

# Guidelines for Design of Water Reticulation and Pumping Stations

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# GENERAL

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## Scope of this Manual

The guidelines are intended to establish a degree of uniformity for design, drawings, specifications, and construction of all water reticulation projects.

It covers investigation and design of reticulation facilities. For specialist areas of reticulation design further information may be required. The mechanical and electrical design manuals are referenced where necessary.

This scope applies to equipment and assets in all of these areas of Watercare's network.

- Headworks (raw water dams, intakes, weirs, pump stations and watermains)
- Water treatment plants and filter stations
- Reticulation (treated water reservoirs pump stations, and watermains)

Watercare's Project Delivery Manual and the documents linked to it will provide additional guidance for the design process.

## Standards and Specifications

References to the standard documents and drawings to be used for design are included in the Appendices.

These include:

- external standards currently used
- internal standards
- common reference material
- Wastewater reticulation and general standards drawings

## Related Documents

- OSH Guidelines for the prevention of falls
- NZS/AS 1657-1992 Fixed platforms, walkways, stairways and ladders - Design, construction and installation
- OSH Code of Practice for Manual Handling
- OSH Guide for Safety with Underground Services

## Water supply contracts with customers

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General design parameters are set out in this document. Particular conditions of supply to each local authority define the requirements for water quality, pressure, and flow at bulk supply points, and these may diverge from the general basis of design.

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## Water Pressure

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### Maximum static pressure

- 120m from Ardmore and Huia Filter Stations
- 145m from Waitakere and Nihotupu Filter Stations

### Consumption estimates

- Auckland 410 l/h/day
- Hibiscus Coast 310 l/h/day
- Beachlands Maraetai 310 l/h/day

### North Shore City consumption estimates

- Residential 200 l/h/day peak flow 600 l/h/day
- Commercial 4m<sup>3</sup>/ha/day peak flow 12 m<sup>3</sup>/ha/day
- Industrial 8.6m<sup>3</sup>/ha/day peak flow 13 m<sup>3</sup>/ha/day

## Requirements

Pressure at supply points shall be able to provide at least 25m head (at peak demand) at the service connection plus an allowance where houses are on ground elevated above street level and an allowance for Territorial Authority reticulation losses of up to 2m per kilometre for areas supplying more than 80,000m<sup>3</sup> pa minimum demand. It is the Territorial Authority's responsibility to provide adequate pressure for consumers in areas not meeting this minimum demand requirement. This standard shall be waived only to meet emergency fire requirements.

The maximum static pressure to consumers should be no greater than 70m water head. For bulk mains, pipe friction losses should not exceed 1m/km.

Hydrants shall be on LNO reticulation only unless otherwise agreed.

## Pressure Zones

Local body reticulation is required to adhere to pressure zones established according to ground level contours but dropping by not more than 2m per km from the supply meter, in order that high pressure water is not reticulated to low level customers.

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## Capacity and Flows

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### General

For all new mains the ultimate capacity should be fixed from the Colebrook-White equation. Roughness factors  $k$  (mm), are based on Table 3 in *Charts for Hydraulic Design of Channels and Pipes*, Hydraulic Research Wallingford, 6<sup>th</sup> Edition 1990. Generally a  $k$  value of 1.5mm is used for concrete lined steel pipes. While ultimate flows are normally based on the figures noted below, mains should be designed for the situation which produces the greater demand between:

- peak demands in all zones
- fire flow in one zone and average flow in the other zones.

### **Residential Zones**

The values used for residential zones are 25 to 30 persons per hectare based on a gross area including streets, local schools, local reserves etc. For smaller solely residential areas the assumed density is 30 to 40 persons per hectare based on gross area which includes streets. Section sizes shall be considered in selecting the densities within the ranges stated. Special consideration shall be given to any low or high density area. In all cases figures used shall take note of District Plan information.

In residential zones the average demand per person is 200 litres per day. Peak demand will be approximately three times this figure.

### **Industrial Zones**

Industrial demand varies considerably and for this reason each area shall be checked for the types of industries which are likely to develop. The figures quoted are intended for industrial areas of over 400 hectares but may be used for smaller areas provided that development of wet or heavy industries is not anticipated. Small areas of heavy industry shall be separately reviewed.

The workday average flows assume 5 working days per week (ratio 1:4) and peak flows 3 x workday average flow.

- Annual average flow (AAF) 25 l/s per 100ha
- Workday average flow (WAF) (1.4 x AAF) 35 l/s per 100ha
- Peak flow (PF) (3 x WAF) 105 l/s per 100ha

The calculations shall be based on gross areas which include streets etc.

### **Commercial and Other Zones**

North Shore City Council estimates for commercial use are shown in the basic design data section. Watercare has no formal design parameters for commercial or other zones. Large commercial areas, hospitals and other special zones should be separately reviewed.

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# WATERMAIN DESIGN

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## Overview

These notes give the general basis of Watercare watermain design. While they are to be used for general guidance, engineers are expected to use normal engineering discretion in particular design. Where variations to normal practice are proposed, this should be brought to the attention of section heads before drawings and specifications are finalised.

## Site Investigations

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### Requirements

During the preparation of drawings and specifications, site investigations are required to cover the following matters:

1. Survey and service information
2. Nature of the material to be excavated and the material on which the work will be founded. This information will be obtained by geological investigations as required, drilling and sampling and unconfined compression tests. The engineer responsible should inspect all samples obtained while they are in a fresh condition. Where tunnelling is proposed test bores should be located adjacent to the tunnel route, rather than directly on line. Past experience has shown that boreholes above the tunnel often cause complications during tunnelling due to the ingress of groundwater.
3. Groundwater level should be obtained in porous strata and should be quoted as at that date.
4. Natural cross drainage and what is required to provide for it. Culverts require proper design and allowance for increase in run-off due to later development of the area. Culvert lengths should not be too short.
5. The effect of any banks on drainage or acceptability of country for farming or housing. Upstream hollows may at times require filling and this should be watched when walking over the line. Batters may be required to be quite flat to allow use of farm machinery, e.g. 1 in 4 to 1 in 10.
6. The possibility of corrosive groundwater (or soils). It is the responsibility of the Engineers concerned to ensure that these and any other necessary investigations are made. Such of them as are required to ensure that the engineering implications, including cost, of any proposed location are satisfactory should be carried out as early as possible and preferably before the final survey is done.

## Hydraulic design

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### Grades and Velocity

The minimum grade is to be 1 in 500. For gravity bulk mains, average velocity should be between 0.5 and 1.0 m/s. For pumped pipelines, maximum velocity should not exceed 2.5m/s.

