstructed by the collapsed masonry units and other material.

J3 – Joint Codes

J3.1 – Joint Faulty

Code	Description	
JF	Joint – Faulty[1,5,6]. Joint sealing defects or physical damage to joints, excluding open and displaced joints. Physical damage relates specifically to occurrences within 100mm either side of the joint centre referred to as the 'Joint Zone'[1,5]	
	Additional Information	
	Characterisation – additional code to describe the type of sealing or physical damage associated with the observed Joint Fault	
	C	Cracks (Circumferential/Longitudinal/Multiple)
	B	Broken pipe – blocks or pieces of pipe, including those made with cracks starting and ending at the joint face.
	D	Damaged end of pipe – such as chipping of the pipe ends or damage to the pipe surface
	X	Seal – the sealing of the joint is faulty, excluding as a result of C, B and D, but could be due to evidence relating to breaching of the joint seal due to the opening or displacement of the joint
	Quantification – Evidence of a pathway through the joint or pipe wall, or the extent of the pipe circumference with broken pieces of pipe and the extent to which they have become displaced[4] (Method 1 and variation). Record using additional code to describe the observations as follows:	
	S	(i) Small, there are defects visible but there is no evidence of a pathway through the joint, or that cracks extend all the way through the pipe wall (ii) Small[4], broken pieces are up to 10% of the pipe circumference and not displaced by more than half the pipe wall thickness
	M	(i) Medium, there is no clear evidence that there is a pathway through the joint, or that the cracks extend all the way through the pipe wall (ii) Medium[4], broken pieces are up to 25% of the pipe circumference and not displaced by more than half the pipe wall thickness
	L	(i) Large, there is clear visual evidence that there is a pathway through the joint or the cracks extend all the way through the pipe wall[3] (ii) Large[4], broken pieces are more than 25% of the pipe circumference or pieces are displaced by more than half the pipe wall thickness or have fallen out/in[7]
Circumferential location: Record the extent of the crack as a pair of clock references		
Continuous Defect: Not Applicable[2]		

Notes:

1. If the cracking or damage extends for a distance of more than 100mm from the joint it is not considered to be a joint fault and should be recorded under the relevant condition code
2. Faulty joints are coded as individual defects and cannot be recorded as a set of continuous defects, i.e. consecutive joints with the same type of defect cannot be covered under a single continuous defect.
3. Describe the evidence for the Large severity band in the remarks
4. Quantification based on defect code PB applies only where the B characterisation is used
5. Not used for faulty welds in PE, Steel or PVC pipe or protective liners
6. Where the joint is Open or Displaced these codes shall be recorded separately
7. Where broken pieces have fallen out completely, this shall be noted in the remarks.

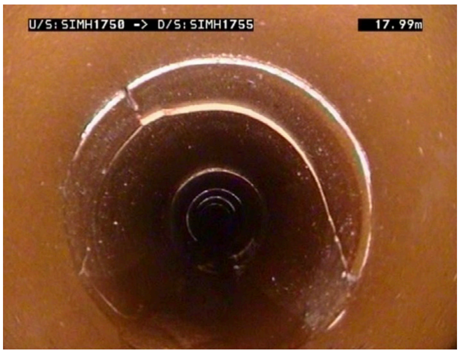
Examples:

J3.1.1 – Cracking within Joint Zone (C)

Dist.	Cont.	Code	Char.	Quant.	From	To
3.2		JF	C	S	11	1

Remarks: Longitudinal crack within Joint zone (<100mm from joint centre)

J3.1.2 – Broken Pipe within Joint Zone (B)



Dist.	Cont.	Code	Char.	Quant.	From	To
18.2		JF	B	L	7	4

Remarks: Pipe broken with displaced pieces within the joint zone extending more than 25% of the pipe circumference and displaced by more than half the pipe wall thickness.

J3.1.3 – Damaged end of pipe (D)

Dist.	Cont.	Code	Char.	Quant.	From	To
26.6		JF	D	L	7	8

Remarks: End of the spigot is chipped exposing edge of displaced rubber ring.

J3.1.4 – Faulty Seal (X)

Dist.	Cont.	Code	Char.	Quant.	From	To
34.5		JF	X	L	12	12

Remarks: Sealing rubber ring is broken and hanging inside the pipe

34.5		*O*	*P*	*S*	*2*	*5*

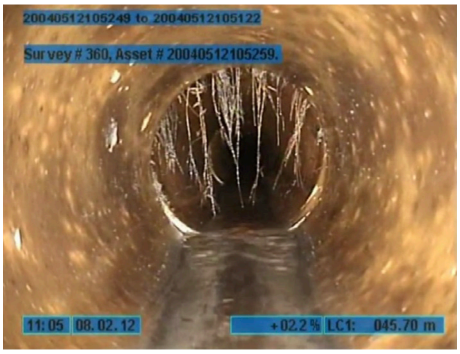
Remarks: *Rubber ring*

Dist.	Cont.	Code	Char.	Quant.	From	To
6		JF	X	L	12	12

Remarks: Encrustation deposits (left) and staining (right) from leakage through joint

6		*ED*		*S*	*6*	*12*

Remarks: *Buildup on joint*



Dist.	Cont.	Code	Char.	Quant.	From	To
46		JF	X	L	12	12

Remarks: Roots entering through faulty joint seal

46		*JD*	*V*	*S*	*4*	*8*

Remarks: *Slight displacement*

46		*RI*		*S*	*9*	*3*

Remarks: *Intruding through faulty joint seal – effective reduction in diameter <10%*

J3.2 – Joint Open

Code	Description	
JO	Joint – Open. Pipes segments are displaced longitudinally[1,4,5,6]	
	Additional Information	
	Characterisation – additional code to identify rotation or angular displacement at the joint	
	A	Angular displacement – the joint is open on one side causing the pipe alignment to deflect.
	Quantification[2] – Width of the longitudinal displacement (e.g. the distance between the end of the spigot and the inside of the socket of the adjacent pipe, *Outlier Method 1*). Record using additional code to describe the observations as follows:	
	S	Small, longitudinal displacement up to 20mm
	M	Medium, longitudinal displacement between 20mm and 40mm
	L	Large, longitudinal displacement greater than 40mm

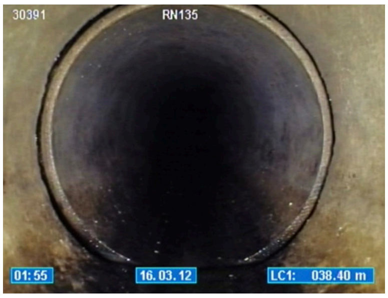
Circumferential location[3]**:** For Angular deflection, record the pair of clock references at the points at which the two pipe segments appear to intersect each other, in the clockwise direction of the open joint gap.

Continuous Defects: Not Applicable[7]

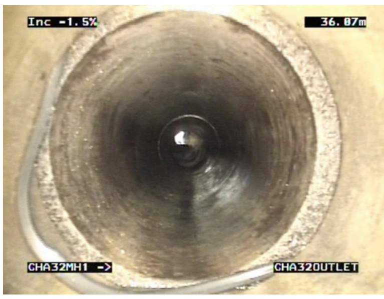
Notes:

1. Make due allowance for normal material, dimension and joint construction tolerances and do not code as JO if joint 'gap' is within normal tolerance.
2. Where the joint gap can be measured, the longitudinal displacement shall be recorded in the Remarks field
3. No clock references are required if there is no angular defection through the joint.
4. Where Joint sealing defects or physical damage within the joint zone is present defect code JF shall also be recorded separately and in addition to JO.
5. Where the joint is also vertically or horizontally displaced, defect code JD shall also be recorded separately and in addition to JO.
6. Where a curve has been deliberately introduced in to a pipeline using an angular deflection, feature code LU, LD, LL or LR should also be recorded separately and in addition to JO.
7. Open joints are coded as individual defects and cannot be recorded as a set of continuous defects, i.e. consecutive joints with that are open cannot be covered under a single continuous defect.

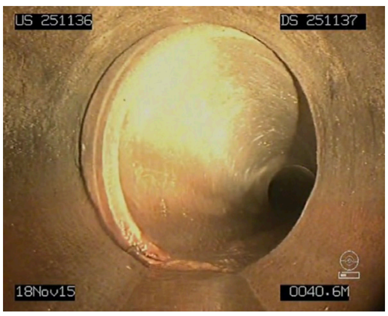
Examples:



Dist.	Cont.	Code	Char.	Quant.	From	To
1.7		JO		S		



Dist.	Cont.	Code	Char.	Quant.	From	To
3.8		JO		S		
3.8		*JF*	*X*	*L*	*4*	*10*
Remarks: *Rubber sealing ring displaced*						
3.8		*O*	*P*	*S*	*5*	*9*
Remarks: *Rubber ring hanging inside the pipe*						



Dist.	Cont.	Code	Char.	Quant.	From	To
40.9		JO	A	L	6	12
40.9		*LD*	*R*			
Remarks: *Pipe deviates right >45°*						
40.9		*JF*	*X*	*M*	*12*	*12*
Remarks: *Rubber sealing ring seat in collar exposed but no ring visible*						

J3.3 – Joint Displaced

Code	Description	
JD	Joint – Displaced. The pipe segments have a vertical or horizontal displaced to each other.[1,2,3]	
	Additional Information	
	Characterisation – additional code to describe the direction of displacement.	
	V	Vertical Displacement – the joint has a step up or down in the pipe alignment at the joint.
	H	Horizontal Displacement – the pipe alignment has shifted left or right at the joint.
	Quantification – Percentage reduction in the pipe diameter[4] (*Method 2*). Record using additional code to describe the observations as follows:	
	S	Small, displacement has resulted in a reduction of the pipe diameter up to 10%
	M	Medium, displacement has resulted in a reduction of the pipe diameter between to 10% and 25%
	L	Large, displacement has resulted in a reduction of the pipe diameter greater than 25%

Circumferential location[5]: Record the pair of clock references at the points at which the two pipe segments appear to intersect each other, in the clockwise direction of the exposed joint face.

Continuous Defects: Not Applicable[6]

Notes:

1. Make due allowance for normal material, dimension and jointing construction tolerances and do not code as JD if the joint displacement is within normal tolerance.
2. Where Joint sealing defects or physical damage within the joint zone is present defect code JF shall also be recorded separately and in addition to JD.
3. Where the joint is also 'open' the defect code JO shall also be recorded separately and in addition to JD.
4. Measurement of the reduction in diameter is based on the smallest diameter dimension as a result of the displacement
5. The order of the clock references shall describe the displacement of the invert
6. Displaced joints are coded as individual defects and cannot be recorded as a set of continuous defects, i.e. consecutive joints with that are displaced cannot be covered under a single continuous defect.

Examples:

Dist.	Cont.	Code	Char.	Quant.	From	To
2.1		JD	V	S	9	3

Remarks: Vertical displacement up to 10% of the pipe diameter

Dist.	Cont.	Code	Char.	Quant.	From	To
20.1		JD	V	M	8	2

Remarks: Vertical displacement down > 10% of the pipe diameter

Dist.	Cont.	Code	Char.	Quant.	From	To
20.1		*JF*	*X*	*L*	*12*	*12*

Remarks: *Soil visible through displacement*

Dist.	Cont.	Code	Char.	Quant.	From	To
20.1		*SV*				
20.1		*WL*	*T*			

Remarks: *Flow depth holding 10% due to displacement in invert*

J3.4 – Weld Defect

Code	Description	
W	Weld Defect. A defect in a joint weld is evident. This includes welded joints in PE, Steel and PVC pipe materials	
	Additional Information	
	Characterisation[1] – additional codes to describe type of nature of the weld defect	
	C	Weld is cracked
	X	Weld is defective exhibiting unevenness or malformation or porosity or shrinkage or contamination or other detrimental feature
	LF	Weld exhibits a lack of fusion between the weld and one or more of the items being joined
	D	Displacement, where the pipe ends (as part of PE butt weld) are displaced relative to one another[2]
	AA	Angular Misalignment (Butt Weld). The pipe ends are not aligned squarely3
	A	Misalignment (Electrofusion Joint). The electrofusion joint has been welded at an angle on one or both sides of a coupler[3]
	I	Incorrect insertion – pipe ends not inserted correctly into an electrofusion coupler, pipe ends not cut square or pulled out of position during welding resulting in an internal gap[4]
	M	Electrofusion coupler (PE welding only) has partially melted. Welding wires may or may not be visible
	O	Ovality and “flat areas”. One or more pipe ends are deformed causing an annular gap between the pipe and the electrofusion coupler
	U	Weld exhibits undercut at the toe of weld (steel welding only)
	Z	Other weld defect
	Quantification – No additional quantification required.	
Circumferential location: Record the location of the weld defects as a single or pair of clock reference as appropriate		
Continuous Defects: Not Applicable[5]		

Notes:

1. Provide a description of the weld defects seen in the remarks
2. Record the estimated displacement at the weld as percentage (%) of the pipe wall thickness
3. Record the estimated extent of misalignment, measured at a point 300mm from centre of the pipe joint
4. Record the estimated or measured internal gap in the remarks
5. Defective welds are coded as individual defects and cannot be recorded as a set of continuous defects, i.e. consecutive defective welded joints cannot be covered under a single continuous defect.

Examples:

J3.4.1 – Incorrect Insertion (I)

Dist.	Cont.	Code	Char.	Quant.	From	To
55.6		W	I		12	12

Remarks: Poorly prepared pipe ends with internal gap within the electrofusion coupler of >5% of the pipe diameter (more than 10mm)

J3.4.2 – Electrofusion coupler (PE welding only) has partially melted (M)

Dist.	Cont.	Code	Char.	Quant.	From	To
2.8		W	M		10	2

Remarks: Melt has flowed out and filled the gap between the two pipe ends and is slightly protruding

Dist.	Cont.	Code	Char.	Quant.	From	To
28.3		W	M		10	

Remarks: Melt has flowed out a small gap between the cut-out pipe and EF saddle with wires exposed

J3.4.3 – Ovality (O)

Dist.	Cont.	Code	Char.	Quant.	From	To	Remarks
52.3		W	O		12	12	2 brick courses missing. Leakage through mortar joints evident by ED
52.3		*WL*	*C*				Flow depth increases to approx. 5% due to EF joint ovality

J3.5 – Manhole (or Chamber) Joint Faulty

Code	Description
MHJ	Manhole (or Chamber) Joint Faulty. The bond or seal between the pipe and node structure (including chambers, catch pits, wingwalls, etc) is faulty, such that the seal between pipe and structure is broken or defective and there is a pathway to the outside of the pipe.
	Additional Information
	Characterisation – Additional codes are not required.
	Quantification[1] – No additional quantification required.

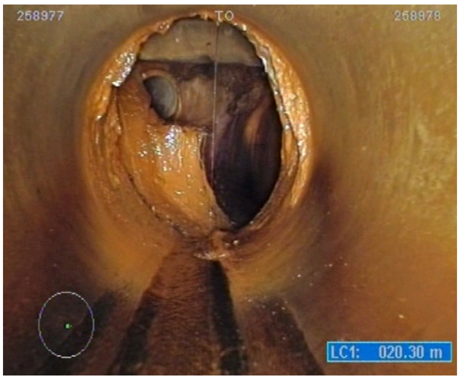
Circumferential location: Record the location of the observed fault as a single or pair of clock reference as appropriate

Continuous Defect: Not Applicable

Notes:

1. A description of the defective manhole joints shall be provided in the remarks.

Examples:



Dist.	Cont.	Code	Char.	Quant.	From	To
20.7		MHJ			12	12
Remarks: Manhole joint seal defective						
20.7		*ED*		*S*	*7*	*5*
Remarks: *Buildup on the end on the pipe at entrance to the manhole*						
20.7		*IP*		*M*	*12*	*6*
Remarks: *From Manhole seal*						

Dist.	Cont.	Code	Char.	Quant.	From	To
20.2		MHJ			12	12
Remarks: Manhole joint seal defective, roots intruding						
20.2		*BRI*			*2*	*6*
Remarks: *Roots growing through manhole connection reducing cross-section by >50%*						

J3.5.1 – Liner Terminations with Manholes/Chambers

Dist.	Cont.	Code	Char.	Quant.	From	To
0.5		MHJ			8	11
Remarks: Gaps/defects in the end seal with the manhole						

L4 –Laterals Codes

L4.1 – Lateral

Code	Description	
L	Lateral – Defect free lateral connection that would not attract a defect code of LF, LP or LX1. The type of connection (e.g. Junction, saddle or stub) and the estimated diameter of the lateral is recorded in the Remarks field.	
	Additional Information	
	Characterisation – additional codes to describe the connectivity of the lateral	
	O	Open – the lateral is Open, i.e. does not have a blank cap visible
	B	Blank – the lateral is not connected (closed) and a blank cap is visible2
	Quantification – no additional quantification required.	
Circumferential location: Record the position of the lateral connection as a single of clock reference for the center of the lateral pipe.		
Continuous Feature: Not Applicable3		

Notes:

1. Where defect codes LF, LP or LX would apply, LO or LB feature codes are not used
2. The cap is sealed with no defects. If the cap is leaking or is displaced/cracked or broken the code LF is used
3. Laterals are coded as individual defects or features and cannot be recorded as a set of continuous defects, i.e. consecutive lateral connections cannot be covered under a single continuous code.

Examples:

L4.1.1 – Open (O)

Dist.	Cont.	Code	Char.	Quant.	From	To
15.6		L	O		9	
Remarks: AC Junction 100mm						
14.4	*S1*	*S*	*W*	*M*	*4*	*8*
Remarks: *Minor abrasion in the invert*						

Dist.	Cont.	Code	Char.	Quant.	From	To
29.5		L	O		3	
Remarks: PE Fusion saddle connection, 100mm						
29.3	*S1*	*DG*		*S*	*4*	*8*
Remarks: *Slight fat buildup above the flow level*						

Dist.	Cont.	Code	Char.	Quant.	From	To	Remarks
17.3		L	O		12		Lateral Connection Repair, 100
17.3		PR	L		10	2	CIP Lateral Connection Repair (LCR)

L4.1.2 – Blank (B)

Dist.	Cont.	Code	Char.	Quant.	From	To
15.6		L	B		3	

Remarks: Lateral is capped

L4.2 – Lateral Faulty

Code	Description	
LF	Lateral – Faulty[3,4]. Joint sealing defects or physical damage to lateral connections, excluding protruding laterals and defects within the lateral pipe. Physical damage relates specifically to occurrences up to the first joint, inside the lateral stub and an area of pipe wall around the lateral connection, that extends 50mm circumferentially fromthe internal face of the lateral connection pipe, referred to as the 'lateral Connection Zone'[1].	
	Additional Information	
	Characterisation – additional code to describe type of sealing or physical damage associated with the lateral connection.	
	C	Cracks (Circumferential/Longitudinal/Multiple) inside the lateral stub or pipe wall within the lateral connection zone.
	B	Broken pipe – blocks or pieces of pipe, including those made with cracks inside the lateral stub or pipe wall within the lateral connection zone.
	D	Damaged lateral pipe/joint – such as chipping of the first joint or stub pipe with the main.
	X	Seal – the sealing of the lateral connection is faulty, excluding as a result of C, B and D, but could be due to evidence relating to breaching of the joint seal due to the opening or displacement of the first joint or poor/ missing sealing
	Quantification – Evidence of a pathway through the joints or pipe wall (*Method 1*). Record using additional code to describe the observations as follows:	
	S	Small, there are defects visible but there is no evidence of a pathway through the lateral connection, or that cracks extend all the way through the pipe wall
	M	Medium, there is no clear evidence that there is a pathway through the lateral connection, or that the cracks extend all the way through the pipe wall
	L	Large, there is clear visual evidence that there is a pathway through the lateral connection or the cracks extend all the way through the pipe wall[2]
Circumferential location: Record the position of the lateral connection as a single of clock reference for the center of the lateral pipe.		
Continuous Defect: Not Applicable[5]		

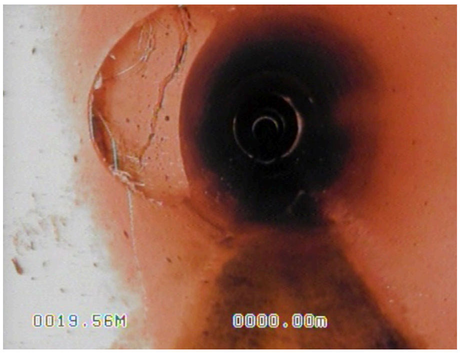
Notes:

1. If the cracking or damage extends beyond the lateral connection zone, it is not considered to be a faulty lateral and should be recorded under the relevant condition code
2. Describe the evidence for the Large severity band in the remarks
3. Describe in the remarks the estimate diameter of the lateral pipe
4. If the lateral is protruding or there are defects visible inside the lateral beyond the first joint, the defect codes LP or LX, respectfully, shall be recorded separately and in addition to LF.
5. Faulty laterals are coded as individual defects and cannot be recorded as a set of continuous defects, i.e. consecutive faulty laterals with the same type of defect cannot be covered under a single continuous defect.

Examples:

L4.2.1 – Cracks (C)

Dist.	Cont.	Code	Char.	Quant.	From	To
6.5		LF	C	L	3	
Remarks: Displaced cracks inside the lateral stub. Poor seal around lateral connection						
6.5		*GC*				
Remarks: *Discolored flow in the lateral*						



Dist.	Cont.	Code	Char.	Quant.	From	To
19.7		LF	C	L	9	
Remarks: Circumferential crack (Large). Roots visible inside lateral but not extending into the main						

L4.2.2 – Broken Pipe (B)

Dist.	Cont.	Code	Char.	Quant.	From	To
19.7		LF	B	L	11	
Remarks: Lateral connection is broken and the lateral partially protruding into the main						
19.7		*LP*		*M*	*11*	
Remarks: *Broken lateral connection protruding >10% in to the main*						

Dist.	Cont.	Code	Char.	Quant.	From	To
4.2		LF	B	L	12	
Remarks: Lateral connection is broken with the broken pipe partially blocking the lateral						
4.2		*SV*				
Remarks: *Stones/bedding visible through gap around the broken lateral connection*						

Dist.	Cont.	Code	Char.	Quant.	From	To
46.3		LF	B	L	2	
Remarks: Lateral stub pipe is broken with the broken pipe missing						
46.3		*TM*				
Remarks: *Small cavity (Tomo) visible through broken stub*						

L4.2.3 – Seal (X)

Dist.	Cont.	Code	Char.	Quant.	From	To
17.4		LF	X	M	12	

Remarks: Missing internal mortar. Possible pathway around the saddle connection

Dist.	Cont.	Code	Char.	Quant.	From	To
24.3		LF	X	L	10	

Remarks: Missing mortar and Tomo visible through wall gap at lateral connection

Dist.	Cont.	Code	Char.	Quant.	From	To
24.3		*TM*				

Remarks: *Small cavity evident around lateral faulty lateral connection*

Dist.	Cont.	Code	Char.	Quant.	From	To
33.6		LF	X	M	2	

Remarks: First joint is displaced with possible pathway through joint.

Dist.	Cont.	Code	Char.	Quant.	From	To
8		LF	X	L	3	

Remarks: Roots entering through faulty seal of the blank cap

Dist.	Cont.	Code	Char.	Quant.	From	To
8		*GC*				

Remarks: *Roots in lateral almost entering the main*

L4.3 – Lateral Protruding

Code	Description	
LP	Lateral – Protruding2,3. The pipe is protruding into the inspected pipe.	
	Additional Information	
	Characterisation – Additional codes are not required	
	Quantification – Percentage reduction in the pipe diameter[1] (*Method 2*). Record using additional code to describe the observations as follows:	
	S	Small, protruding lateral has resulted in a reduction of the pipe diameter up to 10%
	M	Medium, protruding lateral has resulted in a reduction of the pipe diameter between to 10% and 25%
	L	Large, protruding lateral has resulted in a reduction of the pipe diameter greater than 25%
Circumferential location: Record the position of the lateral connection as a single of clock reference for the center of the lateral pipe		
Continuous Defect: Not Applicable[4]		

Notes:
1. Measurement of reduction in diameter is based on the diameter dimension between the end of the protruding lateral and the pipe wall opposite.
2. Describe in the remarks the estimate diameter of the lateral pipe.
3. If the lateral has a faulty lateral seal or physical damage with the lateral connection zone or there are defects visible inside the lateral beyond the first joint, the defect codes LF or LX, respectfully, shall be recorded separately and in addition to LP.
4. Protruding laterals are coded as individual defects and cannot be recorded as a set of continuous defects, i.e. consecutive protruding laterals cannot be covered under a single continuous defect.

Example:

Dist.	Cont.	Code	Char.	Quant.	From	To
31.2		LP		L	10	
Remarks: Lateral protruding >25% (almost 50%)						
31.2		*LF*	*X*	*M*	*10*	
Remarks: *Missing internal mortar, possible staining below lateral connection*						

L4.4 – Lateral Problem

Code	Description	
LX	Lateral – Problem[2]. There are defects visible in the lateral pipe, beyond the first joint with the main.	
	Additional Information	
	Characterisation – additional codes to describe type of defect visible inside the lateral pipe.	
	B	Blocked lateral – the lateral pipe appears to be block
	C	Branch Cracked – Circumferential/Longitudinal/Multiple cracks visible inside the lateral
	D	Displaced[3] – Joints inside the lateral are displaced
	R	Some Roots – Roots seen inside the lateral
	SE	Soil Entering – Soil or deposits from outside of the lateral can be seen in the lateral pipe
	Z	Other
	Quantification[1] – No additional quantification required.	
Circumferential location: Record the position of the lateral connection as a single of clock reference for the center of the lateral pipe.		
Continuous Defects: Not Applicable[5]		

Notes:

1. Provide a description of the defects seen in the remarks
2. If the lateral has a faulty lateral seal or physical damage with the lateral connection zone or is protruding, the defect codes LF or LP, respectfully, shall be recorded separately and in addition to LX.
3. To be used for joints that are displaced inside the lateral after the first joint. Use LFX if the first joint is displaced.
4. Roots that are growing down the lateral and entering the inspected pipe shall be recorded separately using the defect code RI.
5. Defective laterals are coded as individual defects and cannot be recorded as a set of continuous defects, i.e. consecutive defective laterals cannot be covered under a single continuous defect.

Examples:

L4.4.1 – Branch Cracked (C)

Dist.	Cont.	Code	Char.	Quant.	From	To
10.8		LX	C		9	
Remarks: Longitudinal Crack in the Lateral pipe beyond the first Joint						
10.8		*LF*	*X*	*L*	*9*	
Remarks: *First joint seal is faulty with leakage staining (2 – 4 o'clock) and minor root intrusion*						

L4.4.2 – Displaced (D)

Dist.	Cont.	Code	Char.	Quant.	From	To
35.9		LX	D		3	
Remarks: Significant joint displacement beyond the first joint						

S5 –Service Related Codes

S5.1 – Debris Silty

Code	Description	
DE	Debris Silty[1,2] – refers to silt, sand, mud or gravel deposited in the pipeline.	
	Additional Information	
	Characterisation – Additional codes are not required	
	Quantification – Reduction in the diameter of the pipe because of the deposits (*Method 2*). Record using additional code to describe the observations as follows:	
	S	Small, reduction of up to 10% of the pipe diameter
	M	Medium, reduction between 10% and 25% of the pipe diameter
	L	Large, reduction between 25% and 50% of the pipe diameter

Circumferential location: No clock references are required.

Continuous Defect: Where the longitudinal length of pipe with silty deposits exceeds 1 metre, the defect shall be recorded as a Continuous Defect[3]

Notes:

1. The type of deposits, and the extent of any pre-cleaning should be noted in the remarks field.
2. Where the reduction is diameter is >50%, the defect shall be coded using the defect code BDE, Pipe Blocked (with debris).
3. Either truly continuous or where debris is interspersed spaced less than a metre apart.

Examples:

Dist.	Cont.	Code	Char.	Quant.	From	To
32.3	S1	DE		S		

Remarks: Silty Gravels up to 10% reduction in diameter

Dist.	Cont.	Code	Char.	Quant.	From	To
0.9		DE		M		

Remarks: Rocks and Stones up to 25% reduction in diameter

S5.2 – Debris Greasy

Code	Description	
DG	Debris Greasy[1,2,3] – refers to fat, scale and all adhering material, except encrustation deposits.	
	Additional Information	
	Characterisation – Additional codes are not required	
	Quantification – Reduction in the diameter of the pipe because of the greasy deposits (*Method 2*). Record using additional code to describe the observations as follows:	
	S	Small, reduction of up to 10% of the pipe diameter
	M	Medium, reduction between 10% and 25% of the pipe diameter
	L	Large, reduction between 25% and 50% of the pipe diameter

Circumferential location: Record the location of the greasy deposits on the pipe wall with a pair of clock references.

Continuous Defect: Where the length of pipe with greasy deposits exceeds 1 metre, the defect shall be recorded as a Continuous Defect[4]

Notes:
1. Do not use where the deposits are corrosion products from the corrosion or chemical attack of concrete. Where this occurs the surface damage defect code SCP should be used.
2. The type of greasy deposits, and the extent of any pre-cleaning should be noted in the remarks field.
3. Where the reduction is diameter is >50%, the defect shall be coded using the defect code BDG, Pipe Blocked (with fat).
4. Either truly continuous or where fat deposits are interspersed spaced less than a metre apart.

Examples:

Dist.	Cont.	Code	Char.	Quant.	From	To
22.3	S1	DG		S	9	3
Remarks: Thin layer of fat on the pipe roof						
22.3	*S2*	*S*	*W*		*4*	*9*
Remarks: *From flow in the pipe*						

Dist.	Cont.	Code	Char.	Quant.	From	To
67	S1	DG		M	8	6
Remarks: "chunks" of fat remaining attached to the pipe wall post cleaning (pipe was blocked before the cleaning)						

S5.3 – Encrustation Deposits

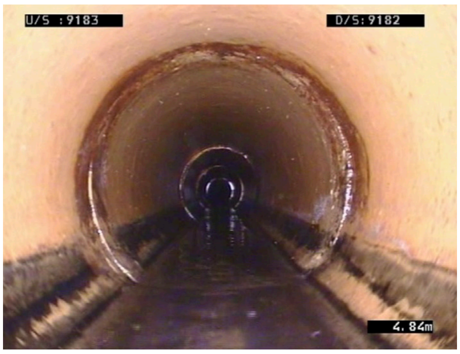
Code	Description	
ED	Encrustation Deposits[1] – deposits left by the partial evaporation of infiltrating ground water containing dissolved salts/ minerals. Can be a very thin layer but may build up to thicker deposits on the pipe wall over time.	
	Additional Information	
	Characterisation – Additional codes are not required	
	Quantification – Reduction in the diameter of the pipe because of the deposits (*Method 2*). Record using additional code to describe the observations as follows:	
	S	Small, reduction of up to 10% of the pipe diameter
	M	Medium, reduction between 10% and 25% of the pipe diameter
	L	Large, reduction between 25% and 50% of the pipe diameter

Circumferential location: Record the location of the deposits on the pipe wall with a pair of clock references.

Continuous Defect: Where the length of pipe with encrustation deposits exceeds 1 metre, the defect shall be recorded as a Continuous Defect[2]

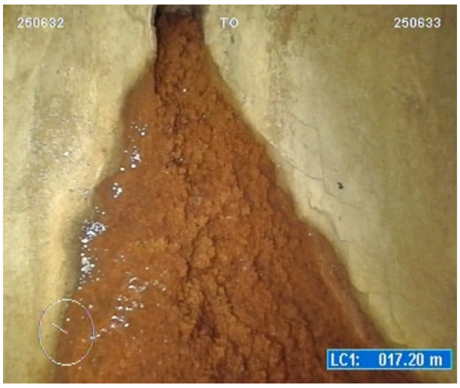
Notes:
1. Where the reduction is diameter is >50%, the defect shall be coded using the defect code BZ, Pipe Blocked (add comment that blockage is due to ED in the remarks).
2. Either truly continuous or where encrustation deposits are interspersed spaced less than a metre apart.

Examples:



Dist.	Cont.	Code	Char.	Quant.	From	To
5		ED		S	8	4
Remarks: Thin layer buildup of encrustation deposits on the pipe wall around joint with faulty joint seal						
5		*JF*	*X*	*L*	*7*	*4*

Dist.	Cont.	Code	Char.	Quant.	From	To
2.8		ED		M	7	5
Remarks: Buildup of encrustation deposits on the pipe wall around joint with faulty joint seal						
5		*JF*	*X*	*L*	*7*	*5*



Dist.	Cont.	Code	Char.	Quant.	From	To
17.2		ED		S	7	10
Remarks: Build up of encrustation deposits on the pipe wall around joint with faulty joint seal						
17.2		*JF*	*X*	*L*	*7*	*10*
17.2		*JO*		*S*		
Remarks: *Joint open up to 20mm*						
17.2		*IP*		*S*	*7*	*10*
Remarks: *Seeping infiltration evident on the ED (visible as the wet sheen)*						

S5.4 – Root Intrusion

Code		Description
RI		Root Intrusion[1] – tree roots entering the pipe through a pipe defect2. The growth of the roots inside the pipe have the effect of obstructing/restricting the flow in the pipe.
		Additional Information
		Characterisation – additional code to describe type of sealing or physical damage associated with the lateral connection.
	F	Fine Roots – a relatively small number of flexible minor roots
	M	A mass of mostly fine roots, which has developed into an interwoven clump
	T	Tap roots – a small number of major roots (10mm or greater) without a significant mass of fine roots
	RB	Recently cut interwoven mass of mostly fine roots leaving a beard of roots
	RF	Recently cut fine roots – a relatively small number of cut minor roots remain
	RT	Recently cut tap roots – a small number of cut major roots (10mm or greater) is evident
		Quantification[3,4] – Reduction in the diameter of the pipe by the roots (Method 2). Record using additional code to describe the observations as follows:
	S	Small, reduction of up to 10% of the pipe diameter
	M	Medium, reduction between 10% and 25% of the pipe diameter
	L	Large, reduction between 25% and 50% of the pipe diameter

Circumferential location: Where there is only a single root present, record the location as a single clock entry. Where the extent of the root intrusion/growth is more extensive, use a pair of clock references to describe the location

Continuous Defect: Where the length of pipe where roots are present exceeds 1 metre, the defect shall be recorded as a Continuous Defect[5]

Notes:
1. Where the effective reduction is diameter is >50%, the defect shall be coded using the defect code BRI, Pipe Blocked (with roots).
2. The defect is recorded separately using the appropriate defect code.
3. Consideration should be given to the effective reduction in the pipe diameter, e.g. a "curtain" of fine roots extending over the full pipe diameter may be coded within the small severity band if the effect actual reduction in the diameter is less than 10% (where the curtain "flaps" out of the way of the flow.
4. Describe the nature of the root intrusion and the extend of any root cutting in the remarks field.
5. Either truly continuous or where roots are interspersed occurring within a metre apart for greater than 1m.

Examples:

S5.4.1 – Fine Root Intrusion Through Joint

Dist.	Cont.	Code	Char.	Quant.	From	To
3.6		RI	F	S	12	12
Remarks: Fine roots through faulty joint seal. Although the location of the roots almost covers a substantial portion of the pipe diameter, they only effectively reduce the pipe diameter by <10% as flow in the pipe would push the roots up						
3.6		*JF*	*X*	*L*	*12*	*12*
Remarks: *Faulty joint seal evidenced by the roots growing through the joint*						

S5.4.2 – Recently Cut Root Beard

Dist.	Cont.	Code	Char.	Quant.	From	To
3.3		RI	RB	L	9	5
Remarks: Root beard post pipe cleaning (fine roots have been removed)						
3.3		*JF*	*X*	*L*	*12*	*12*
Remarks: *Faulty joint seal evidenced by the roots growing through the joint*						
3.3		*JD*	*H*	*S*	*10*	*5*

S5.4.3 – Tap Root

Dist.	Cont.	Code	Char.	Quant.	From	To
18.8		RI	T	M	6	12
Remarks: Tap root growing through faulty joint seal						
3.6		*JF*	*X*	*L*	*12*	*12*
Remarks: *Faulty joint seal evidenced by the root growing through the joint*						

S5.5 – Obstruction

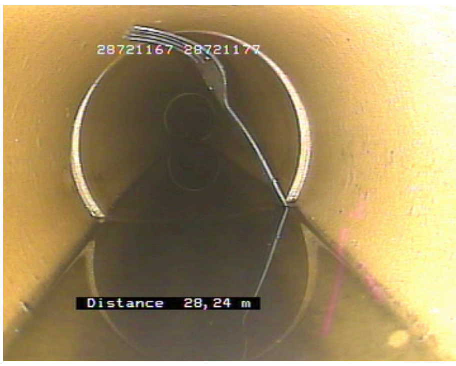
Code		Description
O	Obstruction[1,3] in the pipeline – something (other than roots, silty deposits, greasy deposits) are obstructing the flow in the pipe	
	Additional Information	
	Characterisation[2] – additional code to describing the permanence of the obstruction	
	T	Temporary - obstruction is potentially removable and is not attached to or imbedded in the pipe wall
	P	Permanent – obstruction is a fixed feature or external object projecting through the pipe wall
	S	Service Crossing through the pipe
	Quantification – Reduction in the diameter of the pipe by due to the obstruction (*Method 2*). Record using additional code to describe the observations as follows:	
	S	Small, reduction of up to 10% of the pipe diameter
	M	Medium, reduction between 10% and 25% of the pipe diameter
	L	Large, reduction between 25% and 50% of the pipe diameter
Circumferential location: Where the obstruction is at one point, record the location as a single clock entry. Where the extent of the obstruction is more extensive, use a pair of clock references to describe the location.		
Continuous Defect: Where the length of obstruction exceeds 1 metre, the defect shall be recorded as a Continuous Defect[4]		

Notes:

1. Where the effective reduction is diameter is >50%, the defect shall be coded using the defect code BZ, Pipe Blocked (add comment to describe the cause of the blockage in the remarks).
2. A description of the obstruction shall be noted in the remarks field.
3. Code does not apply to items such as a build-up of paper.
4. Either truly continuous or where obstructions are interspersed occurring within a metre apart.

Examples:

S5.5.1 – Temporary Obstruction (T)



Dist.	Cont.	Code	Char.	Quant.	From	To
28.4		O	T	S	11	5
Remarks: Fork stuck in pipe joint						
28.4		*JO*	*A*	*S*	*10*	*2*

S5.5.2 – Permanent Obstruction (P)

Dist.	Cont.	Code	Char.	Quant.	From	To
14.6		O	P	S	12	
Remarks: Steel bar intruding into the pipe						
14.6		*PH*		*S*	*12*	
Remarks: *Hole due to steel bar punched into the pipe, but appears sealed*						
14.6		*LF*	*X*	*S*	*3*	
Remarks: *Internal mortar seal missing*						

Dist.	Cont.	Code	Char.	Quant.	From	To
42		O	P	M	12	7
Remarks: PE Butt Weld bead partially removed						

Dist.	Cont.	Code	Char.	Quant.	From	To
24.5		O	S	M	10	2
Remarks: Service strike with steel pipe crossing the pipe						
24.5		*PH*		*M*	*10*	*2*
Remarks: *2x holes where pipe enters and leaves the pipe – not sealed*						
24.5		*ED*		*S*	*2*	*10*
Remarks: *Slight buildup of ED on pipe wall as a result of ground water infiltration through the pipe holes (also possible IP that cannot be seen from this distance)*						

Dist.	Cont.	Code	Char.	Quant.	From	To
1.8	S1	O	P	M	5	7
Remarks: Concrete in the pipe invert						
2		*JF*	*X*	*L*	*7*	*5*
Remarks: *Faulty joint seal evidenced by ED buildup on pipe wall*						
2		*ED*		*M*	*7*	*5*
Remarks: *Buildup of ED on pipe wall as a result of ground water infiltration through faulty joint seal*						

S5.6 – Blocked Pipe

Code	Description	
B	Pipe Blocked[1,2,3] – refers to where Roots, greasy deposits, silty deposits or other obstructions reduce the pipe diameter by >50%	
	Additional Information	
	Characterisation – additional codes to describe the nature of the blockage	
	RI	Root blockage
	DE	Silt/sand/gravel blockage
	DG	Fat blockage
	Z	Other blockage4
	Quantification – No additional quantification required.	
Circumferential location: No Clock Positions are required		
Continuous Defect: Not Applicable		

Notes:

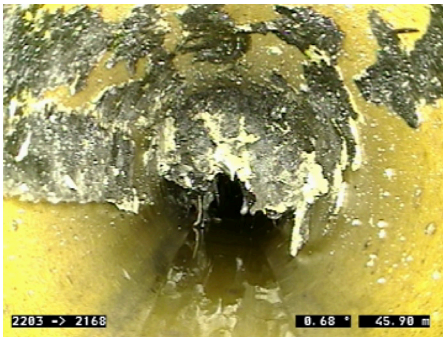
1. Code is not used if blockage is because of the pipe collapsing.
2. Where a blockage cannot be seen due to the water level or confirmed as a blockage by the investigation, this code should not be used. Instead the rise in water level shall be coded by the feature code WL.
3. Where obstruction is ≤50% of the pipe diameter use the codes RI, DG, DE or O as appropriate.
4. Provide a description of the nature of the blockage in the remarks field.

Examples:

S5.6.1 – Root Blockage (RI)

Dist.	Cont.	Code	Char.	Quant.	From	To
81.6		B	RI			
Remarks: Roots fill the pipe						
81.4		*WL*	*T*			
Remarks: *Flow depth approx. 40% of pipe diameter – holding due to blockage*						

S5.6.2 – Fat Blockage (DG)



Dist.	Cont.	Code	Char.	Quant.	From	To
46.1		B	DG			
Remarks: Fat Blockage - obstructing >50% of the pipe diameter						
40.2	*S1*	*DG*		*S*	*9*	*4*
Remarks: *Thin layer of fat on the top half of the pipe*						
46.1	*F1*	*DG*		*S*	*9*	*4*

S5.6.3 – Other (Z)

Dist.	Cont.	Code	Char.	Quant.	From	To
17.7		B	Z			
Remarks: Blockage – concrete obstruction in pipe >50% of pipe diameter						

S5.7 – Dipped Pipe

Code	Description	
DP	Dipped Pipe[1,2,5] – a sag or belly in the pipe causing the flow in the pipe to pond. Dipped pipes are generally identified by increasing depth of flow then returning to previous flow depth. An important aspect of for the use of this code is to ensure that the cause of the increase depth of flow is not due to something obstructing the flow downstream[3].	
	Additional Information	
	Characterisation[2] – Additional codes are not required.	
	Quantification – Maximum depth4 of flow in the dip relative to the pipe diameter (*Outlier Method 3*). Record using additional code to describe the observations as follows:	
	S	Small, maximum flow depth up to 25% of the pipe diameter
	M	Medium, maximum flow depth between 25% and 50% of the pipe diameter
	L	Large, maximum flow depth greater than 50% of the pipe diameter

Circumferential location: No clock references are required

Continuous Defect: Dipped pipes exceed 1 metre in length and therefore dips are recorded as a Continuous Defect[6].

Notes:
1. Where a dip appears to continue through a manhole, but the pipeline on the other side of the manhole is not inspected, the DP code is not used and the rise in water level is recorded using the feature code WL.
2. Where a dip is proven by inspection to continue through a manhole and finish on the other side of the manhole, it is recorded as two separate dips; the first finishing at the manhole, and the second starting at the finish manhole (recorded as part of the other inspection). Where this is the case, this shall be noted in the Remarks.
3. If it is found that the rise in water level is due to obstructions to the flow downstream, then the DP code shall not be used. In this case the rise in water level shall be recorded using the feature code WL and the appropriate condition code for the cause of the obstruction.
4. The assessment of the maximum flow depth shall include the deduction of the 'normal' flow depth.
5. If the flow in the dip is turbid, care should be taken to check for occurrence of debris below the flow. Evidence may include but not limited to the rocking camera travel along the pipe or disturbed flow ahead of the camera.
6. Dips must be truly continuous and not interspersed ponds of water.

Example:

Dist.	Cont.	Code	Char.	Quant.	From	To
2.7	S1	DP		M		

Remarks: Start of the dip indicated by the increasing flow depth

S5.8 – Exfiltration

Code	Description
EX	Exfiltration – There is a visible flow of water out of the pipe through a pipe defect
	Additional Information
	Characterisation – Additional codes are not required.
	Quantification – No additional quantification required.

Circumferential location: Record the point or extent of the defect that where the exfiltration is observed as one or two clock references

Continuous Defect: Not Applicable[1]

Notes:
1. Exfiltration is coded as individual defects (separate exfiltration sources occurring within 1m can be covered under a single entry) and cannot be recorded as a set of continuous defects, i.e. consecutive locations of infiltration cannot be covered under a single continuous defect.

Example:

Dist.	Cont.	Code	Char.	Quant.	From	To
0.5		EX			5	7
Remarks: Flowing out of the pipe through displaced joint						
0.5		*JD*	*V*	*L*	*3*	*11*
0.5		JF	X	L	12	12

S5.9 – Infiltration Present

Code	Description	
IP	Infiltration Present[1,2] – visible infiltration through a pipe defect is occurring at the time of the inspection.	
	Additional Information	
	Characterisation[2] – Additional codes are not required.	
	Quantification – the rate of visible occurring (*Outlier Method 6*). Record using additional code to describe the observations as follows:	
	S	Small, seeping/Sweating (wet) or dripping flow
	M	Medium, running (visibly moving) flow
	L	Large, gushing or jetting (pressure flow)
Circumferential location: Record the point or extent of the defect that where the infiltration is observed as one or two clock references		
Continuous Defect: Not Applicable[3]		

Notes:

1. Evidence of infiltration occurring previously (staining or encrustation deposits) without infiltration actively occurring does not qualify for this code.
2. Encrustation deposits at the source of active infiltration are coded separately and in addition to this code.
3. Infiltration is coded as individual defects (separate infiltration sources occurring within 1m can be covered under a single entry) and cannot be recorded as a set of continuous defects, i.e. consecutive locations of infiltration cannot be covered under a single continuous defect.

Examples:

Dist.	Cont.	Code	Char.	Quant.	From	To
19.6		IP		S	12	5
Remarks: Seeping infiltration through lifting eye. Seeping infiltration visible as the wet sheen on the pipe wall						
19.6		*CF*			*12*	
Remarks: *Lifting eye*						

Dist.	Cont.	Code	Char.	Quant.	From	To
18.1		IP		M	7	9
Remarks: Running infiltration from longitudinal crack near joint						
17.6		*CL*	*C*		*9*	
Remarks: *Crack edges chipped and IP through crack*						

Dist.	Cont.	Code	Char.	Quant.	From	To
19.3		IP		L	6	12
Remarks: Jetting infiltration through faulty joint seal						
19.3		*JF*	*X*	*L*	*7*	*2*
Remarks: Infiltration through joint and build-up of ED						
19.3		*ED*		*S*	*8*	*2*
Remarks: *Build-up on pipe wall around joint*						

S5.10 – Water Level

Code	Description	
WL	Water Level[1,2] – The presence and nature of water and changes in depth of water above the invert. Change in depth, recorded as a % of the pipe diameter is noted in the Remarks field	
	Additional Information	
	Characterisation – additional codes to describe the clarity of the water	
	C	Clear water
	T	Turbid or discoloured water
	Quantification – No additional quantification required.	
Circumferential location: No clock references are required		
Continuous Feature: Not Applicable		

Notes:
1. Not used when the rise/fall in water depth is due to the presence of a Dip.
2. WL code shall be entered at the start of the inspection and at any notable change in depth (or colourisation) there after.

S5.11 – Line Deviates in Alignment

Code	Description	
LD	Line Deviates – the pipe alignment changes up/down or left/right[1]	
	Additional Information	
	Characterisation[2] – additional codes to describe the change in alignment	
	D	Down
	U	Up
	L	Left
	R	Right
	Quantification – No additional quantification required.	
Circumferential location: No clock references are required		
Continuous Feature: Not Applicable		

Notes:
1. Includes change in alignment through factory made bends or angular open joints.
2. Describe the extent of the change in alignment as best as possible as a degree of angular change, or change in grade or descriptive alternative in the Remarks field.
3. Where the inspection is carried out from the downstream node (upstream direction) the Characterisation code selected shall reflect the change in direction as it would be observed if the inspection was from the upstream node (downstream direction).

S5.11.1 – Down (D)

Dist.	Cont.	Code	Char.	Quant.	From	To
7.2		LD	D			
Remarks: 45° ramp down						
7.2		*CF*				
Remarks: *Start of Syphon (top of syphon)*						
7.0		*LC*				
Remarks: *Cement lining (steel pipe) not present*						

S5.11.2 – Up (U)

Dist.	Cont.	Code	Char.	Quant.	From	To
1.5		LD	U			
Remarks: 15° -20° ramp up						
1.5		*JD*	*H*	*S*	*6*	*12*
Remarks: *Horizontal displacement (10% of pipe diameter)*						
1.5		*JO*	*A*	*M*	*2*	*11*
1.5		*JF*	*X*	*L*	*12*	*12*
Remarks: *Joint seal faulty with staining and ED on pipe wall around the joint*						
1.5		*ED*		*S*	*3*	*6*
Remarks: *Buildup on pipe joint*						

16 – Inspection Information Codes

16.1 – Construction Feature

Code	Description
CF	Construction Feature[1] – refers to features in the pipe that are either built into the pipe or are part of the pipe construction. Generally, these will be drainage fittings (other than manholes) such as inspection covers, but could include features such as lifting eyes.
	Additional Information
	Characterisation – Additional codes are not required
	Quantification – No additional quantification required.

Circumferential location: Record the location of the blockage as a pair of clock reference as appropriate

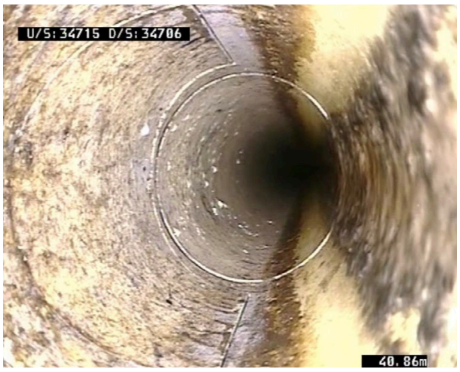
Continuous Feature: Where the length of construction feature exceeds 1 metre, the CF shall be recorded as a Continuous Feature[2].

Notes:

1. Provide a description of the construction feature in the remarks field.
2. Features can be truly continuous or point features which repeat at regular intervals along a pipeline, in at least three out of four adjoining pipe segments.

Examples:

The following is intended to provide some examples of types of Construction Features



Dist.	Cont.	Code	Char.	Quant.	From	To
40.9		CF			9	3
Remarks: PVC inspection point (camera is rotated 90 degrees						
40.8	*S1*	*DG*		*S*	*9*	*3*
Remarks: *Thin layer of fatty deposits on the pipe wall*						

Dist.	Cont.	Code	Char.	Quant.	From	To
6		CF			12	
Remarks: Sealed lifting eye with chipping and small amount of reinforcing steel exposed. (Exposed reinforcement is not coded separately)						

Dist.	Cont.	Code	Char.	Quant.	From	To
67.6	S1	CF			4	9
Remarks: Drainage 'weep' holes in rows						

Dist.	Cont.	Code	Char.	Quant.	From	To
1.6		CF				
Remarks: Factory bend (PVC)						
1.6		*LD*	*R*			
Remarks: *15° bend right*						

16.2 – General Comment

Code	Description
GC	General Comment[1] – This code is used to provide any relevant information that is not provided through specific defect or feature codes. A descriptive comment is provided in the Remarks field
	Additional Information
	Characterisation – Additional codes are not required
	Quantification – No additional quantification required.

Circumferential location: Where relevant, record the location of the feature as a single or pair of clock references

Continuous Feature: Where the length of feature exceeds 1 metre, the GC shall be recorded as a Continuous Feature[2].

Notes:

1. It should not be used where a specific defect or feature code is applicable.
2. Features can be truly continuous or point features which repeat at regular intervals along a pipeline, in at least three out of four adjoining pipe segments.

16.3 – General Photograph

Code	Description	
GP	General Photograph[1,2] – A still photograph has been taken to record the general condition at a location in the pipe	
	Additional Information	
	Characterisation – additional codes to describe the orientation of the camera for the photograph[3]	
	L	Facing Left
	R	Facing Right
	U	Facing Up
	D	Facing Down
	F	Facing Forward
	B	Facing Backward
	Quantification – No additional quantification required.	

Circumferential location: No clock references are required

Continuous Feature: Not Applicable

Notes:

1. A description of the purpose of the photograph shall be made in the Remarks field
2. This code should not be used for the Photographs of defects or feature; these should be 'attached' to a specific code. The GP code may be used if there is a need for a second photograph of a defect or feature. In this case a note shall be made to this effect in the Remarks field.
3. Where the orientation of the camera is a mixture (e.g. the camera is facing Up and Left) the Characterisation that best describes the orientation shall be chosen.

16.4 – Loss of Vision

Code	Description	
LOV	Loss of Vision – the view in the pipe is obscured (>50% of vision is reduced).	
	Additional Information	
	Characterisation[1] – additional codes to describe the reason for the vision loss	
	UW	Under Water
	G	Grease on lens
	S	Steam or fog in the pipe
	EF	Equipment Failure
	Z	Other
	Quantification – No additional quantification required.	

