C1 INTRODUCTION

The following design criteria have been prepared as a general guideline to watermain design and layout. Prior to commencing design, the Consulting Engineer shall discuss with the City their specific requirements with respect to the design service area, sizing and modelling requirements for the proposed watermain system. For further information and background, the Consulting Engineer shall refer to the "Guidelines for the Design of Water Distribution Systems" prepared by the Ministry of Environment Culture and Parks.

City watermains shall be designed using the greatest possible demand considering the full range of potential land uses which could occur in an area. The Consulting Engineer shall consider all potential uses in an area as well as the potential density to which the area could be developed in future. It is recommended that assumptions be reviewed with the City before a system is designed. Long term land uses shall be considered in accordance with the City's Official Plan and approved Secondary Plans.

The design shall encourage movement of water through all water system lines and eliminate dead ends and parts of systems where water stagnation can occur resulting in potential reduction of residual chlorine below limits set by Safe Drinking Water Act (SDWA).

The following Design Criteria are provided as a guide for the design of typical developments, which shall contain a variety of users. For specific sites, actual flow requirements shall be determined where high water uses are expected.

Residential demand and peaking factors have been adopted from the Region of York (Region) practices, however, for local mains in non-residential areas in the City, a more site specific criteria than the Region uses is required.

The Consulting Engineer shall ensure that all design work has been prepared in accordance with all applicable codes and regulations and MECP requirements.

C2 DESIGN WATER DEMANDS

C2.1 Design Demand

Watermains shall be sized to meet the greater of either:

- Maximum day demand plus fire flow or
- Maximum hour demand

C2.2 Fire Flow

Fire flows shall be calculated as outlined in the current edition of "Water Supply for Public Fire Protection, A Guide to Recommended Practice" by the Fire Underwriters Survey, as follows:

- Residential minimum 7,000 l/min
- Non-Residential shall be designed in accordance with the "Water Supply for Public Fire Protection, A Guide to Recommended Practice" by the Fire Underwriter Survey

C2.3 Population

Population and equivalent population shall be calculated on the basis of the following population densities:

Table 1: Population and Equivalent Population

Residential Unit Type	People/Unit
Single Family Detached/Semi-Detached Houses	4.0
Townhouses	3.8
Apartments	3.0
Non-Residential Land Usage	**Equivalent Population**
Schools	60 people/ha of gross floor area
Light Industrial (No major office component)	70 people/ha of gross floor area
Offices	150 people/ha of gross floor area
Commercial (Retails)	100 people/ha of gross floor area
Heavy Industrials (flow demands to be calculated from first principles)	Use First Principles
Mixed Uses	330 people/ha of site area

C2.4 Average Day Consumption Rates

- Residential 365 l/c/d (Litre/Capita/Day)

C2.5 Peaking Factors

In order to calculate various demand conditions, the following Peaking Factors shall be applied to the Average Day Consumption Rates:

Table 2: Peaking Factors

Condition	Peaking Factors	
	Residential	Non-Residential
Maximum Daily Demand	2.0	1.4
Maximum Hour Demand (PM)	4.5	0.8
Maximum Hour Demand (AM)	2.0	2.5
Minimum Hour	0.7	0.7

C3 HYDRAULIC DESIGN

C3.1 Design Flow

The design of water distribution system shall be based on the Hazen Williams Equation.

$$Q = 0.84918\ CAR^{0.63}\ S^{0.54}$$

Where Q = Flow (m^3/s)

A = Cross-Sectional Flow Area (m^2)

C = Coefficient of Roughness

R = Hydraulic Radius (m)

S = Slope of the Energy Grade Line (m/m)

The following Hazen-Williams "C" values, as recommended by MECP, shall be used for the design of water distribution systems, regardless of material:

Table 3: Hazen-Williams C-Factor

Diameter (mm)	C-Factor
150	100
200-250	110
300-600	120
Over 600	130

In evaluating existing systems for expansion, the C-factor shall be determined by actual field tests, wherever possible. Should the field tests value for C-factor be greater than the above, then the above values shall be used.