Pipelines should have sufficient grade to facilitate air movement to air release valve positions during pipeline charging.

## Cover and Levels General

The level of Watercare mains in relation to future development and reticulation and industrial premises must be considered. Generally cover in roads shall be 1.0m and that in berms and open country shall be 0.75m.

## Special Hydraulic Conditions

The pumping of large diameter (1000mm or greater) mains over long distances may require special considerations such as the provision of a surge tank.

## Losses in Fittings and Bends

Losses to be allowed are given in millimetres for angles and velocities shown and for values of:

**Table 1 Losses in Fittings and Bends (mm)**

Velocity m/s	Angle			
	0 <sup>0</sup>	30 <sup>0</sup>	60 <sup>0</sup>	90 <sup>0</sup>
0.61	2.5	3.6	4.9	6.1
0.91	5.5	8.0	11.0	13.5
1.22	9.9	14.4	19.7	24.3
1.52	15.3	22.4	30.6	37.7
1.83	22.2	32.4	44.4	54.6
General	$\frac{0.13v^2}{2g}$	$\frac{0.19v^2}{2g}$	$\frac{0.26v^2}{2g}$	$\frac{0.32v^2}{2g}$

$R/d \geq 3$  where:

- R = C/L radius
- d = pipe diameter

For R/d of 2, increase losses by 50%. Where bends are formed of chords instead of curves, an increased loss may also need to be provided for. R/d should preferably be kept at 3 or over where possible. Values under 2 are undesirable.

## Connections

The only connections to local Territorial Authority reticulation shall be via bulk supply meters which are described in a subsequent section of this manual.

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## Pipeline location

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### Pipeline corridor

Where possible mains should be laid within the road reserve in public roads. Pipes laid in private property often lead to later problems with building limitations and restricted access for repair.

Easements are required for mains in private property. Easements are required for mains laid in public reserves mainly to record the fact that a pipe is there in case the reserve is sold by the Territorial Authority. Pipes laid in road reserves need no easement but have caused serious problems including expensive replacement and damages costs where the road reserve has been subdivided and sold to unwitting home builders. Road reserves in which the road has not already been constructed should therefore be avoided unless the designer can ensure in some way that this problem does not recur.

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## Metering

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### General

Magnetic flowmeters are to be used at all bulk supply points and as required at pump station and network monitoring sites. The greatest number of meters will be at the supply points where there are specific requirements for accuracy and continuity of service.

### Accuracy

Bulk supply meters are the basis for water charges to the local authority customers. The supply agreements require meter accuracy of within  $\pm 2\%$  of true flow volume over a monthly period. A magflow meters inherently loses some degree of accuracy at very low velocity (night-time) flow, and this reduced accuracy is compensated for by better than 2% through the normal velocity range.

Reticulation flowmeters are required to perform to a similar accuracy, because these are used together with other network data to check on a mass balance within parts the system.

### Meter size

The size of a meter will be governed by the current minimum flow rate and predicted maximum flow requirements. Velocity should be in the range between 0.5m/sec to a maximum of 6.0m/sec. The sizing calculations are to be verified by specialist staff familiar with the manufacturer's and Watercare's requirements.

### Installation

The pipework configuration should aim to replicate the conditions under which the meter was calibrated and tested by the manufacturer. To achieve the velocity requirements, it may be necessary to taper down from the supply pipeline diameter to the meter diameter.

Pipework design is to provide smooth laminar water flow and be within the specified velocity tolerances flowing through the meter body. The standard Watercare requirements for pipework associated with a meter include

- 10 pipe diameters of pipe of the same bore as the meter on the upstream side
- 5 diameters of the same sized pipe downstream of the meter
- a taper shall not be sharper than 1:7 (on diameter). The pipe wall thickness is to match the dimensions of the larger diameter adjoining pipework
- pipework is to be internally lined so that there is a smooth transition in thickness along the taper.
- There shall be a smooth transition and no steps between the taper section bores and flanges, and between the taper and connecting pipework
- All pipes and taper sections shall have a roundness on the nominal bore diameter that shall not exceed the misalignment tolerances shown in Table 1

**Table 1 Tolerance for misalignment and diameter**

Meter nominal bore (mm)	Maximum misalignment (mm)
< 50	1.5
50 – 300	2.0
> 300	4.0

In the process of upgrading a mechanical meter to a magflow meter, at some sites the ideal upstream and downstream flow conditions cannot be achieved without major cost to rebuild the chamber and adjacent assets. It may be acceptable to reduce the straights to 5 diameters upstream and 2 diameters downstream, or in some cases to even less. Where there will be less than ideal conditions available, the pipework design should be submitted to the Watercare meter specialist, who may forward the design to the manufacturer for approval.

The process of meter assembly into the pipework is set out in the standard specification for meter installation, and standard drawing no. 2001979-020 shows details of the bolts, cabling and fittings associated with the meter.

## Verification

Meters will be verified annually as part of the supply contract requirements. The test uses a process recommended by the manufacturer, and this is carried out on the electronic components, without the need to remove the flow tube from the pipeline.

## Equipment make

Meters and the associated electronic equipment will be as specified in the preferred equipment list.

## Pipeline design features

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## Materials

- Pipe materials and quality should give a service life of 50 to 100 years. New designs should be evaluated by discounted cash flow.
- Non toxic, non taste lining materials, curing compounds, sealants, and repair materials shall be employed in all water conduits and reservoirs. Before any material is used inside these structures, proof of its non toxicity shall be submitted from an approved testing laboratory.
- Pipelines will generally be made from spiral welded concrete lined mild steel pipe. Watercare has a range of pipe diameters, shown in the pipe supply specification, which do not necessarily match other industry standard sizes.
- Bypass, scour pipework and supply offtake pipework 200mm and smaller is generally fabricated from API Schedule 40 pipe and fittings which are epoxy paint lined.
- Other types of steel pipe, polyethylene, and other materials should be considered especially in the smaller diameters.

## Pipe and flange standards

Watermain pipes are made to NZS 4442, but to Watercare's own diameters. Refer to the pipe supply specification "Section 205 – Supply of Spiral Welded Steel Pressure Pipe".

Flanges for pipework and valves are generally dimensioned to BS EN 1092. These have similar dimensions to the now superseded BS 4504, but some flange thicknesses have been changed.

During refurbishing in facilities where older BS 10 flanges have been widely used, a decision may be required as to whether to use BS 10, AS 2192 (similar dimensions to BS 10), or BS EN 1092 for flanges on new works.