Circumferential location: No clock references are required

Continuous Feature: Where the longitudinal length of pipe where there is a loss of vision exceeds 1 metre, the LOV shall be recorded as a Continuous Feature.

Notes:
1. Provide a description of the reason in the Remarks field.

Examples:

16.4.1 – Steam or Fog (S)

Dist.	Cont.	Code	Char.	Quant.	From	To
6.02		LOV	S			
Remarks: Unable to see the pipe due to Fog						
6.02		*IA*				
Remarks: *Inspection Abandoned due to Loss of Vision*						

16.4.2 – Grease on Lens (G)

Dist.	Cont.	Code	Char.	Quant.	From	To
48.1		LOV	G			
Remarks: Unable to see the pipe due to Waterdrops/grease on the lens						

16.4.3 – Underwater (UW)

Dist.	Cont.	Code	Char.	Quant.	From	To
2.22		LOV	UW			
Remarks: Unable to see the pipe due to the camera being under water						
2.3		*DE*		*M*		
Remarks: *Gravels*						

16.5 – Change in Video Volume Reference (Video File Name)

Code	Description
TC	Change in video volume reference[1] – Allows reporting that the video and/or video clip volume reference has changed during an inspection. The new file reference number is recorded in the remarks
	Additional Information
	Characterisation – Additional codes are not required
	Quantification – No additional quantification required.
Circumferential location: No clock references are required	
Continuous Feature: Not Applicable	

Notes:
1. Where an inspection from the other direction is filmed on a separate video file, TC shall be coded at the start of the reverse inspection (immediately after feature code IS).

16.6 – Inspection Starts

Code	Description
IS	Inspection Starts – The first entry for all condition inspection reports. The location of the camera (node name/reference) at the start of the inspection is described in the Remarks field[1,2]
	Additional Information
	Characterisation – Additional codes are not required
	Quantification – No additional quantification required.
Circumferential location: No clock references are required	
Continuous Feature: Not Applicable	

Notes:
1. The description of the location of the camera at the start of the inspection, should include a description of the position of the camera at the start node, i.e., center of node, or entry to pipe, or inside the pipe, etc.
2. Where the camera is not starting in the center of the node, a reason for this should be included in the remarks, e.g. due to a dropper or bend.

16.7 – Inspection Ends

Code	Description
IE	Inspection Ends – The final entry code for all inspection reports, unless an inspection is abandoned prior to reaching the end of the inspection, in which case the feature code IA is used. The description of the location of the camera (node name/reference) where the inspection is ended is described in the Remarks field[1,2]
	Additional Information
	Characterisation – Additional codes are not required
	Quantification – No additional quantification required.
Circumferential location: No clock references are required	
Continuous Feature: Not Applicable	

Notes:
1. The inspection typically ends at the finish node, but may also be at the point of abandonment if the inspection from the other direction could not be completed.
2. The description of the location of the camera at the end of the inspection should include describe the position of the camera at the finish node, i.e., center of node, or entry to node, or point of previous abandonment etc.
3. Where the camera is not finishing in the center of the node, a reason for this should be included in the remarks, e.g. due to a drop or bend.

16.7 – Inspection Abandoned

Code	Description
IA	Inspection Abandoned[1] – The final code for inspections that are abandoned prior to completing the inspection. The reason for the abandonment is noted in the Remarks field.
	Additional Information
	Characterisation – Additional codes are not required
	Quantification – No additional quantification required.
Circumferential location: No clock references are required	
Continuous Feature: Not Applicable	

Notes:

1. If the abandonment is due to a defect, the defect(s) is recorded separately.

C Private Drains and Sewers

C1 Introduction

Private drains and sewers are also commonly referred to as 'Private Laterals'. They are privately owned (not owned or maintained by the local Authority or water utility). They provide wastewater and stormwater service from the building to either the Public main or public lateral. The inspection reporting and the classification of defects and features is essentially the same as for public pipelines, as described in Part B of this manual. There are several unique characteristics that make the inspection of private drains and sewers different from public sewers. These include:

- Little information is usually held by councils on the location and position of private laterals. Plumbing and drainage as-builts are often missing from property files, not current or very schematic. Private sewers are generally not recorded as an asset in council asset management systems so are not recorded on the Council GIS
- There are limited access points into private drains for inspection and testing
- They are a small diameter, mostly 100mm, but some have a 90mm internal diameter
- They have multiple bends and multiple fittings
- Older pipes are predominantly clay (glazed and un-glazed) with some Asbestos Cement installed in the 60s & 70s (typically mirroring the materials used in public sewers in the area to a degree). New construction is now typically using PVC
- Commonly shallow depths and flat grades. Sometimes subjected to traffic loadings or damage by landscaping and further development
- Wastewater entry points at the building are typically sealed by a U bend (water-trap).
- Typically, limited entry points to access the private Stormwater lateral.

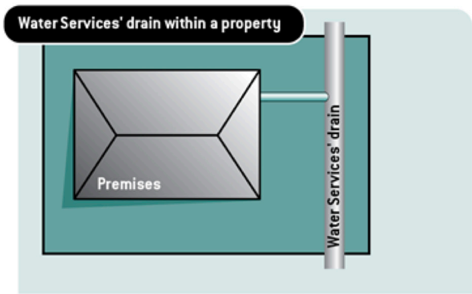
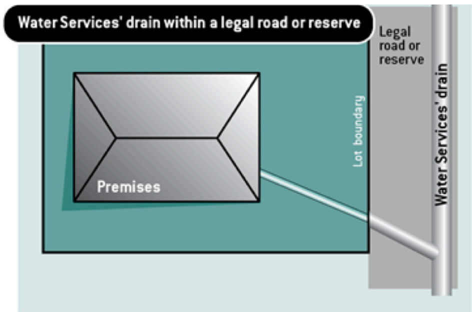
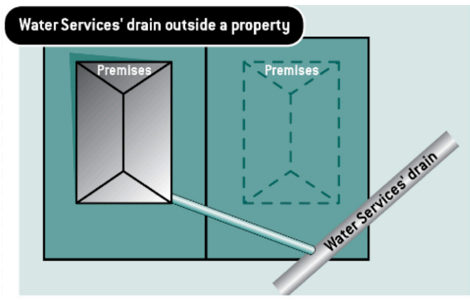
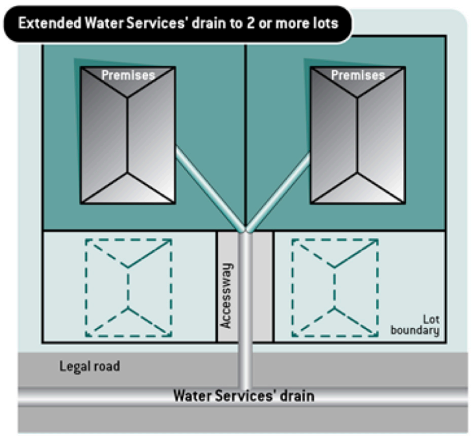
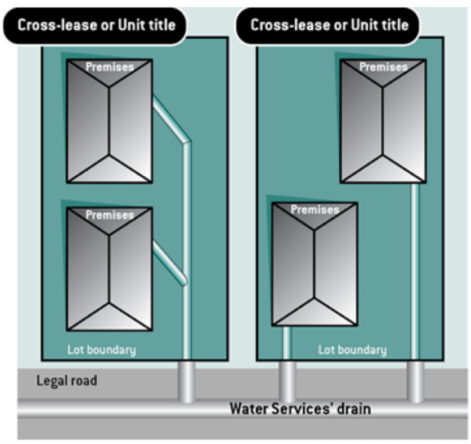
Understanding the extent of the private lateral to be inspected and the differences between public mains and private laterals is important for the inspection of private drains and sewers. This section outlines the specific requirements for their CCTV inspection.

C2 Determining Ownership

The definition of what is a private drain or sewer is not consistent across New Zealand Local Authorities with variable policies determining the ownership of drains and sewers and the location of the change of ownership in various circumstances.

Before a CCTV inspection is carried out, a clear understanding of where the boundary between the private lateral and public sewer is located needs to be sought from the Local Authority or water services utility. In some cases, ownership policies within a Council have changed over time, such that a lateral that was once public could now be considered to be private or visa-versa. Table C1.1 outlines common examples of definitions of private drains and sewers based on different scenarios.

Table C1.1 – Examples of private lateral ownership

Scenario		Ownership
1		All Local Authorities consider where a lateral serves one property and the lateral is entirely within that private property it would be a private lateral.
2		Most Local Authorities consider where a private lateral crosses a property boundary into a legal road or reserve, the lateral ownership will change to public. Some will define the lateral to be private right up to the connection to the council main, even if this is under the public road.
3		Some Local Authorities consider where a lateral crosses a property (Lot) boundary into a neighbouring private property, the ownership would remain private, (owned by the property it serves) up to the public main. Conversely some Local Authorities, like scenario 2, consider where a private lateral crosses any property (Lot) boundary the ownership changes to public.
4		Most Local Authorities consider where a lateral serves two or more properties it is public. A shared drain could also have been installed as a 'Drain in Common' and considered to be private.
5		Most Local Authorities consider where a lateral serves two cross leased properties then it is private, and the owners of the cross leased properties jointly own, and are responsible for, its maintenance.

Drainage within an industrial park, retirement village, school, etc, i.e. multiple buildings within a larger site might be public, private or a mix depending on the asset owner approval.

The ownership policies of the private lateral connection to the public main or manhole, (where the drain or sewer is private all the way to the public sewer) also varies significantly. Ownership may change at an inspection point (including Buchan Trap), the top of a riser from the main or at the main itself. Where the private drain or sewer extends to the public main, the inspection should include to stub connection onto the public sewer.

C3 Separate and Combined Drainage

In older areas the private drainage for wastewater and stormwater may be combined and this should be noted in the Header field "Use of Pipeline (Header code ACK).

In most systems the private drainage pipes will be separated for wastewater and stormwater. However, there may be deliberate, or unintended, interconnections between the private drainage systems. These will be of particular interest to the public drainage owner as they are a source of inflow into the wastewater system, or contamination in the stormwater system.

The inspection may also determine that the private drainage has been connected to an incorrect council drain, e.g. private stormwater to public wastewater or private wastewater to public stormwater.

Where these situations are identified they shall be reported to the public asset owner, including providing a copy of the inspection report and video.

C4 Inspection Equipment Capability

The lateral pipe diameter bends and components, (such as gully traps and vents) restrict the type of inspection equipment that can be used.

CCTV inspection equipment needs to be capable of negotiating bends up to 90° and gully traps in 100mm sewer pipes. The CCTV camera must have a radio sonde or similar for locating the position of the lateral and underground features such as bends and junctions. The camera shall be connected to a video recorder, ideally with video header recording capability, and provide the minimum output requirements as set out in Section A3.

A description of types of inspection equipment is provided in Section A2.3.

C5 Inspection Requirements

C5.1 General Requirements

CCTV inspections of private drains and sewers shall generally be in accordance with section B1.2 Camera Operation except as modified in this section. Inspections of private drains and sewers shall include the full private lateral network for the property, from the house to the junction with a public drain or sewer.

A complete inspection shall consist of an inspection of all pipes upstream of the public connection, including all branch lines to downpipes, catchpits, gully traps and terminal vents, (refer Figure C1.1). Generally, the inspection will terminate at the exterior wall of the building unless the drain continues under the floor without a gully trap, drainage sump or vent at the wall-line.

Access to private drains and sewers for inspection, should primarily be obtained at the following points:

- Access points, such as chambers or inspection points where installed
- Gully traps (wastewater)
- Buchan traps (wastewater)
- Down pipes (Stormwater)
- Drainage sumps for surface, sub-surface and retaining wall drainage
- Any other surface level entry point, such as an inspection pipe accessible from the surface.

When accessing the private sewer through a Gully Trap, the Gully should be plunged to breach the water trap prior to the insertion of the CCTV Camera to prevent fouling of the camera lens.

If access is not possible from the above points, the Contractor may need to modify the existing drainage or excavate to expose a section of sewer pipe to gain access to the lateral. Excavation of, or modification to, existing private drains or sewers to gain access for CCTV inspections shall only be carried out with the written approval of the property owner and completed by a registered plumber or drainlayer. In some circumstances a building consent may be required.

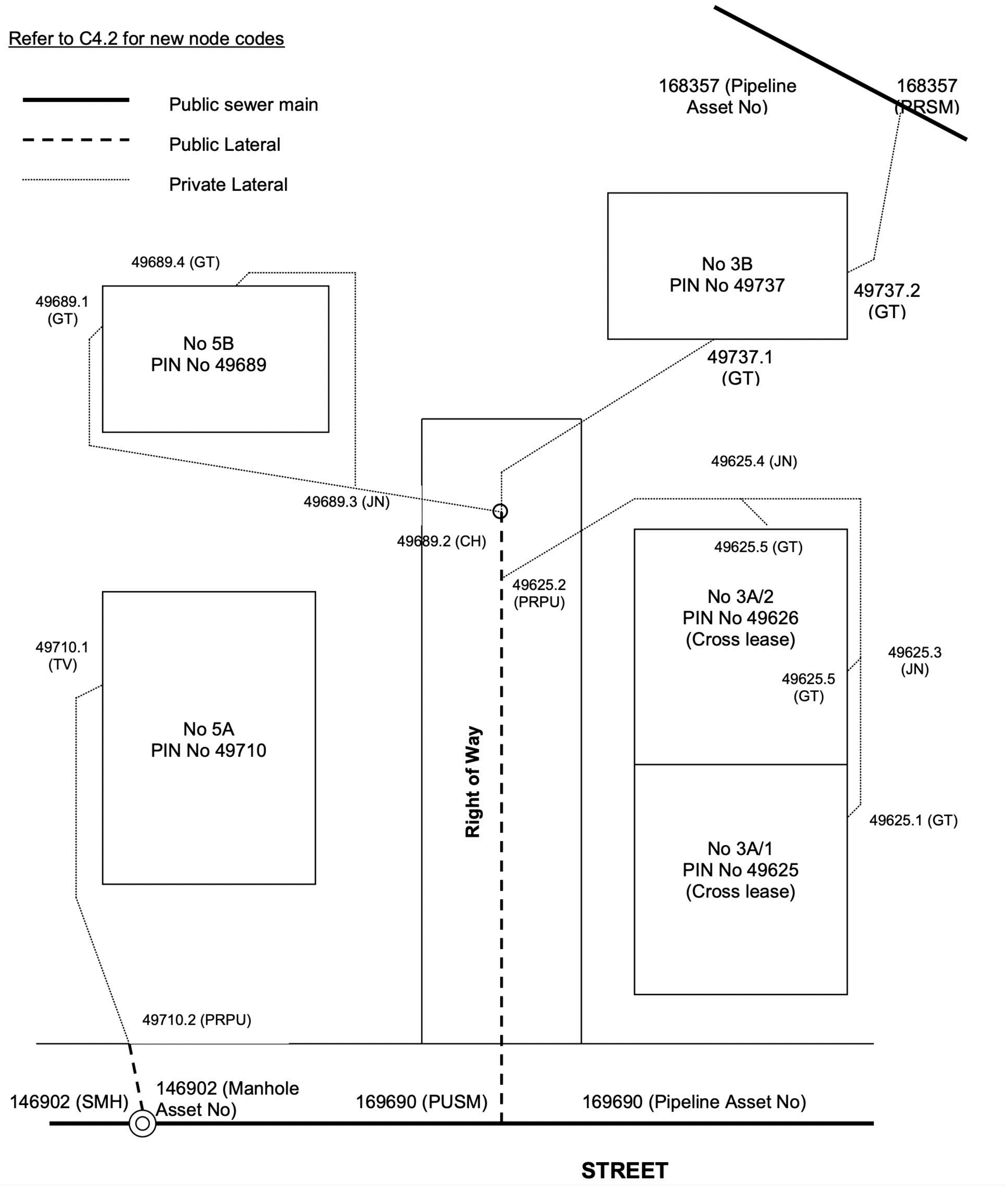
The speed of travel of a fixed axial push camera along the pipe is to be no greater than 4 metres per minute in continuous travel. Given the nature of push-cam travel, the operator may need to push forward and then pull back to view defects. The camera shall be paused at least a pipe diameter distance in front of each pipe defect or feature for at least 5 seconds. Where friction does not allow for a smooth progress along the pipe, push the camera should be progressed through to the end of the pipe section and pulled back at a reduced speed to allow better viewing of defects.

C5.2 Node Identification

Node points on private drains and sewers shall be identified as follows:

1. Where a downstream node is a junction to a sewer/stormwater main, or public manhole, the node shall be identified by the asset number of that pipeline or manhole.
2. Where the outlet pipe at a node (for example an access chamber) services two or more properties, the primary ID number for that node shall be the property closest to it.
3. All other nodes on private laterals shall be allocated ID numbers consisting of a primary number and an extension. The primary number shall be the Property Identification Number (PIN) of the property served by that node, followed by an extension of .1, .2, .3 etc.
4. Node Types and the following codes shall be used:
    - Access Shafts (AS) or Chambers (CH)
    - Catchpits (CP)
    - Downpipes (DP)
    - Inspection Points (IP)
    - Junctions of branch lines (JN)
    - Buchan Traps (BT)
    - Gully Traps (GT)
    - Terminal Vents (TV)
    - Private Lateral connection to a Public Lateral (PRPU)
    - Private Lateral connection to a Public Main (PRMN)
    - Private Lateral connection to a Public Manhole (PRMH)
5. Node locations and allocated reference numbers shall be recorded on the Private Drainage Plan and logsheets.

Figure C1.1 – Examples of node identification using different scenarios.



C5.3 Measuring the length of Inspected Private Drains and Sewers

The Inspection should commence or end (dependant on whether the inspection is commencing from public main or at the building) at the furthest gully trap from the connection to the public main (PRMN) or public lateral (PRPU). The Contractor shall identify the status of all branch laterals connecting onto private drain or sewer, (JN) i.e. confirm whether they are live, blank or dead. All live branch laterals shall be inspected.

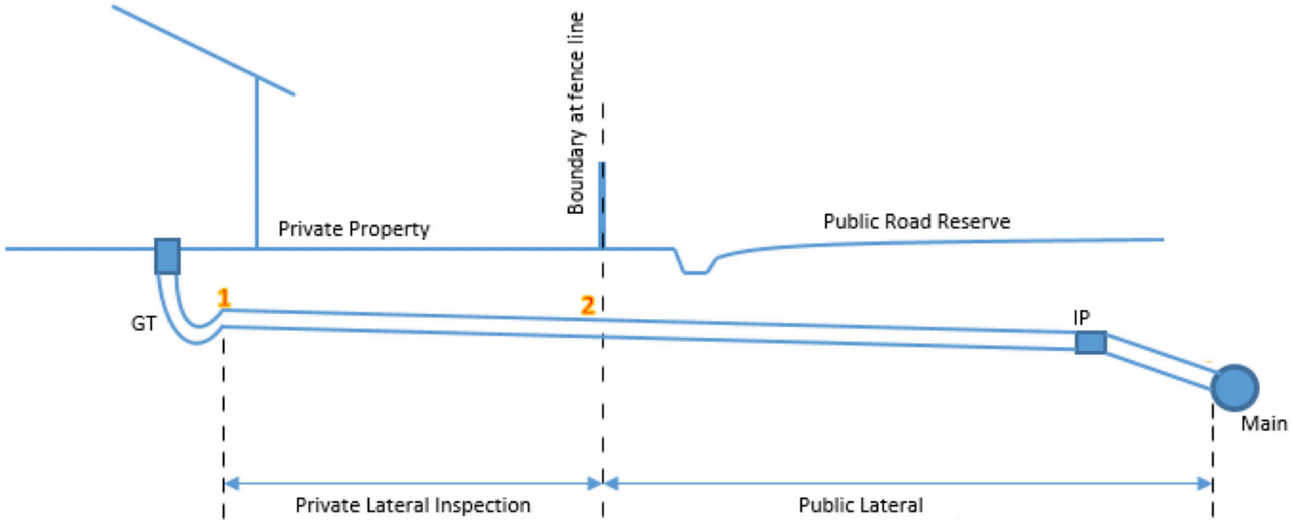
When accessing the private sewer via a gully trap or vent, the CCTV distance counter shall be zeroed once the camera has passed through the gully trap or vent stack and into the pipe.

The inspection is ended at the private lateral connection to the public network (PRMN, PRMH or PRPU) or at the junction where the private branch lateral joins the private lateral (JN).

There shall be a separate logsheet for each setup, including branch lines. For example, a property which has a main private lateral from the furthest Gully Trap connecting to the public sewer, and two branch lines. In total, there will be three logsheets. One for the main private lateral, and one each for the branch lines connected to it.

The total inspected length is the sum of the inspected lengths of all the inspections required to completely inspect the private drain or sewer.

Figure C1.2 – Diagram showing example of the start and end point for the private lateral inspection



***1** – Start point of the inspection (entering through the Gully Trap (GT)*
***2** – End point of the inspection (private lateral connection to the public lateral (PRPU)*

C5.4 Starting at a Surface Node

To help identify and confirm the location of the surface node (e.g. Gully Trap, Buchan Trap, or Vent) a brief (10 to 15 seconds) video recording shall be undertaken showing a view of the surface node and its surrounds, including identifiable features and entry point, before insertion of the CCTV camera.

This recording can be before or after the screen header (refer C6.1)

C6 Deliverables

As part of an inspection the following must be completed and submitted to the requestor of the inspection:

A. Video Records

B. Inspection Logsheets

C. Private Drainage Plan

C6.1 Video Records

The Inspection Screen Header shall display for at least 5 Seconds and contain the following information:

- Property Identification Number (PIN)
- Street address
- Date
- Name of the company carrying out the inspection
- Name of the camera operator
- Start node ID – End node ID
- Inspection Direction

The inspection header can be a screen text or a video recording of a black/white board with the details.

During the inspection the following minimum information should be continuously displayed:

- The measured distance the camera has travelled from the start node.
- Start and end manhole/node ID’s (if the video inspection equipment can display this information).

C6.2 Inspection Logsheets

Electronically produced logsheets shall be supplied for each private lateral inspected.

C6.2.1 Header Information

Header information on the CCTV logsheet shall be provided as set out in Section B2.2 Header Classification Codes.

The Property Identification Number (PIN) of the property discharging to the upstream node shall be recorded in the “AssetID” Header field (Header Code AAA). Where more than one logsheet is required to fully inspect each property, the second and subsequent inspection Asset ID’s shall use the Property Identification Number (PIN) followed by the suffix A, B, C, etc.

Only the upstream and downstream node numbers, (the start and end nodes) are recorded on the logsheet header, regardless of how many intermediate nodes may be identified along the length of the lateral. Any intermediate nodes will be recoded under the observation reporting portion of the logsheet.

C6.2.2 Observation Information

Generally, the observations shall be classified as per Section B2.3 Condition Classification Codes.

Where the purpose of the inspection is to identify sources of ground water infiltration, alternative classification systems such as those in Section E4, sub-section E4.4.1 could be used in place of Section B2.3.

The classification standard used shall be recorded in the Header field “Standard” (Header code ABA).

C6.3 Private Drainage Plan

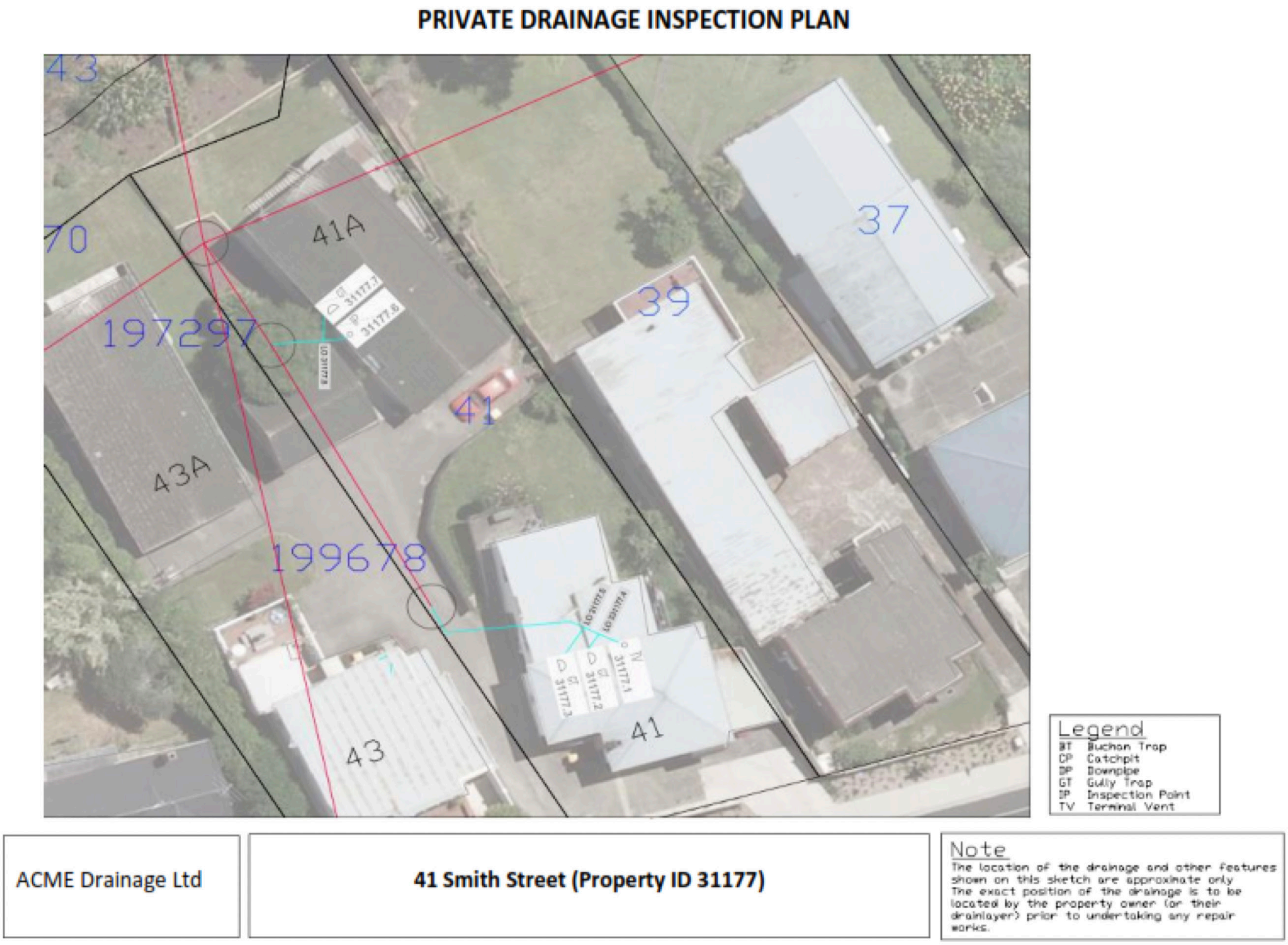
A drawing shall be prepared showing the layout of the private drains or sewer and the position of the node points relative the buildings, property boundaries and permanent features of the property.

The following should be marked on the diagram where applicable:

- Street address
- Lateral ID (refer C5.2.1)
- Node Points (refer C4.2)
- Route of laterals inspected as located and measured using the CCTV radio sonde to determine the alignment and depth of the lateral sewer to +/- 500 mm horizontal alignment and +/- 5% vertical depth.
- The property boundary
- Depth of lateral at the boundary (where it crosses a boundary)
- Distance from the point the lateral crosses the boundary to the closest boundary line running at a tangent (separating neighbouring property where applicable)

The best format for the plan is one taken from a GIS with aerial view showing the property boundaries and position of the public pipes.

Figure C.3 – Example of a Private Drainage Inspection Plan



D1.1 Preparation of Manholes for Inspection

D1.1.1 Introduction

This section covers the requirements for cleaning manholes prior to visual inspection. The aim is to provide guidance on when and what type of cleaning should be undertaken, and how to minimise damage to the walls, components or the ground surrounding the manhole.

General reference should be made to section B1.1, Preparation of Drains and Sewers for Inspection, (Clauses B1.1.2 and B1.1.3) which covers generic information, that is applicable to manholes or chambers. The items in this section cover specific information relevant only to manholes and chambers.

D1.1.2 Recommended Pre-Inspection Cleaning

Pre-cleaning of manholes prior to inspection is dependent on the purpose of the inspection and its condition.

Table D1.1.1 outlines the recommended level of pre-cleaning.

Refer to Table B1.1.3 (Section B1.1) for recommended pressure if cleaning is required, with reference to concrete and brick/masonry materials.

Table D1.1.1 – Recommended cleaning for Manholes or Chambers

Purpose of Inspection	Recommended Cleaning
Identify the general structural and service condition of the manhole/chamber.	Do not clean prior to inspection1.
Identify sources of infiltration	Do not clean prior to inspection1.
To identify all structural faults, e.g. to determine a repair strategy	Full/heavy cleaning of the manhole to remove all foreign material. Cleaning should include manhole/chamber walls, benching, underside of lids and landings and components3.
Observe level of surcharging within the network	Do not clean prior to inspection1.
Inspection of manholes/chambers that appear to be in Poor Structural Condition	Do not clean prior to inspection2.
Inspection of pipes suspected to be in Poor Structural Condition	Carry out an initial inspection without cleaning, as cleaning may cause further damage and cause the pipe to fail.

Notes:

1. If roots are obstructing the camera or view of the manhole/chamber wall, they should be cut back by hand tools or by water blaster, enough to allow the camera/scanner to move through or view the manhole/chamber wall. However, care should be taken not to remove all service related evidence.
2 As per note 1, but extreme care required with water blasters – restricted to a ‘light’ low pressure wash of water only. Use of hand tools only is recommended.
3 If necessary, large roots or hard encrustation deposits shall be removed by entering the manhole and cut/scraped with hand or power tools (HS&E considerations to be fully considered and employed).

D1.1.3 Care and Considerations When Cleaning

Consideration needs to be given to ensuring that:

- Ground around the manhole is not eroded or damaged.
- The manhole being cleaned is not damaged. If damage is observed to be occurring to any of the manhole/chamber components during the cleaning operation, cleaning should stop immediately. The asset owner shall be notified, and an agreement reached on methodology to proceed.
- Care required when water blasting manhole benching to prevent damage.
- All material washed or scraped from the manhole/chamber shall be trapped and removed from the manhole. Debris shall not be allowed to travel downstream of the manhole being cleaned. The Contractor shall be responsible for the disposable of the removed materials from the site at the end of each work day. The removed material should not be allowed to accumulate, except in enclosed containers. All materials removed are to be disposed of in a safe and legal manner at an approved location appropriate to the degree of contamination of the removed material.

D1.2 Manhole Inspection Operation

D1.2.1 General

This section provides for inspections undertaken using a range of methods generally described by the following:

Table D.1.2.1 – General

Name	General Description
Personnel Entry	Suitably trained and equipped personnel enter the manhole and record what they see and measure
Action camera[1]	A video camera used for 'action' activities is attached to a pole and the manhole inspected. Typically, has limited lighting, zoom or locating capability.
Pole camera[1]	A more sophisticated camera with better lighting, pan and zoom capability is attached to a pole and the manhole inspected. May have ability to track depth of insertion. May have the ability to look directly down.
CCTV[1]	Purpose built CCTV for inspections with lighting, pan and zoom, location recording and ability to look directly down.
Digital Scanner[1]	Specialist manhole inspection equipment providing high speed 360o recording that allows for later inspection of detail.
Inspection of pipes suspected to be in Poor Structural Condition	Carry out an initial inspection without cleaning, as cleaning may cause further damage and cause the pipe to fail.

[1] **Refer to Section A2 for detailed description**

Although the procedures in this section are intended for the inspection of manholes conducted by the entry of personnel and/or by the movement of a CCTV camera or optical scanner through the structure, visual inspection from the surface, without camera equipment, could be undertaken with appropriate procedural modification.

To ensure that all defects and features are correctly and fully identified there must be a full and clear view of the manhole and information that is presented on the video recording needs to be accurate and provide as much information about the condition of the structure as possible.

There are many factors that influence the view of the manhole and information collected. Principally these factors include:

- The type of inspection. An inspection involving the entry of personnel will enable the most comprehensive information on the structural condition, followed by CCTV/scanner inspection, with the least comprehensive being a visual inspection from the surface.
- The capability of the camera or scanner system, if used, (including the suitability of the equipment for the job, the recording quality and the file media)
- The inspection methods employed by the Inspector or CCTV camera operator.
- The setup of equipment, the speed the camera/scanner equipment moves up/down the manhole, and the steps taken to fully capture the information found during the inspection.
- The environment within the manhole, for example attached deposits such as fat, root growth or debris that may obstruct the view of the various components.
- Lighting
- The inspection is limited to the inside of the manhole and provides no indication of the condition of the outside of the structure

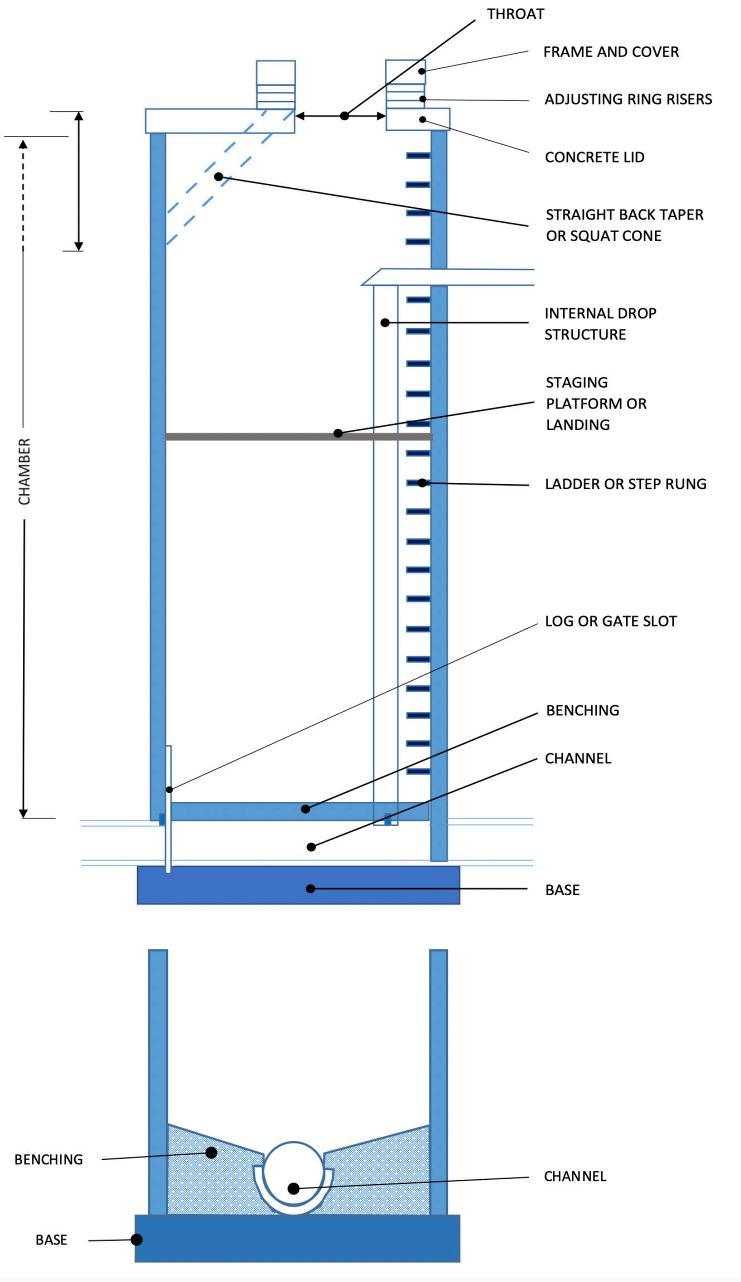
Prior to commencing any work on site, the inspection shall be planned. This shall include, but not be limited to:

- Understand the purpose of the inspection and any specific requirements the asset owner is requesting
- Collect information on the assets to be inspected, including GIS maps and attributes (e.g. manhole material, depth and diameter)
- Determine if pre-cleaning of the manhole is required
- Location and/or raising of the manhole for access
- Is flow control required, and if yes, at what times and how will this be implemented to stop overflows?
- Are there any accessibility restrictions – where are the manholes located, does access to private properties need to be arranged?
- What is the specific health and safety issues that will need to be eliminated or minimised (including traffic control, dogs, confined space entry, etc)?

D1.2.2 Manhole Components

There are many manhole designs and layouts. Figure D1.2.1 shows a typical manhole layout with common components labelled. This is given for general illustrative purposes and reference only and is not technically correct about location and scale.

Figure D1.2.1 – Illustration of the layout of a typical manhole and naming of components



D1.2.2 Starting the Manhole Inspection

D1.2.2.1 Location of the Manhole

Prior to undertaking the inspection, a video or still image(s) shall be captured showing the location of the manhole and the position of the manhole cover, before the manhole cover is removed. The footage/images shall be taken so that:

- The location can be seen relative to structures or features nearby the manhole, i.e. fences, roads, buildings etc.
- The position of the manhole cover to the surrounding surfaces and its height. The footage or images shall clearly show whether the manhole cover is sitting higher than, lower than, or flush with the ground surface.
- The condition of the manhole cover and frame and how it is seated can be seen.
- Any settlement issues with the surface around the manhole cover can be observed.

If necessary the footage shall be taken from more than one direction or angle, or more than one photograph maybe required.

The type of cover, cover material and its position (height relative to the surrounding surface) will be recorded in the manhole header fields (refer to Section D2.1, clause D2.1.3.1 Measuring depth and dimensions).

Figure D1.2.2 – Examples of manhole location images

D1.2.2.2 Setup and Direction of Inspection

The recording of the inspection shall start from the manhole frame downwards to the channel.

CCTV camera's or scanners shall be set up at the entrance and position so that the camera/scanner is as close to the centre of the manhole chamber as practicable.

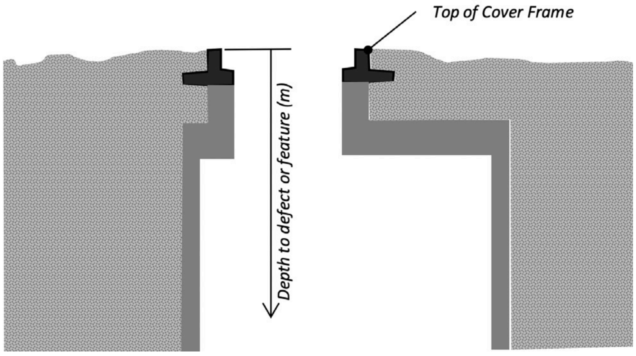
An initial view of manhole shall be provided looking down the manhole, so all features can be seen in relation to each other with the outlet shown in the 12 o'clock position. The manhole cover frame must be included in the initial inspection footage.

Figure D1.2.3 Initial view at the start of the inspection, outlet at 12o'clock and the cover frame visible

D1.2.2.3 Reference Point for Vertical Distance Measurement

All measurements to manhole features or defects shall be measured from the top of the manhole cover frame.

Figure D1.2.4 – Measurements to all features and defects are measured from the top of the cover frame



Measurements shall be recorded to an accuracy based on the method of inspection, as described in Table D1.2.1.

Table D1.2.1 – Minimum required accuracy of measurements based on the method of inspection

Method of Inspection	Depth to Connecting Pipes	Depth to Defects
Personnel Entry	±25mm	±25mm
CCTV Camera/Scanner	±50mm	±100mm
Pole Camera/Action Camera	±50mm	±500mm

There some cases where the manhole does not have cover frame or throat. The most common example of this is stormwater manholes with large scruffy domes that are seated directly on top of the chamber risers. In these cases, the vertical measurements shall be taken from the top of the manhole riser.

D1.2.2.4 Screen Headers (for Inspections with Cameras or Scanners)

Screen Header Display (Start of Inspection)

A screen header shall be included at the start of the recording of each inspection. Some devices do not have the ability to generate a screen header like a standard CCTV camera is able to. In those cases, a screen header can be edited onto the screen post survey or alternatively, a whiteboard template could be filled in and then filmed at the very start of the recording. The header screen shall be displayed on the video recording between 3-5 seconds.

As a minimum the following information shall be displayed and recorded on the screen as follows:

- The unique Asset ID of the manhole that is being inspected
- Use of the manhole/pipeline (refer to Character code for header field CCJ, Section D2.2)
- Name of the Contractor and camera Operator
- Measured chamber dimension
- Inspection date and time
- Purpose of the inspection (refer to Character code for header field CBP, Section D2.2)
- Cleaning Status (refer to Character code for header field CCL, Section D2.2)

Additional information may be requested by the asset owner, which may include but not be limited to:

- Client reference number
- Location/address
- Name of the Client
- Weather (refer to Character code for header field CDA, Section D2.2)

Continuous Screen Display (Running Page)

During the inspection, where the equipment is able to display screen information, the following minimum information shall be visible and recorded:

- The measured distance the camera has travelled from the top of the Cover Frame.
- Manhole/node Asset ID

Any information displayed on the screen shall be easily seen, but not adversely obstruct the view of the manhole. The displayed information shall be positioned in the corners of the recorded image and shall never be positioned in the centre of the screen. If necessary, the information shall be temporarily removed from the screen to enable a clear view of a defect.

End of Inspection Screen Display

At the end of the inspection a screen display shall be provided to confirm the end of the inspection and any relevant information. The information to be provided depends on the inspection completion status, the reason for the end of the inspection and whether there are any changes from what was expected when the inspection commenced.

Table D1.2.2 – End of inspection screen display information

Situation	Information to be displayed
Where a full inspection of the manhole is completed (refer sub-section D1.2.4.1)	• Statement "Inspection Complete"
Where a full inspection of the manhole is not able to be completed (refer sub-section D1.2.4.2)	• Statement "Inspection Abandoned" • Statement about the reason for the abandonment

D1.2.3 Carrying Out the Inspection

D1.2.3.1 Flow Levels During Inspections

The inspection shall be carried out in low flow conditions to maximise the view of the manhole and to ensure all its components can be seen, particularly the lower part of the manhole such as channel, benching and pipe/manhole wall interfaces. Unless specified or agreed in advance of the inspection with the asset owner, the maximum depth of flow shall not exceed half the depth of the channel. Inspection of new manholes, (as-built inspections) shall be undertaken with no live flows, or a maximum depth of flow of 5% channel diameter.

To reduce the depth of flow through the manhole, flow control measures may be required. This may involve the following:

- Returning at an off-peak time when the flow rates have reduced. Off-peak times vary according to location and use of the pipeline, but in general this would be between 10am – 3pm and after 9pm in residential areas. Industrial/ commercial areas will have unique profiles.
- Controlling (limiting) the flow, or by-pass pumping the flow around the manhole being inspected (plugging manholes upstream of the manhole). A flow model or flow rates shall be sought from the asset owner for large diameter/high flow pipes or where a pressure sewer main discharges at a location upstream of the asset to be inspected.

D1.2.3.2 Camera Speed (for Inspections with Cameras or Digital Scanners)

A. Cameras (CCTV, Action Camera or Pole Camera)

The camera shall travel down through the manhole as smoothly and consistently as possible, at a speed that enables the camera operator to identify potential defects and stop the camera at the defect/ feature.

Progression through the manhole shall not be unnecessarily limited or delayed. Where the camera is stationary in the manhole for longer than 20 seconds, the video recording shall be paused until the camera recommences its travel through the manhole.

For Pole Cameras or Action Cameras that are not able to view vertically down the manhole chamber, the inspection shall progress at no greater than 0.5m depth intervals with a full 360-degree rotation to check for defects or features, (refer to clause B1.2.3.3) ensuring that the full manhole throat, cone and chamber is observed.

B. Digital Scanners

Scanners shall be lowered, or raised, (some scanners start at the bottom of the manhole and are raised to the top) at a speed set according to the manufacturer's recommendations.

D1.2.3.3 Observing Defects and Features

A. Where Inspection is undertaken using Cameras or Digital Scanners

For all types of filmed inspections there must be sufficient lighting to illuminate all features and defects in the manhole that the camera is pointing at.

Where a CCTV camera (or camera that is able to view vertically down the manhole chamber) is used the camera shall be stopped where any defect or feature can be clearly viewed, in focus, within the full circumference of the manhole. This position is a distance approximately the width of the manhole from the defect or feature. The camera shall remain stationary, at this location, looking vertically down the manhole chamber, while continuing the image recording for 5 to 10 seconds.

For all other cameras, the camera shall be held stationary tilted or angled perpendicular to the pipe wall at the depth of the defect or feature and facing towards the 12 o'clock location. The inspection shall then be continued by panning or rotating the camera in a clockwise direction around the manhole circumference, (360 degrees) stopping to clearly view all defects. It shall take at least 20 to 25 seconds to complete a full 360-degree rotation turning the camera as smooth as possible.

To gain a clear view of all pipes connected to the manhole, the camera shall stop during the panning/turning operation and ensure all the lateral connection seals can be seen. The camera shall then be pointed at the entrance to the pipe so that the pipe is luminated up to at least the first joint. Where a pole camera is used zooming up the pipe shall be carried out.

In the case where a vertical crack in the manhole wall is observed, the crack shall be traced to its lower extremity to determine its extent and then the inspection is resumed at the top (start) of the crack.

Stopping and panning over defects or features is not relevant when using scanners for the manhole inspection (refer Section A2)

B. Where inspection is completed by personnel entry

The inspector enters the manhole to carry out a visual inspection, following risk assessment and confined space entry requirements, including where required, obtaining an entry permit. The inspection shall consist of the same identification and classification of defects as the non-entry camera/scanner inspection. In addition to the visual inspection the inspector shall undertake non-destructive testing and assessment of the manhole, with emphasis on the following components:

- Benching and Channel. The inspector shall examine the benching testing soundness of the benching material, looking for erosion, 'rat holes', loose mortar, loose channel pipe or evidence that there is no concrete under the half-round invert channel. Where holes are evident, these shall be probed with a cold chisel or similar to check for solid material beneath.
- Inlet and outlet pipes. The Contractor shall check the condition of the pipes for up to 200mm from the manhole wall, for cracking or breaks in the pipe wall.
- Riser joints. Using a cold chisel or similar, check the hardness of mortar jointing in riser joints. Any soft mortar shall be scraped out as deep as possible. Where there appears to be extensive soft mortar, a representative area shall be scraped out.
- Chamber or cone taper wall. Where there is evidence of corrosion, scrape the surface, using a cold chisel, to remove any loose/soft cement to assess the depth to solid/competent concrete.
- Check for defective components, such step rungs or bolts that are corroded or loose.

D1.2.3.4 Photos

The asset owner shall specify the need for photographs in the technical specification.

Photographs are often taken to record the:

a) General condition

b) Condition where it changes significantly during the inspection

As a minimum, a photograph is taken every time one of the following defects are encountered:

i. Broken/Deformed Components

ii. Hole, soil visible or Tomo's

iii. Significant corrosion or erosion

iv. Intrusion of an external object (excluding lateral connections/droppers)

v. Other defects with Medium or Large quantification

vi. Blockages or obstructions within the channel or visible inside lateral connections

Where a CCTV camera, (or camera able to view vertically down the manhole chamber) is used, the primary picture taken shall be a 'straight down view' looking down the manhole. The camera shall be positioned as described for pipes in clause B1.2.3.3.

For all other inspections, Pole Cameras or Action Cameras that are not able to view vertically down the manhole chamber, or the second/subsequent photographs (with CCTV camera) is in a panned position (zoomed if required). The second or subsequent photographs shall be added to the log sheet report using the General Photograph code (GP). Remarks shall be provided to describe the view perspective if the image has been zoomed.

Figure D1.2.5 – Examples of photos

Example 1st photo showing corroded step rung

Example 2nd photo providing a panned view of corroded step rung

D1.2.4 Ending the Manhole Inspection

D1.2.4.1 Complete Inspection

The manhole inspection shall end when:

- The camera reaches the channel invert or top of the flow through the manhole OR
- The scanner was able to traverse the entire manhole from the channel invert or top of the flow through the manhole to above the cover frame OR
- Entry personnel were able to inspect all the manhole components including the benching and channel.

B1.2.4.2 Abandoned Inspections

The inspection shall be abandoned when either the entry personnel or the camera/scanner is prevented from proceeding any further through the manhole. There could be many reasons that may prevent the camera from proceeding such as:

- Roots obstructing the camera within the throat, cone or shaft
- Obstructing step rungs, staging bars or landing
- Where the flow is surcharged above the benching

D1.2.5 Manhole Diagram

A diagram of the manhole shall be prepared and provided in addition to the inspection log sheet. The format for the diagram shall be specified in the technical specification.

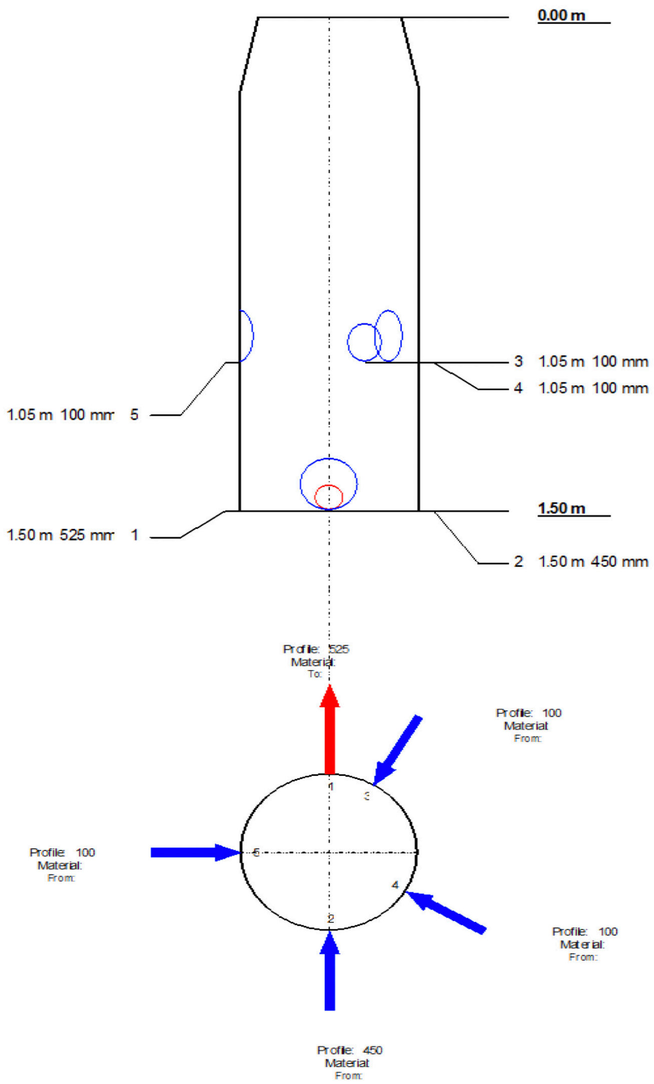
The diagram shall show the layout of the inlet and outlet pipes in both plan and section views. The following information shall be recorded on the diagram:

- Inlet and outlet pipe locations. These shall be recorded with the main outlet pipe at 12 o'clock.
- Depths to invert of all inlet and outlet pipes.
- Pipelines discharging to the manhole 600mm or more above the invert of the outlet shall be labelled as "Drop Pipe: Internal (or External or Free Fall)" as appropriate.
- The nominal diameters of all inlet and outlet pipes. (i.e. 100mm, 150mm, 200mm, 225mm etc)
- "Special" inlet and outlet pipes shall be appropriately labelled. Such pipes may include rising mains, overflow pipes, a second outlet pipe (in flow bifurcation manholes) and stub ends.

In addition, the following information may also be requested by the asset owner, which may include but not limited to:

- Each inlet and outlet gravity sewer main pipe labelled with the pipe asset ID or the closest upstream or downstream manhole ID.
- Each private lateral inlet pipe labelled with the property address(es) that it services.
- Observed connecting pipe material.

Figure D1.2.6 – Example Manhole Diagram



D1.2.7 Changes to the Asset Being Inspected

The location/position of the manhole may be identified as different from that shown in the asset owners GIS. In these cases, the inspector must report and provide marked-up sketches in line with clause B1.2.5 under Section B1.2 CCTV Camera Operation.

D1.2.8 Reporting of Hazards and Significant Defects

There are situations that may be found during the inspection of a manhole which requires urgent attention by the asset owner to avoid blockages, causing overflows and environmental damage or ensure the safety of the public, contractors or the asset owner's staff.

Significant structural defects found in the manhole could indicate that a failure of the component is imminent and urgent action is needed to prevent the failure. Where the following defects are found during an inspection, the inspector shall notify the asset owner as soon as possible:

- Wall Broken, Large severity (HWBL)
- Wall Holed, Large Severity (HWHL)
- Missing Masonry Units, Large severity (HMMNVL)
- Tomo (HTM)
- Broken Cover or Cover Frame or loose Cover Frame (HFRCB or HFRFB or HFRFL)
- Missing cover (HFRCM)
- Severely corroded step rungs, staging bars/platform or bolts securing the staging bars/platform (HSLLC, HSLSC, HSLLCC, HSLRC)

All obstructions, deposits (HDG, HDE and HED) and tree root intrusions in the manhole channel or obstructing more than 50% of the outlet pipe diameter are defined as significant flow capacity hazards, with high risk of blockage and an overflow occurring. Where these defects are found, the inspector shall notify the asset owner as soon as possible. If these hazards are removed with cleaning or root cutting as part of the inspection, the hazard shall still be notified, but communicated that the hazard has been removed.

