General Civil Construction Standard

No. CG

Ver.1

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Definitions

Assets	Water and wastewater infrastructure owned and operated by Watercare.
As specified	In reference to quality control check sheet templates, an action of audit to be undertaken if specified by the designer or terms of the contract.
Brownfields	A land area that has existing or legacy infrastructure, or land that has been polluted.
Backfill	To refill an excavation created during construction for the installation of pipework, foundations etc.
Competent person	A person who is qualified because of a specific knowledge, training and applicable experience that is familiar with the Health and Safety at Work Act and conversant in identifying and taking corrective action to potential dangers in the workplace.
Controlling authority	Person(s) in a position of responsibility that is authorised to make a decision on changes, provide access and provide direction.
Embankment	An rise above the immediate surrounding land to redirect overland flows, or prevent flooding, or a raised bank to carry roads or railways across low-laying areas.
Engineer	In reference to quality control check sheet templates, a suitably qualified and experienced person to witness and sign-off on the quality and compliance of the work being audited. The quality control checks do not relieve the requirement for producer statements to be signed by a suitable engineering professional attesting that the works have been constructed in accordance with this construction Standard.
ESF	Watercare's engineering standards framework is the single point of access for current standards that allows engineering work to comply with the requirements under the Watercare Bylaw.
Equipotential bonding	Equalising the electrical potential between an electrical connection and a grounding electrode to metal conductors, such as steel pipes that could become conductive.
Fill	Human created debris discovered within an excavation.
Greenfields	A land area that has no prior infrastructure development and is unpolluted.
Hazard	Potential source of harm.
Infrastructure	Facilities in an operational capacity that is managed by a controlling authority.
Risk	Combination of the probability of the harm caused by a hazard and the impact or severity that may result.

Specific drawings	Drawings created to inform specific construction requirements from design basis that are not captured by the standards drawings.
Utility	A public agency, organisation or entity that is licensed to operate and maintain infrastructure for a public service.

1. Introduction

1.1 Purpose and Scope

This standard has been developed to provide the minimum standard of civil construction work acceptable to Watercare. Additional clauses must be added to contracts where specific site constraints exist. This general civil construction document must be supplemented with standards applicable to the specific operational area (see Section 2). The content of this standard may not be changed or amended. Equivalent or alternatives may only be used on written approval from Watercare. Construction work shall be completed by persons competent in their work possessing a minimum skill and competency level required from this standard.

1.2 Applicability

This standard applies to all civil construction work for infrastructure delivered by, or vested to, Watercare. The level of workmanship and quality shall be demonstrated to meet this standard.

1.3 'Must' versus 'Shall' versus 'Will'

Where the verbs must, shall and will (or its past tense forms) are used they describe a requirement for compliance with the statement in which it is used.

'Shall' and 'must' expresses a mandatory condition or action. 'Will' is used to prescribe a performance outcome or intent.

2. Standard documents overview

2.1 Relationship of Watercare standards

Watercare standards comprise of codes of practices, design standards, standard design drawings, construction standards, and asset and material standards.

The Watercare standards sets are requirements additional to nominated national standards, international standards and industry best practice to meet, and in some cases exceed legislative requirements, to accomplish long term operability and good asset management practices to benefit our customers. The interface of these standards with each other and the project specifications are as follows:

2.1.1 Design standards

The design standard sets a level of design for particular types of infrastructure based on operational area and associated risk. The design standards provide the minimum criteria for:

- Establishing standard design drawings
- Interface design between standard drawings and specific design
- Establishing the correct sizing of components to meet the baseline parameters of the standard drawings
- The basis for developing tailored designs

2.1.2 Design drawings

The standard design drawings support the requirements of the design standard. Minimum and maximum criteria are set, and specific standard details are shown.

2.1.3 Asset and material standards

The asset standards describe the requirements for asset creation, asset numbering, asset capture, production of manuals and operational documentation. Material standards describe the minimum compliance requirements of materials supplied for asset acceptance. Often selected materials will have limitations of use and requirements specific to the operating environment and infrastructure classification. Section 6 describes

the minimum requirements applicable to this standard. Additional requirements may be specified based on the specific design.

2.1.4 Construction standards

Construction standards prescribe the methods and requirements for workmanship to be employed when constructing works in accordance with the design requirements, standard drawings and bespoke designs. To achieve the best outcome the construction requirements focusses on proven methods and best practice to ensure quality is maintained to achieve the design life of infrastructure and that maintainability, health and safety and environmental requirements are met. Where construction standards are used or referred to in contracts they form part of the specification of the contract.

2.1.5 Project specific specification

These specifications identify site/project specific requirements that are not covered by the normative construction standards or standard design drawings identified during specific design.

2.2 Review and approval of construction standards

Section 2.2 is provided for information only.

Watercare updates standards from time to time. Users of this document should ensure that the latest version is used. Suggestions for improvement of this standard will be welcomed. They should be sent to: **Principal Engineer - Standards, Watercare Services Limited, Private Bag 92521, Wellesley Street, Auckland 1141.**

Alternatively place feedback electronically at: Engineering Standards Framework

2.2.1 Watercare's engineering standards framework

The Watercare standards are provided in the online engineering standards framework (ESF). The system provides guidance to the end user to find the applicable standards for the operational area in which design, construction or maintenance is performed. The system ensures that the latest versions of standards are available. The standards are uncontrolled when copied or printed.

2.2.2 Governance of standards

Changes to standards are made under a governance structure to evaluate any change or improvements against factors such as Health and Safety, legislative compliance, standards, best practice and reliability.

2.3 Design build projects

Design build projects shall follow the minimum requirements set out in the standard documents for design and construction.

3. Quality control and quality assurance

3.1 Auditing during construction

A construction management plan shall identify the quality control points. This standard includes a number of quality control/assurance templates that highlight key compliance checks to be carried out during construction. These quality control templates shall be completed as part of the construction work together with any project specific record keeping requirements for Watercare. The templates provided are the minimum checks that need to be completed and in some instances are required to be completed more than once depending on the type of installation. See Section 4.

3.2 Change orders affecting quality

Any change orders for the works shall not compromise quality, safety and regulatory requirements. Any proposed change shall be evaluated against the applicable standard and be demonstrated to comply with the applicable certification and proof of quality documentation.

4. General engineering document submittal requirements

All construction work shall have an accepted construction management plan before any work can commence. This document shall identify the overall planning, coordination and control of the construction activities from start to finish.

4.1 Quality control templates

The completed quality control or quality assurance sheets shall be provided during the identified stages in the construction management plan. All the applicable quality controls shall be completed and signed-off before Watercare will accept the assets.

Items noted as "required" on the QA/QC sheets must be provided or completed and items noted "As specified" is the quantity or requirements that are specified in the particular clauses of construction or referenced standard (whichever takes priority). Certification blocks that is greyed out with "N/A" defines that the item does not apply to the particular party for certification, or that there are no documentation required for the item.

The QA/QC templates shall be certified to confirm that all actions have been completed by each individual.

4.2 Documents for commissioning or livening of civil structures

The prerequisite for construction work that requires progressive commissioning or livening is to provide sufficient supporting documentation for the safe and effective operation of the parts. This documentation shall comprise of:

- Preliminary as-built drawings (redline mark-ups)
- Signed-off pre-commissioning test results
- Process/piping and instrumentation diagrams (P&ID)
- Draft operations and maintenance (O&M) manual
- Residual risks register
- Commissioning plan

At completion of the construction work the following minimum documentation is required in its final format for handover to Watercare:

- Post construction residual risk register
- Operation and maintenance manual
- Design drawing sets (pdf), as-built drawings (AutoCAD) and survey data
- Assets certificates
- Material compliance certificates
- Engineering producer statements
- Construction completion report
- Quality control certificates

Specific details of the content of the above documents and templates are available from Watercare's Data and Asset Information standard, Material supply standard and CAD manual.

***Note** – The above listed documents are required for general civil construction works. Where specific infrastructure is constructed and this standard is supplemented by the specific standard associated with a component, the additional requirements are provided in the specific standard.*

5. Referenced standards

5.1 General

This standard makes reference to a number of national and international standards. The latest version of these standards shall be used at all times.

5.2 Standards list

This standard must be read in conjunction with the national and international standards listed below. Where conflict or ambiguity exists this standard shall take precedence.

Earthworks and roading

NZS4402 Methods of testing soils for civil engineering purposes
Approved Code of Practice HSNOCOP 55 Storage of Explosives
BS 5930 Code of Practice for ground investigations
NZTA F2 (New Zealand Transport Agency) – Specification for pipe subsoil drain construction
TNZ B/02 (New Zealand Transport Agency) – Specification for construction of unbound granular pavement layers
NZTA M1 (New Zealand Transport Agency) – Specification for roading bitumens
NZTA M10 (New Zealand Transport Agency) – Specification for dense graded and stone mastic asphalts

Pipe and duct laying

AS/NZS 2566 Buried flexible pipelines, Part 2: Installation
AS/NZS 2032 Installation of PVC pipe systems
AS/NZS 2033 Installation of polyethylene pipe systems
AS/NZS 4130 Polyethylene (PE) pipes for pressure applications
POP001 Electrofusion jointing of PE pipes and fittings for pressure applications
POP003 Butt fusion jointing of PE pipes and fittings – recommended parameters
POP005 Packaging, handling and storage of polyethylene pipes and fittings
AWWA C209 Cold-applied tape coatings for steel water pipe, special sections, connections and fittings

Pipe lining

ISO 11298 Plastic piping systems for renovation of underground water supply systems
Part 1 – General
Part 2 – Lining with continuous pipes
Part 3 – Lining with close fit pipes
AS/NZS 1516 The cement mortar lining of pipes in-situ
AS1012 part 24 Methods of testing concrete – Determination of the tensile bond strength of concrete – Repairs and strengthening systems

Concrete

AS/NZS 1554 part 3 Welding of reinforcing steel
NZS 3104 Specification for concrete production
NZS 3109 Concrete construction
NZS 3111 Methods of test for water and aggregate for concrete
NZS 3112 Methods of test for concrete
Part 1 Tests relating to fresh concrete
Part 2 Tests relating to the determination of strength of concrete
Part 3 Tests on hardened concrete other than strength
Part 4 Tests relating to grout
NZS 3114 Specification for concrete surface finishes
NZS 3121 Specification for water and aggregate for concrete
NZS 3152 Specification for the manufacture and use of structural and insulating lightweight concrete
AS/NZS 4671 Steel reinforcing materials
AS/NZS 4672 part 1 and part 2 Steel pre-stressing materials
AS/NZS 3679 part 1 Structural steel – Hot-rolled bars and sections

Formwork

AS 3610 Formwork for concrete

Painting

BS5252 Framework for colour co-ordination for building purposes
ASTM D-610-08 Method of evaluating degree of rusting on painted steel surfaces
AS/NZS 2311 Guide to the painting of buildings
AS/NZS 2312 part 1 Guidelines for the protection of iron and steel against exterior atmospheric corrosion

Steel Structures Painting Council (SSPC) Painting manual
Volume 1: Good painting practice
Volume 2: Systems and specifications

Demolition

AS2601 Demolition of structures

Masonry

NZS 4210 Masonry construction: materials and workmanship
AS 1316 Masonry cement
AS/NZS 2699 part 1 and 2 Built-in components for masonry construction
AS/NZS 2904 Damp-proof courses and flashings
New Zealand Building Code (NZBC)

Plumbing

AS/NZS 2845 Water Supply – Backflow prevention devices – Materials, design and performance requirements
NZS 4503 Hand operated firefighting equipment
AS/NZS 1221 Fire hose reels
NZS 7643 Installation of uPVC pipe systems
AS/NZS 1477 PVC pipes for pressure applications
AS/NZS 3879 Solvent cements and priming fluids for PVC (PVC-U and PVC-M) and ABS pipes and fittings
BS 143 and 1256 Threaded pipe fittings in malleable cast iron and cast copper alloy
BS EN 877 + A1 Cast iron pipes and fittings, their joints and accessories for the evacuation of water from buildings. Requirements, test methods and quality assurance
BS EN 12502-3 Galvanised coatings
NZS/BS 1387 Steel tubes for threading to BS21 pipe threads
New Zealand Building Code (NZBC)

Carpentry

AS/NZS 1748 Timber - Stress Graded – Product Requirements for mechanically stress graded timber
NZS 3604 Timber Framed Buildings
NZS 3602 Timber and Wood-based Products for use in Building
New Zealand Building Code (NZBC)

Metal roofing

New Zealand Building Code NZBC E2/AS1 External moisture
4.0 Flashings
5.0 Roof/wall junctions
6.0 Parapets
8.0 Roof claddings
8.1 General
8.4 Profiled metal
AS/NZS 4534 Zinc and zinc/aluminium-alloy coatings on steel wire
NZ Metal Roofing Manufacturers Inc: NZ metal roofing & wall cladding code of practice
NZS 3604 Timber framed buildings

6. Materials

6.1 Material standards

Materials shall include all equipment, machinery, components or products used to complete the works.

All materials necessary for the work shall be supplied in accordance with Watercare's material standards. Materials shall be new and suitable for their intended purpose and performance requirements.

Watercare lists a number of pre-evaluated materials as either an accepted material or a standardised material.

6.2 Accepted and standardised materials

- Accepted material: materials that have been evaluated for use or a specific function in an operational area, but does not imply exclusive use. Materials not on this list require evaluation against Watercare's materials standards prior to being used.

- Standardised material: A selection of materials that shall be exclusively used for a specific operational area or function. In some instances materials under this list are provided under commercial agreements that ensure long term serviceability, component compatibility or availability of spare parts.

6.3 Recycled and reused materials

Recycled material and material reuse shall not be accepted unless specifically approved by Watercare.

7. Health and Safety

All work shall be conducted in accordance with the requirements of the Health and Safety at Work Act 2015. Watercare requires that all contractors undergo a Health and Safety induction programme provided by Watercare prior to any work progressing. Health and safety is the responsibility of every person.

The minimum health and safety requirements set out by Watercare must be adhered to and the documentation and procedures must be of an acceptable standard:

- Describe the processes to assure compliance with systems, good practice and legislation.
- Provide information to demonstrate that the Health and Safety Management System is capable of managing specific hazards and meeting Watercare minimum requirements. Regulations, approved codes of practice and industry standards or guidelines should be referenced as the basis for hazard controls.
- Provide a Health and Safety Management Plan which addresses controls and unique high risk activities or components of the work.
- Demonstrate the proposed risk controls are adequate and identify alternatives to further reduce risk. Where administrative controls are used, it must be demonstrated that these are sufficient, robust and how they will be properly managed.
- Provide the names of Health and Safety staff and their responsibilities.
- Verify that all workers have received adequate training for managing the hazards and risks and undertaking the work safely.
- Conduct and record site specific inductions.
- Where work is on an existing Watercare facility or asset an Access Authority is required before work can start.

8. Asset capture

Asset information shall be progressively captured and supplied in accordance with the requirements of Watercare's asset information standards.

9. Civil construction

Work in public areas and road reserve

Work in the road reserve shall comply with the New Zealand Code of Practice for working in the road (NZCOP), and the specific requirements of the Auckland Transport Code of Practice (ATCOP). Work in any public area shall require prior written approval by the controlling authority.

All requirements for working in the road such as corridor access request (CAR) and traffic management plan(s) (TMP) shall be implemented and maintained. Any person employed to carry out traffic management duties shall hold approved qualifications at National Certificate Level for road opening operations, supervision and traffic management.

Work in private property

Written confirmation from the private property owner or controlling authority shall be obtained before work commences in any private property. Locations of access ways and fill areas on property(ies) shall be arranged under the entry agreement with the owner of the property.

Work in private property shall minimise inconvenience to the occupiers. Any damage by the contractor must be rectified immediately at the contractor's expense.

C1. Site roading

This section covers access driveways and areas of paving associated with Watercare facility sites. It does not cover major earthworks or construction of roads that will be heavily trafficked or are in the road reserve. Under these circumstances the Auckland Transport Code of Practice (ATCOP) or New Zealand Transport Agency (NZTA) requirements shall be the default requirement.

C1.1 General

Construction of site roading shall comply with the NZTA listed TNZ or NZTA specifications as amended by this standard unless shown otherwise on the specific drawings.

C1.2 Paving subgrade preparation

Excavation practices shall comply with Section C2 of this standard. The sub-grade shall be backfilled capable of sustaining minimum 110 kPa in the long term without subsidence. The cross-fall shall be finished to the level shown on the drawings.

C1.3 Subsoil drains

Subsoil drains shall be constructed in accordance with NZTA F2. Drains shall be of minimum 300mm width with a depth to invert between 250mm to 500mm. All drains shall have outlets into cesspits or other stormwater drainage structures. Stormwater drains shall not be connected or directed to the wastewater system. Filter material shall be scoria chip graded 20 to 7. PVC pipes must not be used.

C1.4 Basecourse and sub-base

Sub-base and basecourse shall be constructed in accordance with TNZ B/02. Sub-base aggregate shall be GAP 65 spread evenly over the full formation area and compacted to a minimum thickness of 200mm. The base course shall be AP40 crushed aggregate to a minimum finished thickness of 100mm.

C1.5 Asphaltic concrete

Asphaltic concrete shall be supplied in accordance with NZTA M10, mix designation DG7. Bitumen shall be NZTA M1 approved with an 80-100 penetration grade.

Construction shall be in accordance with NZTA M10. Layer thickness shall be 30mm. The asphaltic concrete shall have a well compacted dense surface, uniformly graded and free from irregularities. There shall be no area where water will pond.

C1.6 Kerbing

Kerbs shall be of minimum 17.5 MPa precast concrete or alternatively cast in situ (extruded) concrete to a profile that matches existing kerbs or as specified on the specific drawings.

C1.7 Stormwater drainage

Precast cesspits shall be constructed using minimum 25 MPa grade concrete. Cesspits shall be watertight and support the grating at grade. The grating and frame shall be standard heavy duty non-roc pattern cast iron, set in concrete. Unless otherwise noted, outlets shall be trapped. Gully traps shall be compliant with New Zealand standards for either cast iron or glazed earthenware unless noted on the specific drawings.

Unless the material is noted on the specific drawings, pipe and fittings will be selected from concrete, glazed earthenware, polyethylene or uPVC that shall comply with Watercare's material standards and constructed in accordance with Section C3 of this standard.

Where stormwater is connected outside the site the construction shall comply with the Auckland Council Stormwater Code of Practice.

C1.8 QA/QC template

Quality control shall be demonstrated to meet the testing frequency within the production tolerances as set out in NZTA M10.

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Asphalt grading	DG7 grade, NZTA M10, Table 3.2	Required	Required	As specified
2	Binder content	Quality control sheet supplied in compliance with Table 1 of TM6003 (Explanatory notes to NZTA M1)	Required	Required	As specified
3	Maximum specific gravity	Within limitations set by Table 9.2 of NZTA M10	Required	Required	As specified
		Sign-off			

C2. Earthworks

This section covers site clearing, removal and stockpiling of materials, bulk and detail excavation and backfilling for general civil construction works.

C2.1 General

Safe excavation practices shall be followed in accordance with the WorkSafe NZ: Approved Code of Practice for Safety in Excavations and Shafts for Foundations. Work shall be carried out in accordance with the applicable resource consents and environmental compliance requirements. Finished surfaces shall be formed and set out to the levels as shown on the specific drawings and be free of depressions and loose materials.

C2.2 Site preparation

Suitable temporary fencing and signage shall be erected that will control overall access to the site as well as entry into specific excavation areas as necessary for the protection of the public.

The trimming or temporary relocation of trees or shrubs will be undertaken with the consent of the owner of the vegetation. Vegetation that requires protection shall be fenced off beyond its drip-line or as otherwise prescribed by the consenting authority prior to earthworks commencing in the vicinity. All cleared material shall be removed from the site.

Tree stumps shall be completely removed. Hollows formed by the stump removal shall be backfilled and compacted level with the surrounding area.

C2.3 Geotechnical investigations

In some instances Watercare may provide geotechnical site investigation reports or a geotechnical baseline report (GBR). No responsibility is accepted for its accuracy or relevance. This information shall not be considered as complete and shall be supplemented as necessary for the site specific activities.

All investigation locations shall be surveyed and immediately after the investigations are completed backfilled and sealed. All additional geotechnical information obtained shall be uploaded to the Auckland Geotechnical Database, at the following location: (https://agd.projectorbit.com/)

C2.4 Topsoil stripping

Topsoil shall be stripped from all areas to be excavated, backfilled or otherwise disturbed as part of the construction works. The topsoil shall be stockpiled in an appropriate area clear of the site.

The depth of topsoil stripped shall be:

- At least 300 mm in farmland, residential property or other cultivated areas, or
- At least 150 mm elsewhere, or
- The full depth of topsoil when less than the above depths exist.
- Completely removed from embankments.

C2.5 Stockpiling

Unless required by the conditions of consent or specific requirements, stockpiles shall be held at the site. Different material types shall be excavated and stockpiled separately. Stockpiles shall be safe and stable with steep faces that allows maximum drainage. Silt barriers shall be installed around stockpiles with suitable drainage. Stockpiles shall be covered with a suitable geotextile to prevent erosion or covered with grass of minimum 90% covering from a suitable seed mix.

Materials unsuitable for reuse shall be removed from site and disposed to an appropriate tip site. Material inappropriately stockpiled that has become unsuitable for reuse shall be removed and replaced.

C2.6 Excavation support and perimeter protection

Temporary works design shall be undertaken and installed to provide safety for persons working in and around the excavation that complies with Health and Safety regulations. The design shall be undertaken (PS1) or certified (PS2) by a Chartered Professional Engineer registered with IPENZ for the relevant practice area.

The temporary works design shall allow for the safe removal of the supports at completion of the works. In exceptional cases where the removal of temporary support poses a risk to adjacent property or structures the temporary works shall be incorporated into the permanent work on prior approval of Watercare.

C2.7 Excavation general

Any excavation work that is notifiable under the Health and Safety at Work Act shall be lodged with WorkSafe New Zealand. Copies of notifications shall be supplied to Watercare.

Current services plans from all utility controlling authorities shall be obtained and the services located and marked on site. Utility service providers shall be notified in writing of any intention to excavate within the vicinity. Unless otherwise shown on the specific drawings no excavation shall be closer than 500mm to any other utility service or any special backfilling material for that utility. For work close to existing Watercare assets the Watercare Bylaw shall be followed.

The ground shall be excavated to the minimum depths necessary for the construction. Deeper excavation may be required to secure a firm foundation. The extra depth shall be backfilled either with concrete or an approved hardfill compacted as specified by the designer. Foundations shall be prepared with any fissures cleaned and backfilled with all loose materials removed.

C2.8 Water in excavations

Excavations shall be kept free of water during construction with all practicable steps undertaken to prevent water from entering the excavation. Water discharged from excavations shall be disposed of in a consented manner. All pipework, sub-drains and sumps shall be installed and the pumping plant operated and maintained as necessary to deliver and maintain the excavation free from water.

Temporary sub-drains or sumps will only be allowed under any permanent work if essential to keep the excavation clear of water. Temporary sub-drains and sumps shall be blocked off and backfilled with concrete until watertight when no longer required.

The construction methodology shall ensure there is no risk of hydrostatic uplift or ground subsidence as a consequence of the works.

C2.9 Excavation for trenches

The width and depth of trenches for pipelines shall be to exact dimensions. Additional excavation is permitted at connections and joints to allow safe and efficient working areas when making connections. Where specific design of the trench limits the width between soil faces the excavation shall not exceed the given dimensions.