Weld neck flanges made to match Watercare pipes are stocked for watermain projects. Where API Schedule 40 pipework is used, then standard off-the-shelf weld neck and slip-on flanges can be utilised.

## Pipeline design

- Design guidelines for pipework, valve, and chamber features are shown on drawing 2001979-086.
- Pipework and pipe supports are generally to be designed for an operating pressure of 16 bar and a test pressure of 20 bar. Alternative pressure rating may be appropriate for specific parts of the network that cannot be subjected to these pressures.
- Pipe bridge design shall be subject to specific structural design of the pipe and supports for empty and full pipe static loads, any dynamic loads, and full seismic provisions.
- Pipes are to be buried where possible. Large pipes have a minimum of 1.2m cover (to leave space for smaller service conduits overhead) and smaller sizes have no less than 1m in open country and in streets.
- Thrust blocks are required at bends where continuous welding is not possible.

- Pipeline gradient should be arranged to minimise the number of humps and hollows. Avoid creating flat areas where air removal during pipe filling will be difficult.
- Air valves are required on humps and scour valves in hollows, all installed in chambers for maintenance purposes.
- The scour chamber drainage is to be configured to avoid erosion at or near the discharge point.
- Pipe trenches are to be drained as required, especially in hollows and on long gradients. This can be provided by perforated drain pipes laid in the bottom of the trench with suitable release points. This is to prevent ground water from surfacing in hollows and in the road, and to prevent empty pipes from floating out of the ground.
- Use concrete lined mild steel mitre bends for buried pipework outside chamber.
- Cathodic protection is applied to all welded steel pipes. Detailed design at fittings, chambers, actuated valves, bridge supports, pumping stations and similar sites should eliminate all sources of current leakage to earth.

### **Configuration for line valves, PRVs, and meters**

- Line valves (with by-passes) are required at approximately every 1.6km along the pipeline.
- Apart from valves adjacent to the meter, generally use gate valves up to 200mm dia. and butterfly valves above this size. Line valves over 300mm diameter are to be geared and in chambers
- The valve upstream of a meter in principal pipeline to be same nominal size as meter.
- The isolation valve downstream of meter is to be same nominal size as the pressure reducing valves (PRV) where fitted, so that the gate valve can be direct bolted to PRV. The valve should be the same size as the meter if NRV required instead of PRV.
- Design PRV bypass pipework for maximum ultimate flow rate in the pipeline at the projected minimum pressure differential.
- Provide a bypass pipeline on the PRV in meter chamber pipework. If dual PRVs, provide bypass to principal PRV only.
- Bypass pipelines up to 200mm dia are to be API line pipe (Schedule 40) or equivalent, otherwise use CLS pipe and fittings.
- The design of bypass connection to main pipeline is to allow for reasonable pipework fitting tolerance. This may be achieved by the use of slotted raised face flanges.
- It is preferred that a gate valve be used for bypass isolation. It is to be located to allow adequate clearance from valving in principal pipeline.
- Bypass pipeline to be vertically under principal pipeline so that bypass isolation valve does not intrude on working space, ie minimise obstructions. The bypass valve is to be fitted with handwheel and valve orientation is to be “user-friendly” which means that main axis of bypass valve generally vertical.

- Customer meter connections should be taken from line valve bypass pipework, and should be configured to keep the supply active even when a section of the main is out of service.
- An isolation valve is to be installed on each side of PRV/NRV to enable PRV to be maintained (generally on annual basis).
- Arrange for PRVs to have non-return valve (NRV) function, ie PRV/NRV.

## Metering pipework

- Provide 10 diameters of straight pipe upstream of the meter and five diameters of straight pipe downstream (d/s). The diameter of these sections of pipe is to be within +/- 2mm of the meter diameter.
- Tapers for the meter pipework may be located outside the chamber.
- Make allowance for the magflow meter to be upgraded to diameter of PRV/NRV in the future.
- Magflow meters to have a bolted joint close by to take temperature stress off the meter flanges.
- Valves adjacent to meter
  - On meters up to 200 dia., use gate valves (GV) u/s and d/s and arrange for them to be operated from ground level
  - On meter 250 dia, use GV u/s (if room permits otherwise butterfly valve (BV)) and BV d/s
  - On meters 300 dia. and above, use BV u/s and d/s.
- When the meter is in a chamber separate from the valves install a carrier pipe between magflow and PRV/NRV chambers to assist removal of magflow meter. Locate the dismantling joint/flange adaptor in PRV/NRV chamber.

## Chambers

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### Chambers location and dimensions

- Where possible chamber access should be clear of the roadway and traffic to minimise the traffic management required for chamber entry. Allow for future road widening
- A single chamber is to be used where practical for each chamber site. If a single large chamber uneconomical, consider multiple chamber arrangement, eg consider locating magflow meter in separate rectangular or circular chamber. Although these guidelines generally refer to rectangular chambers, the same principles apply for circular chambers.
- The chamber dimensions are to be the greater of 1500mm, or 500mm each side from the outside of the flanges to the inside of the wall. Where this is not achievable due to a site constraint, the positioning of the pipe off-centre is to be investigated.
- Minimum clearance under the principal pipe is to be 600mm, OR maximum height to top of principal pipe above floor is to be 700mm.

- Regularly maintained fittings including valve handwheels are to be between 730 and 1340mm above floor or platform level (OSH manual handling requirements). If there is no PRV and bypass, minimum clearance under pipe can be 300mm.
- Internal height of chambers to be a minimum of 2150mm (AS 1657).
- Minimum thoroughfare (working) space to any pipe fittings, eg valve flanges, handwheels, meter flanges, PRV flanges, from walls or handrails to be 650mm in a horizontal plane.
- Minimum gap to valve flanges or handwheels, and meter flanges is to be 300mm when a thoroughfare space is provided on the opposite side of the pipework, ie when a fitting can be maintained from one side only.
- Minimum vertical clearance from bypass pipe flange to be 100mm for 100 dia. pipework and 150mm for 150 and 200mm dia. pipework. Horizontal clearances to be 300mm from chamber walls.
- Minimum gap from a wall to PRV flanges is to be 650mm on each side.
- Minimum clear width of any platform to be 600mm.
- In large rectangular chambers, provide two access hatches, one for person access and the other for equipment access. This provides for reasonable lighting and ventilation.