C3.2 System Pressures

The maximum recommended static pressure shall be 650 KPa (95 psi). The Consulting Engineer shall indicate on the plot plans and any water distribution analysis, where the maximum static pressures shall exceed 550 KPa (80 psi), in which case pressure reducing valves (PRV) are required inside the building before the meter. In no case can the pressure on the system exceed 700 KPa (100 psi).

The pressure during maximum hourly demand shall not fall below 300 KPa (44 psi).

The pressure during simultaneous maximum day demand & fire flow shall not fall below 140 KPa (20 psi).

C3.3 Minimum Pipe Sizes

Residential Developments	150 mm diameter or 50 mm diameter copper on cul-de-sacs as per Standard Drawings
Industrial/Commercial Developments	300 mm diameter

C4 WATERMAIN

C4.1 Location

Watermains shall be placed on the side of the road with the most service connections in accordance with Standard Drawings and **always** within the widest boulevard. The prefered location for the watermain is on the north and east side of the road. All watermains shall be designed as looped sytems in order to eliminate dead ends, wherever possible.

Watermains shall not be constructed under culverts. In this case, watermains shall be designed to go around end of culverts. Should a watermain cross a watercourse, TRCA approval will be required.

C4.2 Depth

All watermains and appurtenances shall have a minimum cover of 1.75 m below road centreline. At watercourses, creeks, culverts, ditches etc. a minimum of 1.2 m cover from the obvert to the finish grade shall be permitted when adequate frost protection is provided. In all cases, maximum cover shall not exceed 2.25 m, except at crossings.

C4.3 Clearances

Clearances between sewers and watermains shall be designed in accordance with the M.O.E. design guidelines. The clearance requirements for normal conditions are summarized below.

Sanitary sewers shall cross under watermains with sufficient vertical separation (minimum 0.50 m) to allow for proper bedding and structural support of the watermain and sewer main.

Where it is not possible for the sewer to cross under the watermain, the sewer shall cross above the watermain with a minimum of 0.5 m between the top of the watermain and the outside face of the sewer. The sewers shall be adequately supported to prevent excessive deflection of joints and settling. The length of the watermain shall be centred at the point of crossing so that the joints are equidistant and as far as possible from the sewer.

Parallel sewer and watermain installations shall maintain a minimum horizontal clearance of 2.5 m or latest MECP requirements.

Water box shall be located with minimum 0.3 m clearance from the driveway.

C4.4 Cul-de-Sacs and Dead-ends

Wherever possible, the distribution system shall be designed to be looped to eliminate dead-end sections. Watermains on cul-de-sacs shall be looped through an easement or dedicated block to an adjacent watermain, as a preferred option.

If looping to an adjacent watermain is not feasible, then it shall be looped back to the main system (Refer Option 1; MW 29).

If looping back to the main system is not feasible as per the given criteria, then 50 mm minimum diameter copper watermain shall be used in the cul-de-sac bulb only, providing domestic supply (Refer Option 2; MW 29). A maximum of 16 houses may be served with the 50 mm copper watermain. Hydrants in this option shall be on a dedicated 150 mm service connected to the distribution main on the intersecting street.

If any of the above options are not feasible, then an auto flushing station shall be provided at the end of cul-de-sac (Refer Option 3; MW 29). This option can only be used for temporary situations.

Two separate supply feeds shall be required to ensure adequacy and reliability of water supply at all times for fire fighting purposes unless accepted by the Fire Chief. A single feed up to a maximum of 16 houses is acceptable (Refer Option 2: MW 29).

An auto flushing station is required at the temporary dead end.

C4.5 Watermain and Fittings Materials

For complete use of accepted products – refer to the most current version of City of Markham Approved Materials List (Annex 3A).

A chamber shall be required at all locations wherever there is a change on the watermain material. All couplers used in the chamber must be listed on the Approved Materials List (Annex 3A).