Where trenches are constructed in an embankment the stability and integrity of the embankment shall not be compromised.

C2.10 Excavation for structures

Structures include underground chambers, wells, anchor blocks, permanent piles, concrete bases and any other building requiring a ground foundation. The excavation shall be to the lines and levels on the specific drawings.

The bottom of the excavation or load bearing area shall be of undisturbed material graded and trimmed, or as otherwise specifically designed, to levels on the specific drawings.

C2.11 Excavation by hydrovac

Hydrovac excavation may only be used in small localised areas as an alternative to hand excavation. The excavation shall be directed away from bearing surfaces of existing structures to ensure the structural purpose and integrity of the existing structures is not compromised. The excavation shall be to a level above the required lines and levels of the design. Hand excavation or mechanical plant shall be used to finish the excavation to the required dimensions.

The hydrojet or wand shall never remain motionless and may not advance ahead of the vacuum unit so as to cause flooding of the excavation area or washout of adjacent utility service bedding. The maximum water pressure for straight nozzles shall be 100bar and for spinning nozzles 200bar. Pressure shall be monitored and the water supply fitted with an emergency shut-off at the wand as well as at the truck connection.

The hydrovac equipment and operators shall be protected by equipotential bonding. Hydro excavation in the vicinity of energized plant or damaged cables shall be excavated with the infrastructure isolated and where practical de-energised.

The excavation shall be screened to prevent any flying debris causing harm or damage.

C2.12 Excavation by explosive blasting

Explosive blasting works shall be notified to WorkSafe NZ. A hazard and risk assessment shall be completed and reviewed by Watercare. Blasting shall be carried out by the NZQA certificated construction blaster (appropriate level for activity) responsible for the blasting work.

Storage and handling of explosives shall comply with the Approved Code of Practice HSNOCOP 55 Storage of Explosives. Only daily requirements shall be held on site.

All charges shall be screened to prevent any flying debris and all necessary steps shall be taken to warn traffic, workers, nearby residents, and the public when shots are about to be fired. Evidence is to be provided that the amplitude of ground vibration due to any blast does not to exceed 0.25 mm when measured at a distance of 150m from the seat of the blast.

C2.13 Excavation material classification

Common material: Common excavation shall include material with plastic properties, un-cemented granular materials and slightly cemented materials, such as earth, clay, silt, sand, gravel, peat, sludge and shall include isolated boulders less than 300mm diameter and pockets of strongly cemented material of less than 0.2 m^3 per 1 m^3 in volume. The soil strength in this category is 25 kPa to 100 kPa with the standard penetration test (SPT) or N value 3 to 20.

Hard ground: Hard ground excavation shall include cemented material such as: sandstone, mudstone, Parnell grit, breccia, volcanic tuff deposits. which exhibit strengths ranging from low to high and which require more effort to excavate than common material but which is capable of being excavated with a modern hydraulic bucket in good condition. The soil strength in this category is 100 kPa to 200 kPa with the standard penetration test (SPT) or N value 20 to 49.

Loose Rock: Loose boulders are greater than 300mm in diameter and with ratio greater than 0.2 m^3 per 1 m^3 to hard ground or common material. Loose rock also includes intact rock with unconfined compressive strength (UCS) of 1 to 50 MPa that can be effectively broken by rock breakers or loosened by hydraulic bucket.

Rock: Rock shall be limited to sound, in-situ basalt, greywacke, or argillite, which requires the use of large efficient rock breakers or explosives to excavate. N value is 50 or greater. The unconfined compressive strength (UCS) of intact rock is greater than 50 MPa for this material class.

Fill: Fill material may be of various grade or material type and is typically found in brownfield areas. The composition and integrity of fill material found other than described in the geotechnical report, shall be referred to Watercare.

C2.14 Backfill and fill in general

Prior to backfilling all forms and debris shall be removed from the excavation. Temporary support works and timbering shall be removed progressively.

Backfill material capable of compaction to this standard or as otherwise required by the specific drawings shall be used for backfilling. Excavated material unsuitable for backfill shall be disposed of as surplus material. Suitable backfill material shall be:

- Clean fill free of organic matter
- Free from hazardous substances or contaminants
- Plastic index less than 30
- Capable of achieving the compaction criteria in Section C2.15

The backfill placed within 300mm of any structure shall be ordinary surround material unless otherwise specified.

C2.15 General compaction of backfill

Backfill shall be placed in layers less than 230 mm thick in accordance with table C2-1, unless specified otherwise for a specific pipe material. Care must be exercised during placing and compacting to prevent displacement or damage of infrastructure and in such a manner as to avoid uneven loading. Hand rammers may be used where there is a risk of displacement or damage to infrastructure.

Table C2-1 Compaction requirements

Also see requirements for specific installation material that may vary from the below table.

Application requiring compacted backfill	Modified maximum dry density %
Building foundations beneath hardfill	95
Backfill behind walls or chambers	90
Areas of fill in non-trafficked open ground	90

Hardfill within 300mm of the underside of a concrete floor slab shall be placed and compacted in layers less than 150mm in thickness. Hardfill within 100mm of the underside of a concrete floor slab shall be less than AP 20 in size.

C2.16 Backfill material classification

Ordinary backfill: Material free of organic matter, hazardous contaminants and any other substance which prevents satisfactory placing and compaction.

Ordinary surround material: Ordinary backfill as above but also free of clay lumps and stones retained on a 75mm sieve and not more than 10% shall be stones retained on a 25mm sieve.

Granular surround material: This shall be imported material, or site excavated crushed and graded stone, graded as for ordinary surround material. Coarse sand or fine scoria may only be used when specified.

Hardfill: Hardfill shall be of granular nature, free of organic matter, hazardous contaminants or other deleterious material. Hardfill shall be approved before placing and may include but is not limited to: Run of pit (ROP), scoria, concrete washings, reject base course, natural gravel etc.

Refer to the specific requirements for pipe materials under the pipe and duct laying sections in this standard under section C3.

C2.17 Surface reinstatement

Unless different surface reinstatement is specified in part or whole, the surface of all disturbed areas shall be reinstated to its original condition and matching adjoining surfaces. Landowner approval of the reinstatement shall be obtained.

Roading and footpath reinstatement shall be to the controlling authority's specification.

C2.18 Top soil and grass reinstatement

Areas to be grassed shall be neatly graded to provide a finished level flush with kerbs and mowing strips or to levels shown on the specific drawings. Mowing strips shall be 300 mm wide constructed from 17.5 MPa grade concrete with joints at 2 m intervals. The strip shall be finished off to give a straight even edge and smooth top, level with the final grade of the grassed area.

Areas to receive grass shall be uniformly relieved by cultivation and ripping. Areas that do not have at least 100 mm of topsoil shall first be uniformly and lightly compacted and evenly graded to 100 mm below finished grade before spreading 100 mm of weed free topsoil.

Fertiliser (containing three parts superphosphate and one part of sulphate of ammonia) shall be spread at the rate of 50 g/m^2 over all areas to be grassed, and the topsoil cultivated to a minimum depth of 75 mm. All sticks, stones, and other debris shall be removed and the area lightly rolled.

Unless otherwise specified grass seed containing a high proportion of perennial rye shall be sown in suitable weather conditions as prescribed by the supplier at the rate of 35 g/m^2 and hand raked into the top 20mm of soil. Maintenance of the grassed area shall continue until minimum 90% coverage is obtained in all areas. During this period the area shall be watered, weeded, re-sown, rolled and mown as often as necessary. Any undue settlement shall be made good. Once the coverage has been obtained a further application of fertiliser at the rate of 50 g/m^2 shall be applied.

C2.19 Surplus material

Surplus material remaining after completion of the work or material removed during construction that will not be reused shall be disposed off-site to an appropriate tip site.

C2.20 Record keeping

The following records shall be maintained during the work:

- Extent of excavation and backfill areas
- Type and quantity of excavated and backfill material
- Compaction records and the location of tests
- Material quantity removed from site with tip site dockets

C2.21 QA/QC template

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Services located	Mark-outs and plans	Required	Required	N/A
2	Clearing and establishment	As consented, accepted construction plan	N/A	Required	As specified
3	Topsoil	Identified, graded, stored	N/A	Required	As specified
4	Geotechnical investigation	Recorded, surveyed, uploaded to AGD, restored	Required	Required	Required
5	WorksafeNZ notification	Notifiable works – response from Worksafe NZ	Required	Required	Required
6	Excavation	Material classification, test records and quantity records	Required	Required	N/A
		Temporary support design PS1 / PS2	Required	Required	N/A

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
		Line and level correct (survey), clear of debris and defects	Required	Required	As specified
7	Backfill	Temporary support removal plan	Required	Required	N/A
		Backfill material grading	N/A	Required	Required
		Plastic index <30. NATA/IANZ test lab results	Required	Required	N/A
		Compaction test. NZS 4402, Test 5.1.2 and 5.1.4 – NATA/IANZ test lab results	Required	Required	N/A
		Compaction test location records	Required	Required	N/A
8	Reinstatement	Topsoil replaced to 100mm depth, clear of stones and debris, 90% grass cover	N/A	Required	Required
		Controlling authority(ies) sign-off	Required	Required	Required
9	Surplus material removed	Site inspected. Tip facility records provided	Required	Required	N/A
		Sign-off			

C3. Pipe and duct laying

This section covers the general civil construction of underground pipelines and ducting for Watercare's services. This section does not include mechanical construction requirements for particular requirements of welding, flanges and fittings. Where 'pipe' or 'piping' is referred in this section it shall be read to mean any pipe or conduit for the purpose of ducting.

C3.1 General Pipeline construction

Pipe shall be transported and handled according to the manufacturer's requirements for the specific material type to avoid damage. Pipe shall be stacked not more than three layers high and without placing excessive loads on the lower layers. Stacks shall be arranged not to place any load on pipe ends. Pipe supports shall not create point loads on the pipe. Pipe ends shall be capped. Excess pipe shall be returned to the specified Watercare storage facility.

All non-metallic pipelines shall have an accepted tracer wire installed over the entire length of the installation with suitable connecting stations where practicable. Additionally pipe installed by open trenched methods shall have an applicable warning strip i.e. "CAUTION – WATER MAIN BELOW" or an approved equivalent of minimum 100mm width at 450mm above the pipe. The service appropriate colour coding shall be to AS/NZS2648:

Service	Colour
Electricity	Orange
Gas	Yellow
Water	Blue
Communications	Green
Firefighting*	White
Sewerage	Cream
Reclaimed water	Purple

*applies to dedicated fire lines. Reticulation mains with hydrants installed on them shall be blue.

Trench bedding and pipe surround shall be progressively inspected as the work continue. Pipe shall not be installed before a new section of bedding has been inspected. Open trenches shall not progress more than 75m ahead of completely backfilled and sealed section or as otherwise limited by the controlling authority.

On completion of the pipe installation (for any pipe laying technique) the pipe shall be tested for oval caused by superimposed loads and inappropriate sidewall support. On completion all pipework shall be CCTV inspected for defects.

***Note** – Where an installation technique other than open excavation is employed the specific requirements are described in the following sections. The general requirements set out above also apply to these other techniques.*

C3.1.1 Position tolerances

Pipe shall be installed to the line and level required on the specific drawings. The position tolerance for pipe laying at any point along the length of the installation shall be within ±30 mm from the specified design. Additionally the following specific allowances apply:

- No over vertical (causing upstream ponding) for any wastewater or drainage pipeline.
- Horizontal directional drilling (HDD) to a maximum horizontal deviation of 100mm.
- Pipe jacking, boring or tunnelling to a maximum horizontal deviation of 100mm.

Pipe penetrations into any structure shall be to the location and tolerances specified on the specific drawings.

C3.1.2 Bedding material, pipe surround and compaction

Filling of bedding and pipe surround material shall be to the dimensions specified on the standard drawings for the appropriate installation area and service type or as otherwise stated by the design specific drawings.

Bedding and pipe surround material shall be as specified on the standard drawings or as otherwise stated by the design specific drawings (i.e. earthquake resilient design or rigid pipe as per section C3.9). Alternative bedding material may be proposed but requires specific approval (must comply with AS/NZS 2566 for flexible pipe or AS/NZS 3725 for rigid pipe).

Where there is a risk of soil fines migrating into the trench the affected section shall be lined with geotextile.

Compaction of the bedding and pipe surround backfill shall be 70% of the density index (95% dry density ratio) for cohesion-less soils for both trafficable and non-trafficable areas and is based on the standard detail. Compaction shall be as specified when using an approved alternative. Pipe deflection shall comply with the standards for flexible and rigid pipe installation and compared against the calculated short and long term deflection for acceptance.

For concrete encasement the concrete shall be vibrated into position from one side of the pipe only. The concrete shall have a slump value of 180-200mm.

***Note** – the above requirements are for open trench excavation in competent soils. Where an installation technique other than open excavation is employed the specific requirements are described in the applicable section in this standard.*

The trench design will be based on geotechnical findings during design investigations. Where it is identified that the geotechnical conditions differ, it must be reported to the designer to review the pipe bedding specification to confirm that there is no risk of subsidence, hydrostatic uplift or any other soil conditions that may compromise the pipeline integrity.

C3.1.3 Pipe laying in embankment

Pipe laying in embankments shall be to the specific design requirements. Where a trench preparation requires over excavation to be corrected and/or where the embankment material differs in type and compressibility from the design conditions the designer shall specify the corrective action.

C3.1.4 Pipelines through structures

Pipes passing through structures shall be thoroughly cleaned and wrapped with an accepted protective coating to the coating manufacturer's specification. The protective wrapping shall be extended minimum 150mm beyond the face of the structure. The following wrapping types shall apply:

- Steel or ductile iron: bituminous or petrolatum based
- Plastic to steel, or to ductile iron interface: bituminous

Hydrophilic water-stop seal shall be applied as required for chambers and manholes to ensure there is no leakage between the pipe and the structure. Where puddle flanges are installed the wrapping shall be to the base of the puddle flange on each side, not over it.

Before the pipe is cast in place and after placing any reinforcing steel the pipe wrapping shall be inspected for any defects. The specific design may require pipework to freely move through a penetration.

C3.1.5 Parallel pipeline separation

Parallel pipelines laid concurrently in the same trench shall have minimum clearances between pipes and other services as shown in the table below. Where pipes of different diameters are placed the clearance required by the larger service shall be observed.

Table C3-1 Minimum parallel separation

External pipe diameter (De)	Minimum clear spacing
≥63 to ≤375	300
>375 to ≤600	600
>600 to ≤800	1000
>800	1000 + De/4

C3.1.6 Vertical separation from other services

For greenfields the minimum separation distances between other services is set out in the Watercare Code of Practice for Land Development and Subdivision.

Vertical clearance at crossing services shall be minimum 150mm, in each instance the other utility's specific requirements needs to be confirmed.

Clearances less than 150mm must be designed for. High density polystyrene (30kg/m³) or similar packing method accepted by both affected utilities, demonstrated to withstand the design superimposed load, shall be installed across the immediate interface where the clearance is less than 150mm.

C3.1.7 QA/QC template

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Storage and handling	Pipe ends capped, Stacked safely, less than 3 high, pipe ends clear	N/A	Required	N/A
2	Pipe inspection	Free from damage. Pipe lining cracks restored (as applicable to pipe material)	N/A	Required	Required
3	Trench installation	Warning strip installed	N/A	Required	As specified
4	Traceability	Non-metallic pipe with tracer wire, continuity test certified	Required	Required	N/A
5	Position	Requirements of C3.1.1	N/A	Required	As specified
6	Pipe through structures	Protective wrapping 150mm beyond each face	N/A	Required	As specified
7	Material outer protection, wrapping, joint inspection	Coating or wrapping completed as required for the specific material.	N/A	Required	As specified
8	Separation	Parallel according to table C3-1	N/A	Required	Required
9	Vertical crossings	Min. 150mm, other services load protected	N/A	Required	Required

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
10	CCTV	CCTV inspection – Reviewed for defects. Lining repairs completed.	Required	Required	N/A
11	Deflection check	Pipe tested for deflection after backfill and compaction to AS/NZS2566. Rigid pipe test at manufacture and compared to installation	Required	Required	Required
12	Testing & disinfection	Testing requirements for pressure, non-pressure pipe, or sleeve as appropriate. Refer to Section 10	Required	Required	N/A
		Sign-off			

C3.2 Pipe jacking, boring or tunnelling and shaft sinking

C3.2.1 General

Contractor's staff shall be appropriately trained and the day-to-day activities of the tunnelling or jacking operations shall be appropriately managed in accordance with the Health and Safety at Work, Mining Operations and Quarrying Operations regulations as well as the implementation requirements of Worksafe NZ's high hazard unit.

The tunnelling or jacking installation design shall be appropriate for the work and the contractor shall include specific risk mitigation plans for Watercare's consideration.

Appropriate storage shall be allocated for excavated material. All excavations, headings and tunnels shall be adequately supported at all times.

Any removal of water during the work shall not cause subsidence, damage to the works or damage to any other property. Once completed shafts and tunnels shall be watertight with no signs of seepage.

Sufficient ventilation shall be provided at all times during construction.

The type of tunnelling operation method shall be limited to the internal dimension of the pipe tunnel in accordance with the British Tunnelling Society and the Pipe Jacking Association:

Table key:

Acceptable – undertake assessment of the risks and controls associated with the tunnelling works.

Avoid – Requires robust technical assessment to justify the tunnelling technique and deviation from acceptable criteria. Appropriate health and safety controls and risk management shall be in place.

Not Acceptable – This technique may not be used under any circumstances. An alternative solution shall be sought.

Tunnelling and Pipejacking: Guidance for Designers

This document is a best practice consensus agreed between the Health & Safety Executive, British Tunnelling Society and the Pipe Jacking Association.

Internal dimensions for pipejacks and tunnels below 3.m diameter and indicative drive lengths

Not Acceptable
Avoid
Acceptable

Table 1 – Nominal internal diameter of pipeline or tunnel linings

Excavation technique	<0.9m	0.9m	1.0m	1.2m	1.35m	1.5m	1.8m	>1.8m
Pipejack – machine; remote operation from surface	Acceptable (See Table 2)							
Pipejack – machine; operator controlled below ground	Not Acceptable			Acceptable				
Pipejack – hand dig	Not Acceptable			Avoid				
Tunnel – machine operator controlled + mechanical erector	Not Acceptable					Avoid		Acceptable
Tunnel – hand dig + mechanical erector	Not Acceptable					Avoid		
Timber heading – hand dig	Not Acceptable			Avoid				

Table 2 – Indicative drive lengths (e.g. between shafts) and maximum number of drives

Excavation technique	<0.9m	0.9m	1.0m	1.2m	1.35m	1.5m	1.8m	>1.8m
Pipejack – machine; remote operation from surface	Drive length limited only by capacity of jacking system			250m		400m	>500m (See note 7)	>500m (See note 7)
	Man entry not acceptable		Avoid man entry					
Pipejack – machine; operator controlled below ground	Not Acceptable			125m	200m	300m	500m	>500m (See note 7)
Pipejack – hand dig (See note 6)	Not Acceptable			*25m – 2 drive lengths	*50m – 2 drive lengths	*75m – 2 drive lengths	*100m – 1 drive length. Plan to use minidigger if over 2.1m dia	
Tunnel – machine operator controlled + mechanical erector	Not Acceptable					*250m	*500m	>500m (See note 7)
Tunnel – hand dig + mechanical erector (See note 6)	Not Acceptable					*50m – 1 drive length	*100m – 1 drive length. Plan to use minidigger if over 2.1m dia	
Timber heading – hand dig (See note 6)	Not Acceptable			*25m – 2 drive lengths Minimum cross section inside frames 1.2m high x 1.0m wide				

C3.2.2 Jacking pits, headings and shafts

Construction of shafts and chambers required for the works shall be specifically designed to accommodate the tunnelling or jacking method. The construction design shall allow for removal and reinstatement as required by this standard. The design shall be provided with PS1 and its implementation by PS4 producer statements.

A safe means of access and egress shall be provided. Where any mechanical means is provided, ladder access shall also be provided.

The base shall be concreted and any segmented joints grouted or annulus filled, refer section C3.2.4. Openings in shafts and pits shall only be made after grouting has been completed. All openings shall be engineered and drawings provided.

C3.2.3 Installations under roads or other facilities

The installation under roads or other facilities must not:

- Interfere with the normal operation of the road or facility
- Cause any damage, deformation or weakening of the road or facility
- Interfere with any other facility or utility service

C3.2.4 Over excavation and grouting

The product pipe shall not be subjected to hydrostatic pressure from the grout or aquifer system during the grouting phase that cannot be withstood by the specified product pipe. The contractor shall provide design calculations to show that the anticipated net pressure on the tunnel is less than 2.5 times the critical buckling pressure of the tunnel. The grouting process shall not deform the product pipe or dislodge supports and move the pipe from its designed alignment.

The maximum length between grouting points shall be 30m for augers or jacked pipes and progressive for tunnel boring machines.

Any gaps between the outside of the pipe wall and the surrounding soil shall be pressure grouted with free flowing filler for the full length of the bore to provide structural support for the tunnel and to seal against groundwater.

The grout shall have a minimum 100 year life expectancy.

C3.2.5 Pipe jacking

It shall be demonstrated that the jacking loads are less than the maximum loads that the jacking pipe are able to withstand. The jacking ram shall transfer load to the pipe through a thrust ring to provide an even load.

The pipe manufacturer's permitted draw and angular deflection shall not be exceeded at any pipe joint. Cut pipes shall not be jacked. Pipe joints shall be true and the jacking load continuously applied to prevent joints from opening when the jacking loads are removed.

Intermediate jacking pits shall be used to prevent the maximum jacking force being exceeded. The location of the intermediate jacking pits shall be agreed with Watercare in advance.

C3.2.6 Micro-tunnelling

The micro-tunnelling machine shall be selected in respect of the drive length and soil conditions. Micro-tunnelling shall comply with the above sections.

C3.2.7 Reinstatement of jacking pits

Jacking pits or trenches excavated to install pipe shall be reinstated within seven days of completion of pipe installation operations. The order of closing shall be from the tunnelling shield working backwards. The pipe joints in the intermediate jacking pit shall be sealed, the receiving joint face re-packed and the joint closed by jacking the upper-end pipe forward. It is not acceptable to form a pipe joint in the intermediate jacking pit with a pipe cut-in.

C3.2.8 Record keeping

The following records shall be maintained during the tunnelling works on a daily basis:

- Line and level
- Torque
- Thrust on pipe (in required by method)
- Drilling rate
- Pump rate and pressure
- Special events
- Any other as specifically required

C3.2.9 QA/QC template

This template is in addition to C3.1.7

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Work method statement	Accepted to include best practice and regulatory requirements as enforced by Worksafe NZ	Required	Required	N/A
2	Tunnel machine suitability	Evaluation against expected soil conditions	Required	Required	N/A
3	Worksafe NZ notification	Worksafe NZ certification	Required	Required	Required
4	Tracking system accuracy check	Verification to accuracy tolerance per Section C3.1.1	Required	Required	N/A
5	Construction daily records	Section C3.2.8	Required	Required	As specified
6	Grouting plan	Quantity calculation comparison to actual measured	Required	Required	Required
7	Jacking pit/ shaft pit construction	CPEng, PS1 and PS4 to meet selected machine requirements	Required	Required	Required
		Sign-off			

C3.3 Horizontal directional drilling (HDD)

Contractor's staff shall be appropriately trained and the day-to-day activities of the tunnelling or jacking operations shall be appropriately managed in accordance with the Health and Safety at Work, Mining Operations and Quarrying Operations regulations and the enforcement requirements of Worksafe NZ's high hazard unit.