D2.2 Manhole Header Classification Codes

These codes are used to describe information relating to the manhole being inspected. They contain information about the inspection, including asset identification, location, pipe attributes and its condition.

The codes are described within the following four tables. Each table groups the data into different types/purpose of information i.e.

D2.2.1 Header codes to describe the location of the inspection

D2.2.2 Header codes for reporting inspection details

D2.2.3 Header codes for recording manhole details

D2.2.4 Header codes for recording miscellaneous information

The main reporting codes for the inspection header are based on those specified in the European Standard, EN 13508 “Investigation and assessment of drain and sewer systems outside buildings – Visual inspection coding system” and WSA 05, “Conduit Reporting code of Australia”. The exception is 12 codes CBQ to CBV, CCZ, CCCA to CCCE. These additional codes have been provided to cover New Zealand specific information fields that are not covered by the EN13508-2 and WSA 05. The header reporting codes are generally not included in the naming of the header fields but are intended to be used as a reference for the format for the electronic transfer of data (refer to Appendix A). Some header code fields are not used in New Zealand and these are denoted in the header code tables (retained in the tables for completeness of information).

The sub-codes (described in the “Data to be recorded” column in the tables) are New Zealand specific but some are based on the Australian WSA 05 sub-codes where applicable. These sub-codes are mnemonic and would need to be converted if it is required to report in EN 13508 format.

Table D2.2.1 – Header codes to describe the location of the inspection

Header Code	Header Field	Data to be recorded		Format
CAA	Asset ID	Unique asset identification number as supplied by the asset owner or generated by the Contractor if the inspected pipe is a new asset.		Short Text
CAB	Asset coordinate (Optional)	Grid reference (coordinates of the asset)		Short Text
CAC to CAI	Not Used			
CAL	Location type (Optional)	Record the location of the manhole as follows:		Char
		B	Bushland / Parkland	
		BO	Under a permanent building (Built Over)	
		C	Under a waterway (Creek)	
		D	On a property with buildings (Developed)	
		DA	Difficult Access e.g. motorway or operational railway land	
		F	In a Footway beside road	
		G	Gardens	
		M	In other pedestrian area (Mall)	
		NS	In berm beside a road (Nature Strip)	
		P	In field (Paddock)	
		R	In a Road or other carriage way	
		W	Water foreshore	
		Z	Other—further details shall be stated in remarks	
CAM	Asset Owner (Optional)	The name of the asset owner		Short Text
CAN	Town or suburb (Optional)	The name of the town or suburb as specified by the asset owner		Short Text
CAO	District/Catchment (Optional)	The name of the district or catchment as specified by the asset owner		Short Text
CAP	Name of network (Optional)	The name of the network, or a conduit system reference as specified by the asset owner		Short Text
CAQ	Land ownership (Optional)	Record the ownership of the land denoted as:		Char
		C	Public land (Council or Crown land)	
		Q	Not known (Query)	
		T	Private land	
CAR	Manhole type	Record the type of manhole as:		Char
		S	Standard	
		V	Vented	
		CP	Catchpit	
		IC	Inspection Chamber	
		LH	Lamp hole	
		IP	Inspection Point (Dry Chamber)	
		Z	Other—further details shall be stated in remarks	

D2.2.2 – Header codes for reporting inspection details

Header Code	Header Field	Data to be recorded		Format
CBA	Standard	The version of the standard used to record the data. This shall be in the form NZPIM (Gravity)—4th Edition 2018		Short Text
CBB	Original coding system (Optional)	Where the coding has been translated from an earlier version or from another system, the name of the original coding system.		Short Text
CBC	Not Used			
CBD	Not Used			
CBE	Method of inspection	Record the method used to inspect the manhole as follows:		Char
		FZ	Inspection by means of a Fixed position Zoom pipeline camera	
		FN	Inspection by means of a Fixed position Non-zoom camera	
		M	Direct inspection of a manhole by an operator (Manned)	
		PS	Inspection by means of a remotely controlled 3D optical Pipeline Scanner passed through the manhole	
		S	Inspection from the Surface only	
		Z	Other – further details shall be recorded using the general header comment (Code CDF) as the next code	
CBF	Date of inspection	Record the short date of the inspection using the DD/MM/YYYY format, e.g. 01/09/2018 means 1 September 2018. Leading zeros shall be included where necessary		Short Date (DD/MM/YYYY)
CBG	Time of inspection	The time as specified in ISO 8601 using the 24-hour hh:mm format. e.g. 14:41 means 2.41 pm local time. Leading zeros shall be included where necessary		Time (hh:mm
CBH	Name of Operator	Record the name of the inspection equipment operator.		Short Text
CBI	Operator's Reference (Optional)	The reference code or name for the inspection supplied by the operator or the operator's company		Short Text
CBJ	Asset owner's Reference (Optional)	The reference code or name for the inspection supplied by the asset owner		Short Text
CBK	Storage medium for video (optional)	Record the type of media used for storing moving images as follows:		Char
		CD	Video CD. Details of format shall be recorded in remark	
		DVD	Digital Versatile Disc. Details of format shall be recorded in remark	
		PHD	Portable Hard Drive. Details of format shall be recorded in remark	
		USB	Universal Serial Bus. Details of format shall be recorded in remark	
		Z	Other—full details shall be recorded in a general header comment (code CDF) immediately following	
CBL	Not Used			
CBM	Not Used			
CBN	Not Used			
CBO	Video volume reference	Where CBK is recorded as PHD or USB or Z, record the file name for the video file. The file name must be unique, and where applicable conform to the asset owner's specified file naming convention. Where CBK is recorded as CD or DVD, record the storage media reference name. This media name must be unique.		Short Text

Header Code	Header Field	Data to be recorded		Format
CBP	Purpose of inspection	Record the purpose of the inspection as follows:		Char
		C	Completion of an earlier abandoned inspection	
		IE	Suspected infiltration problem (Infiltration Exam)	
		IP	Investment Planning	
		NC	Final inspection of a New Construction	
		OE	Suspected operational problem (Operational Exam)	
		R	Routine inspection of condition	
		RC	Final inspection of renovation or repair (Renovation/ Repair Control)	
		S	Sample inspection	
		SE	Suspected structural problem (Structural Exam)	
		T	Transfer of ownership	
		W	End of Warranty period	
		Z	Other—the reason shall be recorded as a header remark (code CDE) immediately following	
CBQ	Manhole Depth	Record the measured depth of the manhole (m). The measurement is from the top of the cover frame. Where the manhole cannot be measured, (i.e. inspection is not able to be completed) the value to be recorded in the manhole depth field shall be, (in the following order): 1. The GIS / asset owner's data for depth, if physical measurement is not possible 2. Left blank, if the GIS depth is not available		Number (#.#)
CBR	Survey depth	The recorded depth of manhole (m) that has been surveyed.		Number (#.#)
CBS	Inspection Completion Status	Record the completion status of the inspection as follows:		Char
		IC	Inspection Complete	
		UI	Uncompleted Inspection	
CBT	Name of Coder	Record the name of the person who encoded the manhole condition.		Short Text
CBU	Date of Data Entry (Optional)	The date of the data entry (coding is undertaken) if different to the date of inspection.		Short Date (DD/MM/YYYY
CBV	Location and name of the manhole sketch	A copy of the link to the manhole sketch		Short Text

D2.2.3 – Header codes for recording manhole details

Header Code	Header Field	Data to be recorded		Format
CCA	Shape of Access/Throat	Record the shape of the opening i.e. the most restrictive opening into the manhole		Char
		C	Circular	
		O	Oval	
		R	Rectangular	
		T	Triangular	
		Z	Other—a description shall be included as a general header comment (code CDE) immediately following	
CCB	Width of Access/Throat	The width / diameter (maximum clear opening) of the throat in mm. Where there is no throat (e.g. large scruffy dome) the field shall be left blank.		Number (##)
CCC	Breadth of Access/Throat	The breadth (minimum clear opening) of the throat in mm. Where there is no throat (e.g. large scruffy dome) the field shall be left blank.		Number (##)
CCD	Material	The material of the fabric of the manhole, under the coding of Table B1 of Appendix B. Where a manhole is a combination of two or more materials e.g. a concrete base and brick walls, record all materials e.g. CP/BR. Where the manhole has been lined the Material, field shall be left blank.		Short Text
CCE	Not used			
CCF	Shape of chamber	Record the cross section of the chamber of the manhole as follows:		Char
		C	Circular	
		R	Rectangular/Square	
		X_	Local section – code to be specified by asset owner and prefixed by an X	
		Z	Other – further details are to be recorded in remarks	
CCG	Chamber Unit Length	Length of individual prefabricated units, (m) where applicable, is recorded (similar to Joint Spacing in pipelines)		Number (#.##)
CCH	Chamber Width/Diameter	The width or diameter of the chamber section in mm		Number (##)
CCI	Chamber Breadth	The breadth of the chamber section in mm — not required where both dimensions are the same e.g. circular		Number (##)
CCJ	Use of manhole	Record the type of use of the manhole as follows:		Char
		COM	Combined system (Sewage and Stormwater combined)	
		M	Manhole serves two systems, one carrying sewage, the other stormwater (Multiple) and joining at this manhole	
		O	Other – describe the use of the manhole	
		Q	Not known	
		S	The manhole is designed to carry only Sewage	
		SW	The manhole is designed to carry only Storm Water	
CCK	Not used			
CCL	Cleaning	Record whether the manhole was cleaned prior to the inspection as follows		Short Text
		LC	The manhole was Light Cleaned prior to the inspection	
		HC	The manhole was Heavy Cleaned prior to the inspection	
		NC	The manhole was Not Cleaned prior to the inspection	
		RC	The manhole was Root Cut prior to inspection	

Header Code	Header Field	Data to be recorded		Format
CCM	Not used			
CCN	Shape of Cover	Record the shape of the cover (manhole lid) as follows (refer to appendix E) :		Short Text
		C	Circular	
		R	Rectangular	
		RDS	Rectangular/Square (Diagonal Split)	
		RDO	Rectangular/Square (Double Opening)	
		T	Triangle	
		Z	Other – further details are to be recorded in remarks	
CCO	Not Used			
CCP	Width of cover	The width / diameter of the cover in mm. Where there is no throat (e.g. large scruffy dome) the field shall be left blank.		Number (#)
CCQ	Breadth of cover	The breadth of the cover in mm. Where there is no throat (e.g. large scruffy dome) the field shall be left blank.		Number (#)
CCR	Form of access within manhole	Record the type of steps as follows:		Char
		D	Double width step irons – wide enough for two feet	
		L	Ladder	
		N	No provision	
		S	Single with step irons – wide enough for one foot	
		T	Toe Holes	
		Z	Other – further details are to be recorded using the general comment header code (CDF) as the next code	
CCS	Material of steps or ladder	Record the material of the ladder using the codes in Table B1 of Appendix B		Char
CCT to CCW	Not used			
CCX	Type of cover	Describe the type of access cover using following load classifications (duty Classes) as described in AS 3996 and material types. Alternatively, an asset owner could develop a set of codes suitable for its unique combination of cover types. (Also refer to Appendix E)		Char
		ACI	Class A Non-Traffic Cast Iron	
		ACIG	Class A Non-Traffic Cast Iron Grated	
		BCI	Class B Light Vehicle Cast Iron	
		BCIG	Class B Light Vehicle Cast Iron Grated	
		CCI	Class C Heavy Commercial Cast Iron	
		DCI	Class D Heavy Commercial (Fast) Cast Iron	
		DCIN	Class D Heavy Commercial (Fast) Cast Iron Non-Rock	
		DDI	Class D Heavy Commercial (Fast) Ductile Iron	
		DDIG	Class D Heavy Commercial (Fast) Ductile Iron Grated	
		DDIH	Class D Heavy Commercial (Fast) Ductile Iron Hinged	
		DDIHG	Class D Heavy Commercial (Fast) Ductile Iron Hinged - Grated	
		GISD	Galvanized Iron, Scruffy Dome	
		Z	Other – Description to be provided in the Comments field (CDF)	

Header Code	Header Field	Data to be recorded		Format
CCY	Type of lifting arrangements	Describe the lifting provision as follows (refer to appendix E):		Char
		T	T Slot – single central	
		T2	T Slot – 2 or more T slots	
		H	Lifting Hook – single central	
		H2	Lifting Hook – 2 or more lifting hooks	
		P	Pick hole – Single	
		P2	Pick hole – 2 or more	
		B	Bolt or cam locks	
		N	No lifting arrangements	
		Z	Other – further details are to be recorded using the general comment header code (CDF)	
CCZ	Depth of Access/Throat	Measured depth of the manhole access or throat measured in metres (m)		Number (#.##)
CCCA	Cover height	Record the cover height in relation to its surroundings as follow:		Char
		HIGH	Higher than surrounding	
		LVL	Level with surrounding	
		LOW	Lower than surrounding	
CCCB	Total Structural Score	Calculated total structural score		
CCCC	Structural Peak Score	Calculated peak structural score		Number (##)
CCCD	Structural Mean Score	Calculated mean structural score		Number (##)
CCCE	Total Service Score	Calculated total service score		Number (##)
CCCF	Service Peak Score	Calculated peak service score		Number (##)
CCCG	Service Mean Score	Calculated mean service score		Number (##)
CCCD	Structural Peak Grade	Calculated peak structural condition grade		Integer (1-5)
CCCE	Service Peak Grade	Calculated peak service condition grade		Integer (1-5)

D2.6 – Header codes for recording miscellaneous information

Header Code	Header Field	Data to be recorded		Format
CDA	Precipitation (Optional)	Record the precipitation as follows:		Char
		N	No precipitation	
		R	Precipitation (rain)	
		S	Melting Snow or ice	
CDB	Temperature (Optional)	Temperature (Optional)		Char
		C	Below freezing (Cold)	
		W	Above freezing (Warm)	
CDC	Flow control measures (Optional)	Record the measures taken to deal with the flow at the time of the inspection as follows:		Char
		B	Flows have been Blocked or diverted upstream	
		N	No measures taken	
		P	Flows Partially blocked or diverted upstream	
		Z	Other—record further details in remarks	
CDD	Atmosphere (Optional)	Record the nature of the atmosphere within the manhole as follows:		Char
		H	Hydrogen Sulphide – record reading from gas detector in remarks	
		M	Methane – record reading from gas detector in remarks	
		N	Non-hazardous atmosphere	
		O	Oxygen deficiency or excess	
		OF	Other Flammable gas – record type of gas where known in remarks	
		Z	Other – record the name as a header comment, code CFE	
CDE	Tidal influence (Optional)	Record tidal influence as follows:		Char
		A	At or above high tide level	
		B	Below high tide level	
CDF	General comment	Record any information that cannot be included in any other way		Long Text

D2.3 Manhole Condition Classification Codes

The condition classification codes and their definitions are described within this section, along with examples. A summary of the Main Codes and Characterisation codes (Char.) is provided in Table D2.3.1.

Table D2.3.1 – Summary of Main and Characterisation Codes

Groups	Main Code	Main Description	Char.	Quant. (Method)	Characterisation Description	Clause	Page
Manhole Wall Codes	HCV	Cracking Vertical		1		MW1.1	
			C	-	Crack edge Chipped		
			B	-	Slabbing		
			D	-	Crack faces are Displaced		
	HCC	Cracking Circumferential		1		MW1.2	
			C	-	Crack edge Chipped		
			D	-	Crack faces are Displaced		
	HCM	Cracking Multiple		1		MW1.3	
			C	-	Crack edge Chipped		
			B	-	Slabbing		
			D	-	Crack faces are Displaced		
	HWB	Wall Broken		3v		MW1.4	
	HWH	Wall Holed		3v		MW1.5	
	HPF	Deformed Plastic Manhole	C	-	Cracking	MW1.6	
			B	2	Buckling		
			IC	-	Inverse Curvature		
			D	2	Elliptical Deformation		
	HDF	Deformed Manhole Segment		O4		MW1.7	
	HS	Surface Damage	W	-	Wall roughened	MW1.8	
			S	-	Spalling		
			WM	-	Wall Missing		
			AE	3	Aggregate Exposed		
			AP	3	Aggregate Projecting		
			AM	3	Aggregate Missing		
			RC	3	Reinforcement Corroded		
			RV	3	Reinforcement Visible		
			RVP	3	Reinforcement Visible Projecting		
			CP	3	Corrosion Products visible		
			MD	3	Mechanical Damage		
			H	3	Holed		
			WS	3	Wall Staining		
	HPL	Protective Lining Defective	WV	2	Wrinkling – Vertical	MW1.9	
			WC	2	Wrinkling – Circumferential		
			W	2	Wrinkling – multiple patterns		
			B	-	Blistered		
			BU	2	Bulged		

Manhole Wall Codes *(cont.)*	HPL	Protective Lining Defective *(cont.)*	D	-	Detached		
			C	-	Dis-Colouration		
			WD	-	Weld defective		
			RC	-	Re-establishment of Connection done improperly		
			L	-	Leak		
			H	-	Holed		
			RM	-	Rendered mortar Missing		
			Z	-	Other		
	HPR	Point Repair	I	-	Injected mortar/sealant	MW1.10	
			Z	-	Other		
	HSV	Soil Visible through defect		-		MW1.11	
	HTM	Tomo		-		MW1.12	
	HCX	Manhole Chamber Collapse		-		MW1.13	
	HDC	Dimension Change		-		MW1.14	
	HPC	Pre-cast Chamber Segment Length Change		-		MW1.15	
	HMC	Material Change		-		MW1.16	
Manhole Masonry Codes (For brick, blockwork and stone construction)	HMM	Missing Mortar		3		MM2.1	
	HMUS	Masonry Unit Separation		O2		MM2.2	
	HDMU	Displaced Masonry Units	I	3	Moving Inwards	MM2.3	
			O	3	Moving Outwards		
	HMMU	Missing Masonry Units	V	3	More Masonry Visible	MM2.4	
			NV	3	No more masonry Visible		
	HMX	Masonry Manhole Collapsed		-		MM2.5	
	HMMU	Missing Masonry Units	V	3	More Masonry Visible	MM2.4	
			NV	3	No more masonry Visible		
	HMX	Masonry Manhole Collapsed		-		MM2.5	
Manhole Joint Codes	HJFX	Chamber Joint Faulty Seal		1		MJ3.1	
	HJO	Chamber Joint Open		O1		MJ3.2	
			A	O1	Angular displacement		
	HJD	Chamber Joint Displaced		2		MJ3.3	
Manhole Lateral Codes	HL	Connecting Lateral Pipe	ID	-	Internal Drop Structure	ML4.1	
			ED	-	External Drop Structure		
			CD	-	Cascading Drop		
			PD	-	Protruding Drop		
			CB	-	Channel in Benching		
			UB	-	Under benching		
			AC	-	Across benching		
			VP	-	Ventilation Pipe		
			B	-	Blank		
	HLF	Connecting Lateral Pipe Sealing Faulty	C	1	Cracked	ML4.2	
			B	1	Broken		
			D	1	Damaged		
			X	1	Seal		

Groups	Main Code	Main Description	Char.	Quant. (Method)	Characterisation Description	Clause	Page
Manhole Lateral Codes *(cont.)*	HLX	Connecting Lateral Pipe is Defective	B	-	Blocked	ML4.3	
			C	-	Branch Cracked		
			R	-	Some Roots		
			SE	-	Soil Entering		
			Z	-	Other		
	HDP	Defective Drop Pipe	B	-	The Drop Pipe is Blocked	ML4.4	
			C	-	The Drop Pipe is Cracked		
			D	-	The Drop Pipe is Deformed		
			M	-	The drop pipe is missing or has been dislodged, separated and/or disconnected so that flow is not being directed to the channel in the base of the structure		
			T	-	The outlet of the drop pipe is not correctly positioned so that flow is misdirected or is causing unnecessary turbulence and/or splashing		
			Z	-	Other		
Cover and Frame	HFR	Defective Cover and/or Frame	CB	-	Cover cracked or Broken	MCF5.1	
			CD	-	Cover Deformed		
			CM	-	Cover Missing		
			CR	-	Cover Rocking		
			FB	-	Frame cracked or Broken		
			FL	-	Frame Loose		
			FD	-	Frame Displaced		
			FM	-	Frame Missing		
			G	-	Gap or hole between Access/ Throat, Lid or Chamber		
			HD	-	Holding down bolts missing or defective		
			Z	-	Other		
	HUF	Devices Under Cover and Frame	AB	-	Access Barrier	MCF5.2	
			SD	-	Sensing Device		
			ST	-	Sediment or Litter Trap		
			Z	-	Other		
	HUX	Defective Devices Under Cover and Frame	D	-	Device is present but defective	MCF5.3	
			M	-	All or part of the device is missing with evidence that one was previously present		
			U	-	Device is unlocked or disconnected		
	HVT	Vent	D	-	Vent is structurally defective	MCF5.4	
			SW	-	Surface Water can enter the manhole through the vent		

Groups	Main Code	Main Description	Char.	Quant. (Method)	Characterisation Description	Clause	Page
Steps/Rungs, Platforms and Landings	HSL	Defective Step or Ladder	ED	-	Plastics encapsulation of step or staging bar is damaged or broken	MR6.1	
			HC	-	Ladder handrail is corroded		
			LC	-	Ladder cracked.		
			LCC	-	Ladder support corroded (Ladder clip corroded)		
			LCL	-	Ladder support loose (Ladder clip loose)		
			LCM	-	Ladder support missing (Ladder clip missing)		
			LRM	-	Ladder rung missing		
			RC	-	Ladder rung corroded		
			SB	-	Step bent		
			SC	-	Step corroded		
			SL	-	Step loose		
			SM	-	Step missing		
			TH	-	Defective toe hole		
			RG	-	Rags or other material caught or hanging on the steps or ladder		
			Z	-	Other		
	HSP	Safety bars or staging platform		-		MR6.2	
			BB	-	One or more safety bars bent or broken		
			BC	-	One or more safety bars corroded		
			BL	-	One or more safety bar/ platform fixings is loose or broken		
			BM	-	One or more safety bars missing with evidence that they previously existed		
			Z	-	Other		
	HTD	Tie Down Bolt		-		MR6.3	
			C	-	Tie down bolt/hook corroded		
			B	-	Tie down bolt/hook bent		
			M	-	Missing with evidence that they previously existed		
			Z	-	Other		
Benching and Channel	HCH	Defective Channel	X	-	Defective	MB7.1	
			M	-	Missing with evidence that a channel previously existed		
			D	O3	Channel dipped/ponding		
	HBN	Defective Benching	X	-	Defective	MB7.2	
			M	-	Missing with evidence that benching previously existed		
			N	-	No benching		

Groups	Main Code	Main Description	Char.	Quant. (Method)	Characterisation Description	Clause	Page
Benching and Channel *(cont.)*	HFC	Flow Control Device	FL	-	Float operated valve	MB7.3	
			FV	-	Flap valve		
			G	-	Sewer Gauging Station		
			MF	-	Measuring flume e.g. venturi		
			OP	-	Orifice plate		
			P	-	Penstock, gate stop, valve etc.		
			SS	-	Special structure e.g. flap gate or other controls in a purpose-built structure		
			TR	-	Trash rack, screens,		
			V	-	Vortex flow control		
			W	-	Weir		
			Z	-	Other		
Service Related Codes	HDE	Debris Silty		2		MS8.1	
	HDG	Debris Greasy		2		MS8.2	
	HED	Encrustation Deposit		2		MS8.3	
	HRI	Root Intrusion	F	2	Fine Roots	MS8.4	
			M	2	Mass of mostly fine roots interwoven into a clump		
			T	2	Tap roots		
			RF	2	Recently cut Fine roots		
			RB	2	Recently cut interwoven roots leaving a Beard		
			RT	2	Recently cut Tap roots		
	HO	Obstruction	P	2	Permanent	MS8.5	
			T	2	Temporary		
	HB	Blocked Channel	RI	-	Root Blockage	MS8.6	
			DE	-	Silty Debris Blockage		
			DG	-	Fat Blockage		
			Z	-	Other		
	HEX	Exfiltration		-		MS8.7	
	HIP	Infiltration Present		O6		MS8.8	
	HWL	Water Level		-		MS8.9	
Inspection Information Codes	HCF	Construction Feature		-		MI9.1	
	HGC	General Comment		-		MI9.2	
	HLOV	Loss of Vision	UW	-	Under Water	MI9.3	
			G	-	Grease on lens		
			S	-	Steam		
			EF	-	Equipment Failure		
			Z	-	Other/Unknown		
	HIS	Inspection Starts		-		MI9.4	
	HIE	Inspection Ends		-		MI9.5	
	HIA	Inspection Abandoned		-		MI9.6	

Groups	Main Code	Main Description	Char.	Quant. (Method)	Characterisation Description	Clause	Page
Inspection Information Codes *(cont.)*	HSC	Sealed Conduit Through Manhole	CM	-	Proper access provisions exist but Covers are Missing	MI9.7	
			CS	-	Access is possible, but Covers are Sealed		
			NA	-	There is No Access to the conduit		

MW1 –Manhole Wall Codes

MW1.1 – Cracking Vertical

Code	Description	
HCV	Cracking – Vertical[1, 2, 7.]	
	Additional Information	
	Characterisation – additional code to describe specific structural features associated with the cracking used when they are present:	
	C	Chipping/splintering of the wall fabric along the crack edge
	B	Slabbing of the pipe wall fabric[6, 8]
	D	Vertical Displacement of the crack edges
	Quantification[4] – Evidence of a pathway through the Manhole wall (*Method 1*). Record using additional code to describe the observations as follows:	
	S	Small, crack is visible but does not extend all the way through the manhole wall
	M	Medium, crack is open and possibly the crack extends all the way through the manhole wall.
	L	Large, there is clear visual evidence that the crack extends all the way through the manhole wall[3]
Circumferential location: Record the position of the crack as a single clock reference[5]		
Continuous Defect: Where the vertical length of cracking exceeds 1 metre, the crack shall be recorded as a Continuous Defect[7]		
Descriptive Location: Additional code to describe the location of the defect as follows:		
	TH	Throat/Access
	LI	Lid
	T	Taper
	CH	Chamber

Notes:
1. Single cracks may branch and re-enter the main crack forming before stopping.
2. Where there are other vertical cracks present, these are coded as separate entries.
3. Describe the evidence for the large severity band in the remarks.
4. Not required when C, D or B characterisation codes are used.
5. If crack branches or varies in clock position, use the median clock reference.
6. The terms slabbing, shear slabbing, or slab shear refers to a radial shear failure of the concrete which occurs from the yielding of the structural reinforcement steel due to excessive tension. Slabbing is characterized by slabs of concrete "peeling" or delaminating from the reinforcing steel as it straightens.
7. Vertical cracking must be truly continuous for greater than one metre within the same component.
8. Not used for cracking in the concrete lid or non-circular MH Chambers.

Example:

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
X		HCV	C		CH	12	

Remarks: Vertical crack with chipping of the edges

MW1.2 – Cracking Circumferential

Code	Description	
HCC	Cracking – Circumferential[1].	
	Additional Information	
	Characterisation – additional code to describe specific structural features associated with the cracking used when present:	
	C	Chipping/splintering of the wall fabric along the crack edge
	D	Vertical Displacement of the crack edges
	Quantification[3] – Evidence of a pathway through the manhole wall (*Method 1*). Record using additional code to describe the observations as follows:	
	S	Small, crack is visible but does not extend all the way through the manhole wall
	M	Medium, crack is open and possibly the crack extends all the way through the manhole wall.
	L	Large, there is clear visual evidence that the crack extends all the way through the manhole wall[2]
Circumferential location: Record the extent of the crack as a pair of clock references[4]		
Continuous Defect: Not Applicable		
Descriptive Location: Additional code to describe the location of the defect as follows:		
	TH	Throat/Access
	T	Taper
	CH	Chamber

Notes:

1. Single cracks may branch and re-enter the main crack, or change clock position before stopping.
2. Describe the evidence for the large severity band in the remarks.
3. Not required when C, D or B characterisation codes are used.
4. If crack branches, or varies in clock position, use the median clock reference and describe the position of the crack using a pair of clock references in the remarks.

Example:

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
X		HCC		L	CH	11	1
Remarks: Vertical crack with chipping of the edges							
Y		*HL*	*CB*			*12*	
Remarks: *225mm Outlet.*							

MW1.3 – Cracking Multiple

Code	Description	
HCM	Cracking – Multiple. Cracking in both vertical and horizontal (multiple) directions. The cracks branch but do not form ‘blocks’ of broken wall [1, 5]	
	Additional Information	
	Characterisation – additional code to describe specific structural features associated with the cracking used when present:	
	C	Chipping/splintering of the wall fabric along the crack edge
	B	Slabbing of the pipe wall fabric[4,6]
	D	Vertical Displacement of the crack edges
	Quantification[3] – Evidence of a pathway through the manhole wall (*Method 1*). Record using additional code to describe the observations as follows:	
	S	Small, crack is visible but does not extend all the way through the manhole wall
	M	Medium, crack is open and possibly the crack extends all the way through the manhole wall.
	L	Large, there is clear visual evidence that the crack extends all the way through the manhole wall[2]
Circumferential location: Record the extent of the cracking as a pair of clock references.		
Continuous Defect: Where the vertical length of cracking exceeds 1 metre, the crack shall be recorded as a Continuous Defect[5]		
Descriptive Location: Additional code to describe the location of the defect as follows:		
	TH	Throat/Access
	LI	Lid
	T	Taper
	CH	Chamber

Notes:

1. Use code HPB if crack branches form ‘blocks’
2. Describe the evidence for the large severity band in the remarks
3. Quantification is not required when C, D or B characterisation codes are used
4. The terms slabbing, shear slabbing, or slab shear refers to a radial shear failure of the concrete which occurs from the yielding of the structural reinforcement steel due to excessive tension. Slabbing is characterized by slabs of concrete “peeling” or delaminating from the reinforcing steel as it straightens
5. Vertical cracking must be truly continuous for greater than one metre within the same component.
6. Not used for cracking in the concrete lid or non-circular MH Chambers.

MW1.4 – Wall Broken

Code	Description	
HWB	Wall – Broken. Pieces[1] of manhole structure have fallen out or are displaced from one another or could become displaced.	
	Additional Information	
	Characterisation – There are no Characterisation codes for this defect	
	Quantification – The extent of the manhole circumference / perimeter with broken pieces of wall and the extent to which they have become displaced. Record using additional codes to describe the observations as follows:	
	S	Small, broken pieces are up to 10% of the manhole circumference / perimeter and not displaced by more than half the manhole wall thickness.
	M	Medium, broken pieces are up to 20% of the manhole circumference / perimeter and not displaced by more than half the manhole wall thickness.
	L	Large, broken pieces are more than 20% of the manhole circumference / perimeter or pieces are displaced by more than half the manhole wall thickness or have fallen out/in[2]
Circumferential location: Record the extent of the broken wall as a pair of clock references.		
Continuous Defect: Where the length (vertically) of broken area exceeds 1 metre, the PB shall be recorded as a Continuous Defect[3]		
Descriptive Location: Additional code to describe the location of the defect as follows:		
	TH	Throat/Access
	LI	Lid
	T	Taper
	CH	Chamber

Notes:
1. Pieces or 'blocks' formed by cracks connecting in a mosaic arrangement, including those made with cracks starting and ending at a joint (benching, corner, pre-cast joint).
2. Where broken pieces have fallen out of position (missing) this should be noted in the remarks. If the manhole is constructed from bricks the relevant MU ('masonry code" should be used).
3. Broken Wall (including all associated cracked) must be truly continuous for greater than one vertical metre within the same component.

MW1.4 – Wall Broken

Code	Description	
HWH	Wall Holed. A hole has been cut or 'punched' into the manhole, either to gain access to the manhole e.g.to make a connection that wasn't used, or through unintentional 3rd party damage to the manhole wall[1,4]	
	Additional Information	
	Characterisation – There are no Characterisation codes for this defect	
	Quantification – The extent of the wall circumference/ perimeter) that has been holed by the impact and whether there has been any repair (*Method 3 variation*). Record using additional codes to describe the observations as follows:	
	S	Small, hole (any size) that has been repaired by covering or filling the hole, with no evidence that it is open to the outside of the manhole
	M	Medium, pipe hole up to 5% of the pipe circumference / perimeter
	L	Large, pipe hole greater than 5% of the manhole circumference / perimeter
Circumferential location: Record the extent of the hole as a pair of clock references.		
Continuous Defect: Where the length (vertical) of pipe hole exceeds 1 metre, the HWH shall be recorded as a Continuous Defect[6]		
Descriptive Location: Additional code to describe the location of the defect as follows:		
	TH	Throat/Access
	LI	Lid
	T	Taper
	CH	Chamber

Notes:

1. A hole in the manhole wall as a result of a Piece(s) or 'blocks' of manhole wall, formed by a mosaic of cracks, falling out of position should be coded using defect code HWB.
2. The surmised reason for the hole and evidence or otherwise of its repair is noted in the "Remarks" field.
3. Where an object is protruding through the wall hole, this shall be coded separately and in addition to the HWH
4. Where more than one hole occurs within one metre, they are entered as one hole. The quantification considers the combined loss of circumference.
5. If steel reinforcement is visible within the hole this is coded separately using code HRV
6. The hole must be truly continuous for greater than one vertical metre within the same component.

MW1.6 – Deformed Plastic Manhole

Code	Description	
HPF	Deformed Plastic Manhole. Refers to flexible manhole/chambers (e.g. PVC, PE, GRP, Steel) that has been deformed due to external pressure or loading.	
	Additional Information	
	Characterisation – additional code to describe the type or orientation of the deformation:	
	D	Elliptical deformation
	C	Cracking – cracks, fractures, rips or ruptures that can occur in circumferential, longitudinal or multiple directions
	B	Buckling – longitudinal or radial wavy deformation of the Chamber wall due to large circumferential stresses
	IC	Inverse Curvature – buckling that results in an inwards buckling of the Chamber wall (pipe all curves into the pipe) due to excessive loading
	Quantification[1,2] – Amount of deformation that has occurred expressed as a % of the reduction in manhole diameter (*Method 2*). Record using additional code to describe the observations as follows:	
	S	Small, deformation resulting in a reduction in diameter of up to 10%
	M	Medium, deformation resulting in a reduction in diameter between 10% – 25%.
	L	Large, deformation resulting in a reduction in diameter of greater than 25%
Circumferential location: No clock references are required.		
Continuous Defect: Where the length (vertically) of deformation exceeds 1 metre, the HPF shall be recorded as a Continuous Defect[3]		
	Descriptive Location: Additional code to describe the location of the defect as follows:	
	TH	Throat/Access
	T	Taper
	CH	Chamber

Notes:

1. Identifying plastic deformation up to 10% can be very difficult by visual inspection alone. Quantification of pipe deformation may require additional investigations (e.g. laser profiling).
2. Not required when C or IC characterisation code is used.
3. The deformation must be truly continuous to be applied.

MW1.7 – Deformed Manhole

Code	Description	
HDF	Deformed Manhole or hinged cracked manhole chamber. Identified by parallel longitudinal cracking through the manhole segment. Typically occurring at points: 12 O'clock, 3 O'clock, 6 O'clock and 9 O'clock. The longitudinal cracking associated with the deformation is included in the DF code[1,2]	
	Additional Information	
	Characterisation – There are no Characterisation codes for this defect	
	Quantification – Amount of deformation that has occurred expressed as a % of the reduction in manhole diameter (*Outlier Method 4*). Record using additional code to describe the observations as follows:	
	S	Small, Not Applicable
	M	Medium, deformation resulting in a reduction in diameter of up to 10%.
	L	Large, deformation resulting in a reduction in diameter of greater than 10%
Circumferential location: No clock references are required.		
Continuous Defect: Where the length (vertically) of deformation exceeds 1 metre, the HDF shall be recorded as a Continuous Defect[3]		
Descriptive Location: Additional code to describe the location of the defect as follows:		
	TH	Throat/Access
	T	Taper
	CH	Chamber

Notes:

1. This code is used if at least 3 parallel longitudinal cracks are visible in their typical arrangements above the flow in the invert (often continuous cracks that are expected at 6 o'clock are obscured by the flow or debris in the manhole).
2. The longitudinal cracks are not coded separately. Branching cracks, including those perpendicular to the longitudinal cracks, or broken pipe, are not coded, but should be noted in the remarks field.
3. The deformation must be truly continuous to be applied.
4. Record the value of the reduction in diameter in the remarks.

MW1.8 – Surface Damage

Code	Description	
HS	Surface Damage. The inside surface of the manhole has been damaged. This includes abrasive erosion, chemical/bacterial corrosion, spalling, delamination, chips and mechanical damage.	
	Additional Information	
	Characterisation – additional code to describe the type/extent of damage that has occurred:	
	W	Wall Roughened – light surface damage where the surface of the manhole is slightly worn
	S	Spalling of concrete surface, including localized chipping or where layers or small fragments have broken from the wall surface due to the expansion action of corroded reinforcement
	WM	Wall Missing - A section of the wall has completely corroded/eroded away
	AE	Aggregate Exposed – concrete aggregate is visible
	AP	Aggregate Protruding – coarse concrete aggregate is projecting from the surface of the wall
	AM	Aggregate Missing – coarse concrete aggregate is projecting from the surface and the damage has extended sufficiently that individual pieces of aggregate have been removed.
	RV	Reinforcement Visible[4] – Steel reinforcement is visible with little or no corrosion evident
	RC	Reinforcement Corrosion – The concrete cover to the steel reinforcement has been removed due to corrosion/erosion/spalling/other and the reinforcement steel is corroded and may have extended sufficiently that the steel has been removed[4].

HDF *(cont)*	RVP	Steel Reinforcement is visible and projecting into the manhole3
	WS	Wall Staining – staining/discoloration of the manhole wall2
	CP	Corrosion Products from the corrosion or chemical attack are visible as a build-up on the wall surface
	H	Holed – damage has extended right through the wall in localised areas
	MD	Mechanical Damage – surface of the wall has been damaged by equipment e.g. cleaning equipment (jetters, root cutters) or other equipment.
	Quantification[1] – The extent of the pipe circumference with surface damage evident. (*Method 3*). Record using additional code to describe the observations as follows:	
	S	Small, damage covering up to 10% of the manhole circumference / perimeter
	M	Medium, damage covering between 10% to 25% of the manhole circumference / perimeter
	L	Large, damage covering greater than 25% of the pipe circumference / perimeter

Circumferential location: Record the extent of the surface damage as a pair of clock references.

Continuous Defect: Where the length (vertically) of surface damage exceeds 1 metre, the defect shall be recorded as a Continuous Defect[5]

Descriptive Location: Additional code to describe the location of the defect as follows:

TH	Throat/Access
LI	Lid
T	Taper
CH	Chamber

Notes:
1. Not required when W, S and PM characterisation codes are used.
2. Wall staining is often due to the corrosion of the underlying steel reinforcement. Staining may also be due to non-corrosion related influences such as staining by agents within the storm water or wastewater flow or groundwater infiltration. WS should only be used for corrosion related activity.
3. This may also occur in the manufacture of concrete manhole if the reinforcement is unintentionally placed/displaced in the wrong position or insufficient concrete cover is placed.
4. If reinforcement is completely corroded away, this shall be noted in the remarks field.
5. Surface Damage must be truly continuous for greater than one metre.

Example:

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
18.54	S1	HS	AP		12	12	CH
Remarks: Corrosion of chamber wall – aggregate protruding							
19.29	*F1*	*HS*	*AP*		*12*	*12*	*CH*

MW1.9 – Protective Lining Defective

Code	Description	
HPL	Protective Lining Defective. The lining of a manhole is defective. This relates to liners installed within a manhole for protection, sealing or rehabilitation.	
	Additional Information	
	Characterisation – additional code to describe the nature of the defect:	
	WL	Wrinkling - Vertical
	WC	Wrinkling - Circumferential
	W	Wrinkling – multiple patterns
	B	The lining is blistered
	BU	The liner is Bulged or deformed
	D	Detached – The lining has become detached from the host pipe wall
	C[2]	Discoloration – the lining material has localized staining or discoloured pigmentation
	WD[3]	Weld Defective – A weld in the lining is defective
	L[4]	Leak – Water is observed seeping or leaking through or from behind the liner wall
	H	Holes or perforations are evident in the liner
	RC	Re-establishment of Connection done improperly
	RM	Rendered Mortar Missing
	Z	Other – provide description in the Remarks
	Quantification[1] – Percentage reduction in the pipe diameter (*Method 2*). Record using additional code to describe the observations as follows:	
	S	Small, reduction in pipe diameter of up to 10%
	M	Medium, reduction in diameter between 10% and 25%
	L	Large, reduction in diameter greater than 25%
Circumferential location: Record the extent of the surface damage as a pair of clock references		
Continuous Defect: Where the length (vertically) of defective portion of liner exceeds 1 metre, the defect shall be recorded as a Continuous Defect[5]		
Descriptive Location: Additional code to describe the location of the defect as follows:		
	TH	Throat/Access
	T	Taper
	CH	Chamber

Notes:

1. Quantification only applies when WV, WC, W and BU Characterisation code is used.
2. Not used when staining/discoloration is from agents within the stormwater or wastewater flow, or lubricants or resins used in the lining. Reason for the staining is noted in the remarks field.
3. Not used for defect joint welds in PVC, PE or Steel pipes.
4. Only used when no holes (H) are evident.
5. Defective Protective Lining must be truly continuous for greater than one metre.

Example:

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
X		HPL	RM		CH	7	11

Remarks: Rendered mortar has bulged and some of the mortar is missing.

MW1.10 – Point Repair

Code	Description	
HPR	Point Repair – A small section of the manhole has been repaired with an injected sealing material or other sealing method.	
	Additional Information	
	Characterisation[1] – additional codes to describe the type of repair:	
	I	Injected Mortar/Sealant
	Z	Other
	Quantification – No additional quantification required.	
	S	Small, reduction in pipe diameter of up to 10%
	M	Medium, reduction in diameter between 10% and 25%
	L	Large, reduction in diameter greater than 25%
Circumferential location: Where the repair affects only a portion of the circumference / perimeter, record the location or extent of the repair as one or two clock references.		
Continuous Feature: Not Applicable		
Descriptive Location: Not Applicable		

Notes:
1. Provide a description of the repair in the Remarks field.

MW1.11 – Soil Visible through Defect

Code	Description	
HSV	Soil Visible[1,2] – the soil or trench material outside the manhole is visible through a defect.	
	Additional Information	
	Characterisation – There are no Characterisation codes for this defect.	
	Quantification – No additional quantification required.	
Circumferential location: No clock references are required.		
Continuous Defect: Where the vertical length of visible soil, through a defect exceeds 1 metre the soil visible shall be recorded as a Continuous Defect[3]		
Descriptive Location: Additional code to describe the location of the defect as follows:		
	TH	Throat/Access
	LI	Lid
	T	Taper
	CH	Chamber
	B	Benching
	C	Channel

Notes:
1. Where a Tomo, (cavity/void) is visible the defect code HTM should be used instead of this code, even if some soil is still visible.
2. Where more than one defect through which soil is visible occurring within one metre, they are entered as one entry.
3. Either a single defect or where multiple defects spaced less than a metre apart.

MW1.12 – Tomo

Code	Description
HTM	Tomo – a cavity or void outside the manhole is visible through a defect[1]
	Additional Information
	Characterisation – There are no Characterisation codes for this defect.
	Quantification – No additional quantification required.

Circumferential location: No clock references are required as these are described by the defect through which the Tomo can be seen.

Continuous Defect: Where the longitudinal length of the Tomo, through a defect exceeds 1 metre the Tomo shall be recorded as a Continuous Defect[2]

Descriptive Location: Additional code to describe the location of the defect as follows:

TH	Throat/Access
LI	Lid
T	Taper
CH	Chamber
B	Benching
C	Channel

Notes:

1. Where more than one defect through which Tomo is visible occurring within one metre, they are entered as one entry.
2. Either a single defect or where multiple defects spaced less than a metre apart.

MW1.13 – Manhole Chamber Collapsed

Code	Description
HCX	Manhole Chamber Collapsed – full structural failure of the manhole. The fabric of the manhole structure has wholly or partly fallen into the chamber so that the channel, benching and pipework at the base of the structure is not visible or accessible.
	Additional Information
	Characterisation – There are no Characterisation codes for this defect.
	Quantification – No additional quantification required.

Circumferential location: No clock references are required.

Continuous Defect: Not Applicable

Descriptive Location: Not Required

MW1.14 – Dimension Change

Code	Description
HDC	Dimension Change[1,3] – changes in diameter/dimensions of the manhole during the inspection. Can also be used for changes in shape.
	Additional Information
	Characterisation – There are no Characterisation codes for this defect.
	Quantification – No additional quantification required.

Circumferential location: No clock references are required.

Continuous Defect: Not Applicable[2]

Descriptive Location: Additional code to describe the location of the defect as follows:

TH	Throat/Access
CH	Chamber

Notes:
1. Record the previous and new dimensions in the Remarks field.
2. Dimension change is coded as an individual feature and is not covered under a continuous feature.
3. Applies when the change in dimensions occurs within the same manhole component, and not at the change between components i.e. Throat/Access to Chamber.

MW1.15 – Chamber Segment Length Change

Code	Description
HCC	Chamber Segment Length Change[1] – the joint spacing of the pre-cast Chamber Segments has changed. The new joint spacing length is recorded in the Remarks field.
	Additional Information
	Characterisation – There are no Characterisation codes for this defect.
	Quantification – No additional quantification required.

Circumferential location: No clock references are required.

Continuous Defect: Not Applicable

Descriptive Location: Not Required

Notes:
1. This code is used where the joint spacing length has changed without the material (or lining) changing.

MW1.16 – Material Change

Code	Description
HMC	Material Change[1] – The manhole material has changed. A description of the previous and new manhole materials is noted in the Remarks field.
	Additional Information
	Characterisation – There are no Characterisation codes for this defect.
	Quantification – No additional quantification required.

Circumferential location: No clock references are required.

Continuous Feature: Where the length (vertically) of the material change exceeds 1 metre, the MC shall be recorded as a Continuous Feature.

Descriptive Location: Additional code to describe the location of the defect as follows:

TH	Throat/Access
CH	Chamber

Notes:
1. Applies when a change in material occurs within the same component and not at the change between components.

MM2 –Masonry Codes

MM2.1 – Missing Mortar

Code	Description	
HMM	Missing Mortar[1,2] – All or part of the mortar from between the masonry units (typically bricks) are missing.	
	Additional Information	
	Characterisation – There are no Characterisation codes for this defect	
	Quantification – Extent of the manhole circumference / perimeter where the mortar is missing (*Method 3*). Record using additional code to describe the observations as follows:	
	S	Small, mortar missing up to 10% of the manhole circumference / perimeter
	M	Medium, mortar missing between 10% and 25% of the manhole circumference / perimeter
	L	Large, mortar missing from 25% or greater of the manhole circumference /perimeter

Circumferential location: Where only one or a few masonry units are affected, record the location as a single clock entry. Where the extent of the missing masonry units is more extensive, use a pair of clock references to describe the location.

Continuous Defect: Where the length (vertically) of separation exceeds 1 metre, the defect shall be recorded as a Continuous Defect[3]

Descriptive Location: Additional code to describe the location of the defect as follows:

TH	Throat/Access
T	Taper
CH	Chamber

Notes:

1. Code does not refer to missing mortar render. Where this occurs the defect code HRM should be used.
2. Where infiltration (HIP), root intrusion (HRI) or exfiltration (HEX) is apparent through the mortar course, this is evidence of mortar loss and this code should be used. The HIP, HRI or HEX is coded in separately and in addition to this code.
3. Missing Mortar must be truly continuous for more than one metre.

MM2.2 – Masonry Unit Separation

Code	Description	
HMM	Masonry Unit Separation[1,2,3] – the regularity of the original bond pattern has been disturbed with masonry courses separating along mortar joints.	
	Additional Information	
	Characterisation – There are no Characterisation codes for this defect	
	Quantification – The width of the gap separation (*Outlier Method 2*). Record using additional code to describe the observations as follows:	
	S	Small, gap separation width 20mm
	M	Medium, gap separation width between 21mm and 50mm
	L	Large, gap separation greater than 50mm

Circumferential location: Record the extent of the separation as a pair of clock references.

Continuous Defect: Where the length of pipe with separation exceeds 1 metre, the defect shall be recorded as a Continuous Defect[3]

Descriptive Location: Additional code to describe the location of the defect as follows:

TH	Throat/Access
T	Taper
CH	Chamber

Notes:

1. Code applies when there is a minimum separation of 2x standard mortar joint width (or 20mm)
2. Cracking of masonry units where present shall be coded separately and in addition using defect codes HCV or HCH
3. Defect must be truly continuous for greater than one metre.

MM2.3 – Displaced Masonry Unit

Code	Description	
HDMU	Displaced Masonry Unit. One or more masonry units moved from their original position (but not fallen out).	
	Additional Information	
	Characterisation – additional code to describing the direction of movement:	
	I	Moved Inwards
	O	Moved Outwards
	Quantification – Extent of the pipe circumference where the masonry units are observed as displaced. Record using additional code to describe the observations as follows:	
	S	Small, displaced masonry units are up to 10% of the circumference / perimeter
	M	Medium, displaced masonry units are between 10% and 25% of the circumference / perimeter
	L	Large, displaced masonry units are greater than 25% of the circumference / perimeter
Circumferential location: Where only one or a few masonry units are displaced, record the location as a single clock entry. Where the extent of the displaced masonry units is more extensive, use a pair of clock references to describe the location.		
Continuous Defect: Where the length (vertically) of displaced masonry exceeds 1 metre, the defect shall be recorded as a Continuous Defect[1]		
Descriptive Location: Additional code to describe the location of the defect as follows:		
	TH	Throat/Access
	T	Taper
	CH	Chamber

Notes:
1. Defect must be truly continuous for greater than one metre.

MM2.4 – Missing Masonry Unit

Code	Description	
HMMU	Missing Masonry Unit. One or more masonry units (usually brick) are missing i.e. have fallen out.	
	Additional Information	
	Characterisation – additional code to describing the extent of further brick layers:	
	V	Another layer of masonry is visible through the hole left by the missing masonry unit(s)
	NV	No more masonry units are visible through the hole left by the missing masonry unit(s)1
	Quantification – Extent of the pipe circumference where the missing masonry units are observed. Record using additional code to describe the observations as follows:	
	S	Small, missing masonry units are up to 10% of the circumference / perimeter
	M	Medium, missing masonry units are between 10% and 25% of the circumference / perimeter
	L	Large, missing masonry units are greater than 25% of the circumference / perimeter
Circumferential location: Where only one or a few masonry units are missing, record the location as a single clock entry. Where the extent of the missing masonry units is more extensive, use a pair of clock references to describe the location.		
Continuous Defect: Where the length (vertically) of missing masonry exceeds 1 metre, the defect shall be recorded as a Continuous Defect[2]		
Descriptive Location: Additional code to describe the location of the defect as follows:		
	TH	Throat/Access
	T	Taper
	CH	Chamber

Notes:
1. Soil or earth visible shall be coded separately and in addition using the defect code HSV. HTM should be used if a Tomo (cavity/void) is visible.
2. Defect must be truly continuous for greater than one metre.

MM2.5 – Masonry Manhole Collapsed

Code	Description
HMX	Masonry Manhole Collapsed[1] – full structural failure and the masonry manhole. The fabric of the manhole structure has wholly or partly fallen into the chamber so that the channel, benching and pipework at the base of the structure is not visible or accessible.
	Additional Information
	Characterisation – There are no Characterisation codes for this defect.
	Quantification – No additional quantification required.

Circumferential location: No clock references are required.

Continuous Defect: Not Applicable

Descriptive Location: Not Required

MJ3 –Manhole Joint Codes

MJ3.1 – Chamber Joint Faulty Seal

Code	Description	
HJFX	Chamber Joint Faulty Seal[1,2,3,4] The sealing of pre-cast chamber or throat/access segments joints are defective.	
	Additional Information	
	Characterisation – There are no Characterisation codes for this defect.	
	Quantification – Evidence of a pathway through the joint (*Method 1*). Record using additional code to describe the observations as follows:	
	S	Small, there is damage visible but there is no pathway through the joint
	M	Medium, there may be a pathway through the joints or the cracks may extend all the way through the manhole wall.
	L	Large, there is clear visual evidence that there is a pathway through the joints or the cracks extend all the way through the manhole wall2

Circumferential location: Record the extent of the defective joint seal as a pair of clock references.

Continuous Defect: Not Applicable[5]

Descriptive Location: Additional code to describe the location of the defect as follows:

TH	Throat/Access
T	Taper
CH	Chamber

Notes:

1. Code covers pre-cast chamber or throat joint sealing defects only (e.g. there is evidence that the joint sealing is faulty such as infiltration present, roots, encrustation deposits etc, or there is evidence to suggest that the sealing maybe faulty.
2. Cracking or structural damage at the joint is coded separately, recorded under the relevant condition code, there is no ‘joint zone’ applicable.
3. Describe the evidence for the Large severity band in the remarks.
4. Where the joint is Open or Displaced these codes shall be recorded separately.
5. Faulty joints are coded as individual defects and cannot be recorded as a set of continuous defects, i.e. consecutive faulty joint seals with the same type of defect cannot be covered under a single continuous defect.