PVC

Class 150, DR-18 to AWWA C-900

Copper

Type K copper to ASTM B-88

Ductile Iron

Manufactured to AWWA C-152 with standard thickness cement lining (AWWA C-104), push on joints complete with bonding straps or lock wedges

Table 4: Size and Class

Size	Class
Up to and including 300 mm dia	52
400, 600 mm dia	53
Crossings	54 or as specified
Casing Spacers	Select from Waterworks accepted Product List

Fittings

- Ductile iron to AWWA specification C-135 Class 350
- All fittings supplied with MJ glands and gaskets, cor blue nuts and bolts

Couplings

- Cast couplings supplied with stainless bolts and nuts, epoxy coating and shall conform to AWWA C114

Flanged Coupling Adapters

- Supply with stainless steel bolts and nuts and epoxy coating

Tapping Sleeves

- Stainless steel only, for all pipe materials, constructed entirely of type 304 stainless steel, all welds to be fully passivated by chemical dip method

Table 5: Tapping Size

Main Size (mm)	Maximum Tapping Size (mm)
150	150
200	200
250	250
300	300
400	400

Service Saddles

- Double bolt manufactured of type 304 Stainless Steel welded construction completely passivated by chemical dip method
- Tap to be AWWA thread
- Sizing as follows; AC pipe - all sizes
  PVC pipe - all sizes
  DI pipe - 32 mm – 50 mm
  CI pipe - 32 mm – 50 mm

Repair Clamps

- Manufactured of type 304 Stainless Steel, welded construction, completely passivated by chemical dip method
- Taper gasket and copper electrical continuity strip

Horizontal Bends

90° bends are acceptable for watermain below 300 mm

Two - 45° bends shall be provided for watermain 300 mm or greater when making 90° turn

If the construction experiences site specific constraints, the Director of Engineering may approve 90° bends in consultation with the Director of Environmental Services

Vertical Bends

Maximum vertical bends, for any size of watermain, shall not be more than 45°. Two - 22.5° bends are preferable as compared to one-45° bend

C4.6 Backflow Prevention Devices

To comply with AWWA C506-78, the following device size shall be used:

Table 6: Device Size

Watermain Size (mm)	Device Size (mm)
100 – 150	25
200-250	40
300 and up	50

C4.7 Protective Coatings

All metal fittings and metal pipe in chambers or direct bury, with the exception of hydrants and fittings of all stainless steel construction, shall have protective coatings applied.

Protective coatings shall be petroleum based products consisting of a primer paste, cold applied mastic and cold applied anti-corrosion tape, applied to manufacturers' specifications and/or the City inspector.

Aluminum foil duct tape to be applied to PVC watermain immediately adjacent to MJ glands to prevent anti-corrosion tape from contacting the pipe.

C4.8 Joint Restraints

PVC Pipe

- Conform to AWWA C900-89 or C905-88 and shall adhere to UNI-B-13-92 and ULC standard testing procedures

Ductile Iron Pipe

- Conform to AWWA/ANSI C151/A21.51-91 and shall adhere to ULC standard testing procedures

C4.9 Tracer Wire

Tracer wire shall be installed on all non-metallic watermains (PVC, HDPE and Concrete Pressure Pipe) with fibre tape placed at 3.0 m intervals

Materials

- 12 gauge stranded copper with TWU insulation
- joined by use of bronze split bolt connectors and wrapped with rubber insulating tape and electrical tape

C4.10 Sacrificial Anodes

Sacrificial anodes shall be installed on metal watermains and fittings in accordance with Standard Drawings

All metallic fittings, excluding boot of hydrant, shall be wrapped with accepted petroleum tape ("Denso" or equivalent)

Anodes to be installed on all buried metallic fittings, except for stainless steel

Anode connections to be cadwelded only. Cadweld site to be coated with TC mastic or accepted equivalent. Connections to copper pipe to be completed with a stainless steel gear clamp or a ground clamp