The Contractor shall provide the following items:

- Calculations
- Construction and environmental management plan
- Tracking systems
- Drilling fluid management plan
- Contingency plans

The drill string entrance angle shall be between 8 and 20 degrees. The drilling activity will be surveyed and include the use of a wire line steering system to guide the direction of drilling. A surface tracking system may be used where necessary or an alternate method(s) to achieve the designed vertical and horizontal alignment.

Ballast shall be inserted into the product pipe for neutral buoyancy when submerged in drilling mud. The pipe must be sealed at either end with a cap or a plug to prevent water, drilling fluids and other foreign materials from entering the pipe.

Pipe rollers, skates or other protective devices shall be used to prevent pipe damage during pull-back and also to eliminate ground drag. Recommended reaming diameters are listed in the following table.

Table C3.3-1 Recommended reaming diameters

Pipe Outside Diameter (mm)	Back – Ream Hole Diameters (mm)
63	75 to 100
90	100 to 150
110	150 to 200
160	250 to 300
225	300 to 350
315	350 to 400
≥ 315	At least 1.5 times pipe OD

C3.3.1 Calculations

The calculations will confirm that the following has been accounted for in the installation methodology:

a) The bending radii do not exceed allowable limits
b) Pre-installation loads including hydrostatic test loads and self-weight spanning between any supporting structures do not exceed allowable limits
c) The installation loads shall consider:
    i. Bending stresses due to radius of curvature and pipe over bend
    ii. Maximum installation force on the product pipe
    iii. Stresses due to frictional drag
    iv. Stresses due to torsional force
    v. Hydrostatic load due to ground water
    vi. Earth overburden loads
    vii. Loads resulting from drilling fluid and/or grouting
    viii. Construction installation loadings do not exceed allowable limits

C3.3.2 Construction Plan

The following information shall be submitted with respect to the construction plan:

a) Type and capacity of drilling rig to be used on the project, including thrust and rotary torque. The drilling rig pull/push capacity should be at least equal to twice the weight of the product to be pulled or the weight of the drilling rod in the hole, whichever is greater
b) Type and capacity of mud mixing system
c) Access requirements to site
d) Drawing of work site indicating the location and footprints of all equipment, location of entry and exit pits and the location of slurry containment pits
e) A listing of any specialised support equipment (if applicable), including sucker trucks and/or pumps for mud recycling
f) Down-hole tools and their suitability for the expected ground conditions
g) Management of groundwater during drilling and grouting processes
h) Construction records including:
    i. Diameter of pilot hole
    ii. Number and size of pre-reams
    iii. Back ream rate
    iv. Use of rollers, baskets and side booms to suspend and direct the pipe during pull-back
    v. Pull in rate
    vi. The number of sections in which the pipeline is to be installed
    vii. The drill alignment plan in the form of an electronically generated bore plan
    viii. Drilled bore logs and any computer output data from steering and tracking systems for each part of the works

ix. Grouting type and procedure

C3.3.3 Tracking Systems

The appropriateness of the system shall be confirmed for the site specific conditions with the following details:

a) Type
b) Operating range
c) Degree of accuracy

C3.3.4 Drilling Fluids Management Plan

An appropriate drilling fluid shall be used to suit the ground conditions during the pipe installation operations.

Details of any drilling fluids proposed and the estimated volumes to be used are to be submitted to Watercare before any drilling. Drilling fluids to be used shall be environmentally sound and biodegradable.

Drilling fluid pressures shall be continually monitored by a down-hole data logger to avoid or minimise hydraulic fracturing or over excavation. Extreme care shall be taken in minimising the loss of drilling fluids onto the ground or the environment. If hydraulic fracturing, loss of fluid or no returns are discovered the process shall be halted until the issue is rectified.

Cuttings and spent drilling fluids shall be disposed of properly and shall comply with the local authority regulations.

C3.3.5 Contingency Plans

Contingency plans must be in compliance with national standards, relevant legislation and resource consent conditions and shall be developed for the following:

a) In case of spill or surface seepage (e.g. drilling fluids, hydraulic fluids and spoils), including measures to contain and clean the affected area
b) Recovery method in the case of a stuck drill head
c) The remedial treatment of joints, fractures and any other defects in the strata in the event of drilling fluid loss, cuttings loss or groundwater loss during the drilling, reaming and pipe installation processes
d) Correction of ground heave or subsidence

C3.3.6 Grouting

Grouting shall be in accordance with section C3.2.4.

C3.3.7 Record keeping

The following records shall be maintained during the drilling works on a daily basis:

a) Details for each of the drilling stages - reaming sizes/steps
b) Drilling mud volumes, viscosity, density and pH
c) Drill bit type and size
d) Torque
e) Pull/thrust on pipe
f) Drilling rate
g) Pump rate and pressure
h) Special events

C3.2.6 QA/QC template

This template is in addition to C3.1.7

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Work method statement	Accepted to include best practice and regulatory requirements as enforced by Worksafe NZ	Required	Required	N/A
2	HDD plant suitability	Evaluation against expected soil conditions	Required	Required	N/A
3	Worksafe NZ notification	Worksafe NZ certification	Required	Required	Required
4	Construction daily records	Section C3.3.7	Required	Required	N/A
5	Pipe load force calculations		Required	Required	Required
6	Drill fluid mix	Evaluate against ground conditions.	Required	Required	N/A
7	Tracking system accuracy check	Calibration	Required	Required	N/A
8	Bore plan		Required	Required	N/A
9	Pilot bore drill logs	Drilling rate	Required	Required	N/A
10	Pilot bore accuracy verification	Within allowable tolerance Section C3.1.1	Required	Required	Required
11	Drill fluid ongoing tests	Test records	Required	Required	As specified
12	Back ream rate calculation	Data logged ream rate corresponds to calculation	Required	Required	Required
13	Pull back force data log results	Conforms with calculation in item 5	Required	Required	Required
14	Pipe pull visual inspection	Damage <10% gouge depth	N/A	Required	As specified
15	Grout results	Measured values compared to calculated quantity.	Required	Required	Required
		Sign-off			

C3.4 Installation of polyethylene pipe

Polyethylene may be installed by open trench excavation or horizontal directional drilling.

The polyethylene pipe suitability shall be confirmed for the type of installation. Where Watercare is supplying the pipe material, installation method shall be appropriate for the pipe material.

Pipes shall be visually inspected before installation and shall satisfy the requirements listed in the below table. The delivery dockets and pipe inspection reports are to be submitted to Watercare within two working days of the delivery.

Table C3.4-1 Visual inspection requirements

Condition	Requirement
Branding	The pipe material, size and SDR details on the drawings agree with the pipe branding. Branding shall be to the Watecare material standards.

Condition	Requirement
Out of roundness	Within testing standard.
Reversion	The pipe shall not exhibit strong reversion at the pipe ends.
Eccentricity	Pipe wall thickness measured at any point with Vernier callipers.
Surface finish	There shall be no extrusion die marks or spider-lines, or evidence of crazing, flaking, indication of disintegration, pitting, or discolouration.
Scratches	None on the internal surface. External surfaces shall be free from longitudinal or circumferential sharp scratches deeper than 10% of the pipe wall thickness.

Watercare shall be advised if any of the pipes or fittings delivered to site do not meet the requirements of the visual inspection. Fittings and accessories shall be stored in their original containers or suitable protective bins.

Polyethylene pipe can expand and contract when exposed to temperature changes. Pipes must not be secured by backfilling until this contraction has taken place and branches and end fittings must not be completed until this time. Where pipelines are installed by HDD the pipe stretch shall have recovered and thermal contraction complete before restraining the pipe.

Anchor blocks shall be installed as specified by the drawings with a protective polythene membrane to prevent damage to the pipe.

C3.4.1 Pipe curving

Where site conditions and practical restraints of bending large diameter pipe allow, small deflections in the pipe can be achieved by bending of the pipe barrel.

The bending radius, $\mathbf{R_b}$ for such bends shall be greater than the pipe manufacturer's allowance as defined by the below equation with a 1.25 factor of safety applied.

$$Rb = n\frac{EI}{M} \quad or \quad Rb = n\frac{EDo}{2Sb}$$

R_b = minimum bending radius (m)
M = bending moment (N.m)
S_b = allowable bending stress for the pipe material (MPa)
E = Short term Modulus of Elasticity (for PE 100 E=950 MPa)
I = moment of inertia (m^4)
Do = Mean pipe outside diameter (m)
n = Safety factor (1.25)

Bends or manholes (for gravity wastewater, drainage and ducts) shall otherwise be installed.

***Note** – Pipe installed for services other than pressure installations may only be curved on approval from Watercare.*

C3.4.2 Pipe bends and fittings

Bends and fittings shall be shop-fabricated by the pipe supplier or by an approved specialist fabricator. Fabrication on site is not permitted.

Short bends shall be formed by butt welding mitred segments of the same material as the pipe. Unless specified otherwise, the maximum deflection angle at any mitre shall not exceed 18 degrees. The ends of bends and fittings shall have straight sections of at least 1.5 pipe diameters to facilitate welding on site.

Heavier wall pipe shall be used in the manufacture of fittings where necessary to maintain the specified pressure rating.

Fabricated PE fittings shall be joined to the pipeline by butt-welding. To achieve this where heavier wall pipe is required to fabricate the fitting, the pipe shall be machined to match the wall thickness of the pipeline.

C3.4.3 Pipe jointing

Jointing shall be by fusion butt welding of the material. Electrofusion couplers, mechanical PE couplers or flanges welded to the pipe shall be used only where specified.

A Work Method Statement (WMS) shall be supplied for the works being undertaken. The WMS must be approved prior to the work commencing, including pre-qualification test weld work. Refer to Section 10.3 for joint testing requirements and methods.

Pipes shall be jointed in accordance with the Plastics Industry Pipe Association (PIPA) POP001 for electrofusion methods and POP003 for butt fusion methods. For joints by any other mechanical means the mechanical construction standard shall apply.

No construction welding shall proceed until the contractor has proven pre-qualification test welds are ductile for each nominated welder and the pre-qualifications are confirmed by Watercare as being acceptable.

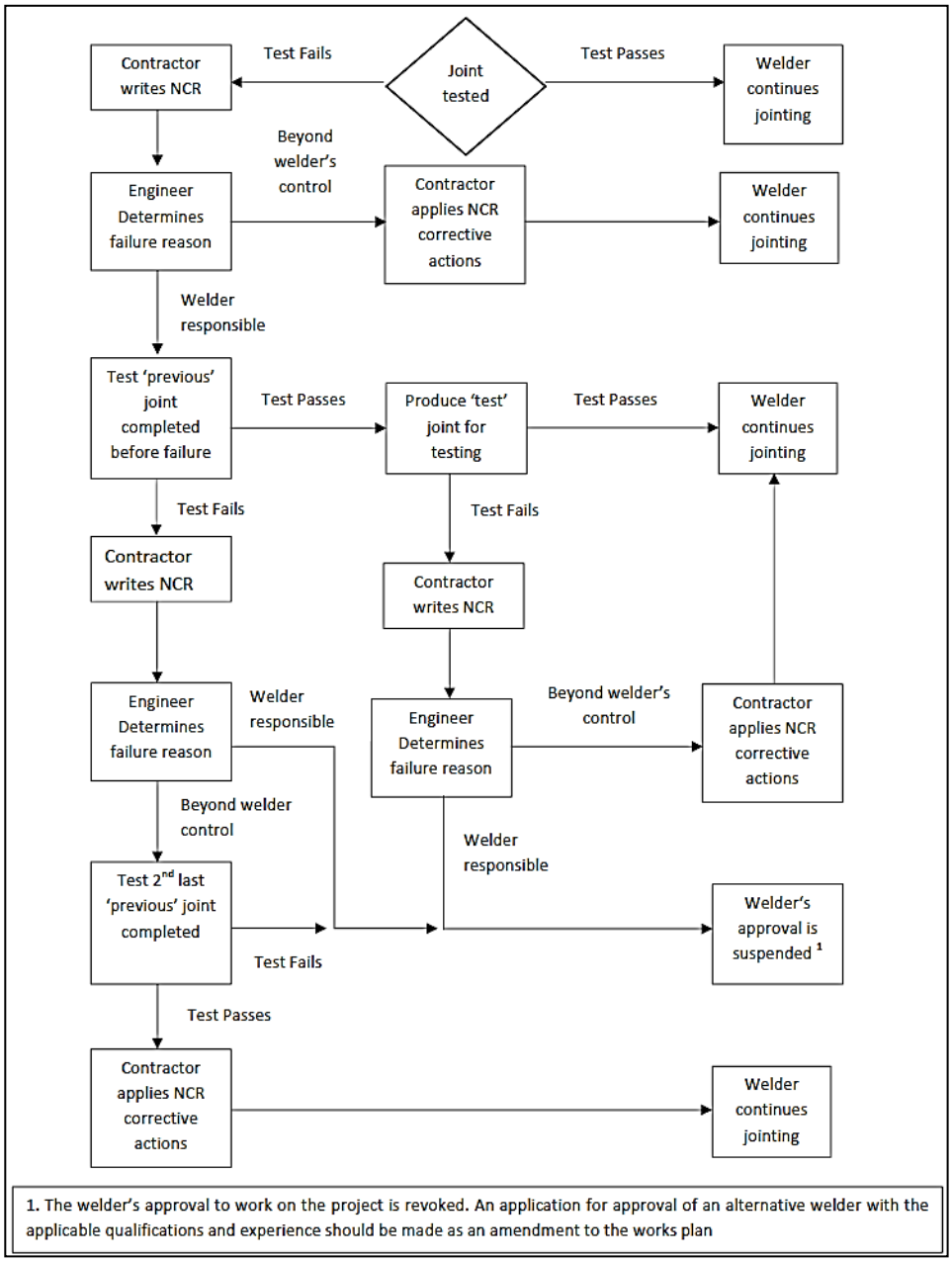
All construction welding shall be undertaken using the same welding operators, welding machines, plant and welding parameters that produced the acceptable pre-qualification welds. Change or substitution of any plant and/or operator requires a repeat of the pre-qualification weld using the new plant and/or operator.

If a pre-qualification test weld does not meet the acceptance criteria the contractor shall take corrective actions and submit a non-compliance report (NCR) on its findings and the action taken. The welding parameters shall not be changed without written consent. The contractor shall then prepare and test three additional pre-construction test welds at its cost.

During construction destructive testing shall be undertaken. The number of welds to be removed shall be one in every 20 welds completed (5%) per pipeline or a minimum of 2 whichever is the greater. Construction welds shall be taken at random, and wherever possible will be taken from the pull-off side of the butt-welding machine to reduce replacement time.

Where a construction test weld fails destructive testing refer the below flow chart for quality assurance process.

Chart C3.4.3-1 Destructive testing QA flow chart



Hand scraping is not allowed. All jointing shall take place with alignment clamps, mechanical peeling tools and pipe cleaning equipment. The alignment clamps shall be arranged so that there is no stress on the joint area. Where pipe oval of any joint fitting exceeds the manufacturer's recommendation the pipe shall be re-rounded by a re-rounding clamp. The re-rounding clamp and alignment clamps shall not be removed until the cool time has elapsed.

The welder's certification number is to be stamped on the bead of each butt welded joint. Beads shall not be removed unless specified.

C3.4.4 Equipment

Butt welding machine

Details of the butt welding machine, including its age and maintenance history shall be provided with the calibration certificate. Calibration of the machine and heater plate shall be completed to the manufacturer's specification. The butt welding machine shall not be a manual type. The machine shall be capable of logging (and download to MS Excel) the following:

- Weld number or identifier
- Weld location
- Welding machine including model & serial number
- Welding operator and certification number
- Pipeline label including material type, OD, SDR, the actual mean wall thickness
- Date
- Time
- Ambient temperature
- Machine cylinder area and ram ratio
- Heater plate area
- Software version
- Heater plate temperature
- Pressure and time parameters achieved:
    - Drag pressure
    - Bead build-up pressure and time (P1 & T1)
    - Heat soak pressure and time (P2 & T2)
    - Maximum change over time (T3)
    - Maximum time to achieve weld pressure (T4)
    - Welding and cooling pressure (P3)
    - Maximum and minimum bead size after cooling (mm)

Electrofusion welding control box

Details of the electrofusion control box and the data logger shall be provided including their age and maintenance history and evidence that the control box has a current certificate of calibration for Watercare's acceptance. The electrofusion control box shall be an automatic bar code scanner machine.

Calibration of the electrofusion control box shall include calibration and operation checks to the manufacturer's specification.

All electrofusion welds shall be a data-logged recording (and download to MS Excel) of the following:

- Weld number or identifier
- Weld location
- Welding machine
- Welding operator and certification number
- Pipe and fitting details
- Date
- Time
- The fusion-cool cycle was completed correctly, or
- The error code where the fusion-cool cycle did not complete correctly

Miscellaneous equipment

- Petrol chain saws shall not be used to cut PE pipe. Large diameter PE pipe may be cut using an electric chainsaw without the chain oiler operating, or an electric reciprocating saw, or specialised PE pipe cutter. Smaller diameter PE pipe, <300mm OD, shall be cut with a rotary pipe cutter or clean hand saw.
- Isopropyl Alcohol (IPA) having a concentration of 95% or greater shall be used for pipe cleaning prior to welding. IPA wipes specifically for PE electrofusion welding or IPA liquid with lint free cotton cloth is accepted. Acetone is not allowed.
- Alignment clamps shall be used. The clamp leg shall be 2.5 to 3 times the pipe OD in length with at least 2 clamps on each leg.

C3.4.4 QA/QC templates

This template is in addition to C3.1.7

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Work Method Statement	Document provided and accepted	Required	Required	Required
2	Pipe inspected	No visual damage, eccentricity and dimensions to AS/NZS 4130	N/A	Required	As specified
3	Welding machine calibration	Calibration certification current	Required	Required	Required
4	Training & competency certification of operators	NZQA recognised qualification. Current experience in pipe size and type to be welded.	Required	Required	Required
5	Pre-qualification weld test results	All welds ductile. NATA/IANZ accredited laboratory test to ISO 13953/4/6, ISO 21751	Required	Required	N/A
6	Welding data Logging	Excel format with required data	Required	Required	As specified
7	Tent/ shelter over welding	Site inspections	N/A	Required	As specified
8	Pipe ends sealed during welding	Site inspections	N/A	Required	As specified
9	Construction weld test results	Ductile. NATA/IANZ accredited laboratory test to ISO 13953/4/6	Required	Required	As specified
10	Clean working space, no mud or standing water on trench floor	Site inspection	N/A	Required	As specified
Butt weld specific					
11	Butt Weld parameters	Calculated by pipe size and type	Required	Required	N/A
12	Heater plate manual readings (4 per day)	Daily checks completed – forms supplied	Required	Required	N/A
13	Weld beads inspected (butt welding)	Tolerances to POP003	N/A	Required	As specified
Electro-fusion joint specific					
14	Pipe surface preparation	Using mechanical peeling tool (no hand-scraping) >0.2mm < 0.5mm material removed	N/A	Required	As specified
		Sign-off			

Daily Heater Plate Temperature QA Check Sheet

Contract No.____________________Date:___________________Welder:________________________________

Time	
Pipe Size	
Show position of pipe and temperature check locations	
Temperature at Position °C	
1.	2
3	4

Time	
Pipe Size	
Show position of pipe and temperature check locations	
Temperature at Position °C	
1.	2
3	4

Time	
Pipe Size	
Show position of pipe and temperature check locations	
Temperature at Position °C	
1.	2
3	4

Time	
Pipe Size	
Show position of pipe and temperature check locations	
Temperature at Position °C	
1.	2
3	4

C3.5 Repair of polyethylene pipe

This section shall be read in conjunction with the requirements for the installation of polyethylene pipe and the material and mechanical standards applying to the specific repair solution.

The repair of PE pipelines may be achieved using butt welding, electrofusion welding and PE mechanical connectors. Generally butt welding is unsuitable in most repair situations and is more practical for off-site fabrication of repair pieces.

The type of failure shall be identified before affecting a repair. The typical failure modes and repair solutions are:

Table C3.5-1 PE repair solutions

Type of Failure/Damage		Acceptable Repair
1	Very small scale mechanical damage - surface gouge or abrasion	Electrofusion repair saddle
2	Damage at high point where control of water in pipeline not a concern	Cut-out damaged section of pipe and replace using PE pipe spool and electrofusion couplers
3	Mechanical damage - such as excavator strike	Cut-out short section of pipe and replace using electrofusion flange adapter, or mechanical flange adapter
4	Pinhole leak	Cut-out short section of pipe and replace using electrofusion flange adapter, or mechanical flange adapter
5	Broken butt-weld	Cut-out short section of pipe and replace using electrofusion flange adapter, or mechanical flange adapter
6	Large scale mechanical damage - such as pipe scoring	Cut-out affected section of pipe and join-in new pipe spool using electrofusion flange adapter, or mechanical flange adapter
7	Brittle cracking including slow crack growth (SCG) failure	Cut-out affected section of pipe and join-in new pipe spool using electrofusion flange adapter, or mechanical flange adapter

For any welded type repair the pipe shall not be backfilled or returned into service before the required cooling time has lapsed.

It is preferred that joints are repair by butt or electrofusion welding. Non-welded joints shall be flanged or use an accepted proprietary self-restrained product used. The repair solution class and pressure rating shall be the same or greater than the existing pipe.

C3.6 Installation of welded steel pipelines

Steel pipe may be installed by various methods depending on the purpose of the pipe. The requirements in this section apply to the permanent installation of steel pipe for purposes other than unprotected or sacrificial sleeves, in a trench or above ground.

C3.6.1 Pipe bends and other assemblies

This section shall be read together with the mechanical construction standards. Any tapers or bends shall be constructed to the dimensions as specified by the drawings for steel pipe assemblies.

Pipe internal linings or external corrosion protection shall be of the same parent product as the main pipeline or similar accepted alternative according to the operational requirements. Linings and external corrosion setback shall allow for site installation and jointing.

C3.6.2 Pipe joints

Socket and spigot joints shall be drawn fully home using safe working practices that do not deform the pipe or damage internal linings. A full fillet weld structurally joining the pipes shall be made externally and internally (pipelines >700mm), in accordance with the standard drawings and the mechanical construction standard. No person shall enter any pipe for internal work where a body needs to fully enter the pipe on pipes less than 700mm internal diameter.

Where it is necessary to deflect a joint the maximum deflection for steel pipe socket and spigot joints is listed in the table below:

Table C3.6.2 -1 Allowable spigot and socket joint deflection

Nominal bore (NB) mm	Maximum deflection angle (degrees)
150	7
200	6
250	5.5
310	5
390	5
470	4.5
550	4
630	4
700	3.5
730	4
760	4
810	4
910	3.5
1070	3.5
1300	3
1500	3
1700	3.5
1900	3

Pipe assemblies without a formed spigot and socket shall be installed using welding bands in accordance with the standard drawings or as otherwise directed by the specific drawings.

Flanges and isolation joints or other mechanical couplings shall only be installed in accordance with the design drawings. For details of forming mechanical joints the mechanical construction standard shall apply.

Access manholes to Watercare standard design shall be installed on pipework of 700mm diameter or larger to facilitate safe access to complete internal pipe welding. The location of access manholes shall be at the discretion of the contractor and stated in the work method statement. The frequency and type of access manhole used shall be submitted to Watercare for acceptance.

