CITY OF BURNABY

ENGINEERING DEPARTMENT

ADDENDUM #1 - December 2024

DESIGN CRITERIA MANUAL - November 2019

Addendum #1 to the Design Criterial Manual November 2019

The following are amendments to the City of Burnaby Engineering Department Design Criteria Manual, November 2019. These amendments are effective as of December 2024.

Section	Sub-Section	Type of Change	Change
1. Introduction	1.8 Burnaby Town Centre Standards	Add new sub-section 1.8	1.8 Burnaby Town Centre Standards This Design Criteria Manual shall be used in conjunction with the latest version of the Burnaby Town Centre Standards document, which specifies design criteria for all works within Town Centres as specified in the document.
3. Water Distribution	3.20 Service Connections	Delete last sentence of first paragraph and replace with	The minimum service size of all new development is 38mm.
6. Roads	6.10 Sidewalks and Walkways	Delete and replace paragraph two with	The following minimum requirements apply to sidewalks: • Minimum width: 1.8 m (excluding adjacent curb) • Cross-slope: 2%, except at driveways and wheelchair ramps • Drainage: Slope towards gutter Walkway widths and grade requirements are indicated in Tables 6.1 and 6.2, respectively
6. Roads	6.2 Road Classifications	Revise reference to figures	Revise all reference to figures in this section as per the following: Figure A3 – Burnaby Major Roads Figure 6.9 – Arterial Primary Figure 6.8 – Arterial Secondary Figure 6.7 – Major Collector Primary Figure 6.6 – Major Collector Secondary Figure 6.5 – Major Collector Greenway Figure A4 – Burnaby Minor Roads Figure 6.3 – Local Collector Figure 6.2 – Local Residential Figure 6.1 – Lanes

<table>
<tr><td>6. Roads</td><td>Figure 6.2</td><td>Remove and replace with</td><td>Figure 6.2, dated October 2024, attached. Updated figure includes 1.8m minimum sidewalk width and back boulevard width that varies.</td></tr>
<tr><td>6. Roads</td><td>Figure 6.3</td><td>Remove and replace with</td><td>Figure 6.3, dated October 2024, attached. Updated figure includes 1.8m minimum sidewalk width and back boulevard width that varies.</td></tr>
<tr><td>6. Roads</td><td>Figure 6.1</td><td>Add new figure</td><td>Figure 6.1, dated October 2024, attached.</td></tr>
<tr><td>6. Roads</td><td>6.16.5 Minimum Pavement Structure for Asphalt Concrete (A.C.) Pavement</td><td>Remove and replace with</td><td>Remove entire table in section and replace with:
<table>
<tr><th>Road Classification</th><th>Minimum Pavement Structure</th></tr>
<tr><td>Arterial & MRN</td><td>60mm Superpave 19nms (MRN Roads)/ 60mm Superpave 12.5nms (Arterial)
100mm Lower Course #1 (in two lifts)
100mm – 19mm Crushed Granular Base
300mm – 75mm Crushed Granular Subbase</td></tr>
<tr><td>Industrial & Commercial Roads (Local and Collector)</td><td>50mm Upper Course #1
100mm Lower Course #1 (in two lifts)
100mm – 19mm Crushed Granular Base
300mm – 75mm Crushed Granular Subbase</td></tr>
<tr><td>Multi-Family (Local and Collector)</td><td>50mm Upper Course #1
75mm Lower Course #1
100mm – 19mm Crushed Granular Base
250mm – 75mm Crushed Granular Subbase</td></tr>
<tr><td>Local</td><td>40mm Upper Course #2
45mm Lower Course #1
100mm – 19mm Crushed Granular Base</td></tr>
</table>
</td></tr>
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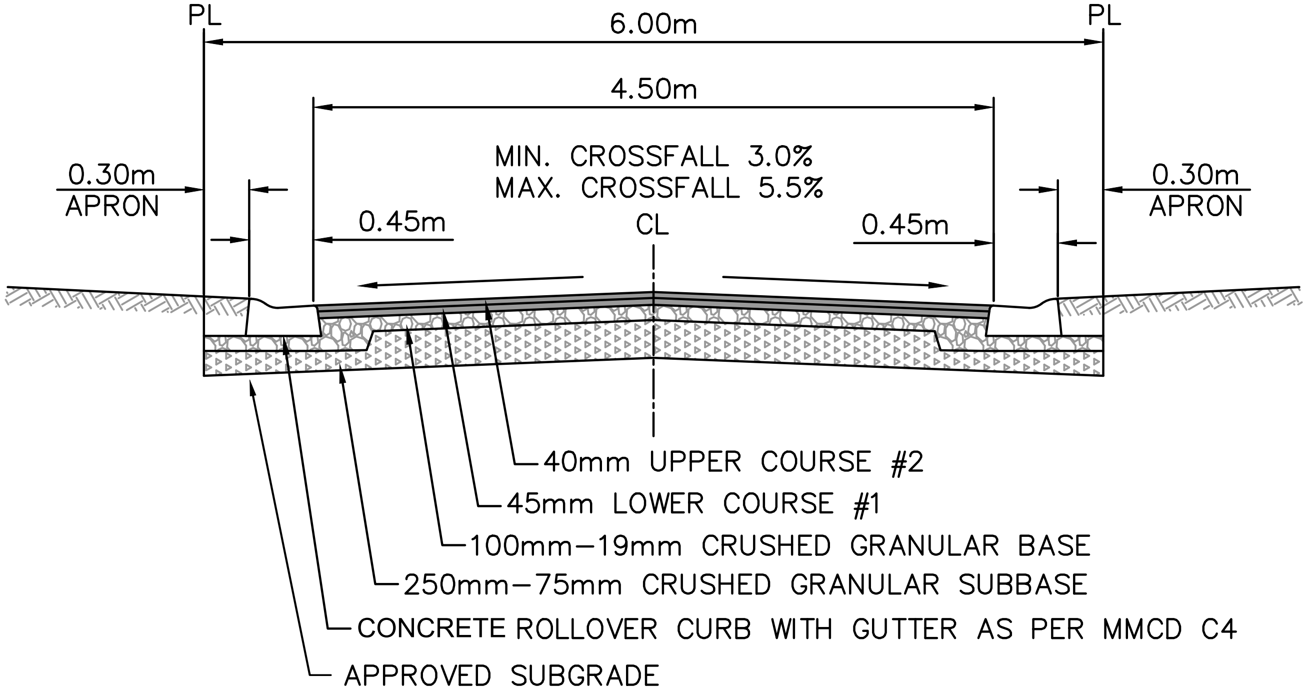
<table>
<tr><td></td><td></td><td></td><td><table>
<tr><td></td><td>250mm – 75mm
Crushed Granular
Subbase</td></tr>
<tr><td>Lane</td><td>40mm Upper Course #2
45mm Lower Course #1
100mm – 19mm
Crushed Granular Base
250mm – 75mm
Crushed Granular
Subbase</td></tr>
<tr><td>Multi-Use Path</td><td>35mm Upper Course #2
40mm Lower Course #2
75mm – 19mm Crushed
Granular Base
250mm – 75mm
Crushed Granular
Subbase</td></tr>
</table></td></tr>
<tr><td>Table of Contents</td><td></td><td>Remove and Replace list of figures with</td><td>Figure A4 – Burnaby Minor Roads
Figure 6.1 – Lanes
Figure 6.2 – Local Residential
Figure 6.3 – Local Collector
Figure A3 – Burnaby Major Roads
Figure 6.5 – Major Collector Greenway
Figure 6.6 – Major Collector Secondary
Figure 6.7 – Major Collector Primary
Figure 6.8 – Arterial Secondary
Figure 6.9 – Arterial Primary</td></tr>
</table>

END OF DOCUMENT

FIGURE 6.1



NOTES:

1. PAVEMENT STRUCTURE INCLUDING BASE GRAVELS TO BE AS PER CITY OF BURNABY DRAWING BBY–R114.
2. TYPE V CB'S ARE TO BE INSTALLED AT LOW POINTS AND CONNECTED TO STORM SEWER.
3. TYPE V CB'S ARE TO BE INSTALLED WHERE THE LANEWAY INTERSECTS A ROADWAY.
4. REFER TO BURNABY DRAWING BBY–S110 FOR TYPE V CB DETAILS.
5. PAVED APRONS ARE ONLY PERMITTED AT DRIVEWAYS, GARAGE DOORS AND/OR PEDESTRIAN ENTRANCES. OTHERWISE APRONS ARE TO BE GRAVEL OR GRASS.

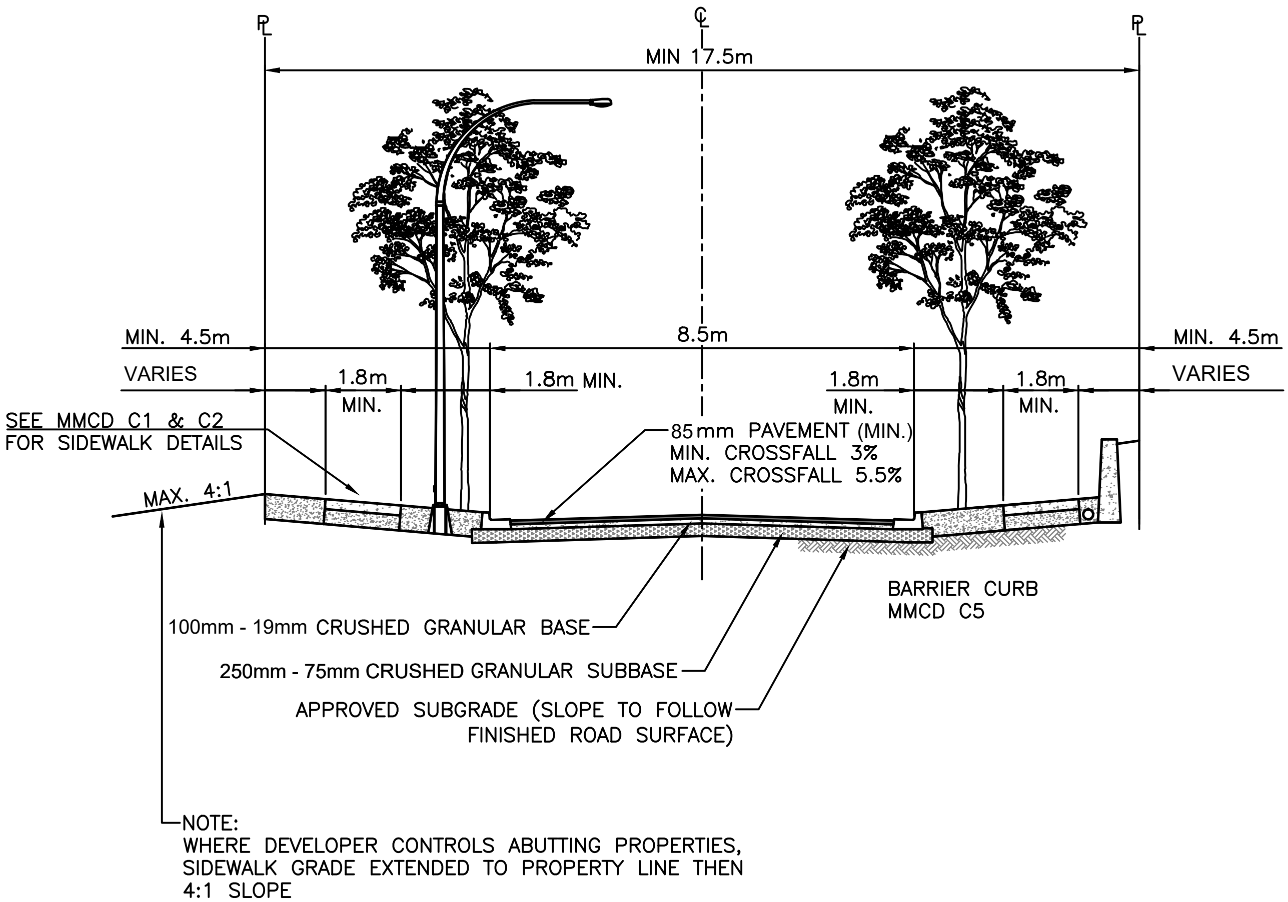
NO.	DATE	REVISION	APP'D	BY

City of Burnaby
ENGINEERING DEPARTMENT

TYPICAL LANE
CROWN SECTION

DRAWN BY: | SCALE: N.T.S.
APPROVED BY: | DATE: DEC 2024

FIGURE 6.2



NOTE:

1. WHERE DEVELOPMENT ABUTS EXISTING PROPERTIES, SIDEWALK GRADE EXTENDED TO 0.6m BACK OF WALK THEN 4:1 SLOPE AND/OR RETAINING WALL TO MEET EXISTING GRADE AT PROPERTY LINE.
2. MIN. PAVING UNDERTAKEN IN TWO LIFTS:
   LOWER COURSE MIN. 45 mm
   UPPER COURSE MIN. 40 mm
3. DRAIN TILE TO BE INSTALLED WHERE REQUIRD.
4. PLANTING AND SOD IN FRONT AND REAR BOULEVARDS TO MMCD STANDARDS AND BURNABY SUPPLEMENTALS.

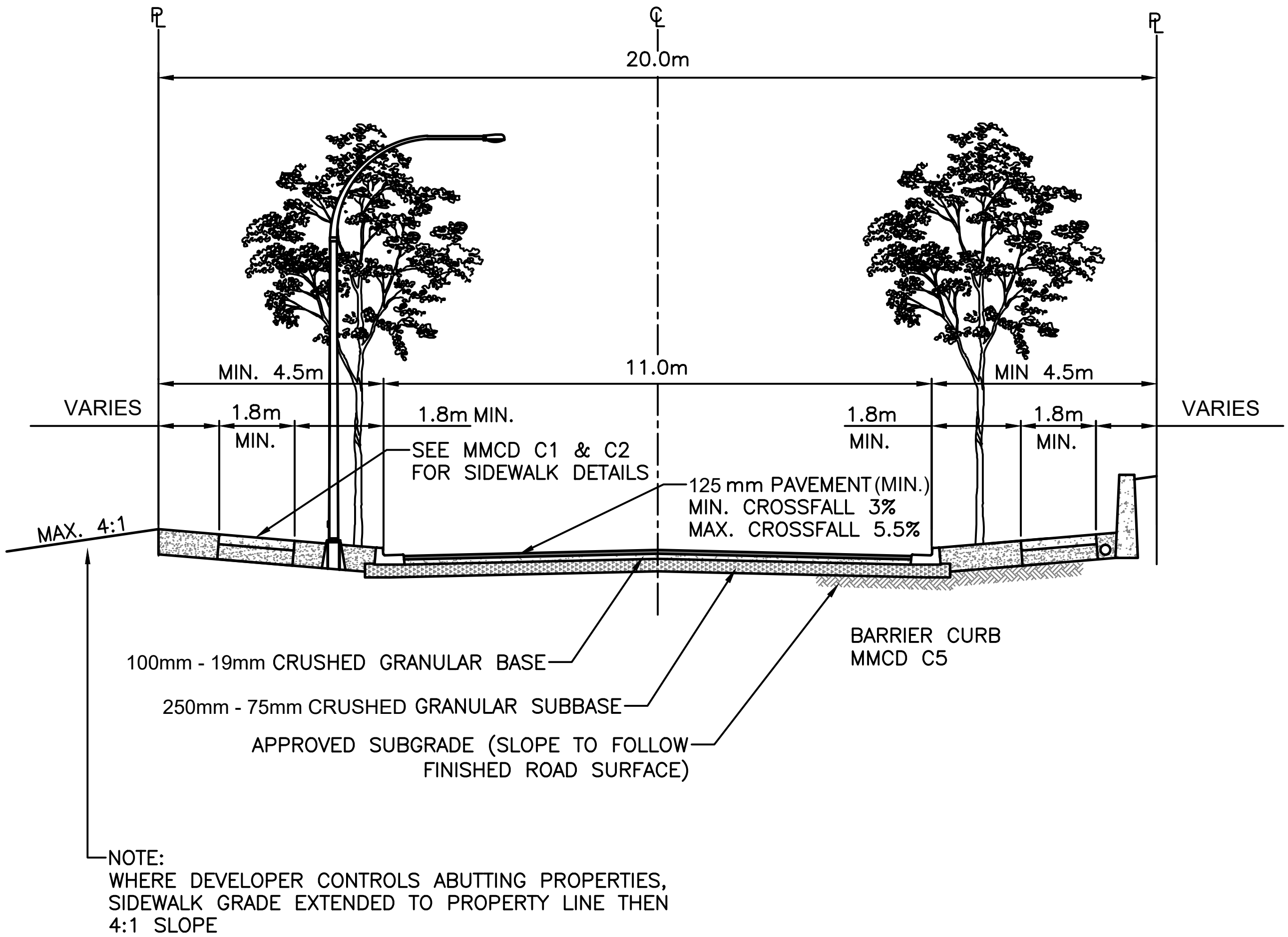
NO.	DATE	REVISION	APP'D	BY

City of Burnaby
ENGINEERING DEPARTMENT

LOCAL RESIDENTIAL
BURNABY MINOR ROADS

DRAWN BY:	SCALE: N.T.S.	BBY-
APPRV'D BY:	DATE: DEC 2024	

FIGURE 6.3



NOTE:
1. WHERE DEVELOPMENT ABUTS EXISTING PROPERTIES, SIDEWALK GRADE EXTENDED TO 0.6m BACK OF WALK THEN 4:1 SLOPE AND/OR RETAINING WALL TO MEET EXISTING GRADE AT PROPERTY LINE.
2. MIN. PAVING UNDERTAKEN IN TWO LIFTS:
   LOWER COURSE MIN. 75 mm
   UPPFR COURSF MIN. 50 mm
3. DRAIN TILE TO BE INSTALLED WHERE REQUIRED.
4. PLANTING AND SOD IN FRONT AND REAR BOULEVARDS TO MMCD STANDARDS AND BURNABY SUPPLEMENTALS.

NO.	DATE	REVISION	APP'D	BY

City of Burnaby
ENGINEERING DEPARTMENT

LOCAL COLLECTOR / MULTI–FAMILY LOCAL
BURNABY MINOR ROADS

DRAWN BY:	SCALE: N.T.S.	**BBY-**
APPRV'D BY:	DATE: DEC 2024	

CITY OF BURNABY

ENGINEERING DEPARTMENT

DESIGN CRITERIA MANUAL

November 2019

1.0 INTRODUCTION

1.1 The Use of this Design Criteria Manual

This Design Criteria Manual replaces all previous versions and revisions. Always verify that you are using the most recent version. Information regarding current revisions to the design criteria may be obtained at the Infrastructure and Development Services Division of the Engineering Department. It is the Design Engineer's responsibility to verify that the most current criteria are being used prior to initiating and submitting detailed designs for developments and capital works.

1.2 Intent of these Standards

This manual has been prepared for providing guidelines to the Engineering Designer and the development industry in the design of engineering services, facilities and infrastructure within the City of Burnaby.

It is intended to provide the minimum design criteria and standards for proposed infrastructure works for the City of Burnaby. The onus is on the Engineering Designer to ensure that their designs meet the accepted engineering principles that are appropriate for the site conditions and their accepted use.

The City relies on the Engineering Designer for professional expertise and thorough review of their submissions and for appropriate adoption of the requirements set out in this manual.

1.3 Applications of these Design Criteria

The guidelines and performance standards defined in this manual shall apply to the preparation of all engineering designs and drawings for, and execution of projects in the City of Burnaby.

These standards are set out as minimum requirements and shall not be considered a rigid requirement where variations acceptable to the City will achieve better technical and sustainable solutions. Engineering Designers are encouraged to seek innovative and superior solutions where appropriate. A Design Engineer who wishes to adopt criteria not specifically included in, or variant from those within this manual, shall justify the proposed change in a letter/report prepared, signed and sealed by a qualified professional engineer. Submissions must demonstrate that the proposed change is equivalent to, or better than the guideline.

In spite of using these standards and specifications, the Developers and their Consulting Engineers remain responsible for the design and construction of municipal infrastructure utilities according to good engineering standards, which are adequate to address the specific needs and site conditions of their project.

The Engineering Designer must be satisfied that the design criteria contained herein are applicable to the project at hand, and must apply more stringent criteria where appropriate. The Developers and Engineering Designers are fully responsible for designing to standards which exceed the standards outlined in this manual, when specific site conditions dictate that more stringent performance measures are required.

All designs and construction details for City infrastructure services shall be in accordance with this Design Criteria Manual, the City of Burnaby Standard Construction Documents (General Conditions, Supplementary Specifications and Supplementary Standard Drawings), and the most recent Master Municipal Construction Documents – Volume II – Specifications and Standard Detailed Drawings, as adopted by the City.

When conflicts or discrepancies appear between "similar" drawings and/or specifications prepared by the City of Burnaby and those presented in the Master Municipal Construction Documents, the Designer shall review the conflict or discrepancy with the Engineer and shall obtain the Engineer's approval for the correct drawing and/or specification before proceeding.

1.4 Revisions to this Design Criteria Manual

The criteria and design parameters contained in the manual are subject to constant review and re-evaluation, and the Engineer reserves the right to initiate revisions or additions to these criteria when he/she deems it necessary.

The Engineer encourages submissions at large from Design Engineers wishing to amend the City's Design Criteria. Such submissions shall be in a report format, signed and sealed by a professional engineer, and shall include clear and succinct expressions of concern, suggestions for alternatives including economic, engineering and environmental benefits and recommendations, to address improvements to the current Design Criteria.

The Engineer may, at his/her sole discretion, review, assess and accept or adopt in whole or in part, the submissions and/or the recommendations from a Design Engineer for inclusion within the Design Criteria Manual at a future date.

1.5 Interpretation of the Design Criteria

The City reserves the right to the final decision with regard to the interpretation of the intent of the Design Criteria and these standards, and with regard to the acceptability of changes from the standards, or of standards proposed by the Engineering Designer.

Final decisions, interpretations and approvals will be given by the Engineer.

1.6 Statutory Requirements for Approvals by Other Authorities and the City

The Engineering Designer shall remain responsible for compliance with all the statutory requirements of other relevant authorities which are mandated to regulate and approve such works and shall arrange for and secure all approvals from the appropriate authorities.