Materials

a) Zinc: High grade zinc of 99.9% purity conforming to alloy specification ASTM B-418

Packaged in water permeable cardboard container filled with 20% bentonite/5% sodium sulphate/75% gypsum mixture

Supply with 3 m of #10-7 strand copper wire with THW insulation silver soldered to a ¼" electro-galvanized steel core extending 100% of the anode length

b) Magnesium: Primary metal only conforming to alloy specification ASTM B843-93

Packaged in water permeable cardboard container filled with 20% bentonite/5% sodium sulphate/75% gypsum mixture

Supply with 3 m of #10-7 strand copper wire with THW insulation silver soldered to a ¼" electro-galvanized steel core extending 100% of the anode length

C4.11 Foam Swabbing

All new watermains up to and including 300 mm, shall be cleaned by foam swabbing to remove all debris in the pipeline in accordance with "Water Testing Procedures" -Appendix XII (refer to City's "Municipal Inspection & Construction Guidelines").

C4.12 Water Quality Sampling, Pressure Testing and Disinfection

All quality sampling, pressure testing and disinfection shall be conducted in accordance with "Water Testing Procedures"-Appendix XII (refer to City's "Municipal Inspection & Construction Guidelines").

C4.13 Restraint/Thrust Blocks

All watermains constructed in fill area shall have restrained joints restraining 12.0 m (two pipe lengths) beyond the fill area.

Joint restrainers and/or concrete thrust blocks shall be used on all fittings. Joints to be restrained in all opposing direction of thrust forces. In accordance with Standard Drawings, all vertical bends and adjacent joints shall be restrained by accepted restrainers.

All fittings which shall be cut into an existing watermain pipe shall be specifically designed to be self restrained.

Concrete thrust blocks shall be installed at all horizontal and vertical bends, tees and dead ends in accordance with Standard Drawings.

C4.14 Metering Requirements

Buildings that shall be metered individually require separate water service connections to the public main.

If multiple buildings shall be served by a single connection to the main, then a bulk meter is required, in accordance with the Standard Drawings.

Meter size shall be determined by the Consulting Engineer based upon the flow rate and water demand, not just the size of service connection provided.

For meters placed inside a building, cable and conduit shall be provided to the outside to enable remote reading.

C4.15 Suspended Watermains

Suspended watermains from bridges, or other superstructures, shall require approval from the owner of the superstructure) and shall be properly insulated and heat traced. Weatherproofing jackets shall be applied to cover the insulated watermains. The thickness of the insulation shall be minimum 50 mm or as approved by the City. The location(s) of the available power source for connection of the heat tracing system shall be confirmed with the City.

Where a watermain is proposed to be suspended over a watercourse, the design shall verify whether the associated crossing structure spans the 100-year erosion limit of the watercourse prior to considering the design (*TRCA Crossings Guideline for Valley and Stream Corridors*, Sept 2015).

C5 HYDRANTS & APPURTENANCES

C5.1 Maximum Spacing

The following spacing shall be used:

Table 7: Maximum Spacing for Hydrants

Residential areas (excluding Townhouses)	120 m maximum spacing or a maximum hose length of 75 m whichever is more stringent
Townhouses and High-rise Residential areas	90 m maximum spacing or a maximum hose length of 75 m whichever is more stringent
Industrial, Commercial, Institutional areas	90 m maximum spacing or a maximum hose length of 75 m whichever is more stringent

C5.2 Hydrant Location

- Hydrants shall be located on the extension of the side lot line if possible. In all cases hydrants shall be a minimum of 1.2 m from driveways, trees, bushes, poles, posts, etc. and other vertical obstructions.
- Fire hydrants shall be installed at the ends of the rear laneways on the street boulevard.
- A hydrant shall be installed at the turnaround of every cul de sac.
- Hydrants are not permitted in laneways.
- Hydrants are required at high points in the watermain that are greater than 250mm.