## Chamber design

- Loadings and concrete designs shall be in accordance with the current editions of NZS 4203 and NZS 3101 respectively. The wall units shall be designed for maximum ground loading with roof slabs off and shall have suitably sized openings cast in them to accommodate pipework.
- The floor slab shall have a 28 day strength of 25 MPa and is to be underlain by a 50mm thickness of 10 MPa site concrete. It shall be cast with at least 1:100 slope to the sump to prevent any pooling.
- The components of the line valve and meter chambers, apart from their floor slabs, shall be constructed from precast concrete units. The minimum thickness and concrete 28 day concrete strength of the components shall be 200mm and 40 MPa respectively.
- The chamber wall design shall take into account all external loads and pipe thrusts. It may be assumed that any dismantling joint tie bars on the pipework are correctly tensioned.
- The assumed water table level shall be at full height of the chamber, which shall be designed to resist uplift.
- Chambers are to be ventilated and drained to keep equipment dry.
- Provide gravity drainage from magflow chamber and magflow chamber to PRV/NRV chamber if possible. Include a sump pump in the PRV chamber if gravity drainage is not practicable.
- Lighting to be provided in chambers with different floor levels, eg proposed Henderson Valley Rd line valve and meter chamber. Intensity of lighting is to be to NZS 6703.

## Chamber roof

- Design chamber roof as a removable reinforced concrete slab(s), to support Transit HN-HO-72 loading and shall take into account impact loading. Provide 'Reid Swiftlift' anchors for safe lifting.
- Provide equipment access lid (either standard 500mm dia. non-rock lid and frame or standard rectangular cover and frame depending on required clearance to fitting) preferably directly above principal PRV (if more than one) through which the "internals" of this PRV can be removed.
- Where it is not possible to install a lid above a maintainable item then suitable lifting arrangements must be made.
- At man-access points, make provision for the installation of an extendable ladder – see the standard ladder drawing.
- Loadings and concrete designs shall be in accordance with NZS 4203 and NZS 3101 respectively.
- All access and inspection lids in the berm shall be set 50mm above the existing ground level, and for chambers in the carriageway, the lid levels shall be flush with the finished road surface.
- Any joints in roof slabs shall be sealed to prevent the ingress of water. A compressible sealant shall be used between the walls and the roof slabs prior to the installation of the roof slab.
- The chamber lid is to be installed on a compressible sealant strip along the top of the walls. This shall not prevent the roof being lifted off for future major maintenance in the chamber.

## Pipeline construction drawings

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### Plans and long sections

Full plan and long-section drawings are to be produced from the design process, including information on

- pipe size and wall thickness,
- gradients,
- ground levels and cover depth,
- trench drainage,
- control valve, air valve and scour valve chamber and chamber drains,
- valves and connections,
- services near or crossing the pipeline,
- surface features,
- CP features, and
- anything else relevant to construction or operation of the pipeline.

Standard drawings are to be utilised where practical, and these should be referenced from the plans and long sections. Where a standard drawing is

to be modified for a particular project it must be titled and numbered within the project set of drawings.

## **Pipeline construction**

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- All buried fittings are wrapped with insulating and anticorrosive tape to minimise corrosion and tracking to earth by cathodic protection current.
- Fine grained back fill material against the pipe coating to minimise the risk of wrapping damage.
- Valves and pipework in chambers to be painted in accordance with the standard painting specification, to protect against corrosion.
- Construction of pipelines and chambers and reinstatement work in roadways must follow the AUOG “Code of Practice for Working in the Road”.
- Unless specifically required otherwise, test pressures on all parts of the water reticulation network shall be 20 bar, for an operating maximum pressure of 16 bar.
- Prior to the casting of the chamber components, a design certificate signed by a Chartered Professional Engineer and method of construction of the chambers shall be approved by the engineer.
- Prior to backfilling the chamber, the contractor shall waterproof the surfaces of the walls and floor nib.
- After the installation of any equipment which may be damaged by water, the contractor shall ensure that all openings that may allow water to enter chambers, are temporarily sealed, and are then finally sealed at chamber completion.

### **As built records**

All deviations from the design made during construction, together with any additional information discovered in the process shall be put onto the as built drawings.

Complete and accurate as built drawings are required before handover to Operations.

## **Redundant pipelines and chambers**

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### **Ownership and safety**

Redundant sections of pipeline are to be sold (with the full legal process for change of ownership), removed, or infilled completely to prevent collapse or groundwater transport.

Equipment is to be retrieved from redundant chambers, which are then to be made safe from access or collapse. The chamber will generally to be broken down to below ground level and backfilled, or dealt with as is appropriate for the site or as required by the local authority.

## Tunnels

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### Design

Design of water tunnels shall be to the earthquake code. Overflows require discharge consents. Voids above the tunnel lining should be filled with concrete or grout, especially at faults or where construction cave-ins occurred, to prevent progressive collapse of the ground above when timbering falls into decay. Design has evolved to a concrete lined standard horseshoe section with a free water surface at the level for maximum capacity. Some advantages are:

- Economical structural design yet the shape is practical for tunnel driving.
- Minimum hoop tension from internal pressure.
- Dissolved oxygen is maintained or increased with a ventilated free surface.
- Minimal requirement for water hammer protection.  
Usually a suitable of overflow or goose-neck stand pipe at each end of a tunnel serves the dual role of venting the tunnel during filling and emptying and also gives suitable surge pressure relief. Provision of surge pressure relief should, however, be checked when supplying a reservoir from a Filter Station.
- For raw water tunnels, leak sealing is necessary only at portals (unless permanent drawing down of the water table is a problem) because leakage inwards from unpolluted catchments into tunnels can make a notable contribution to the yield. Note that Mangatawhiri and Wairoa tunnels were measured as contributing 1.4Mld/km (megalitres per day per kilometre).

For treated water tunnels a sealed lining is required throughout to prevent ingress of polluted ground water. Temperature cracking of in-situ cast linings can cause leaks in the best of linings. Hence it is important to seal all construction joints and to install an under-drain to keep ground water pressure below supply pressure. Also a suitably arranged under-drain can be pressurised to test the lining for leakage.

The main disadvantage with a free water surface is the long and varied response time for flow changes to be felt in long tunnels.

Where pressure tunnels are required (supply to reservoir etc.) an overflow of adequate capacity at TWL, will serve as a suitable surge chamber. Design shall be to the water retaining code.

### Tunnel/Aqueduct Inspections

Internal inspection in conduits, 5 yearly or when the opportunity arises, should cover; signs of structural distress, sealant failure, concrete deterioration, and debris accumulations. Internal inspections of tunnels with pipes and accessways should be a continuing process with an eye for; leaking pipes joints, undue corrosion, hazardous obstructions or debris piles, spalling ceiling in unlined sections and structural distress in lined sections.