Example:

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
X		HJFX		L	CH	6	9
Remarks: Joint seal between Chamber and Lid is faulty with infiltration.							
X		*HIP*		*M*	*CH*	*6*	*9*
Remarks: *Running infiltration through joint ‘splashing’ on benching.*							

MJ3.2 – Chamber Joint Open

Code	Description	
HJO	Chamber Joint – Open. Pre-cast manhole chamber segments are displaced vertically[1,3,4].	
	Additional Information	
	Characterisation – additional code to identify rotation or angular displacement at the joint:	
	A	Angular displacement – the joint is open on one side causing the segment alignment to deflect.
	Quantification[2] – Width of the vertical displacement (e.g. the distance between the one segment and the adjacent segment, *Outlier Method 1*). Record using additional code to describe the observations as follows:	
	S	Small, vertical displacement up to 20mm
	M	Medium, vertical displacement between 20mm and 40mm
	L	Large, vertical displacement greater than 40mm

Circumferential location[2]**:** For Angular deflection, record the pair of clock references at the points at which the two chamber segments appear to intersect each other, in the clockwise direction of the open joint gap.

Continuous Defect: Not Applicable[5]

Descriptive Location: Additional code to describe the location of the defect as follows:

TH	Throat/Access
T	Taper
CH	Chamber

Notes:
1. Where the joint gap can be measured, the vertical displacement shall be recorded in the Remarks field.
2. No clock references are required if there is no angular defection through the joint.
3. Where Joint sealing defects or physical damage is present these defects shall be recorded, in addition, under the relevant condition code.
4. Where the joint is also horizontally displaced, defect code HJD shall also be used.
5. Open joints are coded as individual defects and cannot be recorded as a set of continuous defects, i.e. consecutive joints with that are open cannot be covered under a single continuous defect.

MJ3.3 – Chamber Joint Displaced

Code	Description	
HJD	Chamber Joint – Displaced. The pre-cast chamber segments have been horizontally displaced relative to each other.[1,2]	
	Additional Information	
	Characterisation – There are no Characterisation codes for this defect.	
	A	Angular displacement – the joint is open on one side causing the segment alignment to deflect.
	Quantification – Percentage reduction in the manhole diameter[3] (*Method 2*). Record using additional code to describe the observations as follows:	
	S	Small, displacement has resulted in a reduction of the manhole diameter up to 10%
	M	Medium, displacement has resulted in a reduction of the manhole diameter between to 10% and 25%
	L	Large, displacement has resulted in a reduction of the manhole diameter greater than 25%

Circumferential location: Record the pair of clock references at the points at which the two chamber segments appear to intersect each other, in the clockwise direction of the exposed joint face.

Continuous Defect: Not Applicable[5]

Descriptive Location: Additional code to describe the location of the defect as follows:

TH	Throat/Access
T	Taper
CH	Chamber

Notes:
1. Where Joint sealing defects or physical damage is present these defects shall be recorded, in addition, under the relevant condition code.
2. Where the joint is also 'open' the defect code HJO shall also be used.
3. Measurement of the reduction in diameter is based on the smallest diameter dimension as a result of the displacement.
4. Displaced joints are coded as individual defects and cannot be recorded as a set of continuous defects, i.e. consecutive joints with that are displaced cannot be covered under a single continuous defect.

ML4 –Lateral (connecting pipe) Codes

ML4.1 – Lateral

Code	Description	
HL	Lateral connecting pipe[1] – A lateral pipe connects to the manhole structure.	
	Additional Information	
	Characterisation – additional codes to describe the type of lateral connection:	
	ID	Internal Drop Structure
	ED	External Drop Structure
	CD	Cascading Drop
	PD	Protruding Drop
	CB	Channel in Benching
	UB	Under benching
	AC	Across benching
	VP	Ventilation Pipe
	B2	Blank
	Quantification – No additional quantification required[3]	

Circumferential location: Record the position of the lateral connection as a single of clock reference for the center of the lateral pipe.

Continuous Defect: Not Applicable

Descriptive Location: Not Required

Notes:
1. Code is always used if there is a lateral connecting pipe, regardless if there are defects present.
2. The cap is sealed with no defects. If the cap is leaking or is displaced/cracked or broken the code HLF is used.
3. Describe in the remarks the estimate diameter of the lateral connecting pipe.

Example:
Lateral connecting pipe – Under Benching

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
1.02		HL	UB		3		
Remarks: 100mm Connecting under benching.							
0.2		*HS*	*AP*		*12*	*12*	*CH*
Remarks: *Down to channel.*							
1.3		*HL*	*CB*		*12*		
Remarks: *300mm Outlet.*							

Note: appears that HS AP is also present in the throat or lid.

ML4.2 – Connecting Lateral Pipe Sealing Faulty

Code	Description	
HLF	Connecting Lateral Pipe Sealing Faulty[1,2,5] Joint sealing defects or physical damage to pipe connections to the manhole. Physical damage relates specifically to occurrences up to the first joint (or 0.5m from internal manhole wall, whichever comes first) inside the pipe and a 50mm area of manhole wall around the pipe connection, referred to as the 'lateral Connection Zone'[1]	
	Additional Information	
	Characterisation – additional code to describe type of sealing or physical damage associated with the lateral connection:	
	C	Cracks (Circumferential/Longitudinal/Multiple) inside the pipe or in the manhole wall within the lateral connection zone.
	B	Broken pipe – blocks or pieces of lateral pipe, including those made with cracks in manhole wall within the lateral connection zone.
	D	Damaged lateral pipe/joint – such as chipping of the first joint inside the pipe.
	X	Seal – the sealing of the pipe connection is faulty, excluding as a result of C, B and D, but could be due to evidence relating to breaching of the joint seal due to the opening or displacement of the first joint or poor/ missing sealing
	Quantification – Evidence of a pathway through the joints or pipe wall (*Method 1*). Record using additional code to describe the observations as follows:	
	S	Small, there is damage visible but there is no pathway through the joints or the cracks do not extend all the way through the manhole wall
	M	Medium, there may be a pathway through the joints or the cracks may extend all the way through the manhole wall.
	L	Large, there is clear visual evidence that there is a pathway through the joints or the cracks extend all the way through the manhole wall3

Circumferential location: Record the position of the lateral connection as a single of clock reference for the center of the connecting pipe.

Continuous Defect: Not Applicable[6]

Descriptive Location: Not Required

Notes:
1. Lateral Connection sealing faults are coded in addition to code HL.
2. If the cracking or damage extends beyond the lateral connection zone, it is not considered to be a connection fault and should be recorded under the relevant condition code.
3. Describe the evidence for the Large severity band in the remarks.
4. If there are defects visible inside the lateral beyond the first joint, the defect code HLX shall be recorded separately.
5. Does not cover defective drop pipes. Defective drop pipes are coded using HDP.
6. Faulty pipe connections are coded as individual defects and cannot be recorded as a set of continuous defects, i.e. consecutive faulty laterals with the same type of defect cannot be covered under a single continuous defect.

Example:

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
0.88		*HL*	*ID*		*8*		
Remarks: *100mm Internal Drop.*							
0.88		HLF	X		8		
Remarks: No internal seal around connection – possible pathway to the outside.							

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
1.4		*HL*	*ID*		*8*		
Remarks: *100mm Internal Drop – outlet obstructing channel*							
0.88		HLF	X		8		
Remarks: No internal seal around connection No evidence of a pathway							
1.9		*HDE*		*S*	*7*	*9*	*B*
Remarks: *Soil deposits on benching.*							
2.15		*HL*	*CB*		*6*		
Remarks: *100mm*							
2.15		*HO*	*P*	*L*			
Remarks: *Dropper outlet obstruction the channel.*							
2.15		*HDE*		*L*			*C*
Remarks: *Paper buildup due to obstructing dropper outlet.*							

ML4.3 – Lateral Connecting Pipe is Defective

Code	Description	
HLX	Lateral connecting pipe is defective[2,3] There are defects visible in the connecting pipe, beyond the first joint or 0.5m inside the lateral pipe, whichever comes first.	
	Additional Information	
	Characterisation – additional codes to describe type of defect visible inside the lateral pipe.	
	B	Blocked lateral – the lateral pipe appears to be blocked
	C	Branch Cracked – Circumferential/Longitudinal/Multiple cracks visible inside the lateral
	D	Displaced – Joints inside the lateral are displaced
	R	Some Roots – Roots seen inside the lateral
	SE	Soil Entering – Soil or deposits from outside of the lateral can be seen in the lateral pipe
	Quantification[1] – No additional quantification required.	
	S	Small, there is damage visible but there is no pathway through the joints or the cracks do not extend all the way through the manhole wall
	M	Medium, there may be a pathway through the joints or the cracks may extend all the way through the manhole wall.
	L	Large, there is clear visual evidence that there is a pathway through the joints or the cracks extend all the way through the manhole wall[3]

Circumferential location: Record the position of the lateral connection as a single o'clock reference for the center of the lateral pipe.

Continuous Defect: Not Applicable.

Descriptive Location: Not Required.

Notes:

1. Provide a description of the defects seen in the remarks.
2. Defective lateral connecting pipes are coded in addition to code HL. If the connecting pipe has a faulty lateral seal or physical damage within the lateral connection zone the defect code HLF shall be recorded separately.
3. Roots that are growing down the lateral and entering the inspected manhole shall be recorded separately using the defect code HRI.

ML4.4 – Defective Drop Pipe

Code	Description	
HDP	Defective Drop Pipe. An internal or external drop pipe is defective[1]	
	Additional Information	
	Characterisation – additional codes to describe type of nature of the defect.	
	B	The Drop Pipe is Blocked
	C	The Drop Pipe is Cracked
	D	The Drop Pipe is Deformed
	M	The drop pipe is missing or has been dislodged, separated and/or disconnected so that flow is not being directed to the channel in the base of the structure
	T	The outlet of the drop pipe is not correctly positioned so that flow is misdirected or is causing unnecessary turbulence and/or splashing
	Z	Other
	Quantification – No additional quantification required.	
	S	Small, there is damage visible but there is no pathway through the joints or the cracks do not extend all the way through the manhole wall
	M	Medium, there may be a pathway through the joints or the cracks may extend all the way through the manhole wall.
	L	Large, there is clear visual evidence that there is a pathway through the joints or the cracks extend all the way through the manhole wall3

Circumferential location: Record the position of the lateral connection as a single of clock reference for the center of the lateral pipe.

Continuous Defect: Not Applicable.

Descriptive Location: Not Required.

Notes:
1. Defective drop pipes are coded in addition to code HL.

Example:
Drop Pipe is Cracked

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
1.02		HL	ID		9		
Remarks: 150mm Internal Drop.							
1.02		HDP	C		9		
Remarks: Top of the Dropper (inspection) is cracked and broken.							
1.1		*HL*	*ID*		*6*		
Remarks: *150mm.*							

MCF5 – Cover and Frame

MCF5.1 – Defective cover and/or Frame

Code	Description	
HFR	Defective cover and/or frame[1]	
	Additional Information	
	Characterisation – additional codes to describe type of nature of the defect:	
	CB	Cover cracked or Broken
	CD	Cover Deformed[2]
	CM	Cover Missing
	CR	Cover Rocking
	FB	Frame cracked or Broken
	FL	Frame Loose
	FD	Frame Displaced
	FM	Frame Missing
	G	Gap or hole between the frame and Access/Throat, Lid or Chamber
	HD	Holding down bolts missing or defective
	Z	Other – provide description of defect in the remarks
	Quantification – No additional quantification required.	

Circumferential location: Not Required.

Continuous Defect: Not Applicable.

Descriptive Location: Not Required.

Notes:
1. Record as many entries as required to describe defects to the cover and or frame.
2. Covers plastic manhole covers or materials that can act in a plastic way.

Example:
Defective Cover and/or frame – Gap or hole between frame and Lid.

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
0.1		HFR	G				

Remarks: Frame sitting upon a brick with a gap between the frame and lid.

MCF5.2 – Devices Under Cover and Frame

Code	Description	
HUF	Devices Under Cover and Frame[1]	
	Additional Information	
	Characterisation – additional codes to describe type device:	
	AB	Access Barrier
	SD	Sensing Device
	ST	Sediment or Litter Trap
	Z	Other – provide description of defect in the remarks
	Quantification – No additional quantification required.	
Circumferential location: Not Required.		
Continuous Defect: Not Applicable.		
Descriptive Location: Not Required.		

Notes:
1. Record as many entries as required to describe devices that may be present under the cover and frame.

Example:
Device Cover and frame – Access Barrier

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
0.1		HUF	AB				

Remarks: Impact Safety Grille.

MCF5.3 – Defective Devices Under Cover and Frame

Code	Description	
HUX	Defective Device Under Cover and Frame[1]	
	Additional Information	
	Characterisation – additional codes to describe type of nature of the defect:	
	D[2]	Device is present but defective
	M	All or part of the device is missing with evidence that one was previously present
	U	Device is unlocked or disconnected
	Quantification – No additional quantification required.	
Circumferential location: Not Required.		
Continuous Defect: Not Applicable.		
Descriptive Location: Not Required.		

Notes:
1. Code is used in addition to HUF where required.
2. Describe the nature of the defect in the remarks.

MCF5.4 – Vent

Code	Description	
HVT	Vent is installed in the manhole.	
	Additional Information	
	Characterisation – There are no Characterisation codes for this defect.	
	D	Vent is structurally defective[2]
	SW	Surface Water can enter the manhole through the vent
	Quantification – No additional quantification required.	
Circumferential location: Record the position of the vent as a single or pair of clock reference.		
Continuous Feature: Not Applicable.		
Descriptive Location: Additional code to describe the location of the defect as follows:		
	LI	Lid
	T	Taper
	CH	Chamber

Notes:

1. Record as many entries as required to describe defects that may be present.
2. Describe the nature of the defect in the remarks.

MR6 – Steps/rungs, platforms and landings

MR6.1 – Defective Step, Ladder or Staging Platform

Code	Description	
HSL	Defective Step, Ladder or Staging bar[1]	
	Additional Information	
	Characterisation – additional codes to describe type of nature of the defect:	
	ED	Plastics encapsulation of step or staging bar is damaged or broken
	HC	Ladder handrail is corroded
	LC	Ladder cracked.
	LCC[2]	Ladder support corroded (Ladder clip corroded)
HSL *(cont)*	LCL	Ladder support loose (Ladder clip loose)
	LCM	Ladder support missing (Ladder clip missing)
	LRM[3]	Ladder rung missing
	RC[2]	Ladder rung corroded
	SB	Step bent
	SC[2]	Step corroded
	SL	Step loose
	SM[3]	Step missing
	TH	Defective toe hole
	RG	Rags or other material caught or hanging on the steps or ladder
	Z	Other – provide description of defect in the remarks
	Quantification – No additional quantification required.	

Circumferential location: Record the location of the defective component with a single clock references.

Continuous Defect: Where the extent (vertical height) of ladders/steps is greater than 1m, they are coded as continuous defects.

Descriptive Location: Not Required.

Notes:
1. Where there is more than one type of defect present the highest-ranking defect is recorded (refer to Section D1.2, sub-clause D1.2.4.6 Encoding Defects within a Metre of Pipe – Hierarchy of defects).
2. Codes used where steel is corroded. If only surface rust is present, use Z Characterisation and note in the remarks.
3. Not coded if steps or ladder intentionally removed or not installed.

Examples:

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
0.6	S1	HSL	SC		9		
Remarks: Steps Significantly corroded.							
2.7	*F1*	*HSL*	*SC*		*9*		
3.1		*HDE*		*S*	*9*	*10*	*B*
Remarks: *Soil deposits on the benching.*							

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
15.3	S1	HSL	LRM		12		
Remarks: Ladder significantly corroded, and rungs are missing.							
15.3		*HS*			*12*	*12*	*CH*
Remarks: *Concrete Corrosion with aggregate missing.*							

MR6.2 – Safety bars or staging platform

Code	Description	
HSP	Safety bars or staging platform. Safety bars or staging platform is present.	
	Additional Information	
	Characterisation[1] – additional codes are used when the safety bars or staging platform is defective to describe type of nature of the defect.	
	BB	One or more safety bars bent or broken
	BC	One or more safety bars corroded
	BL	One or more safety bar/platform fixings is loose or broken
	BM	One or more safety bars missing with evidence that they previously existed
	Z	Other – provide description of defect in the remarks
	Quantification – No additional quantification required.	

Circumferential location: Not Required.

Continuous Defect: Not Applicable.

Descriptive Location: Not Required.

Notes:
1. When the staging platform is not defective, a characterisation code is not recorded.

Example:


Dist.	Cont.	Code	Char.	Quant.	Location	From	To	Remarks:
3.4		HSP	BL					Staging Platform – fixings appear to be defective
3.4		HED		S	7	9	CH	ED from leakage at Staging platform fixings
3.4		HIP		S	7	9	CH	Seepage – ED surface appears to be wet

MR6.3 – Tie Down Bolt

Code	Description	
HVT	Tie down bolt is present[1]	
	Additional Information	
	Characterisation – There are no Characterisation codes for this defect.	
	C	Tie down bolt/hook corroded
	B	Tie down bolt/hook bent
	M	Missing with evidence that they previously existed
	Z	Other – provide description of defect in the remarks
	Quantification – No additional quantification required.	
Circumferential location: Record the location of each tie down bolt with a single clock references.		
Continuous Feature: Not Applicable.		
Descriptive Location: Additional code to describe the location of the defect as follows:		
	LI	Lid
	T	Taper
	CH	Chamber

Notes:
1. Each Tie down bolt is recorded individually.
2. When the tie down bolt is not defective, a characterisation code is not recorded.

MB7 – Benchimg and Channel

MB7.1 – Defective Channel

Code	Description	
HCH	Defective Channel.	
	Additional Information	
	Characterisation – additional codes are used to describe type of nature of the defect:	
	X	Defective
	M	Missing with evidence that a channel previously existed
	D	Channel dipped/ponding
	Quantification[1,2,3,4,5] – Maximum depth of flow in the dip relative to the pipe diameter (*Outlier Method 3*). Record using additional code to describe the observations as follows:	
	S	Small, maximum flow depth up to 25% of the pipe diameter
	M	Medium, maximum flow depth between 25% and 50% of the pipe diameter
	L	Large, maximum flow depth greater than 50% of the pipe diameter
Circumferential location: Not required.		
Continuous Defect: Not Applicable.		
Descriptive Location: Not Required.		

Notes:
1. Quantification is only used when the 'D' Characterisation code is used.
2. Used where the flow through the manhole is ponding within the manhole channel. The 'D' Characterisation code is not used where the water level in the channel is high due to quantity of flow or obstruction/other issue downstream of the manhole.
3. If rise in water level is due to issues downstream, then the feature code HWL shall be used.
4. The assessment of the maximum flow depth shall include the deduction of the 'normal' flow depth.
5. If 'D' Characterisation code is not used, then describe the type and nature of the defect in the remarks.

MB7.2 – Defective Benching

Code	Description	
HBN	Defective Benching.	
	Additional Information	
	Characterisation – additional codes are used to describe type of nature of the defect:	
	X	Defective1
	M	Missing with evidence that benching previously existed
	N	No benching
	Quantification – No additional quantification required.	

Circumferential location: Not required.

Continuous Defect: Not Applicable.

Descriptive Location: Not Required.

Notes:
1. Describe the type and nature of the defect in the remarks.

Example:

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
X		HBN	N				
Remarks: No benching in the manhole.							
X		HDE		S	C		
Remarks: Silt, stones in the base of the manhole.							

MB7.3 – Flow Control

Code	Description	
HFC	Flow Control Device Present[1]	
	Additional Information	
	Characterisation – additional codes are used to describe type of flow control device:	
	FL	Float operated valve
	FV	Flap valve
	G	Sewer Gauging Station
	MF	Measuring flume e.g. venturi
	OP	Orifice plate
	P	Penstock, gate stop, valve etc.
	SS	Special structure e.g. flap gate or other controls in a purpose-built structure
	TR	Trash rack, screens,
	V	Vortex flow control
	W	Weir
	Z	Other – describe the type of flow control device in the remarks
	Quantification – No additional quantification required.	

Circumferential location: Not required.

Continuous Defect: Not Applicable.

Descriptive Location: Not Required.

Notes:
1. If the flow control device is defective, this should be described in the remarks.

MS8 – Service Related Codes

MS8.1 – Debris Silty

Code	Description	
HDE	Debris Silty[1,2] – refers to silt, sand, mud, gravel or other deposits in the manhole.	
	Additional Information	
	Characterisation – There are no Characterisation codes for this defect.	
	Quantification – Reduction in the diameter of the channel because of the deposits (*Method 2*), or depth of debris on the benching (*Outlier Method 7*). Record using additional code to describe the observations as follows:	
	S	Small, reduction of up to 10% of the channel diameter or, up to 10mm on benching
	M	Medium, reduction between 10% and 25% of the channel diameter or, 10mm to 50mm on benching
	L	Large, reduction of greater than 25% of the channel diameter or, >50mm on benching
Circumferential location: No clock references are required.		
Continuous Defect: Not Applicable.		
Descriptive Location: Additional code to describe the location of the defect as follows:		
	B	Benching
	C	Channel

Notes:

1. The type of deposits and source of the debris (i.e. deposits from the flow, or soil from outside the manhole) should be noted in the remarks.
2. Where the reduction is diameter is >50%, the defect shall be coded using the defect code HB, Blocked.

Example:

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
2.23		HDE		M			C
Remarks: Paper buildup from 100mm lateral and other debris in channel from blank lateral.							
0.7	*S1*	*HSL*	*SC*		*8*		
Remarks: *Step rungs has slight corrosion.*							
2.25		*HL*	*CB*		*12*		
Remarks: *150mm outlet.*							
2.21		*HL*	*CB*		*4*		
Remarks: *100mm paper debris in channel.*							
2.22		*HL*	*CB*		*6*		
Remarks: *100mm.*							
1.9	*F1*	*HSL*	*SC*		*8*		
Remarks: *End of steps partially in buried in benching slight corrosion.*							
1.9		*HL*	*CB*		*9*		
Remarks: *150mm.*							
2.22		*HL*	*B*		*10*		
Remarks: *100mm blank connection – debris in the channel.*							

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
X		HDE		L	B		
Remarks: Thick layer of debris on the benching.							
Y		*HDE*		*S*	*C*		
Remarks: *Thin layer of silt in the channel.*							

MS4.2 – Debris Greasy

Code	Description	
HDG	Debris Greasy[1,3] – refers to fat, scale and all adhering material, except encrustation deposits.	
	Additional Information	
	Characterisation – There are no Characterisation codes for this defect.	
	Quantification – Reduction in the diameter / width of the manhole component and or channel because of the greasy deposits (*Method 2*)[2]. Record using additional code to describe the observations as follows:	
	S	Small, reduction of up to 10% of the channel diameter
	M	Medium, reduction between 10% and 25% of the channel diameter
	L	Large, reduction of greater than 25% of the channel diameter

Circumferential location[4]**:** Record the location of the greasy deposits on the manhole wall or benching with a pair of clock references.

Continuous Defect: Where the length (vertically) of manhole with greasy deposits exceeds 1 metre, the defect shall be recorded as a Continuous Defect[5]

Descriptive Location: Additional code to describe the location of the defect as follows:

TH	Throat/Access
LI	Lid
T	Taper
CH	Chamber
B2	Benching
C	Channel

Notes:

1. Do not use where the deposits are corrosion products from the corrosion or chemical attack of concrete. Where this occurs the surface damage defect code HSCP should be used.
2. Quantification is based on Outlier Method 7 where the fat is located on the benching.
3. Where the reduction of diameter is >50% in the channel, the defect shall be coded using the defect code B, Blocked.
4. Where deposits are in the channel, circumferential location is not required.
5. Either truly continuous or where fat deposits are interspersed spaced less than a metre apart.

Example:

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
2.6		HDG		M			C
Remarks: Fat build in channel.							
2.5		*HDE*		*S*	*8*	*11*	*B*
Remarks: *Soil deposits on the benching.*							
2.6		*HL*	*CB*		*12*		
Remarks: *150mm outlet.*							
2.5		*HL*	*CB*		*4*		
Remarks: *100mm.*							
1.8		*HL*	*ID*		*6*		
Remarks: *100mm – discharges under benching – slightly obstructing in the channel.*							
2.6		*HO*	*P*	*S*	*6*		
Remarks: *Outlet of dropper obstructing flow.*							
2.54		*HL*	*CB*		*8*		
Remarks: *100mm.*							

MS4.3 – Encrustation Deposits

Code	Description	
HED	Encrustation Deposits[1] – deposits left by the partial evaporation of infiltrating ground water containing dissolved salts/ minerals. Can be very a thin layer but may build up to thicker deposits on the manhole wall over time.	
	Additional Information	
	Characterisation – There are no Characterisation codes for this defect.	
	Quantification – Reduction in the diameter / width of the manhole and or channel because of the deposits (Method 2)[2]. Record using additional code to describe the observations as follows:	
	S	Small, reduction of up to 10% of the manhole diameter / width
	M	Medium, reduction between 10% and 25% of the manhole diameter / width
	L	Large, reduction of greater than 25% of the manhole diameter / width
Circumferential location[3]**:** Record the location of the deposits on the manhole wall or benching with a pair of clock references.		
Continuous Defect: Where the length of pipe with encrustation deposits exceeds 1 metre, the defect shall be recorded as a Continuous Defect[4]		
Descriptive Location: Additional code to describe the location of the defect as follows:		
	TH	Throat/Access
	LI	Lid
	T	Taper
	CH	Chamber
	B2	Benching
	C	Channel

Notes:

1. Where the reduction is diameter is >50% in the channel, the defect shall be coded using the defect code HB, Blocked.
2. Quantification is based on Outlier Method 7 where the fat is located on the benching.
3. Where deposits are in the channel, circumferential location is not required.
4. Either truly continuous or where encrustation deposits are interspersed spaced less than a metre apart.

MS4.4 – Root Intrusion

Code	Description	
HRI	Root Intrusion[1] – tree roots entering the manhole through a wall defect. The growth of the roots inside the manhole can have the effect of obstructing/restricting the flow in the channel. Root growth elsewhere in the manhole does not affect the serviceability of the manhole, unless roots grow down into the channel.	
	Additional Information	
	Characterisation – additional codes to describe type of root growth as follows:	
	F	Fine Roots – a relatively small number of flexible minor roots
	M	A mass of mostly fine roots, which has developed into an interwoven clump
	T	Tap roots – a small number of major roots (10mm or greater) without a significant mass of fine roots
	RB	Recently cut interwoven mass of mostly fine roots leaving a beard of roots
	RF	Recently cut fine roots – a relatively small number of cut minor roots remain
	RT	Recently cut tap roots – a small number of cut major roots (10mm or greater) is evident
	Quantification – Reduction in the diameter of the manhole or channel by the roots (Method 2)[2]. Record using additional code to describe the observations as follows:	
	S	Small, reduction of up to 10% of the pipe diameter
	M	Medium, reduction between 10% and 25% of the pipe diameter
	L	Large, reduction between 25% and 50% of the pipe diameter
Circumferential location[3]**:** Where there is only a single root present, record the location as a single clock entry. Where the extent of the root intrusion/growth is more extensive, use a pair of clock references to describe the location.		

Continuous Defect: Where the length (depth) of manhole where roots are present exceeds 1 metre, the defect shall be recorded as a Continuous Defect[4]

Descriptive Location: Additional code to describe the location of the defect as follows:

TH	Throat/Access
LI	Lid
T	Taper
CH	Chamber
B2	Benching
C	Channel

Notes:

1. Where the effective reduction is diameter is >50%, the defect shall be coded using the defect code HB, Blocked. Consideration should be given to the effective reduction in the channel diameter, e.g. a "curtain" of fine roots extending over the full pipe diameter may be coded within the small severity band if the effective actual reduction in the diameter is less than 10% (where the curtain "flaps" out of the way of the flow.
2. Where the roots are located on the benching quantification is based on Outlier Method 7.
3. Where roots are in the channel, circumferential location is not required.
4. Either truly continuous or where roots are interspersed occurring within a metre apart for greater than 1m.

Example:

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
0.1		HRI	M	S	12	12	TH
Remarks: Mass of mostly fine roots.							
1.2		*HRI*	*M*	*S*	*12*	*12*	*CH*

MS5.5 – Obstruction

Code	Description	
HO	Obstruction in the Manhole – something (other than roots, silty deposits, greasy deposits) is obstructing the flow through the manhole Channel.	
	Additional Information	
	Characterisation – additional code to describing the permanence of the obstruction:	
	T	Temporary – obstruction is potentially removable and is not attached to or imbedded in the channel
	P	Permanent – obstruction is a fixed feature or external object projecting through the channel
	Quantification – Reduction in the diameter of the channel by the obstruction (*Method 2*). Record using additional code to describe the observations as follows:	
	S	Small, reduction of up to 10% of the channel diameter
	M	Medium, reduction between 10% and 25% of the channel diameter
	L	Large, reduction of greater than 25% of the channel diameter

Circumferential location: Where the obstruction is at one point, record the location as a single clock entry. Where the extent of the obstruction is more extensive, use a pair of clock references to describe the location.

Continuous Defect: Not Applicable.

Descriptive Location: Not Required.

Notes:

1. A description of the obstruction shall be noted in the remarks field.
2. Code does not apply to items such as a build-up of paper.
3. Where the length (vertically) of obstruction exceeds 1 metre, the HO shall be recorded as a "Continuous Defect".

MS5.6 – Blocked Channel

Code	Description	
HB	Blocked Channel – refers to where Roots, greasy deposits, silty deposits or other obstructions reduce the channel diameter by >50%[1]	
	Additional Information	
	Characterisation – additional codes to describe the nature of the blockage:	
	RI	Root blockage
	DE	Silt/sand/gravel blockage
	DG	Fat blockage
	Z	Other blockage[2]
	Quantification – No additional quantification required.	
Circumferential location: Record the location of the blockage as a pair of clock references as appropriate.		
Continuous Defect: Not Applicable.		
Descriptive Location: Not Required.		

Notes:
1. Where a blockage cannot be seen due to the water level or confirmed as a blockage by the investigation, this code should not be used.
2. Provide a description of the nature of the blockage in the remarks.

MS4.8 – Exfiltration

Code	Description
HEX	Exfiltration – There is a visible flow of water out of the manhole through a channel defect.
	Additional Information
	Characterisation – There are no Characterisation codes for this defect
	Quantification – No additional quantification required.
Circumferential location: Not required.	
Continuous Defect: Not Applicable.	
Descriptive Location: Not Required.	

MS5.9 – Infiltration Present

Code	Description	
HIP	Infiltration Present[1,2,3] – visible infiltration through a defect is occurring at the time of the inspection.	
	Additional Information	
	Characterisation – There are no Characterisation codes for this defect.	
	Quantification – the rate of visible occurring. Record using additional code to describe the observations as follows:	
	S	Small, seeping (wet) or dripping flow
	M	Medium, running (visibly moving) flow
	L	Large, gushing or jetting (pressure flow)
Circumferential location[4]: Record the point or extent of the defect that where the infiltration is observed as one or two clock references.		
Descriptive Location: Not Required.		

Notes:
1. Evidence of infiltration occurring previously (staining or encrustation deposits) without infiltration actively occurring does not qualify for this code.
2. Encrustation deposits at the source of active infiltration are coded separately and in addition to this code
3. Infiltration is coded as individual defects (separate infiltration sources occurring within 1m can be covered under a single entry) and cannot be recorded as a set of continuous defects, i.e. consecutive locations of infiltration cannot be covered under a single continuous defect.
4. Where infiltration is entering through a channel defect, circumferential location is not required.

MS8.9 – Water Level

Code	Description	
WL	Water Level – The presence and nature of the depth of water above the invert.	
	Additional Information	
	Characterisation – additional codes to describe the clarity of the water:	
	C	Clear water
	T	Turbid or discoloured water
	Quantification – No additional quantification required.	
Circumferential location: No clock references are required.		
Continuous Feature: Not Applicable.		
Descriptive Location: Not Required.		

MI9 – Inspection Information Codes

MI9.1 – Construction Feature

Code	Description
HCF	Construction Feature[1] – refers to features in the manhole that are either built into the manhole or are part of the manhole construction.
	Additional Information
	Characterisation – There are no Characterisation codes for this feature.
	Quantification – No additional quantification required.
Circumferential location: Record the location of the feature as a pair of clock reference as appropriate.	
Continuous Feature: Where the length (vertically) of construction feature exceeds 1 metre, the HCF shall be recorded as a Continuous Feature[2]	
Descriptive Location: Not Required.	

Notes:

1. Provide a description of the construction feature in the remarks field.
2. Features can be truly continuous or point features which repeat at regular intervals along a pipeline, in at least three out of four adjoining pipe segments.

MI9.2 – General Comment

Code	Description
HGC	General Comment[1] – This code is used to provide any relevant information that is not provided through specific defect or feature codes. A descriptive comment is provided in the Remarks field.
	Additional Information
	Characterisation – There are no Characterisation codes for this feature.
	Quantification – No additional quantification required.
Circumferential location: Where relevant, record the location of the feature as a single or pair of clock references.	
Continuous Feature: Where the length (vertically) of the feature exceeds 1 metre, the GC shall be recorded as a Continuous Feature[2]	
Descriptive Location: Not Required.	

Notes:

1. It should not be used where a specific defect or feature code is applicable.
2. Features can be truly continuous or point features which repeat at regular intervals along a pipeline, in at least three out of four adjoining pipe segments.

MI9.3 – Loss of Vision

Code	Description	
HLOV	Loss of Vision – the view in the manhole is obscured.	
	Additional Information	
	Characterisation[1] – additional codes to describe the reason for the vision loss:	
	UW	Under Water
	G	Grease on lens
	S	Steam or fog in the manhole
	EF	Equipment Failure
	Z	Other
	Quantification – No additional quantification required.	

Circumferential location: No clock references are required.

Continuous Feature: Where the vertical length of manhole where there is a loss of vision exceeds 1 metre, the HLOV shall be recorded as a Continuous Feature.

Descriptive Location: Not Required.

Notes:

1. Provide a description of the reason in the Remarks field.

MI9.4 – Inspection Starts

Code	Description
HIS	Inspection Starts – The first entry for all condition inspection reports.
	Additional Information
	Characterisation – there are no Characterisation codes for this feature.
	Quantification – No additional quantification required.

Circumferential location: No clock references are required.

Continuous Feature: Not Applicable.

Descriptive Location: Not Required.

MI9.5 – Inspection Ends

Code	Description
HIE	Inspection Ends – The final entry code for all inspection reports, unless an inspection is abandoned prior to reaching the end of the inspection, in which case the feature code IA is used. The description of the location of the camera where the inspection is ended is described in the Remarks field[1,2]
	Additional Information
	Characterisation – there are no Characterisation codes for this feature.
	Quantification – No additional quantification required.

Circumferential location: No clock references are required.

Continuous Feature: Not Applicable.

Descriptive Location: Not Required.

MI9.6 – Inspection Abandoned

Code	Description
HIA	Inspection Abandoned[1] – The final code for inspections that are abandoned prior to completing the inspection. The reason for the abandonment is noted in the Remarks field.
	Additional Information
	Characterisation – There are no Characterisation codes for this feature.
	Quantification – No additional quantification required.

Circumferential location: No clock references are required.

Continuous Feature: Not Applicable.

Descriptive Location: Not Required.

Notes:
1. If the abandonment is due to a defect, the defect(s) is recorded separately.

MI9.7 – Sealed Conduit Through Manhole

Code	Description	
HSC	Sealed Conduit Through Manhole[1]	
	Additional Information	
	Characterisation[1] – Record details of the access to the conduit using the following codes:	
	CM	Proper Access Provisions Exist but Covers are Missing
	CS	Access is Possible, but Covers are Sealed
	NA	There is No Access to the Conduit
	Quantification – No additional quantification required.	

Circumferential location: Record the location of the feature as a single or pair of clock references.

Continuous Defect: Not Applicable.

Descriptive Location: Not Required.

Notes:
1. Record the diameter of the conduit, and if possible, the type of service conduit in the remarks.

Example:

Dist.	Cont.	Code	Char.	Quant.	Location	From	To
0.8		HSC	NA		4	7	
Remarks: 100mm (Estimated).							
0.5		*HL*	*PD*		*6*		
Remarks: *100mm.*							
1.5		*HL*	*CB*		*6*		
Remarks: *150mm.*							

E1 Preliminary Condition Grading

'Preliminary Condition Grades' (1 – 5) express the structural and service condition of the inspected asset based upon the reported defect observations by a process called scoring analysis. This section sets out the process for the calculation of Preliminary Condition Grades.

Numerical values (0 – 165) have been assigned to each defect and quantification band as a weighted score. The scores are allocated for both service and structural defects. They are derived from New Zealand experience based on their likely effect on reducing life expectancy, or the possibility that they may lead to a loss of service. Generally, the higher the score the more severe the impact.

Structural and Service preliminary grades are determined by which range of scores the Peak Score falls within. Preliminary Condition Grades are an indicative measure of the likelihood of service or structural failure. Refer to Section E2 (sub-sections E2.3.and E2.4) for information on the use and interpretation of the Preliminary Condition Grades.

The scores that have been allocated to the various structural and service defects are given in the following tables:

Pipes

Manholes

The service scores in Table E1.5 have been provided as an alternative set of weighted scores that can be used for calculation of Stormwater Preliminary Condition Grades.

Defect codes typically only have either a Structural or Service score. However, in some instances, defect codes may have both a structural score and a service score. For example, a collapsed pipe is a structural failure of the pipe, but also results in the service failure of the pipeline. Hence it has both a structural score in Table E1.3 and a service score in Table E1.4 (and E1.5). Another reason is that in some circumstances the presence of a service defect, in combination with a structural defect, (e.g. a crack with a tap root intruding through it) could indicate that the structural defect may deteriorate more quickly than it may otherwise, and therefore a structural score for some service defects is appropriate. For these reasons, the provision for some defects to contribute to both the structural and service condition calculations, ensures for a more accurate preliminary grading.

E1.1 Scoring Analysis

The first step in the process is to calculate the three Key Condition Indicators for structural and service condition. These are: Total Score, Peak Score and Mean Score.

A Total Score

The Total Score is the sum of all the individual (point and continuous defect) scores assigned to the defects recorded in the inspection. Where more than one defect code has been recorded at the same longitudinal distance, a score for each defect will be applied and summed.

Where there are continuous defects the value of the score for that defect is dependent on the type of continuous defect (refer to Section B2.1 Coding Principles, sub-section B2.1.6.3H) as follows:

Per Metre continuity	the value of the continuous defect is the weighted score multiplied by the longitudinal length of the continuous defect. *e.g.: The value of a medium severity longitudinal crack (CLM) that extends for a length of 2.5m = 37.5 i.e. (2.5m @ 15 per m)*
Per Defect continuity	the value of the continuous defect is the value of the weighted score for the defect (regardless of the length of the continuous defect) *e.g.: The value of a small severity fat deposit (DGS) that extends for a length of 20m = 10 i.e. (1 defect @ 10)*

The Total Score reflects the magnitude and number of defects within the asset but does not include consideration of the length of the asset. A high Total Score on a short asset is potentially quite different to the same score on a much longer asset.

B Peak Score

The Peak Score reflects the value of the worst single defect or combination of defects within any one metre length of the asset.

The Peak Score is determined by methodically summing all of the scores for all defects within any one metre length of pipe, then assessing which one metre section(s) has the largest summed value. The largest value is the 'peak' score.

When summing all scores within any one metre of the pipe, scores from any continuous defects running into, or through the nominal metre are included. As this assessment is only considering a single metre of pipe at any particular time, the type of continuous defect does not affect the value of the score that it contributes. A continuous defect that starts, stops, or passes through, the metre being considered contributes towards the peak score a full metre value of a Per Metre continuity score or the full defect score for a Per Defect Continuity, (i.e. the value of the weighted score). Even if a continuous defect only extends from or into a portion of the one metre length being summed, it will never contribute less than value of the weighted score.

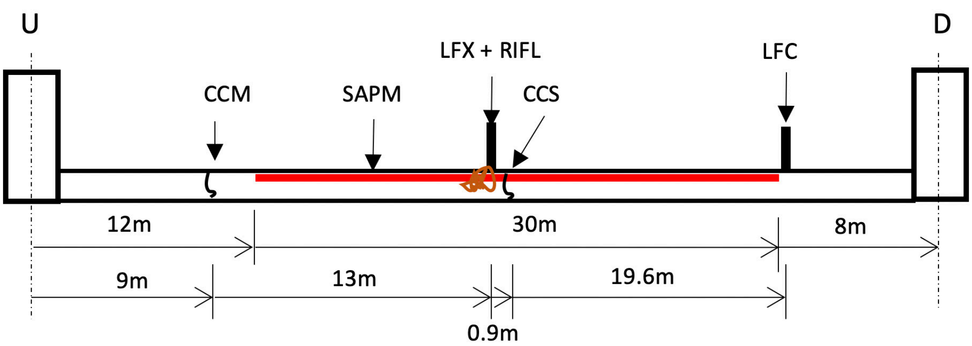
C Mean Score

The Mean Score is the average defect score per metre of the asset surveyed. It is calculated by dividing the Total Score by the Surveyed Length.

Mean Score = Total Score/Surveyed Length

Figure E1.1 provides a worked example of the calculation of the structural scores using pipe inspection results.

Figure E1.1, example of scoring analysis carried out on a completed pipe inspection



Longitudinal Distance	Continuity	Main + Characterisation Codes	Quantification	Structural Defect Score
0.0		IS		0
9.0		CC	M	7
12.0	S.1	SAP		30
22.0		LFX	L	10
22.0		RIF	L	10
22.9		CC	S	2
42.0	F.1	SAP		30
42.5		LFC	M	6
60		IE		0

Aggregated score 22m to 23m +(10 + 10 + 2) + 30 SAP continuity = 52

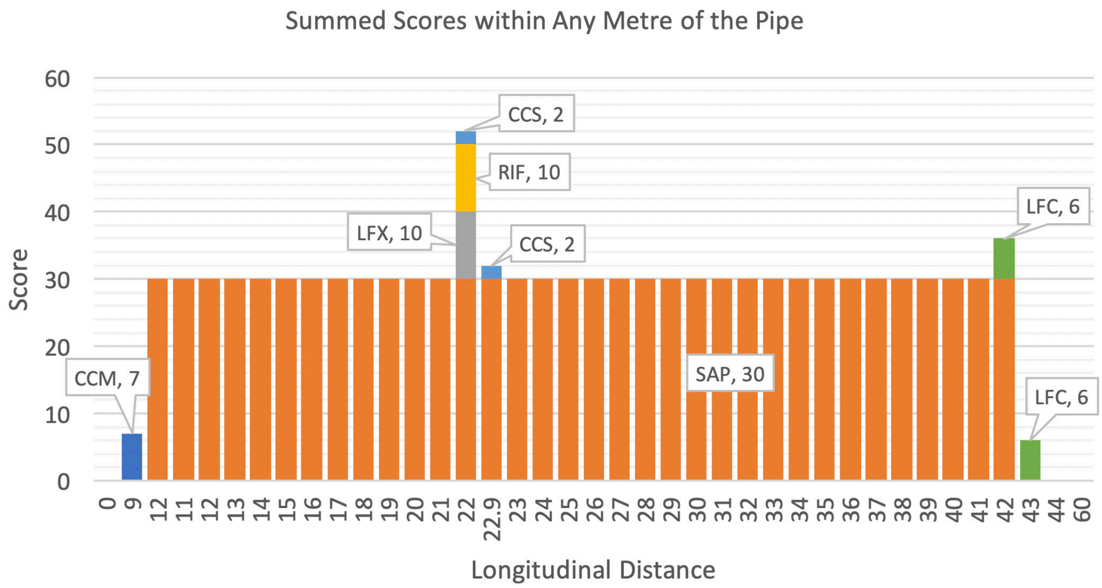
The Total, Mean and Peak structural scores calculated for the above example pipe inspection are as follows:

Total Score = **935** (sum of all individual defect scores (7+10+10+2+6 = 35) + Per metre Continuity score (30m @ 30 per m = 900)

Mean Score = **15.6** (Total Score (935) ÷ Survey Length (60m))

Peak Score = **52** (highest score over any 1m of pipe, refer to Figure E1.2)

Figure E1.2, graphical example of determining Peak Score for the example given in Figure E1.1



E1.2 Determining the Preliminary Condition Grade

The Preliminary Condition Grade (Structural and Service) for an asset is determined by comparing the calculated Peak Score against the condition grades in the grading threshold tables, (table E1.1 and table E1.2) below. Both the Structural and Service grades use the same peak score ranges, but separate definitions have been provided for interpretation. The Structural and Service Grades in Table E1.1 and E1.2 are aligned with the International Infrastructure Management Manual (IIMM) condition grading descriptions.

Table E1.1, Grading Thresholds with Structural Condition Definitions

Preliminary Condition Grade	Description	Definition (Structural) – Generally aligning with IIMM definitions but requiring further assessment to confirm that alignment	Peak Score
1	Very Good	As new condition. No structural defects or evidence of internal deterioration.	0 to 5
2	Good	Some structural defects evident, causing minor deterioration. If defects worsened it would not result in structural failure.	5.1 to 20
3	Moderate	Structural defects present with moderate deterioration that is beginning to affect structural performance. If the defects worsened it could lead to structural failure	20.1 to 35
4	Poor	Significant defects with serious deterioration evident affecting the structural integrity. If defects worsened it would lead to structural failure.	35.1 to 60
5	Very Poor	Deterioration has extended to a point where structural failure is imminent or has already occurred.	>60

Table E1_2, Grading Thresholds with Service Condition Definitions

Preliminary Condition Grade	Description	Definition (Service) – Primarily relating to operation and maintenance of the pipe and requiring consideration for renewal planning	Peak Score
1	Very Good	As new condition. No, or insignificant, loss of hydraulic performance has occurred and there is little likelihood of surcharge or overflow.	0 to 5
2	Good	Some defects present causing minor loss of hydraulic performance and there is only a minor likelihood of surcharge or overflow.	5.1 to 20
3	Moderate	Defects present causing moderate loss of hydraulic performance and there is moderate likelihood of surcharge and possible overflow.	20.1 to 35
4	Poor	Significant defects are present causing serious loss of hydraulic performance and there is a significant likelihood of surcharge and overflow.	35.1 to 60
5	Very Poor	Defects are such that service failure has occurred and the pipe is blocked and surcharging and/or overflow is imminent or has occurred.	>60

The recording of 'Asset Condition' in any AMIS should clearly identify the source and basis of that grading as they are not the same. Possible sources are:

1. New Zealand Pipe Inspection Manual (3rd Edition). This will typically be a score based on the 'Peak Structural Score' but might also be based on mean score or service score
2. Preliminary Condition Grading based on this manual
3. Final Condition Grade based on detailed assessment of the pipe by an experienced reviewer.

E1.3 Defect Scores

The structural and service defect scores for pipes and manholes are provided in the following tables. Only defect codes that have either structural or service scores are provided. Where a defect code or Characterisation code is not provided in the tables, then no score is applicable for that situation, and is not included in the scoring analysis for Total, Peak or Mean.

Tables on the following page.