C5.3 Hydrant Materials

To conform to ANSI/AWWA C-502, have FM and ULC approvals and supplied as follows:

Nozzles

- 2 – 65 mm CSA hose nozzles
- 1 – 100 mm storz nozzles with black cap marked “STORZ”

Operation

- Left hand open

Seating

- Brass seat casing to brass main valve seat, fully draining

Connection

- MJ Boot

Intermediate Section

- Ductile iron with break away flange at ground level
- Internal operating rod to have break away coupling at ground level
- Zinc anode installed on operating rod just above the drip valve
- Hydrant shall be clearly marked on the outside indicating brass to brass seating, draining, zinc anode and depth of bury

Upper Barrel

- Shall be able to position upper barrel at any angle to obtain proper orientation to the street
- Clearly mark with manufacturer's name, model number and date of manufacture

Protective Coatings

Treat with protective coatings to comply with the following specifications:

- Surface preparation – commercial sand blasting (SSPC-SP6-63)
- Base Coat – Belzona liquid anode applied as per the manufacturer's specifications (factory installed)
- Finish Coat – Tremclad Rust Paint standard yellow
    - damaged base coat areas to be properly touched up with liquid anode prior to finish coat

Hydrant Extensions

- Multiple extensions on one hydrant are not accepted
- Break away flange required at ground level
- Extension rod to have break away coupling at ground level

C5.3 Anti-tampering Devices

Accepted anti-tampering devices shall be installed on all hydrants after watermain passes all required testing and system water quality is accepted by the Director of Engineering.

Materials

- To be cadmium or zinc plated steel with a 75 mm yellow reflective adhesive stripe on the entire length of both outer sides
- Designed so that operating nut and nozzle caps cannot be turned, secured to the hydrant by banding strap

- Banding strap to be of metal material which is easily broken by hydrant key for emergency use by the Fire Department

C5.4 Fire Flow Test

Fire flow tests shall be conducted on all hydrants upon completion of any new watermain and prior to building permit availability.

C6 VALVES

C6.1 Valve Locations

Intersections

- Tee-Intersections 2 valves
- Cross-Intersections 3 valves

The valves shall be located at the point where the projection of the street line intersects the watermains.

Additional valves may be required at the request of the Director of Engineering.

Maximum Spacing

300 m or maximum 40 service connections. No more than four valves to be operated to isolate a section of watermain

C6.2 Valve Materials

- Valves supplied for projects west of McCowan Rd. (centre line) shall be left hand close
- Valves supplied for projects east of McCowan Rd. (centre line) shall be right hand close

Only gate valve is permitted for watermain 400 mm and smaller, in general. Butterfly valves are to be used for watermain 450 mm and larger upon acceptance of the Director of Engineering.

Gate valves and Butterfly valves (if permitted), shall be to the following specifications:

Gate Valves

- 100 – 400 mm size shall be resilient seat to AWWA C-509
- MJ or flanged ends as required
- With 304 stainless steel trim
- With 50 mm square operating nut
- MJ valves supplied with MJ glands and gaskets, cor blue bolts and nuts
- Flanged valves supplied with red rubber gaskets and 304 stainless steel nuts and bolts

Butterfly Valves

- Use for valves 450 mm and larger to AWWA C-504
- Valve operator suitable for continuous submersion and manufactured by the valve manufacturer
- MJ or flanged ends as required
- With 304 stainless steel trim
- With 50 mm square operating nut

- MJ valves supplied with MJ glands and gaskets, cor blue bolts and nuts
- Flanged valves supplied with red rubber gaskets and 304 stainless steel nuts and bolts

Valve Boxes

- 100 mm sliding type box
- 0.75 m length top section
- 1.75 m length lower section complete with guide plate

Valve Box Extensions

- Valve boxes shall be extended from the lower section only
- Cast iron of the same size diameter as the valve box lower section
- Coupled to the lower section by means of a flexible rubber coupling

Brass Fittings

Main Stops

- Conform to AWWA C-800
- To be ball valves
- Compression joint x compression joint

Curb Stops

- Conform to AWWA C-800
- To be ball valves
- Compression joint x compression joint
- Shall be available in draining type as specified

Corporation couplings

- Conform to AWWA C-800
- Compression joint x compression joint

C6.3 Valve Chambers

Conform to OPSS 1351 and CSA A257.4.