External inspection of aqueducts and tunnel portals should be done annually and would include; signs of subsidence of foundations, integrity of air vent pipes, failure of movement joints and security of man-holes, scour and line valves.

All weather access shall be maintained to all important tunnel portals and aqueducts.

## **Additional Information**

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### **Inspections**

Inspection of water mains should be undertaken every two years. The lines shall be walked looking for leaks and potential problems from external activities. All fittings such as air valves scour valves, meters, line valves, by passes and valve chambers etc. shall be checked for actual or potential deterioration and faults.

### **Miscellaneous**

Total expenditure by the community must be considered as well as that of Watercare alone but Watercare mains must take precedence over local reticulation.

### **Legislation**

- Resource Management Act.
- Consents to scour watermains - See the Environmental Engineer - Water.



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# PUMPING STATION DESIGN

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## Scope

This section addresses the civil and mechanical requirements for pumping stations. Details of control systems and electrical design are covered elsewhere.

## Purposes

A pumping station may serve one or several of these of these and other purposes.

- Supply to high level reservoirs
- Boosting pressure to high level areas
- Increasing flows through watermains to improve quality
- Increasing flows through watermains to increase flows and pressures
- Emergency supplies

## Capacity

Pumping Station capacity specified is based on peak inflow calculated on normal design parameters. Normally 100% standby capacity is installed.

Economic use of power to pumping stations is arranged, only where it does not compromise supply, to take advantage of:

- Low night tariffs.
- Off peak use where peak load charges apply.
- Using a minimum number of pumps at any one time during a given meter period, where peak load charges are levied on this minimum number.
- Use of gravity feed instead of pumped supply to marginal reservoirs when pressures are high in the early morning.

The duration of pump operation as suggested by these considerations will influence the design pumping rate for a station in relation to network flow requirements.

## Operational control

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The station will be fully automatic. Pumps will start, change speed (where appropriate) or stop, as directed by the control sequences of the local PLC, with input from district control loops (local reservoir or pressure sensor) and from the Central Control Room (CCR).

Operational control of pumping stations will be in accordance with a combination of the following operation modes.

- Manual control in the pump station with the alternative of automatic control by reservoir level and/or time clock from local PLC and/or

- Remote control from the CCR for all treated water pump stations or
- Remote control from the controlling filter station for all low level headworks reservoirs and well supply pump stations.

In general all pumping stations should continue in a predetermined mode directed by the local PLC if contact with the control room or control sensors is lost.

All pump stations have relevant operating parameters such as valve settings, flow rates, pumping rate, motor current, and other operational parameters remotely monitored at The CCR. Equipment and sensors need to be compatible with the Scada system.

All stations require provision for connecting emergency standby generation directly into the switchboard.

#### Monitoring

A magnetic flow meter(s) is to be provided to record station discharge flow and pump performance. Pressure transducers and flow captors are required on inlet and outlet pipelines from each pump.

The flow and pressures will be relayed to The CCR via the Scada system

## Pumps

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### Pump head – discharge requirements

The number of pumps installed will depend on required capacity and economic selection and standby capacity. Full standby capacity has been provided in recent designs i.e. 1 duty, 1 standby (2 pumps minimum). With two duty pumps, a third standby is provided on the assumption that only one duty pump will fail at a time.

Pumps are to be specified to handle the peak design flow against the computed total head. Consideration can be given to the effect of wear on pump performance, or increased pipeline losses, by requiring a capacity above peak design. High static head/flat friction curve situations are most susceptible. This should be approached cautiously keeping in mind the capacity of the downstream system.

Pumps may have either fixed or variable speed motors, designed to deliver the required flow at the available head. Pump curves will show the appropriateness of the pumps for their application.

Problems can also occur where the system curve is very close to either the end of the pump curve or where the head curve becomes very steep at the high flow end. It is useful to require factory pump test results for flow conditions some distance beyond the design duty range where there is concern.

Pumps and motors are normally specified to operate satisfactorily for six starts per hour condition.

To limit wear and to minimise noise issues, motor speed should not exceed 1450rpm.

Noise for workers inside the station, and noise breakout from the station needs consideration for variable speed motors and larger pump/motor sets.

## Standby Pump Sets

In pumping stations supplying high level service reservoirs or in pressure boosting stations, a standby pump set is required, of a capacity equal to the largest duty set in the pump station. Alternative supply pump stations to filter stations from low level headworks reservoirs do not require standby sets because maintenance and repairs can be affected without disruption to supply.

The main purpose of the standby pump is to give continued operation during duty pump failure, and to maintain peak capacity capability while pumps or motors are being maintained. During periodic maintenance, when a pump is removed, the station is left with no standby. The designer and Operations staff must be aware of this to minimise the vulnerable period. Special attention needs to be given to quick and easy removal, access, handling, and cleaning. The purchase of a spare pump to be held in store may be considered.

## Valves and Pipework

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### General

Most station pipework will be fabricated from concrete lined steel pipe, although smaller pipework may be epoxy lined.

Valves will be required to isolate each pump from the station pipework to allow it to be removed without preventing operation of other machines in the station.

Bypass pipework may be required connecting high pressure and low pressure parts of the systems, and this may require careful selection of valves.

Sluice valves will be non rising spindle, anticlockwise closing, with a position indicator.

Pipework will be designed to be easily assembled and dismantled. It will be necessary to remove valves and pumps, therefore provide anchors and supports for self sufficiency, i.e. avoid the need for temporary supports during maintenance.

Flexible couplings are usually required between each pump and the pipework to minimise noise transmission and to facilitate pump and pipework alignment. Substantial thrust provisions may also be required to restrain the pump and adjacent pipework.

Check there is adequate clearance for bolt removal and replacement, and gasket insertion. Where necessary detail double ended rod and nuts in place of bolts.

See the Preferred Equipment list for pumps, motors, valves and other station equipment. Check valves will be conventional reflux type.

Adequate clearance from the station structure and from pipework and other equipment must be provided to allow bolt removal and equipment dismantling

Cathodic protection isolation should be installed on the inlet and outlet pipelines at the nearest fitting to the pump station, to isolate the pipeline from station equipment which has electrical earthing.

## **Building and Amenities**

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### **General**

Unless specifically decided otherwise, external elevations will be designed by an architect, with the aim of minimising visual intrusion to the present and likely future neighbourhood. The building should be constructed with vandal resistant and minimal-maintenance materials, and configured in a way that does not permit damage to services or access to the roof or any high points on the structure.