Where this Design Criteria Manual refers to bylaws, acts, regulations and standards, this shall mean the most recent edition as amended of the reference document.

Where, due to amendment of statutory requirements, conflicts or inconsistencies with this Design Criteria Manual arise, the Engineering Designer is to be responsible for applying the more stringent requirement, and shall refer the issue to the Engineer.

1.7 Certifications

Design Engineers shall accept responsibility for all aspects of their designs and inspections associated with their designs. The Design Engineer must be in good standing and registered with Engineers and Geoscientists BC (EGBC) and be currently practicing in the appropriate engineering discipline. By way of the Design Engineer's seal, they are certifying that the works have been designed and inspected to good engineering standards and in accordance with the latest edition of the City of Burnaby Design Criteria Manual, Standard Drawings and Specifications adopted by the City of Burnaby. All submissions including drawings, reports, calculations, inspection reports or other such information as required, is to be submitted under the Design Engineer's seal and signature.

2.0 GENERAL

2.1 General Items

2.1.1 Glossary of Terms

The following terms found in the Design Criteria Manual shall have the meanings indicated herein:

"City" shall mean the City of Burnaby as a corporate body, or the Engineering Department, as represented by the Engineer.

"Engineer" shall mean the professional Engineer authorized by the Director of Engineering of the Engineering Department to review and accept, on behalf of the Engineering Department: proposals, reports, documents, design submissions, and detailed engineering designs and drawings pertinent to infrastructure utilities to be incorporated in the City.

"Consultant", "Engineering Consultant", "Consulting Engineer", "Design Engineer", "Engineering Designer", Engineer of Record", Designer" and "Contract Administrator" shall mean the professional Engineers, singular or jointly, responsible for the preparation of: proposals, reports, documents, design submissions, and detailed engineering designs and drawings pertinent to infrastructure utilities and services to be incorporated in the City.

"Developer" shall mean the proponent of a land development proposal, or the Owner as defined in a Servicing Agreement. Requirements of the Developer stated in this manual, or standards, may, where appropriate, apply to an Engineering Consultant or Contractor acting on the Developer's behalf.

"Independent Utility" shall mean private companies, crown corporations and regional government utility organizations providing services such as electric power, gas, petroleum products, steam heat, water, sewerage, and communications (telephone, cable, microwave, and fiber optic lines).

"Specifications" shall mean the Master Municipal Construction Documents (MMCD) Volume II – Specifications and the City of Burnaby Standard Construction Documents – Supplementary Specifications, latest revision, including all amendments and appendices.

"Standard Drawings" shall mean the Master Municipal Construction Documents (MMCD) Volume II – Standard Drawings, and the City of Burnaby Standard Construction Documents – Supplementary Standard Drawings, latest revision, including all amendments and appendices.

2.1.2 Existing Services

Existing service information is available from the City. These records are made available on the understanding that the City cannot, and does not, guarantee their accuracy. The Design Engineer or user of such information shall make appropriate verification to ensure the accuracy of critical details.

2.1.3 Expansions of the City's Infrastructure Systems and Extension of Mains

Expansion of the City's infrastructure systems or extensions of water, sanitary and storm mains from the existing systems shall be in strict conformance with the appropriate regulations and bylaws applicable to the proposed extensions. Any expansions of the City's infrastructure and extension of mains shall be in accordance with the City of Burnaby Design Criteria Manual.

2.1.4 Approved Materials and Products

Materials and products which are approved for use in the City are published in the City of Burnaby Supplementary Specification and Detail Drawings Documents. Some reference to materials and products may be made in this Manual, Supplementary Specifications, or on Supplementary Standard Drawings. If the appropriate use of certain materials or products is in doubt, confirm the acceptance of the material or product with the Engineer prior to its incorporation into a design.

2.1.5 Units

The units for all design and construction shall be SI (International Systems of Units), and shall conform to the Canadian Metric Practice Guide, CSA CAN3Z234.2.

2.1.6 Drawing Preparation

Engineering drawings, details, sketches and digital files prepared for submission to the City must conform to the City of Burnaby Construction Drawing Standards and Digital Infrastructure Data Standards and are required to contain the following data:

- graphics of existing municipal and Independent Utility services;
- written approvals from Independent Utilities;
- graphics and annotations of proposed services;

- attributes of proposed services;
- information pertaining to the description of the project and the consulting engineering company.

The data provided by the City will be based on NAD83 (NMIP93) with UTM grid coordinates. The proposed data must be based on the same projection and shown in its true geographic location.

2.2 Independent Utilities

It is the Design Engineers responsibility to include consideration of Independent Utility infrastructure in the design of municipal infrastructure. Written approval of Independent Utilities of required extensions and modifications to independent utility systems are to be obtained by the Consultant and included with the submission of engineering drawings to the Engineer under section 2.1.6.

2.3 Servicing Requirements related to Zones

The minimum type of services under various zones shall be in accordance with the Burnaby Subdivision Control Bylaw No. 5953, the Burnaby Zoning Bylaw No. 4742 and the Burnaby Official Community Plan.

2.4 Utility Rights-of-Way Widths

Only when specifically approved by the Engineer, any City service to be located within a utility right-of-way, must meet the following minimum widths of rights-of-way:

a) <u>for a single service</u>

R.O.W. width = twice the depth from the surface to the crown of the pipe PLUS trench bottom width (3 metres minimum width)

b) <u>for two services within the same trench</u>

R.O.W. width = twice the depth from the surface to the deeper pipe PLUS trench bottom width (6 metres minimum width)

c) <u>for two or more services adjacent to one another but in separate trenches</u>

R.O.W. width = cumulative widths for single services PLUS any difference to provide the required separation (6 metres minimum width)

d) When the service is within a City road allowance but the distance from the property line to the centre of the main is less than one half of the width necessary for a single service, the difference shall be provided as a right-of-way on the adjacent property.

In all cases the width of rights-of-way shall be sufficient to permit an open excavation with side slopes in accordance with the WSBC regulations, without impacting on or endangering adjacent structures, or creating hazardous conditions during construction. The right-of-way shall be made accessible by municipal maintenance crews.

Where required, sanitary trunk and interceptor sewers shall have rights-of-way wide enough for future widening and/or twinning. The width of the right-of-way shall be the required separation between pipe centre lines plus 2 times the depth to the crown of the deeper sewer.

The Design Engineer shall provide cross sections on the design drawings, indicating the minimum safe distances to the adjacent building footings based on a safe angle of repose from the limits of the excavation.

The maximum depth of sewers in a right-of-way shall be 3.5 m from finished ground surface to the pipe crown unless approved by the Engineer.

2.5 Utility Separation: Sanitary or Storm Sewer vs. Water Mains

Requirements for separation of sanitary or storm sewers from watermains are as follows, unless otherwise approved by Fraser Health Authority and the Engineer:

2.5.1 Horizontal Separation

At least three (3) m horizontal separation should be maintained between a watermain and either a sanitary sewer or a storm sewer.

In special circumstances, specifically in rock or where the soils are determined to be impermeable, lesser separation than 3.0 m may be permitted provided that:

- The sewer and watermains are installed in separate trenches and the watermain invert is at least 0.5 m above the crown of the sanitary sewer or storm sewer, and the joints are wrapped with heat shrink or petrolatum tape in accordance with the latest version of AWWA Standards C217, and C 214 or C209; or,

- The pipes are installed in the same trench with the watermain located at one side on a bench of undisturbed soil at least 0.5 m above the crown of the sanitary sewer or the storm sewer, and the joints of the watermain are wrapped with heat shrink plastic or packed with compound and wrapped with petrolatum tape in accordance with the latest version of AWWA Standards C217, and C 214 or C209.

2.5.2 Vertical Separation

Where a sanitary sewer or storm sewer crosses a watermain, the sewer should be below the watermain with a minimum clearance of 0.5 m, and the joints of the watermain, over a length extending 3 m either side of the sewer main, are to be wrapped with heat shrink plastic or packed with compound and wrapped with petrolatum tape in accordance with the latest version of AWWA Standards C217, and C 214 or C209.

Where it is not possible to obtain the vertical separation indicated above, and subject to approval of the Engineer, the following details may be used:

- The water pipe joints should be wrapped as indicated above, and
- The sewer should be constructed of pressure pipe, such as high density polyethylene (HDPE) or PVC with fused joints and pressure tested to assure it is watertight.

2.5.3 Sewers in Common Trench

Storm and sanitary sewers may be installed in a common trench, provided that the design has taken into account:

- Interference with service connections;
- Stability of the benched portion of the trench;
- Conflict with manholes and appurtenances.

The horizontal clearance between sewer pipes should be no less than 1.0 m and the horizontal clearance between manholes should be no less than 0.3 m, unless otherwise approved by the Engineer.

2.6 Trenchless Technologies

Installation or rehabilitation of pipelines by trenchless methods is frequently mandatory or desirable.

Circumstances favouring trenchless installation include:

- Installation or rehabilitation in heavily built-up areas
- Stream crossings
- Highway crossings.

Available technologies include the following:

- Slip-lining - see Burnaby Standard Supplementary Specifications
- Cured-in-place pipe (CIPP) – see Burnaby Standard Supplementary Specifications
- Pipe bursting
- Horizontal directional drilling (HDD)
- Microtunnelling
- Pipe jacking

2.7 Seismic Design Standards

All bridges, utilities, pump stations and related infrastructure shall be designed in accordance with current seismic design standards, as approved by the Engineer.

3.0 WATER DISTRIBUTION

3.1 General

Water system extension and modifications shall be designed in accordance to available Burnaby Waterworks Plans or as directed by the Engineer, and shall conform to the Provincial Ministry of Health, the Municipal Officer of the Fraser Health Authority and the Drinking Water Protection Act.

3.2 Metering

At all commercial, industrial and institutional (ICI) service connections, a water meter shall be provided, complete with control valves, backflow preventer and chamber, in accordance with the City of Burnaby Waterworks Regulation Bylaw No. 3325 and the latest version of the City Water Service, Water Billing & Water Meter Installation Guide.

For multi-family residential developments, a spool piece of sufficient size shall be included (in a mechanical room or otherwise) to accommodate future meter installation.

For single family and duplex home sites, a meter box and setter shall be installed at the property line for each unit, to accommodate future meter installations.

The developer's consultant shall submit water demand and meter sizing calculations for review and approval.

3.3 Per Capita Demand

When assessing the domestic demands within the water distribution system, the following criteria shall be used, in the absence of metering data:

Zoning/Use	Per Capita Demand	Average Day Multiplier	Maximum Day Multiplier	Peak Hour Multiplier
Residential	318 L/cap/day	1	2	4
Multi-Family Residential	318 L/cap/day	1	1.5	2

Where there are a known or projected number of lots or units to be developed, the Design Engineer shall estimate populations based on equivalents of 3.1 capita/unit for a single family/duplex, and 2.8 capita/unit for multi-family developments. An additional 50% capita is to be added for secondary suite and bed and breakfast uses, or as directed by the Engineer.

3.4 Non-Residential Demand

Commercial, industrial and institutional demands should be determined using specific data related to the development or zoning and to the Official Community Plan. In the absence of such data, use the above residential per capita demands and multipliers and the following equivalent population factors:

Land Use	Equivalent population/ha (gross)
Commercial	90 people/ha
Institutional	50 people/ha
Industrial	90 people/ha

Alternatively, the projected water use may be based on the following minimum non-residential demand:

Zoning/Use	Per Capita Demand	Average Day Multiplier	Maximum Day Multiplier	Peak Hour Multiplier
ICI properties	25,740 L/ha/day	1	1.2	1.2
School	113 L/student/day	1	1	0.8
Hospital	767 L/bed/day	1	1	0.8

For identified commercial and institutional facilities, typical average daily demands shown in Figure 3.1 (at the end of this section) may be used as a guide, subject to approval by the Engineer.

3.5 Fire Flows

Fire flows should be determined in accordance with the requirements of the current edition of "Water Supply for Public Fire Protection – A Guide to Recommended Practice", published by Fire Underwriters Survey (FUS).

Where fire flow values, as determined by FUS calculations, are not available because details of the development are not known, the following minimum requirements shall apply:

Developments	Minimum Fire Flow
Single Family Residential (SF)	90 L/s
Multi-Family Residential (MF)	200 L/s
Commercial (or MF/Commercial mix)	250 L/s
Institutional	200 L/s

Industrial	250 L/s

Where the existing water system cannot meet the fire flow requirements for fire protection of a particular development, the Developer will be required to either upgrade the existing distribution system to meet the estimated demands or make whatever improvements necessary to reduce the fire flow requirements of the development. The final strategy to meet fire flow requirements will be subject to the approval of the Engineer.

3.6 Design Flows

System design flows should be based on the ultimate population (including secondary suites plus bed & breakfast) and fully developed non-residential land use as anticipated in the Official Community Plan.

Equivalent populations for non-residential flows can be estimated using the established non-residential demands and the Maximum Day per capita demand.

Total design flows (Q_{design}) are to be the greater of the following:

$Q_{design} = D + F$ Maximum Day Demand for the population or equivalent population plus the Fire Flow, or

$Q_{design} = H$ Peak Hour Demand for the population or equivalent population

3.7 Water Pressure

- Maximum allowable pressure 1035 kPa (150 psi)
- Minimum pressure at Peak Hour Demand (H) 300 kPa (40 psi)
- Minimum pressure throughout the entire zone during design Maximum Day and Fire Flow Demand (D + F) 150 kPa (20 psi)

Where the maximum pressure exceeds 515 kPa (75 psi), service connections must be individually protected by the addition of pressure reducing valves located in the buildings being serviced.

Determination of pressure limits should include consideration of property elevations relative to street level. The hydraulic grade elevations of the various pressure zones are shown in Figure 3.1 (at the end of this section).

Anticipated flows and pressures within the distribution system may be estimated through computer modelling, under future Max Day and FF conditions, as provided by the Engineer.

3.8 Hydraulic Design

Use a proven and calibrated network analysis computer model, as approved by the Engineer, based on the Hazen-Williams formula:

$$Q = \frac{CD^{2.63}\, S^{0.54}}{278780}$$

Where: Q = Rate of flow in L/s
D = Internal pipe diameter in mm
S = Slope of hydraulic grade line in m/m
C = Roughness coefficient

In the absence of field measured values, suggested C factors may include the following:

For DI and AC mains, C = 110 for 150 mm diameter and smaller, or 125 for watermains larger than 250 mm.

For CI mains, C = 65 for 150 mm and smaller, or 100 for 200 mm and larger.

Other formulas and methods may be used, subject to the approval of the Engineer.

The maximum allowable design velocity under fire flow conditions shall be 3.0 m/s.

The City of Burnaby has working models available for most pressure zones. Information regarding working water models is available upon request; however, verification and calibration of the available working water models is the responsibility of the Design Engineer.

In the absence of a working water model, the available head conditions during the assessment of water system adequacy may include the following approach:

3.8.1 Feeder Mains

For design of feeder mains, the pertinent pump station, PRV station, or direct connection to a designated Metro Vancouver trunk main may be taken as the source node for analysis with the discharge head at the station/trunk as the starting input head.

3.8.2 Local Mains

For design of local mains, the source node(s) for the analysis may be taken from:

- For design flows not exceeding 120 L/s, the tie-in point(s) to the nearest 300 mm or larger diameter watermain(s) continuously tied to an adequate supply source.
- For design flows exceeding 120 L/s, the tie-in point to the nearest Metro Vancouver trunk or feeder main, PRV, pump station or reservoir.

3.8.3 Input head(s) at source node(s)

- Where water modelling information is not available and when approved by the Engineer, the input head(s) at the source node(s) may be estimated as 70% of the respective designated static head (pressure zone designation). This will be the lesser of:70% of the difference between the hydraulic grade elevation of the pressure zone and the ground elevation of the source node, or
- 70% of the difference between the local hydrant pressure readings and the ground elevation of the source node.

3.9 Minimum Pipe Diameter

Development Zoning	**Minimum Main Sizes**	
	Connected at One End Only	**Connected at Both Ends**
Single Family Residential	200 mm*	150 mm
Multi-Family Residential	250 mm	200 mm
Commercial	300 mm	250 mm
Institutional	250 mm	200 mm
Industrial	300 mm	250 mm

Note: *For looped watermain in residential subdivisions of lengths less than 500m, the diameter may be reduced to 150mm, provided that fire flow requirements can be met. The distribution main minimum diameter may be further reduced to 100 mm provided that the main terminates in a short (80 m or less) residential cul-de-sac and serves no fire hydrants or fire sprinkler systems.

The above minimum watermain sizing does not remove the requirement to assess for low pressure considerations under fire flow conditions. Low pressure considerations will need to be assessed as part of the design process with provisions for upgrades made accordingly. Consult with the Engineer for modelled “pressure vs flow” computer model estimates.

3.10 Dead Ends

Watermains must be looped wherever possible. Where dead ends are unavoidable, and approved by the Engineer, blow-offs or blow-downs should be provided. Blow-off and blow-down sizes are:

- 50 mm dia. for 100 and 150 mm dia. watermains
- 100 mm dia. for 200 mm dia. and larger watermains

Where practical and approved by the Engineer, a hydrant may serve a secondary role, as a blow-off. From end caps and blow-offs, pipe joints shall be restrained for a minimum of two pipe lengths.

3.11 Minimum Depth of Cover

Watermains and services are to be installed at a minimum cover of 1.0 m except where otherwise approved by the Engineer.

Subject to approval of the Engineer, the minimum cover may be reduced to 0.75 m, provided that adequate protection is incorporated in the design. In all cases, the depth of cover must be of sufficient depth to:

- prevent freezing (given soil type and groundwater levels);
- clear other underground utilities;
- provide mechanical protection from external loads.

3.12 Grade

Where possible, the minimum grade of watermains should be 0.1%. Pipe grades should be designed to minimize the number of high points within the system.

Pipe grades should be straight lines between deflection points, with elevations recorded at all deflection points.

Where the pipe slope exceeds 10%, provide anchorage and/or joint restraints, trench dams and trench drainage. Where the slope equals or exceeds 15%, provide a geotechnical report with recommendations on construction for review by the Engineer.

3.13 Corrosion Protection

To protect against the potential of corroded metallic pipe lines and appurtenances, soil corrosivity testing and analysis shall be conducted along the proposed alignment of all new watermains to determine the corrosive nature of the native soils. Test methodology shall include measurement of electrical resistivity soils testing for corrosiveness to metallic watermain and appurtenances as per AWWA Standard C105/A21.5 10-point system, investigation and testing for stray DC electrical currents such as ICCP systems and review of available system leak records. If the soils are determined to be corrosive, cathodic protection, in addition to the provision of poly-encasement or other measures, shall be included to prevent the corrosion of metallic watermain and appurtenances.

Results of all corrosion testing and subsequent design shall be submitted to the Engineer for record purposes.

3.14 Valves

In general, valves should be located as follows:

- In intersections, either in a cluster at the pipe intersection or at projected property lines, to avoid conflicts with curbs and sidewalks, the following minimum number of valves shall be installed:
  - 3 valves at “X” intersection
  - 2 valves at “T” intersection
- Not more than 200 m apart;
- Not more than 1 hydrant isolated;
- Not more than 30 service connections isolated.
- Gate valves are required on mains smaller than 450 mm diameter.
- Butterfly valves may be used in mains 450 mm diameter and larger, upon approval of the Engineer.
- Valves on mains larger than 300 mm diameter may be one size smaller than the watermain (with suitable reducers) or two sizes smaller for watermains 450 mm and larger, upon approval of the Engineer.

3.15 Hydrants

Fire hydrants should be located at street intersections and as follows:

- Not more than 180 m apart or more than 90 m from a building or residence.
- In accordance with “Water Supply for Public Fire Protection – A Guide to Recommended Practice” published by Fire Underwriters Survey.
- 2.0 m (1.0 m for residential areas) back from curb or 0.5 m back of sidewalk.
- At street intersections, set back 3.0 m from projected property lines.
- Minimum 1.5 m clear of any other structure, pole or other obstruction.
- At property lines in mid-block locations.

- Provide adequate hydrant spacing on both sides of arterial or divided roadways of four lanes or more (e.g.,Willingdon, Hastings, Kingsway, and Lougheed Hwy).

3.16 Air Valves

Combination air vacuum/release valves should be installed at the summits of all mains of 150 mm diameter and larger, except as follows:

- Where the difference in elevation between the summit and valley is less than 600 mm.
- Where it can be shown that air pockets will be carried by typical flows.

Minimum air valve sizes, subject to design analysis, are as follows:

Water Main Size	Valve Size
250 mm and smaller	25 mm
300 to 600 mm	50 mm
Larger than 600 mm	Special Design

Air valves must be vented to an appropriate above-grade location to eliminate any potential for cross connection in a flooded or contaminated chamber.

Where practical, and approved by the Engineer, a hydrant may serve a secondary role as an air release or blow-off, when located at local high points.

3.17 Thrust Restraints

Concrete thrust blocking or adequate joint restraining devices must be provided at bends, tees, wyes, reducers, plugs, valves and hydrants. For end caps and blow-offs, pipe joints shall be restrained for a minimum of two pipe lengths. Joint restraints are preferred in areas of soft, compressible soils.

The restraint system must take into account potential future excavations in the vicinity of the watermain. Design calculations must be based on fitting type, water pressure and existing soil conditions.

3.18 Mainline Pipe

In general, all watermains shall be ductile iron pipe (Class 50). Avoid use of less common 100mm, 250mm and 350mm pipe diameters for mainline (unless timely material supply is assured). Seek approval from the Engineer regarding the use of all pipe sizes greater than 450mm and alternate materials (PVC, PVCO, HDPE and steel) for use under special applications. All ductile iron pipe shall be encased with 8 mil polyethylene (poly encasement) in accordance with AWWA C105. Ductile iron pipe, in all applications and sizes 300mm and larger, shall include boltless restrained joints (TR Flex, or approved equivalent) unless otherwise approved by the Engineer. Observe special design requirements in seismically sensitive areas as described in Section 3.22.