The internal pipe lining shall be repaired for all pipe joints where the steel is exposed. Any rust, loose paint or other deleterious matter shall be removed. Repairs (epoxy and mortar compliant with AS/NZS4020) shall be completed in accordance with the lining product instructions. Where concrete lining is used the repair shall be smooth and continuous with the original lining either side of the joint.

Concrete lined pipes smaller than 700mm in diameter, or where the pipe joint cannot be reached for internal repair without entry, shall be repaired by other means. Solutions may include that the internal joint be prepared with an accepted rapid setting mortar before the joint is closed or where welding bands are used a temporary inflator expanded against the joint allowing the lining to be repaired by external injection of the grout. Accepted proprietary internal joint repair products or the use of robotics may be other solutions.

C3.6.3 Corrosion protection

Internal coating or lining shall be applied in accordance with the applicable material supply standard for the specified service application.

Concrete lining repairs shall be made to any cracks, defects or weld joints where the concrete lining separation is greater than 1mm. An accepted product shall be used that is fully tested to comply with AS/NZS 4020. Refer to section C3.6.2 for internal lining repair at pipe joints.

An accepted tape coating shall be used as external protection for buried pipe and pipe assemblies and be applied in accordance with the product manufacturer specification. Pipe lengths shall be factory wrapped. Pipe assemblies shall be wrapped by the fabricator. Only joints, site installed fittings or repairs shall be wrapped on site. The construction and quality assurance for the tape coating systems shall comply with the requirements of AWWA C209 except:

- Apply primer to the bare steel surface and overlapping 150mm over the existing wrapping
- The tape shall be applied in a smooth wrinkle free coating with a minimum spiral overlap of 67% to achieve three layers

External epoxy coating for exposed pipe shall be factory applied for pipe lengths. Pipe assemblies shall be prepared and painted by the fabricator. Surface pipe shall be epoxy paint coated to the applicable painting standard. (See section C5)

Where pipe transitions from buried to painted pipe above surface an ultraviolet resistant protective tape system shall be applied with an overlap of at least 150mm below ground onto the buried protective wrapping, extending to 500mm beyond where the pipe is clear of the buried surface.

Direct current voltage gradient (DCVG) integrity testing shall follow visual inspection. Any holidays found shall be repaired and retested. Refer to Section 10.12 for testing requirements.

C3.6.4 Concrete lined steel pipe - Wastewater specific requirements

Minor grading deflection shall be achieved within the spigot joint or welding band allowable tolerances.

Pipe bends are only allowed for pressure systems. Directional change for gravity systems shall be through a wastewater manhole in accordance with the standard drawings.

C3.6.5 QA/QC templates

This template is in addition to C3.1.7

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Socket deflection	Within limitations of table C3.6.2-1 (measure/survey)	(per joint) Required	Required	N/A
2	Weld band, socket and spigot joint test	Nitrogen/air test pipe ≥700mm test record	(per joint) Required	Required	As specified
3	Corrosion protection	3 layer overlap (67% per lap)	N/A	Required	As specified
		Pull test as per AWWA C209	Required	Required	As specified
		Visual inspection	N/A	Required	As specified
		DCVG survey test results	Required	Required	N/A
4	Components for use with potable water	AS/NZS4020 compliant	Required	Required	N/A
		Sign-off			

C3.7 Installation of PVC pipelines

Pipe delivered to site shall be checked for any damage and completeness (gaskets in place). The pipe class and dimensions shall be confirmed to be in accordance with the specific drawings and the applicable material standard. PVC pipe shall be protected from ultraviolet exposure.

Particular care shall be taken to prevent gaskets being exposed to heat, oil, grease or other contaminants.

C3.7.1 Pipe Joints

Pipe may be cut using a power handsaw or a clean hack saw. The end of the pipe shall be bevelled at 15° for 50% of the pipe wall thickness with a purpose bevelling tool or fine wood rasp. The bevel shall be consistent around the pipe circumference and free of any burrs.

An accepted lubricant shall be applied to the joint in accordance with the manufacturer's requirements. The pipe joints shall be aligned vertically and horizontally driving the joint in. The bar-and-block method shall be used to make the joint. On large pipe diameters mechanical assistance may be required. Reference lines shall be used to prevent excessive force and to ensure the joint is fully home.

C3.7.2 QA/QC template

This template is in addition to C3.1.7

Quality / Control		**Measurement**	**Certification**		
			Document supplied	Site supervisor witness	Engineer witness
1	Socket preparation	Pipe bevelled and free of burrs	N/A	(per joint) Required	As specified
2	Socket witness marks	Joints drawn fully home	N/A	(per joint) Required	As specified
		Sign-off			

C3.8 Installation of Ductile Iron (DI) pipe

Pipe delivered to site shall be inspected for defects including but not limited to lining and external coating defects, gasket condition (spigot jointed pipes) or conforming flange requirements and cracks.

Pipe protective coatings shall be holiday tested. Repair to any defects identified shall be corrected in accordance with Section C3.6.3.

C3.8.1 Pipe Joints

See the mechanical construction standard for flange joints.

Spigot and socket joints shall be installed with the socket (bell) facing the direction of installation. The end of the pipe shall be bevelled at 15° for 50% of the pipe wall thickness with a purpose bevelling tool or fine wood rasp. The bevel shall be consistent around the pipe circumference and free of any burrs.

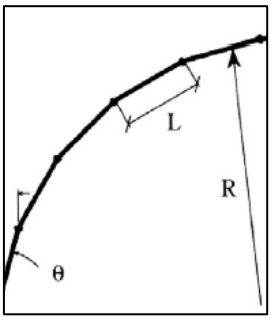
An accepted lubricant shall be applied to the joint in accordance with the manufacturer's requirements. The pipe joints shall be aligned vertically and horizontally before driving the joint in. The bar-and-block method shall be used to make the joint. On large pipe diameters mechanical assistance may be required. Reference lines shall be used to prevent excessive force and to ensure the joint is fully home.

Mechanical joints shall be fitted in accordance with the manufacturer's requirements and protected against corrosion as per Section C3.6.3.

C3.8.4 Pipe deflection with spigot joints

Where pipe is required to be deflected over a long radius the deflection may be achieved in deflecting the spigot joints. The installation of the joint shall be straight as per Section C3.8.1 and the deflection only applied once the joint is fully drawn.

The deflection shall be applied to the manufacturer's recommendation. In the absence of manufacturer data the following formula shall be applied as a guideline:



R = L/(2 tan Θ/2)

Where:

R = Radius of curve (metre)
L = length of pipe (joint to joint in metre)
Θ = Deflection angle (degrees)

Allowable angle deflection angle per joint

Nominal pipe size (mm)	Deflection angle Θ (degrees)
80	5
100	5
150	5
200	4
250	4
300	4
350	3
400	3
450	3
500	3
600	3
700	2
800	2
900	1
1000	1

All joints must be checked on site to ensure that joint seals make full contact and are fully functional.

C3.7.2 QA/QC template

This template is in addition to C3.1.7

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Socket preparation	Pipe bevelled and free of burrs	N/A	(per joint) Required	As specified
2	Socket witness marks	Joints drawn fully home	N/A	(per joint) Required	As specified
3	Corrosion protection	Holiday testing for coating defects. Defect repaired	N/A	Required	As specified
		Sign-off			

C3.9 Concrete and Ceramic pipes (Wastewater only)

C3.9.1 General

This section covers concrete pipe for wastewater application, both gravity and pressure applications. Pipe delivered to site shall be inspected for defects. Damaged or broken pipe shall not be accepted. Pipe may not be unloaded by rolling to ground or similar that would result in impact on the pipe. Pipe shall be kept clean. Rubber rings shall not be stored in sunlight and care shall be taken with storage to prevent deformation.

C3.9.2 Cutting of pipes

The cut shall be made using a diamond or abrasive saw. The whole cut shall be in the same plane through the full thickness of the pipe wall, and shall be within a tolerance of 6 mm from the true cut line. Pipe reinforcing shall be cut cleanly and flush with the finished concrete surface. Explosive or impact chisel methods shall not be used for cutting pipes.

C3.9.3 Pipe Laying

Pipe laying tolerance shall be in accordance with the general civil construction standard. Bedding requirements shall be in accordance with the standard drawings for concrete pipe. Unless otherwise shown on the specific drawings, the bedding shall be Type H2.

Concrete bedding shall be in accordance with the requirements in section C4:

- Concrete need not be weight-batched.
- Curing is not required.

The surround material shall be placed as soon as possible after the pipes have been inspected, any concrete bedding has attained sufficient strength and the testing requirements have been complied with. Compaction and backfilling shall be to the general civil construction standard.

C3.9.4 Laying on a curve

Pipe laying on curves shall be as specified or shown on the specific drawings. Pipe joint shall be to the manufacturer recommendations.

Where pipes with rubber ring joints are to be laid on curves and the curves are to be taken up in the joints, each pipe shall be entered and pushed home with the pipe in line with the previous pipe. The deflection required to make the curvature shall be made by moving the free end the required amount.

C3.9.5 Rubber ring joints

Rubber ring joints shall be made to the pipe manufacturer's requirements, and:

- Out of alignment joint shall not be forced, but parted and remade.
- Joints shall be inspected to ensure the rubber ring is in its location (checked with a feeler gauge) and free of twists.

C3.9.6 Mechanical joints

Mechanical joints shall be installed in accordance with the mechanical construction standard. All joints shall be wrapped with an accepted corrosion protection system.

C3.9.7 Repair

Refer to section C4.7 for repair and rehabilitation of concrete pipe for wastewater applications.

C3.9.8 QA/QC Template

This template is in addition to C3.1.7

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Pipe inspection	Free from damage. Seals stored appropriately	N/A	Required	Required
2	Pipe cutting	6mm tolerance	N/A	Required	As specified
3	Pipe laying	Bedding type as specified (per section). Type H2 normative if not specified	N/A	Required	As specified
		Laying on curve – under approval and to the required standard method	N/A	Required	As specified
4	Joints	Fully drawn, inspected for defects	N/A	Required	As specified
		Mechanical joints wrapped to manufacturer requirements	N/A	Required	As specified
5	CCTV	CCTV inspection – Reviewed for defects	Required	Required	Required
6	Testing & disinfection	Testing requirements for pressure or non-pressure pipe as appropriate	Required	Required	Required
		Sign-off			

C3.10 Pipe structural lining

C3.10.1 General

A pre- and post-lining close circuit television (CCTV) inspection shall be completed to assess the damage or pre-replacement condition, after surface cleaning and preparations and to verify the successful installation of the lining solution. Lining solutions with any compounds or lubricating systems used in potable water applications shall be fully tested to comply with AS/NZS 4020.

C3.10.2 Access

Siting of access locations shall be provided for Watercare's consideration as part of the construction management plan. Where access is obtained through chambers, existing lids or similar infrastructure, best care shall be taken to retain these for re-use.

The pipeline shall be accessed on approval and only after shutdown is confirmed by Watercare. A minimum of five working days' notice is required prior to any shutdown, but may be extended due to operational constraints.

C3.10.3 Pipeline cleaning

Cleaning prior to CCTV shall only be completed where sediment deposits are likely to obscure defects. Cleaning methods may include:

- Water scour
- Air scour
- Swabbing or pigging
- Water jet

The construction management plan shall include any cleaning method limitations considering the pipe material, class and expected condition to conserve the pipe's integrity.

C3.10.4 CCTV requirements

The CCTV shall be produced in accordance with the Watercare Data and Asset Information standard for inspection and collection of data. Survey logs shall be provided identifying all visible defects, including measurements of the existing lining thickness on the vertical and horizontal axis at each end of each pipe section.

C3.10.5 Pipe repairs

Prior to the relining of each section, where a section of pipe has been removed at a fitting, a single pipe section shall be provided to make up the whole distance between the fitting and the end of the pipe.

The installation of replacement pipe sections is not required where it is demonstrated that the liner system shall fully withstand all internal and external loads.

In the case of steel or ductile iron pipe the acceptable protective wrapping shall be applied to the manufacturers' instruction or as otherwise amended by the general construction standards.

C3.10.6 Polymer lining methods

The polymer lining method shall be appropriate for the pipeline faults. The lining material shall be fully structural. Methods for pressure water applications are:

- Swage lining
- Cure in place pipe (CIPP)
- PE slip lining
- PE fold and form

Unless specified, the contractor shall provide the following information based on the selected lining type:

- Hydraulic, soil and dynamic loads
- Lateral consideration resulting from adhesion to the host pipe
- Material type selection in accordance with the above loading criteria
- In the case of slip lining the annulus grouting procedure

Connections and joints:

Joints shall be welded between connection points. The welding practices shall be in accordance with the general construction standard for the applicable material type.

Connections such as tees, bends or valves shall be with a purpose adaptor for the lining type. Connections made with ductile iron or steel are permissible on the condition that the joint between the host, lining and new fitting provides the desired structural integrity.

C3.10.7 Cement and mortar in-situ lining methods

For wastewater applications refer to Section C4.7.

The cement mortar lining shall be machine applied to 10mm thickness with an allowable variance of ±1.5mm. Any fittings attached to the pipe shall be prevented from blocking, and where able, the lining shall be hand finished. Any hand reinstatements of fitting connections or small patch repairs shall be within 24 hours of the machine application. Where the machine accessed the pipe, the machine application shall be fully completed with the machine, cut back 75mm and hand rendered. The mortar lining shall be allowed a minimum of 72 hours curing time. Steel pipe that has been cut open shall be prepared with an acceptable high heat resistant mortar that will seal the mortar behind the weld. This mortar shall be allowed to cure according to the manufacturer's recommendation before completing the weld.

Surface preparation:

The cleaning effort shall be such that the pipeline is a bare surface without any loose debris or rust. Concrete lined pipe shall be cleaned without damage to the existing concrete or concrete lining.

C3.10.8 Record keeping

The record form shall be completed per component rehabilitated or in the case of pipelines between access points, batches or shifts. Records for polymer lining systems shall follow the requirements for the material type within this standard. For mortar lining the following template shall be used:

Structure information			
Contractor		Installation site identifier	
Asset ID		Address	
Access location			
Grout mix			
Date		Time	
Manufacturer batch number			
Mix composition		Mix Volume	

C3.10.9 QA/QC Template

Quality / Control		**Measurement**	**Certification**		
			Document supplied	Site supervisor witness	Engineer witness
1	CCTV - start	Records evaluated against design stage records	Required	Required	N/A
2	Pipe cleaning	AS/NZS 1516 preparation for lining.	N/A	Required	As specified
3	Product compliance	Watercare material standards	Required	Required	Required
4	Mortar application records	Min. 10mm, ±1.5mm.	Required	Required	N/A
5	Testing	Samples to AS 1012 part 24, tensile bond strength (mortar lining)	Required	Required	N/A
		Pressure testing and weld samples as per the general civil standard	Required	Required	As specified
6	CCTV – final	U3 finish. No visible slumping or cracking	Required	Required	Required
		Sign-off			

C3.11 Pipelines brought into service

All construction test certifications and required operational documentation shall be provided before applying to bring the pipe into service. The pipe shall then be leak tested and made ready for final connection. For more information refer to the Watercare Code of Practice for commissioning.

***Note** – Where disinfection of pipes are required before making the connection, the disinfection and testing shall be done as part of bringing the pipe into service due to chlorine retention times. See Watercare's code of practice for water reticulation disinfection.*

A method statement for final connection works shall be provided for acceptance a minimum of four weeks before the programmed cut-in.

The method statement shall include but not be limited to:

- Position of "stop-ends" to minimise the length of untested section when making the final connection
- Test water source and disposal
- Plant, equipment and resources to be used

- Programme
- Lines of communication

C4. Concrete

C4.1 Construction of reinforced concrete structures

Where concrete is used in conduits, water retaining structures and manholes, the provisions of NZS 3106 shall apply. NZS 3106 will take precedence over NZS 3109, where there is conflict. No calcium chloride shall be used in reinforced concrete.

Concrete mix shall achieve 28 day strength of 30MPa unless otherwise specified. The ratio of 7 to 28 day strength shall be as specified but not less than 1.3 (or 60% of 28 day strength). Construction shall not progress if the 7 day test indicates concern of achieving full 28 day strength.

Where concrete is used in conduits, water retaining structures, manholes, sewage chambers and wet wells or where concrete is in contact with the ground, the water-cement ratio shall not exceed 0.5.

Air entrained concrete shall not be used in lifts greater than 2.5m. Concrete shall be placed in its final position within 1½ hours of cement introduction to the aggregates. The time lapse for concrete handling from the mixer or agitator truck shall not exceed 30 minutes.

Concrete pumping shall follow the contractor's methodology, designed task specifically and as accepted by Watercare, observing the following:

- Aluminium pipes shall not be used
- A lubricating mortar run to waste shall be used at the pump start
- Slump test at the supply hopper and placement end pipeline
- Concrete compression test samples shall be taken at the placement end

In addition to Clause 7.7.1 of NZS 3109 should rain threaten an exposed concrete pour, suitable covers shall be put in place before the pour commences.

Curing compounds shall only be used where specified, less than 6 hours after screeding to the manufacturer's requirements and shall restrict the loss of water to less than 0.55 kg/m^2 in 72hours.

C4.1.1 Reinforcement

Reinforcing shall be inspected and certified in accordance with the supply standard before installation and before concrete is placed. Reinforcement shall be placed straight between specified bends.

All deformed bar reinforcement, noted on the drawings as either H or HD followed by the bar size, shall be Micro Alloyed manufacture Grade 500 ductility Class E to comply with AS/NZS 4671 carrying the SEISMIC 500E MA identifier. Plain round reinforcing**,** noted on the drawings as R followed by the bar size, bar shall be Grade 300 complying with AS/NZS 3679.1

Pre-stressed reinforcing shall comply with AS/NZS 4672 to the specific design.

Approval to weld reinforcement is required in every case and drawings shall be included with each application for approval showing the position and type of each weld. Welds shall be in compliance with AS/NZS 1554 part 3. Welds shall be more than 10x bar diameters from bends.

In addition to the requirements of NZS 3101 and NZS 3190, the manufactures instructions with respect to the bending and re-bending of steel shall be strictly followed. Details can be found at www.reinforcing.co.nz.

The concrete cover to steel reinforcement shall be the greater of:

- The values given in NZS 3101:Part 1, or
- the values given in the tables below (design life specific, normally 100 years), or
- the cover shown on the drawings.

Table C4.1.1-1 Minimum required cover for a specified intended life of 50 years

Exposure classification	Cement binder type	Specified compressive strength fc' (MPa)						
		25	30	35	40	45	50	60-100
		Minimum Required Cover (mm)						
AI	GP, GB or HE	25	20	20	20	20	20	20
A2	GP, GB or E	35	30	30	25	25	25	20
BI	GP,GB or HE	40	35	35	30	30	30	25
B2	GP,GB or HE	-	45	40	35	30	30	25
C[(1)]	30% FA	-	-	-	60	60	60	55
C[(1)]	65% GBS	-	-	-	-	50	50	50
C[(1)]	8% MS	-	-	-	-	60	50	50

Notes:

1. For zone C the total binder content shall be equal to or greater than 350kg/m3 and water to binder ratio shall not exceed 0.45. The minimum cover for the C zone shall be 50mm.

Table C4.1.1-2 Minimum required cover for a specified intended life of 50 years

Exposure classification	Cement binder type	Specified compressive strength fc' (MPa)						
		25	30	35	40	45	50	60-100
		Minimum Required Cover (mm)						
AI	GP, GB or HE	35	30	30	30	30	30	25
A2	GP, GB or E	50	40	40	35	35	35	30
BI	GP,GB or HE	55	50	45	40	40	35	30
B2	GP,GB or HE	-	65	55	50	45	40	35
C[(1)]	30% FA	-	-	-	-	70	60	60
C[(1)]	65% GBS	-	-	-	-	60	50	50
C[(1)]	8% MS	-	-	-	-	-	50	50

Notes:

1. For zone C the total binder content shall be equal to or greater than 350kg/m3 and water to binder ratio shall not exceed 0.45. The minimum cover for the C zone shall be 50mm.

Abbreviations used in the above tables are as follows. (Refer to NZS 3101:Part 1 for full definition)

FA	fly ash
GB	general purpose blended cement
HE	high early strength cement
MS	amorphous silica
GBS	ground granulated iron blast furnace slag

The minimum cover for a surface in contact with the ground shall be 75mm, or 50mm if using a damp proof membrane between the ground and concrete.

Unless otherwise specified, the cover required for exposure classification B2 with an intended life of 100 years shall be used.

C4.1.2 Construction joints

Construction joints shall be in continuous unbroken lines. Unless otherwise specified construction joints shall be as shown on the specific drawings.

In water retaining structures, immediately before placing the new concrete on a horizontal joint the roughened surface shall be primed with a neat cement grout layer of 5mm thickness and a water cement ratio less than 0.32. Any alternative joint surface preparation shall be subject to approval.

C4.1.3 Contraction joints

Contraction joints shall be formed where specified. In water retaining structures the joints shall incorporate an acceptable water stop unless otherwise specified.

The surfaces of contraction joints shall be left smooth. Where details of contraction joints are not shown on the specific drawings a tapered rebate shall be formed in the joint. The taper will have an average width of one third of the thickness of the concrete and a depth of not more than half the width.

C4.1.4 Slump tolerance

For water retaining structures, slump tolerances shall be half those given in Table 9.1 of NZS 3109.

C4.1.5 Vibration

Internal vibrators shall be on approval. If scum, devoid of coarse aggregate appears on top of or ahead of concrete after specified compaction (Clause 7.5.5 of NZS 3109), the laitance layer shall be removed to waste and replaced with concrete and before any consecutive layers are placed.

C4.1.6 Surface finish

Formwork, concrete proportions and workmanship shall be such that no patching of concrete surfaces will be required. The minimum standard of surface finish shall be as indicated in the table below. A uniform finish standard shall be provided to any designated location.

Table C4.1.6-1 Minimum standard of surface finish

Location	Surface finish
Concealed foundation surfaces	F1
Top surface of foundation pads	U2
Visible foundation surfaces	F5
Site concrete	U1
Interior walls	F3
Exterior walls	F5
Floor and roof slabs	U2
Formed concrete to take plaster	F2

C4.1.7 Penetrations through structures

All embedded items shall be accurately set and supported in place until the concrete has set. In addition to Clause 5.5 of NZS 3109:

- Place such pipes or items in the forms before placing the concrete, or
- Provide approved block-outs in the forms
- Position penetrations on construction joints to minimise shrinkage cracking where feasible
- Construction joints around block-outs shall have approved keys formed and/or be roughened to an amplitude of 5mm
- Block-outs shall be shaped to allow removal of all air displaced by the subsequent grouting of the penetration

When grouting in pipes and other items, concrete grout (or approved alternative) of at least equal strength to the surround concrete shall be used. An acceptable expansive admixture, applied in accordance with the manufacturer's instructions shall be used in the grout to ensure a watertight joint. Penetrations for pressure rated pipe (other than thin walled sleeves) shall be sealed against water ingress with an overlapping strip of an acceptable hydrophilic sealant encased at least 70mm in the concrete casting.

Penetrations to the structure shall be grouted in place by placing the grout under a head of at least 100 mm. The concrete shall completely fill the spaces to achieve the same water tightness as the rest of the structure.

Pipes less than 75 mm diameter in cored holes shall be fixed in place by dry pack mortar or cement grout with a suitable bonding agent.