E1.3 – Defect Scores

Table E1.3 – Pipe Structural Scores

Code Type (Structural)	Main Code	Char.	Description	Structural Score (Quantification Band)		
				Small	Medium	Large
Cracks Longitudinal	CL			3	15	21
		C	Crack edge chipped		26	
		B	Slabbing		35	
		D	Crack faces are displaced		90	
Cracks Circumferential	CC			2	7	12
		C	Crack edge chipped		15	
		D	Crack faces are displaced		22	
Cracks Multiple	CM			10	25	30
		C	Crack edge chipped		35	
		B	Slabbing		45	
		D	Crack faces are displaced		90	
Joint Displaced	JD	*Main Code with no Characterisation covers 3rd or earlier standard*		*1*	*6*	*20*
		V	Vertical offset			
		H	Horizontal offset			
Joint Faulty	JF	*Main Code with no Characterisation covers 3rd or earlier standard*		*4*	*10*	*17*
		C	Cracked	3	10	15
		D	Damaged	3	6	17
		X	Seal	1	6	10
		B	Broken	11	21	36
Joint Open	JO			1	5	15
		A	Angular displacement			
Manhole (or Chamber) Joint Faulty	MHJ				10	
Lateral Sealing Faulty	LF	*Main Code with no Characterisation covers 3rd or earlier standard*		*2*	*6*	*15*
		C	Cracked	1	6	15
		B	Broken	10	20	30
		D	Damaged	3	5	17
		X	Seal	1	6	10
Masonry Unit (Brick) Separation	MUS			15	26	50
Dropped Invert (Brick)	DI			36	61	90
Masonry (Brick) Pipe Collapsed	MX				165	
Missing Masonry (Brick) Units	MMU	V	More bricks visible	15	30	45
		NV	No more bricks visible	25	55	70
Displaced Masonry Units (Bricks)	DMU	I	Moving inwards	26	51	90
		O	Moving outwards			
Missing Mortar	MM			5	18	26
Pipe Broken	PB			30	51	100

Code Type (Structural)	Main Code	Char.	Description	Structural Score (Quantification Band)		
				Small	Medium	Large
Deformed Plastic Pipe	PF	*Main Code with no Characterisation covers 3rd or earlier standard*		*25*	*50*	*90*
		B	Buckling	*30*	*50*	*90*
		IC	Inverse curvature	*40*	*61*	*90*
		DV	Vertical deformation	*25*	*50*	*90*
		DH	Horizontal deformation			
		C	Cracking		90	
		G	Corrugation growth		25	
Deformed Pipe	DF	*Main Code with no Characterisation covers 3rd or earlier standard*		NA	55	100
		V	Vertical deformation			
		H	Horizontal deformation			
Pipe Holed	PH			25	40	90
Surface Damage	S	D	*Damage (Other) this covers surface damage defects for 3rd Edition or earlier standard*	*6*	*21*	*61*
		W	Wall roughened		6	
		S	Spalling		26	
		PM	Pipe missing		125	
		AE	Aggregate exposed	6	15	20
		AP	Aggregate projecting	18	30	36
		AM	Aggregate missing	30	50	60
		RC	Reinforcement corroded	20	60	100
		RV	Reinforcement visible	20	40	80
		RVP	Reinforcement visible projecting	20	50	100
		CP	Corrosion products visible	15	26	35
		MD	Mechanical damage	20	30	40
		H	Holed	25	50	70
		WS	Wall staining	5	20	36
		DL	Delamination	30	50	90
		T	Tuberculation	25	40	65
Protective Lining Defective	PL	*Main Code with no Characterisation covers 3rd or earlier standard*		5	25	50
		WL	Wrinkling - Longitudinal	5	30	55
		WC	Wrinkling - Circumferential	2	5	20
		W	Wrinkling - Multiple patterns	5	30	55
		B	Blistered	5	20	30
		BU	Bulged	20	35	55
		D	Detached	20	35	55
		C	Discolouration		10	
		E	End or edge of the patch repair lining is defective or irregular		5	
		WD	Weld defective		40	
		RC	Re-establishment of connection done improperly		10	
		L	Leak		8	
		H	Holed		8	

Code Type (Structural)	Main Code	Char.	Description	Structural Score (Quantification Band)		
				Small	Medium	Large
Protective Lining Defective *(cont)*		RM	Rendered mortar missing	40		
		SJ	Spiral joints separated	40		
Soil Visible Through Defect	SV			30		
Tomo	TM			40		
Pipe Collapsed	PX			165		
Weld Defect	W	C	Weld is cracked	25		
		X	Weld is defective	21		
		LF	Weld exhibits a lack of fusion	30		
		D	Displacement (Butt Weld)	30		
		AA	Angular misalignment (Butt Weld)	30		
		A	Misalignment (Electrofusion)	25		
		I	Incorrect insertion (Electrofusion)	*25*		
		M	Electrofusion coupler (PE welding only) has partially melted	21		
		O	Ovality and "flat areas" (Electrofusion)	25		
		U	Weld exhibits undercut at the toe of weld (steel welding only)	25		
		Z	Other weld defect	25		
Dipped Pipe	DP			1	6	26
Root Intrusion	RI	*Main Code with no Characterisation covers 3rd or earlier standard*		3	10	10
		F	Fine roots	3	10	10
		M	Mass of mostly fine roots	3	10	10
		T	Tap roots	3	10	10
		RF	Recently cut fine roots	3	10	10
		RB	Recently cut root beard	3	10	10
		RT	Recently cut tap roots	3	10	10
Exfiltration	EX			10		
Infiltration Present	IP			1	10	10

Table E1.4 – Pipe Service Scores

Code Type (Service)	Main Code	Char.	Description	Structural Score (Quantification Band) Small	Medium	Large
				Small	Medium	Large
Cracks Circumferential	CC	D	Crack faces are displaced	2		
Cracks Multiple	CM	D	Crack faces are displaced	2		
Joint Displaced	JD	*Main Code with no Characterisation covers 3rd or earlier standard*		8	22	36
		V	Vertical offset			
		H	Horizontal offset			
Joint Faulty	JF	B	Broken	1	1	6
Joint Open	JO			2	6	8
		A	Angular displacement	3	8	21
Manhole (or Chamber) Joint Faulty	MHJ			8		
Lateral Protruding	LP			10	25	36
Masonry Pipe Collapsed	MX			165		
Displaced Masonry Units	DMU	I	Moving inwards	6	8	10
		O	Moving outwards			
Missing Mortar	MM			2	6	8
Pipe Broken	PB			2	2	6
Deformed Plastic Pipe	PF	*Main Code with no Characterisation covers 3rd or earlier standard*		*1*	*10*	*25*
		B	Buckling	3	10	30
		IC	Inverse curvature	15	25	30
		DV	Vertical deformation	1	10	25
		DH	Horizontal deformation			
		C	Cracking	8		
		G	Corrugation growth	21		
Deformed Pipe	DF	*Main Code with no Characterisation covers 3rd or earlier standard*		NA	6	25
		V	Vertical deformation			
		H	Horizontal deformation			
Pipe Holed	PH			3	10	20
Surface Damage	S	D	*Damage (Other) this covers surface damage defects for 3rd Edition or earlier standard*	*6*	*8*	*23*
		W	Wall roughened	2		
		S	Spalling	5		
		PM	Pipe missing	55		
		AE	Aggregate exposed	5	6	7
		AP	Aggregate projecting	6	7	8
		AM	Aggregate missing	7	8	9
		RC	Reinforcement corroded	15	16	17
		RV	Reinforcement visible	10	11	12
		RVP	Reinforcement visible projecting	12	13	14
		CP	Corrosion products visible	2	3	4
		H	Holed	10	25	35

Code Type (Service)	Main Code	Char.	Description	Structural Score (Quantification Band)		
				Small	Medium	Large
Surface Damage *(cont)*						
		DL	Delamination	10	25	35
		T	Tuberculation	15	30	55
Protective Lining Defective	PL	*Main Code with no Characterisation covers 3rd or earlier standard*		8	27	40
		WL	Wrinkling - Longitudinal	5	15	30
		WC	Wrinkling - Circumferential	15	30	50
		W	Wrinkling - Multiple patterns	10	25	40
		B	Blistered	5	15	25
		BU	Bulged	15	30	50
		D	Detached	15	30	50
		E	End or edge of the patch repair lining is defective or irregular	5		
		RM	Rendered mortar missing	10		
				40		
Pipe Collapsed	PX			165		
Debris Silty	DE			15	35	60
Debris Greasy	DG			10	30	55
Dipped Pipe	DP			6	35	60
Encrustation Deposit	ED			10	30	55
Root Intrusion	RI	*Main Code with no Characterisation covers 3rd or earlier standard*		*10*	*30*	*55*
		F	Fine roots	5	15	25
		M	Mass of mostly fine roots	15	35	60
		T	Tap roots	12	22	55
		RF	Recently cut fine roots	5	10	20
		RB	Recently cut root beard	15	35	60
		RT	Recently cut tap roots	10	21	50
Exfiltration	EX			10		
Infiltration Present	IP			6	21	30
Obstruction	O	P	Permanent	15	35	60
		T	Temporary	15	35	60
		S	Service Crossing	15	35	60
Pipe Blocked	B	RI	Root Blockage	100		
		DE	Silty debris blockage			
		DG	Fat blockage			
		Z	Other			

Table E1.5 – Pipe Service Score (Stormwater)

Code Type (Service – SW)	Main Code	Char.	Description	Structural Score (Quantification Band)		
				Small	Medium	Large
Cracks Circumferential	CC	D	Crack faces are displaced		2	
Cracks Multiple	CM	D	Crack faces are displaced		2	
Joint Displaced	JD		*Main Code with no Characterisation covers 3rd or earlier standard*	8	22	36
		V	Vertical offset			
		H	Horizontal offset			
Joint Faulty	JF	B	Broken	1	1	3
Joint Open	JO			2	6	8
		A	Angular displacement	3	8	21
Manhole (or Chamber) Joint Faulty	MHJ				5	
Lateral Protruding	LP			3	10	15
Masonry Pipe Collapsed	MX				165	
Displaced Masonry Units	DMU	I	Moving inwards	6	8	10
		O	Moving outwards			
Missing Mortar	MM			2	6	8
Pipe Broken	PB			2	2	6
Deformed Plastic Pipe	PF		*Main Code with no Characterisation covers 3rd or earlier standard*	*1*	*10*	*25*
		B	Buckling	3	10	30
		IC	Inverse curvature	15	25	30
		DV	Vertical deformation	1	10	25
		DH	Horizontal deformation			
		C	Cracking		8	
		G	Corrugation growth		21	
Deformed Pipe	DF		*Main Code with no Characterisation covers 3rd or earlier standard*	NA	6	25
		V	Vertical deformation			
		H	Horizontal deformation			
Pipe Holed	PH			3	10	20
Surface Damage	S	D	*Damage (Other) this covers surface damage defects for 3rd Edition or earlier standard*	6	8	23
		W	Wall roughened		2	
		S	Spalling		5	
		PM	Pipe missing		35	
		AE	Aggregate exposed	5	6	7
		AP	Aggregate projecting	6	7	8
		AM	Aggregate missing	7	8	9
		RC	Reinforcement corroded	15	16	17
		RV	Reinforcement visible	10	11	12
		RVP	Reinforcement visible projecting	12	13	14
		CP	Corrosion products visible	2	3	4
		H	Holed	10	25	35
		DL	Delamination	10	25	35

Code Type (Service – SW)	Main Code	Char.	Description	Structural Score (Quantification Band)		
				Small	Medium	Large
Surface Damage *(cont)*	S	T	Tuberculation	15	30	55
Protective Lining Defective	PL	*Main Code with no Characterisation covers 3rd or earlier standard*		*8*	*23*	*40*
		WL	*Wrinkling - Longitudinal*	5	15	30
		WC	Wrinkling - Circumferential	15	30	50
		W	Wrinkling - Multiple Patterns	10	25	40
		B	Blistered	5	15	25
		BU	Bulged	15	30	50
		D	Detached	15	30	50
		E	End or edge of the patch repair lining is defective or irregular	5		
		RM	Rendered mortar missing	10		
Pipe Collapsed	PX			165		
Debris Silty	DE			10	30	60
Dipped Pipe	DP			6	25	50
Encrustation Deposit	ED			10	30	55
Root Intrusion	RI	*Main Code with no Characterisation covers 3rd or earlier standard*		10	33	70
		F	*Fine roots*	*5*	*15*	*25*
		M	Mass of mostly fine roots	15	35	60
		T	Tap roots	12	22	55
		RF	Recently cut fine roots	5	10	20
		RB	Recently cut root beard	15	35	60
		RT	Recently cut tap roots	10	21	50
Exfiltration	EX			10		
Infiltration Present	IP			4	15	20
Obstruction	O	P	Permanent	15	35	60
		T	Temporary	15	35	60
		S	Service Crossing	15	35	60
Pipe Blocked	B	RI	*Root Blockage*	100		
		DE	Silty Debris Blockage			
		DG	Fat Blockage			
		Z	Other			

Table E1.6 – Manhole Structural Scores

Main Description	Main Code	Char.	Characterisation Description	Channel			Benching			Adjusting Ring Risers (Throat)			Concrete Lid			Chamber/ Taper			Cover & Frame		
				S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L
Cracking Vertical	HCV									1	6	12	2	12	18	5	15	23			
		C	Crack edge chipped								12			21			26				
		B	Slabbing								27						90				
		D	Crack faces are displaced								16			28			35				
Cracking Circumferential	HCC									1	5	7				2	12	18			
		C	Crack edge Chipped								7						18				
		D	Crack faces are Displaced								9						22				
Cracking Multiple	HCM									5	10	12	10	20	24	12	25	30			
		C	Crack edge Chipped								14			28			35				
		B	Slabbing								18						61				
		D	Crack faces are Displaced								18			36			45				
Wall Broken	HWB									24	41	50	24	41	80	30	51	100			
Wall Holed	HWH									15	24	36	30	45	95	30	45	95			
Deformed Plastic Manhole	HPF	C	Cracking								36			36			45				
		B	Buckling							12	20	36				30	50	90			
		IC	Inverse Curvature							16	24	36				40	61	90			
		D	Elliptical Deformation							10	20	36				25	50	90			
Deformed Manhole Segment	HDF										22	40					55	100			
Surface Damage	HS	W	Wall roughened								2			5			6				
		S	Spalling								12			24			30				
		WM	Wall Missing								50			100			125				
		AE	Aggregate Exposed							2	6	8	5	12	16	6	15	20			
		AP	Aggregate Projecting							8	12	14	16	24	29	20	30	36			
		AM	Aggregate Missing							12	20	24	24	40	48	30	50	60			
		RC	Reinforcement Corroded							14	24	40	29	48	80	36	60	100			
		RV	Reinforcement Visible							8	16	32	16	32	64	20	40	80			

Main Description	Main Code	Char.	Characterisation Description	Channel			Benching			Adjusting Ring Risers (Throat)			Concrete Lid			Chamber/ Taper			Cover & Frame		
				S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L
Surface Damage *(cont)*	HS	RVP	Reinforcement Visible Projecting							12	20	40	24	40	80	30	50	100			
		CP	Corrosion Products visible							6	10	14	12	21	28	15	26	35			
		MD	Mechanical Damage							8	12	16	16	24	32	20	30	40			
		H	Holed							10	20	28	20	40	56	25	50	70			
		WS	Wall Staining							2	8	14	4	15	29	5	20	36			
Protective Lining Defective	HPL	B	Blistered							4	16	24				5	20	30			
		BU	Bulged							16	28	44				20	35	55			
		D	Detached								64						80				
		C	Dis-Colouration								8						10				
		WD	Weld defective								32						40				
		RC	Re-establishment of Connection done improperly								8						10				
		L	Leak								6						8				
		H	Holed								6						8				
		RM	Rendered mortar Missing								32						40				
		WV	Wrinkling Vertical							4	24	44				5	30	55			
		WC	Wrinkling Circumferential							2	4	16				2	5	20			
		W	Wrinkling – multiple patterns							4	24	44				5	30	55			
		Z	Other								24						30				
Soil Visible through defect	HSV				30			30			15			30			30			6	
Tomo	HTM				50			50			25			50			50			10	
Manhole Chamber Collapse	HCX			165																	
Missing Mortar	HMM									2	7	10				5	18	26			
Masonry Unit Separation	HMUS									6	10	13				15	26	50			
Displaced Masonry Units	HDMU	I	Moving Inwards							10	13	14				26	51	90			
		O	Moving Outwards							10	13	14				26	51	90			

Main Description	Main Code	Char.	Characterisation Description	Channel			Benching			Adjusting Ring Risers (Throat)			Concrete Lid			Chamber/ Taper			Cover & Frame		
				S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L
Missing Masonry Units	HMMU	V	More Masonry Visible							6	12	18				15	30	45			
		NV	No more masonry Visible							15	33	56				25	55	70			
Masonry Manhole Collapsed	HMX			165																	
Chamber Joint Faulty Seal	HJFX									1	6	10				1	6	10			
Chamber Joint Open	HJO									0	2	6				1	5	15			
Chamber Joint Open (cont.)	HJO	A	Angular displacement							0	2	6				1	5	15			
Chamber Joint Displaced	HJD									1	2	8				1	6	20			
Connecting Lateral Pipe Sealing Faulty	HLF	C	Cracked				*Applied to any component (Location not required)*									1	6	15			
		B	Broken				*Applied to any component (Location not required)*									10	20	30			
		D	Damaged				*Applied to any component (Location not required)*									3	5	17			
		X	Seal				*Applied to any component (Location not required)*									1	6	10			
Defective Drop Pipe	HDP	C	The Drop Pipe is Cracked	6																	
		D	The Drop Pipe is Deformed	10																	
		Z	Other	8																	
Defective Cover and/or Frame	HFR	CB	Cover cracked or Broken	36																	
		CD	Cover Deformed	10																	
		CM	Cover Missing	61																	
		CR	Cover Rocking	6																	
		FB	Frame cracked or Broken	49																	
		FL	Frame Loose	10																	
		FD	Frame Displaced	10																	
		FM	Frame Missing	61																	
		G	Gap or hole between Access/ Throat, Lid or Chamber	3																	
		HD	Holding down bolts missing or defective	5																	
		Z	Other	10																	

<table>
<tr><th rowspan="2">Main Description</th><th rowspan="2">Main Code</th><th rowspan="2">Char.</th><th rowspan="2">Characterisation Description</th><th colspan="3">Channel</th><th colspan="3">Benching</th><th colspan="3">Adjusting Ring Risers (Throat)</th><th colspan="3">Concrete Lid</th><th colspan="3">Chamber/ Taper</th><th colspan="3">Cover & Frame</th></tr>
<tr><th>S</th><th>M</th><th>L</th><th>S</th><th>M</th><th>L</th><th>S</th><th>M</th><th>L</th><th>S</th><th>M</th><th>L</th><th>S</th><th>M</th><th>L</th><th>S</th><th>M</th><th>L</th></tr>
<tr><td rowspan="3">Defective Devices Under Cover and Frame</td><td rowspan="3">HUX</td><td>D</td><td>Device is present but defective</td><td colspan="18">5</td></tr>
<tr><td>M</td><td>All or part of the device is missing with evidence that one was previously present</td><td colspan="18">2</td></tr>
<tr><td>U</td><td>Device is unlocked or disconnected</td><td colspan="18">3</td></tr>
<tr><td>Vent</td><td>HVT</td><td>D</td><td>Vent is structurally defective</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">25</td><td></td><td></td><td></td><td colspan="3">25</td></tr>
<tr><td rowspan="15">Defective Step or Ladder</td><td rowspan="15">HSL</td><td>ED</td><td>Plastics encapsulation of step is damaged or broken</td><td colspan="18">1</td></tr>
<tr><td>HC</td><td>Ladder handrail is corroded</td><td colspan="18">21</td></tr>
<tr><td>LC</td><td>Ladder cracked.</td><td colspan="18">24</td></tr>
<tr><td>LCC</td><td>Ladder support corroded (Ladder clip corroded)</td><td colspan="18">21</td></tr>
<tr><td>LCL</td><td>Ladder support loose (Ladder clip loose)</td><td colspan="18">21</td></tr>
<tr><td>LCM</td><td>Ladder support missing (Ladder clip missing)</td><td colspan="18">24</td></tr>
<tr><td>LRM</td><td>Ladder rung missing</td><td colspan="18">61</td></tr>
<tr><td>RC</td><td>Ladder rung corroded</td><td colspan="18">36</td></tr>
<tr><td>SB</td><td>Step bent</td><td colspan="18">5</td></tr>
<tr><td>SC</td><td>Step corroded</td><td colspan="18">36</td></tr>
<tr><td>SL</td><td>Step loose</td><td colspan="18">21</td></tr>
<tr><td>SM</td><td>Step missing</td><td colspan="18">61</td></tr>
<tr><td>TH</td><td>Defective toe hole</td><td colspan="18">10</td></tr>
<tr><td>Z</td><td>Other</td><td colspan="18">10</td></tr>
<tr><td colspan="20"></td></tr>
<tr><td rowspan="3">Safety bars or staging platform</td><td rowspan="3">HSP</td><td>BB</td><td>One or more safety bars bent or broken</td><td colspan="18">36</td></tr>
<tr><td>BC</td><td>One or more safety bars corroded</td><td colspan="18">36</td></tr>
<tr><td>BL</td><td>One or more safety bar/platform fixings is loose or broken</td><td colspan="18">36</td></tr>
</table>

<table>
<tr><th rowspan="2">Main Description</th><th rowspan="2">Main Code</th><th rowspan="2">Char.</th><th rowspan="2">Characterisation Description</th><th colspan="3">Channel</th><th colspan="3">Benching</th><th colspan="3">Adjusting Ring Risers (Throat)</th><th colspan="3">Concrete Lid</th><th colspan="3">Chamber/ Taper</th><th colspan="3">Cover & Frame</th></tr>
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<tr><td rowspan="3">Defective Devices Under Cover and Frame</td><td rowspan="3">HUX</td><td>D</td><td>Device is present but defective</td><td colspan="18">5</td></tr>
<tr><td>M</td><td>All or part of the device is missing with evidence that one was previously present</td><td colspan="18">2</td></tr>
<tr><td>U</td><td>Device is unlocked or disconnected</td><td colspan="18">3</td></tr>
<tr><td>Vent</td><td>HVT</td><td>D</td><td>Vent is structurally defective</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">25</td><td></td><td></td><td></td><td colspan="3">25</td></tr>
<tr><td rowspan="14">Defective Step or Ladder</td><td rowspan="14">HSL</td><td>ED</td><td>Plastics encapsulation of step is damaged or broken</td><td colspan="18">1</td></tr>
<tr><td>HC</td><td>Ladder handrail is corroded</td><td colspan="18">21</td></tr>
<tr><td>LC</td><td>Ladder cracked.</td><td colspan="18">24</td></tr>
<tr><td>LCC</td><td>Ladder support corroded (Ladder clip corroded)</td><td colspan="18">21</td></tr>
<tr><td>LCL</td><td>Ladder support loose (Ladder clip loose)</td><td colspan="18">21</td></tr>
<tr><td>LCM</td><td>Ladder support missing (Ladder clip missing)</td><td colspan="18">24</td></tr>
<tr><td>LRM</td><td>Ladder rung missing</td><td colspan="18">61</td></tr>
<tr><td>RC</td><td>Ladder rung corroded</td><td colspan="18">36</td></tr>
<tr><td>SB</td><td>Step bent</td><td colspan="18">5</td></tr>
<tr><td>SC</td><td>Step corroded</td><td colspan="18">36</td></tr>
<tr><td>SL</td><td>Step loose</td><td colspan="18">21</td></tr>
<tr><td>SM</td><td>Step missing</td><td colspan="18">61</td></tr>
<tr><td>TH</td><td>Defective toe hole</td><td colspan="18">10</td></tr>
<tr><td>Z</td><td>Other</td><td colspan="18">10</td></tr>
<tr><td rowspan="3">Safety bars or staging platform</td><td rowspan="3">HSP</td><td>BB</td><td>One or more safety bars bent or broken</td><td colspan="18">36</td></tr>
<tr><td>BC</td><td>One or more safety bars corroded</td><td colspan="18">36</td></tr>
<tr><td>BL</td><td>One or more safety bar/platform fixings is loose or broken</td><td colspan="18">36</td></tr>
</table>

Main Description	Main Code	Char.	Characterisation Description	Channel			Benching			Adjusting Ring Risers (Throat)			Concrete Lid			Chamber/ Taper			Cover & Frame		
				S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L
Safety bars or staging platform *(cont)*	HSP	BM	One or more safety bars missing with evidence that they previously existed	36																	
		Z	Other	10																	
Tie Down Bolt	HTD	C	Tie down bolt corroded											2			5				
		B	Tie down bolt bent											1			4				
		M	Missing with evidence that they previously existed											5			5				
		Z	Other											1			1				
Defective Channel	HCH	X	Defective	10																	
		M	Missing with evidence that a channel previously existed	21																	
Defective Benching	HBN	X	Defective	10																	
		M	Missing with evidence that a channel previously existed	21																	
Root Intrusion	HRI	F	Fine Roots	2	6	6	2	6	6	2	5	5	3	10	10	3	10	10	3	10	10
		T	Tap roots	2	6	6	2	6	6	2	5	5	3	10	10	3	10	10	3	10	10
		RF	Recently cut Fine roots	2	6	6	2	6	6	2	5	5	3	10	10	3	10	10	3	10	10
		RB	Recently cut interwoven roots leaving a Beard	2	6	6	2	6	6	2	5	5	3	10	10	3	10	10	3	10	10
		RT	Recently cut Tap roots	6	6	6	6	6	6	5	5	5	10	10	10	10	10	10	10	10	10
Exfiltration	HEX			40																	
Infiltration Present	HIP			1	10	10	1	10	10	1	6	6	1	10	10	1	10	10	1	10	10

Table E1.7 – Manhole Service Scores

Main Description	Main Code	Char.	Characterisation Description	Channel			Benching			Adjusting Ring Risers (Throat)			Concrete Lid			Chamber/ Taper			Cover & Frame		
				S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L
Manhole Chamber Collapse	HCX			165																	
Masonry Manhole Collapsed	HMX			165																	
Defective Drop Pipe	HDP	B	The Drop Pipe is Blocked	30																	
		M	The drop pipe is missing or has been dislodged, separated and/ or disconnected so that flow is not being directed to the channel in the base of the structure	25																	
		T	The outlet of the drop pipe is not correctly positioned so that flow is misdirected or is causing unnecessary turbulence and/or splashing	21																	
Vent	HVT	SW	Surface Water can enter the manhole through the vent										10			10			0		
Defective Step or Ladder	HSL	RG	Rags or Other Material caught or hanging on the steps or ladder	*22*																	
Defective Channel	HCH	X	Defective	19																	
		M	Missing with evidence that a channel previously existed	35																	
		D	Channel dipped/ponding	4																	
Defective Benching	HBN	X	Defective	*10*																	
		M	Missing with evidence that benching previously existed	21																	
		N	No benching	10																	
Debris Silty	HDE			15	35	60	8	18	30												
Debris Greasy	HDG			10	35	55	5	18	28	3	9	14	3	9	14	3	9	14			
Encrustation Deposit	HED			10	30	55	4	12	22	3	8	14	3	8	14	3	8	14			
Root Intrusion	HRI	F	Fine Roots	5	15	25	3	9	15	1	4	6	1	4	6	2	6	10	1	4	6
		M	Mass of mostly fine roots interwoven into a clump	15	35	60	9	21	36	4	9	15	4	9	15	6	14	24	4	9	15

Main Description	Main Code	Char.	Characterisation Description	Channel			Benching			Adjusting Ring Risers (Throat)			Concrete Lid			Chamber/ Taper			Cover & Frame		
				S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L
Debris Silty	HDE			15	35	60	8	18	30												
Debris Greasy	HDG			10	35	55	5	18	28	3	9	14	3	9	14	3	9	14			
Encrustation Deposit	HED			10	30	55	4	12	22	3	8	14	3	8	14	3	8	14			
Root Intrusion	HRI	F	Fine Roots	5	15	25	3	9	15	1	4	6	1	4	6	2	6	10	1	4	6
		M	Mass of mostly fine roots interwoven into a clump	15	35	60	9	21	36	4	9	15	4	9	15	6	14	24	4	9	15
		T	Tap roots	12	22	55	7	13	33	3	6	14	3	6	14	5	9	22	3	6	14
		RF	Recently cut Fine roots	5	10	20	3	6	12	1	3	5	1	3	5	2	4	8	1	3	5
		RB	Recently cut interwoven roots leaving a Beard	15	35	60	9	21	36	4	9	15	4	9	15	6	14	24	4	9	15
		RT	Recently cut Tap roots	10	21	50	6	13	30	3	5	13	3	5	13	4	8	20	3	5	13
Obstruction	HO	P	Permanent	15	35	60	*Applied to any component (Location not required)*														
		T	Temporary	15	35	60	*Applied to any component (Location not required)*														
Blocked Channel	HB	RI	Root Blockage	100																	
		DE	Debris Blockage	100																	
		DG	Fat Blockage	100																	
		Z	Other	100																	
Exfiltration	HEX			25																	
Infiltration Present	HIP			6	21	30	6	21	30	6	21	30	6	21	30	6	21	30	6	21	30

E2 Understanding Asset Condition

E2.1 Introduction

Defects vary significantly in relation to their impact on the ability of a pipe to reliably convey flows (serviceability), and the extent to which they are indicators of the eventual structural failure of an asset. Understanding condition and monitoring deterioration and the level of service provided is fundamental to asset management. This section provides guidance for Asset Managers to understand inspection condition outputs. The use of the Preliminary Condition Grade, (1 – 5) described in Section E1 is discussed, and when further, more detailed, engineering assessment should be considered to determine a Final Condition Grade.

E2.2 Asset Condition Reporting

A defined condition grade is essential information for the Asset Manager. It can be used to:

- Track the gradual deterioration of the pipe or manhole over time
- Build an understanding of how this deterioration occurs and how it varies
- Provide information that informs the planning of asset renewals
- Confirms the need to renew pipes that have reached the end of their useful lives
- Allows the valuation, and associated depreciation, of pipes to be determined in a consistent manner.
- Provide a consistent basis for reporting of asset condition and national benchmarking exercises

The Structural and Service condition grades are described in Tables E1.1 and E1.2 in Section E1 – Preliminary Condition Grading. These tables align the condition grade with a corresponding description and definition. The grading system provides a way of describing the condition based on the evidence of deterioration (the type and scale of the defects present) and the relative position the asset is in to either structural failure or loss of flow containment.

The reporting of asset condition also extends beyond just the condition grade. Various definitions of condition are used, in isolation and in combination, for various purposes, and all add value to the overall asset management of pipes and manholes. Table E2.1 illustrates the different ways that asset condition can be described and measured and how they relate to each other. The table, for simplicity only lists the start and end of life points. It can be expected that assets will deteriorate on a path from grade 1 to grade 5, with grades 2, 3 and 4 tracking the deterioration between these extremes, although this may not be linear or in equal time steps. The movement from one condition grade to the next simply reflects the defects that are observed and their alignment with the expected condition for that description. The length of time that it is expected to take until a grade 5 is reached is likely to vary from one asset to another. Depending on the factors that influence the asset life, a pipe or manhole will transition between the condition steps more, or less quickly, than other nominally similar pipes in a different operating environment. Understanding this variability is a key aspect of asset management.

Likelihood of Failure and Useful Remaining Life, which are often used somewhat interchangeably, are both measures of the extent of deterioration that has occurred, and the path to inevitable failure, but are used for different purposes within asset management.

Likelihood of Failure is of interest to the asset manager in relation to expected performance in the relatively near future, as the asset enters the range where failures are statistically likely to occur. This is particularly relevant for assets with an elevated Criticality, where intervention is required to avoid failure. Such assets might also have only a few years of Useful Remaining Life, but it is risk (*Likelihood of Failure and Criticality*) that is the driver for the response.

Table E2.1 – Valid descriptions of pipe condition

Consideration	Typical Description at Start of Life	Position To	Typical Description at End of Life
Structural Condition Grade	***Grade 1*** – Very good - condition as new per manufacturers specification and installed in approved manner.	→	***Grade 5*** – Very poor condition. Little, if any, capability* to provide required Level of Service at acceptable risk. Asset is failing or may have already failed.
Service Condition Grade	***Grade 1*** – Full service capability* available.	→	***Grade 5*** – Service cannot be reliably provided. Failures occur.
Likelihood of Failure	***Low*** – Predictable load carrying performance well within the capability* of the pipe.	→	***High*** – The capability* of the pipe to resist a load is equal or less than the imposed load upon it. The pipes ability to continue to function for any reliable period without complete failure (collapse or overflow) cannot be reasonably determined.
Useful Remaining Life	Full design or life available (>50 years).	→	No reliable remaining life (0 – 3 years). Asset may actually be beyond normally expected or economic life

*Note *Capability may be defined in several ways depending on the required function of the asset. Will typically include consideration of its ability to resist a structural load, hydraulic capacity, resistance to blockages, extent of infiltration and inflow, acceptable level of maintenance, etc.*

For non-critical assets, the focus is more on when in the future the renewal of the asset should be planned for, and therefore the Useful Remaining Life (the estimated amount of time left until the pipe reaches the end of its useful life) is a much more valuable consideration, as the current Likelihood of Failure maybe very low. Table E2.2 provides indicative values for Useful Remaining Life, based on the condition grade and the expected relationship to the asset management planning cycle. Note that this is based on 'typical' pipe performance in a 'typical' operating environment.

Table E2.2 – Indicative values for Remaining Useful Life with reference to the planning cycle

Grade	Useful Remaining Life	Planning Cycle
1	> 50 years	Outside 30-year Infrastructure Planning Cycle
2	30 – 50 years	Outside 30-year Infrastructure Planning Cycle
3	10 – 30 years	Inside 30-year planning cycle, but outside Long-Term Plan (LTP) 3-year planning cycle
4	3 – 10 years	Inside 10-year planning cycle but outside Long-Term Plan (LTP) 3-year planning cycle
5	<3 years	Inside 10-year planning cycle but outside Long-Term Plan (LTP) 3-year planning cycle

Note: *The table is based on a 50+ year expect useful life. If the expected useful life of the pipe is expected to be substantially greater than 50 years, the range of values provided for grades 1 and 2 would be expected to 'stretch' to accommodate the longer time, however the stated Useful Remaining Life for grades 3, 4 and 5 could be expected to stay relevant for planning purposes. Regardless of the expected useful life, the time for expected remaining life for grades 1 and 2 would be well outside of the 30-year infrastructure planning cycle.*

E2.3 Use of the Preliminary Condition Grading

Section E1: Preliminary Condition Grading sets out the process for the calculation of a condition grade by combining the scores associated with the reported defects, termed Scoring Analysis.

Preliminary Condition Grades are not intended to provide an absolute condition assessment, or identify which individual pipes need repair, maintenance, or renewal. They are intended to provide:

- An indication of the likelihood of a service or structural failure.
- A basis for reporting of asset condition and national benchmarking exercises
- A trigger to indicate possible problem areas for further intensive study or engineering assessment.
- A comparison against other assets which may indicate patterns of deterioration or future budgeting requirements

They are considered 'preliminary' condition grades as they are only based on the analysis of the reported defects. While the weighting of the defects scores have been be assigned based on the expected response of an asset to the presence of the defect, or combination of different defects, at a single location, (within one metre length of pipe) it ultimately relies on accurate defect reporting and cannot take into account specific site conditions, or include a step where an assessor stands back and asks, "What are the observations actually telling me about this pipe?".

Where it is important to have a comprehensive understanding of the pipe condition, a detailed assessment may need to be undertaken to determine a Final Condition Grade, and the preliminary condition grades provide a useful filter that can be reliably used to identify the assets needing further assessment (refer to E2.5).

Table E2.3 provides an interpretation of the Preliminary Condition Grades with respect to short and long-term planning and whether further detailed assessment may be required. The use of this interpretation relies on the asset manager having confidence in the accuracy of the inspection reporting.

Table E2.3 – Interpretation of Preliminary Condition Grades

Preliminary Condition	Grade Range	Interpretation
Low Preliminary Condition Grade	1 to 3	Indicates that there are few, if any, defects of any consequence that are likely to impact on the structure and/or serviceability of the pipe in the short to medium term. The asset owner may have an interest in the nature of the faults that are occurring to build an overall picture of how this pipe is deteriorating over time, and how its long-term renewal will need to be provided for. These considerations may warrant a further detailed assessment of the pipe. Otherwise, the asset owner might simply record the relevant scores as Preliminary Condition Grade in their Asset Management Information System (AMIS).
High Preliminary Condition Grade	4 or 5	Indicates that there are defects present that have the potential to impact on the structure and/or serviceability of the pipe in the short to medium term and this would warrant a further detailed engineering assessment. The intent of this further detailed assessment is to confirm the exact nature of the defect(s), determine if an intervention is required, how urgent that intervention should be and the nature of the works that would provide the most cost-effective outcome. The *Preliminary Condition Grade* can be recorded in the AMIS but should not be directly used for justifying short term renewals.

E2.4 Interpreting condition scores to help understand condition

The Scoring Analysis process undertaken to determine the Preliminary Condition Grades calculates three scores:

- Total Score
- Peak Score
- Mean Score

These scores can provide useful insight into the magnitude of the defects and their distribution throughout the asset. The following provides guidance on the interpretation of the calculated scores and how they can be used to enhance the understanding of pipe condition.

E2.4.1 Use of Total Score

The Total Score is the sum of all the individual scores assigned to the defects recorded in the inspection of the asset. The Total Score reflects the magnitude of the defects within the asset but does not include consideration of the length of the asset. A high Total Score on a short asset has potentially quite a different interpretation to the same score on a much longer asset. Because of this the Total Score by itself can only provide limited qualitative information and cannot quantify the deterioration of any particular metre of pipe *i.e. it may indicate a high total score for an asset length, but it cannot discern whether all the defects are occurring in one location or throughout the whole asset length.*

E2.4.2 Use of Peak Score

The Peak Score is the maximum sum of all the defect scores within any one metre length of asset. The Peak Score reflects the value of the worst defect, or combination of defects, and indicates the likelihood of structural or service failure of the asset at that point. The Peak Score is used within the Preliminary Grading process described in Section E1 to determine the Preliminary Condition Grade.

If the Peak Score is high (>60) this is a strong indicator of possible structural or service failure of the asset in the short term, and the location within the pipe where the peak score occurs is likely to be the site of the failure. A very high peak score (≥ 165) would be indicative of an asset where failure has already occurred.

A lower Peak Score (<20) is a strong indicator that any defects present are minor and there is little likelihood of failure in the short to medium term. The location of the low peak score within the asset may, or may not, be the location of a future failure as the pipe will be affected by many and various defects throughout its length over time.

The Peak Score provides the best indication of the presence of defects that are tracking towards pipe or service failure. However, it provides no information about the condition of the pipe either side of that location other than it is better than the Peak Score. In isolation, the Peak Score cannot inform how many defects there are, or their distribution throughout the asset.

E2.4.3 Use of Mean Score

The mean score is the average defect score per metre of inspected pipe, calculated by dividing the Total Score by the inspected length. The Mean Score in isolation, as with the Total Score, provides an incomplete, and potentially very misleading, indication of the condition of the worst section of the pipe and the likelihood of failure. This is because the quantum of the inspected length influences the result

e.g. An asset with only a single significant defect (score of 100) that is short (10m long) will generate a Mean Score of 10 (score of 10 per metre of inspected pipe). Whereas the same defect in a longer asset (100m long) will only generate a Mean Score of 1 (score of 1 per metre of inspected pipe). Even though the defect is the same in each case, and the likelihood of failure is the same, the interpretation of the Mean Score, in isolation, would be quite different.

However, the Mean Score does provide some insight into the distribution and scale of defects, throughout the pipe, when the value of the Mean Score is considered in combination with the value of the Peak Score. When considered with the Peak Score this can provide an early indication of whether a spot repair, or an end to end renewal, is likely to be required.

i.e. an asset with a Mean Score that is very low in comparison to the Peak Score, indicates that most of the asset has defects with a value much less than the value of the 'Peak'. Conversely, if the Mean Score was of similar value to the Peak Score, this would indicate that the asset has frequent defects throughout the asset of similar magnitude to the 'Peak'.

E2.4.4 Alternative Methods for Analyzing Observation data and Preliminary Condition Grades

Other analysis methods are used by some other countries to interrogate the observation data results to give an understanding of condition and defect distribution. One such system is the PCAP Quick Rating method developed by the National Association of Sewer Service Companies (NASSCO) in North America. NASSCO assign each structural defect code a grade of 1 to 5, With 1 being the least severe and 5 being the most severe defect. The overall pipe condition is determined by the highest defect grade over the pipe length.

The PCAP Quick Rating method reports the two highest condition grades that are observed and the number of times they occur. This is expressed by the display of four numerical characters, which represent:

1. The first number is the highest severity grade occurring along the entire pipe length.
2. The second number is the total number of times that the highest severity grade was occurs in along the pipe length. This character may be one or more digits.
3. The third number is the next highest severity grade occurring along the pipe length.
4. The fourth number is the total number of the second highest severity grade occurrences. This character may also be one or more digits.

E.g. a code of 3.2.2.4 would mean that the pipe's worst severity grade for any defect was 3 (moderate defect) and that there were two defects identified with a severity of grade 3, and four grade 2 defects were identified in the pipe segment. This also summarizes that no grade 4 or 5 defects were found.

The quick grading system allows the pipe defects to be summarized in an efficient manner. This type of coding system provides a quick summary that can help prioritise information and better understand the overall condition. More information on this method can be found at www.nassco.org.

E2.5 Final Condition Grade (Engineering Condition Assessment)

E2.5.1 Expected Outcomes of an Engineering Condition Assessment

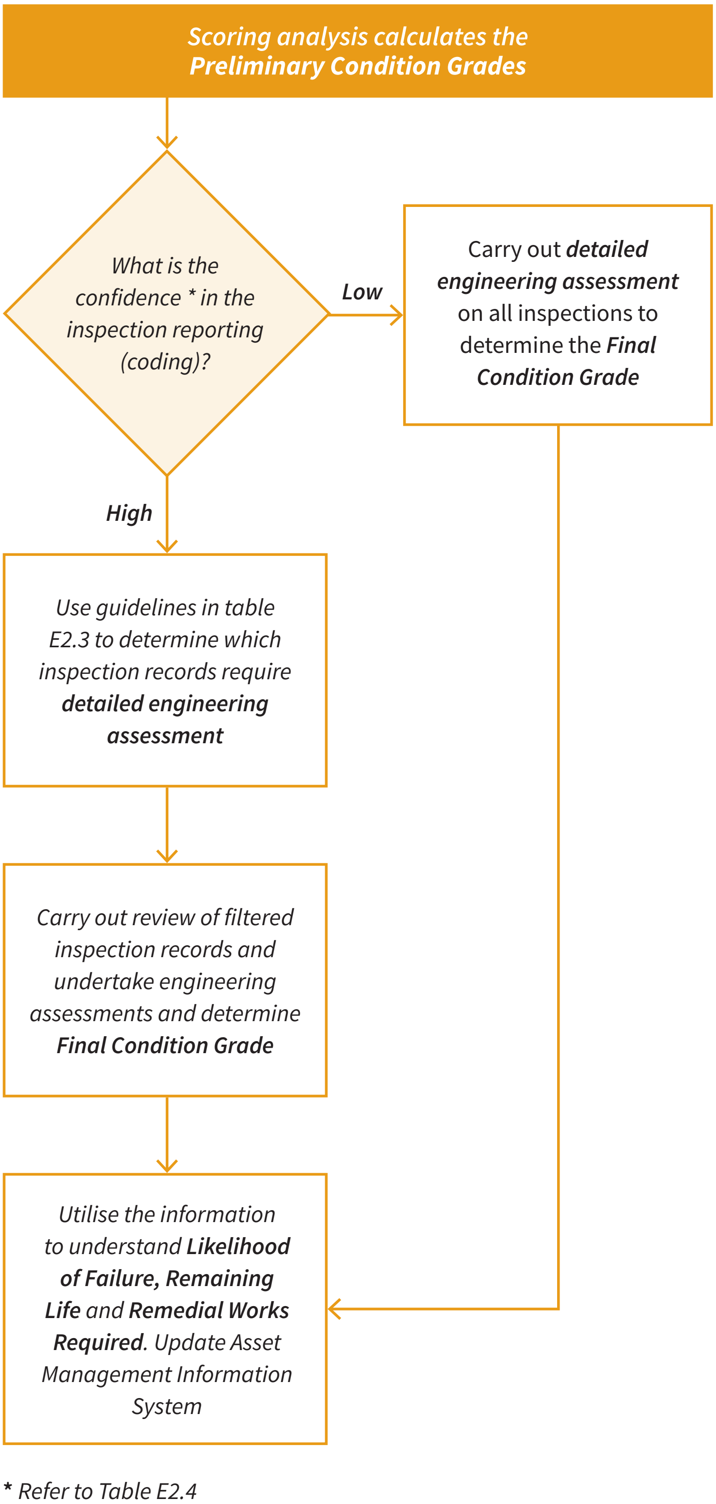
In undertaking a detailed engineering condition assessment, and determining a Final Condition Grade, the asset manager is essentially looking for 3 discrete outcomes:

1. ***Confirmation of the extent and nature of defects that are present*** – The use of this manual to code and report the pipe condition should accurately identify the location, type, and severity, of the defects that are present. The assessment will confirm that they have been correctly classified, but will, importantly, be more focussed on how the defects interact with each other to potentially make the overall impact on the pipe better or worse than the inspection outputs might indicate, and the variability (or consistency) of the defects along the pipe
2. ***Alignment of defects with expectations*** – The assessor will usually be aware of the age of the pipe, its operating environment, the behaviour of other similar pipes and the extent of deterioration that would be expected at the time of the inspection. If the actual condition of the pipe is significantly better, or worse, than expected then either the underlying assumptions about the pipe are inaccurate or there is something different about this pipe that is influencing its behaviour. This might apply to this pipe alone or may indicate new knowledge that should be applied to an identified cohort of other, nominally similar, pipes.
3. ***What needs to be done*** – The determination of what should now be done to the pipe is specific to the pipe, its operating environment and the aspirations and risk appetite of the asset owner. Determining the appropriate remedial response will consider the nature and distribution of the defects and economics of repair versus renewal. The pipe criticality (Consequence of Failure) will be an important factor in this consideration.

E2.5.2 Detailed Assessment Process Overview

Figure E2.1 provides an overview of the process for carrying out a detailed condition assessment to determine a *Final Condition Grade*. The *Preliminary Condition Grades* provide a useful filter when considered in relation to the purpose of the inspection (refer to Table E2.5). Understanding the accuracy of the inspection reporting is therefore an important consideration for the asset manager, as it determines the level of confidence in the *Preliminary Condition Grades*, and how much time and resource needs to be invested into undertaking a further assessment.

Figure E2.1 – Overview process for carrying out a detailed condition assessment



Monitoring and auditing the accuracy of the condition reporting is vital during the inspection phase of a condition assessment programme, and is covered within Section A4, Quality Control and Management of this manual. However, in building quality in from the start, the asset manager should ensure that CCTV inspectors employed to undertake the inspections are competent and reference to Section A4.3, Qualifications and Competency should be made.

Table E2.4 – Recommended approach to assessment based on the confidence in the accuracy of the inspection reporting (coding)

Scenario	Likely Effect	Recommended Approach
Low confidence in the accuracy of the inspection reporting	The preliminary grades are calculated based on the contractor's defect observations. If there is low confidence in the reporting the resulting preliminary grades are likely be compromised.	Recommend carry out engineering assessment on all inspections to determine the final condition grade.
High confidence in the accuracy of inspection reporting	The preliminary grades will provide a good indication of the extent and severity of defects	Recommend carry out engineering assessment in line with Table E2_3 to determine the final condition grade.

Table E2.5 – Approach to undertaking an engineering assessment based on the purpose of the inspection.

Purpose of the Inspection	Consideration	Suggested Assessments
Planned Inspection of critical pipe	Management of critical pipes requires timely intervention to avoid pipe failures and so it is important that the understanding of the pipe condition is sufficient to enable intervention before pipe failure.	Recommend that a quick review of pipes with preliminary grades 1 and 2 is undertaken, to ensure no significant issues are present, and engineering assessment of pipes with preliminary grades 3, 4 and 5 to finalise condition grades.
Planned Inspection of non-critical pipe	Timing for intervention prior to failure is not the focus, but there is a need to ensure that there is enough information available for short to medium term renewal planning.	Recommend quick review of pipes with preliminary grades 1, 2 and 3 and engineering assessment of pipes with preliminary grades 4 and 5.
Reactive Maintenance Inspections	These inspections are usually targeted to pipes with known problem areas or to determine what remedial or preventative action is required to be taken.	Review of all inspection reports and carry out remedial works as required.
Inspections before and after construction work over the pipe	A clear understanding of the pipe condition and potential for deterioration with changes to loading or adjacent works is required to inform decisions.	Recommend engineering assessment of all pipes inspected.
Inspection of new or lined pipe	Assessment for the acceptability of new or lined pipe is not based on the pipe condition grade.	Recommend assessment in line with section E3 of this manual

E2.5.3 Updating the Asset Management Information System (AMIS)

As noted in Section E1, Preliminary Condition Grading, the recording of 'Asset Condition' in any AMIS should clearly identify the source and basis of that grading as they are not the same. There should be clear delineation, within the AMIS, between the Preliminary Condition Grade and the Final Condition Grade. They are determined using different methods and should have a different interpretation for use in asset management decisions.

E3 Assessment of New and Lined Pipe

E3.1 General

CCTV inspection is increasingly specified in New Zealand as part of field testing and quality assurance inspections for newly installed or rehabilitated pipe. The Assessment of New and Lined Pipe is not based on scoring analysis and preliminary condition grade criteria, but instead on the assessment of any defects and whether they are within the acceptable serviceability limit of the pipe. This section provides guidelines for asset owners to help evaluate information provided by CCTV inspections and to enable them to differentiate between defects that are acceptable, defects that need repair, and defects that need further engineering assessment or further investigation.

The guidelines are based on the assumption that any new or lined pipeline shall achieve the asset owner's objectives by complying with the functional requirements set during the investigation and design stages of the project. The asset owner's objectives generally include, but are not limited to the following:

1. Not adversely affect the environment by:
    - Causing flooding
    - Contaminating or damaging receiving water courses
    - Contaminating groundwater
    - Causing odours or producing corrosive gases.
2. Structural integrity under design loads
3. Durability to achieve design life
4. Water tightness to specified level
5. Ability to be maintained as planned
6. Does not adversely affect adjacent soil, structures and utility services
7. Maintaining design flow.

Any defect which does not affect any of the above objectives would generally be classified by asset owners as acceptable, while defects that affect one of more would be classified as not acceptable.

This section of the manual refers to specific design and installation standards and industry guidelines. These references are provided for background and context to the acceptance guideline tables that are provided. Assessors should review the documents to understand the definitions, parameters and their interpretations as part of determining the final decision of acceptability.

E3.1.1 Limitation of available CCTV inspections

The information available from CCTV inspections is limited to an internal visual inspection of the pipe and associated structures within the physical limitations of the equipment (refer to Section A2). In particular, CCTV has significant limitations with quantifying dimensions inside the pipe, confirming water tightness and understanding the conditions outside the pipe that might affect its durability and future performance.

Man entry inspection of large diameter pipes can facilitate taking measurements, and undertaking some non-destructive testing, or sampling etc. However, this type of information is not able to be obtained from standard CCTV inspections.

E3.1.3 Minimum requirements for inspection observations

To allow assessors to best evaluate the real and potential effects of any defect it is important that the CCTV inspection captures a sufficient view and examination of the extent of all visible defects. CCTV Operators need to look for and clearly show the following in the CCTV footage:

- All manufacturing marks, stamps, writing, scratches or stains appearing on the pipe surface
- The location, position and full description and extent of longitudinal or circumferential cracks or marks
- Chipping or spalling of crack edges and whether it is a single or branching crack

- Signs of autogenous healing
- Evidence of infiltration
- Any signs of exposed reinforcement or products of steel corrosion
- Joint gap opening width or angular deflection
- Joint displacements
- Exposed joint seals and seal locations
- Ovality/deflection of the pipe
- Dimples, bulges and other reflective shapes in close fit liners

Where possible the CCTV inspection equipment used for the inspection of new pipe should have the capability to measure the width of joints gaps (type 2/v classification, refer to Section A2.5). As a minimum the equipment should have the capability to pan and tilt to observe the joints (type 2/iv classification, refer to Section A2.5)

E3.1.4 Safety in assessment

The Evaluation and Acceptance Criteria presented in Clauses E3.2.4 and E3.3.3 includes a list of possible defects that may require the Engineer to assure, so far as is reasonably practicable, if the defect in the pipeline involves any risk to the health and safety of persons who:

- Use or maintain the pipeline.
- Are normally in the vicinity, or exposed to the pipeline, or whose health and safety may be affected by an activity related to the pipeline.

To fulfil their responsibilities, assessors who identify such a risk must provide up-to-date information within their assessment, including but not limited to:

- Any risks or hazards identified in the pipeline, including the results of any further calculations or testing; and
- The necessary steps, training, monitoring, instruction or supervision needed to ensure that the pipeline is used without risks to health and safety.

E3.1.5 Additional inspections, information or assessments that may be required

Full evaluation of defects may require further investigations or additional information to be gathered and reviewed. This may include:

- Pressure tests (water tightness, low pressure air or vacuum)
- Ovality/Deflection inspections (laser profiling or proving pigs)
- Destructive material testing
- Hydraulic and structural design data, parameters or assumptions
- Plans and long sections of the installation to verify location and effect on other structures.
- Geotechnical and chemical tests of surrounding soil
- Test results on bedding materials and compaction results
- Understanding of the embedment material compaction methods and equipment
- Any notes in drain layer logs or pipes delivery sheets regarding factory repairs or acceptable pre-installation defects.
- Factory made marks identifying factory repairs.
- Any notes or information on post-installation repairs if any.
- Dates and conditions of installation
- Review of pre-rehabilitation CCTV inspections
- Measurement of pipe gradient and any variation of gradient
- Existence of dips where self-flushing gradients might not occur

E3.2 Assessment of new reinforced concrete pipes

The assessment of defects in this section is based on the Serviceability Limits for design and installation of concrete pipes and the definition of minor acceptable defects in new, as supplied, pipes defined in AS/NZS 4058:2007 Precast concrete pipe (pressure and non-pressure) for Steel Reinforced Pipes. Other documents include the Concrete Pipe Association of Australasia, (CPAA) guidelines and publications, and common installation and acceptance standards used in New Zealand, such as AS/NZS 3725:2007 Design for installation of buried concrete pipes and various Territorial Local Authority codes of practice.

E3.2.1 Specific requirements

Concrete pipes in New Zealand are manufactured to meet the requirements of AS/NZS 4058:2007. The structural design of pipes is optimised, by pipe manufacturers, to the most feasible design that meets the requirements of the 'standard' and controlled by factory testing. The following provides some background information on the basis for the acceptance criteria:

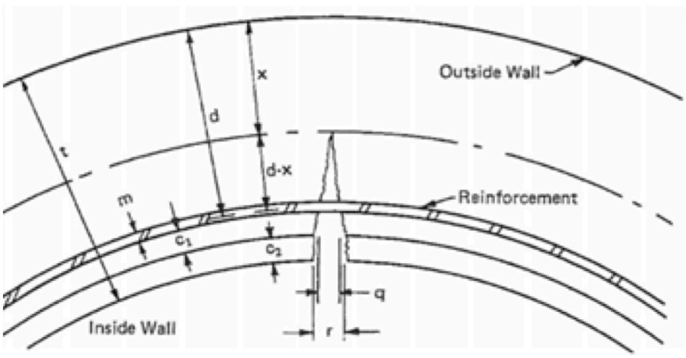
E3.2.1.1 Cracking

Concrete pipes are designed and installed to carry imposed loads by ring action only. The forces that are developed in the pipe by the imposed load are carried by the structural capacity of the steel reinforced pipe wall.

Longitudinal cracks

Pipes under service loads are designed to crack longitudinally within the internal face tension zone with a maximum crack width of 0.15mm for pipes with 10mm cover to the reinforcing. The allowable crack width increases proportionally with the increase of cover, as shown in the figure E3.1 below:

Figure E3.1 – Forces carried by "cracked" section reinforced concrete pipe wall (American Concrete Pipe Association (ACPA 1980)



Note: Longitudinal cracking transfers the stress in from the concrete to the steel reinforcement in the pipe wall.

Circumferential cracks

Concrete pipe has one, or two, layers of spiral structural reinforcement which is designed to develop the ring or hoop strength in the pipe. Longitudinal reinforcement is only used to hold the reinforcement cage in-place prior to concrete placement. AS/NZS 4058:2007 does not provide for any flexural resistance in the longitudinal direction, (beam action) other than the inherent flexural strength of the concrete section. Where there is an excessive load, or an unsupported span, stresses that exceed the tensile capacity of the section can occur and circumferential cracks will develop. Circumferential cracks are much less of a structural concern than longitudinal cracks. Crack acceptance is dependent on the width of the crack, the presence of ground water and the aggressive nature of the ground outside of the pipe.

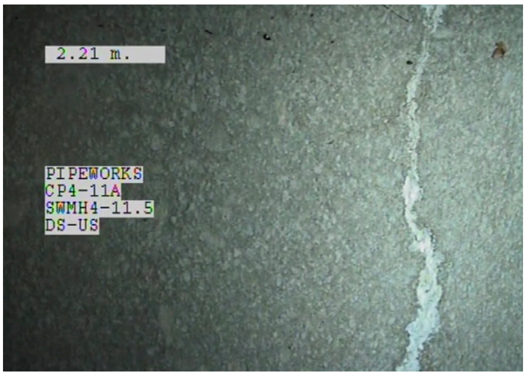
Multiple cracks

Multiple cracks in a restricted area are caused by an impact on the pipe, most likely because of construction equipment striking the pipe or compaction equipment used with insufficient cover. The assessment of these cracks can be made on the same basis as the circumferential and longitudinal cracks.

E3.2.1.2 Autogenous Healing

Concrete has the ability to repair or heal cracks in the presence of moisture. This process is known as autogenous healing. Water passing through cracks in concrete dissolves small amounts of calcium in the cement. It has been found that, given favorable conditions, the dissolved calcium will be deposited in the void spaces of the crack and eventually will seal them, and re-establish any lost structural integrity of the concrete structure. The autogenous healing process in concrete pipe is particularly common because the service conditions often provide an ideal environment for autogenous healing to take place. Autogenously healed defects, observed in CCTV inspection of concrete pipe, are considered acceptable unless the project specific or Asset Owners specification specifies otherwise.

Figure E3.2 – Autogenously healed crack



E3.2.1.3 Pre-Installation Defects

AS/NZS 4058:2007 allows the supply and installation of concrete pipes with minor defects with, or without, factory repair. When such defects are observed during inspection they shall be accepted unless otherwise specified.

Acceptable cracks in pipes prior to installation are defined by AS/NZS 4058:2007, clause 3.4.2.2 (a) which states: *"Clearly visible cracks not extending through the pipe wall, and whose width as determined by Appendix C of AS/NZS 4058:2007, at a depth of 3mm, is not greater than the values given in Table 1, except for sewage pipes and pipes intended for use in marine environments, the maximum crack width for a Type 1 defect is 0.10mm regardless of cover".*

Figure E3.3 – AS/NZS 4058:2007 Table 1: Maximum Width of Type 1 Cracks

Cover (mm)	Maximum acceptable crack width (mm)
10	0.1
>10 - 20	0.15
>20	0.2

AS/NZS 4058:2007 also accepts wider cracks after repair and/or repair and test. The pipes to site in this state should be clearly marked prior to delivery, such that they can be identified in the CCTV inspection. Where such cracks are observed in the CCTV inspection, they are considered acceptable, unless otherwise specified.