3.19 Chambers

Chambers or manholes containing valves, blow-offs, meters, or other appurtenances should allow adequate room for maintenance, including headroom and side room. Access openings must be suitable for removing valves, and equipment. The chamber is to be provided with a drain to a sanitary sewer where possible or storm sewer or ditch, complete with de-chlorination provisions and backflow prevention to prevent flooding of the chamber. Rock pits may be considered subject to suitable soil and groundwater conditions. A pumping system may be required where a gravity system is not available.

Adequate venting should be provided. The Engineer may require provision of forced ventilation, lighting, heating and dehumidification. Access and ventilation details, provision for “double-block-and-bleed” in below grade structures must comply with WSBC requirements.

3.20 Service Connections

Service connection size should be calculated on the basis of the designated land use including sprinkler systems and/or on-site hydrants, where applicable. The minimum service size is 20 mm.

Locate connections in accordance to the Standard Detailed Drawings. Each service should have provisions for future water meter installation (meter box and setter for residential connections) and shut-off located within 150 mm street side of the property line. Each connection of 100 mm diameter or larger requires premise isolation in accordance with the City of Burnaby Cross Connection Control Standards Manual (Plumbing Bylaw 6335).

All non-residential service connections shall have provisions for metering and back-flow prevention, in accordance with the most recent City of Burnaby Metering Guidelines.

3.21 Alignments and Corridors

On straight roads, watermains should have straight alignments with uniform offsets between intersections. Curved alignments, parallel to property lines, are subject to approval by the Engineer. Design joint deflections should be limited to half the maximum deflection specified by the pipe and fitting manufacturers. Locations of short lengths, or field cut pipes, must be recorded during construction.

Mains should be located such that each property served has at least one side fronting the watermain.

Where a watermain is approved for crossing private land, right-of-way requirements are as indicated in Section 2.0, General Design Considerations.

Clearance from sewers is as indicated in Section 2.0, General Design Considerations.

3.22 Water System Seismic Design

All water pipe lines shall be designed to mitigate leakage or loss of service resulting from ground deformations. Most earthquake damage to buried pipelines occurs from pipeline deformation caused when pipelines are forced to move with surrounding soils. Ground displacements may be caused by either temporary seismic wave propagation effects or permanent ground displacements resulting from moderate or high soil liquefaction potential or slope instability.

3.22.1 Affected Areas

Areas of potential water system seismic vulnerability (liquefiable soils) are delineated in Figure 3.1.

3.22.2 Pipeline Design

a) In areas subject to permanent ground deformation, soil liquefaction or landslide, as identified in Figure 3.1, the following requirements shall be met:

   i. Materials;
   Watermains shall be constructed of restrained ductile iron pipe or fused HDPE (Min DR11, DIOD) pipe, or as otherwise approved by the Engineer. PVC is not allowed in seismically sensitive areas. All pipe fittings, valve bodies, hydrants and related water system components to be made from ductile iron.

ii. Joint Restraints;
All DI pipe joints, 100 mm and larger, shall be restrained using boltless restrained pipe (TR FLEX) or an approved equivalent methodology.

iii. Pipe Wrapping;
All DI pipe shall be encased with 8 mil polyethylene (poly encasement) in accordance with AWWA C105.

iv. Connections to Structures;
The designer shall calculate the expected differential movement between pipe and structure and provide a design that will accommodate the anticipated movement. Use flexible expansion joints where specified.

v. Service Connections;
Provide an offset or loop in the service connection to accommodate movement up to 0.5 m of the pipeline through the soil.

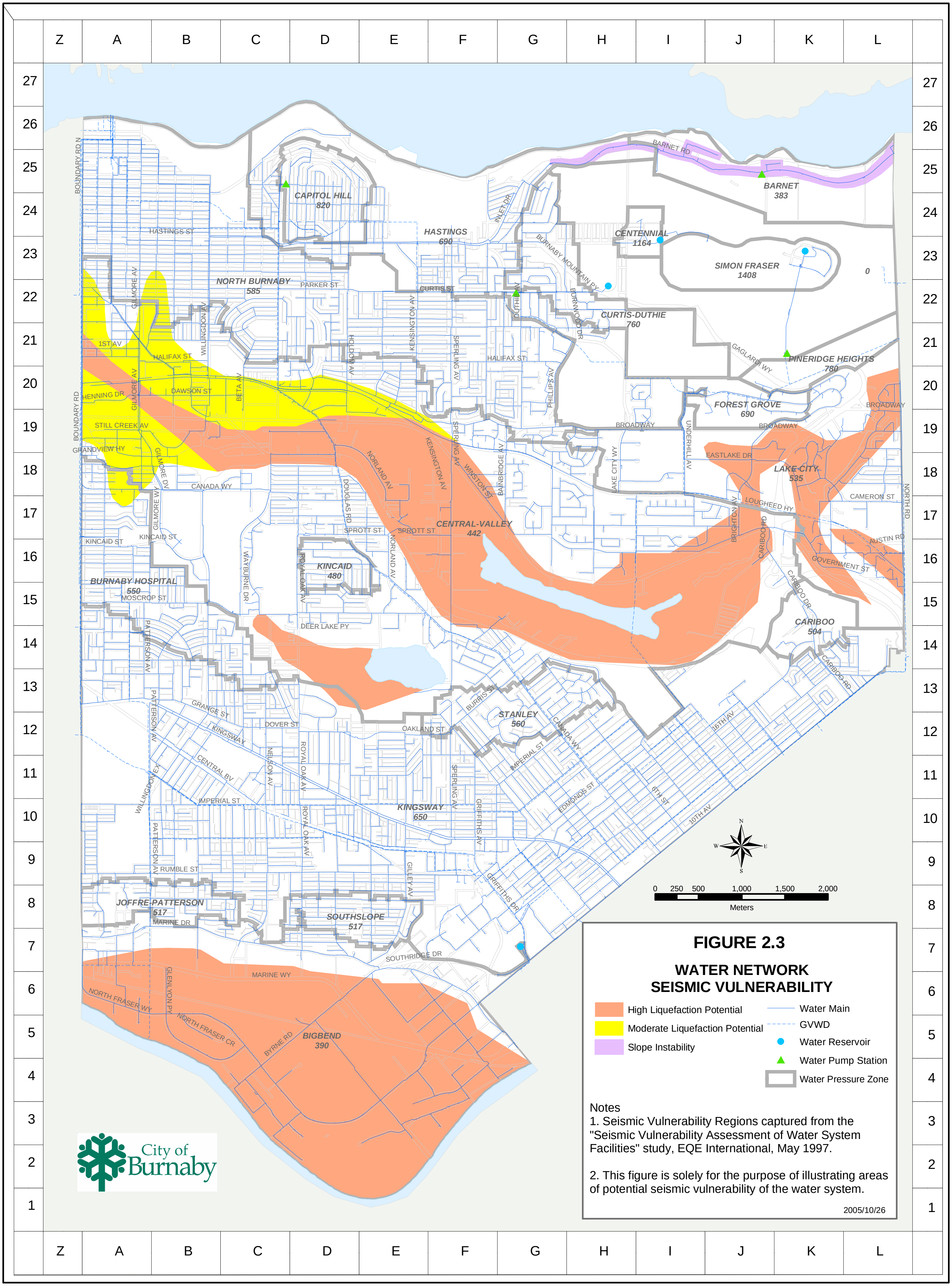


FIGURE 2.3

WATER NETWORK SEISMIC VULNERABILITY

Notes
1. Seismic Vulnerability Regions captured from the "Seismic Vulnerability Assessment of Water System Facilities" study, EQE International, May 1997.

2. This figure is solely for the purpose of illustrating areas of potential seismic vulnerability of the water system.

3.23 Reservoirs

3.23.1 Preliminary Design

Reservoir design shall include a preliminary design which is to be approved, on a project-by-project basis by the Engineer, before detailed design begins. Preliminary design shall include, as a minimum, the following:

- selection of materials (concrete or steel) and design standards provisions for access and overflow
- volume (Total Storage)
- shape, depth and cover
- number of cells
- geotechnical report on foundation conditions
- appearance

3.23.2 Capacity

Reservoirs should be designed to suit the particular circumstances. Reservoir capacity should be calculated by the following formula:

Total Storage Volume = A + B + C

Where: A = Fire Storage (from Fire Underwriters Survey guide)
B = Equalization Storage (25% of future Maximum Day Demand)
C = Emergency Storage (25% of A + B)

Subject to the results of a detailed engineering analysis, and approval of the Engineer, the requirement for emergency storage (C) may be reduced or eliminated based on consideration of the following:

- dependability of water source;
- reliability of the supply system;
- presence of more than one supply source;
- whether the reservoir is part of a large system;
- presence of other reservoir(s) in system;
- applicability of standby power;
- need for adequate circulation of reservoir water to maintain water quality.

3.23.3 Structural Design Codes

Design in accordance with the latest edition of the B.C. Building Code and one of the following specialty codes:

- American Concrete Institute (ACI) 350/350R: Code Requirements for Environmental Engineering Concrete Structures, and Commentary
- Portland Cement Association (PCA): Circular Concrete Tanks Without Pre-stressing
- ACI 350.3/350.3R: Seismic Design of Liquid Containing Concrete Structures, and Commentary
- American Waterworks Association (AWWA) D110: AWWA Standard for Wire and Strand-Wound Circular Pre-stressed-Concrete Water Tanks
- AWWA D115: AWWA Standard for Circular Pre-stressed Concrete Water Tanks with Circumferential Tendons
- AWWA D100: AWWA Standard for Welded Steel Tanks for Water Storage
- AWWA D103: AWWA Standard for Factory-Coated Bolted Steel Tanks for Water Storage

3.23.4 Design Features

Seismic Loading Design for the following:

- Watertight structure and fully operational mechanical equipment, following a 475-year return period earthquake.
- Repairable damage and no uncontrolled release of water following a 2500-year return period earthquake.
- Two cells, each containing one-half of total required volume and capable of being drained and filled independently. A single cell reservoir may be considered under the following circumstances:
    - total volume less than 4500 m^3
    - alternative storage available
    - alternative storage or supply source scheduled to be available within 5 years.
- Overflow drain sized to handle design inflow.
- Separate inlet and outlet pipes, located and oriented to provide circulation within the reservoir.
- Independent drain outlet at bottom.

- Roof access hatch sized and located for safe and convenient access for personnel, parts, temporary ventilation facilities and cleaning equipment into each cell.
- Hatches: watertight aluminium, complete with hinges and related hardware, drains, locks and intrusion alarms.
- Ventilation pipes or openings sized to handle appropriate intake and exhaust air volumes for filling and draining the reservoir. Include security considerations.
- Reservoir floor to slope to drain sump in concrete structures and in steel structures where possible. Drain as low as possible in steel structure.
- Drain sump in concrete reservoirs to be minimum 1000 mm x 1000 mm x 400 mm; invert of drain pipe to be flushed with sump floor; grating to be installed over sump.
- Zoned sub-drains under floor to collect, drain and allow monitoring of any leakage.
- Stairways or stainless steel or aluminium interior wall ladder from road access to floor. All ladders and stairs to meet WCB regulations, including attachment points for fall arrest equipment.
- Fall prevention railings.
- All pipework within the reservoir to be PVC, stainless steel, fibreglass or steel or ductile iron coated to AWWA standards.
- All metal parts within the reservoir including bolts, nuts, screws, anchors, ladders, etc. to be stainless steel.
- Pressure transducer or ultrasonic level controls for each cell. Provisions for Scada.
- Sample lines for at least one sample per 1000 m^3 volume within each cell.
- Washdown connection in each cell, complete with backflow preventer and 65 mm diameter pipe.
- Convenient maintenance access.
- Fencing, lighting, locks, alarms and other security facilities to minimize vandalism and prevent water contamination.

3.23.5 Valve Chambers

Reservoir piping is to incorporate a valve chamber with the following design features:

- Chamber to include all valves associated with the reservoir
- Design in accordance with seismic codes noted above
- Entrance at grade large enough to permit safe removal of largest equipment

- Lifting beams and hoists where necessary to enable removal of heavy equipment
- Space for safe and convenient operating and maintenance access to all valves, piping, equipment and instrumentation; provisions for double-block-and-bleed
- Interior and exterior of all steel piping to be coated to AWWA standards, or stainless steel
- Floor drains and drainage system
- Located above 200-year flood level or 1.0 m above the highest recorded flood elevation

Additional features which may be required, subject to system operations details, include the following:

- Sampling ports for inlet, outlet and reservoir water
- Flow measurement and recording devises
- Heat, light and ventilation to local and WSBC standards
- PLC-controlled inlet valve and level monitoring and control system
- Connection to SCADA system, if applicable
- Uninterruptible power supply (UPS) for control system
- Chlorine residual analyser for reservoir inlet and outlet
- Provision for re-chlorination facilities
- The designer is to provide three hard copies and a digital (pdf) file of a comprehensive Operations and Maintenance Manual

3.24 Pump Stations

3.24.1 Preliminary Design

Pump station design must include a preliminary design which is to be approved, on a project-by-project basis by the Engineer, before detailed design begins. Preliminary design should include, as a minimum, the following:

- Location and access provisions
- Capacity
- Number and types of pumps
- Preliminary piping layout
- Type and appearance of structure
- Foundation conditions
- Maintenance requirements

- Energy requirements
- Standby power
- HVAC
- Controls and monitoring (SCADA)
- Security (alarms, video, etc.) provisions

3.24.2 Capacity

Pumping capacity should be designed to suit the particular circumstances. In general, capacity should meet maximum day demand with the largest pump set out of service and balancing storage on line. If balancing storage is not on line, pumping capacity should meet peak hour demand with the largest pump out of service. Standby power should be provided to allow the greater of maximum day demand plus fire flow or peak hour demand (D+F, or H) during power outage.

3.24.3 Design Features

- Structure, piping and mechanical systems designed in accordance with seismic codes for post-disaster structures.
- Location above 200-year flood level or 1.0 m above the highest recorded flood elevation.
- Reinforced concrete, block work, or brick construction designed to incorporate aesthetic considerations.
- Access doorways sized for safe and convenient removal and replacement of the largest piece of equipment. Lifting hooks or rails with pulley blocks required.
- Adequate HVAC and lighting.
- Standby power, unless fire storage and balancing and/or emergency storage is available without pumping.
- Electric motors to be 600 volt, 3 phase, premium efficiency, with thermal protection. Lower voltage (280V, 3 phase) may be considered, depending upon service voltage available from power company.
- Motors 100 hp and above to have analog vibration recording and protection.
- Air relief discharge and pilot lines to be piped to floor drains.
- Housekeeping pads for MCC’s.
- Hydraulically operated or motorized pump control valves with isolation valves, unless pumps have variable speed drives which control transient pressures.
- Flow meters and totalizers.
- Check valves with indicators.

- High pressure and surge relief valves with isolation valves, if warranted by system characteristics and transient analysis.
- Suction and discharge pressure gauges, with isolation valves, for each pump.
- Mechanical pump seals.
- Water quality sampling ports.
- Interior and exterior pipework coated to AWWA standards, or stainless steel.
- Pump system to be PLC-controlled and connected to SCADA system, if applicable.
- Hour meters and ammeters for each pump.
- Power factor correction, if required by the power company.
- Noise attenuation to suit the location and Burnaby standards and requirements.
- Equipment to be new, CSA approved and have minimum one-year guarantee on parts and labour. All equipment must be tested prior to acceptance.
- Designer is to provide three copies of a comprehensive Operating and Maintenance Manual for new equipment installed.

3.25 Pressure Reducing Valve (PRV) Stations

PRV station design parameters proposed by the Designer should be reviewed and approved on a project-by-project basis by the Engineer, before detailed design proceeds.

PRV stations shall be designed with a preference for above-ground installations (avoiding confined space entry complications) and the general design criteria noted below.

3.25.1 Preliminary Design Parameters

Design flows:

- Peak hour (min 40 psi)
- Maximum Day plus fire flow, MD + FF.
- Continuous, emergency or fire flow operation

Chamber (or kiosk) details:

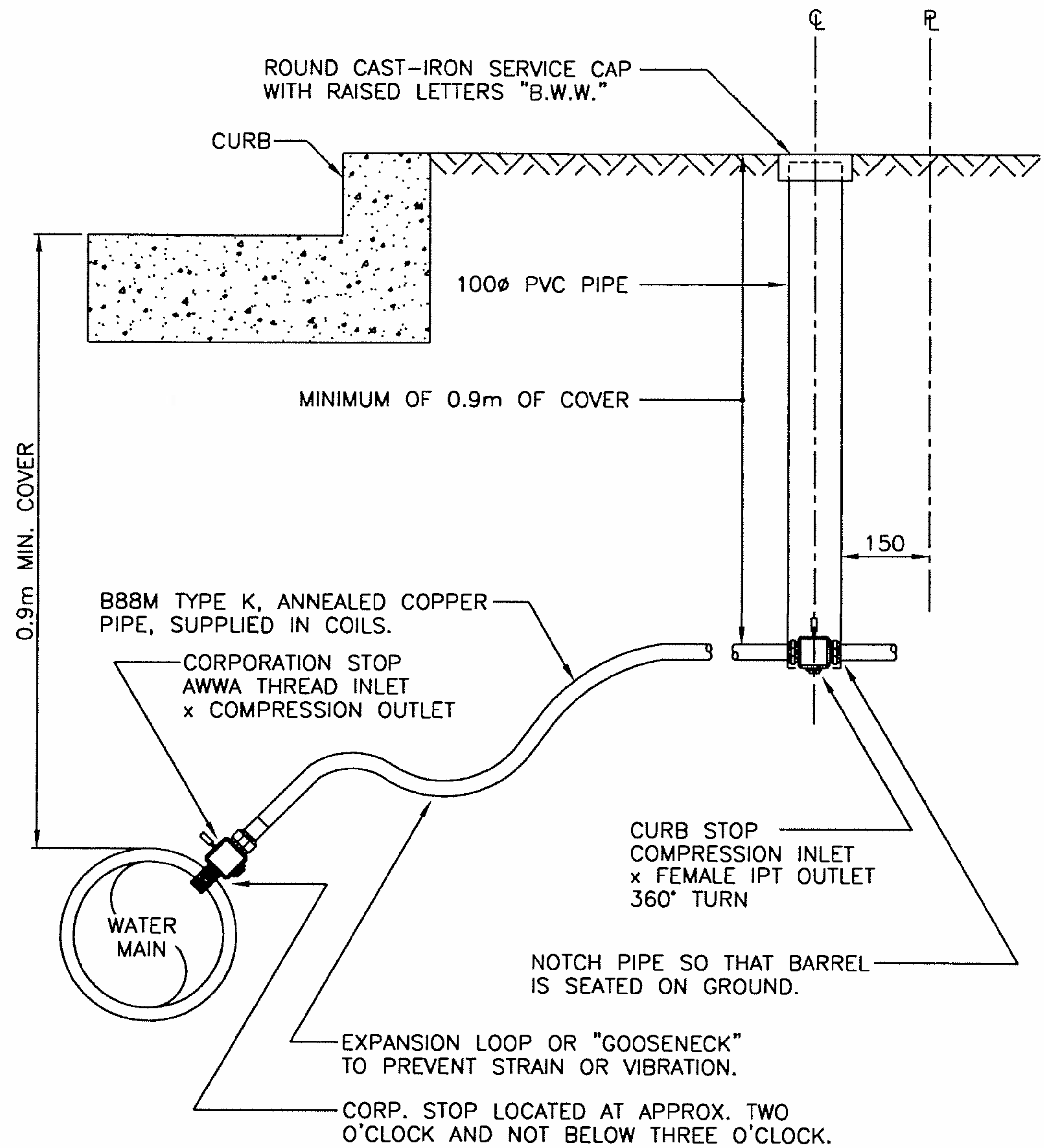
- Structure, access and confined space provisions
- Controls and monitoring (Scada)
- Meters and pressure monitoring in/out
- HVAC where specified

3.25.2 Design Features

- Minimum chamber size: 3 m x 2 m x 1.7 m (inside dimensions).
- Structure and piping in accordance with Chambers, Reservoir Valve Chambers and Pump Stations sections.
- External bypass with closed valve.
- Parallel pressure reducing valves sized for peak hour and maximum day plus fire flows.
- Isolating valves, double-block-and-bleed
- Air release valves.
- Basket strainers upstream of each control valve.
- Flow meter.
- Interior and exterior pipework coated to AWWA standards, or use stainless steel.
- Forced air ventilation plus heat and light, subject to Engineer's review.
- External kiosk, if electrical and electronic equipment is included.
- Double block and bleed if height requirement is exceeded
- PLC-controlled with connection to SCADA system, if applicable, including:
  - Discharge and suction pressure transmitters
  - Flow transmitter
  - Uninterruptible power supply (UPS)
  - Operator interface panel
- Designer is to provide three hard copies and a digital (pdf) copy of a comprehensive Operating and Maintenance Manual.

Figure 3.2 Typical Average Annual Daily Water Demands

FACILITY		UNIT	AVERAGE DEMAND L/(person or unit)/day
Assembly hall		Seat	8
Automobile dealer/renter		Hectare	30,000
Automobile:	Service station	Set of pumps	2,000
	Car wash	Vehicle served	5,000
Bed and breakfast		Patron	150
Bowling Alley		Lane	800
Camp:	Children's central toilet and bath	Person	180
	Day, no meals	Person	50
Campground		Site	600
Curling club		Lane	8,500
Golf course		Hectare	1,500
Greenhouse		Hectare	27,000
Ice arena		Rink	85,000
Office		Employee	50
Picnic park, with flush toilets		Visitor	30
Restaurant:	Conventional	Seat	150
	24 hour	Seat	200
	Tavern	Seat	80
School:	Day, with cafeteria or lunchroom	Student	60
	Day, with cafeteria and showers	Student	70
	Boarding	Student	400
Self-service laundry		Machine	2,000
Shopping centre		m^2	0.10
Swimming pool with toilet and shower		Patron	50
Theatre		Seat	15



NOTES:

1. 20mmø CONNECTIONS SHALL BE DIRECT TAP INTO D.I. MAINS.
2. 25mmø CONNECTIONS SHALL BE INSTALLED WITH BRONZE BODY SERVICE SADDLE AND DOUBLE STAINLESS STEEL STRAPS.
3. ALL BALL VALVES SHALL BE FULL FLOW, FULL PORT.
4. FOR DITCH CROSSINGS MINIMUM DEPTH OF COVER OVER THE SERVICE CONNECTION SHALL BE 1.5m MEASURED FROM THE CROWN OF THE ROAD OR 0.3m BELOW DITCH INVERT WHICHEVER IS GREATER.
5. ALL DIMENSIONS IN MM UNLESS OTHERWISE NOTED.