C4.1.8 Records

In addition to Clause 303.1 of NZS 3104, the mix design shall be identified and any admixtures shall be included on the delivery docket.

C4.1.9 QA/QC template

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Concrete construction plan	Including delivery scheduling plan to meet timeframes	Required	Required	N/A
2	Confirm required concrete strength	As specified or minimum required from this standard	Required	Required	Required
3	Reinforcing inspection	According to specific drawings	Required	Required	Required
		Deformed bar SEISMIC 500E. Test certification of steel required	Required	Required	Required
		Plain bar grade 300. Test certification of steel required	Required	Required	Required
		Welding 10x dia. from bends	Required	Required	Required
4	Formwork	Cover requirement met, Tables C4.1.1 -1/2	Required	Required	Required
5	Concrete plant certification	Certification graded ready mixed concrete plant to NZS3104 (High grade or special grade)	Required	Required	N/A
6	Vibration	Witnessed to comply with requirements of NZS3109, any laitance replaced	N/A	Required	As specified
7	Test reports	Supply source	Required	Required	N/A
		Mix identification and compressive strength	Required	Required	Required
		Location of structure	Required	Required	N/A
		Batch number	Required	Required	N/A
		Time and date	Required	Required	N/A
		Time prepared	Required	Required	N/A
		Slump 0.5x values of table 9.1, NZS 3109	Required	Required	Required
		7 day test	Required	Required	Required
		28 day test	Required	Required	Required
8	Construction and contraction joints	Inspected as per drawings	N/A	Required	As specified
9	Surface finish	Table C4.1.6-1	N/A	Required	As specified
10	Testing tanks and reservoirs	Complete test to Section 10.5.4	Required	Required	Required
		Sign-off			

C4.2 Construction of enclosed chambers, manholes and small structures

C4.2.1 General

Concrete mix shall be minimum 25 MPa at 28 days unless shown to be a higher strength on the specific drawings.

For manholes the concrete haunching and encasement to pipe penetrations shall be from 25MPa grade concrete and shall be formed such that the inside face follows the original inside line of the manhole.

Wastewater manhole benching shall be cast and troweled to shape, sloping towards the channel at minimum 1:12. The troweled surface shall be smoothed to U2 finish. Plastering over the concrete finish is not accepted.

C4.2.1 Foundation

The structure shall be founded on a firm and stable base, with site concrete as required, to provide a clean working surface for construction of the manhole.

C4.2.2 Roof slab, lids and access

All lids shall support HN-HO-72 loading. Access holes and other entry points shall be cast into the slab, not cut. The lids shall be fixed to the slab as shown in the standard drawings.

Person accessible entries shall have a minimum clear access of 600mm diameter. Entries or other openings where a person can fall into a pit or chamber with the access lid removed, shall be fitted with an accepted safety grille.

Step rungs or ladders shall be as shown on the drawings and manufactured from an accepted material to the Watercare material supply standard. Refer to Watercare's mechanical construction standard for construction and installation requirements.

C4.2.3 Infiltration performance

The sealing between joints shall be with an acceptable material providing 100 year performance and installed to the manufacturer's requirements. The sealing material shall meet the minimum infiltration test performance criteria applicable to the installation circumstances.

C4.2.4 QA/QC template

Quality / Control		**Measurement**	**Certification**		
			Document supplied	Site supervisor witness	Engineer witness
1	Set-out	Line and level in accordance with specific drawings	N/A	Required	N/A
2	Foundation	Inspected, sound/firm	N/A	Required	As specified
3	Concrete	Records: Min 25 MPa or higher as specified	Required	Required	N/A
4	Penetrations	All cast in place	N/A	Required	Required
5	Vertical	Survey	Required	Required	N/A
6	Infiltration	Applicable test per Section 10.5.2	Required	Required	Required
7	Roof slab/Lid	HN-HO-72 certified	Required	Required	N/A
		Sign-off			

C4.4 Shotcreting

C4.4.1 General

Concrete shall comply with the requirements of Section C4.1 of this standard. Shotcrete shall be applied using the wet mix process.

C4.4.2 Preparation and trial

Shotcrete specimens shall be sampled and tested for compliance prior to construction.

Remove all unsound material before applying shotcrete. Chip or scarify any area to be repaired to remove offsets without suitable reinforcement. Taper the edges to remove square shoulders at the perimeter of a cavity. Remove all loose material from areas receiving shotcrete. Wet the surface until it is damp, but without visible free water. Do not place shotcrete on frozen surfaces.

Sandblast existing surfaces that do not require chipping to remove paint, oil, grease, and other contaminants and provide a roughened surface for bonding.

C4.4.3 Placement of shotcrete

Shotcrete shall only be undertaken by experienced, specialised persons able to demonstrate work experience of a similar type to the work being undertaken.

- Control thickness, method of support, air pressure, and/or water content of shotcrete to preclude sagging or sloughing off. Discontinue shotcreting and provide suitable means to screen the nozzle stream if wind or air currents cause separation of the nozzle stream during placement.
- Broom or scarify the surface of freshly placed shotcrete to which, after hardening, additional layers of shotcrete are to be bonded. Dampen surface just prior to application of succeeding layers.
- Commence by filling all corners and any area where rebound cannot escape or be blown free. Complete the corners between the web and the flanges of structural steel before application to the flat areas.
- Provide a supply of clean, dry air adequate for maintaining sufficient nozzle velocity for all parts of the work, and if required, for simultaneous operation of a suitable blowpipe for clearing away rebound.
- Hold the nozzle at such distance and angle to place shotcrete behind reinforcement before any material is allowed to accumulate on the face. Do not place shotcrete through more than one layer of reinforcing steel rods or mesh in one application unless the steel is properly encased, as demonstrated by pre-construction tests.
- Test to determine if any voids or sand pockets have developed around or behind reinforcement by probing with a pointed tool after the shotcrete has achieved its initial set.
- Use adequate ground wires or other accepted means to establish the thickness, surface planes, and finish lines of the shotcrete. Maintain specified tolerances by keeping ground wires secure and taut.

C4.4.4 Finishing

Provide natural gun finish unless otherwise specified. Avoid trowelling thin sections of shotcrete unless both trowelling and the start of moisture curing take place within a short time after placement.

Do not remove high spots until the shotcrete is stiff enough to withstand pull of the cutting device.

C4.4 5 Joints

Construct joints as indicated in the specific drawings. Unless otherwise shown, construction joints are to be tapered to a shallow edge from about 25 mm thick. If the joint will be subjected to compressive stress, use non-tapered joints and take special care to avoid or remove tapped rebound at the joint. Make construction joints perpendicular to the main reinforcement.

C4.4.6 QA/QC template

Quality / Control		**Measurement**	**Certification**		
			Document supplied	Site supervisor witness	Engineer witness
1	Experienced operator	Demonstrated to be suitable for task	Required	Required	N/A
2	Trial	5 samples tested per test panel at 7 days and 28 days. NATA/IANZ laboratory results complying with NZS 3109	Required	Required	N/A
3	Site preparation	Inspected to be clean , cleared of debris, loose soil, sandblasted etc.	N/A	Required	Required
		Contact surfaces dampened	N/A	Required	Required
4	Placement	Ground wires in place/similar to gauge thickness	N/A	Required	As specified
		Probe for voids	N/A	Required	As specified
5	Joints	Per drawings	N/A	Required	Required
6	Testing	Test results of cores comply (NATA/IANZ lab tested, NZS3109)	Required	Required	N/A
		Ultrasonic/impact hammer test of	Required	Required	As specified

Quality / Control	Measurement	Certification		
		Document supplied	Site supervisor witness	Engineer witness
	finished area - no voids and thickness meeting as specified.			
	Sign-off			

C4.5 Formwork

All formwork design shall be the responsibility of the contractor. Formwork of a structural nature shall be certified by a Chartered Professional Engineer registered with IPENZ.

Formwork shall provide adequate access to perform compaction and be accurately shaped to position, level, finish and dimensions. Joints shall be designed and constructed to withstand the compaction, vibration and loadings imposed during construction and curing.

The formwork materials shall not absorb moisture and not allowed to bond with the concrete. A non-stain material coating shall be used for surfaces exposed to view. The form-coating material shall not interfere with subsequent bonding to the casting when this is required.

Formwork bolts shall be allowed for extraction without causing damage to the surrounding concrete. Tie bolt holes shall be treated as type B construction joints for 40mm down the hole and rammed with dry pack mortar or an approved equivalent within two days of formwork removal. The minimum cover to embedded tie bolts shall be 50 mm from the finished concrete surface.

C4.6 Concrete defect repairs

This section applies to new concrete constructed as part of the works that has been inspected and found to be defective. Repairs shall only be made that are certifiable by a Chartered Professional Engineer and meet the performance requirement and minimum asset life. Other defects shall be completely removed and replaced.

All non-conforming areas shall be identified in a repair methodology that considers repair material, performance, safety and testing (strength test by NATA/IANZ laboratory) for acceptance by Watercare.

The area for repair shall be prepared using percussive power tools that will remove all loose, cracked or softened material to leave a clean surface of uncompromised aggregate and concrete. The area shall be free from oils or other contaminating deposits.

C4.6.1 Patch repairs

Defects shall be cut out in straight lines at least 10mm deep. The areas shall be soaked before applying repair material to prevent rapid moisture loss to the adjacent concrete.

The patch repair material shall be an acceptable structural grade modified cementitious mortar, compatible with the existing surface and be crack preventative. In deeper sections the repair material shall be built up in layers to prevent slumping, or as otherwise directed by the manufacturer's direction.

The repair shall match the surrounding profile, colour and texture.

C4.6.2 Crack repairs

Cracks shall be repaired by an accepted structural epoxy injection in a continuous operation. The epoxy shall completely fill the crack to restore the strength of the section.

C4.6.3 QA/QC template

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Concrete defects	Finished concrete inspected for defects by structural engineer	N/A	Required	As specified
2	Methodology	Conformed to performance requirements	Required	Required	Required
3	Surface repair	Surface inspected - clean and free of loose debris or contaminants	N/A	Required	As specified
4	Product	Accepted for compliance with performance requirements of concrete	Required	Required	Required
5	Repair test	Accepted methodology. Strength test by NATA/IANZ laboratory	Required	Required	N/A
6	Certification	Producer statements	Required	Required	Required
		Sign-off			

C4.7 Rehabilitation of wastewater pipe and structures with cement mortar

C4.7.1 General

The cement mortar lining shall be accepted corrosion resistant calcium aluminate cement. Any fittings or connection attached to the structure or pipe shall be prevented from blocking, and where able will be hand finished.

C4.7.2 Surface preparation

Concrete surfaces shall be cleaned without causing damage to the existing concrete or concrete lining. The preparation shall remove all:

- Grease, fat, oils, slime deposits, laitance.
- Corrosion products, loose or corroded mortar.
- Previously applied coatings.
- Any substance that could affect the bonding strength.

Any bacteria formation after cleaning shall be removed and treated before the mortar application commences.

C4.7.3 Mortar application

Mortar thickness shall be a minimum of 25mm with maximum ±1.5mm variance, and allowed to cure according to the manufacturer's recommendation. The mortar repair shall be allowed a minimum of 72 hours curing time or sooner as allowed by the accepted product. Application shall be in layers as recommended by the product supplier to prevent slumping.

Pipe lining shall be machine applied. Any hand reinstatements small patch repairs shall be within 24 hours of the machine application. Where the machine accessed the pipe, the machine application shall be fully completed with the machine, cut back 75mm and hand rendered. Steel pipe that has been cut open shall be prepared with an acceptable high heat resistant mortar that will seal the mortar behind the weld.

The mortar surface finish shall be equivalent to U3.

C4.7.4 Record keeping

The record form shall be completed per component that is being rehabilitated or in the case of pipelines between access points, batches or shifts.

Structure information			
Contractor		Installation site identifier	
Asset ID		Address	
Access location			
Grout mix			
Date		Time	
Manufacturer batch number			
Mix composition		Mix Volume	

C4.7.5 QA/QC Template

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	CCTV - start	Records evaluated against design stage records	Required	Required	Required
2	Pipe cleaning	HB84-2006 guidelines	N/A	Required	As specified
3	Product compliance	Accepted material	Required	Required	Required
4	Mortar application records	Min. 25mm, ±1.5mm.	Required	Required	Required
5	Testing	Samples to AS 1012 part 24, tensile bond strength	Required	Required	N/A
6	CCTV – final	U3 finish. No visible slumping or cracking	Required	Required	Required
		Sign-off			

C5. Painting

C5.1 General

This standard applies to the in-situ application of as per the materials standard for painting of general civil and mechanical infrastructure.

The appropriate painting system shall be applied for the structure function and location. All preparation including blasting, priming and system application shall be in accordance with the product supplier's direction. Power tool cleaning shall not be used as an alternative to blast cleaning except for those surfaces, which because of their location, cannot be open blasted.

Coatings shall only be applied to clean and dry surfaces and only in dry weather, except where coating is carried out indoors. Any coating damaged by heat, rain, moisture, or condensation shall be removed and a fresh coating applied. Painting shall not continue if any of the following conditions apply, unless otherwise restricted by the manufacturer:

- The surface temperature is below 8°C or exceeds 30°C
- The surface temperature drops to below 3°C above the ambient dew point
- The relative humidity exceeds 85%
- Inclement weather such as rain, snow, fog, frost, mist or dust
- Excessive high winds

The above moisture restrictions do not apply to paint applications in damp conditions.

***Note** – Watercare has currently standardised on Altex coatings for its pipework, equipment and in aggressive environments such as wetwells. The full manufacturer specifications for the product range and selection for Watercare's infrastructure is available in the materials standard.*

C5.2 Painting of pipes, equipment and structures

The general colour coding and coating specifications for Watercare pipes and equipment is listed in the following tables. For items not listed refer to the specific Watercare area standard. For application details refer to the Altex manufacturer's specification.

Table C5.2-1 Water reticulation services colours

Location	PBS 5252 Colour No.	Colour (Resene)
Pipe bridges	12 B27	Karaka Green
Pipework and valves in chambers	16 A07	Boulder
Pump station and reservoir pipework	18 E 53	Bahama Blue
Pumps	00 A 09	Haze Grey
Inlet valves at reservoirs and pump stations	14 E 56	Fun Green
Outlet valves at reservoirs and pump stations	04 E 53	Guardsman Red
Check valves at reservoirs and pump stations	06 D 45	Peru Tan
Valves with actuators and control valves at reservoirs and pump stations	06 D 45	Peru Tan
Scour valves at reservoirs and pump stations	08 A 14	Bokara Grey (this is black)
Safety handrails	08 E 53	Yellow
Monorail beams at reservoirs and pump stations	12 D 43	Trendy Green
Pump room, motor room, control room floor	00 A 09	Haze Grey

Table C5.2-2 Wastewater reticulation services colours

Location	PBS 5252 Colour No.	Colour (Resene)
Pipe bridges	12 B 29	Karaka Green
Pipework and valves in chambers	00 A 09	Haze Grey
Pump station pipework and valves	00 A 09	Haze Grey
Pumps in drywell	00 A 09	Haze Grey
Electric motors	As Supplied	
Ventilation fans and ducting	Match walls	
Safety handrails	08 E 53	Yellow
Gantry cranes and monorail beams	08 E 53	Yellow
Pump room, motor room, control room floor	00 A 09	Haze Grey

C5.2.1 External pipe painting

When pipes are to be painted externally, the prime coat shall be carried around the ends of the pipe and into the socket, to the edge of the concrete lining or to the setback distance E_c (for E_C value see spiral weld steel pipe supply standard).

Where pipes are to be wrapped, the prime coat shall be applied from the wrapping, around the ends of the pipe and into the socket, to the edge of the concrete lining or to the setback distance E_c.

C5.2.2 Internal pipe painting

Pipe assemblies that are not concrete lined shall be painted in accordance with the manufacturer's requirements. The paint lining shall extend to the setback dimension E_c (for E_c value see spiral weld steel pipe supply standard) from the end of the pipe socket, and the remainder of the socket shall have a primer coat only.

For concrete lined pipe the paint shall overlap the mortar lining on spool sections by 50mm.

Painting shall be completed following all welding and before bolting up of valve assemblies. The mating surfaces of flanges shall remain unpainted. Repair mortar used at flanges to fair off a concrete lining against a flange shall not be applied over painted surfaces.

C5.2.3 Painting of buildings

While materials may be obtained from different makers, for any individual paint system, only one maker's products shall be used. This restriction shall not apply to alkyd enamel top coats used for architectural or decorative purposes only.

Unless otherwise specified, the paint manufacturer's instructions for the application of any paint system shall take precedence over any general requirement in this section.

Zinc rich paint shall consist of zinc dust pigment carried in a suitable medium such that on drying, the film shall contain more than 95% of zinc powder. The zinc powder shall contain more than 97.5% of pure zinc.

The painting applications building and its associated components shall be as per the following tables below.

Table C5.2.3-1 Paint system, preparation and application

***Note** - See tables C5.2.3-2/3 for codes used in this table for preparation and paint systems. The colour codes correspond to BS5252.*

	Item	Preparation	Paint system	Colour BS 5252
a)	Aluminium hatch covers			Unpainted
b)	Cast iron pipework and valves inside control building	Refer to the material supply standard		12D43
c)	Cast iron pipework in wet well	Refer to the material supply standard		Light grey
d)	Copper pipework	T9	S8	To match background
e)	Downpipes, lifting hatch support rails	T6	S9	10B21 (to match roof)
f)	Floor (Concrete) of Switchboard Room	TG-2010-108820 (see note)		Light grey
g)	Formica toilet partition, PVC waste pipes			Unpainted
h)	Galvanised steel handrails and ladders	T6/T7	S9	12D43
i)	Galvanised Steel, fittings and brackets inside valve chamber	T6/T7	S9	12D43
j)	Gutters	-	Coloursteel	Lichen
k)	Interior wooden doors and frames	T4	S17	Clear
l)	Roof - upper surface	-	Coloursteel	Lichen
m)	Roof underside - fibrous plaster	T5	S7	White

Item		Preparation	Paint system	Colour BS 5252
n)	Stainless steelwork in wet well or storage tank			Unpainted
o)	Structural Steel, Monorails etc.	TG-2010-108802 (see note)		22B19
p)	Walls of building & valve chambers, concrete, interior to be **unpainted** – *if nominated as being painted in the particular clauses, use -*	T1	S1	10B15
q)	Walls of building, concrete masonry, Exterior,	T1	S2	10A03
r)	Walls of building, concrete, exterior to be **unpainted,** *- if nominates as being painted in the particular clauses, use -*	T1	S2	10A03
s)	Walls of building, plasterboard, interior	T15	S18	10B15
t)	Walls, concrete masonry, retaining or free standing walls, exterior locations			Unpainted
u)	Walls, concrete, interior and ceiling of wet well and access platform	T1	S14	White
v)	Woodwork - roof beams	-	-	Unpainted

Table C5.2.3-2 Preparation codes for table C5.2.3-1

Treatment	Surface and preparation
T.1	**Concrete and concrete masonry** Remove all fins, mortar splashes, efflorescence, and foreign coatings, brush down to remove dust and loose material. Fill all cavities and depressions with an approved filler. Where form oil has been used, scrub down with detergent and water and finish rinse with clear water to remove all detergent. Prime with two coats of masonry sealer/filler; waterproofing compound.
T.2	As T1, but dampen before primer coat.
T.3	**Woodwork** Remove all dirt, grease, oil, and crayon marks by sanding as necessary. Plug all knot holes and seal all resinous areas and knots with one coat primer. After priming and fixing, stop nail holes, surface indentations and all imperfections, rub down and brush off.
T.4	Remove all dirt grease, oil, crayon marks by sanding as necessary. Plug all knot holes with plastic wood filler.
T.5	**Fibrous plaster** Prepare in accordance with AS/NZS2311
T.6	**New zinc, galvanised and zinc spray surfaces** Wash with white spirit or purpose-made solvents.
T.7	**Weathered zinc, galvanised and zinc spray surfaces** Remove all salt deposits, dust dirt etc. and scrub with stiff bristle brush, and wash with clean water.

Treatment	Surface and preparation
T.8	**Aluminium mill finish, lead, copper** Wash with white spirit and either roughen with abrasive paper or treat with etch primer.
T.9	Roughen with abrasive paper and wash with white spirit or mineral turpentine.
T.10	**Structural steel, iron and welds** Remove rust, mill scale and slag to dull brown or grey finish. Normal procedures in combination or separately as necessary - wire brushing, scraping, hammering, flame cleaning, grinding, sanding, etching and/or use of suitable solvent cleaners. Thoroughly rinse after pickling procedure.
T.11	Blast clean to Swedish Standard SIS 05 5900 class Sa 2½. Prior to blasting welds shall be ground to remove sharp edges, weld-splatter and other sharp edges.
T.12	Flame clean and/or grind or use chemical stripper to remove all primer and mill oil.
T.13	**Painted steel and cast iron (factory applied)** Remove coal tar coating with solvent and clean down.
T.14	Any damaged areas to be wire brushed or sanded to give a clean surface. Wash with white spirit or mineral turpentine.
T15	**Gypsum Plasterboard** Prepare in accordance with AS/NZS2311
T.16	**Steel with zinc rich epoxy primer (factory applied)** Any damaged areas to be wire brushed or sanded to give a clean surface and recoated with zinc rich epoxy primer.
T.17	**Existing painted surfaces** Clean all areas of grease, oil, dirt and dust. Sand to a matt finish.

Table C5.2.3-3 Paint system codes for table C5.2.3-1

System No	Paint system
S.1	Masonry sealer/filler, two coats 100% acrylic high gloss.
S.2	Masonry sealer/filler, epoxy top coat to a dry film thickness of 100 microns.
S.3	Masonry sealer/filler, alkyd undercoat, alkyd high gloss enamel.
S.4	Exterior sealer, alkyd undercoat, alkyd high gloss enamel.
S.5	Alkyd undercoat, alkyd high gloss enamel.
S.6	Alkyd primer, alkyd undercoat, alkyd high gloss enamel.
S.7	Sealer/filler, alkyd undercoat, alkyd high gloss enamel.

System No	Paint system
S.8	Zinc rich paint, zinc chromate primer, alkyd high gloss enamel.
S.9	Zinc rich touch-up, zinc chromate primer or etch primer, alkyd high gloss enamel.
S.10	Touch-up shop primer, metal undercoat, alkyd high gloss enamel.
S.11	Zinc rich epoxy primer (factory applied), touch-up zinc rich epoxy primer, two coats high build epoxy.
S.12	Zinc rich epoxy primer (factory applied), touch-up zinc rich epoxy primer, vinyl etch primer or epoxy primer, alkyd high gloss enamel.
S.13	Touch-up shop primer, metal undercoat, high build epoxy.
S.14	Epoxy primer, two coats of epoxy high gloss.
S.17	Two coats clear varnish.
S.18	Two coats 100% acrylic semi-gloss.
	Paint and surface finish for the motor control panel covered in the specification for Manufacture of Switchboard.

C5.3 Field touch-up painting

Touch-up painting will be required at field welds, bolt assemblies, primed-only surfaces, and to areas damaged during transportation, handling, storage, or construction.

Before touch-up painting:

- All damaged paint film shall be removed
- All grease, oil, dirt or other foreign matter shall be removed
- All edges of sound paint shall be feathered by sanding or grinding
- Existing gloss paint surfaces shall be sanded or abraded for bond (an exception can apply to some urethane topcoats, to be confirmed with the paint manufacturer)

Bare spots that have exposed the prime coat but not the base material shall have one or two finish coats applied to regain the specified film thickness.