All valves greater than 50 mm shall be installed in a chamber. Chambers shall be drained to the storm sewer, where possible.

All mainline valves shall be installed in appropriate sized chambers regardless of the size of watermain.

The top of valve chamber manhole covers shall be set flush with finished grade with the word “WATER” cast in to the lid.

No valve chambers shall be constructed in driveways.

Adjuster Rings

- Round precast concrete adjustment units full circle type with Modulast, mortar joint at the valve chamber cap

- Outside surface to be completey parged prior to backfill

C6.4 Air Valves and Drain Valves

Air valves shall be required at all significant high points. Drain valves shall be required for all significant low points of the distribution system for 250 mm and larger pipes and as directed elsewhere by the Director of Engineering.

Materials

Air valves shall be:

- 25 mm and have 25 mm F.I.P. inlet
- Installed using accepted service saddle and 25 mm AWWA x 25 mm F.I.P. main stop (ball type)
- 25 mm x 100 mm brass nipple shall be used to connect the air valve to the main cock

C7 DISTRICT METERING AREA CHAMBERS

District Metering Area (DMA) chambers are required for new developments where required by the Director of Engineering and in consultant with the Waterworks Department. The size of the chamber shall be determined by the number of metering equipment required.

C8 PERMANENT SAMPLING STATIONS

Sampling stations shall be installed in a location identified by the Director of Engineering. Number and locations of sampling stations shall be based on distribution system model.

C9 FLUSHING STATIONS

A 50 mm diameter pipe attached to a flushing station shall be provided at permanent and temporary dead end watermains (see Standard Drawings MW 7A and MW 7B).

C10 SERVICE CONNECTIONS

For water service connections, refer to Section M – Service Connections.

C11 FIRE SERVICES GENERAL REQUIREMENTS

For hydrant location requirements, see Section C5.

The following is a list of general review criteria for residential developments and shall generally comply with City's By-law 005-104, as amended.

C11.1 Building permits cannot be issued until the following matters have been addressed to the satisfaction of the City's Fire Services:

- a water flow test has been conducted in accordance with NFPA Standard 291 and at no point in the system are the following flow standards for firefighting purposes not met: 7,000 l/m at 140 kpa for detached Residential Units, Multiple-Unit Buildings or such other standards adopted by the City's Fire Services.
- fire flow tests shall be witnessed by the Fire Services.

- two separate accesses into any Subdivision have been provided and kept open for the purposes of emergency services access and egress.
- if two separate accesses c/w full moves cannot be provided, as required above, then:
  a. a single access into any development may be permitted where any Residential Unit or any Multiple-Unit Building to be constructed is not more than 100 m away measured along the said access, from an existing, assumed public highway that is connected to the said single access; or

  b. sprinkler system is provided for all units.

C11.2 Two separate water connections shall be required to ensure adequacy and reliability of the water supply at all times for firefighting purposes unless accepted by the Fire Services. A single feed up to a maximum of 16 houses is acceptable as per Standard Drawing MW29 (Option 2).

C11.3 Watermains not less than 150 mm diameter may be permitted provided modelling is submitted to demonstrate sufficient flows and pressure.

C11.4 Townhouse blocks shall not exceed 45 m in length unless every unit is sprinklered.

C12 MATERIAL SPECIFICATIONS

Refer to the latest “Materials Specifications” issued by the Waterworks Department, attached as Annex 3.

C13 DRINKING WATER WORKS PERMIT

Form 1 - Record of Watermains, duly signed by the Waterworks Department, is required prior to starting any servicing at site. The submission is reviewed and accepted by the City under the MOE Transfer of Review program.

Refer to Engineering Submissions Required Documents (Annex 1) for details.