NO.	DATE	REVISION	APP'D	BY
3	2003/01	NOTES ALLOW APPROVED PRODUCTS		GF
2	2000/01	NOTES REVISED		JK
1	97/01	GENERAL REVISION (L700)		JK

City of Burnaby
ENGINEERING DEPARTMENT

TYPICAL 20mm & 25mm SERVICE CONNECTION

DRAWN BY:	AMKS	SCALE:	N.T.S.	BBY- W102
APPRV'D BY:		DATE:	MAY 68	

4.0 SANITARY SEWER

4.1 General

Sanitary sewers are intended to convey wastewater only. This includes standard domestic plumbing fixtures, floor drains, approved industrial and commercial wastes and unavoidable infiltration. Sanitary sewer systems are intended to exclude storm water, roof drains, footing drains, ground water and other sources of inflow.

At the preliminary design and detailed design stage, include a copy of the network sanitary sewer design sheet and area catchment plan and reference design drawing(s) for review and approval.

Allow for head losses at all deflections, manholes, etc., in the HGL calculations for trunk and interceptor mains.

4.2 Per Capita Flow

Where there are a known or projected number of lots or units to be developed, the Design Engineer shall estimate populations based on equivalents of 3.1 capita/unit for a single family/duplex and 2.8 capita/unit for multi-family developments. Additional capita to be added for secondary suite plus bed and breakfast uses.

Sanitary sewer system design should be based on an average daily dry weather flow (ADWF) of 286 litres per capita per day (L/c/day).

4.3 Non-Residential Flows

Average dry weather flows (ADWF) for non-residential areas shall be based on specific data related to the development or zoning. In the absence of such data or local regulations, use 23,166 L/ha/day for industrial, commercial and institutional (ICI) developments.

4.4 Peaking Factor

The peaking factor is the ratio of peak dry weather flow (PDWF) to the average dry weather flow (ADWF). Where possible, the peaking factor should be based on locally recorded flow data from similar developments. In the absence of such data, the peaking factor is to be calculated using the design residential population or equivalent population, using the Harmon Equation:

$$PF_{Harmon} = 1 + \frac{14}{4 + \sqrt{\frac{\text{Population}}{1{,}000}}}$$

4.5 Design Flow

Design flow, Q = Peak sewage flow from all sources plus infiltration & inflow (I&I)

Where;

Peak sewage flow = ADWF x Peaking Factor

ADWF = per capita flow x aggregate population (population and/or equivalents).

Design flow, Q = peak wet weather flow, PWWF

4.5.1 Inflow and Infiltration (I&I)

Design flow should include an infiltration allowance to cover groundwater infiltration and system inflows. It is anticipated that the actual (field measured) I&I rates of any system will vary according to system age, condition and climatic conditions.

4.5.2 Separated Sewer Areas; I&I allowance

I&I allowance for an existing system is defined as 11,200 l/ha/day plus any additional I&I component deemed necessary for a specific catchment area. The additional I&I values are determined as part of the City’s ongoing system flow monitoring and I&I rate assessment programs. The additional I&I component of the sewage flow in an existing system shall be the difference of the most recently, actual measured I&I value and the standard I&I rate of 11,200 l/ha/day, or as otherwise determined by the Engineer.

Measured I&I values for most areas within the City are available from the Engineer. In the absence of measured values, for the purposes of pipe sizing, the default Inflow and Infiltration (I&I) rate, based on a 5-year, 24 hour rainfall event, shall be twice the standard rate, or 22,400 l/ha/day.

4.5.3 Combined Sewer Areas; I&I allowance

This section applies to all new sanitary construction within existing combined sewer areas of the City where combined sewer separation is being undertaken. This approach accounts for the interim condition where storm flow sources originating from onsite (such as roof water leaders, drainage sumps, etc.) remain connected to the dedicated sanitary sewer system but will ultimately be re-directed to a storm system as part of an overall combined sewer separation strategy. Confirm intended combined sewer separation strategy with the Engineer.

Until full separation of combined sewers is completed and both onsite (private) and offsite (road allowance) storm water components are directed to a designated storm sewer, the interim Inflow and Infiltration (I&I) allowance of a the municipal sanitary sewer system undergoing separation, shall be a minimum of 400,000 l/ha/day. In the interim, the designated sanitary sewer system may operate at a full depth flow condition (i.e. d/D = 1.0) until full sewer separation within the catchment has occurred and all onsite/offsite drainage sources removed and directed to storm. Under the ultimate condition, fully separated, the depth of flow shall be in accordance with Section 4.5.4 Depth of Flow. A fully separated sewer system shall be designed to accommodate both the interim and ultimate conditions represented by the I&I allowances described below.

Sewer area classification	**I&I Allowance**
Separated sewer with measured I&I rate	11,200 l/ha/day plus additional measured I&I component
Separated sewer with unknown I&I rate (default rate)	22,400 l/ha/day
Combined area (interim condition involving un-separated sewer from onsite sources)	400,000 l/ha/day

4.5.4 Depth of Flow

Design gravity sewers so that the depth of flow under maximum design flow condition is as follows:

Pipe Diameter	**Depth of flow (d/D)**
150 mm to 300 mm	50% of pipe diameter
375 mm and larger	70% of pipe diameter

4.6 Pipe Flow Formulas

4.6.1 Gravity Sewers

Use Manning's formula:

$$Q = \frac{AR^{0.667} S^{0.5}}{n}$$

Where Q = Design flow in m^3/s
A = Cross sectional area in m^2
R = Hydraulic radius (area/wetted perimeter) in m
S = Slope of hydraulic grade line in m/m
n = Roughness coefficient = 0.013 for all pipe

4.6.2 Sewage Force Mains

Use Hazen-Williams formula:

$$Q = \frac{CD^{2.63} S^{0.54}}{278780}$$

Where: Q = Rate of flow in L/s
D = Internal pipe diameter in mm
S = Slope of hydraulic grade line in m/m
C = Friction coefficient = 120 for all pipe

4.7 Flow Velocities

Minimum design velocities:

- Gravity sewers: 0.60 m/s
- Force mains: 0.90 m/s

Maximum design velocities:

- Gravity sewers; 4.0 m/s

Where steeper grades are unavoidable, additional design measures shall be taken to prevent excessive pipe wear, erosion and movement.

- Force mains: 3.5 m/s, unless otherwise approved by the Engineer

4.8 Alignment

Except as indicated for Curved Sewers in section 4.11, horizontal and vertical alignments should be straight lines between manholes for gravity sewers, and between defined deflection points for force mains.

Force main line and grade requirements are as indicated for watermains. Air release/vacuum valves (designated for sanitary use) are required at high points.

4.9 Minimum Pipe Diameter

- Collector sewers: 200 mm
- Service connections: 100 mm
- Sewage force mains: 100 mm

4.10 Minimum Grade

Minimum pipe grade of a gravity system shall be 0.5%, or as required to obtain a minimum flow velocity of 0.60 m/s. For the upstream section of a residential sewer serving a design population of 25 or less, the minimum grade is 1.0%, or as otherwise approved by the Engineer.

4.11 Curved Sewers

Where permitted by the Engineer, horizontal and vertical curves may be formed using pipe joint deflections as follows:

- Minimum radius = 60 m.
- Constant radius throughout curve
- Joint deflection not to exceed 50% of maximum recommended by pipe manufacturer.
- Minimum design velocity = 0.9 m/s.
- Curve detail and location to be recorded on record drawings.

4.12 Depth

Sewers should be of sufficient depth to:

- Permit gravity sewer connections to basements.
- Prevent freezing or provide insulation where minimum depth cannot be attained.
- Maintain a minimum 150 mm vertical clearance with other underground utilities.
- Prevent damage from surface loading.
- Minimum cover without concrete encasement: 1.0 m.

Maximum cover depth: 4.0 m, except under special circumstances and with approval of the Engineer.

4.13 Manholes

4.13.1 Locations

Manholes are required at the following locations:

- Every change of pipe size.
- Every change in grade, except as indicated in the Curved Sewers section.
- Every change in direction, except as indicated in the Curved Sewers section.
- Downstream end of curved sewers.
- Every pipe intersection except for 100 mm and 150 mm service connections and junctions with trunk sewers 900 mm and larger.
- Upstream end of every sewer line.
- Every future pipe intersection.
- 150 m maximum spacing; 200m in areas of seismically sensitive, liquefiable soils.
- Outside of wheel paths, where possible.

4.13.2 Hydraulic Designs

- Crown/obvert elevations of inlet sewers shall not be lower than crown/obvert elevation of the outlet sewer and, are subject to the minimum invert drops noted below.
- Minimum drop in invert elevations across manholes:
  - Straight run: 5 mm drop
  - Deflections up to 45 degrees: 20 mm drop
  - Deflections 45 to 90 degrees: 30 mm drop
- Drop manhole and ramp structures should be avoided where possible by steepening inlet sewers. Where necessary, provide drop structures as follows:

Invert Difference	Structure
Up to 0.25 m	Inside Ramp
0.25 to 0.90 m	Outside Ramp
Greater than 0.90 m	Outside Drop*

  * Inside drop may be used if specifically approved by the Engineer.

- Force main discharges should be directed into the receiving manhole outflow pipe. Manhole benching should be extended a minimum 200 mm above the force main crown. If a manhole drop cannot be avoided, an inside drop pipe is required.

4.13.3 Sewer Manhole Exfiltration/Infiltration

- All pipe connections and manhole construction shall be made watertight. Manholes shall be subject to (exfiltration and infiltration) leakage testing to ensure compliance.
- Include flexible pipe-to-manhole connectors and/or gaskets to ensure water tightness of manholes in areas of known or anticipated groundwater table.

4.14 Service Connections

Every legal lot shall be provided with a separate service connection. Residential duplex shall be serviced by a single service connection.

Unless otherwise approved by the Engineer, connections are to serve all plumbing by gravity. Building floor elevations should be established accordingly. Pumped connections may be permitted if requested and approved by the Engineer prior to sewer design, and where restrictive covenants involving owners ongoing maintenance and renewal, are provided.

4.14.1 Size

- Size pipe to accommodate peak design flow.
- Minimum pipe size is 100 mm diameter.

4.14.2 Location and Depth

- Connections to large lots are to be located at the lower portion of each lot. Locate connections in accordance to City of Burnaby Supplementary MMCD Standard Detailed Drawing No. BBY-S212 (see Figure 4.1).
- Depth requirements are as indicated for sewer mains.

4.14.3 Grade

Minimum grade from property line to sewer main:

- 100 mm diameter pipe: 2.0 %
- 150 mm diameter pipe: 2.0 %
- Larger sizes; grades based on minimum velocity of 0.6 m/s

4.14.4 Details

Use standard wye fittings for connections to new mains. For connections to existing mains, use wye saddles or, if approved, insertable tees. The service connection centreline must not be below the sewer main centreline.

Service connections may be permitted into manholes if:

- The connection is not oriented against the flow in the main.
- Manhole hydraulic requirements are met.

Inspection chambers are required on residential connections.

Control manholes are required on all industrial connections and on commercial connections where required by the City.

Manholes are required on service connections larger than 150 mm diameter.

Connections exceeding 30 m in length will be treated as mains.

4.15 Locations and Corridors

Sewers should be located within roadways as shown on the applicable City standard drawings. Servicing from roadways is required unless a depth greater than 4.5 m would be required to provide gravity service. Rear yard sewers and pumped connections are to be avoided, and advance approval of the Engineer is required.

Where a sewer crosses private land, right-of-way requirements are as indicated in Section 2.0, General Design Considerations.

Clearance from watermains is as indicated in Section 2.0, General Design Considerations.

4.16 Pump Stations

The use of pump stations should be avoided where possible. Any proposed use of pump stations must receive prior approval from the Engineer. Preliminary design must be approved by the Engineer before detailed design proceeds.

4.16.1 Preliminary Design Requirements

System Layout: Select location(s) to minimize long-term total number of pump stations.

Location: Adjacent to road, either within right-of-way or fee-simple lot.

Capacity: Dependent upon the development and catchment area. Design must consider short, intermediate and long-term future flows.

Configuration: Above ground or submersible duplex pump system unless otherwise approved in advance.

Other basic criteria shall include provisions for the following:

- Vehicle access for construction and maintenance.
- Aesthetics, noise, odor control and landscaping.
- Security against vandalism and theft.
- Flood elevations and station uplift design.
- Proximity to receiving sewers, watermains, and power sources.
- Minimizing energy requirements.
- Type of Controls:
    - PLC or relays
    - Ultrasonic float controls with single float control as backup
    - SCADA connection
- Standby power and/or emergency storage.
- Subsurface soil and groundwater investigations (construction dewatering requirements) must be undertaken prior to site approval.
- Convenience of operation and maintenance, redundancy.
- Safety for operators and public, confined space requirements.
- Minimal life-cycle cost (Capital, and operations & maintenance costs).

4.16.2 Design Features

1. Pump stations should generally be designed with the minimum of two pumps, each capable of handling the maximum flow condition with any one pump off line. Where the design flow exceeds the capacity of a single, commonly available pump, use three or more pumps with capabilities such that there is always one pump available for standby.
2. Pump requirements:
    - Capable of passing solids up to 75 mm in size. For small flows (<10 L/s), recessed impeller type pumps with 50 mm solids capability may be considered, subject to approval of the Engineer.
    - Maximum motor speed: 1750 RPM. For small flows (<10 L/s), 3500 RPM may be considered subject to approval of the engineer.
    - 600 volt 3 phase electrical power. Lower voltage (208 V, 3 phase) may be considered depending upon service voltage available from the power company.
    - Easily removed for maintenance.
    - Able to operate alternatively and independently of each other.
    - Able to meet maximum flow conditions with one pump in failure mode.

- Sized so that each motor does not cycle more than six times in one hour under normal operating conditions.
- A mixer should be provided, or one pump equipped with an automatic flush valve.

3. Check valves and plug valves located in a separate valve chamber are required on each pump discharge.
4. Gate valve required on influent line outside pump station; sewer rated with packed stuffing box.
5. Pipes and valves required to provide for bypass pumping.
6. Maximum wet well size: 4.0 m diameter.
7. Wet well bottom to be benched to direct solids to pump suction.
8. Pump station lids to be waterproof and provided with locks. Covers may be either aluminium of fibreglass. Lids to be 200 mm to 300 mm above ground level. Safety grating under main hatch. Fasteners to be 316 stainless steel.
9. Station Access to be by aluminium ladder. Ladder to be located to avoid interference with removal and installation of pumps. Ladder to be provided with extension and lock at least 600 mm above station lid. Fibreglass grating platform to be provided above high water level for wet well access. Access, ladder and platform to meet WSBC standards.
10. Access to be located above the 200-year flood level or 1.0 m above the highest recorded flood elevation.
11. Metal stations to be provided with impressed current cathodic protection.
12. Steel and fibreglass surfaces to receive minimum two coats of two-compound white epoxy enamel. Concrete stations to be design to prevent hydrogen sulphide attack.
13. Auxiliary equipment and control panels to be housed in weatherproof kiosk adjacent to station. Kiosk to be not less than 2.0 m and not more than 4.0 m from station lid.
14. Kiosk to contain separate compartment for pump station ventilation fan.
15. Explosion-proof intake fan, activated by a manual switch, and of sufficient capacity to exchange the total volume of air inside the station with fresh air within 3 minutes. Fan to be located in kiosk. Intake duct to terminate near maximum water level. Exhaust vent to be provided in top of pump station.
16. Wiring in station and fan compartment to be explosion-proof, Class 1, Division 2, Electrical design and installation subject to approval by the City of Burnaby Electrical Inspector.
17. Power and control cables to be continuous from within the pump station to within the kiosk.

18. Levels to be controlled by ultrasonic level transmitter and pressure transducer, plus emergency high level floats.
19. Unless otherwise approved by the engineer, controls to be PCL based and connected to SCADA system.
20. Station to be complete with an Uninterruptible Power Supply (UPS) to serve alarms and controls.
21. Control panel to include hour meter and ammeter for each pump.
22. Station to include magnetic flow meter with totalizer and connection to SCADA.
23. Pump control panel to incorporate operator interface with indicator lamps.
24. Control kiosk to be designed to contain control and SCADA equipment on the front panel and power equipment on rear panel. Concrete base to be minimum 75 mm above finished grade.
25. Pump stations to include automatic generator sets for standby power in case of power failure. Provision for connection to the municipal SCADA system to be included. Generator set enclosures to be weatherproof and to include noise control. For small pump stations, emergency storage may be considered in place of standby power. Emergency storage is to be based on 8 hours of average day flows.
26. A 50 mm water connection with standpipe and cross-connection protection must be provided on site for cleaning purposes.
27. Area around station and related equipment or building is to be graded, asphalted and fenced. Size of area to be determined by maintenance requirements and minimum 1.2 m clearance to structures with doors opened. Layout of structures and gates is to provide for clearances for pump removal by hoist truck.
28. Provisions for odour control to City standards; included where specified.
29. Design in accordance with the appropriate seismic standards.
30. Equipment to be new, locally sourced, CSA approved and have minimum one-year guarantee on parts and labour. All equipment must be tested prior to acceptance.
31. Provide three copies of a comprehensive Operating and Maintenance Manual, prior to commissioning. City Operations staff to be consulted regarding facility commissioning requirements.

4.17 Low Pressure Sewers

The City may consider or require low pressure sanitary sewer systems for areas which are beyond the reaches of the gravity sewer system and not large enough to provide justification for a community sewerage pump station, or where soil conditions or topography or downstream trunk system surcharge creates a situation not suitable for a gravity sewer system. A low pressure sanitary sewer system consists of on-site privately owned and operated sewage pumps complete with a force main connected to a City owned and operated low pressure sewage force main system.

Systems in which private pump units discharge into a public gravity sewer are not classified as low pressure sewer systems. Where specifically indicated herein, some of the items included in this guideline are applicable to such other pumped systems.

Pump chamber design and all ancillary component (odour control, auxiliary power, etc.) design within the private property shall be certified by a professional engineer and submitted to the City for record purposes.

4.17.1 Restrictive Covenant

Land title for each property served by a private pump unit located on the property shall include a registered restrictive covenant, filed by the property owner, requiring the property owner to undertake in perpetuity operation, maintenance and renewal, when necessary, of the pump system and connection to the public sewer, including the section of connection pipe on public property or right-of-way. The required format of the restrictive covenant will be provided by the City at the Preliminary Design stage.

4.17.2 Codes and Standards

Low pressure sewer systems and the components thereof shall be designed and constructed in conformance with the following codes and standards:

- British Columbia Building Code, Part 7, Plumbing Services
- British Columbia Electrical Code
- Burnaby Plumbing Bylaw
- Burnaby Sewer Connection Bylaw
- Burnaby Electrical Bylaw
- British Columbia Health Act and Sewage Disposal Regulations
- Greater Vancouver Regional District Sewer Use Bylaw
- WorkSafeBC Regulations
- Master Municipal Construction Documents (MMCD) and City of Burnaby Supplemental Specifications and Detail Drawings
- Master Municipal Construction Documents (MMCD) Design Guideline Manual

In case of conflict between these guidelines and specific items in the above design guideline manual and construction documents, these guidelines will take precedence.

4.17.3 System Layout

The preliminary layout of a proposed low pressure system should be approved by the Engineer before detailed design proceeds.

a) Preliminary Design

The following information is required for a preliminary design submission:

- Plan of the entire area to be served by the proposed system, including adjacent areas currently and potentially served by gravity sewers and community sewage pump stations
- Topographic plan
- Report on soil conditions
- Preliminary layout
- Area development sequence and timetable
- Pump unit power requirements and related details

b) Design Development

Basic data and design criteria for detailed system layout include the following:

- Location, elevation and design flow for each pump unit
- Location and direction of flow of each lateral, branch and main, plus details of the system discharge point. Lay out system to minimize length of runs, avoid abrupt changes in direction and avoid loops
- Location and elevation of system high points. Adjust pipe profiles where possible to avoid high points
- Provision for system maintenance facilities. Allow for system clean outs (inline and system ends) at a maximum of 150 m intervals

Design documents for system approval shall include a plan showing the following information for each property served:

- Building site grade, minimum floor elevation and pump chamber inlet elevation
- Pump unit and service connection locations and elevations
- Pump unit configuration (Simplex or Duplex)
- Pump chamber diameter, depth and operating elevations
- Pump head and capacity requirements, plus recommended manufacturer and model, pump curve and power requirements.
- System curves for each operating condition (Low, Likely, and High).

The low operating condition is defined as the lowest pressure an individual pump could see (i.e., no downstream surcharge, a high Hazen-Williams system coefficient (C=140), and only one pump operating). The likely operating condition is defined as the pressure condition which the system has the greatest probability of seeing (i.e. downstream sewer surcharged to obvert, a medium Hazen-Williams system coefficient (C=120), and a number of pumps operating per Section 4.17.5 (a)). The High operating condition is defined as the pressure condition an individual pump could see (i.e. downstream sewer surcharged to ground surface, a low Hazen-Williams system coefficient (C=100), and all of the system pumps operating).

4.17.4 Hydraulic Design

System design shall include complete hydraulic data for each section of pipe including flows, heads, velocities and maximum retention times. Submission of this information shall include a table showing all of the data for each anticipated stage of the system development.

4.17.5 Design Flows

Design flows for sizing pressure sewers, including service connections and City force mains, shall be determined on the basis of the velocity and head criteria as indicated within the MMCD Design Guideline Manual.

Calculate design flows in individual sections of City force main using one of the following procedures, depending upon the type of development.

a) Single Family Residential Areas

Use the pump capacities, determined as indicated in Section 4.17.13 (Pump Details), and the number of pumps indicated in Table below.