The Standard also accepts surface defects which are defined in Clause 3.4.2.2 (d) as: *"Dents, bulges, chips and spalls of depth or height not more than one quarter of the cover and extending in any direction not more than 50mm. Surface blow holes not exceeding 4mm in depth, or half the cover, whichever is the lesser, 10mm in diameter and distribution not exceeding that shown in Appendix B of AS 3610 for Class 1 finish in Australia and NZS 3114 Class F5 finish in New Zealand".*

AS/NZS 4058:2007 also accepts larger surface defects after repair and/or repair and test (and mark on the pipe prior to delivery). Where these are observed in the CCTV inspection, they are considered acceptable, unless otherwise specified.

E2.2.2 Post Installation Defects

E3.2.2.1 Joint Gaps

Joints are designed by pipe manufacturers with an allowance for a gap between pipes to provide flexibility at the joint for longitudinal movement and deflection. The values for the allowable joint gap vary, but pipe manufacturers can advise the maximum joint gap, or deflection angle, that will not breach the water tightness of the joint.

E3.2.2.2 Water Tightness

Watertight pipes are designed and factory tested to an allowable leakage rate. Therefore, even in a watertight system, it is not uncommon to have some infiltration observed during inspection of installed concrete pipes.

AS/NZS 4058:2007 does not require water tightness testing for Rubber Ring Jointed Stormwater Pipes, unless specified. Pipes joints and walls are only required to be soil/silt tight unless otherwise required by project specifications. Assessment criteria presented in this section recommends professional engineering assessment to verify specific project requirements regarding water tightness.

E3.2.3 Limitation of available inspection technology:

CCTV inspection equipment is not able to accurately measure crack widths to the accuracy required by the relevant standard. As the measurement of the crack width defines their acceptability, this is a significant limitation in the assessment of new concrete pipes. Incorrectly estimating crack widths may result in incorrect assessments. Appendix C, Notes on assessment of crack widths in reinforced concrete pipe, provides guidance on estimating crack widths from CCTV inspections.

E3.2.4 Reinforced Concrete Pipe Evaluation and Acceptance Criteria – Post Installation

Table E3.1 – Assessment of Cracks in New Reinforced Concrete Pipe Post Installation

Defect	Description	More Conditions	Acceptable	Engineering Assessment	Repair or Replace
Longitudinal Crack[3]	Less than 300mm long		✓		
	Autogenously healed		✓		
	Less than 0.15mm width	Full pipe section (joint to joint)	✓		
	0.15mm-0.5mm	Full pipe section (joint to joint)[1]		✓	
		Full pipe section & observed in more than one quadrant[1]		✓	
	0.5mm-1.0mm	Full pipe section (joint to joint)[1]		✓	
		Full pipe section & observed in more than one quadrants			✓
		In an aggressive environment			✓
	More than 1.0mm				✓
Circumferential Cracks[2,3]	Autogenously healed		✓		
	Less than 0.15mm width	Extending full pipe circumference	✓		
	0.15mm-0.5mm	Extending full pipe circumference	✓		
		Multiple circumferential cracks extended full pipe circumference and space less than D/2		✓	
	0.5mm-1.0mm	Extended full pipe circumference	✓		
		Multiple circumferential cracks extended full pipe circumference and spaced less than D/2			✓
		In an aggressive environment or where fine material has been used in the bedding and backfill		✓	
	More than 1.0mm			✓	
Multi-Directional Cracks[2]	Autogenously healed		✓		
	Less than 0.15mm width	Covers area < 25% of circumference of the pipe	✓		
	Less than 0.15mm width	Covers area > 25% of circumference of the pipe		✓	
	0.15mm-0.5mm	Covers area < 25% of circumference of the pipe		✓	
		Covers area > 25% of circumference of the pipe			✓
	More than 1.0mm				✓
All Crack Types[2]	Allow Infiltration	Damp surface only	✓		
		Water Beads on wall		✓	
		Flowing water		✓	
	Allow entry of backfill materials				✓
	Scaling and surface damage			✓	
	Spalling	No exposed reinforcement4		✓	
		Exposed reinforcement		✓	
	Slabbing				✓

Defect	Description	More Conditions	Acceptable	Engineering Assessment	Repair or Replace
All Crack Types[2] *(cont)*	Vertical or side offset of the crack faces	Impedes flow		✓	

1 Engineer to check design capacity and loading
2 Stormwater lines are generally designed with no water tightness requirements unless otherwise specified.
3 Refer to appendix C for guidance on assessment of longitudinal and circumferential crack widths.
4 Where the level of cover to reinforcement is within the criteria specified in AS/NZS 4058 then this can be assessed as acceptable.

Table E3.2 – Assessment of Joint defects in New Reinforced Concrete Pipe Post Installation

Defect	Description	More Conditions	Acceptable	Engineering Assessment	Repair or Replace
Joints with water tightness specified[1]	Open Joint	Within manufacturers acceptable limits	✓		
		Exceeds manufacturers acceptable limits		✓	
		Exposed joint seal			✓
		Allows infiltration or is stained		✓	
Joints with water tightness specified[1]	Open Joint	Allow entry of backfill materials			✓
	Joint with crack in sealing surface	< 0.5mm wide	✓		
		0.5mm - 1.0mm		✓	
		> 1.0mm			✓
Joints with water tightness specified[1]	Joints with chips or spall at the face	No exposed reinforcement	✓		
		Exposed Structural Reinforcement		✓	
	Angle at Joint	Within manufacturers acceptable limits	✓		
		Exceeds manufacturers acceptable limits		✓	
		Causing dip		✓	
	Vertical or horizontal offset	> 10mm		✓	
Joints with water tightness not specified	Open Joint	Within manufacturers acceptable limits	✓		
		Exceeds manufacturers acceptable limits	✓		
		Exposed joint seal	✓		
		Active infiltration or is stained	✓		
		Allow entry of backfill materials			✓
Joints with water tightness not specified	Joint with crack in sealing surface	< 0.5mm wide	✓		
Joints with water tightness not specified	Joint with crack in sealing surface	0.5mm - 1.0mm	✓		
		> 1.0mm		✓	
Joints with water tightness not specified	Joints with chips or spall at the face	No exposed reinforcement	✓		
Joints with water tightness not specified	Joints with chips or spall at the face	Exposed Structural Reinforcement		✓	
	Angle at Joint	Within manufacturers acceptable limits	✓		
		Exceeds manufacturers acceptable limits	✓		
		Causing dip		✓	
	Vertical or horizontal offset	> 10mm		✓	

1 Stormwater lines are generally designed with no water tightness requirements unless otherwise specified

Table E3.3 – Assessment of Pipe Wall defects in New Reinforced Concrete Pipe

Defect	Description	More Conditions	Acceptable	Engineering Assessment	Repair or Replace
Pipe Wall	Infiltration through Pipe Wall with water tightness not specified	Damp surface only	✓		
		Water Beads on wall	✓		
		Flowing water		✓	
		Aggressive Environment		✓	
	Infiltration through Pipe Wall with water tightness specified[1]	Damp surface only	✓		
		Water Beads on wall		✓	
		Flowing water			✓
		Aggressive Environment			✓
	Staining and efflorescence	Staining associated with acceptable cracks	✓		
		Staining associated with acceptable infiltration	✓		
	Staining and efflorescence	Staining associated with unacceptable cracks or infiltration		✓	
		Staining with no crack or infiltration	✓		
Pipe Wall	Staining and efflorescence	Staining associated with unacceptable cracks or infiltration		✓	
		Staining with no crack or infiltration	✓		
Pipe Wall	Spall or hole in wall	Within manufacturers acceptable limits	✓		
		Exceeds manufacturers acceptable limits		✓	
		Exposed Reinforcement		✓	
		Allow infiltration or is stained		✓	
		Allow entry of backfill materials			✓
	Surface defects	Within manufacturers acceptable limits	✓		
		Exceeds manufacturers acceptable limits		✓	
Pipe Wall	Surface defects	Exposed Reinforcement		✓	
		Slabbing			✓
		Allow infiltration or stained		✓	
		Exposed aggregates	✓		

1 Stormwater lines are generally designed with no water tightness requirements unless otherwise specified

E3.3 Assessment of New Plastic Pipe

The classification of defects in this section will be based on the Serviceability Limits for design and installation of plastic pipes. Plastic pipes in this context includes the following pipe materials:

- Polyvinyl Chloride (PVC-U),
- Polyethylene (PE)
- Polypropylene (PP)
- Glass Filament Reinforced Plastics (GRP)

The structural design and installation of buried flexible pipelines is covered by several standards and technical guidelines including:

- AS/NZS 2566.1, Buried flexible pipelines, Part 1: Structural design
- AS/NZS 2566.2 Buried flexible pipelines, Part 2: Installation
- AS/NZS 2032 Installation of PVC Pipe Systems
- AS/NZS 2033, Installation of Polyethylene Pipe Systems
- Plastics Industry Pipe Association of Australia (PIPA) Technical Publications and guidelines
- Territorial Authority codes of practice.

E3.3.1 Specific Requirements

The following provides some background information on the basis for the acceptance criteria:

E3.3.1.1 Deflection/Deformation

All buried flexible pipes, including plastics, utilise support from bedding and surround material, to resist buried structural loads, whilst maintaining suitable Factors of Safety for vertical deflection, pipe strain, and dimensional stability.

The deformation of flexible pipes is much more dependent on the quality and compaction of the bedding (beneath the pipe), and the embedment layer (from the top of the bedding to the top of the overlay), than for rigid pipes, such as concrete. While the tests described in this section measure the deformations that have actually occurred this is also an indication of the extent to which the relevant specification for bedding and backfilling (materials, compaction effort, trench width, etc.) have been observed by the installer. While cracking of rigid pipes is relatively easy to observe with CCTV the deformation of flexible pipes is not. The CCTV will not show obvious signs of deformation when deformation is at or close to the short-term allowable limits.

AS/NZS 2566.2, specifies for the maximum allowable short term (30 days) vertical deflection. These values are laid out in Table 5.6 of AS/NZS 2566.2. Where measurements are made over a period different to 30 days following installation, Table 6.2 of AS/NZS 2566.2 provides for adjustment factors that are applied to the values in Table 5.6.

The allowable short term vertical deflections only apply where the cross-section of the pipe deforms 'elliptically'. Values exceeding the maximum allowable values requires specific engineering assessment to determine acceptability.

Figure E3.4 – Extract of Part of Table 5.6, AS/NZS 2566 Part 2 Installation, Deflection Control Criterial – Allowable Vertical Deflections

Plastic pipe materials	Maximum allowable short-term vertical pipe deflection at 30 days Δy sall %
GRP	4.1
PE 80, PE100, PP-B, PVC-U, PVC-M, PVC-O	5.0

Note: The diameter on which the deflection criteria are based is the pipe wall neutral axis diameter. For practical purposes the mean internal diameter may be used.

Figure E3.5 – Table 6.2, AS/NZS 2566 Part 2 Installation, Time Factors for Deflections (to adjust allowable 30-day deflections given in Table 5.6)

Time interval	Factor
24 hours	0.7
3 days	0.75
7 days	0.85
14 days	0.95
30 days	1.0
3 months	1.1
1 year	1.2
2 years	1.3

Notes: Factor values may be interpolated for intervening time period between 24 hours and 2 years, e.g. for 10 days = 0.85 + ((0.95 – 0.85) x 3/7) = 0.89.

E3.3.1.2 Water Tightness

AS/NZS 2566.2 does not require leakage testing for stormwater pipes, unless specified by Territorial Local Authority codes of practice. For wastewater non-pressure pipes, the standard requires that the plastic pipes do not leak and outlines various leakage test methods and acceptance criteria. On this basis non-pressure wastewater pipes, and stormwater pipes where specified, should not have any observable infiltration through joints and fittings. For plastic stormwater pipe where leakage testing is not specified, infiltration may be observed during the inspection but the assessment criteria presented in this section recommends that professional engineering assessment is undertaken to verify specific project requirements regarding silt tightness.

E3.3.1.3 Joint Gaps

Jointing of PVC shall be undertaken in accordance with AS/NZS 2032 and jointing of PE pipe shall be in accordance with AS/NZS 2033.

Elastomeric joints between pipes are designed by pipe manufacturers with an allowance for a gap between the end of the pipe spigot and the bell of the pipe socket, which allows for joint movement from thermal or seismic causes, and ground settlement. Axial deflection of a joint between pipe to pipe or pipe to fitting, is limited to a specified maximum angle, which varies with joint design, Standard and the depth of insertion of the assembled joint. The value for the allowable joint gap is determined by the position of, and assembly to, the witness mark on the outside of the pipe. Elastomeric joints for PVC pipe to pipe are usually assembled to a witness mark allowing a clearly defined end gap. PVC pipe to fitting joints are normally assembled "fully home" and the end gap will be minimal.

For elastomeric joints, AS/NZS 2566.2 states that a "witness mark is normally positioned on the spigot by the manufacturer to show the optimum insertion depth". This witness mark is not visible on the inside of the pipe, but the pipe manufacturer can advise the maximum and minimum internal joint gap for optimum insertion depth for the joint. The visible gap on the inside of the pipe, in a CCTV image, should be "calibrated" by reference to external examination of the proper "assembled to witness mark" of similar assembled joints.

The maximum allowable axial deflection angle permitted for a joint type can be advised by the pipe manufacturer. This is not readily directly measured by CCTV but an indication of the deflection can be derived from the different joint gap on the inside vs the outside of the deflected joint.

Where the joint gap or angular deflection is not within the specified value provided by the manufacturer, then it is recommended that an engineering assessment is undertaken to determine whether this presents any performance problems.

Where the spigot has been forced past the back of the socket into the barrel of the adjoining pipe, either due to a deflected joint or over-insertion, this is unacceptable and would need to be repaired or replaced.

Metal-banded flexible couplings complying with AS/NZS 4327, or as specified by Territorial authority codes of practice, may be installed to join PVC or PE pipes (or fittings) to pipes (or fittings) of other materials having the same or similar nominal diameter.

E3.3.1.4 PE Welds

The examination and testing of PE pipe welds is based on visual and destructive testing methods. The techniques and acceptance criteria for welded PE pipe (Electrofusion and Butt fusion) based on CCTV inspection uses only visual methods covered in PIPA industry guideline POP014 Assessment of Polyethylene Welds.

E3.3.1.5 Pre-Installation Defects

AS/NZS 2566.2 clause 3.2 (e)(ii) Acceptance Criteria, allows the supply and installation of plastic pipes with minor defects, stating: *"PE/PP/PVC – Cuts or scratches on pipes or fittings shall be within the limits specified in the relevant product standard or relevant material-specific installation standard"*. The clause in the standard refers to external examination, but the acceptance criterion provided in this section also applies to defects observed on the inside pipe wall. When such defects are observed during CCTV inspection they shall be accepted unless otherwise specified.

Both AS/NZS 2032 and AS/NZS 2033 also specify allowable pre-installation surface damage limits.

- AS/NZS 2033 Installation of PE pipe systems, clause 3.3.3 Fitness for use, allows PE pipe external damage up to 10% of the wall thickness, but prohibits kinks in the pipe.
- AS/NZS 2032 Installation of PVC pipe systems, clause 3.3.3 Fitness for use provides a set of criteria for acceptance of pre-installation damage including spigot end ovality. This criterion is set out in Table 3.1 Allowable Limits of Ovality and Surface damage.

Figure E3.6 – Table 6.2, AS/NZS 2566 Part 2 Installation, Time Factors for Deflections (to adjust allowable 30-day deflections given in Table 5.6)

Pipe and fitting type (non-pressure)	Allowable ovality	Allowable damage to external surfaces	
		Pipe and fitting not including the sealing surface	Sealing surface (note 2)
Plain Walled	4.5%	10% of wall thickness	Nil (note 3)
Plain walled (SN 16)	3.0%	10% of wall thickness	Nil
Sandwich construction	4.5%	10% of wall thickness to a maximum of the inner or outer solid wall thickness	Nil
Ribbed and profile wall	5.0%	10% of wall thickness and/or a maximum of 2 consecutive broken ribs	Nil to socket

Notes:
1. Ovality expressed as a percentage of OD.
2. Specific limits applicable only to elastomeric sealed joints
3. In this context 'Nil' equates to no observable damage when viewed without magnification. This means gouges and scores are not acceptable but fine scratches can be tolerated.

AS/NZS 2566.2, Section 3.3 Acceptance After Rectification also states: "For acceptance, rectification of damage or defects in pipeline components shall be in accordance with methods, approved by the specifier, that ensure a service performance at least equivalent to that of undamaged components." Where these repairs are observed as part of the CCTV inspection should be accepted.

Internal "Waviness" or cosmetic "rippling" seen in PVC gravity or pressure pipes of thick wall or large diameter is normal and does not constitute any fault to the pipe or its performance.

Figure E3.7 – Example of 'normal' internal waviness in PVC-U pipe

E3.3.1.6 Dip, Obstructions and Debris

Pipes and fittings shall also be inspected to ensure they are free of obstructions and foreign materials, which might interfere with the performance of the pipeline, and be cleaned if necessary. Any dips identified in the pipe should be assessed for the hydraulic performance.

E3.3.2 Additional Inspections

1. Deflection (deformation) testing. Buried pipe ovality can be measured using the following addition inspections:

- Laser or sonar profiling (All pipe diameters)
- Pipeline pigging (< 750mm diameter). Prover testing in accordance with Appendix O, AS/NZS 2566.2
- Person entry measurements (≥ 750mm diameter). Measurements in accordance with Appendix O, AS/NZS 2566.

2. Dips and variation in the gradient are a common concern. CCTV by itself may not indicate the presence of gradient variation.

- Evidence may be by estimation of the depth of standing water
- The use of an inclinometer
- Use of a Profilometer.

3. The assessment of PE welds by internal inspection is limited by what can be seen by the CCTV equipment and quantified. External visual Inspection of butt or fusion welds prior to installation provides a lot of information that may not be able to be determined from an internal visual inspection alone, including any external cracking or notching, measurement of any angular misalignment, melt indicator pins and the extent of surface preparation. Destructive Testing of Butt and fusion welds as outlined in the Standards and Guidelines provide additional assessment. Some specifications may require the removal of any internal weld bead. This will usually require use of a remote cutter and careful inspection will be required to ensure any scratching or scouring of the pipe adjacent to the weld removal is acceptable.

E3.3.3 Plastic Pipe Evaluation and Acceptance Criteria

Table E3.5– Assessment of Pipe Wall defects in New Plastic Pipe Post Installation

Defect	Description	More Conditions	Acceptable	Engineering Assessment	Repair or Replace
Pipe Wall	Deformation	Vertical deformation (elliptical) within allowable limits	✓		
		Vertical deformation (elliptical) Exceeding allowable limits		✓	
		Horizontal deformation (elliptical) within or exceeding allowable limits		✓	
		Non-Elliptical (Bulge) deformation		✓	
		Post-installation ovality of barrel and joints of PVC pipe within allowable limits	✓		
		Post-installation ovality of barrel and joints of PVC pipe exceeding allowable limits		✓	
		Buckling			✓
		Corrugation Growth (Profiled pipes)			✓
	Surface defects	Cuts or scratches on pipe wall within acceptable limits	✓		
		Cuts or scratches on pipe wall exceeding acceptable limits		✓	
Pipe Wall	Dips	Dip < 10% of pipe diameter	✓		
		Dip ≥ 10% of pipe diameter		✓	
		Dip > 25% of pipe diameter			✓
	Obstructions or foreign materials				✓

Table E3.5 – Assessment of Pipe Joint defects in New Plastic Pipe Post Installation

Defect	Description	More Conditions	Acceptable	Engineering Assessment	Repair or Replace
Elastomeric and Solvent Cement Joints	Open Joint	Within manufacturer’s acceptable limits	✓		
		Exceeds manufacturer’s acceptable limits		✓	
		Over insertion of the spigot (less than acceptable limits)		✓	
		Over insertion of the spigot (forced past the back of the socket)			✓
		Exposed joint seal			✓
		Allows infiltration or stained1			✓
		Allows entry of silt			✓
	Angular Deflection (Elastomeric Joints)	Within manufacturer’s acceptable limits	✓		
		Exceeds manufacturers acceptable limits		✓	
		Exposed joint seal			✓
		Allow infiltration or stained[1]			✓
		Allow entry of silt			✓
	Angular Deflection (Solvent Cement Joints)				✓
Elastomeric and Solvent Cement Joints	Vertical or horizontal displacement				✓
Metal-banded flexible couplings	Open Joint	Within manufacturer’s acceptable limits	✓		
		Exceeds manufacturer’s acceptable limits		✓	
	Angular Deflection	Within manufacturer’s acceptable limits	✓		
		Exceeds manufacturer’s acceptable limits		✓	
	Vertical or horizontal displacement	Within manufacturer’s acceptable limits	✓		
		Exceeds manufacturer’s acceptable limits		✓	
		Allows infiltration or stained[1]			✓
		Allows entry of silt			✓

1 Stormwater lines do not require leakage testing unless otherwise specified

Table E3.5 – Assessment of PE weld defects in New Plastic Pipe Post Installation

Defect	Description	More Conditions	Acceptable	Engineering Assessment	Repair or Replace
Butt Fusion Welds	Cracking	Cracking of any kind anywhere in any direction			✓
	Scoring or Notching other than at interface	Notching or scoring in any direction ≤ 10% of pipe wall thickness	✓		
		Notching or scoring in any direction > 10% of pipe wall thickness		✓	
	Displacement	Where pipe ends are displaced relative to one another ≤ 10% of wall thickness	✓		
		Where pipe ends are displaced relative to one another > 10% of wall thickness			✓
	Angular misalignment	Where pipe ends are not aligned squarely ≤ 5mm at 300mm distance from weld bead	✓		
Butt Fusion Welds	Angular misalignment	Where pipe ends are not aligned squarely > 5mm at 300mm distance from weld bead		✓	
	Blistering, bubbles or lumps on the weld bead			✓	
	Undesirable bead profiles[1]	Weld bead too narrow or undersized		✓	
		Weld bead appears flat		✓	
		Uneven bead size		✓	
Electrofusion Welds	Melt run out	Exceeds manufacturer's acceptable limits			✓
	Misalignment	Next pipe segment appears to have angular deflection ≤ 1.2 degrees	✓		
Electrofusion Welds	Misalignment	Next pipe segment appears to have angular deflection > 1.2 degrees		✓	
	Ovality and "flat areas"	Deformation of pipe end may cause an observable gap. Deformation within acceptable limits	✓		
		Deformation of pipe end may cause an observable gap. Deformation exceeds acceptable limits		✓	
	Incorrect insertion	Within manufacturer's acceptable limits	✓		
		Exceeds manufacturer's acceptable limits			✓

[1] Applies where the internal bead has not been removed

E3.4 Assessment of Newly Installed Lined Pipes

The acceptance criteria in this section is based on the Serviceability Limits for design and installation of lined pipes. The following lining methodologies are covered in this guideline:

- Cured In Place Pipe (CIPP). This includes fully lined pipes, patches (No Dig Spot Repairs, NDSR) and Lateral Junction Repairs (LJR).
- Spiral Wound Pipe. This includes all pipe rehabilitation installed by locking a profile inside an existing pipe.
- Fold and Form liners. These are typically PVC liners, folded to fit into the pipe then re rounded (inflated) to the final shape.

The structural design and installation of lined pipelines is covered by several standards and technical guidelines including:

- AS/NZS 2566.1, Buried flexible pipelines, Part 1: Structural design
- ASTM F1216-09 Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube
- ASTM F1714-08 Standard Practice for Installation of Machine Spiral Wound Poly (Vinyl Chloride) (PVC) Liner Pipe for Rehabilitation of Existing Sewers and Conduits
- ASTM F1947-10 Standard Practice for Installation of Folded Poly (Vinyl Chloride) (PVC) Pipe into Existing Sewers and Conduits
- Territorial Authority codes of practice and specifications.

Note: This section does not cover HDPE or PVC lined concrete pipe. Refer to manufacturers specification for testing/inspection requirements.

E3.4.1 Specific Requirements

The assessment of lined pipe is different to that of 'new' pipes. One of the key reasons for the differences is that lined pipes are installed inside another 'host' pipe that sometimes has significant defects, (referred to as latent defects) which can be reflected in the newly lined pipe as bulges, deformations, reduced dimensions, dips or depressions and are not considered to be liner defects.

The material properties of pipe liners and the effect that live flows can have on the appearance of the liner surface can also be quite different to non-lined pipe.

Because of these differences this guideline sets out the specific requirements and interpretations of CCTV inspection that need to be considered for the assessment of lined pipe. Refer to Appendix D, Notes on Identifying Latent defects and features in Trenchless Liners.

The following provides some background information on the basis for the acceptance criteria:

E3.4.1.1 Deformation/Deflection

As with Plastic pipes, lined pipe relies primarily upon side support to resist vertical loads without excessive deformation. Where the existing pipe is not structurally sound, the liner is designed to take the full soil, surcharge and live loads. The basis for the design of liners depends on the type of liner installed:

Spiral wound liners are designed as a circular profile and utilise ANS/NZS 2566.1. Some deformation of the liner under load conditions is acceptable. AS/NZS 2566.2, provides for the maximum allowable short term (30 days) vertical deflection. These values are laid out in Table 5.6 and 6.2 of AS/NZS 2566.2, (refer to tables E3.4 & E3.5).

Where the existing pipe is deformed, prior to lining, the external diameter of the spiral wound pipe will be installed as a circular pipe, but the diameter will be reduced to fit the minimum dimension available. Where an annular space exists between the spiral wound liner and the existing pipe wall, then this space may need to be filled with grout to ensure even load transfer to the liner. The reduced diameter of the liner is acceptable if it is equal or larger than the minimum diameter required for the hydraulic performance of the pipe.

CIPP and Fold and Form liners are designed to be in contact with the existing pipe wall, which may have lost its circular profile and be deformed. The deformation of the existing pipe will be reflected in the liner, which will appear deformed in the post installation CCTV inspection. The design of CIPP and Fold and Form liners need to allow for any pre-existing deformation/ovality. This observed deformation is acceptable where the ovality is within the parameters used in the structural design for the liner material, and the internal diameter is equal to or greater than the minimum diameter that is required.

E3.4.1.2 Other Latent Defects in Liners

Installed liners must be continuous over the entire length of the installed liner (including host pipe joints) and variation from the true line and grade, or reflected shapes are acceptable provided they are within acceptable limits. The type and extent of acceptable defects or obstructions in the existing pipe vary dependant on the lining methodology:

Spiral Wound Liners. Obstructions will lead to a reduction in the diameter of the liner. Dips, although maybe partially reduced, will also remain and may lead to reduction in the finished internal diameter. The reduced diameter is acceptable if it is equal or greater than the minimum required diameter for that pipe. A review of the pre-lining CCTV inspection may be required to confirm presence of latent defects that would cause the diameter reduction and whether pre-lining repairs were required.

CIPP and Fold and Form liners. Variation from true line and grade maybe inherent because of the condition of the existing pipe. The liners should conform to the existing pipe wall, evidenced by the profile of any broken pipe, holes, open or displaced joints and other irregularities mirrored in the liner material. It may be necessary to review pre-lining CCTV footage to confirm any bulges up to 10 % to 15% of the pipe diameter are related to latent defects in the existing pipe and not liner defects. Latent defects such as obstructions, protrusions and displacements greater than 10% (pipes ≤ 500mm diameter) or 5% (> 500mm diameter), or are positioned within the invert would normally be removed prior to lining.

Where the liners are bulged, or detached from the pipe wall that is not because of acceptable latent defects, then these are defects of the liner and would not be considered acceptable.

E3.4.1.3 Liner Defects

Assessment of acceptability of liner defects requires understanding the cause of the defect and the effect of the defect on the strength, durability and service performance. Defects may be because of pre-installation issues, during installation/inversion, or pipe configuration.

CIPP liners should be free from 'dry spots', (insufficient resin impregnation or washout) lifts including detachments or bulges (insufficient curing, heat sinks or cleanliness of the existing pipe) or blisters, (excessive curing temperatures or resin curing problems) all of which affect the strength of the liner.

Wrinkles and fins occurring due to dimensional variations in the existing pipe, or at bends, may be acceptable depending on their circumferential position and size. In general, circumferential wrinkles that obstruct the flow would not be accepted. If positioned clear of the normal flow these may be acceptable up to 10% of the pipe diameter. Longitudinal wrinkles, or fins greater than 10% of the pipe diameter would require further engineering assessment to determine acceptability.

E3.4.1.4 Water Tightness

Liners should not allow ground water infiltration. Liner defects that allow ground water infiltration include pin holes in the liner material or stitching/seams, defective joints or welds and separated spiral joints. Leakage may be seen in a CCTV inspection as active infiltration or staining where the ground water has discoloured the liner material.

As staining of the liner material may be due to factors other than ground water infiltration, care is required in identifying leakage correctly (refer to Appendix D for further guidance).

E3.4.1.5 Lateral Connections

All 'live' lateral connections shall be accounted for, re-opened and free of obstructions.

For wastewater pipes, or where specified in stormwater pipes, the annulus at the lateral opening should be sealed by installation of a LJR/LCR or hand placed epoxy mortar.

E3.4.1.6 Liner Terminations in Manholes

Liners are not bonded to the existing pipe wall. They are a 'close fit' to the pipe wall; in contact, but with no adhesion. As a result, there is an annulus which can allow ground water or roots, passing through defects in the host pipe, to enter the manholes by tracking between the host pipe and the liner. To ensure that there is no ground water infiltration it is important that a 'seal' is constructed between the liner, host pipe and the manhole wall following the liner installation.

This seal is constructed with a non-shrink epoxy mortar. There should not be any visible gaps or cracks in this seal. In larger pipes the annulus may be grouted but this does not necessarily provide a complete sealing of the gap, and sealing of the termination is still important.

In addition to the creating a seal, the mortar offers two other functions:

- A transition or 'ramp' at the liner interface in the manhole – the liner internal diameter is smaller than the existing pipe, so a step is created in the channel invert. A mortar ramp smoothly transitions the flow from the channel into the liner. Ideally this ramp would have at least a 1 in 2 slope, but a 1 in 1 is acceptable to prevent debris building up.
- Provides a smooth and tidy surface within the manhole that prevents paper or other material catching or building up around the entrance to the liner.

Figure E3.8 – Examples of Liner termination seals (end seals) in manholes

Good example of an end seal and transition in a Spiral Wound pipe.

Good example of an end seal and transition for a CIPP liner.

Liner termination is sealed but there is excess mortar causing rough entry and an obstruction

Excess mortar on end seal affecting the transition between the channel and the liner causing an obstruction to the flow

E3.4.2 Additional Inspections that may be Required

1. Deflection (deformation) testing. Pipe deformation/ovality in liners can be measured using the following addition inspections:
    - Laser or sonar profiling
    - Pipeline Pigging (< 750mm diameter). Prover testing in accordance with Appendix O, AS/NZS 2566.2
    - Person entry measurements (≥ 750mm diameter). Measurements in accordance with Appendix O, AS/NZS 2566.2
2. The assessment criteria in this section is based on an internal visual inspection. To verify the CIPP material properties such as the short term flexural and tensile properties and confirming liner thickness, samples of the liner material should be taken and tested in line with ASTM F1216-09 section 8, Inspection practices. Similarly, for Fold and Form, measuring and confirming the rounded wall thickness as per ASTM F1947-10 clause 7.3 Field Sampling.

E3.4.3 – Lined Pipe Evaluation and Acceptance Criteria

Table E3.5 – Assessment of Lined Pipe

Defect	Description	More Conditions	Acceptable	Engineering Assessment	Repair or Replace
Deflection / Deformation	Existing pipe deformed	Minimum internal diameter Spiral Wound liner ≥ minimum required	✓		
		Minimum internal diameter Spiral Wound liner < minimum required			✓
		Ovality of CIPP/Fold and Form Liner ≤ Design parameter	✓		
	Deformed Liner	Vertical deformation (elliptical) within allowable limits	✓		
		Vertical deformation (ovality) Exceeding allowable limits		✓	
		Buckling, bulges and lifts			✓
Latent Defects	Protruding Reflective shapes	Obstructions, protrusions and displacements in the existing pipe ≤ allowable size	✓		
		Obstructions, protrusions and displacements in the existing pipe > allowable size		✓	
	Concave Reflective shapes	Dimples in CIPP/Fold and Form Liners	✓		
	Dips	Dip not requiring pre-lining repair	✓		
		Unacceptable dip not removed prior to liming			✓
		Minimum internal diameter Spiral Wound liner ≥ minimum required	✓		
		Minimum internal diameter Spiral Wound liner < minimum required			✓
Liner Wrinkles	Circumferential Wrinkles	Above flow level ≤ 10% pipe diameter	✓		
Liner Wrinkles	Circumferential Wrinkles	Above normal flow level > 10% pipe diameter		✓	
		Above normal flow level > 25% pipe diameter			✓
		Within normal flow level >5% pipe diameter			✓
	Longitudinal Wrinkles	Wrinkle/Fin ≤ 10% pipe diameter	✓		
		Wrinkle/Fin > 10% pipe diameter		✓	
		Wrinkle/Fin > 25% pipe diameter			✓
	Multiple Wrinkles		✓		
Dry Spots					✓
Discontinuities		Gaps or sections of the liner not present (existing pipe is visible)			✓
Water Tightness		Active infiltration (any severity) or staining from infiltration			✓
		Manhole termination seals not installed or has gaps			✓
Surface damage	CIPP	Scuffing/scratches on Sacrificial Poly Urethane (PU) layer (or PU layer peeling)	✓		
		Scuffing/scratches deeper than Sacrificial PU layer (>2mm)		✓	

Defect	Description	More Conditions	Acceptable	Engineering Assessment	Repair or Replace
Surface damage *(cont)*	All Liners	Holes drilled/cut or overcuts without repair			✓
		Holes drilled/cut or overcuts repaired by approved method	✓		
Lateral Connections		Open and without obstruction or reduction in lateral diameter ≤ 15%	✓		
		Open but with obstruction or reduction in lateral diameter > 15%		✓	
		Lateral branch liner does not extend past first joint			✓

F1 Ground Water Infiltration Source Detection

F1.1 Introduction

The management of Infiltration and Inflow (I/I) is an issue commonly associated with gravity wastewater networks.

Wastewater networks are typically designed to accommodate the normal wastewater flows from customers, plus additional flows arising from the infiltration of groundwater and the inflow of rainfall. If the groundwater and rain related flows are excessive the network may suffer overflows, capacity provided for growth might not be available, treatment and pumping capacity is overwhelmed, and/or the system might not comply with a range of performance targets and consents.

The analysis of I/I, and the best approach to managing these flows, is a complex task that is extensively covered in the Infiltration and Inflow Control Manual (I/I Manual) published by WaterNZ.

This section covers aspects of pipe and manhole inspections related to the investigation and detection of sources of ground water infiltration through pipe defects. The intention of this section is to provide guidance to Asset Managers, Planners and Engineers on the use of pipe inspection methodologies that are available, in relation to section 13.2 of the I/I Manual. Inflow source detection is not covered here as investigations for inflow largely relate to non-pipe inspection methods.

F1.2 Overview

The I/I Manual covers five fundamental stages of an I/I control strategy:

Stage 1 *Flow Management and Analysis*

Stage 2 *I/I Source Detection*

Stage 3 *Rehabilitation or Treatment*

Stage 4 *Post Rehabilitation Monitoring and Analysis*

Stage 5 *I/I Reduction Effectiveness Assessment*

Source detection is typically undertaken on public and private wastewater assets within a mini-catchment quantified under Stage 1 as having KPI values indicative of being 'leaky' and suitable for I/I reduction treatment. *Stage 2, I/I Source Detection*, includes investigations aimed at better understanding the nature and sources of I/I to enable the assessment and prioritisation of the most appropriate rehabilitation or treatment method. The chosen method is implemented within the Stage 3 rehabilitation works.

Stage 2: I/I Source Detection is the focus of this section.

F1.3 Infiltration Source Detection Investigations

The general methods of Source Detection are outlined in table 13-1 within section 13 of the I/I Manual.

Commonly used sewer leakage assessment methods, such as exfiltration testing, can be cost effective methods to provide an overall Pass/Fail assessment. However, their inability to provide the location and size of leaks, particularly individual joints or service connections, limits their use in remediation and rehabilitation decision support.

Likewise, methods such as CCTV inspection, are limited in their ability to determine the 'leakiness' of individual assets for prioritisation of rehabilitation work or determine a Pass/Fail status.

Source Detection Investigations can be considered under 3 different types of investigation (Types 1, 2, 3). Each Type of investigation provides different levels of information on sources of ground water infiltration.

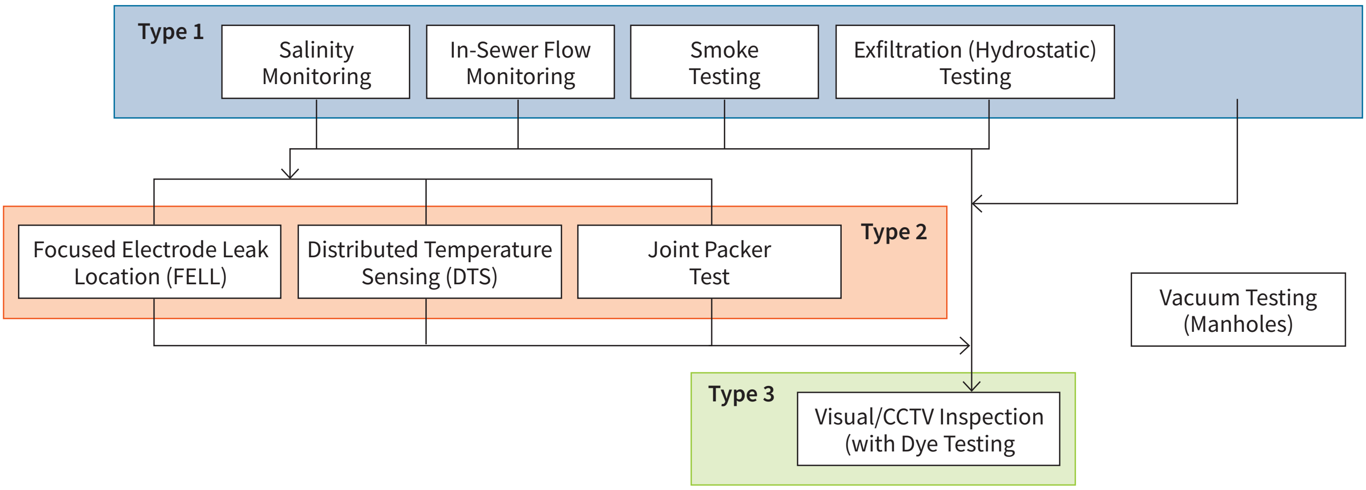
Type 1 Investigations provide information quantifying the level of infiltration contribution of the asset. The general basis for achieving a pass/fail investigation result, except for Smoke Testing, is measurement of the rate of infiltration. Type 1 Investigations can confirm that infiltration can occur but cannot not provide information on the location of this within the asset.

Type 2 Investigations provide information on where ground water can infiltrate, but generally cannot accurately quantify the leakiness of the source and cannot confirm the type of defect or its condition.

Type 3 Investigations cannot quantify leakage or confirm the source of the infiltration (unless active infiltration is occurring, or there is clear evidence of infiltration), but can provide information on the type of defects (and severity) and their location within the pipe.

Figure F1.3 shows the methods, and Types, as a process plan. This provides an indicative approach to the implementation of the investigation methods, starting from quantification (Type 1) through to defect identification (Type 3). Source detection investigations do not require the Types to be completed in a sequential manner and investigations can start at any relevant type. However, the extent of information may be limited, as described above.

Figure F1.3 – Infiltration Source Detection Pipe and Manhole Investigation methods



The following table (Table F1.1) provides commentary on the source detection investigation methods and their use for investigation in publicly and privately-owned wastewater assets.

Table F1.1 – Assessment of Cracks in New Reinforced Concrete Pipe Post Installation

Type	Method	Description	Best Suited for	
			Public	Private
1	Salinity Monitoring	Conductivity testing to detect tidal/seawater infiltration into the sewer. Effective method to determine possible source of infiltration in coastal locations.	✓	×
1	In-Sewer Flow Monitoring	Flow measurement in manholes within mini-catchments to identify/filter sections of pipe with highest levels of I/I.	✓	×
1	Smoke Testing	Defect identification via smoke emission from ground. Affected by soil type and ground water tables. Difficult to determine the location of defects in public or private sewer. Best suited for identifying sources of inflow such as illegal cross connections.	✓	✓
1	Exfiltration (Hydrostatic) Testing	Limited application in public pipelines as it is difficult, or costly, to isolate lateral connections. Without isolating the laterals, it is not possible to determine if leakage is from the mainline or laterals (or both). Care required when testing EW pipes to limited test head to no more than 2.5m. Best suited to testing private laterals (to the lowest gully trap) or manholes.	✓	✓
1	Vacuum Testing	Infiltration testing of manholes. Does not require large quantities of water and uses lower pressure than hydrostatic testing.	✓	
2	Focused Electrode Leak Location (FELL)	Can be used on all pipe sizes and materials (up to 1500mm diameter), provided there is no obstruction to prevent the probe from passing through the pipe. Not suitable for use in the inspection of manholes. Can detect a hole of 0.5% of the pipe diameter (i.e. <1mm in a 150mm diameter pipe) and identify individual near-by leaks if separated by more than 25% of the pipe diameter. The data may be able to be processed to determine small, medium or large leaks. New Technology and may be limited by equipment availability.	✓	✓
2	Distributed Temperature Sensing (DTS)	ocation of groundwater leaks, through pipe wall, joints and laterals, by measurement of the change in relative temperature along the length of a temperature sensitive fiber optic cable, inserted up to 2km within the sewer. Groundwater discharges from laterals is indicated by the location of lateral coinciding with change in temperature but location and nature of defects in the lateral is not provided.	✓	×
3	Visual Inspection	Visual identification of active leaks, or defects in pipes and manholes that would potentially allow ground water infiltration. Inspections may reveal water flowing through holes, cracks and joints at rates that vary from seeping to gushing. However, this only reflects what was occurring at the time of the inspection. It may not reflect what is occurring when it is raining, when tide/river levels are high, or when winter groundwater levels are elevated. It is unable to measure the volume of infiltration or confirm that defects or features do not leak even if there is no visual evidence available (e.g. staining). Dye testing during the inspections to identify 'live and dead' lateral connections should be undertaken.	✓	×
3	CCTV Inspection		✓	✓

F1.4 Use of CCTV Inspection for Infiltration Source Detection

If excessive volumes of infiltration have been measured in a wastewater drainage network, then as discussed in section F1.3, CCTV inspection can be usefully employed as a tool to confirm some of the suspected sources of this.

By itself, a CCTV inspection, (a Type 3 source detection investigation) does not provide any robust information about overall flow rates and how these vary during rain events, or by season. Nor does it provide an accurate measure of the flow rates at the time of inspection. Essentially the CCTV inspection is being used to confirm whether or not the condition of the assets is consistent with the asset owner's understanding of how I/I Is occurring. This should influence the planned rehabilitation or other treatment. If consideration is being given to sealing/lining the public or private pipes the CCTV pipe inspection will also confirm the suitability of the pipe for these works. It may also provide an indication of the potential, but not quantified, benefits of that work.

A CCTV inspection undertaken in compliance with this manual will satisfy the requirements of identifying pipe and manhole defects to enable the assessment and planning of remedial works. If there are high levels of infiltration in the catchment you would initially expect the resulting Preliminary Condition Grades to reveal an elevated Structural Condition Grade (4 – 5) and pipes that are cracked, broken or have holes, all of which are potential entry points for infiltration.

However, it is also possible that the infiltration may be due to faulty joint or lateral connection seals, or coming from the laterals, and therefore a low to moderate Structural Condition Grade may be generated (2 – 3). Likewise, the Service Condition Grades may, or may not, align with the anticipated results.

The outcomes are dependent on the visual evidence that is available at the time of the inspection. The available evidence may vary depending on:

- Soil Type
- Topography
- Location of the pipe
- Ground water table/season
- Depth of the pipe
- Type of bedding
- Pipe Material

Optional Header Fields, ADA "Precipitation" and ADD "Tidal Influence", should be included in the information that is populated by the inspection Contractor.

F41.4.1 Examples Where the CCTV Classification or Grading Systems Have Been Modified to Identify Infiltration

As part of some Infiltration source detection investigations, CCTV inspections reporting methodologies have been modified to be specifically focused on identifying potential sources of infiltration. This is achieved by either modifying the weighted defect scores, or modifying the defect coding, to accentuate structural and service defects that are associated with ground water infiltration to generate outcomes focused on leakage rather than structural or service conditions.

Note that these approaches preceded the development or availability of the FELL technology. They are only CCTV based and therefore still lack the ability to quantify of the amount of infiltration that is occurring and rely on visual evidence of leakage to be available.

Example 1: ProjectCARE, North Shore City Council (now part of Auckland Council) up to 2010

North Shore City Council (NSCC) was hydrostatically testing private wastewater pipes (typically 100mm diameter) to identify pipes that allowed leakage of ground water into the wastewater system and require repair. CCTV inspections, using the 3rd Edition of the New Zealand Pipe Inspection Manual classification and grading process, were then undertaken on those that failed the exfiltration test. However, a large proportion of the properties tested failed (which required a subsequent CCTV inspection) and property owners found this combined information hard to understand, and they were not sure which sections of pipe required repair. The Council investigated the use of modified CCTV defect scores to determine an infiltration condition score and found that the results generated a level of Pass/Fail outcomes that were similar to the more complex, and expensive, hydrostatic testing (note, only the rate of pass/fail were compared, not the quantified rate of leakage). This modified scoring system, and the associated inspection information, (including detailed site sketches) proved to be easier for property owners to understand and allowed the hydrostatic testing to be dis-continued.

Property owners were required to repair drains with modified peak scores above 15 or a modified mean score above 0.5.

Code	Description	Modified Defect Score		
		S	M	L
CC	Crack circumferential	8	15	30
CL	Crack longitudinal	8	15	30
CM	Crack multiple	8	15	30
DF	Deformed pipe	10	15	40
DP	Dipped pipe	2	10	25
IP	Infiltration at pipe wall	15	20	40
JD	Joint displaced	10	15	30
JF	Joint faulty	10	15	30
JO	Joint open	10	15	30
LF	Lateral defective	10	25	50
LP	Lateral protruding	2	15	70
LX	Lateral problem	15	20	40
OP	Obstruction permanent	2	10	30
PB	Pipe broken	15	25	40
PF	Deformed plastic pipe	5	10	30
PH	Pipe holed	15	25	50
PL	Protective lining defective	5	25	60
PX	Pipe collapsed	N/A	N/A	100
SD	Surface damage	3	20	60
RI	Root intrusion	12	25	50

Table F1.2 – NSCC modified Defect Scores based on 3rd Edition of the New Zealand Pipe Inspection Manual Condition Classification Codes and scores for Private Wastewater Pipe Infiltration Source Detection and Pass/Fail Evaluation.

Other Councils have also used this modified scoring and grading system for infiltration source detection on private wastewater pipes, including Waitakere City Council.

Example 2: Christchurch Earthquake Rebuild, SCIRT, Post 2011 Earthquakes

The Stronger Christchurch Infrastructure Rebuild Team (SCIRT) developed an alternative, simplified set of condition classification codes and a grading methodology, for the inspection and assessment of private laterals that were to be connected to replacement vacuum or pressure wastewater systems as part of the Christchurch earthquake recovery. The alternative codes used, their coverage, and interpretation, were changed for the following reasons:

- Simplification: Assessing the condition of private laterals needed to be as simple as possible, to enable quick but consistent data collection, by CCTV operators, or Drainage Contractors, who were not fully trained to the NZ Pipe Inspection Manual Standard. The results also needed to be easily interpreted by lay-people for implementing repairs.
- Robustness: Although simple, it was also important that the process for collecting and assessing the condition of private laterals was comprehensive, accurate and aligned to processes used previously to identify defective private laterals
- Focused on critical issues for Christchurch City Council: The inspection and repair programme associated with the installation of vacuum or pressure wastewater systems, was focused principally on the protection of these systems from damage that maybe caused by the ingress of silt or debris from damaged private laterals. It also needed to consider the long-term cost and effects of ground water ingress downstream wastewater networks.

Table F1.3 provides the classification codes, description and defect scores developed and used by SCIRT for the infiltration source detection. This was focused on private laterals between the surviving house and the vacuum or pressure sewer chamber. The private sewer pipe was assigned a Priority Grading Score (1, 2 or 3), based on the CCTV generated Peak Scores –the combined weighted scores within any 1m of the pipe length.

The Priority Grading was as follows:

Grading Priority 1 (Peak Score ≥60)	Remedial Action required within 6 months
Grading Priority 2 (Peak Score ≥25)	No further action but recommendation for property owner to deal with faults in next 12 months
Grading Priority 3 (Peak Score <25)	No further action

Table F1.3 – SCIRT Alternative CCTV Condition Classification Codes and Defect Scores for Infiltration Source Detection of Private Gravity Wastewater Pipes Connected to Vacuum or Pressure Wastewater Systems

Code	Description	Defect Score		
		S	M	L
J	Joint Seal Faulty	0	15	20
B	Pipe Break	30	60	80
C	Cracking	8	15	20
I	Infiltration Present	5	25	40
O	Obstruction	0	0	0
X	Pipe Collapsed	NA	NA	100
T	Tomo/Cavity behind pipe wall visible	NA	NA	40
R	Root Intrusion	5	5	5
D	Debris Silty	0	0	0
End	Encrustation Deposits	5	5	5
Start	Inspection Starts	NA	NA	NA
End	Inspection Ends	NA	NA	NA
Abandoned	Inspection Abandoned	NA	NA	NA
F	Construction Feature	NA	NA	NA

APPENDIX A FORMAT FOR ELECTRONIC TRANSFER OF CODED DATA

A1: INTRODUCTION

Section B2.1 (sub-section B2.1.4.2 Observation Information Data Fields) and section B2.2 Header Classification Codes, describe the data fields used for the condition inspection reporting system used in New Zealand. This Appendix describes the process and format that can be used for electronic transfer of the coded data. This process is based on the process provided in the Conduit Inspection Reporting code of Australia, WSA 05. The process and format provides a consistent means of presenting the data to enable data exchange between contractors and asset owners (if and exchange protocol is not already defined by the AMIS) and, where desired between asset owners, so that pipeline condition observations can be compared and used to make informed asset management decisions.

Several of the header and observation defect and feature codes are unique to New Zealand. Where data is exchanged with zones outside New Zealand these unique codes will need to be converted/translated to the language independent codes of the European standard or as specified by the asset owner.

A2 GENERAL

Table A1 lays out the field identifiers that are used to define the format for the data transfer structure. The file format enables the data contained in each record to be of variable length, terminating with a carriage control character (¶). Each data within a field is separated using the field separator symbol (,). Data shall be 8-bit characters in accordance with the appropriate part of ISO 8859-1 using the English language code “en”.

Where one file contains data for more than one pipe inspection or manhole inspection, the data shall be separated by a separator record comprising the characters #Z.

A3 FILE FORMAT INFORMATION

The first part of the data for a pipe inspection or manhole inspection shall contain information about the format of the data. Each item shall appear on a separate record (line). Each item shall be prefixed with the character # followed by the identification code for the information, the equals (=) sign and the code for the item. The format information is described in Table A1.

Table A1.1 – Field Identifier Codes

Identification	Description	NZ & AUS Codes
#A1=	The character set by reference to the appropriate part of ISO 8859. For Australia use ISO 8859-1.	#A1=ISO 8859-1
#A2=	The language code. This is used to indicate the language in which the remarks are written. For Australia use the English language code “en” as specified in ISO 639-1.	#A2=en
#A3=	The field separator. This is a single character used to separate the items of data in a record.	#A3=,
#A4=	Decimal point. The character used for the decimal point.	#A4=.
#A5=	The text surround character. This is used before and after text fields where text contains the field separator character.	#A5=”

A4 INSPECTION HEADER INFORMATION

The next set of records contains the inspection header information. Pipe header information shall be coded in accordance with Section B2.2. Manhole header information shall be coded in accordance with Section D2.2.

The information shall be provided first with one or more of header field definition codes to be transferred. The header definition record shall be made up as follows:

a) The identification code #B followed by a two-digit number starting with 01 for the first header definition record, 02 for the next e tc., followed by the equals (=) sign.

b) The header code for the header field as specified in Section B2.2, Tables B2_4 to B2_7 for pipeline inspections and Section D2.2 for manhole inspections, each followed by the field separator.

This is then followed, in a separate record (line), by the header field data, provided in the same order as the preceding header definition codes, each item separated by the field separator (,).

A5 INSPECTION OBSERVATION DATA

This shall be coded in accordance with Section B2.3 for pipes, or Section D2.3 for manholes.