If the base material or substrate has been exposed the area shall be cleaned down to the base metal in accordance with either SSPC SP-3 or SSPC SP-11, and the area touched up as specified by the manufacturer's specification.

Where corrosion has occurred in the base metal due to the damage to the paint system, the area shall be re-cleaned to the original surface preparation requirement and the full specified coating system applied.

C5.4 Protection of work and adjacent equipment

Before commencing any painting work, all exposed hardware and fittings that might be damaged by paint shall be removed and stored ready for re-fixing in the original condition upon completion of the work. Any items not to be blasted or painted (e.g. machined faces, instruments, threaded surfaces, tags, and name plates) are to be adequately masked to protect from blasting damage or overspray. Any overspray or over blast is to be promptly and completely made good.

Clamps or sorting hooks shall be used for handling steel after the prime coat has been applied. Wire rope or chain chokers shall not be used. After the finish coat has been applied, only nylon ropes or rubber covered slings may be used for handling steel during loading, unloading or erection. The Contractor shall rectify any damaged coating.

C5.5 Valve box cover paint colours

Service component	Location	Colour
Hydrant	Water retail networks	Yellow
Valves (Peat valves, shut-off valves, air valves	Water retail networks	White
	Water transmission	Blue
Water meter boxes	Water retail networks	Black
Special controlled zone isolation valve (normally shut position)	Water retail networks	Red
Pressure boundary kits and valves on rising mains	Wastewater retail networks	Red
Grey water (all component)	Grey water	Purple

C5.6 Painting equipment

Equipment shall comply with the recommendations of the coatings manufacturer. Unless otherwise specified:

- Application for coatings is by airless spray or air-assisted airless spray
- Use heavy duty conventional spray equipment or high-volume low-pressure (HVLP) equipment at the correct air and fluid pressures to give correct application
- Brush application is restricted to those areas which cannot be spray-coated due to difficult access or complex shape
- Non-sparking drives are mandatory where fume concentrations have the potential to exceed half of the lower explosive limit

Air supply shall be fit for the purpose, free from contamination and of sufficient pressure and volume for the job. Regulators and gauges shall be provided for the air supply to the pump and pressure pot and the air supply lines shall be fitted with efficient oil and moisture traps.

C5.7 QA/QC template

Paint inspection record							
Project:							
Engineer witness:							
Contractor:				**Sign-off**			
Inspector/supervisor:				**Sign-off**			
Coating specification reference:							
Items inspected							
			Substrate	**Coat 1**	**Coat 2**	**Coat 3**	**Coat 4**
Climate Data	Date/Time						
	% RH						
	Air Temp						
	Dew Point						
	Surface Temp						
Surface Preparation	Date/Time						
	Cleanliness						
	Profile						
Paint/ Application	Type						
	Date/Time						
	Batch Number						
	Mixing						
	Thinning						
Coating Inspection	Date/Time						
	W.F.T						
		Number					
		Min					
	D.F.T	Max					
		Average					
		Std Dev					
	Holiday						
	Appearance						
Comments:							

C6. Demolition and abandonment

C6.1 General

Demolition includes the removal of structures or facilities as well as the safe abandonment of below ground structures and pipelines. Work shall be conducted efficiently and safe in a manner that prevents damage to infrastructure and the environment.

C6.2 Existing work and damage

The structure to be demolished shall be inspected to produce the demolition method. Where available the contractor shall study the structure's drawings and specifications.

Where underground pipelines and structures are to be abandoned and filled, the inspection shall identify defects that may compromise the filling activity.

C6.3 Protection of people, property and environment

Damage to other structures shall be repaired by the contractor to the original condition. A pre-condition survey shall be done on surrounding infrastructure and utility locations identified before any demolition activity commences.

Explosives shall not be used for demolition works.

Adequate support and shielding shall be provided to protect existing structures, the environment, the public and any other person.

Abandonment of structures and the infill material to render the abandoned structure safe shall unless otherwise specified, consider the following requirements, to be accepted by Watercare:

- Short and long term environmental affect i.e. current service condition (damage, joint type), delayed deterioration of the host, etc.
- Risk of future collapse
- Risk of future development over an abandoned structure i.e. housing
- Location of the service i.e. coastal marine, underground aquifers, fissures or underground drains, ground conditions, location to streams, service depth and structural loading
- End cap and filling point design as well as tie-off requirements at completion that is appropriate to the product being used
- Product shrinkage and the risk impact it will have on the structure in its location on either failure or leaching

C6.4 Removal of material

All material and other rubbish generated by demolition activities shall be removed to an appropriate tip site.

C6.5 QA/QC template

Quality / Control		**Measurement**	**Certification**		
			Document supplied	Site supervisor witness	Engineer witness
1	Preparation	Facility plans and specifications	Required	Required	N/A
		Utility service plans and mark-outs	Required	Required	N/A
		Pre-condition survey	Required	Required	N/A
2	Site management	Demolition plan	Required	Required	Required
3	Abandonment	Methodology and product approval	Required	Required	Required
4	Material removal	Appropriate tip site dockets	Required	Required	As specified
		Sign-off			

C7. Masonry

C7.1 Workmanship

Registered masons or tradespeople under the direct supervision of a registered mason shall be used for masonry construction. A registered mason shall be on site at all times during masonry construction work.

Masonry to carry temporary loading shall be certified by a chartered structural engineer. The certification shall be forwarded to Watercare for acceptance.

C7.2 Materials handling and block types

Damaged blocks shall not be used.

Unless shown otherwise blocks for 200 walls shall be open ended web bond beam type blocks type 20.16 except at wall ends which shall be lintel blocks type 20.12 alternating with type 20.13. Use inverted series 20.16 for the first course. Where shown on architectural drawings, use rebated blocks type 20.11 and 20.13 for window jambs and where detailed. For window heads use type 20.08 sill blocks where detailed. Type 20.16 blocks shall not be positioned with webs adjacent to each other.

C7.3 Laying of masonry

Cutting of blocks shall be avoided as far as practicable. Particular care shall be taken in cutting blocks for mitre joints to ensure straight neat edges are achieved and even 10mm mortar joints obtained.

Unless specified otherwise, lay all blocks in running bond. Blocks shall be laid true to line, plumb and level with the thicker end of the shell up in mortar courses. All joints shall be in complete contact with mortar after bedding in. Masonry in construction shall be stabilised as necessary without compromise to the structural integrity to prevent any lateral force that may topple the construction.

All joints shall be tooled appropriately where exposed to view forming sharp, clean lines and compact right joints. Unless specified otherwise all joints shall be formed to a concave shape using a proprietary tool.

After laying, the mortar shall be prevented from drying too rapidly in hot dry weather by applying a very light fog spray several times during the first twenty-four hours.

`Knock-ins' shall only be used on approval. The knock-in shells shall be placed so as not to protrude into the flue to be grouted and yet prevent any grout loss into flues to be unfilled.

Allow for building in all bolts, fixings, ties, joinery pipes, flashings and all other embedded metal work, hardware and all conduited, boxed and wired services as may be required by this and other trades. Only the block layer shall carry out whatever cutting is necessary and all patching and making good required after the other trades have completed their work.

In exposed blockwork, cut-outs shall be symmetrically placed in the block. Cut-outs shall not be visible after the fixing of cover plates.

The block layer shall ensure that positions of reinforcement starters, rebates etc. are located accurately to suit the blockwork.

The starter bars should be checked for position before laying the first course of blockwork. If the starter bars are incorrect then work shall only proceed with written approval. Double cranking of starter bars to align with continuing steel is not acceptable.

C7.4 Clean-out ports

Provide clean-out ports in the bottom course of all high-lift and other walls where cleaning of mortar droppings and debris is not possible by other acceptable means. Use inverted series 20.16 blocks for the first course to each grout lift. Ports shall be a minimum of 200mm high by 100mm wide.

Locate ports at each vertical reinforcing bar position on the wall side, with least visibility. Remove full block face shell and after grouting replace to align with wall face and to form even joints to match existing.

C7.5 Control joints

Reinforce and grout vertical cores to both sides of joints. Control joints shall be sealed with 10mm x 10mm minimum section of grey colour "Thioflex" or approved equivalent, applied to the clean dry joints according to the supplier's instruction. Before caulking, rake out to 20mm depth.

The sealant shall be applied full height both sides of control joints and using masking tape both sides of joints to prevent marking of exposed walls. Remove the tape after the surface has become firm. Shape the sealant to match mortar joints.

C7.6 Reinforcement

Reinforcement shall be as shown on the specific drawings except that links, stirrups and ties shall not be less than Grade 300 plain round bars. All masonry cells shall be solid grout filled. Compaction shall be by rodding or vibration.

C7.7 Filling cores

All grout spaces shall be cleaned out and the mortar joints reached sufficient strength before commencing with grout pour.

C7.8 QA/QC template

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Qualification	Registered mason(s)	Required	Required	Required
2	Material inspection	Block without defects/unbroken	N/A	Required	As specified
3	Joints	10mm even mitre	N/A	Required	As specified
4	Reinforcing	As per drawings and min Grade 300 for links, stirrups and ties.	N/A	Required	Required
5	Test mortar	Min. 3x successive samples at start (min 1 per day). NZS 4210 Appendix 2	Required	Required	N/A
6	Grout spaces cleaned	Visual inspection	N/A	Required	As specified
7	All cores filled	Visual inspection	N/A	Required	As specified
		Sign-off			

C8. Plumbing

C8.1 General

This section covers general domestic or similar type installations. Work shall be carried out to meet the requirements of the Building Regulations 1992 (SR 1992/150) – Section 1. Work shall be carried out by persons authorised under the Plumber, Gasfitters and Drainlayers Act.

Preparatory work including supporting structure, framing and sleeved or formed openings shall be inspected before work commences and any defects immediately made good.

Galvanised steel pipe buried in the ground or in concrete shall have oil and grease removed by solvent washing and then wrapped with an accepted corrosion protection tape. Tape width shall be applied to give 50% overlap.

Runs shall be to even grades and fixed with collars and supports of appropriate materials to suit the pipes. Supports shall be regularly spaced to provide full support and prevent movement and deflection. All bends shall be sweep bends or easy right angle bends. Elbows shall not be used. At ends of horizontal pipe runs and at changes of direction of waste pipes suitable inspection and clearing points shall be included as required by regulations.

Exposed wastes and vents shall be fixed 40mm clear of wall surface using stand-off brackets. Pipes and vents passing through walls and roofs shall be neatly and completely weathered. Wrap pipes with an accepted protective tape, where passing through concrete slabs or walls. Where possible all pipework shall be concealed in walls, ceilings, floors, and ducts or as otherwise shown on the specific drawings.

To prevent electrolytic action, dissimilar materials shall be separated by suitable inert materials as interlayers, sleeves or as applied impervious coatings.

Fixings including nails, screws and bolts shall be fully compatible with and/or of similar materials as the work being fixed and resistant to corrosion.

After completing leakage tests the system shall be flushed with potable water from the highest point at minimum 1m/s flow velocity until the water is running clear.

C8.2 QA/QC template

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Qualifications	Registered as authorised	Required	Required	N/A
2	Pipework inspected	Pipe wrapping Dissimilar materials isolated Directional change with sweep bends	N/A	Required	Required
3	Test	Gravity – leakage test for non-pressurised pipes. Water – pressure tested for plumbing works (see section 10). No leaks	Required	Required	As specified
4	System flushed	Water running clear	N/A	Required	As specified
5	Certificate of Code Compliance	As per the Building Act 2004.	Required	Required	Required
		Sign-off			

C9. Carpentry

C9.1 Workmanship

All timber shall be worked and cut to a proper contact fit in accordance with best trade practice.

All connections shall be accurately made and properly executed to provide sound connections for the class of work required. In exposed work all nails shall be well punched and screws adequately countersunk to allow for finishing with stopping work.

All framing shall be fixed true to line, plumb and square and/or to the plan profiles. The maximum tolerance from plane to plan profiles shall be 6 mm in 3 m measured from a straight edge or template.

Joinery fittings shall be shop manufactured. All work shall be free of defects. All exposed exterior work shall be machine finished. All hammer marks shall be removed. All timber exposed to view shall be dressed and sanded smooth.

All floors shall be sanded to a smooth finish to line level and profile fully compatible with the finish to be applied.

The checking and cutting of timbers and framing shall be reduced to a minimum and checking shall be replaced with bored holes where possible.

The checking of plates and studs shall be less than 15 mm for 75 mm members and 25 mm for 100 mm members. Holes drilled through the centres of members in lieu of checking as above may be to 25 mm diameter and 35 mm diameter respectively.

Beams and joists shall not be notched or holed on their edges at any point closer than 600 mm to the end supports. Holes shall be drilled only along the neutral axis. Holes or notches shall not exceed 1/5th of the depth of the beam or 30 mm diameter or edge dimensions whichever is the lesser.

C9.2 Fasteners and fixings

Electro plated fixings are not permitted. Screws shall be of steel unless otherwise specified and of suitable gauge and length to ensure adequate fixing. Fasteners or fixings where exposed to the weather, or in damp conditions, or through cedar or redwood shall be galvanised steel, brass, copper or stainless steel.

Finishing nails shall be suitable for the class of materials to be fixed.

C9.3 Timber treatment

Unless otherwise specified, the minimum standard of treatment shall be grade H3.1 in accordance with NZS 3602.

Fixing to concrete work shall be made by screwing; nailing or dovetailing using H4 classification treated pine or approved plastic grounds.

Machine stress graded timber to MSG10 in accordance with AS/NZS 1748 shall be used for all roof and floor framing.

C9.4 Timber sizes

All framing timbers unless specified otherwise shall be machine gauged four sides. Dressed timbers shall be to the finished sizes shown on the specific drawings. Other timbers shall not be dressed or thicknessed or cut down by more than 10 mm below the nominal size.

C9.5 Framing

Linings shall not be fixed until the framing and preparatory work has been checked to ensure proper alignment. Linings shall be fixed true to line, plumb and square and straight and flat to plan profile. The maximum tolerance from plane to plan profile shall be as follows:

- Gradual Irregularities: 6 mm in 3m measured from a straight edge or template
- Abrupt Irregularities are not permitted

C9.6 Moisture content

In addition to the requirements of NZS 3602, all finishing timbers and strapping for linings shall be dried to a moisture content between 8% and 13% and shall be kept dry at all times. Timber showing signs of faulty or excessive kiln drying shall be rejected.

Framing timbers shall be reasonably dry when erected and shall have dried to moisture content of between 16% and 20% before internal linings are applied. Framing timbers exposed to view shall be dried to less than 16% moisture content. Finishing timbers in areas shown to be air-conditioned or to be heated by a central plant shall be dried to less than 10% moisture content.

Moisture contents specified above shall be based on oven-dry weight.

C9.7 Material handling

Framing timbers stored on the site shall remain bundled until required for use and protected from moisture, contamination, and excessive sun exposure. All joinery and dressed timbers shall be completely protected from the weather, contamination, and damage for the duration of the work.

C9.8 QA/QC template

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Material storage	Dry, not exposed to elements	N/A	Required	As specified
2	Timber type	H3.1 to NZS3602 (H4 where fixed to concrete); MSG10 to AS/NZS1748 for floor and roof framing	Required	Required	As specified
3	Fasteners	No plated.	Required.	Required	As specified
4	Measure wood moisture content	General 16%-20% Heated functional area <10%	Required	Required	Required
5	Inspect framing	Irregularities less than 6mm in 3m Framing fixed to concrete H4 grade	N/A	Required	As specified
6	Cutting and jointing	Within limits of workmanship requirements.	N/A	Required	As specified
		Sign-off			

C10. Metal roofing

C10.1 General

All material shall be new and free from defects, damage or dirt. The type, class, gauge and profile shall be as per the specific drawings. Underlay shall be breather type and waterproof. Nails, screws and fastenings shall be in accordance with the roofing manufacturer's specifications and comply with the relevant aspects of NZS 3604.

Accessories, capping, flashings and fixings shall match the metal roof type and be in accordance with the roofing manufacturer's requirements.

C10.2 Execution of work

Roofing and accessories shall be stacked on clean, level areas of the site and protected from damage and weather until ready to fix in place. The roof structure shall not be overloaded when roofing materials are placed on the roof area prior to installation.

All installation shall be undertaken by commercial installers, certified by the roofing material manufacturer or other approved experienced and competent roofers familiar with the roofing material to be installed. Clean soft-soled shoes shall be worn by the roofing installers whilst walking on coated roof surfaces.

Installation shall be in accordance with the requirements in the NZ Metal Roofing Manufacturers Inc: "NZ metal roofing and wall cladding code of practice".

C10.3 Joints

All fixings shall be made strictly to the manufacturer's recommendations and/or as shown on the plans or specified in the schedule. Any welding shall be carried out by specialist welders experienced in the class of work required. Expansion joints shall provide full weather tight laps in addition to allowing temperature movements. The contractor shall allow for all special fittings, gaskets and fixing to expansion joints.

Suitable barriers between dissimilar metals shall be provided to prevent electrolytic action and corrosion as recommended by the manufacturer.

C10.4 Capping, flashings and other hardware

The contractor shall provide and fix all the necessary flashings and over-flashings to completely weatherproof the roofing.

C10.5 Damage and performance

Visibly bent, dented or heavily scratched roof sheeting shall be removed and replaced. Scratches to the colour coat that have not penetrated to the base metal and is visible to less than 1% of the sheet surface shall be left as is.

The contractor shall provide a written guarantee of water tightness for a period of five years from the completion of the work.

C10.5 QA/QC template

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Material per drawings	Gauge as specified. Material certified to NZS 3604	N/A	Required	As specified
2	Material inspected for defects	No bends, no dents & scratches <1% of total area.	N/A	Required	As specified
3	Installer certified		Required	Required	N/A
4	Joints inspected	Dissimilar material isolated, weather tight	N/A	Required	As specified
5	Guarantee provided	5 year certification	Required	Required	N/A
		Sign-off			

10. Testing

This section prescribes the testing requirements for the various civil construction components covered in this standard.

10.1 Roading and development

NZ Transport Agency: NZTA M10 Notes, Table N3.1, Design level 1. Standard and Optional tests apply.

10.2 Backfill compaction testing

NZS 4402, Test 5.1.2 and 5.1.4. Testing shall be carried out by a NATA/IANZ accredited laboratory.

10.3 Installation of polyethylene pipe

a) Pipe out of roundness and eccentricity tests as per dimensional tables in: AS/NZS 4130 Polyethylene (PE) pipes for pressure applications.
b) Butt weld test by NATA/IANZ accredited laboratory to ISO 13953.

Butt weld test methodology

Butt welds shall be shown to be fully ductile by destructive testing. Weld samples shall be clearly marked with identifying marks and with the orientation of the weld in the welding machine. The testing laboratory shall be instructed to report test results with reference to the orientation of the weld in the welding machine. The weld beads shall not be removed for testing.

In addition to the weld sample a section of unaffected pipe wall shall also be tested. The following shall be provided in addition to the test report specified by the testing standard:

- Report the strength of each butt-weld test piece as a % of the strength of the unaffected pipe wall
- A graph of load versus extension for all test pieces plus the specimen of unaffected pipe wall shall be plotted on the same axis – the plot shall record load and extension until there is complete separation of all the test pieces
- Clear photographs of showing each test piece in elevation before testing
- Clear photographs of the fracture surface of each test piece after testing
- Observations and clear photographs showing anything unusual that may affect the test

Butt-welds shall be free of visual defects. Unacceptable visual defects include:

- Misalignment equal to or greater than 10 % of the pipe wall thickness
- The bead is not fully rolled-over and symmetrical
- The weld bead is not within the tolerances of POP003
- Pitting or bubbling in the weld bead
- Discolouration of the weld bead
- Inclusions or other obvious faults

Where a butt weld has any of these visual defects it shall be considered unacceptable and shall be cut-out and replaced at the Contractor's cost.

Satisfactory completion of a hydrostatic pressure test shall not constitute acceptance of the butt welds. To be acceptable the butt weld shall:

- Have a strength not less than 95% of the strength of the unaffected parent pipe, and
- Be fully ductile.

c) Electrofusion joint weld test by NATA/IANZ accredited laboratory to ISO 13954
d) Electrofusion saddle weld test by NATA/IANZ accredited laboratory to ISO 13956
e) Extremely thick walled electrofusion assemblies by NATA/IANZ accredited laboratory to ISO 21751

Electrofusion joints and fittings test methodology

Electrofusion socket assemblies such as couplers and bends removed for destructive testing shall have a minimum of 150 mm of pipe length either side of the socket. Tapping saddle samples for destructive testing shall have a minimum of one diameter of pipe either side of the tapping saddle or tapping tee. Weld samples shall be clearly marked with identifying marks.

Electrofusion socket welds shall be free of the following visual defects:

- Misalignment
- Melt rise indicators not rising, or are unequal
- Eruption of melt material past the melt rise indicator
- Hand scraping (not allowed)
- Depth of peel is less than 0.2mm deep
- Mechanical scraping which does not extend past the area covered by the coupler (including area covered during assembly)
- Witness marks not evident
- Loss of melt material past the cold zone
- Element wires extending past the cold zone

Where an electrofusion weld has any of these visual defects it shall be considered not acceptable and shall be cut-out and replaced at the Contractor's cost. Notwithstanding the visual appearance electrofusion welds shall be shown by destructive testing, to fail by ductile rupture of the weld plane. Less than 33% of the total fusion zone may be brittle.

10.4 Steel pipe weld band, socket and spigot joints – Pipe ≥700mm NB

Refer to the Mechanical construction standard.

10.5 Pressure and leakage testing

This specifies methods of tests and their application to field testing of pipelines and manholes for the purpose of determining acceptability. Field testing includes leak or hydrostatic pressure testing, as appropriate, for pressure and non-pressure pipelines and manholes.

Field testing does not replace the test requirements of product standards.

10.5.1 Pipeline testing

Note *- The type of test shall be selected according to the application of the system and the type of material being tested.*

A) Non-pressure pipelines – Field leakage testing

Leakage testing is used to reveal locations of potential infiltration and exfiltration due to the inclusion of damaged pipes, seals, or incorrectly made joints in the pipeline at the completion of installation.

Leakage testing for acceptance of non-pressure pipelines shall be carried out by at least one of the following methods:

A-1) Low pressure air testing; or
A-2) Hydrostatic testing

Note *– Air tests provide qualitative data only, as air pressure losses cannot be related directly to water leakage rates.*

For pipeline test sections installed below the water table and for submarine pipelines, the test pressure used for the hydrostatic test and for the air test, shall be increased to maintain the required differential between internal and external pressure.

A pipeline failing to meet the requirements of the air tests may be retested using the hydrostatic test method.

A-1) Low pressure air test

The test length shall be acceptable where the gauged pressure exceeds 18 kPa (or not more than 7 kPa less than the pressure at the start of the test) for the time interval shown in table A-1 after shut-off of the air supply.