Number of Single Family Residential
Pumps Operating Simultaneously

Number of Single Family Residential Pumps Connected	Number of Pumps Operating Simultaneously
1	1
2 to 3	2
4 to 9	3
10 to 18	4
19 to 30	5
31 to 50	6

51 to 80	7
81 to 113	8
149	9

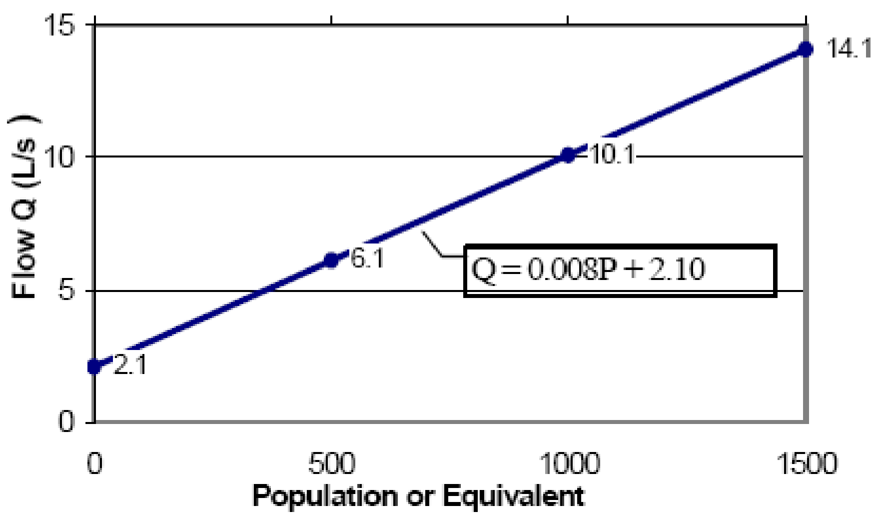
b) Multi-Family, Non-Residential and Mixed Areas

This procedure applies to any development in which pump capacities exceed those for single-family residences. For the upstream end of the system, where there are only one or two connections, assume the connected pumps are operating. Further downstream, use the following equation, the typical form of which is illustrated in Figure below.

$$Q = CP + F$$

Where: Q = Design flow in L/s
C = Coefficient based on type of development and peaking factors; standard value: 0.008
P = Population or equivalent

F = Factor based on minimum flows, standard value: 2.10



4.17.6 Hydraulic Calculations

Criteria for Hydraulic design calculations include the following:

- Pipe flow formula: Hazen Williams, with friction coefficient C=130
- Minimum velocity: V = 0.6 m/s
- Maximum velocity: V = 3.0 m/s
- Maximum operating head (total dynamic head, TDH): compatible with pumps and not exceeding 35 m (343 kPA) unless otherwise approved by the City in advance.

System test pressures shall be 2.0 times the maximum operating head and not less than 700 kPA (71.36 m).

A hydraulic analysis shall be undertaken to ensure that any potential transients (water hammer) resulting from pumps starting, stopping, full load rejection during power failure, etc. do not adversely affect the piping, valves and associated infrastructure within the system.

4.17.7 Pipe

Acceptable pipe materials, among others, include the following:

- High density polyethylene (HDPE) to AWWA C901 for pipes 75 mm diameter and smaller, and AWWA C906 for pipes 100 mm diameter and larger. Typically to iron pipe sizing (IPS) dimensions, pressure class and OD-based dimension ratio (DR): 150 and 17.0 respectively.
- Polyvinyl chloride (PVC) to CSA B137.3, and AWWA C900 or AWWA C905. Outside diameter (OD) to Ductile Iron outside dimensions (DIOD). Pressure class and OD-based dimension ratio (DR): 235 and DR 18 respectively.

Minimum pipe sizes are as follows:

- From pump unit to City low pressure force main: 38 mm internal diameter (ID)
- City low pressure sewage force main: 50 mm ID

Joints: Compatible with pipe material and fittings, and complete with appropriate thrust restraints in accordance with MMCD and supplementary specifications.

Installation Depths: Minimum 0.9 m on public right-of-way and 0.75 m on private property. Maximum depths without approval of City 3.0 m.

Installation between pump unit and City force main shall include appropriate warning tape located above the pipe zone.

4.17.8 Cleanout Manholes

Cleanout manholes are required on low pressure force mains at ends, junctions, low points, changes of direction exceeding 22.5° and at maximum 200 m spacing. Details are shown on the standard drawings. Manhole and cleanout lids shall be labelled “sewer”.

4.17.9 Air Valves

Sewage air vacuum/release valves are required at system high points and major changes in grade (10% or greater). Details of air valve assemblies are shown on the standard drawings.

4.17.10 Discharge Location

Details of the system discharge, located within a City ROW, will be subject to approval at the Preliminary Design stage of a project. Discharge will be into a manhole and will include fittings to make the discharge submerged. Fittings will be removable to provide for flushing.

4.17.11 Service Connections

Service connections to the public sewer shall include integral wye fittings oriented in the direction of flow.

Each service connection shall include a chamber located on private property at the property line. Details of the chamber and valves and fittings to be included are shown on the standard drawings. Check valves shall be epoxy-coated cast iron, full-ported, wye body ball check valves.

4.17.12 Private Pump Unit General Requirements

General requirements include the following:

- Pump unit package design, including the service connection, shall be sealed by a professional engineer registered in the Province of B.C.
- All pump and control equipment shall be certified by CSA or an equivalent Canadian certification agency.
- Pump unit specifications are subject to approval by Engineering at the preliminary design stage of a development.

- Permits:
  - Plumbing permit applications shall be in accordance with the Burnaby Plumbing Bylaw and shall include design drawings, B.C. Building Code. Schedules B-1 and B-2 and a copy of the pump unit operating and maintenance instructions. Building Code Schedule C-B shall be submitted after completion of the installation.
  - Connection permits are subject to approval from Engineering.
  - Electrical permit applications shall be in accordance with the City of Burnaby Electrical Bylaw and shall include design drawings.
- Duplex (two pump) units are required for multi-family and non-residential properties.
- Location: The pump chamber shall be in a location convenient for maintenance. The control/alarm panel shall be located in close proximity to the chamber either outside or inside of the building.
- Detailed, concise operating and maintenance instructions shall be submitted to the owner of each pump unit package. A summary shall be taped to the inside of the control panel door.
- Suppliers Qualifications: Pump unit suppliers shall have documented experience and ability in design, supply and servicing of pump unit packages including pump(s), chamber, piping and controls.

4.17.13 Pump Details

Pumps for low pressure systems shall be submersible grinder pumps. Grinder assemblies shall consist of hardened stainless steel components designed to grind sewage solids into fine particles which pass easily through the pump (with typical 32 mm diameter discharge) and piping.

Pump units shall be capable of discharging the design flow at the maximum operating head. Pump design flow shall be based on minimum flow velocity as indicated under within Section 4.17.6 (Hydraulic Calculations), or the peak dry weather flow calculated as indicated in the Sanitary Sewer System section of the MMCD Design Guideline Manual.

The higher of the two design flows shall be used.

Grinder pumps shall be either centrifugal or semi-positive displacement pumps.

Pump curves shall be “steep” within the design operating range, i.e. where total head is below the maximum operating head, such that the reduction of capacity with increasing head does not exceed 0.03 L/s/m.

Pump units discharging through 100 mm diameter or larger service connections into 150 mm diameter or larger low pressure force mains may be solids-handling submersible centrifugal pumps.

For systems not classified as low pressure sewers where pumps discharge into gravity sewers or force mains from City-owned community pump stations, and where service connections are 100 mm diameter or larger, pumps may be solids handling submersible centrifugal pumps.

Pumps shall be manufactured using durable, non-corrosive metallic components, and shall be supplied with a warranty effective for at least two (2) years after startup.

4.17.14 Pump Chamber Details

Criteria for pump chamber design include the following:

- Material and construction: Fibreglass reinforced polyester (FRP) or high density polyethylene (HDPE) with smooth interior, bottom shaped to avoid solids buildup, walls and bottom of sufficient thickness or with exterior corrugations to withstand soil pressure, and base to include flange for concrete collar to prevent flotation.
- Chamber lid and connections (inlet, discharge, ventilation and electrical) shall be factory-installed and watertight; lid shall be reinforced FRP or galvanized steel and provide access to full diameter of tank.
- Chamber diameter to provide for convenient operating and maintenance access and required storage volumes. Minimum diameter: 750 mm.
- Depth to accommodate inlet and discharge pipe elevations and to provide sufficient operating and storage volumes.
- Chamber volume between pump on and off levels to be based on pump cycle times between 5 and 30 minutes. A typical operating volume for a single family residential unit is 200 L.
- Chamber volume for emergency storage (above normal pump start level) shall be based on minimum 6 hours storage at average dry weather flow (ADWF) calculated as indicated in the Sanitary Sewer System section of the MMCD Design Guideline Manual. Emergency storage may be provided in a separate chamber, or standby power may be provided in lieu of emergency storage.

4.17.15 Piping Details

Piping design criteria include the following:

- Pump chamber piping shall be designed to accommodate easy pump removal and replacement. Unless an approved equivalent system is provided, pump chambers with depth of 1.8 m or greater shall include a pump lift out coupling and slide rail system.
- Pump discharge piping shall include full ported check valve and ball valve.
- Where a slide rail system is not provided, a union shall be included between the two valves.
- An anti-siphon valve is required where a pump is located higher than any part of the low pressure system.

4.17.16 Pump Chamber Ventilation

Each pump chamber shall include a minimum 50 mm diameter vent pipe installed in accordance with the BC Plumbing Code and the Burnaby Plumbing Bylaw (one size smaller than sump inlet).

Unless otherwise approved by the plumbing inspector, the vent discharge shall be installed approximately 600 mm below ground level to the building wall and shall be connected to the building plumbing ventilation system.

If approved by the plumbing inspector, the vent discharge may be located either on the building exterior wall or attached to a post in a secure location if the pump chamber is greater than 25 m away from the building.

4.17.17 Electrical

All materials and installation shall comply with the B.C. Electrical Code and City of Burnaby requirements.

Power supply shall be from the building served by the pump unit. The following nominal service voltages will be acceptable:

- For residential installations: 120/208 V or 120/240 V, single-phase.
- For industrial/commercial installations: as above, or 120/208 V or 347/600 V, three-phase.

Wiring from the building to the pump chamber shall be underground. Where a building electrical system includes emergency standby power, the pump unit power supply shall be connected to the emergency power

4.17.18 Controls

Pump controls shall automatically start and stop the pump(s) and provide a high level alarm.

Level switches shall be either pressure switches, if approved at the preliminary design stage of the project, or float switches.

Unless otherwise approved at the preliminary design stage, power and control wiring shall be continuous from the pump unit and level switches to junction boxes located above grade near the pump chamber or on the exterior of the building.

Where the pump chamber is classified as hazardous, a conduit seal shall be provided between the junction box and the control panel.
The control cabinet shall be installed in one of the following locations:

- On an exterior building wall close to the pump chamber;
- Inside the building near an outside door which is close to the pump chamber; or
- On a post adjacent to the pump chamber if the chamber is located 25 m or more away from the building.
- In accordance with the applicable electrical code

If located outdoors, the control cabinet shall be lockable and weatherproof (EEMAC Type 3) and made from non-corrosive materials. Junction boxes shall be non-corrosive Type 4X.

The control panel shall be approved as specified under PUMP UNIT GENERAL REQUIREMENTS and shall include the following features:

- Control voltage limited to maximum 120 VAC
- White “power on” light
- Float switch indication lights
- Green “pump on” light
- Red “motor overload” light
- Red “over temperature” light, if required by Code
- Manual reset of fault conditions
- High level alarm light and buzzer
- Pump disconnect switch
- Motor starter

- Hand-Off-Auto (HOA) selector switch
- Control transformer, if required to suit control voltage
- Automatic alternator for multiple pump units
- Control Fuse
- Terminal Strip
- Form "C" (SPDT) alarm contact, rated minimum 3A, 120 VAC, wired to a set of isolated terminal blocks.

The alarm circuit shall include an alarm light buzzer and test /silence switch. If the control cabinet is mounted outside, the alarm signal shall be transmitted to an alarm box installed inside the building.

In non-residential, multi-family and other "high value" installations, a remote alarm using telephone auto-dialer or other suitable technology should be considered.

4.18 Sewer System Seismic Design

Special design criteria of sewer systems apply in areas subject to permanent ground deformation due to liquefaction or landslide, where there may potentially be severe sewer failure consequences.

Areas of seismic vulnerability due to soil liquefaction or landslide have been identified in Figure 3.1 "Water Network Seismic Vulnerability", Section 3.0.

4.18.1 Gravity Sewer Seismic Design

In areas of confirmed seismic vulnerability, the sewer shall be designed so that the joints will not separate, and the pipe will experience ductile deformation to accommodate permanent ground deformation during an earthquake. The design shall limit the flotation of the pipe and manhole structures.

Design

Pipe and Fittings

Use of ductile iron (complete with poly-encasement) steel, high-density polyethylene pipe (HDPE), PVC and fittings is required in seismically sensitive areas. Pipe, pipe fittings and pipe coatings shall comply with existing municipal standards. Uses of concrete pipe (either reinforced or un-reinforced), grey or cast iron pipe or fittings is not allowed.

Joint Restraint

All pipeline, fittings and appurtenance points shall be restrained, so that they will not allow pullout when subjected to extension forces. The joint restraint system shall be strong enough to resist loading developed by 50 metres of buried pipe being pulled through the ground (wrapped in polyethylene). An appropriate design reference would be Thrust Restraint Design for Ductile Iron Pipe published by Ductile Iron Pipe Research Association.

Pipe Wrapping

DI Pipe shall be wrapped with 8 mill thickness polyethylene (poly encasement) such as is commonly used for corrosion protection, to minimize soil-pipe interaction.

Pipe Flotation Control

If the pipeline is located within the liquefiable layer and is 500 mm or greater in diameter, provision should be made to limit flotation, either by designing the pipe system for neutral buoyancy in liquefiable soils or positively holding down the pipe to keep it from floating under liquefaction conditions.

Typically, any required floatation control is achieved by encasing the pipe in concrete in order to achieve the specified neutral buoyancy. Under most circumstances, it is acceptable to assume that the pipe is half-full or sewage for the purposes of these calculations.

Manhole Flotation Control

Provision shall be made to limit floatation, either by designing the manhole for neutral buoyancy in liquefiable soils or positively holding down the manhole to keep it from floating, for manholes with one or more pipes of 500 mm or greater diameter entering the manhole.

Typically, any required floatation control is achieved by thickening the concrete base slab in order to achieve the specified neutral buoyancy.

To reduce the number of manholes overall in areas of liquefiable soil, increase the maximum spacing between manholes to 200 m.

Connections to Manholes and Structures

The designer shall calculate the expected differential movement between the pipe and structure, and provide a design that will accommodate the movement to the satisfaction of the Engineer for manholes with pipes of 500 mm or greater diameter, entering the chamber.

Typically, this would be achieved by installing two mechanical couplings or flexible joints in the pipe. One would be located close to the outside face of the manhole barrel and one would be located a short distance away, ideally at the edge of the manhole excavation.

4.19 Force Main Design

The design of sanitary force mains shall be similar to those general requirements for design of water (pressure) pipe described under section 3.0 - Water Distribution, of this design criteria manual.

In addition, all sewage forcemains shall be designed to mitigate leakage or loss of service resulting from ground deformations associated with seismic vulnerability. Areas of potential system seismic vulnerability (liquefiable soils) are delineated in Figure 3.2.

Forcemain designs shall meet the following requirements:

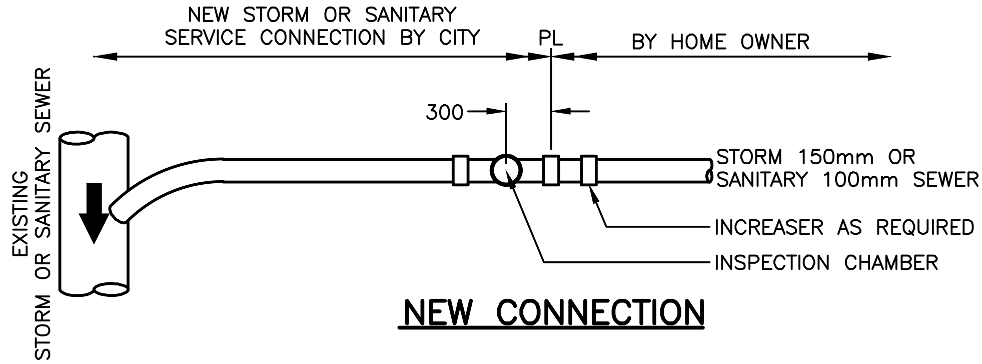
i. Materials;
Forcemains shall be constructed of restrained ductile iron pipe, fused HDPE (Min DR17, IPS) pipe, or as otherwise approved by the Engineer. PVC is not allowed in seismically sensitive areas. All pipe fittings, valve bodies and related system components to be made from ductile iron.

ii. Joint Restraints;
All DI pipe joints shall be restrained using boltless restrained pipe (TR FLEX) or an approved equivalent methodology.

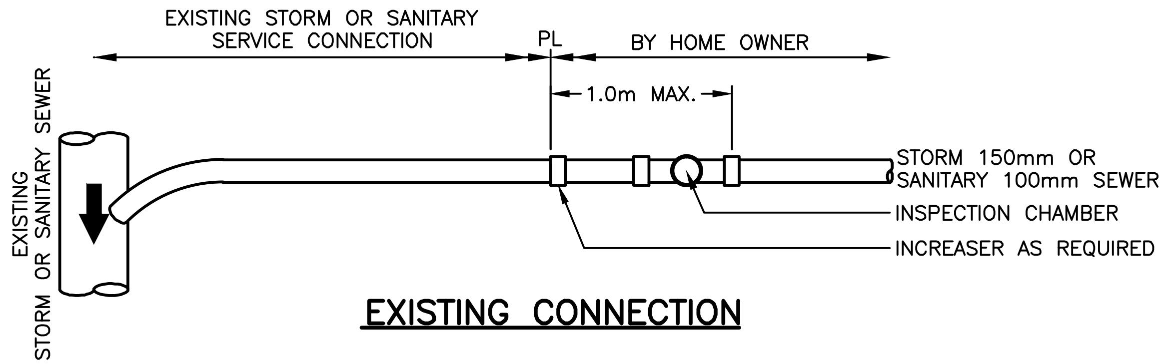
iii. Pipe Wrapping;
All DI pipe shall be encased with 8 mil polyethylene (poly encasement) in accordance with AWWA C105.

iv. Connections to Structures;
The designer shall calculate the expected differential movement between pipe and structure and provide a design that will

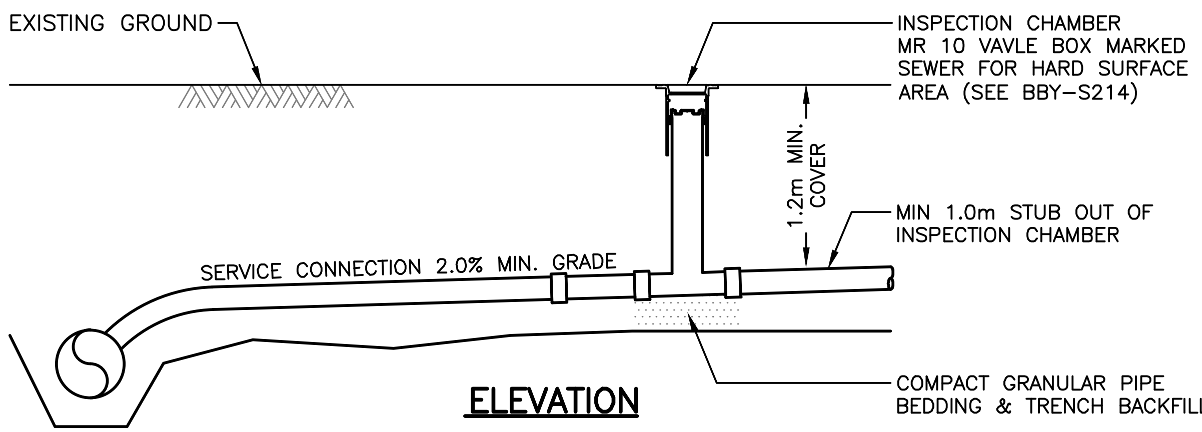
accommodate the anticipated movement. Use flexible expansion joints where specified.



NEW CONNECTION



EXISTING CONNECTION



ELEVATION

NOTE:

1. ALL DIMENSION ARE IN mm UNLESS OTHERWISE NOTED
2. INSPECTION CHAMBER AND RISER PIPE SHALL BE PLUMB VERTICAL
3. INSPECTION CHAMBER LIDS SHALL BE COLOURED "GREEN FOR STORM" AND "RED FOR SANITARY"
4. STORM SEWER CONNECTIONS TO BE 150mm INSPECTION CHAMBERS OR AS SPECIFIED ON CONTRACT DRAWINGS
5. SANITARY SEWER CONNECTIONS TO BE 100mm INSPECTION CHAMBERS OR AS SPECIFIED ON CONTRACT DRAWINGS
6. SEE DRAWING MMCD S9 FOR DETAILS OF INSPECTION CHAMBER AND INSTALLATION REQUIREMENTS
7. HOME OWNER SHALL BE RESPONSIBLE FOR LOCATION AND PROTECTING ALL EXISTING UNDERGROUND UTILITIES ON PRIVATE PROPERTY DURING CONSTRUCTION
8. HOME OWNER RESPONSIBLE TO PLUG INSPECTION CHAMBER FOR TESTING ON PRIVATE PROPERTY
9. HOME OWNER MUST REMOVE PLUG AND FLAPS IN INSPECTION CHAMBER AFTER TESTING AS PER PLUMBING DEPARTMENT INSPECTION
10. HOME OWNER TO INSTALL INSPECTION CHAMBER WHEN TYING TO EXISTING SERVICE CONNECTION UNDER PLUMBING DEPARTMENT INSPECTION

NO.	DATE	REVISION	APP'D	BY
2	2013 FEB	GENERAL REVISION (S120)		HL
1	2000 JAN	GENERAL REVISION		JK

City of Burnaby
ENGINEERING DEPARTMENT

SERVICE CONNECTION TO STORM OR SANITARY SEWER

DRAWN BY:	SCALE: N.T.S.	BBY- S212
APPRV'D BY:	DATE: 1999 FEB	

5.0 STORM DRAINAGE

5.1 General

These guidelines are not intended to be a substitute for sound engineering knowledge and experience. Drainage designs should be prepared under the direction of a design professional who has the appropriate experience and is registered with Engineers and Geoscientists British Columbia.