The first record (line) defines the observation fields that are included in the transferred data. This also defines the order in which the observation field data is given in the subsequent record (line). The inspection data definition record is made up of the identification code "#C=" followed by the observation field codes, separated with the field separator character (,). The WSA 05 observation field codes as given in Table A2.

Table A2 – Inspection Data Field Codes

WSA 05 Code	Observation Field for Reporting
A	Main Code
B	Characterisation
C	*Not Used in New Zealand*
D	Quantification
E	*Not Used in New Zealand*
F	Remarks
G	Circumferential Location, Position From
H	Circumferential Location, Position To
I	Longitudinal/Vertical Distance
J	Continuous Observation Code
K	*Not Used in New Zealand*
L	*Descriptive location field (for Manhole Inspections)*
M	Photograph Reference
N	Video Reference
O	*Not Used in New Zealand*
P	Measurement From (Added for New Zealand)

In a separate record (line) the data for each single observation is provided in the same order as the observation field definition codes, separated by the field separator character (,) and terminated with the carriage return character (¶)

A6 EXAMPLE FORMAT FOR DATA TRANSFER USING NEW ZEALAND CODES

The following example includes one pipe inspection record:

#A1=ISO-8859-1¶

#A2=en¶

#A3=,¶

#A4=.¶

#A5="¶

#B01=AAA,AAD,AAF,AAK,AAR,AAL,ABA,ABE¶

"266789", "125999", "125998", U", " ", "NZPIM (Gravity)— 4th Edition 2018", "TV"

#B02=ABF,ABG,ABH,ABO,ABP,ABQ,ABR,ABS,ABT,ACA,ACB, ACC,ACD¶

22-05-2018, 10:30, "M Smith", "266789_220518.mpg", "IP", 54.6, 54.6, IC, " ", C, , 225, AC,¶

#C=I,J,A,B,D,P,G,H,M,F¶

0.0, , IS, , , U, , , , "Upstream MH 125999",¶

0.0, , WT, , , U, , , , "5%",¶

1.2, S1, DP, , S, , U, , , , ,¶

9.0, F1, DP, , S, , U, , , , ,¶

10.2, , IE, , , U, , , , "Centre of downstream MH 125998",¶

APPENDIX B PIPE MATERIAL AND PIPE LINING MATERIAL CODES

Table B1 – Pipe Material Codes

Material Code	Material Name
RC	Steel Reinforced Concrete
UR	Non-reinforced Concrete
PE	Polyethylene
PP	Polypropylene (including Profiled Wall Pipes)
PVC	Polyvinyl Chloride
FPVC	Fusible Polyvinyl Chloride
GRP/FRP	Glass Reinforced Plastic/Fibre Reinforced Plastic
AC	Asbestos Cement
PFPF	Pitch Fibre
GEW	Glazed Earthenware
EW	Earthenware (unglazed)
VC	Vitrified Clay
CORS	Corrugated Steel Pipe
DI	Ductile Iron
ST	Steel (unlined)
CLS	Cement lined Steel
CI	Cast Iron
BK	Brick and other masonry materials (e.g. Stone, blocks)
CIS	Cast In-Situ concrete or Mortar
ZC	Unidentified type of concrete or cement mortar
ZS	Unidentified type of iron or steel
ZP	Unidentified type of plastics
ZZ	Unidentified material

Table B2 – Pipe Lining (Rehabilitation) Material Codes

Material Code	Material Name
CL	Cement Lining (including Sprayed Concrete or Geopolymer
EP	Epoxy Lining
GRP/FRP	Glass Reinforced Plastic/Fibre Reinforced Plastic
PE	Polyethylene
PVC	Polyvinyl Chloride
CIP	Cured In-Place Polyurethane or Vinyl Ester

APPENDIX C NOTES ON THE ASSESSMENT OF CRACK WIDTHS IN REINFORCED CONCRETE PIPE

C1 INTRODUCTION

When CCTV inspections are used to evaluate the installation quality of new reinforced concrete pipelines, the assessors evaluate the observations against acceptable limits, targets and tolerances. Where cracks in pipes are the focus, the width of the crack is usually specified as a limit for any proposed action. However, accurately measuring the width of the crack is not usually possible from the CCTV video.

The Concrete Pipe Association of Australia, (CPAA) has undertaken testing in a controlled environment to assess the accuracy of estimating the width of cracks using CCTV video. The width of various cracks was estimated by experienced operators and the cracks were then measured using the method specified by the Australian Standard. The results confirmed that CCTV measurements were variable, inaccurate and unreliable. The study identified:

- 90% of the CCTV based estimates were many times greater than the actual readings
- On average, the estimated crack widths were 4 times greater than the actual measurement.
- No estimated width of less than 1mm was recorded by the CCTV operators (e.g. all cracks from 0.05mm to 1mm were recorded as 1mm or more).

Figure C1 – Results of CPAA study comparing estimated widths of crack from CCTV inspection against actual width measurements

The following notes provide guidance to help assessors of new reinforced concrete pipe to better understand the cracking mechanism and more accurately predict crack widths.

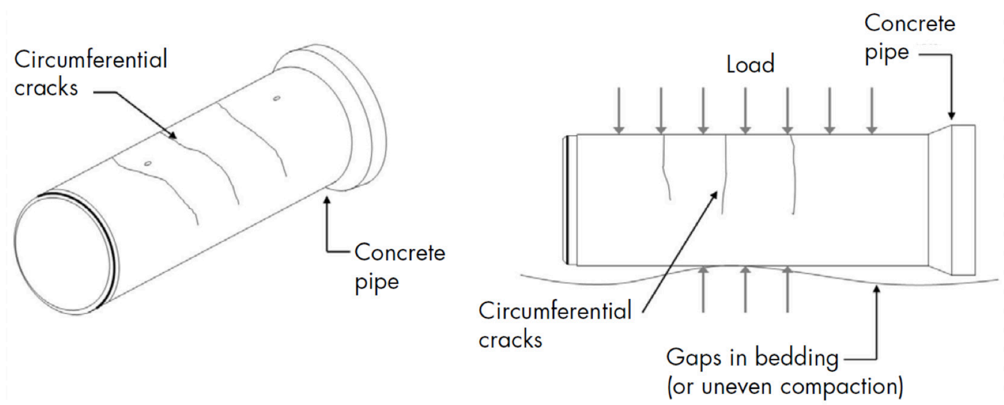
C2 CIRCUMFERENTIAL CRACKS

Assessors can better estimate the width of a circumferential crack by understanding the mechanism of the crack formation, geometry of the concrete pipe section, and its structural design.

C2.1 Mechanism of crack formation:

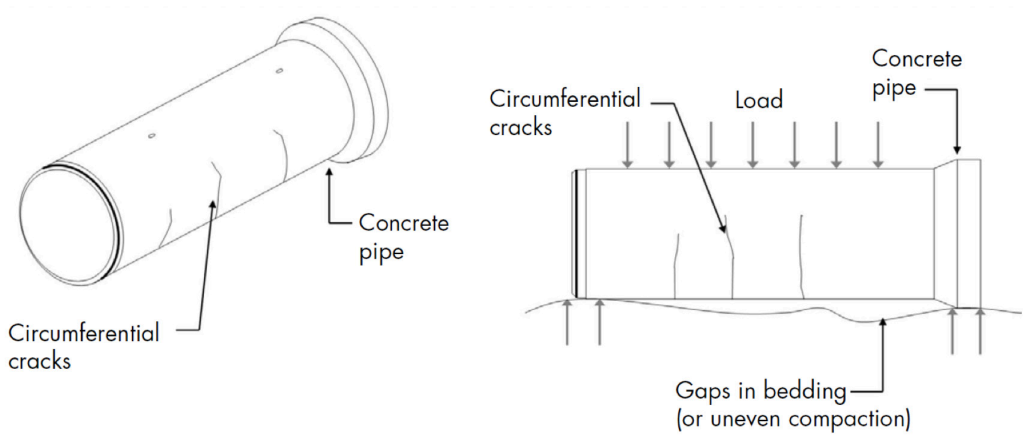
1. Pipes can crack circumferentially at the top of the pipe (crown) where the pipe support is not uniform and it is forced to act as a beam.

Figure C2 – Circumferential cracks at the top of the pipe (CPAA Engineering Guideline, Circumferential Cracking)



2. Pipes can crack circumferentially at the bottom of the pipe (invert) where uniform pipe support is not achieved and the pipe is acting like a beam.

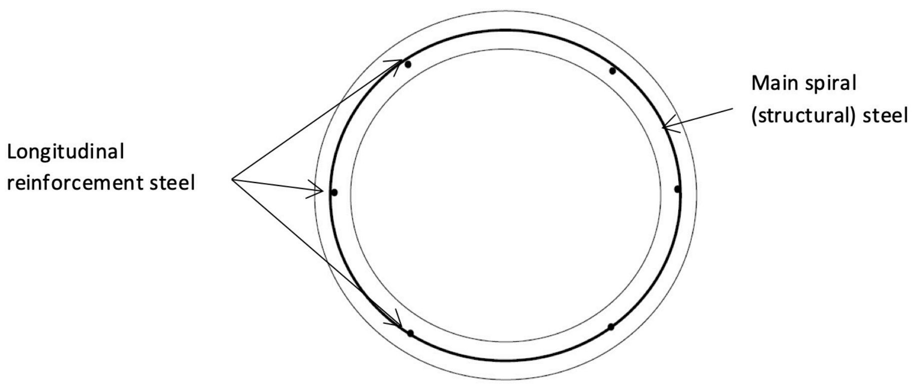
Figure C3 – Circumferential cracks at the bottom of the pipe (CPAA Engineering Guideline, Circumferential Cracking)



C2.2 GEOMETRY AND STRUCTURAL DESIGN OF TYPICAL SMALL DIAMETER RCP IN NEW ZEALAND

The Typical reinforcement arrangement for small diameter pipes are as shown in the figure C4. The longitudinal reinforcement are small diameter wires, arranged as shown in figure C4. The longitudinal reinforcement is securely welded to the main structural spirals, and it is typically not designed to reinforce the pipe section so that it can work as a beam.

Figure C4 – Typical reinforcement arrangement of small diameter concrete pipes

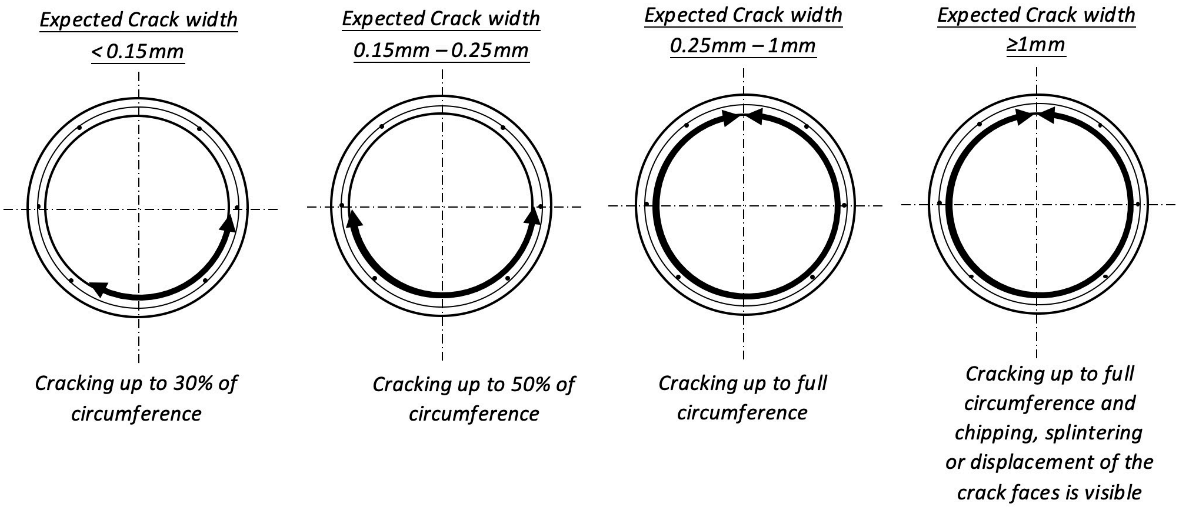


C2.3 MECHANISM OF PIPE CRACKING- ASSESSMENT OF CRACK WIDTH

- Only excessive loads or unsupported spans can cause enough stress to exceed the tensile capacity of the section.
- The maximum tensile stress is either in the crown, or in the invert of the pipe depending on the location of the 'soft' support relative to the location of the joints.
- The axial (longitudinal) reinforcement is only nominal (not structural) and typically smaller than the main helical reinforcement. The main circumferential crack resistance capacity of the pipe comes from the limited tensile strength of the concrete. If this tensile capacity is exceeded cracking will occur.
- The maximum crack widths are at the points of maximum stress. If the steel is still within the elastic range, the cracks will largely close again when the load (which is usually compaction load) is removed. The residual cracks are usually less than 0.15mm width.
- The stress at the centre of the pipe (3 and 9 o'clock) is much lower than the maximum stress. The crack width at these locations is smaller, usually there are only hairline cracks.
- If the stress is not enough to cause a crack to extend fully around the circumference of the pipe, it is generally physically impossible for the crack to be wider than 0.25mm at the point of maximum stress.

- If the static load on the pipe is substantial (e.g. depth of the pipe more than 1500mm) and the crack extends fully around the circumference of the pipe, then the residual crack width at the highest stress point may be up to 0.5mm.
- If the load or compaction load is high enough to cause yielding of the reinforcement steel, the crack width might increase to 1.00mm or more. A clear distortion of the pipe section and a displacement would be observed in such cases.
- In rare cases, a crack might open during construction and fine soil particles enter the crack preventing the steel from returning to its original length. A residual crack of up to 0.5mm might be left in localised locations.

Figure C5 – Provides some examples of expected crack widths based on the above notes.



C2.4 MECHANISM OF INFILTRATION AND AUTOGENOUS HEALING -ASSESSMENT OF CRACK WIDTH:

- Autogenous healing is only possible with water movement through the pipe wall. Dry cracks do not heal autogenously.
- When a CCTV inspection indicates that a crack in a pipeline lower than the water table is dry, this would typically indicate that the crack width is less than 0.15mm and/or that the crack is not all the way through pipe wall.
- A crack less than 0.5mm wide will generally show some dampness either from small severity water infiltration through the crack, from capillary action of the water into the pipe or from the cleaning of the pipe prior to inspection.
- A crack less than 0.5mm wide within the flow zone of the pipe will generally show signs of autogenous healing within a short period after installation.
- Where active infiltration is evident and appears as beads or water (or dripping) or seepage, this will generally indicate a crack width of 0.5mm to 1.00mm.
- Autogenous healing will typically start at the narrowest part of the crack and continue building to the widest part. This means that for circumferential cracks, the healing will typically start from 3 or 9 o'clock and progress towards 12 or 6 o'clock.
- Autogenous healing of cracks more than 0.5mm wide will sometimes appear stained rather than white due to the infiltration of very fine materials mixed with the water. These fine materials can help accelerate the healing process.
- Where there is medium or larger severity ground water infiltration, this would typically indicate that the crack is more than 1.00mm wide.

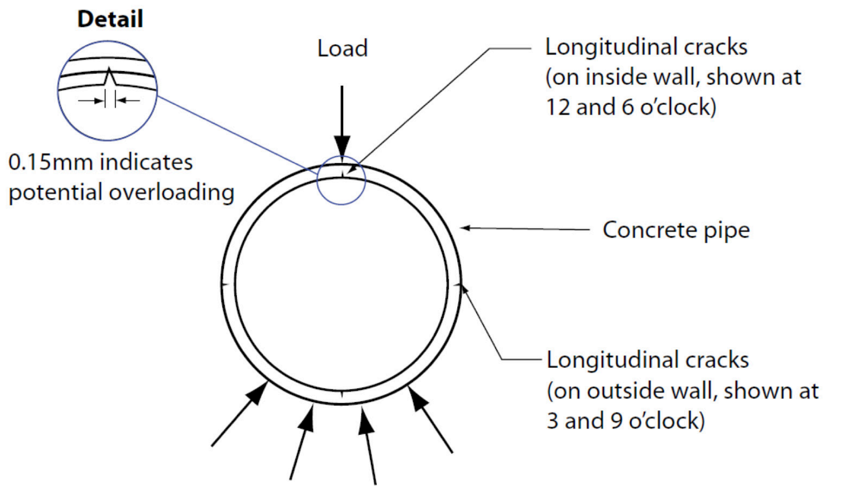
C3 LONGITUDINAL CRACKS

Assessors can better estimate the width of longitudinal cracks by understanding the mechanism of crack formation, the geometry of the concrete pipe section, and its structural design.

C3.1 MECHANISM OF CRACK FORMATION:

Longitudinal cracks run along the axis of the pipeline. They generally occur when the pipe is over loaded. When this type of cracking occurs, it is usually evident at the top or bottom, (i.e. at 12 o'clock or 6 o'clock) of the pipe and usually does not penetrate the pipe wall. Longitudinal cracks are likely to be found in the larger diameter concrete pipes ranging from DN600 upwards.

Figure C6 – Cross-section of a concrete pipe showing the typical location of where longitudinal cracks will occur (CPAA Engineering Guideline, Longitudinal Cracking)

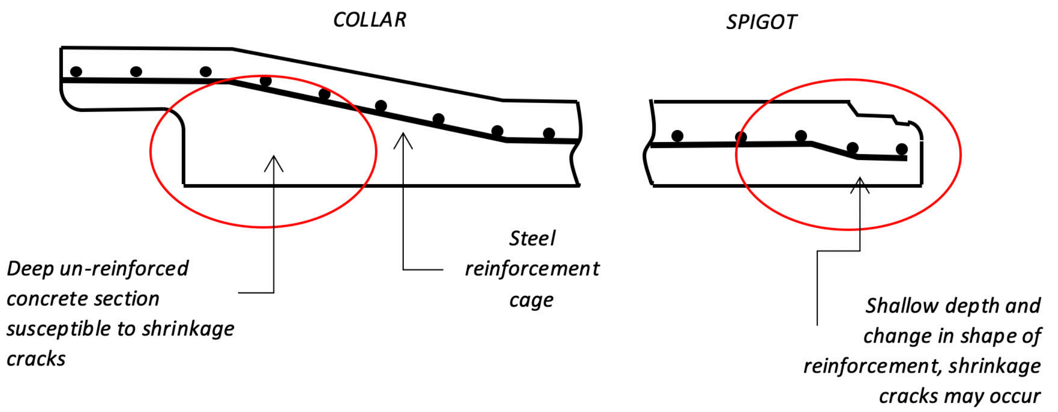


C3.2 SHRINKAGE CRACKS IN PIPE JOINT ZONE

The reinforcement arrangement of some pipes produced in New Zealand is shown in figure C7. The thickened concrete in the collar zone makes this a relatively lightly reinforced weak zone that may cause a small short longitudinal shrinkage crack to form within this zone. Despite the apparent width of this crack, it does not generally extend further than to the structural reinforcement, and hence, is not considered a structural crack, and therefore does not have any effect on the durability or structural integrity of the pipe.

The steel reinforcement in concrete pipes stops a little short of the spigot end of the pipe, (as part of acceptable manufacturing tolerances) and the wall is always thinner than the rest of the pipe wall. The combination of these factors and the normal setting shrinkage of the concrete results in the formation of a very short shrinkage crack at the spigot end that appears in the CCTV as a longitudinal crack. This type of crack will stop when it reaches the steel reinforcement zone and should be assessed as a shrinkage crack with no significant effect on structural integrity and durability of the pipe.

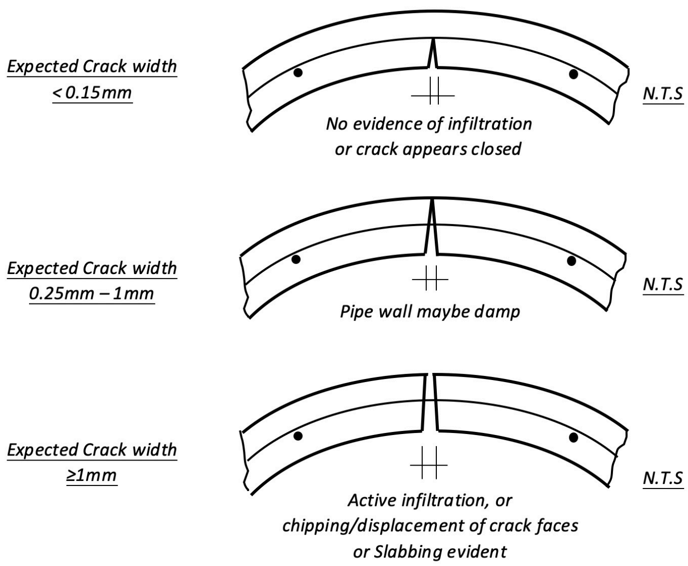
Figure C7 – Typical geometry and reinforcement at the collar and spigot end of a concrete pipe.



C3.3 MECHANISM OF LONGITUDINAL PIPE CRACKING- ASSESSMENT OF CRACK WIDTH:

- Pipes subjected to a load equal to their serviceability limit state may have longitudinal cracks up to 0.15mm wide at the invert or crown (proof load crack).
- Proof load cracks generally extend the full length of a pipe segment (joint to joint) and will have a width of 0.15mm extending not less than 300mm along the pipe.
- Proof load cracks do not extend further through the pipe wall than the neutral axis. Therefore, they remain mostly dry and do not allow infiltration.
- Cracks occurring in pipes that have been load tested in the factory to a proof crack width are usually 'closed' when the test load is released. However, they are still likely to be visible in a CCTV inspection. The width of this type of crack after installation is typically less than the proof load crack width of 0.15mm. (Note: the crack width is limited to 0.1mm for a load tested pipe after the test load is removed)
- Cracks more than 0.15mm wide are generally observed in overloaded pipes where the stress exceeds the capacity of pipe sections.
- Cracks wider than 0.15mm and up to 0.5mm are generally associated with stresses in reinforcement that are within the steel's elastic range. These cracks may extend to the outer face of the pipe wall and show dampness from capillary action.
- Autogenous healing is usually observed on elastic state cracks up to 0.5mm width.
- When the stress in the reinforcement exceeds the yield point of the steel (beyond elastic action), the pipe starts to lose its structural capacity. Cracks with a width greater than 0.5mm and up to 1.0mm and more occur, ground water infiltration becomes more extensive and autogenous healing will not be capable of reinstating the structural capacity of the pipe.
- Over stressed pipe sections generally show slabbing or spalling on the side of the crack. Slabbing is where the stress in the reinforcement steel causes the bars to straighten, causing the concrete surface to 'slab'.

Figure C8 – Expected longitudinal crack widths based on the crack mechanism and evidence



C4 MULTIPLE CRACKS

Multiple cracks usually happen when the pipe is subjected to a severe point load such as impact by a digger or compactor during installation. Crack width can be estimated using the same criteria used for circumferential cracks. The longitudinal crack component of multiple cracks is a result of the mechanical stress and is generally limited in depth to the reinforcement level; hence, the crack width is often limited to 0.15mm or less.

Multiple cracks that include longitudinal or circumferential cracks that combine with the mechanism of cracking previously mentioned above, should be treated separately for better estimation of crack width.

APPENDIX D NOTES ON IDENTIFYING LATENT DEFECTS AND FEATURES IN LINED PIPE

D1 INTRODUCTION

The type of features that can be seen in a CCTV inspection of a lined/rehabilitated pipe are quite different to that of unlined pipes. The key reason for the difference is that lined pipes are installed inside another pipe that sometimes has significant defects, (referred to as latent defects) which can be reflected into the newly lined pipe. These latent defects are not liner defects, but may visually appear as defects in the liner. Understanding the type of features that commonly can be seen, makes identifying the difference between latent defects and liner defects easier. If the latent defects in the existing pipe are significant enough they can cause unexpected or undesired problems in the liners, such as restrictions or reductions in the internal diameter. However, latent defects that may cause problems, post lining, are typically removed or repaired prior to lining.

In addition to latent defects, pipe liners have their own set of specific 'construction features' that would not be seen in unlined pipe. These features may also appear as apparent defects in the liner.

The material properties of pipe liners and the effect that actual flows can have on the appearance of the liner surface can also be quite different to unlined pipe. After installation, staining can make identifying liner defects such as pin holes or leakage more challenging to identify.

These notes aim to provide information to assist CCTV operators and reviewers/assessors tell the difference between an expected feature and a defect in a lined pipe.

D2 LATENT DEFECTS

Latent defects that may typically be seen reflected into a lined pipe include:

- Dips
- Deformation/ovality
- Varying internal dimensions
- Holes
- Joint displacements
- Minor protrusions

In addition to existing defects in the deteriorated host pipe, some normal features in the existing pipe may also be reflected in the liner, such as: lateral connections and inspection points.

How, and what type of, latent defect or type of feature is reflected depends on the type of liner installed. Flexible liners, such as resin impregnated, cured in place pipe, (CIPP) and fold and form liners will conform to the existing pipe surface and therefore any of the typical latent defects or features, listed above, may be reflected in the liner. These will be reflected as dimples, bulges or taking on the same shape as the existing pipe (e.g. deformed/oval shape) and dips will still be present.

Spiral wound pipe liners are typically installed as circular tubes, (other shapes are also possible) and so latent defects in these liners can have the effect of restricting the finished internal diameter. This occurs either because the tube diameter must be reduced to clear obstructions or the expansion 'twist' that occurs at the end of the installation is restricted. Dips will also still be present.

Where a latent defect in the host pipe would result in the lined pipe having an unacceptable defect then the latent defect should be removed prior to the lining taking place or an open-cut renewal/spot repair undertaken. It may be possible to remove the latent defect using trenchless techniques before lining.

Figure D1 provides some examples of latent defects that could be seen in CIPP and Fold and Form liners. These examples of reflected latent defects are not liner defects but should be noted on inspection reports.

Figure D1 Examples of reflected latent defects and existing features in CIPP and Fold and Form liners

CIPP Lateral Junction Repair, (LJR) installed within a deformed pipe (ovality >20%)

PVC Fold and Form liner installed within a deformed pipe (Ovality >20%)

A 'dimple' produced in a PVC fold and Form liner over a lateral connection

CIPP liner reflecting a joint in an EW pipe

Mirrored irregular shape of the broken existing pipe beneath a Fold and Form liner

A small displaced and open joint relected in a Fold and Form liner

D3 CONSTRUCTION FEATURES OF LINED PIPE

Construction features in lined pipe are either components of the liner manufacture, or features that occur as part of the liner installation. These features are not defects, and although they may appear as discontinuities, or as apparent marks in the liner surface, they are normal elements of trenchless liner construction. Liner construction features include:

- **Vacuum/impregnation patches:** During the 'wet out' of a resin impregnated liner, (CIPP) a vacuum is applied, removing the air traped in the liner felt, to ensure that the resin fills all the voids in the liner. This usually requires a small incision to be made through the liner coating into the felt of the liner. As the wet out process is worked through, the vacuum points are removed and the holes patched with a small glue on patch (PVC coated liners) or a small hot glue gun application patch (PE and PU coated liners).
- **Grouting ports:** These are small holes (10mm) drilled in the soffit of a liner (specifically the larger man entry spiral wound liners) to introduce grout to fill any annulus and voids outside the liner. Once the grouting is complete, the hole is plugged and epoxied over to complete the seal.

- **Seams:** CIPP liners are generally manufactured by forming a PVC/PE or Polyurethane (PU) coated felted material into a tube and stitching the two edges of the material together. The seam is produced by a 'flat seam lock stitch' machine. An alternative method of constructing this seam is with an ultrasonic weld which means the stitching is not present, however the seam is still visible. Both processes produce a continuous seam along the longitudinal axis of the liner. This seam may be visible at different positions around the circumference of the pipe.

The seam is typically sealed with a tape that is applied by either heat or ultrasonic welding. The tape seals the holes made by the stitching process and ensures there is no resin leakage before installation and isolates the resin from water or steam during the curing process. The seam tape is sacrificial and once the liner is cured it is no longer required. The seam tape will occasionally come away (peel off) from the liner after a period of time in service, often after cleaning.

Some liners are manufactured as a continous 'sock' and do not have a seam or seam tape. These are typically in smaller (100mm) sizes.

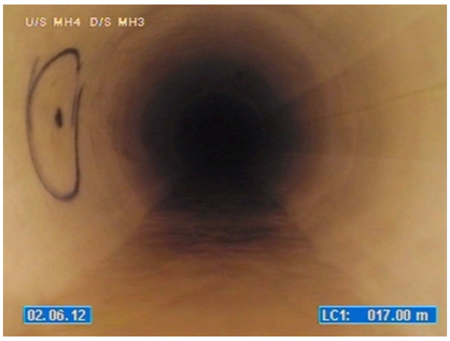
- **Joints (CIPP):** The process for manufacturing CIPP felt liners is usually a continuous process which can be produced in long lengths. The liner is cut to length for a specific line. Occasionally a circumferential seam, connecting two or more lengths of the felt fabric, is required for a particular job. These joints are visible in the finished CIPP. These are characterised by a visibly raised spiral extending around the full circumference.
- **Joints (Large spiral wound pipe):** Spiral winding large bore pipes typically requires multiple coils of material. The old coil will be cut off at 12 o'clock with the new coil butted up to it and the winding process re started. The butt joint is then sealed with an epoxy resin.
- **Laps:** These are most commonly observed in "Pull and Inflate" type of CIPP liners where multiple installations may be required to line the full length of pipe. The lap should face downstream, e.g. the upstream liner should be installed over (after) the downstream liner. The lap will be seen as a slight constriction and a feathered edge on the downstream face of the lap.
- **Inverted Wrinkles:** Occasionally there are surface indentations (inverted wrinkles) visible in the liners surface. These commonly occur in patches or 'pull and inflate' resin liners. They result from the resin conforming to the packer surface and do not compromise the liner performance or strength.
- **Extruded excess resin (feathering at the edges of patch liners or LJRs):** A small amount of resin will ooze out from the end of CIPP patches (patches or LJR's) when the packer, used to install the patch, is inflated. The extrusion may be uneven, or feathered, and may lift or break off over time. It is a characteristic of resin patches.

Figure D2 – Examples of vacuum and impregnation patches in CIPP liners

Vacuum/Impregnation patch – hot patch

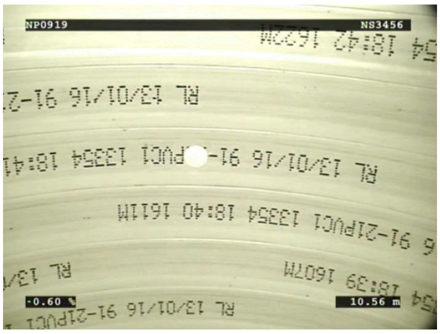
Welded patches will look a bit like a 'repaired hole'. These will often stain quickly, (and the pipe wall around it, as though there had been infiltration) because of the lubricant used to install the liner. An actual hole in the liner would look like a 'cut out' section in the liner and would not appear to be repaired.

Vacuum/Impregnation patch – glued



Glued patches are a circular or rectangular patch sealed (glued) onto the liner to contain the epoxy while it cures. They appear very similar to a tyre puncture repair patch. The example in the picture also has a visible mark drawn onto the liner to guide the placement of the patch (this may not always be visible). Patches may come loose with jetting, which is not a defect in the liner, as the patch is only required for the installation (record if the patch is loose in the remarks)

Figure D3 – Example of a grouting port

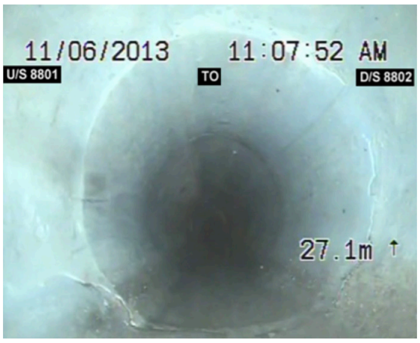


Grouting port in a large diameter spiral wound pipe.

Figure D4 – Examples of seams and joints and laps in CIPP liners

An example of a CIPP liner joint. These appear as 'spiral joint' in the liner. The spiral will start and end on the seam. The presence of the joint does not affect the performance of the liner.

A Lap visible in a CIPP patch repair



A 'Pull and Inflate' liner (installed in sections). The lap for this type of liner should ideally cover the downstream section to minimise the hydraulic effect on the flow. The example in the picture has the lap over the upstream section, which is not ideal (this should be noted in the remarks). A slight lifting if the lap edge is acceptable.

The seam can be either heat sealed (pictured) or stitched. This seam is covered by a seam tape (note the tape band).

Figure D5 – Example of an inverted wrinkle in an LJR

Inverted wrinkles resulting from the resin conforming to the inflatable packer surface

Figure D6 – Examples of extruded resin from a CIPP patch

The photos both show feathering of resin on the edge of a CIPP patch. This epoxy extrusion assists with a smooth transition between the pipe and the patch (i.e. no 'step' between the two).

D4 STAINING OF LINER MATERIAL

The CCTV inspection of the lined pipe may be sometime after the liner and LJR's have been installed. Because of this time lag, staining of the liner may occur and be evident on the stitched seams of the LJR's, inside the lateral leg of the LJR, or on the liner wall. The staining may be because of liner defects allowing ground water infiltration, or maybe due to other reasons. Staining of the liners may be present for the following reasons:

- Staining from ground water infiltrating through a defect in the liner wall, (e.g. pin hole), stitched seam or lack of sealing
- Staining from the wastewater or stormwater flow within the pipe
- Staining from flow coming down the lateral pipe from upstream of the LJR
- Discolouration of the resin at the transitions from a lined main to the patches/LJRs. In the lining process different resins are used. For example, CIPP mains use a polyester resin and NDSRs (No Dig Spot Repair)and LJRs use a vinyl ester epoxy based resin. There is an interaction between the two resins which contributes to the darker colouration and staining at the transitions from a lined main to the LJRs
- Discolouration of the liner material from lubricating oils used in both the pipe liner inversion and the LJR installation, to facilitate the installation of the pipe lining system
- Discolouration from hand written marks or notes made on the sacrificial polyurethane layer of the liner prior to inversion, which have become smudged.

As there are many reasons for the occurrence of staining, it is important that care, and sufficient investigation, is undertaken to ensure that the correct assessment is made. From the above list of typical reasons for the staining of a liner, only the first item on the list (water infiltration) is related to the water tightness of the liners. The following points in the list are alternative potential sources of staining to be considered when determining if the staining is just a feature, or a defect is present.

The CCTV operator should investigate the sites of staining, or potential areas of leakage, sufficiently to determine the cause of the staining, or other evidence that may confirm any liner defects. The CCTV contractor must pan areas of staining on the pipe wall; around the points of connection; and inside the lateral connections. The speed of the panning shall be sufficient to allow observation of any 'point source' for the stains or any visible water on the pipe walls.

Clear evidence of infiltration, may include:

a. Point leakage – staining appears to come from a single point and the staining 'fans' down from the single point.

b. Active infiltration – either seepage (water 'sheen' that is not directly from the flow in the pipe or a jetter), running or squirting water.

Evidence that the staining is not associated with infiltration includes:

a. Staining around the start and end of patches of LJRs, including the lateral leg

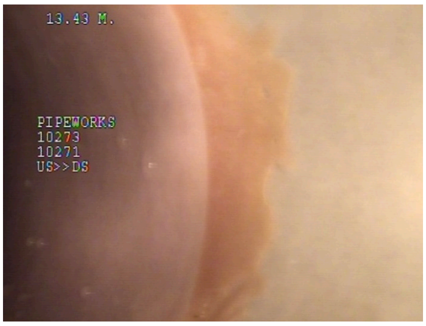
b. Staining does not have an identifiable point source inside the liner,

c. Black, or green coloured (mould) staining around the stitching of LJR seals or on wrinkles

d. Where there is only beaded water on the pipe. This is likely to be splash from water in the pipe.

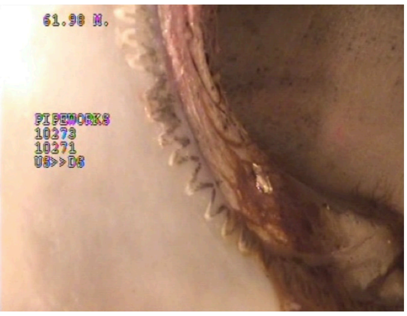
Figure D7 – Examples of staining of liner material not related to leakage

Resin discoloration at the start of an LJR

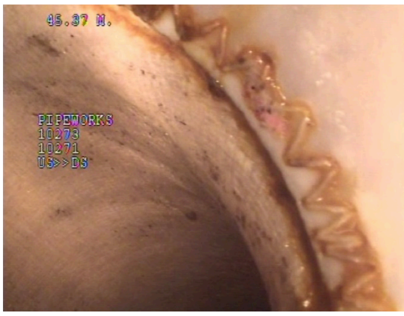


Typical gel tapered out from end of patch or LJR

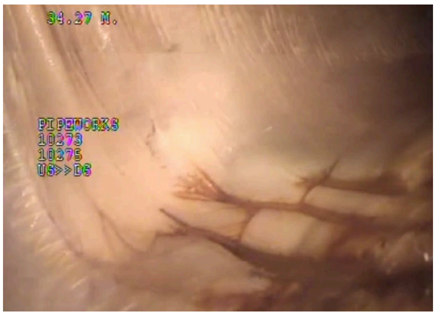
Staining of the LJR invert from flow coming down the lateral. The Lateral has then been lined with a good overlap of lateral liner into LJR. Note the slight discoloration of the resin at the end of the lateral liner.



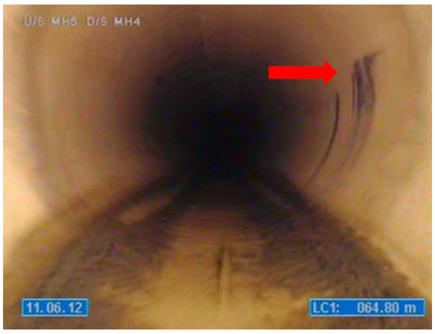
Edge dry, staining present within 'flow zone' of the lateral.



Bacterial growth on the stitching of the LJR and water beading.



Staining in invert/wrinkles of the 'lateral leg' of the LJR from flow down the lateral.



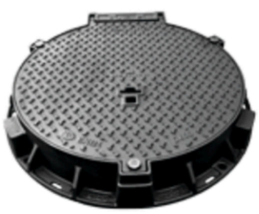
Typical staining from notes written on the liner prior to installation. Staining such as this can also occur where:

a. The installation lubricant has been concentrated, if water was used during the curing process; or,

b. It could indicate a pinhole in the liner. If in doubt, a pressure test should be carried out to confirm the integrity of the liner.

Photo, above, typical staining on the soffit (roof) of a liner, from the lubricants used during installation.

APPENDIX E EXAMPLES OF MANHOLE COVER TYPES, SHAPES AND LIFTING ARRANGEMENTS

Cover Shape	Example	Description	Code for Lifting Arrangements (Header Code CCY)
Circular		Cast iron with 2 pick hole lift arrangement	P2
		Cast iron with single central T slot lift arrangement	T
		Cast Iron with 2 T Slot lift arrangement	T2
		Cast iron with 3 T slot lift arrangement	T2
		Ductile iron hinged cover with bolt lock and specialist type lift arrangement	Z – note the bolt in the general comments
		Ductile iron hinged cover without bolt lock and specialist type lift arrangement	Z
		Cast iron grille	N

Cover Shape	Example	Description	Code for Lifting Arrangements (Header Code CCY)
		Ductile Hinged Iron grille	Z
		Galvanized steel 'Scruffy Dome'	N
Rectangular or Square		Square with 2 lifting hook arrangement	H2
		Hinged, rectangular with 1 lifting hook arrangement	H
		Rectangular, diagonal split with 2 T slot lifts	T2
		Plastic, square cover with hold down bolts	B
		Rectangular, infilled cover with 4 T slot lift arrangement	T2

Cover Shape	Example	Description	Code for Lifting Arrangements (Header Code CCY)
Triangular		Cast iron triangular with single pick hole lift arrangement	P

LOAD CLASS DESCRIPTIONS FOR MANHOLE COVERS RELATING TO USE.

European Standard EN124	Australian Standard AS3996	Description	
Category A 15 KN	**Class A** 10 KN		Examples: Pedestrian footpaths and cycleways, grassed areas
Category B 125 kN	**Class B** 80kN		Examples: Light vehicle driveways, private car parks
Category C 250kN	**Class D** 210kN		Examples: Local roads (limited speed)
Category D 400kN	**Class E** 400kN		Examples: Highways, motorways (high speed)
Category E 600kN	**Class F** 600kN		Examples: Industrial high load areas, including warehouses and docksides
Category F 900kN	**Class G** 900kN		Examples: Airport runways,

APPENDIX F NOTES ON FACTORS RELATING TO VIDEO QUALITY

F1 INTRODUCTION

The quality of the video on playback is dependent on a several factors, which include:

- The camera resolution, quality of lens and light sensitivity.
- The file compression applied to the original video.
- The resolution of the display monitor that the video is viewed on.

This section aims to provide information and guidance on the various factors that influence the 'video quality' and what needs to be considered to achieve the desired outcomes.

F2 CAMERA RESOLUTION AND IMAGE QUALITY

With the development and introduction of digital High Definition (HD) CCTV equipment, analogue, (PAL or NTSE) cameras are now regarded as producing Standard Definition (SD) video. Analogue CCTV cameras are regarded as Standard Definition because they do not produce a high value megapixel image.

The CCTV camera equipment currently in use varies significantly. Although most camera manufacturers make some models of high definition (HD) cameras, most CCTV cameras in use, or still being purchased, are standard definition analogue cameras.

With digital cameras the term "megapixel" is used to give a value to the resolution of the digital picture or video pictures that the camera can produce. The larger the value in megapixels the better the quality of the digital picture or video that is produced. However, with regard to analogue CCTV, resolution is measured quite differently. Instead of "megapixels" the quality of analogue resolution is measured in TV Lines (TVL).

It is not possible to directly compare the resolution described by TV Lines in an analogue camera with digital camera pixels.

F2.1 ANALOGUE CAMERA RESOLUTION

Resolution is the measure of the quality of definition and clarity of a picture. A higher number of TV Lines means that the camera will be able to render images with more detail. Analogue SD camera resolution can be described in the following way:

- A camera that produces less than or equal to 380 TVL (total screen width) of resolution would be regarded as Low Resolution.
- A camera capable of more than 480 TVL (total screen width) resolution would be regarded as High Resolution.
- A camera capable of more than 504 TV Lines (total screen width) of resolution is DVD standard and considered to be broadcast video quality.

The resolution of analogue CCTV cameras varies by camera, model type and manufacturer. Typically, analogue CCTV cameras range from 420TLV up to 800TVL.

The PAL TV broadcast Standard (common type in NZ for analogue cameras, as opposed to NTSE) has 576 visible horizontal scan lines. These are interlaced in two fields, odd lines first followed by even lines in the second field. Two complete fields = One Frame. Frames are refreshed at a rate of 25 Frames per Second and have an Aspect Ratio of 4:3.

Digitalisation of the PAL TV broadcast standard video (necessary as part of the video compression process for analogue CCTV cameras) will always produce a 720 x 576 pixel (0.41MP) resolution at 25 frames per second.

The higher the camera TVL resolution the sharper the generated image. Low TVL resolution cameras will produce grainy video.

A poorly focused lens blurring an image will decrease the transmitted TVL resolution.

F2.2 DIGITAL CAMERA RESOLUTION

Digital HD CCTV camera resolution (High Definition video) can be described in the following way:

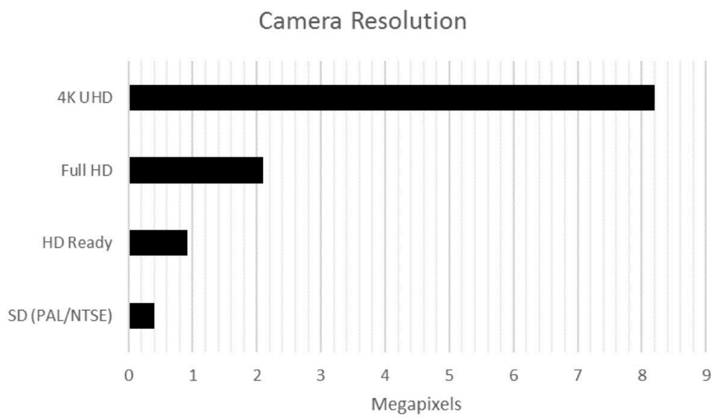
- A camera that produces a frame size of 1280 x 720 (0.921MP) is regarded as "HD Ready"
- A camera that produces a frame size of 1920 x 1080 (2.1MP) is regarded as "Full HD"

- A camera that produces a frame size of 3840 x 2160 (8.2MP) is regarded as "4K UHD"

The frame refresh rate is typically 60 frames per second (Hz).

The selection of the scanning system for digital video can impact on the resolution. Progressive scanning (e.g. 1080p) produces the best consistency for Pipeline inspections. Interlaced Scanning (e.g. 1080i) can lose up to half of the resolution and suffers from "combing artefacts" when the camera pans or there is substantial movement within the frame.

Figure F.1 –Chart illustrating the scale of camera resolution in megapixels (MP)



F2.3 LIGHT SENSITIVITY AND OTHER FACTORS AFFECTING IMAGE QUALITY

Factors other than resolution influence the quality of the CCTV Camera image generated. This includes the lens quality, Chroma (the hue and saturation of the colour captured) and the lux sensitivity. Lux is the metric unit for measuring the amount of light that falls on an object and is the European equivalent of the British foot-candle (or lumen). Specifically, 1 lux equals the amount of light that falls on a one-square-meter surface that is one meter away from a single candle. In effect Lux is the rating of how much light the camera can see without the need for additional lighting. The lower the lux rating, the less additional lighting the camera requires. Overtime the camera components have improved and the lux sensitivity has reduced from a Lux of 20 (20 years ago) to new cameras with a lux rating of less than 1 (virtually able to see in the dark).

Table F.1 – Lux Rating Scale (summarised)

Lux Rating	Material Name
0.0001	Moonless, overcast night sky (starlight)
0.05–0.3	Full moon on a clear night
1	1 candle of light at a distance of 1m from the candle
3.4	Dark limit of civil twilight under a clear sky
20–50	Public areas with dark surroundings
50	Family living room lights (Australia, 1998)
100	Very dark overcast day
320–500	Office lighting
400	Sunrise or sunset on a clear day
1000	Overcast day; typical TV studio lighting
10,000–25,000	Full daylight (not direct sun)

Overall the camera image quality is governed by the combination of the resolution, quality of the lens, chroma and light sensitivity.

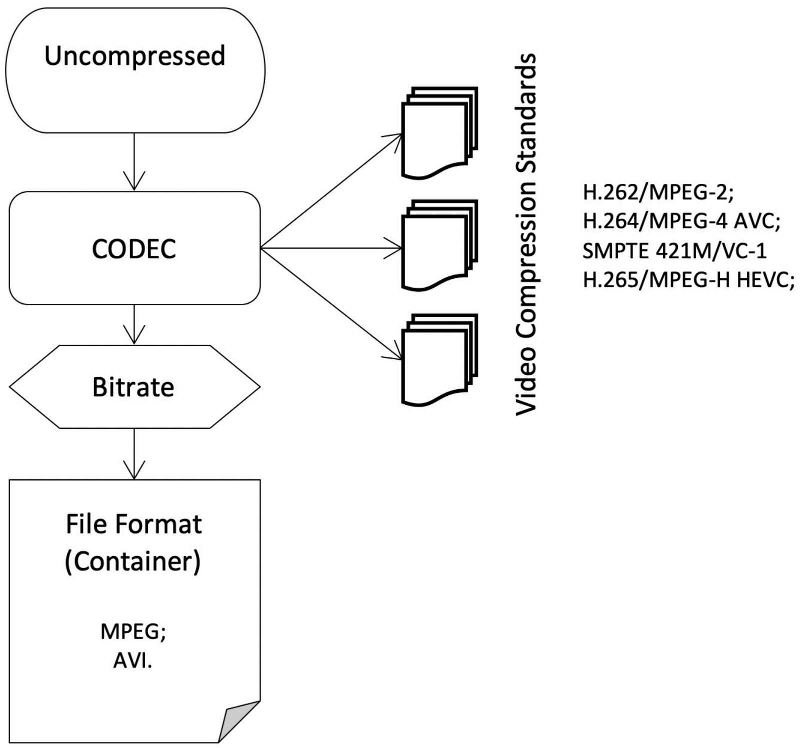
Table F.4 that lists examples of makes and models of CCTV cameras that are in use or available for purchase and provides information on the type of camera, resolution and light sensitivity. The information is based on the public information available from manufacturers.

F3 VIDEO FILES AND DISPLAY RESOLUTION

The size of the 'raw' video files generated by CCTV cameras generates the highest resolution possible for that camera but is generally too large for storing or transmission purposes (external hard-drive or via the web). A single ten minute standard definition video could be as large as 6 Gigabytes in file size. To solve this problem, the raw video is compressed, to a size that is suitable in terms of its required application and acceptable level of quality. It is then is decompressed back again when it is viewed on a video player. The compression of the video and preparation of the final video file is undertaken as part of a process that is outlined in Figure F_2 and detailed in the following sub-sections.

Its is important to remember that this process commences with the uncompressed video image quality of the CCTV camera, (whatever that might be) and that the compression process will result in some level of reduction in that quality.

Figure F.2 – Process for preparation of CCTV Video Files for Transmission or Storage



F3.1 CODEC

Codec is software that compresses or decompresses the video (encode/decode). It converts uncompressed video to a compressed format or vice versa.

Fundamentally video codecs work by separating the video signals that represent luminance (luma) and colour information (chrominance, chroma) then manipulate and edit the signals using complex algorithms to achieve the desired amount of compression.

Codecs can support single or multiple video compression standards or may only cover some of the profiles within a standard.

F3.2 VIDEO COMPRESSION STANDARDS

The compressed data format will conform to a chosen video compression standard. Common video compression standards that are well supported are described in Table F_2.

Table F.2 – Common Video Compression Standards

Video Compression Standard	First Edition (last release edition)	Extended From
H.262/MPEG-2 (Part 2)	1995 (2013)	H.261
H.263/MPEG-4 (Part 2)	1999 (2009)	H.262
H.264/MPEG-4 AVC	2003 (2017)	H.263
SMPTE 421M/VC-1	2006	WMV9
H.265/MPEG-H HEVC	2012 (2018)	H.264
AV1	2016 (2019)	VP10/Daala/Thor

The compression is typically 'lossy', meaning that the compressed video lacks some information present in the original video. A consequence of this is that the decompressed video displayed on the users monitor has a lower quality than the original, uncompressed, video because some of the information to accurately reconstruct the original video has been lost in the compression process.

The compression standards in many cases have been developed to either extend the capability of the earlier standards (refer to the family group of standards H.26x) or for particular end uses (e.g. AV1 which has been designed specifically for video transmission over the internet). With later versions of standards, a substantial improvement in the video quality at the same bitrate, or better data compression at the same level of video quality can be achieved.

Implementation of the standards requires the input of two parameters for the compression application:

1 **Profile** – defines a set of capabilities or uses of the compressed video.

2 **Level** – specifies a set of constraints such as the maximum picture resolution, frame rate and maximum bitrate that a decoder can use.

Table F.3 – Baseline Profile and Level settings for Compression Standards for various resolutions

Compression Standard	Resolution	Frame Size	Profile	Level	Max Bitrate (Mbps)
H.262/MPEG-2	SD	720x576	Main	Main	15
	HD Ready	1280x720	Main	High 1440	60
	Full HD	1920x1080	Main	High	80
H.263/MPEG-4 (Part 2)	SD	720x576	Advanced Simple	1	180
	HD Ready	1280x720	Advanced Simple	2	600
	Full HD	1920x1080	Advanced Simple	2	600
H.264/MPEG-4 AVC	SD	720x576	Main (MP 77)	3	10
	HD Ready	1280x720	High (HiP 100)	3.1	14
	Full HD	1920x1080	High (HiP 100)	4	20
	4K UHD	3840x2160	High (HiP 100)	5.1	240
SMPTE 421M/VC-1	SD	720x576	Advanced	1	10
	HD Ready	1280x720	Advanced	2	20
	Full HD	1920x1080	Advanced	3	45
H.265/MPEG-H HEVC	SD	720x576	Main	3	6
	HD Ready	1280x720	Main	3.1	10
	Full HD	1920x1080	Main	4	12
	4K UHD	3840x2160	Main 10	5	25
AV1	SD	720x576	Main	3	6
	HD Ready	1280x720	Main	3.1	10
	Full HD	1920x1080	Main	4	12
	4K UHD	3840x2160	High	5.1	40

There is no requirement to use a particular compression standard over any other, provided that the appropriate parameters are set, and the user understands the limits of the compression that can be achieved while maintaining the picture quality. In some cases, the codec used may not have all the common standards available, and this may need to be considered when choosing a recording device or codec to use.

F3.3 VIDEO BITRATES

Video bitrates are described in megabits per second. In general, a higher bitrate will accommodate a higher image quality in video output and a larger video size. This is basically because more of the original uncompressed video remains.

In effect, control of the bitrate relates to controlling the end file size – i.e. how much compression is actually applied. This control is limited/tempered by the minimum video quality needed and the maximum bitrate of the chosen profile/level for the compression standard.