Table A-1 is based on an air test pressure of 25 kPa in excess of any external hydrostatic pressure due to groundwater and, on this basis air volume losses shall not exceed the greater of:

a) A rate of 0.0009 $m^3/(min \times m^2)$ of pipe wall area; and
b) A rate of 0.056 m^3/min, which is regarded as the lowest detectable individual air leak
c) Column 2 and column 3 of table 1 give the times and lengths up to which (b) prevails over (a)

***Note** – For safety reasons air test pressures in excess of 50 kPa should not be applied.*

Table A-1 – Low pressure air and vacuum tests – Minimum time intervals for 7 kPa pressure change in pipeline

DN	**Minimum time** (minutes)	**Maximum length for minimum time to apply** (metres)	**Test length** (metres)				
			50	**100**	**150**	**200**	**250**
			Minimum test duration (minutes)				
80	1.5	231	1.5	1.5	1.5	1.5	1.6
100	2	185	2	2	2	2	3
150	3	123	3	3	3	5	6
225	4	82	4	5	8	10	13
300	6	62	6	9	14	18	23
375	7	49	7	14	22	29	36
450	9	41	10	21	31	41	52
525	10	35	14	28	42	56	70
600	11	31	18	37	55	73	92
675	13	27	23	46	70	93	116
750	14	25	29	57	86	115	143
900	17	21	41	83	124	165	207
1000	28	12	51	102	153	204	255
1050	20	18.8	56	112	169	225	281
1200	23	15	73	147	220	294	367
1500	28	12	115	230	344	459	574

NOTE – The time interval may be reduced for a proportionate reduction in the allowable pressure drop. Where there is no detectable change in pressure after 1 hour of testing, the section under test shall be deemed acceptable. This table is based on the following equation: $T = 1.02DikLq$ where T = time for a 7 kPa pressure drop, in seconds Di = pipeline internal diameter, in metres q = allowable volume loss in cubic metre/minute/square metre taken as 0.0009 m3/min.m² $k = 0.054DL$ but not less than 1 L = length of test section, in metres. Columns 2 and 3 have been calculated with $k = 1.0$. The appropriate air or vacuum test/pressure method for pipes larger than DN 750 should be established by reference to the specifier.

Low pressure air test procedure

The procedure shall be as follows:

a) Pump in air slowly until a pressure of 25 + 5−0 kPa is reached. Where the pipeline is below the water table this pressure shall be increased to achieve a differential pressure of 25 kPa. In no circumstances should the actual pressure exceed 50 kPa; NOTE – Rapid pressurisation may cause significant air temperature changes, which will affect the testing accuracy.
b) Maintain the pressure for at least 3 minutes.
c) Where no leaks are detected, shut off the air supply.
d) Where the pipeline fails the test, re-pressurise to 25 +5,−0 kPa and check for leaks by pouring a concentrated solution of soft soap and water over accessible joints and fittings.
e) Repair any defects, then repeat steps (a) to (c).
f) With the air supply shut off, monitor the pressure for the time intervals given in table.

The test length shall be acceptable where the pressure drops by 7 kPa, or less, over the required (tabulated) test period.

Note –

(1) The test length of pipeline should be restricted to pipeline sections between maintenance holes (the most convenient places for inserting test plugs or fixing temporary bulkheads). The method should not be used for test lengths in excess of 250 m and for pipe diameters larger than 1500 mm.

(2) The procedure for low pressure air testing of large diameter pipelines is potentially hazardous because of the very large forces to be resisted by temporary plugs or bulkheads and the serious consequences of accidental bulkhead blow-out. A relief valve, with a 50 kPa maximum setting, should be installed on all pressurising equipment.

A-2) Hydrostatic test

The test length shall be acceptable where the make-up water added is less than the specified allowable. Where not specified, the allowable make up water shall be 0.5 L/hour per metre length per metre diameter.

Hydrostatic test procedure

The procedure shall be as follows:

a) The test pressure shall be not less than 20 kPa, or 20 kPa above the groundwater pressure at the pipe soffit at its highest point, whichever is the greater, and not exceed 60 kPa at the lowest point of the section.
b) Steeply graded pipelines shall be tested in stages where the maximum pressure, as stated above, will be exceeded if the whole section is tested in one length.
c) The pressure shall be maintained for at least 2 hours by adding measured volumes of water where necessary.
d) Any visible leaks detected shall be repaired and the pipeline shall be retested.

B) Pressure pipelines general requirements – Field hydrostatic pressure testing

Hydrostatic pressure testing requires selecting an appropriate configuration of method, pressure, and length of test section.

Compressed air testing shall not be permitted for pressure pipe.

Test parameters and details shall be determined with due consideration to the following:

a) Pipe material
b) Pipe diameter
c) Length of test section
d) Duration of the test
e) Magnitude of test pressure and rate of pressurisation
f) Presence of air in the pipeline
g) Time required for saturation of porous liners

h) Potential movement of pipeline thrust restraints
i) Design pressure for thrust and anchor supports
j) Accuracy of test equipment
k) Ambient temperature changes during testing
l) Presence of leaks in equipment used for testing or equipment attachment points (such as sealing plugs)
m) Potential for leaks in the pipeline

B-1) Selection of test pressure

The hydrostatic test pressure at any point in the pipeline shall be:

a) Greater than the design operating pressure; and
b) Less than 1.25 times the rated pressure of any pipeline component.

***Note** – The design pressure is the maximum system pressure at a point in the pipeline, considering future developments, static pressure, dynamic pressure and an allowance for short-term surge pressure (water hammer), as determined by analysis.*

B-2) Selecting test lengths

The pipeline length tested shall be either the whole or a section (capable of being isolated), of the pipeline depending on the length and diameter, the availability of potable water and the spacing between sectioning valves or blank ends.

The pipeline shall be divided into test sections such that:

a) The hydrostatic test pressure at any point in the pipeline:
   i. Shall be less than 1.25 times the rated pressure of the pipeline, but not less than the designed working pressure at the lowest pressure point (highest elevation point where pipe is tested on a sloped installation); and
   ii. Is less than 1.25 times the rated pressure of any pipeline component;
b) Test sections shall be limited to pipe of the same material. Consideration shall be given to the pressure loading time at the maximum filling rate (see B-3) in determining the test length; and
c) Water is available for the test together with facilities for its disposal, in accordance with regulatory requirements, after the test.

***Note -** Watercare recommends that test sections be done as short as possible to reduce the efforts during fault finding should a test length fail to pass the test. The following should be considered:*
(1) Where long lengths are to be tested, radio or other electronic means of communication between test operatives to coordinate test procedures and thus minimise the test duration is desirable.
(2) Long test sections may incorporate a large number of mechanical joints which should be checked for leakage. The longer the test section the harder it is to locate a leak or discriminate between a leak and other effects such as the absorption of air into solution under pressure.

B-3) Pre-test procedures

The pre-test procedures are as follows:

a. All required temporary and permanent thrust blocks shall be in place, and all concrete shall be adequately cured (normally a minimum of 7 days).
b. Blank flanges or caps shall be installed at the beginning and end of the test section. Testing shall not take place against closed valves. Mechanical ends that are not end load resistant shall be temporarily strutted or anchored, to withstand the test pressures without movement.
c. Pipe ends shall be capped with suitable restrained end caps that will sustain the full test pressure. For steel pipe the Watercare standard test cap detail drawing shall be used.

***Note** – Temporary supports should not be removed until the pipeline has been depressurised. All test personnel should be informed of the loading limits on temporary fittings and supports.*

d. Where practicable, all bolted joints shall be left exposed to allow for re-tensioning during or after testing.

e. Compacted embedment and fill material shall be placed to leave all joints, service connections and ball valves exposed wherever possible.
f. For PE pipelines, the pressurising time shall not exceed 45 minutes.

***Note** – The pressurising time affects the duration of the PE pipeline test.*

g. The test equipment shall be placed in position and checked for satisfactory operation.
h. The pump shall be of adequate size to raise and maintain the test pressure.

***Note** – A pump that is too small may increase the test duration or where too large it may be difficult to control the pressure.*

i. Two calibrated test gauges shall be used to cross check gauge accuracy.
j. Slowly fill the test length of pipeline with water, preferably from the lowest point, ensuring air is vented at the high point valves. Allow a period between a minimum of 3 hours and 24 hours (preferred), for the temperature of the test length and the test water to stabilise and for dissolved air to exit the system. The recommended rate of filling shall be based on a flow velocity of 0.05 m/s, calculated from the following equation:

$$Qf \leq 12.5\pi D2$$

where

Qf = filling rate, in litres per second

D = pipe diameter, in metres

***Note** – The slow rate of 0.05 m/s avoids air entrainment when the filling water is cascading through downward gradients along the pipeline. The period of stabilisation will depend on pipe dimensions, length, material, longitudinal profile, and air exit points. For cement-mortar lined pipe, the pipeline shall be filled at least 24 hours before the commencement of the test, to allow the lining to become saturated.*

A firm foam swab may be used ahead of the fill water to assist air removal especially where the pipeline undulates. Extract the swab at a high-point wash-out. The swab must be removed prior to testing.

Typical pressure test equipment and location are shown in figures B-4-1 and 2.

B-4) Post-test procedures

After testing, pipelines shall be depressurised slowly. All air venting facilities shall be open when emptying pipelines. The test water shall be drained to an approved waterway and all connection points shall be reinstated.

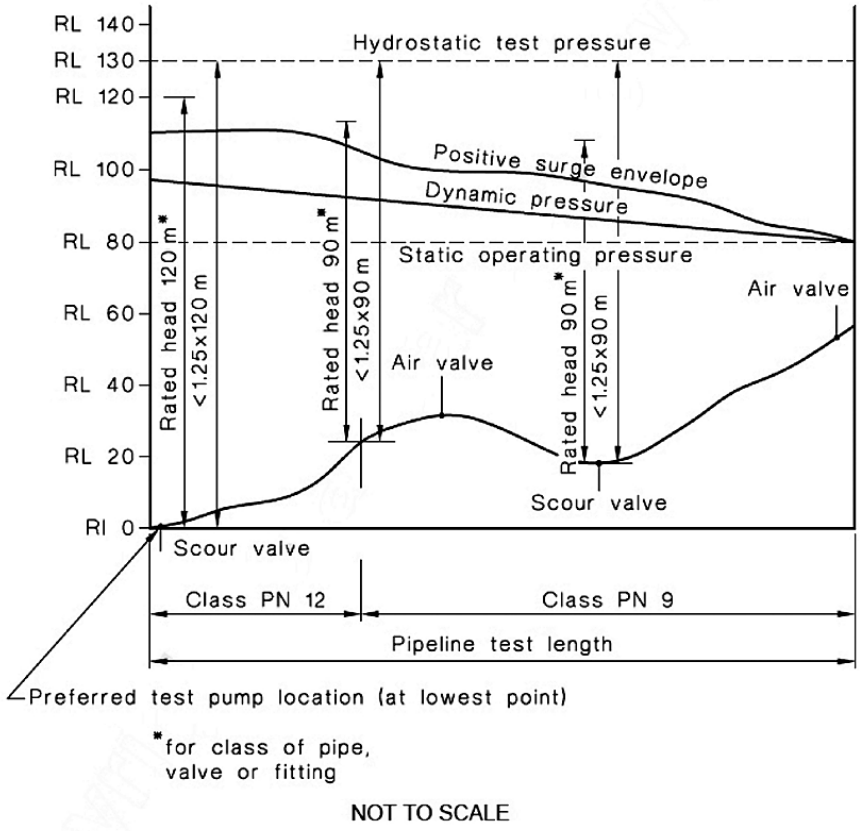


Figure B-4-1 – Typical pressure pipeline under field hydrostatic test

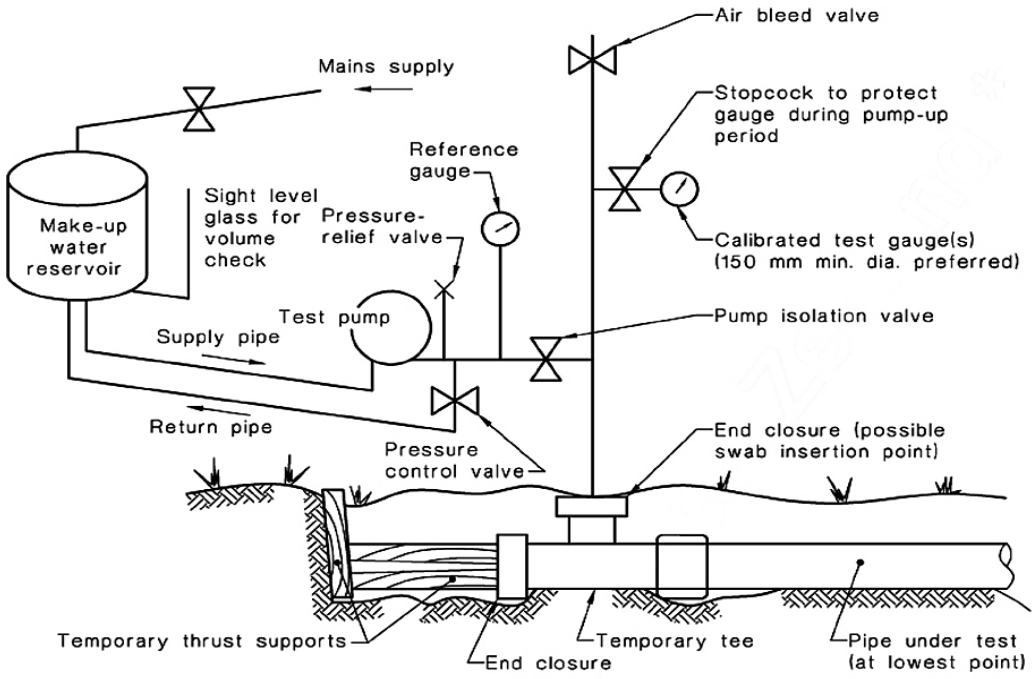


Figure B-4-2 – Typical field pressure test equipment layout (designed as appropriate to the test pressure)

B-5) Constant pressure test (water loss method) – PVC, DI, GRP, and steel pipelines

This test is applicable for PVC, DI, GRP, and steel pipelines.

The procedure shall be as follows:

a) Close all valves apart from the test pump input and pressurise the test length to the specified test pressure (STP) – (see B-2).
b) Apply and then maintain the test pressure by the addition of measured and recorded quantities of make-up water at regular intervals over a period, in the range of 1 hour to 12 hours.
c) Where pressure measurements are not made at the lowest part of the test length, make an allowance for the static head, between the lowest point of the pipeline and the point of measurement.

The quantity of make-up water necessary to maintain the test pressure shall comply with the following equation:

$$Q \leq 0.14LDH$$

Where:

Q = allowable make-up water, in litres per hour

L = length of the test length, in kilometres

D = nominal diameter of the test length, in metres

H = average test head over length of pipeline under test, in metres

***Note** – The make-up water is not a leakage allowance, but is an allowance to cover the effects of the test head forcing small quantities of entrapped air into solution. Normally the test should last for a minimum of 2 hours and be concluded within 5 to 8 hours. The make-up water requirement should reduce with time as air goes into solution. Where, after 12 hours the make-up water still exceeds the allowable limit, testing should cease and the cause of loss investigated.*

Acceptance:

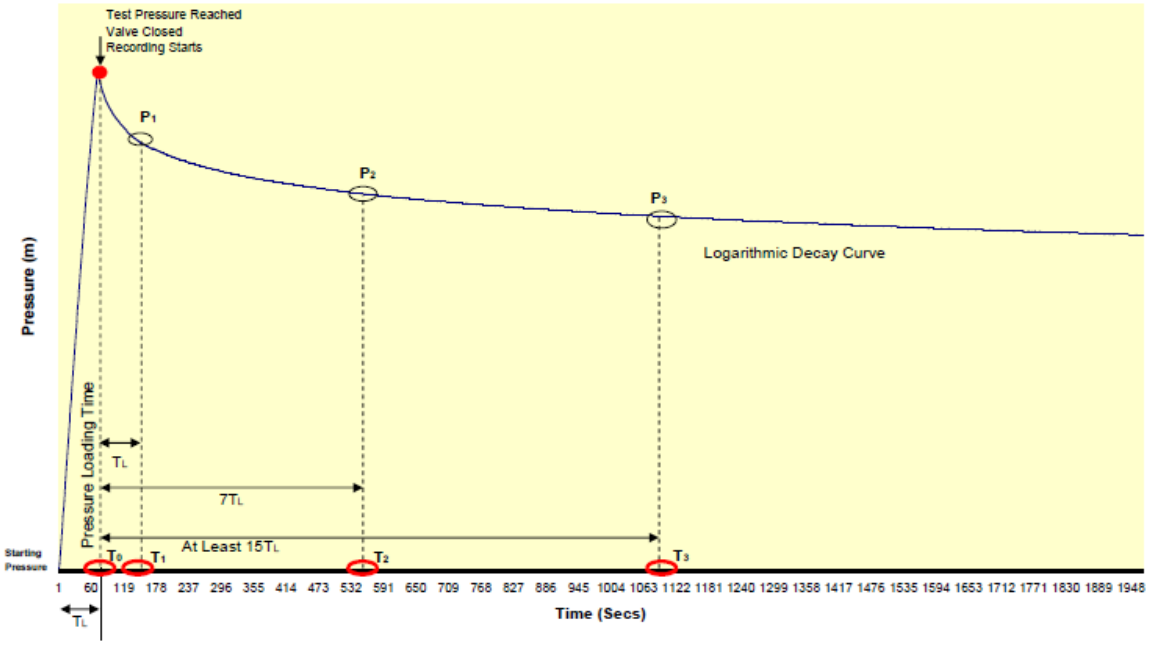
a) The test length shall be acceptable where there is no failure of any thrust block, pipe, fitting, joint, or any other pipeline component.
b) There is no physical leakage.
c) The quantity of make-up water necessary to maintain the test pressure complies with the quantity calculation.

B-6) Pressure decay test for PE pipe larger than DN200 or longer than 250m

This test procedure is applicable to Polyethylene pipe of larger size and length or where larger water systems are being tested (up to 1000m).

The procedure shall be as follows:

a) Close all valves apart from the test pump input and pressurise the test length to the specified test pressure (STP) – (see B-2). The pressure loading time shall not exceed 45min.
b) Once the STP is reached with the conditions met, the pipe line is isolated and pressure allowed to naturally decay.
c) Pressure decay over time in viscoelastic pipe is an exponential form and expressed in a calculated ratio as follows:



Take a first reading of pressure P1 at T1, where T1 is equal to the pressure loading time (TL).

- Take a second reading of pressure P2 at 7TL. Let this be T2.

- Take a third reading of pressure P3 at 15TL. Let this be T3.

- To allow for this stress relaxation behaviour of PE pipelines, calculate the corrected values of T1, T2 and T3.

- Calculate corrected T1: T1C = T1 + 0.4TL
- Calculate corrected T2: T2C = T2 + 0.4TL
- Calculate corrected T3: T3C = T3 + 0.4TL

d) Calculate decay slope ratio (N) values

- Calculate N1:

$$N1 = \frac{(logP1 - logP2)}{(logT2C - logT1C)}$$

- Calculate N2:

$$N1 = \frac{(logP2 - logP3)}{(logT3C - logT2C)}$$

Acceptance:

- For pipe HDD drilled or with compacted backfill: N1 **and** N2 range within **0.04 to 0.05;** or
- For pipe without backfill or constraint: N1 **and** N2 range within **0.08 to 0.10**; and
- There is no physical leakage.
- There is no failure of any component, movement of permanent thrust block or temporary thrust restraint used for testing.
- Should the test fail, after the problem has been repaired the test shall be redone completely.

B-7) Pressure rebound test for PE up to DN 200

This test is applicable to PE and ABS pressure pipelines up to typically 250m length or shorter as to allow rapid pressure reduction when bleeding the system for the rebound test.

The test rig shall be a recently calibrated pressure transducer, data logger, and check pressure gauge that has a dial of at least 100 mm diameter and a pressure range that places the specified test pressure (STP) (see B-2) in

the range 35% to 70% of the gauge's full scale. The transducer and the check gauge shall read within ±5% of each other. If they do not agree within this tolerance, the equipment shall be recalibrated or replaced.

Procedure:

a) Prepare the pipeline in accordance with B-3) pre-test procedure.
b) Make sure that all air is expelled before commencing with the test and that no air is introduced into the section being tested.
c) Maintain the STP for 30 minutes by additional pumping as required.
d) Check for obvious leaks.
e) After 30 minutes at the test pressure, reduce this pressure rapidly by bleeding water from the system (<5min), to a nominal pressure of 2bar at the test gauge.
f) Close the control valve and isolate the test section.
g) Record pressure gauge readings at 5 minute intervals for 1 hour after isolation.

The test length shall be acceptable if:

a) There is no failure of any thrust block, pipe, and fitting, joint, or any other pipeline component.
b) There is no physical leakage.
c) The pressure rises and then remains static or slightly increases during the 1 hour period.
d) This test may be reduced on approval from Watercare to 30min in the rebound phase where there is an operational need to bring the pipe into service quickly.
e) If the pressure does not rise, or falls after an initial rise the test is a fail.
f) Should the test fail, after the problem has been repaired the test shall be redone completely.

B-8) Visual test for small pressure pipelines

This test is applicable for small pipelines of all materials, less than 20m in length, and pipelines without joints other than the end connections (such as coiled pipe).

The procedure shall be as follows:

a) The test pressure (see B-2) shall be applied and the test section isolated by closing the high point air release valves and the pump feed valve.
b) The test section shall be visually inspected for leakage at all joints, especially bolted joints, all fittings, service connections, and ball valves.
c) Pressure gauges shall be checked to ensure that pressure has not fallen significantly indicating an undetected leak.
d) Any detected leak shall be repaired and the section shall be retested.
e) Where no leak is detected, high point air release valves shall be opened, the pipeline shall be depressurised to slowly drain the line into an approved waterway and all connection points shall be reinstated.

The test length shall be acceptable where:

a) There is no failure of any thrust block, pipe, fitting, joint, or any other pipeline component.
b) There is no physical leakage;.
c) There is no pressure loss indicative of a leak.
d) Should the test fail, after the problem has been repaired the test shall be redone completely.

10.5.2 Manhole and chamber (concrete) testing

The type of test shall be selected according to the performance requirement of the system, the type of installation methodology, ground conditions and Health and Safety risk factors associated with the installation. All manhole tests shall include 300mm of the connecting pipework with the lid fitted into place unless otherwise stated.

A) Hydrostatic testing of concrete manholes

This test may be used for manholes up to 3.5m depth and relies on obtaining a proper seal from the pipeline plugs to withstand the hydrostatic pressure. The limitation on this test is the un-uniform pressure distribution and the zero pressure at the top of the manhole will not sufficiently test the top seal of the lid. To test the top seal this test shall be supplemented with the visual check (smoke test) in Section 10.5.2 D) or the low pressure

air test as per Section 10.5.1, A-1). The manhole shall be completely backfilled and interconnected pipework and manholes be vacated before starting the test.

Pre-test procedure:

Ensure that there is no entry into the connecting trench or any connected manhole associated with the manhole being tested. The manhole shall not be pressurised beyond the static pressure and the access hatch shall remain open.

Procedure:

a) Seal pipe or sleeve openings using properly sized or inflatable plugs.
b) Completely fill the manhole to the top of the lid frame with water.
c) Allow the filled manhole to soak for minimum 4 hours.
d) Top up any water loss to the top of the lid frame during the soak period.
e) Measure the water loss over every 1 hour for 8 hours.
f) Empty the manhole and allow standing for 1 hour before doing a visual inspection for groundwater infiltration.

Acceptance:

The average quantity of make-up shall not be more than 0.3 litres per 1m diameter per 1m depth per hour. The post-test visual inspection shall show no evidence of groundwater ingress through any joint.

B) Vacuum test

The vacuum test creates differential pressure between the inside and outside of the manhole. This test shall be completed with the manhole completely backfilled and the lid in place.