These guidelines are intended to cover only the minimum requirements. Drainage designs must conform to local government bylaws, regulations, guidelines and policies plus federal and provincial statutes and guidelines. These include but are not limited to:

- Burnaby City of Burnaby Standard Construction Documents
- Burnaby Subdivision Control Bylaw 1971
- Burnaby Integrated Stormwater Management Plans (ISMP)
- Local Government Act
- Fisheries Act
- Navigable Waters Protection Act
- Wildlife Act
- Migratory Birds Conservation Act
- Dyking Act
- Land Development Guidelines for the Protection of Aquatic habitat (Canada/BC)
- Urban Runoff Quality Control Guidelines for British Columbia (B.C.)
- Effectiveness of Stormwater Source Control (GVRD)
- Metro Vancouver Integrated Liquid Waste and Resource Management Plan

5.2 Stormwater Management

Stormwater management involves the planning and design necessary to mitigate the hydrological impacts arising from development or land use changes.

Adverse hydrological impacts include such things as increased peak storm water flows, erosion, sedimentation, flooding, reduced surface infiltration, reduced minimum groundwater levels and stream flows, water quality deterioration, and degradation of aquatic and wildlife habitats. Mitigation measures include but are not limited to the following:

- Appropriate sizing and routing of pipes and channels

- Major storage flow path routing
- Detention storage
- Sediment Removal and Erosion Control
- Biofiltration
- Landscaping
- Source Control
- Erosion Protection
- Groundwater infiltration
- Subsurface disposal
- Lot Grading

5.3 City of Burnaby Storm Design Manuals, Guidelines and Plans

The City of Burnaby Engineering Design Criteria Manual essentially applies to the modeling, design and construction of drainage systems located in City rights-of-way, easements, lots and parks, and which will be eventually owned and maintained by the City.

In addition to the City of Burnaby Engineering Design Criteria Manual, the Drainage Design is to conform to the following approved City of Burnaby documents:

5.3.1 Stormwater Source Control Guidelines (2012)

Metro Vancouver's Stormwater Source Control Guidelines (2012) is the primary reference for managing private site rainwater and designing water quality facilities and storage structures, located on private property, for managing rainwater flow and water quality for new developments and redevelopment.

5.3.2 Burnaby Integrated Stormwater Management Plans

The City of Burnaby has developed and implemented Integrated Stormwater Management Plans (ISMP) on a watershed basis, which provides the Design Engineer information related to:

- Existing condition of the drainage system and ecological health of the watershed
- Approved goals and strategies for developments to proceed with minimum effects on flooding, erosion water quality and ecological health
- Remedial and new capital works to be incorporated with developments

The Designer of storm drainage systems should first obtain confirmation from the Engineer regarding the particular Integrated Stormwater Management Plan guidelines which apply to the design area, prior to preliminary design.

The ISMP is to be used in conjunction with the Official Community Plan (OCP) and NCP/LCP for controlling permitted development without placing an unacceptable burden on the existing drainage infrastructures.

5.4 Minor and Major Systems

The storm water management system in Burnaby consists of the following components:

5.4.1 The Minor System

Consists of pipes, gutters, catch basins, driveway culverts, open channels,

Watercourses, appurtenances and storm water management facilities, designed to convey flows freely without surcharging (HGL remains below crown of pipe) from a 1 in 10-year return frequency, as directed by the Engineer.

5.4.2 The Major System

Consists of surface flood paths, roadways, swales, culverts, watercourses, associated appurtenances and storm water management facilities designed to convey flows resulting from a 1 in 100-year return frequency.

If required to accommodate low building elevations, and if approved, a piped minor system may be enlarged or supplemented to accommodate major flows.

5.5 Runoff Analysis

Storm drainage design should be carried out using one or both of the following methods as indicated below. Calculations are to be submitted with designs.

- **Rational Method**: Applicable to sites not exceeding 0.5 hectare in area or as directed by the Engineer.
- **Modeled Simulation Method**: Applicable to sites in excess of 0.5 hectare in area or as directed by the Engineer.

Input and output data will be compatible with the City of Burnaby software.

5.6 Rainfall Data

5.6.1 IDF Curves for the Rational Method

Combined data from Confederation Park and WestBurnco rain gauges are to be used in designing drainage infrastructure in The City of Burnaby.

Rainfall Intensity Duration Frequency (IDF) curves in Figure 5.1 are given for the following periods of return:

1 in 2 years
1 in 5 years
1 in 10 years
1 in 25 years
1 in 50 years
1 in 100 years

5.6.2 Rainfall Data for Modeled Analysis and Design

Rainfall hyetographs for use with hydrograph method analyses are to be developed using Metro Vancouver rainfall data.

If applicable rainfall data is not available, the designer is to obtain and interpolate data from area(s) with similar climate. Details of the selection and interpolation procedure are to be documented and submitted to the Engineer for acceptance.

If the critical design condition for a drainage system is either snow melt or a combination of rainfall and snow melt, the Designer is to develop the data from Environment Canada and/or Metro Vancouver records. Metro Vancouver monitored rain gauge locations are shown on Figure 5.2.

5.6.3 Climate Change IDF Curves

Climate change adaptation is an important issue that continues to evolve from ongoing research and modelling efforts. Conclusions from the research indicate a significant increase in rainfall intensity with projections out to 2050 and 2100. Metro Vancouver has recently released a study of the impacts of climate change on precipitation and stormwater management. In the report, moderate change IDF (median or likely increase in rainfall) and high change scenarios (extreme or worst-case increase in rainfall) were created assuming Representative Concentration Pathway (RCP) 8.5 “business-as-usual” greenhouse gas (GHG) emissions. For more information, refer to Metro Vancouver report titled “Impacts of Climate Change on Precipitation and

Stormwater Management (2012)" and tool "IDF Curve Tool and Design Storm Spreadsheet" in Mircrosoft Excel.

Regardless of the analysis method, climate change IDF curves should be used as part of the analysis and design of drainage infrastructure. Using current climate IDF curves for design of new drainage infrastructure may be suitable for only temporary infrastructure (i.e. less than five year design life). Using moderate change IDF curves is suitable for low to medium risk due to failure (i.e., pipes, ditches and driveway culverts) in a minor system. Using high change IDF curves is suitable for high risk due to failure (i.e., culverts/bridges) in a major system.

Justification and decision to use which IDF curve for design of drainage infrastructure, and verification of sufficient overland flow paths to convey flows in excess to piped system capacity, while maintaining public safety and avoiding damage to property, should be documented and submitted to the Engineer for acceptance.

5.7 Discharge Rates and Quality

The Drainage system should include runoff controls to limit post-development peak discharge to the predevelopment rates for 5-year return period storms.

Runoff quality treatment is to be considered in accordance to the City of Burnaby Rainwater Management Design Guidelines. Quality treatment facilities include, but are not limited to, oil/water separators for service stations, silt traps, detention storage facilities, absorbent landscape, grassed swales and constructed wetlands. Designs are to comply with the requirements of the City, federal, provincial and regional statutes and guidelines noted in section 5.1.

Treatment facilities should include provisions for maintenance equipment access.

5.8 Land Drainage, Lot Grading and Sediment Control

All construction projects within the City shall implement Erosion, Sediment/Water Quality control (ESC) measures. These measures shall remain in place until 95% of the construction work is completed.

Lot Grading is to comply with the following:

- Grade lots to drain to the municipal minor of major drainage system, natural drainage path or roadway. Use minimum 1% grade.

- Avoid drainage across adjacent lots. If cross-lot drainage is unavoidable, provide a swale to divert runoff away from the lower lots.
- Grade areas around buildings away from the foundations.
- Where lots are lower than the adjacent roadways, direct road runoff away from buildings and driveways and into a municipal drainage system.
- Set building elevations above the hydraulic grade line (HGL) of the major drainage system. See Minimum Building Elevation (MBE) guidelines.

5.9 Minimum Building Elevations (MBE)

The MBE refers to the elevation of the lowest floor slab in a building or the underside of the floor joists where the lowest floor is constructed over a crawl space. Crawl space is defined as the space between a floor and the underlying ground having a maximum height of 1.2 m to the underside of the joists and not used for the storage of goods or equipment damageable by flood waters.

The MBE of all parcels will be at least 0.60 m above the storm sewer connection invert (at the property line) and 150 mm above the 1 in 100 year storm hydraulic grade line OR the abutting road crown if designed to convey the Major System flow overland.

Areas within the Big Bend may need to meet the requirements of the City of Burnaby Rezoning Bylaw, Section 6.18. The developer will be responsible for confirming the requirements for flood protection.

The MBE will not be adjusted or revised without the written approval of the Engineer.

5.10 Rational Method

The Rational Method for calculation of peak flows for use as indicated in the Runoff Analysis section is as follows:

Q = RAIN Where Q = Peak flow in cubic meters per second (m^3/s)

R = Runoff Coefficient x Adjustment Factor (AF) (see 5.10.2)

A = Area of catchment in hectares (ha)

I = Intensity of rainfall in mm per hour

N = 1/360

5.10.1 Runoff Coefficients

The following runoff coefficients are for use with the Rational Formula. These coefficients are for general application only. Design values are subject to verification by the designer and accepted by the City Engineer.

Higher values may be applicable in those areas which experience rainfall during the winter when the ground is frozen. These values may reach 0.80 to 0.95

Land Use	Percent Impervious	Runoff Coefficient* 5/10 Year Storm
Residential		
RA, RA-G	50	0.45
RH, RH-G	55	0.50
RF, RF-SS, RM-D	65	0.60
RF-G, RM-M, RM-10, RM-15, RM-19, RM-30, RM-45, RM-70, RM-135, RMC-135	65	0.60
RMC-150, RF-9, RF-12, RF-SD	80	0.70
Commercial	90	0.80
Industrial	90	0.80
Institutional (e.g. School, church)	80	0.75
Parks, Playgrounds, Cemeteries, Agricultural land, Grasslands	20	0.25**
Cultivated Fields	30	0.30
Woodlands	5	0.10

* To compute the 100-year flows, increase above runoff coefficients by 20%, up to a maximum of 0.95.
** Passive use parks may reduce coefficient to 0.13.

5.10.2 Runoff Coefficient Adjustment Factor

An adjustment factor (AF) is to be applied to the runoff coefficient to reflect variations in soil permeability and slope.

Soil Type and Slope	AF
Sandy soil with flat slope (up to 5%)	0.9
Sandy soil with steep slope (over 5%)	1.0
Clayey soil with flat slope (up to 5%)	1.0
Clayey soil with steep slope (over 5%)	1.1
Rock	1.1

The above runoff coefficient adjustment factors are for general application. Design values are subject to verification by the designer and accepted by the Engineer.

5.10.3 Rainfall Intensity

The rainfall intensity for the Rational Method should be determined using the appropriate rainfall IDF curve (see Figure 5.1) with the duration equal to the time of concentration (T_c) calculated as indicated below.

5.10.4 Time of Concentration

The time of concentration is the time required for runoff to flow from the most remote part of the catchment area under consideration to the design node. The time of concentration can be calculated using the following formula:

$T_c = T_i + T_t$ Where: T_c = time of concentration (minutes)
T_i = inlet or overland flow time (minutes)
T_t = travel time in sewers, ditches, channels or watercourses (minutes)

Inlet of Overland Flow Time (T_i)

a) Typical inlet times for urban areas are as follows:

Single Family Lot	10 minutes
Multi-Family Lot	8 minutes
Commercial/industrial/institutional	5 minutes

b) The inlet time for larger areas can be calculated using the "Airport Method" as follows:

$$T_i = \frac{3.26\,(1.1 - C)\,L^{0.5}}{S^{0.33}}$$

Where: T_i = inlet time (minutes)
C = runoff coefficient (see above)
L = travel distance (m)(Maximum length = 300m)
S = slope of travel path (%)

Travel Time (T_t)

The travel time in sewers, ditches, channels or watercourses can be estimated using the Modified Manning formula:

$$T_t = \frac{L\,n}{60\,R^{0.667}\,S^{0.5}}$$

Where: T_t = travel time (minutes)
L = length of flow path (m)
n = Manning roughness coefficient:
- 0.050 Natural channels
- 0.030 Excavated ditches
- 0.013 Pipes and concrete lined channels.

R = Hydraulic radius (area/wetted Perimeter) in m
S = slope in m/m

Other formulae are available for calculation of T_i and T_t. Obtain approval from the Engineer.

5.10.5 Design Summary Sheet

All Rational Method design calculations are to be made in metric (SI) units.

Results of computations are to be submitted in digital spreadsheet file format compatible with City of Burnaby software. The submitted calculations will be in accordance with the tabulated form given in Figure 5.3.

5.11 Hydrograph Method

Drainage designs using the Hydrograph Method require computer models capable of modelling the hydrologic characteristics of the watershed and generating flow hydrographs from each sub-catchment for a critical storm or a series of storms and routing the hydrographs through the drainage network pipes, channels and storage facilities.

5.11.1 Model Selection

Selection of computer programs requires review of the historical application of each program in watersheds similar to those under consideration. Before design is commenced, approval of the Engineer should be obtained.

5.11.2 Modelling Procedures

Wherever possible, modelling results should be calculated using observed rainfall and flow data from design watershed or a similar watershed. Sensitivity of the model predictions to variations of key parameters should be tested and the findings used to develop realistic and conservative models. The Engineer will confirm the extent of downstream modelling that will be required.

Post-development hydrographs should be generated at key points of the major drainage system for a 10-year and 100 year design storm with durations of 1, 2, 6, 12, and 24 hours for each development condition. Different storm durations may be required, at the direction of the Engineer. This will identify the critical storm event to be used in designing the systems components. Note that the storm durations that generate the critical peak flow may be different from the durations that generate the critical storage volume. Systems with a number of interconnected ponds or with restricted outlet flow capacity may require analysis for sequential storm events or modelling with a continuous rainfall record.

Detailed designs should include maximum hydraulic gradelines (HGL) of the minor and major systems plotted on profiles of the minor components and compared with minimum building elevations (MBE) to demonstrate flood protection.

5.11.3 Submission of Modelling Results

Modelling results are to be submitted to the Engineer in a report containing at least the following information:

- Plans showing catchment and sub-catchment boundaries, slopes, soil conditions land uses and flow control facilities
- Name and version of modelling program(s)

- Parameters and simulation assumptions
- Design storm details
- Modelling calibration data used
- Pre-development and post-development hydrographs
- Calibration and validation details
- Stage storage/detention results (for detention systems)

5.12 Minor System Design

5.12.1 Pipe and Channel Capacity

Use Manning's formula:

$$Q = \frac{AR^{0.667} S^{0.5}}{n}$$

Where Q = Design flow in m^3/s
A = Cross sectional area in m^2
R = Hydraulic radius (area/wetted perimeter) in m
S = Slope of hydraulic grade line in m/m
n* = Roughness coefficient:
0.013 for all smooth pipes
0.024 for corrugated pipes and culverts

*Note – Any other values of n used are to be approved by the Engineer.

5.12.2 Flow Velocities

Minimum design velocity for pipes flowing full or half full: 0.6 m/s.

Where steep grades result in velocities exceeding 3 m/s, measures are required to prevent pipe erosion and movement.

Where a storm sewer discharges into a watercourse, provide erosion bank protection and, if necessary, energy dissipation facilities. Avoid discharge perpendicular to stream flow.

5.12.3 Ditch Inlets and Outfalls

Ditch inlets to storm sewers should include safety grillage for pipes > 450 mm diameter. Debris screens and sediment basins will be designed to provide unencumbered access for maintenance.

Permanent inlets and outfall structures for pipes larger than 300 mm diameter will be precast reinforced concrete structures. For pipes of 300 mm diameter or less, approved prefabricated or concrete filled bag headwalls may be used.

All ditches and open watercourses receiving discharge from either a Minor or Major drainage system will be provided with erosion protection for a minimum of 3.0 m downstream of the apron of the outfall structure. Where the velocity of flow at discharge is greater than 1.0 m/s, the outfall structure will incorporate an energy dissipating baffle.

Handrails will be incorporated into the structures where a drop of 1.0 m or more exists around the outfall wall and wing walls. Handrail arrangement will take future maintenance requirements into consideration.

5.12.4 Alignment

Except as indicated for Section 5.12.7 Curved Sewers, horizontal and vertical alignments are to be straight lines between manholes. Elevations are to be recorded.

5.12.5 Minimum Pipe Diameter

Storm Sewers	200 mm
Culverts	
Crossing roads	450 mm
Crossing driveways	300 mm
Catch Basin Leads	150 mm
Service Connections	
Residential	100 mm
Commercial/Industrial	150 mm

Downstream pipe sizes are not to be reduced unless the downstream pipe is 600 mm diameter or larger and increased grade provides adequate capacity. Detailed hydraulic analysis is required. The maximum reduction is two pipe sizes.

New culverts will not have a smaller diameter than the next downstream culvert.

5.12.6 Minimum Grade

Minimum grades of storm sewers are as required to obtain the minimum velocity of 0.6 m/s except for catch basin leads and service connections, for which minimum grades are as indicated elsewhere.

5.12.7 Curved Sewers

Where permitted by the Engineer, horizontal and vertical curves may be formed using pipe joint deflections' as follows:

- Minimum radius = 60 m.
- Constant radius throughout the curve.
- Minimum design velocity = 0.9 m/s.
- Joint locations are recorded.

Deflections for the curvature may only be formed by pre-formed mitred bends, with minimum 1.25 m straight sections and maximum 45° mitres.

5.12.8 Depth

Storm sewer should be of sufficient depth to:

- Permit service connections at the pipe crown, for all parcels abutting the sewer.
- Prevent freezing: 0.9 m
- To permit gravity service to all tributary areas beyond the development.
- Clear other underground utilities.
- Prevent damage from surface loading.
- Minimum cover to the external diameter of pipe, without concrete encasement or detailed analysis: 0.9 m

5.12.9 Pipe Joints

Use watertight joints except where storm sewers are part of a subsurface disposal system.

5.12.10 Groundwater Infiltration

In low areas where groundwater concentration may cause surface ponding, reduced soil stability, or submergence of other utilities, provide screened and filtered manhole inlets or perforated sections of storm sewer.

5.12.11 Manholes

5.12.11.1 Locations: A manhole is required at the following locations:

- Every change of pipe size.
- Every change in grade, except as indicated in the Curved Sewers section.
- Every change in direction, except as indicated in the Curved Sewers section.
- Downstream end of curved sewers.
- Every pipe intersection, except for 100 mm and 150 mm service connections, catch basin connections and junctions with trunk sewers 900 mm diameter and larger.

- Upstream end of every sewer line.
- 150 m maximum spacing for all pipe sizes

5.12.11.2 Hydraulic Details:

- Crown elevations on inlet sewers will not be lower than crown elevation of outlet sewer.
- Minimum drop in invert elevations across manholes:
  - o Straight run: 5 mm
  - o Deflections up to 45 degrees: 20 mm drop
  - o Deflections 45 to 90 degrees: 30 mm drop
- Drop manhole and ramp structures should be avoided where possible by steepening inlet sewers. Where necessary, with the Engineer's approval, provide drop structures as follows:

Invert Difference	Structure
Up to 0.25 m	Inside Ramp
0.25 to 0.90 m	Outside Ramp
Greater than 0.90 m	Outside Drop*

*Inside drop may be used if specifically approved by the Engineer.

- Hydraulic losses are to be calculated for manholes with significant change of grade or alignment. For high velocity flows or large pipes (>600 mm), detailed analysis is required. For low velocities and smaller pipes, use the following formula:

$$H_L = \frac{k V^2}{2g}$$

Where: HL = head loss (m)
V = outlet flow velocity (m/s)
g = gravitational acceleration (9.81 m/s^2)
k = head loss coefficient (1.0 for channelled 90°bends and tees, to 1.5 without channelized benching)

5.12.12 Catch Basin Spacing

Catch basins are required at regular intervals along roadways, at intersections and at low points. Refer to MMCD Details and City of Burnaby Supplemental Details for CB arrangements at pedestrian Crossings.

Catch basin spacing is to provide sufficient inlet capacity to collect the entire minor flow or major flow, if required, into the pipe system.

The capacity of a single catch basin can be calculated using the orifice formula:

$$Q = kCA\sqrt{2gh}$$

Where:
- Q = inlet capacity (m^3/s)
- K = clogging factor (0.6)
- C = orifice coefficient (0.8)
- A = open area (0.068 m^2 for Dobney B-23 grate)
- G = gravitational acceleration (9.81 m/s^2)
- h = depth of ponding (m)

Space the catch basins to drain maximum paved areas of:

- 500 m2 on roads with grades up to 4%
- 400 m2 on roads with grades greater than 4%

Other catch basin spacing considerations include:

- Prevent overflows to driveways, boulevards, sidewalks and private property.
- Avoid locating within crosswalks.
- Avoid low points in curb returns at intersections.
- Catch basins to discharge into mainlines.
- Use double catch basins at “sag” points of vertical curves on major flow paths.

Minimum grade of catch basin leads: 2.0%

Lawn basins are required on boulevards and private properties where necessary to prevent ponding or flooding of sidewalks, boulevards, driveways, buildings and yards.

5.12.13 Service Connections

Every legal lot is to be provided with a separate service connection.

Unless otherwise accepted by the Engineer, connections are to serve the perimeter (foundation) drains of all buildings by gravity. Pumped connections may be permitted if requested prior to design and if appropriate covenants are provided.

Other service connection requirements include the following:

5.12.13.1 Size

- Minimum residential pipe sizes are 150 mm diameter, all others are to be as indicated elsewhere.

5.12.13.2 Location and Depth

- Connections to large lots are to be located at the lower end of each lot.
- Locate connections in accordance to City of Burnaby Supplementary MMCD Standard Detailed Drawing No. BBY-S212 (see Figure 4.1 in the SANITARY SEWER section)
- The connection elevation at the property line is to be above the minor HGL.
- Other depth requirements are as indicated for storm sewer mains.