When it comes to choosing what bitrate is best it may be necessary to experiment with samples of video at different bitrates and review the outputs to determine the best bitrate for the given camera. Generally, the higher the camera resolution, the greater the bitrate needs to be to maintain the benefits of the quality of higher resolution. Low bitrates will generally result in a greater loss of information and corresponding reduction in the video quality. How the video will be stored or transmitted (e.g. transmission over the internet) may need to be considered, and some level of compromise accepted. The final video quality should be reviewed and approved by the asset owner as meeting the required standard prior to commencement of inspections.

Where smaller files sizes are required, consideration should be given to using a more sophisticated compression standard where the same comparable video quality may be achieved at a much lower bitrate.

F3.4 DISPLAY RESOLUTION

The resolution of the screen/monitor used to view the video can have an impact on the perceptible quality of the image. The majority of video is viewed on LCD computer monitors that have a display resolution between 1366x768 and 1920x1080 (16:9 aspect ratio).

Where the display resolution is higher than the video resolution the monitor will scale the display down to match the video resolution and this can make the video appear grainier and less defined than the actual resolution. Video with resolutions higher than the display resolution will not result in a poor video quality, but on the other hand will not show the benefit of the increased image quality.

Table F.4 – Examples of CCTV Cameras in use Today or can be Purchased1

Camera Make/Model	Type	Range (Pipe dia.)	Carriage	Digital Resolution	Analogue Resolution	TV Standard	Light Sensitivity	Integrated Laser Caliper	Zoom	Gyroscope
IBAK										
Orpheus 2	Pan & Tilt	>150	Tractor		530 TVL	PAL	1.0 lux (F 1.8, 1/50 s)	Yes	10x optical; 12x digital zoom optional	Yes
Orpheus 3	Pan & Tilt	>150	Tractor		2530 TVL	PAL	1.0 lux (F 1.8, 1/50 s)	Yes	10x optical; 12x digital zoom optional	Yes
Orpheus 2/3 HD	Pan & Tilt	>150	Tractor	1920 x 1080		Full HD	0.5 lux (F 1.8, 1/50 s)	Yes	10x optical / 16x digital	Yes
Orpheus Lite	Pan & Tilt	>150	Tractor		800 TVL	PAL	0,5 lux (F 1.8, 1/30 s)	Yes	10x optical / 16x digital	
Nano	Pan & Tilt	>80	Push rod/tractor		420 TVL	PAL	0,025 lux (F 1.2, 1/50 s)	Yes	No	
Nano L	Pan & Tilt	>80	Push rod/tractor		420 TVL	PAL	0,025 lux (F 1.2, 1/50 s)	Yes	No	
Orion	Pan & Tilt	>100	Push rod/tractor		540 TVL	PAL	0,05 lux (F 1.2., 1/50 s)	Yes	3x digital	
Argus 5	Pan & Tilt	>200	Tractor		460 TVL	PAL	1,5 lux (F 1,8, 1/50 s)	Yes	10x optical, 4x digital zoom optional	
Aspecta	Zoom/Pole Camera				700 TVL	PAL	0,5 lux (F1,6 1/30 s)		30x optical, 10 x digital	
Axialcam	Fixed Axial	>50	Push rod		420 TVL	PAL	0,025 lux		No	
Polaris	Pan & Tilt	>100	Push rod		420 TVL	PAL	0,025 lux (F 1.2, 1/50 s)		No	
Lisy 3	Pan & Tilt	>200	Lateral Launch							
Panoramo 4k	Digital Scanning	>200		4K (4096 × 2160 Pixel)						Yes

Camera Make/Model	Type	Range (Pipe dia.)	Carriage	Digital Resolution	Analogue Resolution	TV Standard	Light Sensitivity	Integrated Laser Caliper	Zoom	Gyroscope
iPEK										
Rovion RCX90	Pan & Tilt	150 - 2000	Tractor		530 TVL	PAL	1 Lux	Yes	10x optical; 12x digital zoom optional	
AGIOLIOS PTP70II	Pan & Tilt	90 - 300	Push rod/tractor		420 TVL	PAL	0.025 Lux	Yes		
Rovion PTC50	Pan & Tilt	100 - 300	Tractor		500 TVL	PAL	0.4 Lux	Yes		
Rovion RAC50	Fixed Axial	100 - 200	Push rod		420 TVL	PAL	0.025 Lux			
Rovion DSIII (Digisewer)	Digital Scanning	200 - 1000	Tractor	0.47 Mpixel		PAL	0.1 Lux			
Quickview	Zoom/Pole Camera			1280 × 720 pixels (2.38 megapixels)						
Supervision SVC75	Pan & Tilt	150 - 1000	Tractor		460 TVL	NTSC & PAL	1 Lux	Yes		
Supervision SVC100/SVC110	Pan & Tilt	150 - 1000	Tractor		460 TVL	NTSC & PAL	1 Lux	Yes	10x optical, 4x digital zoom optional	
Rovver 125	Pan & Tilt		Tractor		460 TVL		3 Lux		10x optical zoom	
Ridgid										
SeeSnake	Fixed Axial	50 - 300	Push rod	656(H) x 492(V)	460TVL	NTSC & PAL				
SeeSnake® MAX rM200 Camera System	Fixed Axial	38 - 150	Push rod	NTSC: 648 x 488; PAL: 768 x 576	460TVL	NTSC & PAL				
SeeSnake® microDrain™ Video Inspection System	Fixed Axial	32 - 75 or 100	Push rod	656 x 492 NTSC	460TVL	NTSC & PAL				
SeeSnake® Mini Video Inspection System	Fixed Axial	40 - 200	Push rod	656(H) x 492(V)	460TVL	NTSC & PAL				

Camera Make/Model	Type	Range (Pipe dia.)	Carriage	Digital Resolution	Analogue Resolution	TV Standard	Light Sensitivity	Integrated Laser Caliper	Zoom	Gyroscope
SeeSnake® microReel Video Inspection System	Fixed Axial	40 - 100/125	Push rod	656 x 492	460TVL	NTSC & PAL				
Pearpoint										
P494	Pan & Tilt	>150	Tractor		625 TVL	NTSC or PAL	<1.0 Lux (@f1.8)		10X optical and 4X digital	
P350 Fixed/Pan & Tilt	Pan & Tilt	150 - 1800	Push rod/tractor		≥ 540 TVL	NTSC or PAL	<1.0 Lux		3x digital	
P350 Pan, Tilt, Zoom	Pan & Tilt	150 - 1800	Push rod/tractor		≥ 530 TVL	NTSC or PAL	1.0 Lux @f1.8		10x optical	
P540 Flexiprobe 25mm	Fixed Axial		Push rod		≥ 460 TVL					
P540 Flexiprobe 32mm self leveling	Fixed Axial		Push rod		≥ 420 TVL					
P540 Flexiprobe 50mm self leveling	Fixed Axial		Push rod		≥ 460 TVL					
P373	Fixed Axial	25 - 100	Push rod				3.0 Lux			
Rausch										
KS 135	Digital pan & tilt	>100	Tractor		540TVL				10x optical, 12x digital	
KS 60 DB	Digital pan & tilt	>100	Push rod/tractor		540TVL					
KS 60 CL (lateral launch)	Pan & Tilt		Push rod/tractor							
ELOOK	Zoom/Pole Camera				700TVL				36x optical, 12x digital	
RCA 4.0 Full HD	Pan & Tilt	100 - 2500	Tractor	1920 x 1080 pixel						
Troglotech										
Troglotech T800	Fixed Axial		Pushrod		540TVL					
Troglotech T812	Pan & Tilt		Pushrod		540TVL					
CUES										

Camera Make/Model	Type	Range (Pipe dia.)	Carriage	Digital Resolution	Analogue Resolution	TV Standard	Light Sensitivity	Integrated Laser Caliper	Zoom	Gyroscope
Digital Universal Camera DUC	Digital Scanning	6 - 60 inch	Tractor	3.1 megapixel						
OZ II	Pan & Tilt	6 - 72 inch	Tractor	.4 MP					10X optical and 4X digital	
OZ III	Pan & Tilt	6 - 48 inch	Tractor	.4 MP					10X optical and 4X digital	

NOTE:

1. Information contained in this table has been sourced from information published by the CCTV camera equipment manufacturers (March 2019). It has been provided as example information and should not be relied upon for information accuracy. The Table does not cover all camera makes and models available. For up to date and detailed information contact the camera equipment manufacturers or agents.

APPENDIX G MODEL PARTICULAR SPECIFICATION

The following model Particular Specifications for CCTV inspection of pipelines and manholes are intended for use where the New Zealand Gravity Pipe Inspection Manual, 4th Edition, 2019 is nominated as the 'General Specification' for pipe or manhole inspections. In preparing the documents for use, specifiers will need to edit the documents by choosing the appropriate options, deleting clauses, or adding additional clauses, to suit the purpose and requirements of the inspection project.

The text contains the following guidance:

- Text in *italics* and coloured red provide editing guidance and is not included in the final document.
- Text coloured blue is information that needs to be provided or selected/deleted as appropriate
- Text coloured green is optional text for inclusion in the clause.

G1 CCTV PARTICULAR SPECIFICATION (PIPELINES)

1. Purpose of Contract

The purposed of this contract is to undertake CCTV pipeline inspection of wastewater and or stormwater pipelines in listed location(s) as part of the following inspection programme: *[modify and delete any not applicable]*

- Planned inspection of Critical assets and Non-Critical assets
- Confirmation of planned asset renewals
- Pre and post build over inspections
- Acceptance of new and rehabilitated assets
- Reactive Maintenance inspections
- *Other specific issue driven inspection*

2. Scope of Works

2.1 The scope of this work involves: *[delete any of the following bullet points that are not applicable]*

- CCTV camera inspection.
- Traffic Management
- Cleaning the pipeline prior to inspection
- Confirming whether laterals are 'live' or 'dead'.
- Confirming the source of all laterals.
- Locating the position of all live laterals on the ground surface and or on marked up drawings
- Locating the position of buried manholes.
- Reporting the position of manholes that are incorrectly positioned on the Clients asset plans.
- Locating the position and depth where a pipe crosses a property boundary on the ground surface
- Locating the position and depth where a pipe crosses beneath a building
- Locating major defects requiring immediate repair.
- Supplementary Inspections (refer to clause 2.5 below)
- Other (Specify)

2.2 The pipelines to be inspected are: *[delete any of the following bullet points that are not applicable]*

- Shown on the attached plans.
- Listed on the attached schedules
- Will be provided as part of separate work instruction(s)
- Other (Specify)

2.3 The works to be carried out are in: *[delete any of the following bullet points that are not applicable]*

- Public roads.
- Private land.
- Council reserves.
- Other (Specify)

2.4 Issues that the CCTV contractor needs to be aware of include: *[delete any of the following bullet points that are not applicable]*

- Pipes to be inspected are downstream of Pump Stations.
- Pipes maybe subject to dry weather flow levels greater than the maximum depth of flow as specified in B1.2.3.1.
- Pipes that are known to contain debris.
- Some Pipes maybe in 'Poor' or *'Very Poor'* condition.
- Pipe materials are not known, or the pipe material information is unreliable.
- Pipes to be inspected may have Polyurethane coated Cured-In-Place patch repairs
- Pipes to be inspected maybe within L1 Traffic control areas.
- Equipment access to some manholes is limited.
- Pipes to be inspected maybe subject to hot water discharges.
- Pipes to be inspected may be subject to aggressive industrial discharges.
- Some properties are known to have specific requirements for entry.
- Some properties connected to the pipelines for inspection have a known history of 'Blow Back' when cleaning has been undertaken.

[Provide details, or any known information, and any specific requirements if any of the points above are applicable]

2.5 Supplementary Inspections *[delete this clause if not applicable]*

The following supplementary inspection methods are included in the contract works: *[delete or modify any of the following bullet points or clauses that are not applicable]*

- Laser Profiling and Sonar Profiling
- Light Detection and Ranging (LIDAR)
- Pipe Proving
- Gyroscopic Profiling
- Extracting pipe coupons
- Ultrasonic Scanning
- Other (specify)

2.6 The following applies regarding the location and access to manholes: *[delete or modify any of the following bullet points or clauses that are not applicable]*

- The Asset Owner has located and opened all manholes prior to the CCTV contract starting.
- The Asset Owner has located and opened all manholes, with the following exceptions which the Contractor is required to locate. *[provide list below or separate document included in the specification appendix]*
- The position and accessibility of the manholes has not been confirmed. The contractor is required to confirm the location of all manholes as part of the works.

When buried manholes are located the contractor is required to: *[delete or modify any of the following bullet points or clauses that are not applicable]*

- Marked the position of the buried manhole on the ground surface, either with a peg, spike or paint. Where a node is in private property, the owner shall be consulted to define an acceptable way of marking the node location. In addition, a marked-up drawing of the manhole location shall be provided, (Refer to B1.2.5 and clause 13.3 of this Particular Specification for requirements of Marked-up Drawing).
- Where the depth to the buried cover is less than 100mm below an unsealed surface, the cover shall be temporarily exposed for access, otherwise the manhole may be raised by the Asset Owner.
- Where the depth to the buried cover is less than 100mm below and unsealed surface, the cover shall be temporarily exposed for access, otherwise the Engineer may instruct the Contractor to raise the manhole.
- Other (specify)

3. Cleaning

3.1 Prior to the CCTV inspections being undertaken the following preparation is required: *[delete any of the following bullet points that are not applicable]*

- Full (Heavy) clean as per description in B1.1.2.1.
- Light cleaning as per description in B1.1.2.2.
- No cleaning prior to inspection as per description in B1.1.2.3.

[delete or modify the following clause statement below as applicable]

CCTV inspections shall be carried out within seven days of cleaning. Any build-up of debris occurring between cleaning and inspection shall be attended to as necessary for a satisfactory picture quality but shall not be considered for additional payment.

[delete or modify the clause statement below as applicable]

If the inspection of a pipeline is unable to be completed from both ends of the pipeline due to debris, roots, fat, or temporary obstruction, then the Contractor is to submit a brief report to the Engineer, within 5 working days, that provides photos of the debris, roots or obstruction and contains details of: [delete any of the following bullet points that are not applicable]

- The location of the debris, roots or obstruction that stopped the inspection.
- The type of debris or obstruction encountered.
- The approximate volume of debris or size of roots.
- The length of pipeline that was unable to be inspected.
- Comments on whether the debris, roots or obstruction is affecting service.
- Comments on whether any structural defects are present or might be present in the pipeline.

The Engineer may then elect to: *[delete any of the following bullet points that are not applicable]*

- Have the debris, roots or obstruction removed by its Maintenance Contractor.
- Instruct the CCTV Contractor to clean the pipe to remove the obstruction.
- Not undertake any further works.

4. Access to Water for Cleaning

[delete the following clauses that do not apply. Modify as necessary]

4.1 Council has number of Contractor's Filling Points. These are located at the following locations: *[identify location of approved filling point(s)]*

- *List locations*

A key is available for Contractor access to these filling points following payment of a $specify refundable key bond. It is the Contractor's responsibility to arrange and pay for the water used for pipe cleaning.

Abstraction of water from fire hydrants will not be permitted.

4.2 Abstraction from fire hydrants is permitted, but a metered stand pipe must be obtained from named location following payment of a $specify refundable bond. It is the Contractor's responsibility to arrange and pay for the water used for pipe cleaning.

[delete the following clause if not applicable]

4.3 Disposal of Material Removed from Pipes

The Contractor is responsible for the disposable of the removed materials from the site at the end of each work day. The removed material should not be allowed to accumulate, other than in enclosed containers. All materials removed are to be disposed of in a safe and legal manner at an approved location. Approved disposal locations are as follows: *[identify location of approved disposal facility(ies)]*

- List approved disposal locations

5. Maintain Access and Wastewater and Stormwater Supply to Properties

A minimum of specified hours prior to entering a private residential or business property, or undertaking work that my impact on the occupier, the Contractor shall make a letter drop notifying the property owners/occupiers of the intention to start work on the property. The letter shall identify any foreseeable disruption the contract works will have on the properties and shall include a 24-hour contact name and telephone number. A copy of the Contractor's letter to the owners/occupiers shall be forwarded to the Engineer for his/her approval prior to delivery.

The Contractor shall continue to liaise with the property and business owners and programme their work to ensure a minimum amount of disruption to the property and business owners.

The Contractor shall maintain wastewater and stormwater services to properties including providing temporary connections where required. Where desired the Contractor may seek the co-operation of the owners/occupiers to minimise flows during the period of the works but there is no obligation for the co-operation to be provided.

Vehicular access to private property must be maintained all times where practical. Where access is affected it to be shall be interrupted for the shortest possible time and access must always be made available outside normal working hours.

6. Maximum Depth of Water Flow

Where the flow cannot be managed to the required depth as specified in B1.2.3.1, the Contractor shall notify the Engineer and agree and seek approval on alternative method to either achieve the required flow depth or agree an acceptable flow depth that can be achieved.

7. Requirements for Multiple Inspections from Both Ends of a Single Pipe Asset

In addition to the requirements specified in B2.1.4.1 the following is required: *[delete any of the following bullet points that are not applicable]*

- The video files of both inspections shall be joined together to create a single video file. The order of the joined files shall be in the order of filming
- The video files shall be provided as two separate files. The Video Volume Reference number of the second, reverse inspection, shall be noted in the General Comments field of the Header.
- The both inspections can be provided under separate inspection headers, but the Preliminary Condition Grade for each must reflect the combined observed defects.

8. Optional Codes

Joint Displaced, Small severity (JD, S) and Joint Open, Small severity (JO, S) defects are: *[delete one the following bullet points]*

- Not required to be recorded.
- Are required to be recorded.

9. Hazards and Significant Defects

In addition to the defects described in B1.2.6, the following defects if found should be reported to the Engineer as soon as possible: *[list additional defects, including characterisation and quantification where necessary]*

- Specify defects to be added to the hazard and significant defect list

10. CCTV Equipment

10.1 The minimum CCTV Camera capability for the contract works, as defined by A2.5 Inspection Equipment Classification Shall be:

Dimension: Specify Dimension 2 or 3

Inspection Resolution: Specify Inspection Resolution iii, iv, v, or vi

11.2 The minimum CCTV camera resolution for the contract works, as described in Appendix F, clauses F2.1 and F2.2 shall be: *[delete the following bullet points that are not applicable]*

- High Resolution
- Broadcast video-Quality
- HD-Ready
- Full HD
- 4K-UHD
- Not Specified

11.3 Specific equipment capability required includes: [delete this clause or any of the following bullet points that are not applicable]

- Laser calliper measurement (Laser dots)
- Built-in Inclinometers
- Radio Sonde location
- Other (Specify)

12 Quality Assurance

12.1 Qualifications and Competency

[delete either 9.1.1 or 9.1.2 and modify as necessary]

12.1.1 CCTV Operator Technician, Coding Technicians and Internal Auditors shall have the qualifications and competence as specified in A4.3.1 and A4.3.2

12.1.2 CCTV Operator Technician, Coding Technicians and Internal Auditors shall hold the minimum qualifications:

Role	Unit Standards	Current Competency Certification	Other
CCTV Operator Technician	Specify if required	Yes/No	Specify specific Requirement e.g. Site Safe
Coding Technician/Auditor	Specify if required	Yes/No	Specify specific Requirement e.g. Site Safe

12.1.3 Change of Operator

If the Contractor wishes to replace the Operator nominated in their tender, the prior approval of the Engineer shall be sought in writing.

12.2 Benchmark Video

The Contractor shall submit for the Engineer's approval, a sample video record for all CCTV cameras that will be used on the contract works, prior to their use on the contract, or as the first output of the contract if not previously used. The sample video record shall be of a complete inspection, including the header. The samples will be used to verify compliance with the required video resolution, file type and quality as part of the Initial and on-going audits carried out by the Engineer.

The Contractor shall also provide a sample electronically generated log sheet. *[delete where not applicable]*

If the Contractor wishes to replace the camera equipment nominated in their tender or quality plan, the prior approval of the Engineer shall be sought in writing and another approved Benchmark video provided.

12.3 Contractor's Quality Auditing Process *[delete or modify 9.3.1 as applicable]*

12.3.1 The Contractor's audit methodology shall be submitted to the Engineer, for approval, prior to the commencement of inspections. The Contractor shall nominate an experienced and 'competent' auditor to undertake on-going auditing of the inspections.

[delete or modify 9.3.2 as applicable]

12.3.2 The frequency of auditing by the Contractor shall be a minimum, either nominated% of total length of assets inspected, or one asset, (whichever is the greater) for each CCTV submission to the Engineer (Batch submission).

[delete or modify 9.3.3 as applicable]

12.3.3 The Engineer Requires the Contractor to provide evidence of the audits being undertaken and the results generated.

12.4 Asset Owners Initial Audit

[delete or modify 9.4.1 as applicable]

12.4.1 The Contractor shall supply the first available video records and log sheets (or database) to the Engineer for auditing, within Specify number working days of completion.

[delete or modify 9.4.2 as applicable]

12.4.2 The Engineer will report the results of the first audit back to the Contractor within *Specify number* working days of receipt of the video.

12.5 Asset Owner's Ongoing Auditing

12.5.1 The Engineer shall undertake ongoing auditing of the works at the following frequency: *[delete the following bullet points that are not applicable varying the values in A4.4.4]*

- Nominated% of completed inspections, increasing to higher nominated% where the accuracy result is less than the minimum specified accuracy level.
- Random 'Spot Checks' only
- Other (specify)

12.5.2 The Specified Accuracy Level (as per A4.4.4) is nominated% *[specify 95% as default or alternative value]*

12.5.3 Specified Tolerance Limit (as per A4.4.4) is nominated% *[specify 90% as default or alternative value]*

13 Deliverables

13.1 Video Files

13.1.1 Video Storage Requirements

The Asset Owner will be storing the video files in the following method, and therefore the supplied video files should be coded to best suit this method: *[delete the following bullet points that are not applicable]*

- Local Server
- External Hard-Drive
- Cloud Storage
- Within Proprietary video management software (to be specified)
- Other (Specify)

13.1.2 Minimum Bitrate [Delete this clause or modify as applicable]

The minimum video Bitrate shall be: specified Bitrate Mbps

13.1.3 Video File Format

Video files shall be provided in the following video container format: *[delete the following bullet points that are not applicable]*

- MPEG [if required this can be specified as to the type of MPEG file i.e. MP4]
- AVI
- HTML5
- Other (Specify)

13.1.4 Video Media for file Transfer

Video files shall be supplied via the following medium:

- DVD
- Flash drive/external hard-drive.
- Upload via file sharing service (to be specified)
- Other (specify)

13.1.5 Video File Naming

The following video file naming convention shall be used, and this shall also be recorded in the Header Field "Video Volume Reference" (Field ABO): *[specifier to describe the convention for providing a unique reference for each video file]*

Specify video file naming convention

13.1.6 Referencing System for Supplied Media *[delete this clause if not using DVD or portable media]*

Where the CCTV video files are to be supplied on DVD or portable hard-drive, the media is supplied is to be labelled in accordance with the following convention: [Specifier to describe the convention for name media]

Specify media naming convention

Where the video files are supplied on a DVD, the Header Field “Video Volume Reference” (Field ABO) shall use the Media Name.

13.1.7 Video Screen Header Information [Delete this clause if no changes or additional screen header information required]

In addition to requirements of B1.2.2.8 Screen Header Display (Start of Inspection) the following additional information is required: *[delete the following bullet points that are not applicable]*

- Client Reference Number
- Location
- Name of the Client
- Weather

The following Screen Header information fields are not required: *[delete the following bullet points that are not applicable]*

- Measured Pipe Diameter
- Purpose of the Inspection
- Cleaning Status

13.2 Inspection Data

13.2.1 Still Images [Delete this clause if no additional still images are required]

In addition to the minimum requirements specified in B1.2.3.5, still images of the following are to be captured and provided: *[modify and delete the following bullet points that are not applicable]*

- All severity “L” defects or defects with a weighted score >35.
- All severity “L” & “M” defects or defects with a weighted score >35.
- Every 10m along the pipeline.
- Other (Specify)

13.2.2 Inspection Reports

Inspection Reports are to be provided in the following format: [delete the following bullet points that are not applicable]

- Computer generated as a PDF file
- Computer generated printed as a hard copy
- Computer generated supplied in proprietary software (to be specified)

[delete the following if PDF Inspection Reports are not provided]

PDF files must be named in the following format: *[specifier to describe the convention for providing a unique reference for each Inspection Report PDF file]*

Specify media naming convention

13.2.3 Exported Data

Header and Observation data is to be export and provided for transfer into the Asset Owners CCTV data management system in the following format: *[delete the following bullet points that are not applicable]*

- InfoNet compliant export format
- WinCan
- Cleanflow
- Exchange format for Hansen Software
- Electronic Data Transfer Format provided in Appendix A
- Other (specify format)
- Export data is not required.

13.2.4 CCTV Summary Sheet *[delete this clause if summary sheets are not required]*

CCTV Summary Sheets in the following format: *[delete the following bullet points that are not applicable]*

- Computer generated as a PDF file

- Computer generated printed as a hard copy
- Computer generated supplied in proprietary software (to be specified)

13.2.5 Header Information Required

The following header information is required to be provided in addition to the mandatory fields specified in B2.2 Header Classification Codes: *[delete the following bullet points that are not applicable]*

- Up node coordinate (AAE).
- Down node coordinate (AAG)
- Location (AAJ)
- Location Type (AAL)
- Asset Owner (AAM)
- Town or Suburb (AAN)
- District/Catchment (AAO)
- Name of Pipe System (AAP)
- Land Ownership (AAQ)
- Drawing Number (AAS)
- Original Coding System (ABB)
- Method of Inspection (ABE)
- Operators reference (ABI)
- Asset Owners Reference (ABJ)
- Storage Medium for video (ABK)
- Date of Data Entry (ABU)
- Depth at Up Stream Node (ACH)
- Depth at Down Stream Node (ACI)
- Jointing Method (ACO)
- Up Node Type (ACP)
- Down Node Type (ACQ)
- Precipitation (ADA)
- Temperature (ADB)
- Flow Control Measures (ADC)
- Tidal Influence (ADD)

13.3 Marked-Up Drawings

Marked-Up Drawings to be provided in:

- ArcGIS
- Printed Hard copies.
- Electronic files (.pdf)/(.jpg)/(.dwg). [modify or delete file extension(s) not required]
- Other (Specify)

G2 CCTV PARTICULAR SPECIFICATION (MANHOLES)

1. Purpose of Contract

The purposed of this contract is to undertake CCTV inspection of wastewater and or stormwater manholes in the listed location(s) as part of the following inspection programme: *[modify and delete any not applicable]*

- Planned inspection of Critical assets and Non-Critical assets
- Confirmation of planned asset renewals
- Pre and post build over inspections
- Acceptance of new and rehabilitated assets
- Reactive Maintenance inspections
- Other specific issue driven inspection

2. Scope of Works

2.1 The scope of this work involves: *[delete any of the following bullet points that are not applicable]*

- CCTV camera inspection.
- Traffic Management
- Cleaning the manholes prior to inspection
- Confirming whether laterals are 'live' or 'dead'.
- Confirming the source of all laterals.
- Locating the position of buried manholes.
- Reporting the position of manholes that are incorrectly positioned on the Clients asset plans.
- Locating major defects requiring immediate repair.
- Supplementary Inspections (refer to clause 2.5 below)
- Other (Specify)

2.2 The manholes to be inspected are: *[delete any of the following bullet points that are not applicable]*

- Shown on the attached plans.
- Listed on the attached schedules
- Will be provided as part of separate work instruction(s)
- Other (Specify)

2.3 The works to be carried out are in: *[delete any of the following bullet points that are not applicable]*

- Public roads.
- Private land.
- Council reserves.
- Other (Specify)

2.4 Issues that the CCTV contractor needs to be aware of include: *[delete any of the following bullet points that are not applicable]*

- Manholes to be inspected are downstream of Pump Stations.
- Manholes maybe subject to dry weather flow levels greater than the maximum depth of flow as specified in D1.2.3.1.
- Manholes to be inspected maybe within L1 Traffic control areas.
- Equipment access to some manholes is limited.
- Manholes to be inspected maybe subject to hot water discharges.
- Manholes to be inspected may be subject to aggressive industrial discharges.
- Some properties are known to have specific requirements for entry.

[Provide details, or any known information, and any specific requirements if any of the points above are applicable]

2.5 Supplementary Inspections *[delete this clause if not applicable]*

The following supplementary inspection methods are included in the contract works: *[delete or modify any of the following bullet points or clauses that are not applicable]*

- Exfiltration (Hydrostatic) Testing
- Vacuum Testing
- Extracting Core Samples
- Ultrasonic Scanning
- Other (specify)

2.6 The following applies regarding the location and access to manholes: *[delete or modify any of the following bullet points or clauses that are not applicable]*

- The Asset Owner has located and opened all manholes prior to the CCTV contract starting.
- The Asset Owner has located and opened all manholes, with the following exceptions which the Contractor is required to locate. *[provide list below or separate document included in the specification appendix]*
- The position and accessibility of the manholes has not been confirmed. The contractor is required to confirm the location of all manholes as part of the works.

When buried manholes are located the contractor is required to: *[delete or modify any of the following bullet points or clauses that are not applicable]*

- Marked the position of the buried manhole on the ground surface, either with a peg, spike or paint. Where a node is in private property, the owner shall be consulted to define an acceptable way of marking the node location. In addition, a marked-up drawing of the manhole location shall be provided, (Refer to B1.2.5 and clause 13.3 of this Particular Specification for requirements of Marked-up Drawing).
- Where the depth to the buried cover is less than 100mm below an unsealed surface, the cover shall be temporarily exposed for access, otherwise the manhole may be raised by the Asset Owner.
- Where the depth to the buried cover is less than 100mm below and unsealed surface, the cover shall be temporarily exposed for access, otherwise the Engineer may instruct the Contractor to raise the manhole.
- Other (specify)

3. Cleaning

3.1 Prior to the CCTV inspections being undertaken the following preparation is required: *[delete one of the following two bullet points]*

- Full (Heavy) clean as per description in D1.1.2, Table D1.1_1
- No cleaning prior to inspection

[delete or modify the following clause statement below as applicable]

CCTV inspections shall be carried out within seven days of cleaning. Any build-up of debris occurring between cleaning and inspection shall be attended to as necessary for a satisfactory picture quality but shall not be considered for additional payment.

[delete or modify the clause statement below as applicable]

If the inspection of a pipeline is unable to be completed due to debris, roots, fat, blockage downstream of the manhole, then the Contractor is to submit a brief report to the Engineer, within 5 working days, that providing the reason including photos detailing the issue

The Engineer may then elect to: *[delete any of the following bullet points that are not applicable]*

- Organise for the Maintenance Contractor to remove the blockage.
- Organise for the Maintenance Contractor to clean the manhole
- Instruct the CCTV Contractor to clean the manhole.
- Not undertake any further works.

4. Access to Water for Cleaning

[delete the following clauses that do not apply. Modify as necessary]

4.1 Council has number of Contractor's Filling Points. These are located at the following locations: *[identify location of approved filling point(s)]*

- List locations

A key is available for Contractor access to these filling points following payment of a $specify refundable key bond. It is the Contractor's responsibility to arrange and pay for the water used for pipe cleaning.

Abstraction of water from fire hydrants will not be permitted.

4.2 Abstraction from fire hydrants is permitted, but a metered stand pipe must be obtained from named location following payment of a $specify refundable bond. It is the Contractor's responsibility to arrange and pay for the water used for pipe cleaning.

[delete the following clause if not applicable]

5. Disposal of Material Removed from Pipes

The Contractor is responsible for the disposable of the removed materials from the site at the end of each work day. The removed material should not be allowed to accumulate, other than in enclosed containers. All materials removed are to be disposed of in a safe and legal manner at an approved location. Approved disposal locations are as follows: *[identify location of approved disposal facility(ies)]*

- List approved disposal locations

7. Maintain Access and Wastewater and Stormwater Supply to Properties

A minimum of specified hours prior to entering a private residential or business property, or undertaking work that my impact on the occupier, the Contractor shall make a letter drop notifying the property owners/occupiers of the intention to start work on the property. The letter shall identify any foreseeable disruption the contract works will have on the properties and shall include a 24-hour contact name and telephone number. A copy of the Contractor's letter to the owners/occupiers shall be forwarded to the Engineer for his/her approval prior to delivery.

The Contractor shall continue to liaise with the property and business owners and programme their work to ensure a minimum amount of disruption to the property and business owners.

The Contractor shall maintain wastewater and stormwater services to properties including providing temporary connections where required. Where desired the Contractor may seek the co-operation of the owners/occupiers to minimise flows during the period of the works but there is no obligation for the co-operation to be provided.

Vehicular access to private property must be maintained all times where practical. Where access is affected it to be shall be interrupted for the shortest possible time and access must always be made available outside normal working hours.

8. Maximum Depth of Water Flow

Where the flow cannot be managed to the required depth as specified in D1.2.3.1, the Contractor shall notify the Engineer and agree and seek approval on alternative method to either achieve the required flow depth or agree an acceptable flow depth that can be achieved.

9. Optional Codes

Joint Displaced, Small severity (HJD, S) and Joint Open, Small severity (HJO, S) defects are: *[delete one the following bullet points]*

- Not required to be recorded.
- Are required to be recorded.

10. Hazards and Significant Defects

In addition to the defects described in D1.2.8, the following defects if found should be reported to the Engineer as soon as possible: *[List additional defects, including characterisation and quantification where necessary]*

- Specify defects to be added to the hazard and significant defect list

11. CCTV Equipment

11.1 The minimum CCTV Camera capability for the contract works, as defined by A2.5 Inspection Equipment Classification Shall be:

Dimension: Specify Dimension 2 or 3

Inspection Resolution: Specify Inspection Resolution iii, iv, v, or vi

11.2 The minimum CCTV camera resolution for the contract works, as described in Appendix F, clauses F2.1 and F2.2 shall be: ***[delete the following bullet points that are not applicable]***

- High Resolution
- Broadcast video-Quality
- HD-Ready
- Full HD
- 4K-UHD
- Not Specified

12. Quality Assurance

12.1 Qualifications and Competency

[delete either 9.1.1 or 9.1.2 and modify as necessary]

12.1.1 CCTV Operator Technician, Coding Technicians and Internal Auditors shall have the qualifications and competence as specified in A4.3.1 and A4.3.2

12.1.2 CCTV Operator Technician, Coding Technicians and Internal Auditors shall hold the minimum qualifications:

Role	Unit Standards	Current Competency Certification	Other
CCTV Operator Technician	Specify if required	Yes/No	Specify specific Requirement e.g. Site Safe
Coding Technician/Auditor	Specify if required	Yes/No	Specify specific Requirement e.g. Site Safe

12.1.3 Change of Operator

If the Contractor wishes to replace the Operator nominated in their tender, the prior approval of the Engineer shall be sought in writing.

12.2 Benchmark Video

The Contractor shall submit for the Engineer's approval, a sample video record for all CCTV cameras that will be used on the contract works, prior to their use on the contract, or as the first output of the contract if not previously used. The sample video record shall be of a complete inspection, including the header. The samples will be used to verify compliance with the required video resolution, file type and quality as part of the Initial and on-going audits carried out by the Engineer.

The Contractor shall also provide a sample electronically generated log sheet *[delete where not applicable].*

If the Contractor wishes to replace the camera equipment nominated in their tender or quality plan, the prior approval of the Engineer shall be sought in writing and another approved Benchmark video provided.

12.3 Contractor's Quality Auditing Process

[delete or modify 9.3.1 as applicable]

12.3.1 The Contractor's audit methodology shall be submitted to the Engineer, for approval, prior to the commencement of inspections. The Contractor shall nominate an experienced and 'competent' auditor to undertake on-going auditing of the inspections.

[delete or modify 9.3.2 as applicable]

12.3.2 The frequency of auditing by the Contractor shall be a minimum, either nominated% of total manhole assets inspected, or one asset, (whichever is the greater) for each CCTV submission to the Engineer (Batch submission).

[delete or modify 9.3.3 as applicable]

12.3.3 The Engineer Requires the Contractor to provide evidence of the audits being undertaken and the results generated.

12.4 Asset Owners Initial Audit

[delete or modify 9.4.1 as applicable]

12.4.1 The Contractor shall supply the first available video records and log sheets (or database) to the Engineer for auditing, within Specify number working days of completion.

[delete or modify 9.4.2 as applicable]

12.4.2 The Engineer will report the results of the first audit back to the Contractor within Specify number working days of receipt of the video.

12.5 Asset Owner's Ongoing Auditing

12.5.1 The Engineer shall undertake ongoing auditing of the works at the following frequency: *[delete the following bullet points that are not applicable varying the values in A4.4.4]*

- Nominated% of completed inspections, increasing to higher nominated% where the accuracy result is less than the minimum specified accuracy level.
- Random 'Spot Checks' only
- Other (specify)

12.5.2 The Specified Accuracy Level (as per A4.4.4) is nominated% *[specify 95% as default or alternative value]*

12.5.3 Specified Tolerance Limit (as per A4.4.4) is nominated% *[specify 90% as default or alternative value]*

13. Deliverables

13.1 Video Files

13.1.1 Video Storage Requirements

The Asset Owner will be storing the video files in the following method, and therefore the supplied video files should be coded to best suit this method: *[delete the following bullet points that are not applicable]*

- Local Server
- External Hard-Drive
- Cloud Storage
- Within Proprietary video management software (to be specified)
- Other (Specify)

13.1.2 Minimum Bitrate [Delete this clause or modify as applicable]

The minimum video Bitrate shall be: specified Bitrate Mbps

13.1.3 Video File Format

Video files shall be provided in the following video container format: *[delete the following bullet points that are not applicable]*

- MPEG [if required this can be specified as to the type of MPEG file i.e. MP4]
- AVI
- HTML5
- Other (Specify)

13.1.4 Video Media for file Transfer

Video files shall be supplied via the following medium:

- DVD
- Flash drive/external hard-drive.

- Upload via file sharing service (to be specified)
- Other (specify)

13.1.5 Video File Naming

The following video file naming convention shall be used, and this shall also be recorded in the Header Field "Video Volume Reference" (Field CBO): *[specifier to describe the convention for providing a unique reference for each video file]*

Specify video file naming convention

13.1.6 Referencing System for Supplied Media *[delete this clause if not using DVD or portable media]*

Where the CCTV video files are to be supplied on DVD or portable hard-drive, the media is supplied is to be labelled in accordance with the following convention: *[specifier to describe the convention for name media]*

Specify media naming convention

Where the video files are supplied on a DVD, the Header Field "Video Volume Reference" (Field CBO) shall use the Media Name.

13.1.7 Video Screen Header Information *[delete this clause if no changes or additional screen header information required]*

In addition to requirements of D1.2.2.4 Screen Header Display (Start of Inspection) the following additional information is required: [delete the following bullet points that are not applicable]

- Client Reference Number
- Location
- Name of the Client
- Weather

The following Screen Header information fields are not required: *[delete the following bullet points that are not applicable]*

- Measured Chamber Dimension
- Purpose of the Inspection
- Cleaning Status

13.2 Inspection Data

13.2.1 Still Images *[delete this clause if no additional still images are required]*

In addition to the minimum requirements specified in D1.2.3.4, still images of the following are to be captured and provided: *[modify and delete the following bullet points that are not applicable]*

- All severity "L" defects or defects with a weighted score >35.
- All severity "L" & "M" defects or defects with a weighted score >35.
- Other (Specify)

13.2.2 Inspection Reports

Inspection Reports are to be provided in the following format: *[delete the following bullet points that are not applicable]*

- Computer generated as a PDF file
- Computer generated printed as a hard copy
- Computer generated supplied in proprietary software (to be specified)

[delete the following if PDF Inspection Reports are not provided]

PDF files must be named in the following format: *[specifier to describe the convention for providing a unique reference for each Inspection Report PDF file]*

Specify media naming convention

13.2.3 Exported Data

Header and Observation data is to be export and provided for transfer into the Asset Owners CCTV data management system in the following format: *[delete the following bullet points that are not applicable]*

- InfoNet compliant export format
- WinCan
- Electronic Data Transfer Format provided in Appendix A
- Other (specify format)
- Export data is not required.

13.2.4 CCTV Summary Sheet [Delete this clause if summary sheets are not required]

CCTV Summary Sheets in the following format: *[delete the following bullet points that are not applicable]*

- Computer generated as a PDF file
- Computer generated printed as a hard copy
- Computer generated supplied in proprietary software (to be specified)

13.2.5 Header Information Required

The following header information is required to be provided in addition to the mandatory fields specified in B2.2 Header Classification Codes: *[delete the following bullet points that are not applicable]*

- Asset coordinate (CAB).
- Location Type (CAL)
- Asset Owner (CAM)
- Town or Suburb (CAN)
- District/Catchment (CAO)
- Name of Network (CAP)
- Land Ownership (CAQ)
- Original Coding System (CBB)
- Operators Reference (CBI)
- Asset Owners Reference (CBJ)
- Storage Medium for Video (CBK)
- Date of Data Entry (CBU)
- Precipitation (CDA)
- Temperature (CDB)
- Flow Control Measures (CDC)
- Atmosphere (CDD)
- Tidal Influence (CDE)

13.3 Marked-Up Drawings

Marked-Up Drawings to be provided in:

- ArcGIS
- Printed Hard copies.
- Electronic files (.pdf)/(.jpg)/(.dwg). [modify or delete file extension(s) not required]
- Other (Specify)

Glossary

Acceptable Risk – Refers to the risk exposure that is deemed acceptable to a utility/company. Acceptable risks are defined in terms of the probability and impact of a particular risk. They serve to set practical targets for risk management and are often more helpful than the idea that no risk is acceptable. In practice, risk often can't be reduced to zero due to factors such as cost and secondary risk.

Action Camera – A compact stationary camera typically mounted on a pole that capable of capturing photos and videos. An example of an action camera would be a Go-Pro.

Asset – A physical component that has value, enables service to be provided and has an economic life greater than 12 months. For example, a section of sewer pipeline is an asset.

Asset Management – Managing infrastructure capital assets to minimise the total cost of owning and operating them, while delivering the service levels customers' desire.

Asset Management Information System (AMIS) – Asset management information systems are used to store and analyse asset data. An asset register is a database or spread-sheet within an asset management information system that enables storage of data.

Asset Manager – The person responsible for managing the Wastewater or Stormwater Network.

Asset Identification Number (Asset ID) – A unique reference name allocated to an asset to identify the asset from any other.

Asset Owner – Utility (Local Council or Water Utility), company or person, (in the case of private laterals) that owns the pipe or manhole asset and/or has responsibility for the asset.

Asset Register – A record of asset information including inventory, historical, condition, construction, technical and financial.

Attributes – Physical properties of an asset. For example, the diameter and material of sewer pipe.

Autogenous Healing – Process where small cracks, typically up to 0.5mm wide, but can be up to approximately 1mm, in concrete pipes "self-heal". Minerals from the ground soil surrounding the pipe are pulled into the crack by ground water seeping into the pipe line. The minerals are deposited in the crack and overtime fill in the crack making it almost water tight.

Beading – Protrusions in a polyethylene pipe created by the joint butt-welding processes. They are normally not very prominent and will normally have been removed by the pipe installation contractor.

Benchmark sample video – A sample of video prepared by the CCTV Contractor prior to the CCTV work commencing, that is agreed between the Contractor and the Asset Owner as representing the acceptable minimum standard of video quality to be provided for the inspections to be undertaken.

Blister – A bubble on the surface of an asset, particularly an assets gel coat or liner. A blister is smaller than a bulge and more likely to occur in a group.

Blow-back – wastewater that is un-intentionally ejected from the sewer, typically through vents in the private laterals due to sudden change between negative and positive pressure created during cleaning as a nozzle passes a lateral connection.

Bulge – A convex part of an otherwise concave or flat plastic pipe or liner. A bulge is larger than a blister and more likely will occur in isolation.

Camera Setup Location – The node where the CCTV inspection started from.

Camera Stopping Position – The stationary position of the camera when a defect or feature is observed, typically about a pipe diameter in front of the defect/feature where it can be clearly viewed in focus, within the full pipe circumference.

CAPEX – Capital Expenditure

Certificate of Competence – Certificate issue by an Asset Owners approved training provider to a CCTV Operator or Reviewer/Coding Technician who has demonstrated that they are able to carry out their work to the required standard of quality and accuracy.

Characterisation Code – a sub-code added to some main codes to further describe the defect or feature.

Circumferential location – One or two clock face references that locate the position of a defect or feature around the pipe or manhole circumference.

Client – The "Client" refers to the organisation which has initiated a body of work. The Client will most commonly be the Asset Owner or the Principal in terms of the contract documents.

Coding Technician – Person responsible for identifying and reporting defects and features from a CCTV inspection but does not operate the camera system. Typically, not field based.

Collapse – Full structural failure and the pipe no longer functions as a free-flowing conduit, although water may still flow through the rubble of the collapsed pipe

Combined Drainage – Pipe work that is designed to transport both Wastewater and Stormwater within the same pipe.

Condition Codes – Alphanumeric codes which represent pipeline or manhole features (such as lateral pipe connections) or defects (such as cracks in a pipe).

Condition Data – The separate components of a condition records. Data may include distance information, condition codes and severity ratings.

Continuous Defect (or Feature) – a defect (or feature) that has a longitudinal length greater than one metre in length and is specified in section B2.3 or D2.3 as being applicable for recording as a continuous defect or feature.

Condition Records – The recorded information that identifies a pipeline defect of feature. The information may include such items as the Longitudinal (or Vertical) Distance, Condition Codes, Circumferential Location and Description Location.

Contractor – The company appointed to carry out work by the Asset Owner or Principal.

Critical Assets – Assets deemed to have a high consequence of failure, this could be financial, loss of service and disruption. Critical assets have a lower threshold for action than non-critical assets.

Defect Score – A specific value given to a specific defect based on the type and severity of that defect

Defect Code – Refer to Condition Codes

Description Location – A code describing the component of the manhole relating to the defect or feature observation.

Design Life – The design life of a pipe is usually the period over which an asset's depreciation is calculated. (The Useful/Service life is often much longer than the design life).

Digital Scanning Camera – High Resolution digital camera (or cameras, some have two or more) that take wide angle (>180o) digital photographs that when processed by software provide a continuous view of the pipeline.

Distance Measurement Unit – Device connected to Camera unit cable reel that measures the cable as it comes off the reel. This measurement is displayed on the screen and can be reset to zero at any time.

Exfiltration – The unintended leakage of wastewater out of the network into the surrounding ground through broken or damaged pipes or manholes.

Features – Attributes or components of the pipe or information related to the inspection being undertaken that are not defects recorded with observation classification codes.

Feature Code – Refer to Condition Codes

Final Condition Grade – Condition grade (1 – 5) assigned to the pipe following an engineering assessment.

Fixed Axial Camera – CCTV Camera where the only view available is along the horizontal axis of the pipe. The camera does not have the ability to pan or tilt.

Focus Length –The distance from the camera to where the pipe is clearly visible. A distance when viewed through camera fills the monitor.

FOG – an acronym for Fats, Oil and grease. Not to be confused with the term fog which refers to a mist occurring in the pipe.

Geographic Information System (GIS) – A framework for gathering, managing and displaying asset data on multiple layers, displayed on maps.

Global Positioning System (GPS) – A method of accurately determining absolute locations and relative levels using multiple observations from geosynchronous satellites.

Ground Water – Water present in the sub-surface strata above or below the pipe.

Header – A header in a CCTV inspection is the selection of information that is used to head up the condition records for a pipeline section. It identifies and describes the pipeline section attributes and records inspection details.

Header Codes – Alphanumeric codes that represent header information, such as inspection status or pipe material.

Header Data – The separate components of headers. Data may include inspection and attribute information.

Hierarchy of defects – A means of ranking defects from the same group of defects to inform which defect should be coded when more than one defect from that defect group occurs within the same metre of pipe.

Hydro-Jetting – Process of cleaning the pipe (removing fat, debris, attached deposits and tree roots) with volumes of water under pressure utilising pumps, hoses and nozzles. Also referred to as just 'Jetting' and 'Water Blasting'.

I/I – Infiltration and Inflow

Inclinometer – A device on the CCTV camera for measuring the grade/ angle of the slope of the camera from the horizontal.

Infiltration – Unintended Ground Water entering the stormwater or wastewater network through defects such as cracks and defective joints in the pipe and manholes.

Inflow – Storm water that enters wastewater network through connections such as down pipes and basement sump pumps that are illegally connected.

Inspection Header – Details of the asset being inspected including date that are displayed on the screen before the inspection begins.

Inspection Data – The information recorded during a CCTV inspection. It may include inspection information, attribute data and pipeline defect and feature information.

Inspection Information – Information relating to an inspection. It may include the date and time of the inspection, the name of the contractor and the name of the operator.

Invert – The bottom surface of the inner wall of a pipe. Circumferential Location of 6 o'clock.

Landing – Intermediate rest platform used to limit the height of a run of steps in a manhole structure.

Latent Defect – An existing defect in the host pipe that is lined over but can still be seen due to slightly misshapen liner at the location of the host pipe defect.

Lateral Connection – Point where a pipe from a branching line connects to the pipe or manhole.

Lateral Connection Zone – An area covering a radius of 50mm of the internal face of the pipe, or manhole, around the lateral connection pipe, and up to the first joint inside the lateral.

LIDAR – Light Detection and Ranging. A method for measurement of the pipe profile.

Likelihood of Failure –A measure of the assets capability to resist the existing or future load upon it. The capability of a pipe with a high likelihood of failure is equal or less than the load acting upon it.

Longitudinal Distance – The distance measured from the start node to a defect, or feature.

Joint Zone – An area of pipe 100mm either side of the joint gap (200mm length centered on the joint)

Main Code – the main observation code which are used to describe defects or features.

Maintenance Contractor – The person, company or department responsible for the day to day maintenance of sewer and stormwater reticulation systems.

Marked-Up Drawing – A redline drawing over an aerial map taken from the Council GIS to show changes or additions to the known network layout.

Masonry – Construction of pipes or manholes out of Brick, Concrete Block or Stone mortared in-place.

Monitors – Screens displaying video play back

Multiple Inspection – An inspection of the same asset from both ends to enable a full inspection of the pipe asset completed under a single inspection header.

Node – Any point or feature other than a manhole which defines an end of a pipeline asset. A node may be a Lamphole, junction, end of pipeline, stormwater inlet or outlet or other features.

Non-Critical Assets – Assets deemed to have a low consequence of failure, this could be financial, loss of service and disruption. Critical assets have a significantly higher threshold for action than critical assets.

Off-set Distance – a distance measurement entered at the start of an inspection to provide for the distance the camera has travelled from the centre of the manhole before the distance counter is able to start measuring.

Operator – The person responsible for preparing and operating the CCTV camera and identifying and recording defects and features.

OPEX – Operational Expenditure

Outlet – the lateral pipe that discharges the flow from a manhole.

Pipe Broken – Pieces or 'blocks' of pipe formed by cracks, (and branching cracks) connecting in a mosaic arrangement, including those made with cracks starting and ending at a joint face or lateral connection. The pieces have fallen out or are displaced from one another or are still in place but could become displaced

Preliminary Condition Grading – A condition grade based upon the reported defect observations and indicates the assets structural or service condition, expressed as a 1 to 5 grade with 5 being the poorest condition.

Proving Pig – A cylindrical device used for proving that the internal dimensions of a pipeline do not fall below a minimum diameter, or that the pipe has a circular profile. Differing in design they are typically manufactured out of foam or polyurethane.

Push Rod – A method of CCTV Camera transportation where the camera is pushed through the pipe by a semi-ridgid cable with the camera is seated on either skids or brushes. Also known as 'push-cam'.

Quantification (Severity) – Quantification code added to some Main and Characterisation Codes to provide an indication to the size or extent of the defect.

RCP – Reinforced Concrete Pipe

Remaining Useful Life – The estimated amount of time left until the asset reaches the end of its useful life.

Rehabilitation/relining – Renovation or renewal of an asset by inserting a lining material inside the original/host pipe.

Reviewer – A person responsible for identifying and reviewing defects and features reported in an inspection report.

Risk Management – Refers to the practice of identifying potential risks in advance, analysing them and taking precautionary steps to reduce the risk.

Scoring Analysis – Method used to evaluate the Preliminary Condition Grades involving assigning scores to defects and calculating key condition indicators and use of grading threshold tables.

Slabbing – Radial shear failure of concrete pipe wall which occurs from the yielding of the structural reinforcement steel due to excessive tension causing the concrete to peel or delaminate. Also referred to as shear slabbing or slab shear.

Soffit – The top surface of the inner wall of a pipe. Circumferential Location is 12 o'clock. Also, sometimes called the Obvert, Crown or Pipe Roof.

Sonde – A radio transmitting probe built into the camera transportation device (or immediately behind it) to enable the position and depth of the camera to be located from the ground surface above it.

Spalling – Breaking or flaking away of chips of material from the surface of an asset by physical and/or chemical processes. The chips removed are considerably larger than individual grains of material by erosion/abrasion.

Spring Line – The horizontal centreline of the pipe, i.e. the line between the 3 o'clock and 9 o'clock positions on the pipe.

Tilting and Panning – Rotating and tilting of the camera head by the operator to closely inspect a defect of feature.

Tomo – Void/gap seen behind the pipe/manhole wall through a defect.

Vertical Distance – The distance measured from the manhole cover frame to a defect, or feature.

Zoom Camera – A stationary camera mounted on a pole with optical and digital zoom capabilities that enable a view down the pipe.