Interior surfaces of the building shall be easily cleaned. The control room floor will be concrete painted with a non-skid surface.

Provide sumps and drains from all chambers. All such drains to be trapped.

Power meters will be inside the building. Provide a potable water supply with washdown capacity. A toilet, wash handbasin, and hot water will probably be required to Building Act requirements.

Lighting is to be provided sufficient for good working visibility under night-time conditions. Natural lighting (windows) is not essential.

Within the building provide curb upstands around floor openings and at platforms. Handrails may be galvanised steel, painted. Allow space for moving switchgear.

Stairs, landings and ladders shall be fabricated in steel and hot dip galvanised. Use standard features where this is practical.

Vehicle access is required, sufficient to remove any of the station equipment.

## **Lifting Gear**

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### **General**

All parts of the machinery areas need to be covered by the lifting gear.

Provide a mono rail, with manual chain block and strategically placed manoeuvring hooks. All lifting equipment requires safety weight certification to be displayed.

In larger stations allow the Hiab equipped truck to go through main doorway, design floor accordingly.

Access for a crane may be achieved by designing all or part of the roof to be removable.

## Ventilation

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Ventilation shall be sufficient to maintain reasonable working conditions when the station has been running at full capacity for an extended period

Particular care is required to minimise noise breakout from the station through the ventilation system.

## Noise Control

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### General

Pump station operation shall not cause any significant noise or other nuisance to residents. The noise level inside the station shall not exceed 80dB. The noise levels on or close to the property boundary shall comply with those set down by the Territorial Authority.

Operational noise will come from pumping machinery, valves, vent fans, compressors, and generators. Depending on location, efforts are to be made to reduce potential nuisance i.e. properly fitted doors and hatches.

Sound absorption panel may be needed within the station to achieve safe working conditions.

## Emergency Provisions

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### Generation

Provision is required at each station to locate and connect a mobile standby generator into the switchboard, to operate the control system, the pumps, and all ancillary services.

Cable access to the switchboard should be arranged so that it is clear of the control room doorway and so that station security can be maintained during a period when a standby power supply is in use.

### Alarms

Low priority

High priority

Apart from the emergency provisions, both the mechanical and electrical installations will be designed with maximum reliability, minimising potential breakdown. Systems will be accessible and robust.

## Pump Station Commissioning and Hand-over

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All operational functionality shall be tested during commissioning of the pump station and witnessed by Water Operations staff.

As part of the hand-over process, the documentation required includes but is not limited to;

- Asset Schedule
- As-Built Drawings
- Functional Descriptions
- Sequential Function Charts
- Moscad / PLC Software
- In Touch Software
- Manufacturer's Manuals
- Commissioning Sheets
- Maintenance programmes

Three copies of the above documentation shall be provided to Water Operations in a specified format.

# RESERVOIR DESIGN

## Reservoir function

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Reservoirs within the water reticulation system serve a number of purposes including;

- Supply storage to surrounding areas in case of supply failure
- Maintain a consistent water pressure to an area
- Ensure water quality
- Level out demand peaks

## Location and level

Top water level shall match the hydraulic gradient appropriate to the pressure zone of the supply area. Note that every alteration to the supply network (new mains, cross connections, control valve operation etc.) alters the hydraulic gradient.

## Quantity

The service reservoirs normal role is to level out demand peaks in the supply and thus require smaller more economical supply mains. Optimum pipe/reservoir sizing and top water levels consistent with present and project population centres and the availability of suitable high ground, is arrived at from operation of the pipe network model of the Auckland distribution system.

In case of a major emergency, storage is provided by the service reservoirs. Watercare plus LNO reservoirs are to be designed to have a total capacity when full, each to two days average demand. However, in the light of recent history, the following approach is considered to be acceptable:

Minimum storage =  $2.0 \times (\text{Average daily demand} - \text{max. supply from all but the largest source})$

## Design Peak Inflows/Outflows

Design peak inflow is taken as  $1.4 \times \text{mean daily demand}$

Peak instantaneous outflow =  $3 \times \text{mean daily flow}$

## Water Quality

Operation of service reservoirs to maintain water quality requires periodic checks by laboratory staff to ensure that water quality does not fall below DWSNZ requirements.

Reservoir supply /withdrawal pipes are arranged where possible to put all supply water through the reservoir to eliminate excessive detention time. If necessary, low head pumps should be installed on the outlet, set to

operate automatically on a time basis at peak demand times to provide a daily flow through the reservoir.

Where for any reason water is likely to stand long enough to produce a chlorine demand, the reservoir may be manually drawn down to no more than 50% full then refilled as soon as possible.

Should a reservoir develop a chlorine demand and should coliform bacteria become detectable, manual chlorine dosing, as prescribed by the laboratory or disposal according to water right requirements shall be carried out.

## Consents

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A discharge permit shall be obtained for the full flow rate of the overflow and for operation of scour facilities.

## Design features for service reservoirs

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### Reservoir structure and chambers

- Architectural and landscaping standards for the reservoir and other structures shall be appropriate to the surrounding environment.
- The reservoir is to be designed as a water retaining structure using conventional design standards, and to the requirements of the Building Code.
- Underfloor drains shall be installed with discharge locations arranged to detect leakage from specific parts of the reservoir.
- The reservoir shall be vented to allow air transfer during normal level changes, with protection over vents to exclude vermin and any unauthorised access.
- There shall be at least two roof access hatches on the reservoir, with standard hatch covers. One is for man access and will include a platform and ladder. The other hatch is for equipment and should have no platform or ladder and should be located next to the overflow if this is practical.
- A fall restraint post shall be fitted near the equipment access hatch on above ground reservoirs with non public access.
- All ladders and platforms shall be made from hot dip galvanised steel and configured as shown in the standard drawings
- If public access to the reservoir roof is not permitted, secure access towers as shown in the standard drawing, shall be provided.
- Handrails on the roof shall be in accordance with standard drawings for public access areas or for work safety in non-public areas.
- The roof rainwater system and site stormwater drainage should discharge to the area stormwater system. If there is no piped system, a proper arrangement must be made for disposal without causing erosion or potential property damage.