5.12.13.3 Slope

- Minimum slope of service connections 150 mm diameter and smaller, from property line to storm sewer main, is 2%
- Larger sizes to be based on achieving a minimum velocity of 0.6 m/s.

5.12.13.4 Details

- Use standard wye fittings for connections to new mains. For connections to existing mains use wye saddles or, if approved, insertable tees.
- Service connections may be permitted into manholes if:
  - The connection is not oriented against the flow in the main.
  - Manhole hydraulic requirements are met.
- Inspection chambers are required on residential connections.
- Manholes are required on service connections larger than 250 mm diam.
- Connections exceeding 30 m in length will be treated as mains.

5.12.14 Locations and Corridors

Storm sewers should be located within roadway rights-of-way at off-sets from property line, as approved by the Engineer.

Servicing from roadways is required unless a pipe depth to invert greater than 4.5 m would be required to provide gravity service. Rear yard sewers and pumped connections are permitted only with prior approval of the Engineer.

Where a storm sewer crosses private land, right-of-way requirements are as indicated in Section 2.0 General Design Considerations. Storm mains in rights-of-way may require access for maintenance at the discretion of the Engineer. Structures and earthworks in or abutting a maintenance access will be designed for vehicle loadings of 10 tonnes.

Clearance from watermains is as indicated in section 2.0, General Design Considerations.

For widths of rights-of-way, refer to section 2.4, General Design Considerations.

5.12.15 Storm Water Pumping from Underground Parkades

Where drainage from underground parkades cannot drain to the Minor or Major System by gravity, the Engineer may allow disposal by a private pumped system discharging to the City storm sewer system. Approval of the Engineer is required prior to design inception.

Pumped drainage will not be permitted where natural ground water occurs within 300 mm of the parkade MBE.

The pumped drainage system will be isolated from the 1 in 100 year storm flows.

An alarm system may be required by the Engineer.

A restrictive covenant will be registered against the property with an underground parkade pumped drainage system. The covenant will indemnify and hold the City harmless from any damage, loss or act resulting from the failure of the pumping system for any reason. In addition, the covenant will describe the maintenance procedures to be followed for the pumping system.

5.12.16 Culverts

All culverts in natural watercourses will be designed to convey the Major Flow volume. The Designer will determine whether the culvert operates under inlet or outlet control conditions. Details will be submitted to the Engineer for approval.

Culverts for driveway crossings will form part of the Minor Flow system, and will be capable of conveying flows resulting from a 1 in 10 year storm event.

Culvert sizes shall be Absolute minimum diameter of 300 mm

Choice of culvert material, including inlet and outlet structures will be justified by the Designer, who will take into account.

- Hydraulic suitability
- Strength
- Resistance to corrosion
- Serviceability
- Environmental compatibility
- Conditions as per Section 5.13.4

5.12.17 Ditches

New open ditches are not acceptable for permanent servicing of land within the Urban Development Boundary of the City.

Where ditches are permitted by the Engineer as part of the temporary works on phased development, they will conform to the following:

- Maximum depth: 1.50 m
- Minimum bottom width: 0.50 m
- Maximum side slope: 1.5 horiz. to 1.0 vert.
- Minimum grade: 0.5% Maximum velocity: 1.0 m/s
  (Where soil conditions permit, or additional protection can be provided, higher velocities may be permitted.)

The minimum right-of-way width for ditches on private property will be 5.0 m. The R.O.W. will be aligned relative to the ditch to permit access for maintenance vehicles, and ditch crossing structures provided to enable vehicular access along the entire length of the R.O.W.

5.12.18 Swales

Swales may be used at the discretion of the Engineer.

Lot grading swales, where used, will be designed to provide protection for the downstream property from overland sheet-flow from uphill properties. Lot grading swales that cross property lines will be protected and secured by a registered easement to the point of discharge.

Lot grading swales will comply with the following:

- Minimum depth: 150 mm
- Minimum width: 1.50 m
- Minimum longitudinal slope: 1.0%
- Maximum velocity: 1.0 m/s

- Lined with turf sod on 150 mm (min) topsoil, or erosion blanket.

Major Flow swales, where used, will be designed to convey the Major Flow to a point of discharge. Major Flow swales will be:

- Designed to convey the designed Major flow
- Designed with anti-scour, erosion protection and energy dissipation measures incorporated.
- Secured and protected by a registered statutory Right of Way
- Provided with maintenance access approved by the Engineer

Roadside Drainage swales, where permitted, will be connected to the Minor Flow system via a trapped catch basin, and be:

- Used where road side ditch drainage is not possible
- Sized to the following dimensions
    - maximum width 2.0 m
    - maximum depth 300 mm
- Located no closer than 2.0 m to the edge of the paved road
    - Designed to have a maximum velocity of 1.0 m/s.
    - Lined with turf sod on 150 mm (min) topsoil, or erosion blanket.

5.12.19 Rock Pits and Dry Wells

Rock pits, dry wells or other on-site disposal will only be permitted, if prior approval is given by the Engineer.

5.13 Major System Design

5.13.1 General

The Major Flow system is to convey flows in excess of the capacity of the Minor system. Where underground routing of the Major Flow volume is chosen by the designer, then the design principles in the above sections relating to Hydrology, are to be adapted to suit. The remainder of this section concentrates on specifications to guide Designers opting for overland flow of the Major Flow.

5.13.2 Surface Flow Routing

All surface flows should have specially designed routes that are preserved and protected by rights-of-way and are designed with maintenance access accepted by the Engineer. Design criteria include:

- HGL is to be at least 300 mm below the MBE of adjacent buildings.
- Maximum flow depth on roadways: 300 mm
- One Lane, or a 3.5 m width at the crown of each roadway, is to be free from flooding.
- Where a roadway is used as a major flow path. The road grades are to be designed to accommodate and control the flow at intersections.
- Flooding is not permitted on private property except in flow channels in municipal rights-of-way.
- Overland routes are required at all sags and low points in roadways and other surface flow routes.
- Major flood routes are required at down-slope cul-de-sacs.

5.13.3 Surface Flow Capacity

Flow capacity of road surfaces and swales can be calculated using the Manning formula, which is presented elsewhere. Typical values of the Manning Roughness Coefficient "n" are:

- 0.018 for paved roadway
- 0.03 for grassed boulevards and swales
- 0.04 to 0.10 for irregular or treed channels

Design detail to include consideration of flow velocities and the potential requirement for erosion control measures.

5.13.4 Culverts and Bridges

Culverts located in natural watercourses or road crossings should be designed to convey the major flow or greater.

Aquatic habitat protection requirements must be considered for culverts in natural channels. Approvals are required under Provincial and Federal legislation. The Design Engineer will ensure compatibility of the proposed design with the current legislation prior to commencing design.

Culvert design calculations and assumptions will be submitted for review and acceptance by the Engineer and other regulatory agencies, and is to be in accordance with the procedures outlined in an applicable design manual.

Inlet and outlet structures are required for all major system culverts. Design considerations are to include inlet control and outlet control conditions, energy dissipation and erosion control.

Culverts and channels under bridges for arterial and collector roads are to be designed to clear the 1:200-year flood level, unless advised otherwise by the Engineer.

5.13.5 Water Courses

Watercourses, including flood plains, are to be preserved and/or designed to protect habitat for aquatic and terrestrial species as well as to convey storm runoff.

Designers must consider the Federal, Provincial and Municipal laws, regulations and guidelines noted above, and must obtain comments and approvals from the appropriate agencies.

5.14 Runoff Controls

Runoff controls are required to meet the objectives of the City of Burnaby ISMP's.

Location and maintenance options for runoff control facilities include:

- On-site, i.e., on multi-family or non-residential development sites - registered covenants to the satisfaction of the Engineer are required to ensure appropriate maintenance by property owners.
- Off-site, i.e., on public lands, road rights-of-way or parks, are under the operation and maintenance jurisdiction of the City, subject to the acceptance of the Engineer.

Control of discharge rates is commonly done through detention storage. Types of storage include:

- On-site, where the flow path is within the storages facility, and
- Off-line, where the storage facility is separate from the normal flow path and is filled by overflow during severe storms.

Refer to the City of Burnaby's Total Stormwater Management Policy documentation for specific storm water management information.

On-site runoff control facility options and design guidelines are provided in the Burnaby Rainwater Management Design Guidelines (BRMDG).

Off-site runoff control facility options and design guidelines include the following:

5.14.1 Underground Storage

- Facilities include tanks and oversized pipes, with outlet controls.
- Tanks may be on-line or off-line.

- Cross sections, inlet and outlet locations, and maintenance access covers should be designed to minimize maintenance requirements.
- Structural design to accommodate traffics loads and groundwater pressure.
- Maintenance access provisions required.
- Generally located on-site.

5.14.2 Dry Detention Ponds

- Intended to provide storage only during severe storm events.
- May be on-line or off-line.
- Generally located off-site.
- May accommodate recreational uses.
- Overflow elevations to be coordinated with MBE's.
- Design details, other than discharge rates should be in accordance with current technologies as outlined in Land Development Guidelines for the Protection of Aquatic Habitat (Canada/B.C.), and related documents.

5.14.3 Wet Detention Ponds

- Intended to provide on-line detention storage and maintain a permanent minimum water level.
- Minimum catchment area of 20 ha to limit number of ponds.
- Generally located off-site.
- May accommodate recreational uses.
- Overflow elevations to be coordinated with MBE's.
- Design details, other than discharge rates, should be in accordance with current technologies as outlined in Land Development Guidelines for the Protection of Aquatic Habitat (Canada/B.C.), and related documents.

5.14.4 Outlet Controls

Outlet controls for storage facilities may be designed using the standard orifice and weir equations:

Orifice Equation:

$$Q = CA(2gh)^{0.5}$$

Where: Q = release rate (m^3/s)
C = orifice coefficient (0.62 for sharp or square edge)
A = area of orifice (m^2)
G = gravitational acceleration (9.81 m/s^2)
h = net head on orifice (m)

Weir Equation:

$Q = CLH^{1.5}$ Where: Q = release rate (m^3/s)
C = weir coefficient
L = effective length of weir crest (m)
H = net head on weir crest (m)

Large storage facilities are to include provisions for discharges at rates greater than the design release rate. Rapid drawdown of the water level may be necessary for emergency purposes or to restore the available storage to accommodate subsequent storm events.

Provisions to accommodate higher discharges will involve oversizing the fixed openings and sewers connected to the control structure. Adjustable mechanisms such as slide gates or removable orifice plates can be used to regulate design release rates. The extent of the oversizing will depend on the capacity of the downstream drainage system.

Design of inlet and outlet structures is to include consideration of energy dissipation and erosion control. Safety grates are required over all inlet and outlet openings larger than 500 mm diameter. Lock for access hatches are required.

Off-site quality treatment facilities include:

5.14.5 Biofiltration Swales and Constructed Wetlands

- Intended to provide biofiltration and sediment removal.
- May be designed to provide on-line detention storage as well as quality treatment.
- May be located on-site or off-site.
- Qualified professional required for design.
- Design requires consideration of climatic conditions.

5.14.6 Oil and Grit Separators

- May be swirl concentrator or equivalent, including proprietary systems such as Stormceptor and Vortechs.
- Proprietary systems must be approved by the Engineer prior to incorporation into the design.

- Design details to be provided by supplier of proprietary system or by designer of equivalent.
- A manufacturer's authorized maintenance schedule to be included in the design notations.

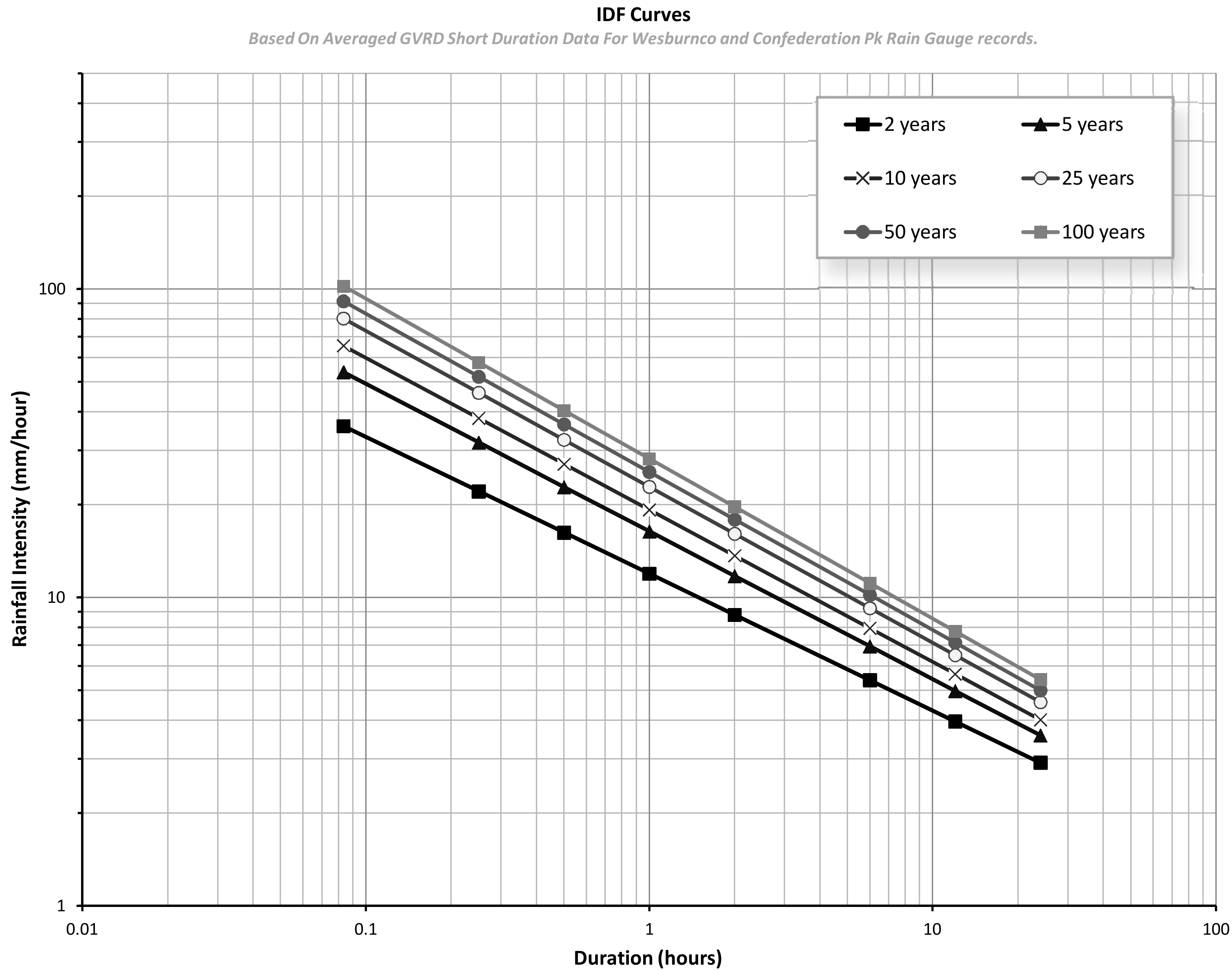
5.15 Sediment and Erosion Control Plan (SCP)

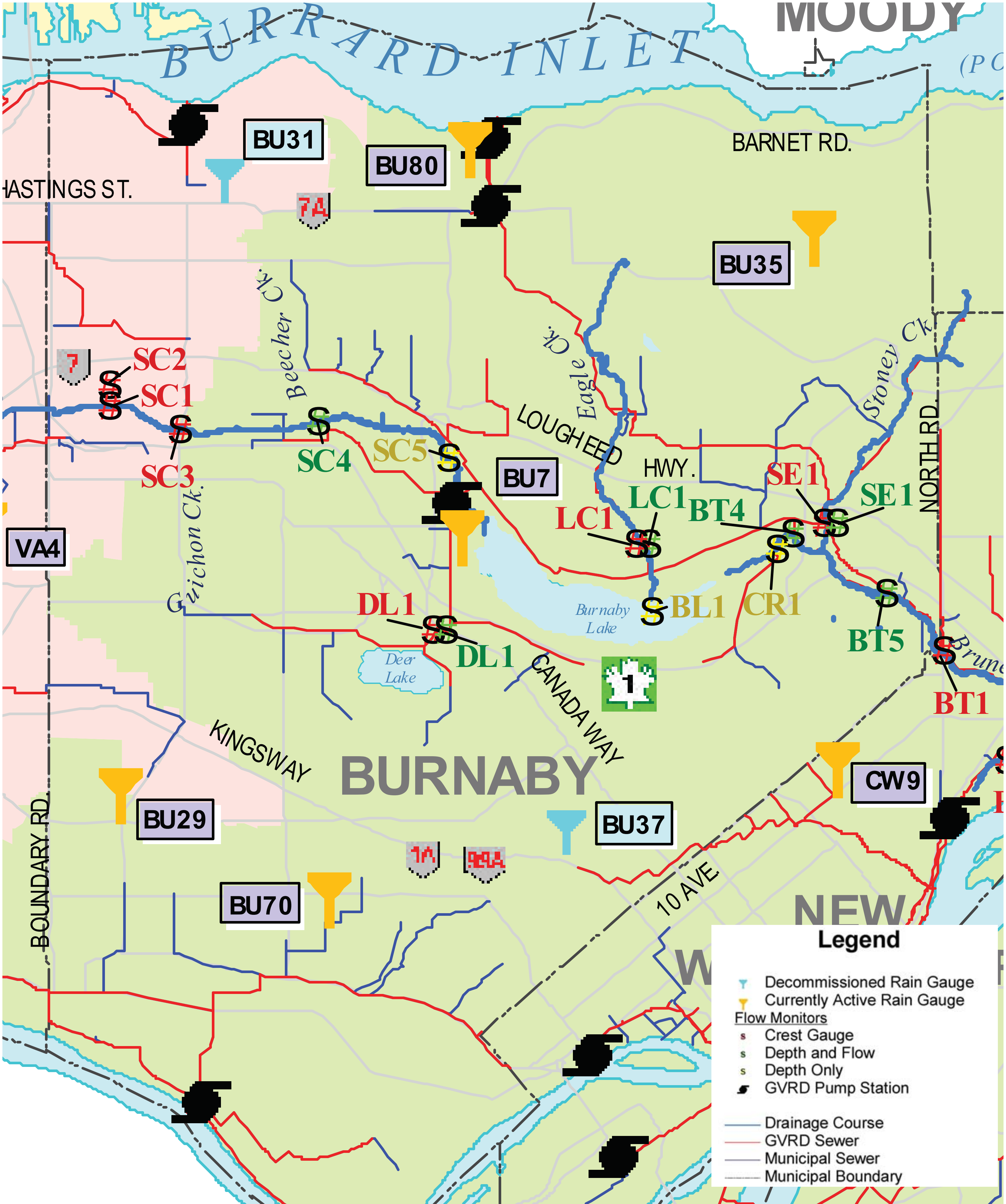
The SCP addresses the proposed methods and systems to be employed to control sediment generated and erosion, as a result of the construction activities throughout all stages of the development.

Developers will be required to provide a SCP, which includes the methodology and procedures to address the following:

- Control, monitoring and testing of sediment discharge and transportation
- Control, monitoring and testing PH of water discharging from the site.
- Control of air borne dust and prevention of sediments on roads.
- Prevention of erosion of exposed surfaces.
- Maintenance of the environmental amenities, such as trees, vegetation, and watercourses of an area.
- Decommissioning of sediment storage facilities.

A separate Sediment Control Plan may be required at specific stages of a project, such as site-grading, servicing and construction, as defined by the Engineer.


IDF Curves
Based On Averaged GVRD Short Duration Data For Wesburnco and Confederation Pk Rain Gauge records.
2 years
5 years
10 years
25 years
50 years
100 years
Rainfall Intensity (mm/hour)
100
10
1
0.01
0.1
1
10
100
Duration (hours)



METRO VANCOUVER RAIN GAUGE DISTRIBUTION WITHIN BURNABY

FOR RAINFALL DATA AND FILES, CONTACT METRO VANCOUVER

CREATED NOVEMBER 2013

STORM SEWER DESIGN & ANALYSIS

CONSULTANT:	
CITY DESIGN No:	
CIVIC ADDRESS:	
REZ No:	
SUB-DIV No:	
BUILDING PERMIT No:	

SHEET ____ OF ____
CHECKED:
DATE OF SIGN-OFF:

LOCATION			**AREA**				**EVENT DURATION**		**INTENSITY**		**FLOW**		**PIPE DESIGN**						Travel Time to D/S MH	**HYDRAULIC RATIO**		**COMMENTS**
Manhole		Drainage Area Description	Sub-catchment Area [A]	Runoff Coeff [R]	R x A = A(t)	A(t) cumm	Time of Concentration	Total Time	1 in 10yr	1 in 100yr	Q10	Q100	Slope	Pipe Dia	Roughness	Q (Full)	Velocity	Length		Q(10) / Q (Cap)	Q(100) / Q (Cap)	
From	To		*(ha.)*	*(C)*	*(ha.)*	*(ha.)*	(min)	(min)	(mm/hr)	(mm/hr)	(l/s)	(l/s)	*(%)*	*(mm)*	*(n)*	*(l/s)*	*(m/s)*	(m)	*(min.)*	(%)	(%)	

DESIGNERS NAME ______________________

DESIGNERS SIGNATURE: ______________________

DESIGNERS SEAL:

6.0 ROADS

6.1 General

The road design guidelines refer to roadways, lanes walkways and bikeways.

In addition to these guidelines, road design should conform to the following guidelines, regulations and legislation:

- The Burnaby Transportation Plan
- TAC – (Transportation Association of Canada) Geometric Design Guide for Canadian Roads
- TAC – Pavement Design and Management Guide
- TAC – Manual of Uniform Traffic Control Devices for Canada (MUTCD)
- TAC – Canadian Guide to Neighbourhood Traffic Calming
- City of Burnaby Bylaws
- Local Government Act (BC)
- Community Charter (BC)
- Motor Vehicle Act (BC)
- TransLink – Transit Infrastructure Design Guidelines
- Canadian Urban Transit Association and TAC – Canadian Transit Handbook
- US Department of Transportation – Roundabouts: An Information Guide
- TAC – Canadian Guide to In-Service Road Safety Reviews
- TAC – Canadian Road Safety Audit Guide
- BC MoT (Ministry of Transportation) – Manual of Standard Signs and Pavement Markings

Road layouts in subdivisions should provide for the continuation or projection of existing roads in the surrounding areas unless topographical conditions and/or neighbourhood planning objectives make such continuation or projection impractical.