Procedure:

a) Clean manhole thoroughly.
b) Seal openings using properly sized or inflatable plugs.
c) Connect seal plate to manhole opening.
d) Draw vacuum of -254mmHg (or -338.6mbar) and isolate valves.
e) Hold test time according to the manhole sizes as listed in the table below:

Depth (m)	**Diameter (mm)**								
	675	900	1050	1200	1350	1500	1800	2400	3000
	Time (s)								
<2	11	14	17	20	23	26	33	39	45
3	14	18	21	25	29	33	41	49	57
3.5	17	21	25	30	35	39	49	59	69
4.3	20	25	30	35	41	46	57	69	81
5	22	29	34	40	46	52	67	81	95
5.5	25	32	38	45	52	59	73	87	101
6	28	35	42	50	53	65	81	97	113
6.5	31	39	46	55	64	72	89	107	125
7	33	42	51	59	68	78	97	115	133

Depth (m)	Diameter (mm)								
	675	900	1050	1200	1350	1500	1800	2400	3000
	Time (s)								
8	36	46	55	64	75	85	105	125	145
8.5	39	49	59	69	81	91	113	135	157
9	42	53	63	74	87	98	121	145	169
9.5	46	58	69	81	94	105	129	153	177
10	49	63	74	87	98	113	139	165	191

f) Release the vacuum and remove the test gear and plugs.

Acceptance:

a) For the duration of the test the vacuum did not drop below -228mmHg (or -304mbar).
b) There are no visible wet patches or "sweating" at any of the pipe penetrations, seals or riser joints.

C) Infiltration test

This test is completed by creating an external water column around the manhole that will force groundwater through any leaking joints. This method is recommended where manholes are over 3.5m deep or that can only be part tested using the hydrostatic testing method up to 3.5m depth. However the limitation on part testing to 3.5m is that the hydrostatic pressure shall be demonstrated to be higher than the groundwater pressure at the location of the joints being tested. The vacuum test procedure is preferred over this option.

This test does not confirm the lid seal and **shall be supplemented** with the visual check (smoke test) in Section 10.5.2, D) or the low pressure air test as per Section 10.5.1, A-1).

Procedure:

a) Excavate or provide a shallow moat of approximately 500mm width around the circumference of the manhole and fill with water.
b) A 32mm PVC sleeve is inserted into the ground adjacent to the manhole wall to 1m below the hydrostatic test depth. The bottom 1m of the sleeve shall be perforated to allow groundwater to enter the sleeve.
c) The water in the moat is filled until the groundwater in the sleeve reaches the level of the water in the moat.
d) The groundwater level is maintained for eight (8) hours.

Acceptance:

There are no visible leaks, wet patches or "sweating" at any of the pipe penetrations, seals or riser joints.

D) Visual check (smoke test)

This test shall only be conducted on manholes where the joints and pipe penetrations being tested have not been backfilled over and are visible for inspection of forced smoke leaking through defective seals. The limitation of this test is to manholes that are not located within a 100 year flood plain level and is suited for low risk shallow manholes only.

Procedure:

a) Seal openings using properly sized or inflatable plugs.
b) Connect seal plate to opening of manhole lid with appropriate connection to introduce the smoke.
c) Introduce smoke into manhole being tested according to the manufacturer's recommendation.

d) The smoke shall be introduced for a minimum of 5 minutes.
e) Inspect joints for smoke leaks.

Acceptance:

There is no smoke leaking from any of the joints.

10.5.3 Manhole (plastic/GRP material) testing

Manholes shall be tested twice:

a) Off-site as a single unit at the manufacturer's facilities according to industry best practice for the material being used; and
b) On installation on site, fully backfilled and connected, and tested per the vacuum test described in Section 10.5.2-B).

The material testing sheets shall be made available for record purposes; having undergone Watercare's pre-approval of the product being installed.

10.5.4 Fluid retaining structures (process tanks, reservoirs, etc.)

This section relates to the testing requirements for single layer fluid storage structures with no pressure applied other than the gravitational weight of the fluid retained. These tests are not for manholes or man access chambers.

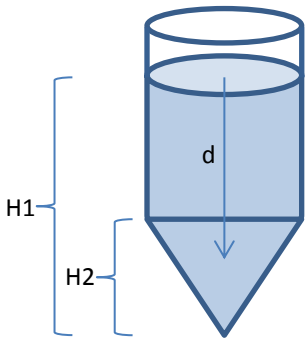
A) Concrete tanks

The test is to demonstrate fluid loss of less than 0.05% of the tank volume per 24 hours period. The test should be conducted long enough to produce at least 15mm drop in the level. The leakage rate is proportional to the depth of water over the leakage point with leakage at the bottom of a tank generally contributing more to the total leakage than a similar defect at a higher level in the tank. For odd shaped tanks such as clarifier tanks the depth shall be expressed as a calculated equivalent depth when determining the minimum test duration time, in example:

Conical structure:

Determine equivalent depth (d) = (H2 x A + [(H1-H2) x A] /3) /A
Determine test time = 0.015/(0.05 x (d)x∏r²) = test days (round up)

Where:
H1 = maximum/full water depth
H2 = side wall height
A = area
r = radius



A further impact on leakage rate determination is the surrounding media of the tank where groundwater could push back on a leak. Unsupported wall structures may deflect. Open lids or ventilation and temperature changes may affect the test results and needs to be accounted for.

Evaporation per hour:

$E_h = \Theta A (Xs – X)$

Θ = (25+19 V) where V = velocity of air above water surface
A = surface area (open to evaporation)
Xs = humidity ration in saturated air

Air Temp °C	Humidity in saturated air (Xs)
0	0.003767
5	0.005387
10	0.007612

Air Temp °C	Humidity in saturated air (Xs)
15	0.01062
20	0.014659
25	0.019826
30	0.027125

X = average humidity ratio over test period

Temperature expansion/contraction:
$\Delta V = \beta Vo \Delta T$
β = Volumetric temperature expansion coefficient (use 0.000214 for water)
ΔV = change in volume
Vo = volume of water
ΔT = temperature change

Pre-test procedure:

a) The structure must not be backfilled; or
b) Where backfill is required as part of the structural integrity design, it shall be ensured that the surrounding soil is not ground water charged. A monitoring bore(s) up to 500mm below the tank foundation shall be provided to monitor ground water levels. If groundwater is present it shall be removed before testing may proceed.
c) Fill the tank with water whilst monitoring all outlet drains, connecting pipes and valves, structural joints, etc. for visible leaks.
d) The structure shall be kept filled with water for minimum 3 days before testing may commence.

Procedure:

a) Confirm positions for measurements from at least two locations 180° apart. On larger tanks it is best to spread locations 90° apart (for 4 locations) to allow for settlement.
b) Measure test starting level.
c) Measure test start water temperature at depths of 500mm below the water surface level and at 2m intervals to the full depth of the tank.
d) Calculate test time required.
e) Repeat measurement every 24 hours.
f) Compute leakage rate over test period. Account for evaporation and temperature change. Where the tank top is sealed ignore evaporation rate. Where the temperature is measured to be constant between measurements, ignore affects.

Acceptance:

Average water loss < 0.05% of total volume per 24 hours of testing.

B) PE, GRP, steel tanks

The test is to demonstrate fluid loss of less than 0.025% of the tank volume per 24 hours period. The test should be conducted long enough to produce at least 15mm drop in the level. Follow the test procedures as for A) concrete tanks. The saturation period of 3 days as part of the pre-test procedures is not required.

Acceptance:

Average water loss < 0.025% of total volume per 24 hours of testing.

10.6 Potable water infrastructure disinfection

Pipelines, tanks and reservoirs for potable water use shall be disinfected in accordance with Watercare's Code of Practice for water reticulation disinfection.

10.7 Concrete – buildings and structures

NZS 3109 to clause 9 by NATA/IANZ accredited laboratory.

10.8 Shotcrete

A test panel at least 1200mm x 1200mm for each mix being considered, the same thickness as the intended structure, using the same construction equipment and for each shooting position to be encountered (i.e. slab, vertical and overhead sections). Provide in the test panel the same reinforcement as intended for the structure in at least half of the panel, to test for proper embedment of reinforcing steel. Sample four cores from the panels for testing at 7 days and 28 days. All cut or broken surfaces shall be dense and free from laminations and sand pockets.

In addition to the concrete testing requirements of NZS 3109 clause 9, complete to NZS 3112 test two 50mm cores recovered from every 75m² of the actual construction. Tests shall be completed by a NATA/IANZ accredited laboratory.

Complete ultrasonic or impact hammer test across the construction area to determine overall uniformity to the specified thickness.

10.9 Masonry

NZS4210, tests per Appendix 2 of the New Zealand standard.

10.10 Testing of plumbing installations

Hot and cold water pipework, fully installed; carry out a hydraulic test of 1.25 times the static head with a minimum of 1200 kPa for a period of 60 minutes. There should be no visible leaks and zero pressure loss.

10.11 Timber moisture content

NZS 3602, General 16%-20%. Heated installation functional area <10%.

10.12 Direct current voltage gradient (DCVG) coating defect survey for new steel pipelines

10.12.1 DCVG survey types

Construction DCVG survey: conducted during the installation of a new pipeline. The survey shall be conducted as outlined in the approved construction management plan. This survey shall be undertaken with the probes positioned over the pipeline, after backfilling of the trench has occurred and prior to sealing the surface with either bitumen or concrete. As this type of survey will generally be done in shorter sections, particular care must be taken when determining chainages and marking of defects.

Commissioning DCVG Survey: completed after installation and construction DCVG survey has been completed. Where the pipeline runs under a sealed surface such as concrete of bitumen, the survey shall be conducted with the probes positioned in a suitable electrolyte (such as soil) as close as practicable to the centre line of the pipe. Where the pipeline runs under a sealed surface, Watercare shall define whether the surface can be saturated with water, or holes must be drilled through the surface to provide suitable contact with the electrolyte.

10.12.2 Minimum qualifications

Task	Minimum Level of Expertise
Field inspection and testing	Corrosion Technician with minimum 2 years' experience in corrosion testing including specific training and experience related to coating defect surveys on pipeline, under the indirect supervision of a Corrosion Technologist
Analysis and	Corrosion Technologist with a minimum 10 years' experience in corrosion testing

Task	Minimum Level of Expertise
approvals	including specific experience related to coating defect surveys on pipelines or Corrosion Technician under the direct supervision and with report review and approvals of a Corrosion Technologist.

Proof of suitable qualification shall be provided to Watercare.

10.12.3 Testing

10.12.3.1 Visual inspection & preliminary tests

Prior to undertaking the DCVG survey, the following inspections and tests shall be undertaken:

a) Record the locations of all electrical earths in the survey report.
b) Record locations of all sacrificial anode beds in the survey report.

Note - *Electrical safety earth beds, such as those installed for the protection of personnel and equipment and mitigation of low frequency induced (LFI) a.c. currents are not to be disconnected from the pipeline unless safe to do so.*

10.12.3.2 Method

The body of Australian Standard AS4827.1 – 2008 Coating defects surveys for buried pipelines Part 1: Direct current voltage gradient (DCVG) provides "normative" advice on coating defects surveys and may be used as an additional guide to testing. However this document supersedes AS 4827.1 when working on Watercare's assets.

a) Signal application

Minimum test point swing is 1000 mV. Lower strengths may only be used if it can be shown that a defect of 0.1% IR will be detected from the equivalent methodology.

The DCVG survey signal may be derived from the installed CP system power supply or applied using portable transformer/ rectifier unit utilizing the system anode ground bed or temporary earth electrode.

Should stray current have significant impact on the accuracy of measured defect IR signals, the sizing of defects shall be undertaken during the period when there is no stray current.

b) Survey methodology

Determining DCVG Signal Amplitude to Remote Earth At Test Points

The procedure to determine the DCVG signal amplitude to remote earth at test point is as follows:

i. Place 1 reference electrode at the base of the test point or other electrical contact point with the soil, while the second electrode contacts the test point or other properly cleaned electrical point in contact with the structure. The potential swing measured by this arrangement is the DCVG signal amplitude between the pipe and the base of the test point.
ii. Measure the voltage gradient from the base of the test point to remote earth by placing 2 probes which are separated on the ground adjacent to the test pipes (unless it was already established that there is no defect causing a voltage gradient adjacent to the test point). These 2 probes are then moved perpendicular in convenient steps at 90 degrees to the pipeline route measuring potential swings until remote earth is achieved. The sum of all potential swings of each step is then calculated from the base of the test point to the remote earth. (NOTE: Well coated pipeline may have a voltage gradient from the base of the test point to remote earth that is negligible unless a coating defect is in close proximity). In most cases, the DCVG signal measured in step (i) will adequately represent the total DCVG signal amplitude at the test point.
iii. The total DCVG signal amplitude at a test point or other connection point is the sum of (i) and (ii)

c) Recording of defects

All defects located during the coating survey shall:

- Be sized to remote earth and the IR drop recorded in mV
- Be marked by driving in a peg or by fluorescent paint where a peg cannot be used.
- Defect information shall recorded that includes:
  - GPS location recorded in NZTM (datum 2000) map coordinates, to the accuracy levels described in the Watercare Data and asset Information standard.
  - Description of the location with reference to the pipeline length, house number, distance from driveway, and other reference details noted to facilitate future re-location of the defect.
  - Offset from pipeline if the defect could not be centred on the pipeline.

A sample format is provided below:

Defect Number	Metreage	GPS Coords East-North	Description of Location	IR (mV)

Example:

Defect Number	Metreage	GPS Coords East-North	Description of Location	IR (mV)
-	0	2661231-6491234	Test point swing. TP1	1500
1	103	2661789-6491456	4m d/s of d/s edge d/way 200 Smith St	5
2	622	2661756-6491789	2m u/s of power pole 21 Brown Rd	7
-	850	2661900-6491551	Test point swing. TP2	1200

d) Coating defect survey - % IR calculation

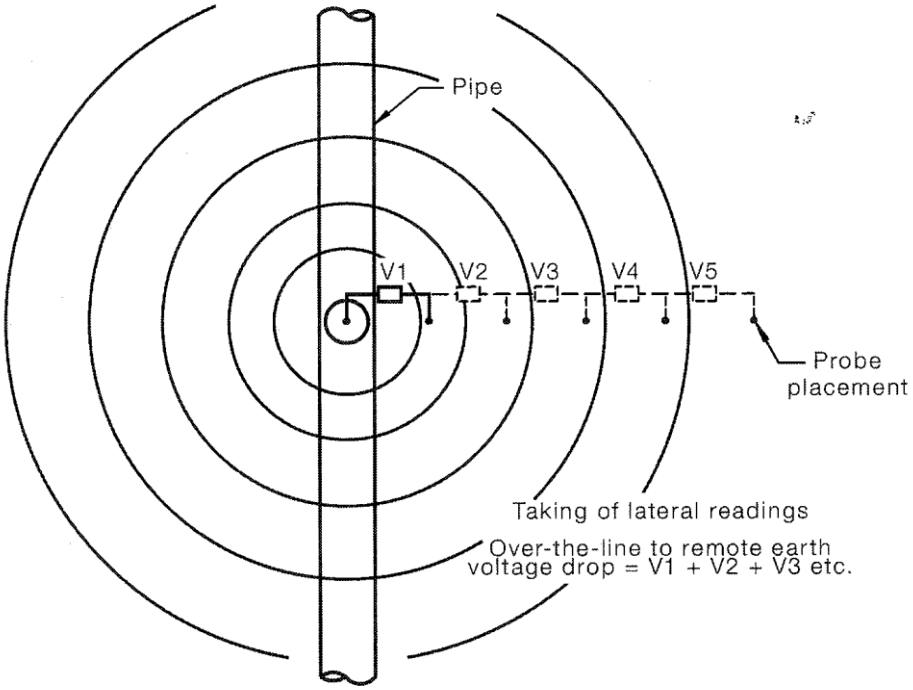
Defect sizes shall be related in terms of %IR by calibrating the measured IR sizes (mV) at defects against the signal size (mV) calculated to exist at the defects' location. The signal size shall be determined from the measured signal size relative at a suitable number of "calibration" points along the pipeline, and attenuation of the signal shall be taken into account between the "calibration" points.

Details of the survey and assessment, including calculated defect sizes (%IR), signal size the electrode potential survey data, shall be reported to Watercare for approval and acceptance immediately upon completion of the survey.

Upon determining the epicentre of the coating defect, a series of lateral stepped potential swings shall be measured, moving from the epicentre toward remote earth. Note that lateral potential swings decay exponentially from the defect and remote earth is located when the lateral DCVG signal amplitude in subsequent steps is negligible compared to the sum of potential swings to that location.

The sum of the potential swings is the IR component over the line of the coating defect to remote earth (S_{OL}) and will be used for calculating " %IR ". Figure 10.12-1 depicts how S_{OL} is calculated.

Figure 10.12-1: Sum of potential swings



Hence, the series of lateral mV readings to remote earth is summed to obtain the S_{OL}. This is defined by equation below:

$$S_{OL} = (V1 + V2 + V3 + V4 + V5\ )\ mV$$

If a defect is located, the %IR is calculated as the IR drop between a point on the ground directly above the coating defect and remote earth, expressed as a percentage of the estimated signal amplitude between the coating defect and remote earth. This is shown by the equation below:

$$\%IR = (S_{OL} \times 100) / S_{CF}$$

Note –

- *Digital voltmeters (DVMs) are not sufficiently accurate to obtain the difference between the 'on and off' pipe-to-soil potentials.*
- *The DVM's sample rate and screen update may not be synchronised with the DCVG pulse.*
- *To reduce error, use the same DCVG instrument for all readings for a given %IR calculation, unless an accurate calibration between instruments has been established.*

10.12.4 DCVG survey procedures

The application of the DCVG survey technique is as follows:

a) The surveyor should walk above the centreline of the buried pipeline and place one probe electrode in front of the other in the soil. Probes should be moist to provide good contact with the electrolyte. This may require the application of water to the electrolyte if the soil is dry or the survey is conducted over a small concrete surface. Should the pipeline run under a sealed road or large concrete surface (such as car park or building foundation), Watercare shall approve the methodology.
b) The probe electrodes should be separated approximately 1.0 to 2.0 metres parallel and above the pipeline searching for voltage gradients along the pipeline. If perpendicular probes are used, one probe should always be directly above the pipeline where achievable.
c) The DC offset and range selector switch is used to bring any pulse onto the meter scale.
d) If a pulse is seen on the meter scale, the direction of the metre indicator deflection is observed as it points toward the electrode that is closest to the coating defect, assuming the electrode closest to the defect is connected to the negative terminal of the voltmeter. Opposite connections will cause the indicator to swing the other way.
e) As the coating defect is approached, the amplitude increases and then reverses when the coating defect is passed. (If using perpendicular probes, the maximum indication will be observed when the probe above the pipeline is directly above the defect. Reversal will not occur once the defect is passed, only a reduction in amplitude).
f) When a reversal of pulse direction is observed, this indicates a coating defect has been traversed. The coating defect location may be identified by retracting slowly to where no pulse is observed. The coating defect epicentre then lies midway between the 2 probe electrodes, and is normally marked by a line on the ground.
g) The surveyor turns 90 degrees to the pipeline and the null process is repeated. A second line is marked, and the location where the two cross is the coating defect epicentre. This location is directly above the actual coating defect.

***Note** - Max spacing between measurements of 5m in rural areas. Depending on signal strength, drilling through tar-seal may be required to achieve a suitable contact with the electrolyte if a suitable swing is not achieved on the berm of the road.*

- *All defect indicators are to be precisely located and recorded. Any indication too small to be precisely located is to be recorded against the meterage range where it was identified.*
- *When surveying over concrete, the concrete shall be wetted to obtain a suitable contact for the probes.*
- *During construction survey (where the pipe has not been connected) all dirt shall be cleared away from bare steel (i.e. uncoated pipe ends, weld plates, AV connections).*
- *In areas with low swing, closer spacing between readings shall be used in addition to greater spacing between probes.*

10.12.5 Acceptance criteria

The following coating performance acceptance / rejection criteria shall apply to all steel pipelines. Other criteria may be adopted by Watercare for other types of coating system subject to sufficient justification of alternative criteria. Watercare shall define the criteria to adopt for existing mains prior to beginning survey.

a) All defect indications equal to or greater than 0.2% IR shall be excavated and repaired providing there is no evidence to indicate that the indications are associated with anodes, or electrical earth (defects at test leads should be excavated no matter the size, as these are likely to be shielded and have different metals).
b) Defects less than 0.2% IR shall be subjected to the following assessments:
    i. If a defect measuring ~ 0.2%IR is excavated and shown to be a significant size, then the next largest shall be excavated to determine the actual size of the defect. This process shall be completed until Watercare determine that the defect is insignificant.
    ii. Where two or more defect indications are separated by a pipe spool length, at least one shall be excavated, inspected and repaired. If the first indication is found to be at a pipe weld joint the other defect(s) shall be excavated.

iii. Should isolated defects of this size (less than 0.2%IR) be located they may not require excavation and repair subject to the following provision: If the specified over-the-line electrode potential survey indicates that a polarized protection level (free of IR component and other interference) of at least 100 mV more negative than the minimum protection criteria specified for the pipeline can be achieved at all points along the affected pipeline section with a total protection current not exceeding 50 mA per kilometre length of the pipeline. All the defects shall be recorded for future reference.

c) Chambers with water, chambers without water- Where a defect is located at a chamber the Watercare shall advise the criteria to adopt. Tees, joints, welds, cadwelds: - All defects located at Tees, joints, welds and cadwelds must always be repaired

10.12.6 Re-test following defect correction

Following rectification of coating defects, details of repairs to the coating and subsequent performance measurements indicating the success of the repair shall be recorded on the pro-forma and supplied to Watercare for retention. All repairs are to have a DCVG carried out following backfill (this may be carried out after the pipe has a minimum of 300 mm cover). It is advised that the pipe either side of the excavation be DCVG tested while the defect being inspected is exposed, to ensure that no defects exist immediately up or downstream of the excavation that may have been shielded by the defect being inspected. The following table shall be used for recording corrected defects.

Logging of defects and repairs:

Defect Number	Metreage (m)	GPS Coords	Description of location	IR (mv)	%IR	**(I)**nspected/ **(R)**epaired/ **(N)**ot Repaired	Description of defect	Likelihood of shielding **(H)**igh **(M)**edium (**L)**ow	Photo Number/ Name	Date Inspected / Repaired	DCVG Survey

10.12.7 Report

All test results shall be recorded and a separate report supplied to Watercare for assessment and acceptance prior to undertaking commissioning of the CP system for the pipeline.

A record of defects shall be submitted to the Watercare for review following the assessment against the acceptance/ rejection criteria and a recommendation for proposed remediation where required to meet the criteria.

The report shall contain the following as a minimum:

a) Pipeline details including route length, diameter, fittings, off-takes, safety earths, sacrificial anodes and CP system components
b) Details of equipment and methodology including method and location of signal injection points and strength of signal
c) Potential survey results including output current and voltage of the direct current (CP) power source
d) Listing of all coating defects located including reference points and GPS identification
e) Where specified in this document, size of defects in term of lateral IR, signal size at calibration points, and calculated defect size represented as %IR
f) Assessment of defect %IR sizes against the acceptance / rejection criteria in this document
g) Recommendations for excavation, physical sizing and repair of defects
h) Provide details of repairs undertaken and subsequent coating survey results indicating the criterion has been satisfactorily achieved.
i) Photo record of defects during repairs

10.13 Mortar rehabilitation (lining repair)

Samples and tensile bond strength tested to AS1012 part 24.