- An overflow shall be sized to take maximum possible inflow.
- Power meters shall be located in an easily accessible but vandal proof position.
- Lighting should be provided inside large valve chambers.
- Vehicle access to valve chamber hatches should be provided.
- Drainage of chambers shall be allowed for.
- Ventilation of large or deep valve chambers shall be provided either by louvre air vents or by forced ventilation.
- The site shall be fenced to prevent unauthorised vehicle access. Site gates shall be as shown in the standard drawing.
- Turning area for a Hiab equipped truck shall be provided for.
- In some cases, parking of vehicles may be permitted on the roof of the reservoir.
- The roof of the reservoir and valve chambers is generally not painted. Other surfaces to be painted should be done in accordance with the standard specification.

### **Valves and pipework**

- Inlets and outlets should be separated to facilitate proper circulation and help maintain water quality. Inlet and outlet pipework should enter and leave the reservoir at the same location if practical and economical.
- The inlet should be configured to encourage circulation of the whole volume of the reservoir.
- Level control should be by altitude control valve (Bermad or Clayton hydraulic type).
- Level transducers shall monitor levels to remote indication at the control room.
- A hydraulic control valve may be required on the outlet pipe to close automatically should there be a sudden drop in water pressure.
- Pipework and valving must allow for practical operation, and for fully draining of the reservoir for periodic cleaning.
- The scour from the reservoir should discharge into a manhole which can be accessed by a tanker for the purpose of the removal of any sludge from the reservoir.
- Pipework shall be concrete lined steel except for castings through reservoir wall which should be Cast Iron.
- Bypass pipework connecting inlet and outlet watermains should be provided for, with valved to allow the reservoir to be taken out of commission without disrupting the connecting pipeline network.
- All valves shall be positioned so as to allow easy assembly and dismantling, adequate clearance for bolt removal and replacement.
- Flexible couplings may be required to account for differential settlement.

- A standard double sample box shall be provided at an easily accessible point, with samples sourced from specified locations within the reservoir.

## **Reservoir Commissioning and Hand-over**

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All operational functionality shall be tested during commissioning of the reservoir and witnessed by Water Operations staff.

As part of the hand-over process, the documentation required includes but is not limited to;

- Asset Schedule
- As-Built Drawings
- Functional Descriptions
- Sequential Function Charts
- Moscad / PLC Software
- In Touch Software
- Manufacturer's Manuals
- Commissioning Sheets
- Maintenance programmes

Three copies of the above documentation shall be provided to Water Operations in a specified format.

## **Reservoir operation**

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Designers should be aware of the operating regime that will relate to the structure being designed.

Operation of Service reservoirs to maintain storage capacity shall be as follows:

- Overall reservoir storage shall not be permitted to fall below one day's average demand.
- Reservoirs which supply discrete areas should be normally operated between full and 75% full. In other cases, except for maintenance purposes, each reservoir should fluctuate between full and half full.
- Reservoirs which are now below hydraulic gradient shall have residual chlorine maintained at 1ppm either by manipulating pumps and valves fortnightly to induce inflow and outflow or by manually adding calcium hypochlorite.

### **Inspections**

Five yearly inspections of service reservoirs are required in order to check for:

- structural integrity, spalling concrete, subsidence

- sealant integrity and leakage to underdrains
- sediment build up anything over 100mm should be removed
- broken (collapsed, sheared, or stretched) stormwater drains (these can contribute to earth movement especially for reservoirs on Waitemata mud stone knolls).

## **APPENDIX A Standard and Reference Documents**

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Concrete Pipe Association of Australia, Concrete Pipe Selector, version  
4.0, CPAA 2000

## APPENDIX B Standard and Reference Drawings

### Chambers

		Current Title	Proposed Title
2005121	001		Water reticulation design guidelines Chambers valves and pipework Configuration and dimensions
2001979	017	Watercare Services water reticulation Standard chamber covers Construction details	Water reticulation standard Rectangular chamber cover Construction details
2001979	051	Watercare Services water reticulation Standard extendable aluminium access ladder Plan section & bracket detail	Water reticulation standard Extendable aluminium access ladder Plan section & bracket detail
2001979	059	Watercare Services water reticulation Standard fixed aluminium access ladder Plan, section and bracket details	Water reticulation standard Fixed aluminium access ladder Plan, section and bracket details
2001979	077	Watercare Services water reticulation Standard fixed aluminium access ladder Details of access ladder & lids	
2001979	078	Watercare Services water reticulation Standard extendable aluminium access ladder Details of manhole access lids	

### Hatch covers

2001979	001	Watercare Services water reticulation Standard sealed access hatch Assembly (sheet 1 of 2)	Water reticulation standard Sealed access hatch cover Layout and component list
2001979	002	Watercare Services water reticulation Standard sealed access hatch Assembly (sheet 2 of 2)	Water reticulation standard Sealed access hatch cover Assembly details
2001979	003	Watercare Services water reticulation Standard sealed access hatch Component 1	Water reticulation standard Sealed access hatch cover Frame and details
2001979	004	Watercare Services Water reticulation Standard sealed access hatch Component 2	Water reticulation standard Sealed access hatch cover Cover and details
2001979	005	Watercare Services water reticulation Standard sealed access hatch Components 7, 8, 9, 10, 14	Water reticulation standard Sealed access hatch cover Cover stay and packer components
2001979	006	Watercare Services water reticulation Standard sealed access hatch Components 3, 4, 5, 6, 15	Water reticulation standard Sealed access hatch cover Hinge and clamp details
2001979	007	Watercare Services water reticulation Standard sealed access hatch Components 11, 12, 13, 16, 17, 18	Water reticulation standard Sealed access hatch cover Cover stay components

**Pipe and flange manufacture**

2001979	018	Watercare Services water reticulation Standard pipelines Steel pipe spigot and socket joints	Water reticulation standard Steel pipe spigot and socket joints Design dimensions
2001979	065	Weld neck flanges 100 to 200	Water reticulation standard Steel weld neck flanges Flanges 100 N.B. 150 N.B. & 200 N.B.
2001979	066	Weld neck flanges 250 to 400	Water reticulation standard Steel weld neck flanges Flanges 250 N.B. 300 N.B. & 400 N.B.
2001979	067	Weld neck flanges 450 to 600	Water reticulation standard Steel weld neck flanges Flanges 450 N.B. 500 N.B. & 600 N.B.
2001979	068	Weld neck flanges 700 to 900	Water reticulation standard Steel weld neck flanges Flanges 700 N.B. 800 N.B. & 900 N.B.
2001979	069	Weld neck flanges 1000 to 1700	Water reticulation standard Steel weld neck flanges Flanges 1000 N.B. 1200 N.B. & 1700 N.B.

**Pipeline construction**

2001979	039	Watercare Services water reservoirs Standard reservoir equipment Steel post & brackets for harness safety lines	Water reticulation standard Reservoir safety equipment Steel post & brackets for harness safety lines
2001979	019	Watercare Services water reticulation Standard pipelines CLS pipe welding and testing details	Water reticulation standard CLS pipe joints Welding and testing details
2001979	021	Watercare Services water reticulation Standard bolt tightening sequence 32 hole flange to 48 hole flange	Water reticulation standard Bolt tightening sequence 32 hole flange to 48 hole flange
2001979	022	Watercare Services water reticulation Standard bolt tightening sequence 8 hole flange to 28 hole flange	Water reticulation standard Bolt tightening sequence 8 hole flange to 28 hole flange
2001979	031	Watercare Services water reticulation Standard tapping ports Tapping ports for cast iron and concrete lined pipes	Water reticulation standard Pipeline tapping ports Details for cast iron and steel pipes
2001979	060	Watercare Services water reticulation Standard pipelines CLS pipe bend setout details	Water reticulation standard CLS pipeline bends Setout dimensions
2001979	061	Watercare Services water reticulation Standard pipelines Scour valve chamber details – sheet 1	Water reticulation standard Scour valve chamber Details – sheet 1 of 2
2001979	062	Watercare Services water reticulation Standard pipelines Scour valve chamber details	Water reticulation standard Scour valve chamber Pipe reinforcement and details– sheet 2 of 2
2001979	063	Watercare Services water reticulation Standard pipelines 150mm dia & 80mm dia air valve chamber details – sheet 1	Water reticulation standard Chamber for 150mm dia & 80mm dia air valves Chamber and details

2001979	064	Watercare Services water reticulation Standard pipelines 150mm dia & 80mm dia air valve chamber details – sheet 2	Water reticulation standard 150mm dia & 80mm dia air valves Pipe reinforcement details
2001979	074	Watercare Services water reticulation Standard pipelines Access manhole – bolted down type	Water reticulation standard Access manhole Bolt down type
2001979	075	Watercare Services water reticulation Standard pipelines Access manhole – weld down type	Water reticulation standard Access manhole Weld down type
2001979	092	Standard CLS & plastic pipe installation Pipes in trench Typical bedding, backfill and reinstatement details	Reticulation standard CLS & plastic pipe pipes in trench Typical bedding, backfill and reinstatement details
2000244	021	Standard pipe bedding Details Concrete and ceramic pipes	Reticulation standard Concrete and ceramic pipes in trench Typical bedding, backfill and reinstatement details

### Flowmeters

2001979	020	Watercare Services water reticulation Standard magflow meters Magflow meter – earthing details	Water reticulation standard Magflow meter Installation details in steel pipeline
2001979	071	Watercare Services water reticulation Standard magflow meters – buried installations Magflow meter – earthing details	Water reticulation Magflow meters – buried installation Installation details

### Reservoirs

2001979	009	Watercare Services water reservoirs Standard landing and ladders Details of hinge, support and gate catch	Water reticulation standard Reservoir landing and ladders Details of hinge, support and gate catch
2001979	010	Watercare Services water reservoirs Standard landing and ladders Plans and details of landing, end plates and lower steps	Water reticulation standard Reservoir landing and ladders Plans and details of landing, end plates and lower steps
2001979	011	Watercare Services water reservoirs Standard landing and ladders Plans and elevations of alternative landings	Water reticulation standard Reservoir landing and ladders Plans and elevations of alternative landings
2001979	014	Watercare Services water reservoirs Standard latch crox lock Components 1 and 2	Water reticulation standard Reservoir latch crox lock Components 1 and 2
2001979	015	Watercare Services water reservoirs Standard reservoir access tower Details – sheet 1	Water reticulation standard Reservoir access tower Details – sheet 1
2001979	016	Watercare Services water reservoirs Standard reservoir access tower Details – sheet 2	Water reticulation standard Reservoir access tower Details – sheet 2
2001979	053	Standard water structures Positioning of reservoir roof hatches Details of roof hatches over existing openings	Water reticulation standard Positioning of reservoir roof hatches Details of roof hatches over existing openings

2001979	054	Standard water structures Reservoir vent covers and hole cover plates Details of vent covers over existing openings	Water reticulation standard Reservoir vent covers and hole cover plates Details of vent covers over existing openings

**Miscellaneous**

2001979	008	Watercare Services water reticulation Standard roadway security gate General arrangement and gate catch details	Water reticulation standard Roadway security gate General arrangement and gate catch details
2001979	029	Watercare Services water reticulation Standard CLS pipe testing Gen arrangement and details of stop ends type 1 to type 4	Water reticulation standard CLS pipe testing stop ends type 1 to type 4 General arrangement and details
2001979	032	Watercare Services water reticulation Standard manhole soffit plate for flow streamlining Details and elevation on soffit plate	Water reticulation standard Manhole soffit plate for flow streamlining Details and elevation on soffit plate
2001979	033	Watercare Services water reticulation Standard Moscad RTU Pole mounting plate	Water reticulation standard Antenna pole mounting plate Details
2001979	034	Watercare Services water reticulation Standard single and double tap Details of sample box	Water reticulation standard Single and double sample tap Details of sample box
2001979	047	Watercare Services water reticulation Standard handrail for non public areas Elevation and fixing details side wall mounting	Water reticulation standard Handrail for non public areas Elevation and fixing details side wall mounting
2001979	048	Watercare Services water reticulation Standard handrail for public areas with children under 6 Elevation and fixing details side wall mounting	Water reticulation standard Handrail for public areas with children under 6 Elevation and fixing details side wall mounting
2001979	049	Watercare Services water reticulation Standard handrail for non public areas Elevation and fixing details top surface mounting	Water reticulation standard Handrail for non public areas Elevation and fixing details top surface mounting
2001979	050	Watercare Services water reticulation Standard handrail for public areas with children under 6 Elevation and fixing details top surface mounting	Water reticulation standard Handrail for public areas with children under 6 Elevation and fixing details top surface mounting
2001979	055	Watercare Services water headworks 'V' notch seepage weirs Typical details	Water reticulation standard 'V' notch seepage weirs Typical details
2001979	076	Watercare Services water reticulation Standard ventilation louvre boxes Single and double duct systems	Water reticulation standard Ventilation louvre boxes Single and double duct systems
2001979	079	Watercare Services water reticulation Standard aluminium bracket for access ladders Typical details	Water reticulation standard Aluminium bracket for access ladders Typical details