6.2 Road classifications

The road classifications in the City of Burnaby road network are based on a hierarchy of street classifications differing in functions, traffic service and volumes. Major Roads and Minor Roads under the jurisdiction of the City of Burnaby are classified as follows:

Burnaby Major Roads – see Figure 6.4

- **Arterial Primary** – means a highway whose primary function is to carry interregional and intermunicipal traffic through the City and between town Centers, with direct access generally not permitted or restricted to major traffic generating land uses. The design traffic volume is 20,000 to 60,000 vehicles per day (see Figure 6.2).
- **Arterial Secondary** – means a highway whose primary function is to carry intermunicipal and local traffic between major activity centres in the City, with direct access generally not permitted or restricted to major traffic generating land uses. The design traffic volume is 12,000 to 40,000 vehicles per day (see Figure 6.3).
- **Major Collector Primary** – means a highway whose primary function is to carry traffic between major activity centres in the City, with direct access generally not permitted or restricted to major traffic generating land uses. The design traffic volume is 12,000 to 40,000 vehicles per day (see Figure 6.4).
- **Major Collector Secondary** – means a highway whose primary function is to carry intermunicipal and local traffic between major industrial, commercial and high density residential areas and major activity centres in the City, with direct access generally not permitted or restricted to major traffic generating land uses. The design traffic volume is 5,000 to 20,000 vehicles per day (see Figure 6.5).
- **Major Collector Greenway** – means a highway whose primary function is as an entrance way to Town Centres and the Civic Centre incorporating enhanced standards of design. Access is restricted to right-turn only at major traffic generating land uses. The design traffic volume is 5,000 to 12,000 vehicles per day (see Figure 6.6).

Burnaby Minor Roads – see Figure 6.1

- **Local Collector** - means a highway whose primary function is to carry traffic between local residential streets and Major Roads and to provide direct access to individual properties. Provisions to be made for cyclists and pedestrians as well as vehicular traffic. The Local Collector standard shall be used where a local road serves multi-family, commercial or industrial developments. The design vehicular traffic volume is 1,000 to 5,000 vehicles per day (see Figure 6.8).

- **Local Residential** - means a highway whose primary function is to carry traffic and provide direct access to individual properties. The design traffic volume is less than 3,000 vehicles per day (see Figure 6.9).

Road classifications also include the following:

Lane – A lane is a roadway with the primary function of providing land access, typically at the rear of abutting properties. Lanes are not intended to carry through traffic. Rear lanes should eliminate the need for front driveways.

Walkway and Bike Paths – Walkways and bike paths are paths which follow routes independent from motor vehicle roadways, sidewalks and bike lanes.

Cul-de-Sac Bulbs – The bulb radius is to be a minimum of 11 m in residential areas and 14 m in industrial areas, measured to the face of curb. Maximum grade on the cul-de-sac bulb is 8%.

Interim Roads – A 6.0 metre pavement width shall be provided on an interim basis until the full width can be achieved, except where the road is providing access to more than 50 lots or units, or is servicing commercial/industrial properties, in which case the pavement width shall increase to 8.5 metres.

Medians and Islands – The Designer is to obtain confirmation of the Engineer of requirements for medians and islands, including the portions of medians that are to be hard surface or landscaped. For typical cross sections of median/island installations, see Figure 6.10.

6.3 Cross-Section Elements

The required road cross-section elements are shown in Table 6.1.

The right-of-way and pavement widths shown in Table 6.1 are subject to increases to accommodate the following:

- Intersections
- Turn Lanes
- Bike Lanes
- Bus Bays
- Centre medians
- Transit priority (queue jumper) lanes
- Truck climbing lanes
- Snow storage

Table 6.1 Road Cross-Section Elements

Road Classification	Right-of-Way[1] (m)	Pavement Width[1] (m)	Minimum Travel Lanes	Travel Lane (m)	Parking Lane[2] (m)	Bike Lanes[1]	Number of Sidewalks	Median (m)
Local Residential	20	8.5	2	2.5	2.5	N/A	2	N/A
Local Collector	20	11.0	2	3.0	2.5	TBD	2	N/A
Major Collector Secondary	20	11.0	2	3.1	2.4	TBD	2	N/A
Major Collector Greenway	24.4	11.0	2	3.1	2.4	2 x 1.8 m	2	4.4
Major Collector Primary	27.6	18.6	4	3.3 + 3.5	2.5	TBD	2	N/A
Arterial Secondary	31	18.6	4	3.3 + 3.5	2.5	TBD	2	3.4
Arterial Primary	39.3	26	6	3.5	2.5	2 x 1.8 m	2	4.3
Lane	6	5.2	N/A	N/A	N/A	N/A	N/A	N/A
Walkway and Bike Path	4.5	2.5	N/A	N/A	N/A	N/A	N/A	N/A

Notes: [1] Where the Burnaby Transportation Plan identifies a road as a Cycle Road, the outside travel lane shall be widened to 4.2 m (Major Collector Greenway) or 4.3 m (Arterial Primary) on both sides or a 1.8 m lane added on both sides, and the right-of-way width adjusted to accommodate the extra width. For right and left-turn lanes, use a minimum lane width of 3.1 m.

[2] The provision of parking lanes may be restricted in certain areas.

6.4 Alignments

6.4.1 Grade

Normal grade limits are shown in Table 6.2.

Use of the maximum grades should be restricted to cases where:

- Desirable grade cannot be obtained due to topographical constraints
- The geometric design of intersections can be improved by increasing grade on the minor street to avoid compromising design of the major street

Maximum grades for through roads at intersections are 2% less than the maximum grades shown on Table 6.2. The reduced grades are applicable to lengths equal to the Stopping Sight Distances.

6.4.2 Vertical Curves

Vertical curve limits, as shown on Table 6.2 are defined by the "K-Value" which is the ratio of the curve length in metres to the algebraic difference in percent grades.

Use of K-values below the desirable limits shown in Table 6.2 are restricted to cases justified by topographical constraints and subject to approval by the Engineer.

The following K-values may be used for streets classified as Local Residential Road, provided that the Local Residential Road is marked with a STOP Sign at the intersecting street.

Classification	**K-Values**			
	Crest Curves		**Sag Curves**	
	Minimum	**Desirable**	**Minimum**	**Desirable**
Arterial or Collector	4	6	4	6
Local	2	4	2	4

Table 6.2 Alignment Standards

Classification	**Min. Design Speed (km/h)**	**Max. Super-Elevation (%)**	**Min. Radius (m)**	**Grade (%)**		**K-Value**				**Minimum Sight Distance (m)**	
						Crest Curves		Sag Curves			
				Min.	Max[3]	Min	Desir	Min	Desir	Stopping	Decision
Arterial Road	70	6[1]	190[2]	0.5	8	20	25	15	25	110	200-270
Collector Road	50	6[1]	110[2]	0.5	10	7	10	7	12	65	140-190
Local Road	50	3	80	0.5	12	7	10	6	10	65	140-190
Lane	30	0	20	1.0	12	4	5	4	7	45	110-160
Driveway Multi-Family	30	-	-	0.5	12	-	-	-	-	-	-
Driveway Single Family	-	-	-	0.5	15	-	-	-	-	-	-
Emergency Access	30	-	-	1.0	15	-	-	-	-	-	-
Walkway	--	-	-	1.0	15	-	-	-	-	-	-

Notes: [1] Maximum super-elevation reduced to 4% where there are intersecting roads or private accesses.

[2] Minimum radii approaching intersections within the decision sight distance range: 400 m for Arterials and 250 m for Collectors.

[3] Maximum grades approaching intersections are 2% less than indicated. Reduction applies for length equal to Stopping Sight Distance.

6.4.3 Cross-Slopes

Standard roadways should have a centreline crown.

The standard cross-slope is 2.5%. Minimum and maximum values are 2% and 4%.

Under adverse topographic conditions, and with the approval of the local authority, offset crown or uniform cross fall may be used.

The location of offset crowns should be 2.5 m from the high side curb or pavement edge.

Super-elevation should be used as indicated in the TAC Geometric Design Guide and as shown in Table 6.2.

Cross-slope at Intersections

At intersections, the cross fall of the minor street should be varied to suit the profile of the major street. The maximum rate for changing cross fall at intersections is as follows:

Arterial	3% in 30 m
Collector	4% in 30 m
Local	6% in 15 m

6.5 Intersections

6.5.1 General

Intersections should be as close as possible to right angles. The maximum variation, subject to approval of the Engineer, is 20°.

The minimum centre line to centre line spacing between opposing tee intersections is 60 m.

The minimum spacing between four-legged intersections on arterial streets is as required to provide a minimum 40 m of left turn storage (at both intersections), 35 m of transition between storage lanes and an allowance for turning movements.

6.5.2 Curb Returns

Intersection	Design Vehicle	Notes
Art - Art	B-TRAIN	No encroachment
Art – Coll	A-TRAIN	No encroachment
Art - Local	BUS	Minor encroachment may be permitted if volume is low
Coll - Coll	TST	Minor encroachment in Town Centres may be permitted if truck volume is low
Coll - Local	CAR/RT	Also use BUS template if turning movement is on a bus route
Local - Local	CAR, I-BUS	Also check that I-BUS with encroachment is available to accommodate fire trucks

6.5.3 Corner Cuts

Corner cuts should be sufficient to provide a minimum 4 m distance from curb face to property line. Minimum corner cuts are as follows

Intersection Type		Corner Cut
Arterial and Collector		5 m x 5 m
All other roadway intersections		3 m x 3 m
Lane to Lane		3 m x 3 m
Lane to Arterial		3 m x 3 m
Residential Lane to all other roads		Not Required
Commercial/Industrial lane to any road		3 m x 3 m

6.5.4 Left Turn Channelization

Details of left turn channelization are to be in accordance with the TAC Geometric Design Guide. Left Turn Bays should be opposing.

6.5.5 Sight Distances

In addition to the site distance limits listed elsewhere for vertical curves, intersection sight distance must be in accordance with TAC Geometric Design Guide.

6.5.6 Curb Extensions

Curb extensions, also known as bulges or bulbs, should be considered for speed reduction, reduced pedestrian crossing distance and improved pedestrian visibility. Design in accordance with TAC Canadian Guide to Neighbourhood Traffic Calming. Provisions for safe passage of bicycles and adequate turning movements for trucks are to be incorporated through or around curb extensions, and design turning movements are to be assessed and verified using the turning templates for the appropriate class of vehicle, as approved by the Engineer.

6.5.7 Turn Delineation

Guiding lines should be used in intersections with multiple turn lanes or skewed legs.

6.5.8 Roundabouts

Roundabouts may be approved or required by the Engineer as an alternative to other types of intersection traffic control. Roundabout design should be in accordance with US Department of Transportation – Roundabouts: An Information Guide.

Signs and pavements markings for roundabouts are to be in accordance with MUTCD.

6.6 Railway Grade Crossings

Locations and details of railway grade crossing are subject to the requirements included in TAC Geometric Design Guide and references noted therein.

Railway signs are to be in accordance with MUTCD.

6.7 Traffic Control Devices

Traffic control devices and signs and pavement markings are to be in accordance with MUTCD. Traffic signals are to be in accordance with Section 8.0 of this manual.

6.8 Cul-de-Sacs

The maximum road length for a cul-de-sac, as measured from the edge of the intersecting through road to the centre of the cul-de-sac bulb, is 200 m.

Details are to be in accordance with the TAC Urban Supplement to the Geometric Design Guide. Unless otherwise approved, turnaround areas are to be circular.

6.9 Traffic Barriers

Traffic Barriers are to be placed where warrants exist in accordance with the Roadside Safety section of the TAC Geometric Design Guide. Details are to be as indicated in the TAC guide.

6.10 Sidewalks and Walkways

The requirements for sidewalks are as shown in Table 6.1.

The following minimum requirements apply to sidewalks:

- Minimum width: 1.5 m (excluding adjacent curb)
- Cross-slope: 2%, except at driveways and wheelchair ramps
- Drainage: Slope towards gutter

Walkway widths and grade requirements are indicated in Tables 6.1 and 6.2, respectively.

For pedestrian bridges or underpasses, the minimum walkway width is 2.5 m.

Wheelchair ramps from sidewalks, medians and traffic islands to crosswalks should be provided at intersections and walkways. Locations and details of ramps and related pedestrian safety features should be in accordance with the City of Burnaby Standard Construction Drawings and the TAC Geometric Design Guide.

For Greenway Trails and Urban Trails design criteria, see section 9.4 under STREET LANDSCAPING.

6.11 Bikeways

Cycling facilities will be required as part of the roadway design at locations identified in the Burnaby Transportation Plan and in consultation with the Engineer.

Bikeway functional classifications include the following:

- Multi-use Trail: Physically separated from roadway
- Bike lane: Separated from motor vehicle traffic lane by paint line or other delineator
- Bikeways: Street shared by bicycles and motor vehicles and designated by signs

Multi-use trails, lanes and bikeways are to be in accordance with TAC Geometric Design Guide

6.12 Transit Facilities

The requirement of transit facilities, including bus bays, will be established by the Engineer in cooperation with TransLink. Bus Bay details should be in accordance with the Pullputs section of the TAC Geometric Design Guide.

Transit signs should be in accordance with MUTCD.

Additional guidelines are included in TransLink - Transit Infrastructure Design Guidelines, Canadian Urban Transit Association and TAC - Canadian Transit Handbook.

6.13 Driveways

6.13.1 Residential Access to Arterial Roads

Residential driveway access to an arterial or a major collector road is not permitted unless alternate access is not possible. Wherever possible, alternate local road, frontage road or lane access should be dedicated to preclude residential driveways accessing directly onto arterial or major collector roads.

6.13.2 Number of Driveways

a) Residential Zones:

- One driveway per lot;

- Second driveway permitted for corner lot if driveway is not on an arterial or major collector road;
- Second driveway permitted at the discretion of the Engineer for lots abutting additional road frontage;
- Where a residential lot abuts roads of different classifications, the principal driveway should access the road of the lower classification.

b) Commercial, Industrial, Institutional, Comprehensive, Rural, and Multifamily Developments:

- Upon demonstrated need, the Engineer may approve more than one access.

6.13.3 Driveway Location and Width

Subject to compatibility with City bylaws, use the following dimensions and locations:

a) Residential Zones: Driveways located on corner lots shall be located no closer than 6 m from the lot corner closest to the intersection. Provision of adequate sight distance should be considered in accordance with the TAC Geometric Design Guidelines.

Minimum and maximum widths of urban residential driveways are 3 m and 6 m respectively.

b) Commercial, Industrial, Institutional, Comprehensive, and Multifamily Developments: Driveways to corner lots should be located no closer than 12 m from the property line of the adjoining road. Provision of adequate sight distance should be considered in accordance with the TAC Geometric Design Guidelines.

The minimum width of a driveway to a property having one or more access is 4.5 m for one way access and 6.5 m for two way access with a maximum of 11 m. Where a corner lot adjoins roads of different classifications, the principal driveway should access the road of a lower classification, except for commercial sites where access may be provided from both roads, subject to the Engineer’s approval.

A minimum of 1.5 m distance must be provided from the edge of the driveway to hydro poles, guy wires, signs, fire hydrants trees and similar fixed obstructions.

c) Where lane access is available, the driveway should be located off the lane.

6.13.4 Driveway Grades

General limits on driveway grades are as indicated in Table 6.2 Driveway access grades should be designed to permit the appropriate vehicular access for the zone, without "bottoming-out" or "hanging-up". From the edge of pavement to property line, the driveway should allow proper boulevard slope to drain towards the road. The maximum grade on any driveway must not exceed 15%. Maximum 10% grade break transition at property line.

6.13.5 Driveway Letdown and Curb Return

At the discretion of the Engineer, access to large parking areas, commercial, industrial, and multifamily developments may be by curb return rather than a driveway letdown.

6.13.6 Access Management

In addition to the above driveway guidelines, access management techniques, including driveway consolidation, medians and turn restrictions should be applied in accordance with the Access section of the TAC Geometric Design Guide.

6.13.7 Queuing Storage

Minimum queuing storage at parking lot driveways, measured from driveway exit or property line to the closest on-site parking stall or aisle should be as follows:

Number of Parking Stalls	Length of Storage (m)
0 to 100	6
101 to 150	12
151 to 200	18
Over 200	24

6.14 Clearances

6.14.1 Clearance at Bridges

Horizontal clearances in metres from edge of travel lane should be as follows:

Classification	Overpass Lane Edge to Rail or Parapet		Underpass Lane Edge to Abutment or Wall	
	Sidewalk*	No Walk	Sidewalk*	No Walk
Arterial	2.5	1.0	2.5	1.8
Collector	2.25	1.0	2.5	1.5
Local	2.25	1.0	2.5	1.25

*Sidewalk – minimum 1.6 m wide and minimum 200 mm above road grade.

Urban Trails – minimum 4.0m wide plus separation from traffic

Minimum vertical clearance from finished road grade to bottom of underpass: 5.5 m.

6.14.2 Aerial Utilities

Type	Vertical Clearance
Communications and guy wires	5.0 m
Electrical conductors to 90000V*	5.5 m

* For higher voltages, check with power company.

6.14.3 Signs and Poles

Horizontal clearance from edge of travel lane to face of power pole or sign:

- Roadways without curbs: 2.0 m
- Roadways with curbs: 0.3 m minimum. 1.0 m preferable except where sidewalk is adjacent to curb, in which case 1.6 m is preferable.

Use of minimum clearance should be justified by safety appurtenances such as poles with break-away or frangible bases or signs of light weight fabrication.

Horizontal clearance to lighting and sign poles and signal controller cabinets in accordance with Sections 7.0 and 8.0 of this guide.

6.14.4 Trees

Minimum horizontal clearance from edge of travel lane to face of tree trunk: 0.75 m.

Horizontal clearance from edge of driveway, curb return or above ground utility to tree trunk: 2.5 m.

6.14.5 Drainage Structures and Traffic Barriers

Clearances in accordance with the Roadside Safety section of TAC Geometric Design Guidelines.

6.15 Underground Utility Locations

Underground utility locations within a road right-of-way will vary with the road cross section. General guidelines include the following:

- Manholes and valve boxes clear of wheel paths. Typically, wheel paths are located at 1.0 m, 2.0 m, 4.3 m and 5.9 m from the edge of the outside travel lane.
- All utilities clear of curbs.
- Watermains under a sidewalk.
- Sanitary sewers at pavement centre line.
- Storm sewer 1.2 m from sanitary sewer.
- Electrical, telephone and gas in boulevard.

6.16 Pavement Structures

6.16.1 General Pavement Design

Pavement design should be based on one of the following methods:

- Pavement design as shown on the typical Burnaby Cross-Sections
- Any design method covered in the TAC Pavement Design and Management Guide.
- Past history of successful pavements in adjacent similar areas.

Pavement design is to include consideration of the subgrade soil type, frost susceptibility, moisture conditions and subgrade drainage provisions.

Minimum design life for all classifications of roads: 20 years.

6.16.2 Subgrade Soil Classification

Soils are characterized according to the Unified Soil Classification System (USCS) which uses symbols such as GW to classify soils according to particle size and distribution and plasticities. Details of USCS are contained in the TAC Pavement Design and Management Guide and other publications.

6.16.3 Pavement Deflections

Pavement deflections are commonly measured with a Benkelman Beam. (see TAC Pavement Design and Management Guide.) Maximum Benkelman Beam deflections (mean plus two standard deviations) for design of new roads and overlays, and for confirming acceptability of complete roads, are as follows:

Local: 1.7 mm
Collector: 1.3 mm
Arterial: 1.0 mm

Design of arterial roads should include consideration of the number of Equivalent Single Axle Loads per Lane per Year (ESAL).

6.16.4 Minimum Pavement Structures

Regardless of the method used for pavement structure design, pavement component thickness should be equal to or greater than the minimum thickness shown below.

Minimum pavement structures shown below are based on the subgrade soil classifications indicated.

Subgrade soils having classifications of MH, CH, OH and Pt require special treatment or removal and replacement with soil having a higher classification.

6.16.5 Minimum Pavement Structure for Asphalt Concrete (A.C.) Pavement

Classification	**Minimum Thickness With Subgrade Soil Classification SC & Better**
Local	75 mm A.C surface course 100 mm base course 250 mm subbase
Collector	35 mm A.C surface course 80 mm A.C. lower course 100 mm base course 250 mm subbase
Arterial	50 mm Super Pave A.C surface course 100 mm A.C. lower course 100 mm base course 300 mm subbase

6.16.6 Minimum Pavement Structure for Portland Cement (P.C.) Pavement

Classification	Minimum Thickness With Subgrade Soil Classification SC & Better
Local	125 mm P.C. concrete 75 mm base course
Collector	150 mm P.C. concrete 75 mm base course
Arterial	175 mm P.C. concrete 75 mm base course

6.16.7 Minimum Asphalt Concrete Pavement Overlay

Where existing pavements are to be overlaid, the minimum overlay thickness is two times the Maximum aggregate size, but no less than the following:

Classification	Minimum Asphaltic Concrete Overlay Thickness
Local	25 mm
Collector	40 mm
Arterial	50 mm

6.16.8 Frost Susceptible Areas.

For areas of frost susceptibility where the subgrade soil classifications are GM, GC, SM, SC, ML, CL, or OL, the pavement structure should include granular material to the minimum depth as defined below.

Classification	Minimum Frost Protection Depth as % of Frost Penetration
Local	20%
Collector	35%
Arterial	50%

Where the minimum frost protection depth exceeds the minimum pavement structure depth, granular material having a fines content of less than 12% should be placed below the pavement structure to make up the difference.

6.16.9 Minimum Structures for Sidewalk, Walkways and Driveways

1. Asphalt Concrete

Item	Structure
Sidewalk, Walkway and Driveway	50 mm asphaltic concrete 75 mm base course 250 mm subbase

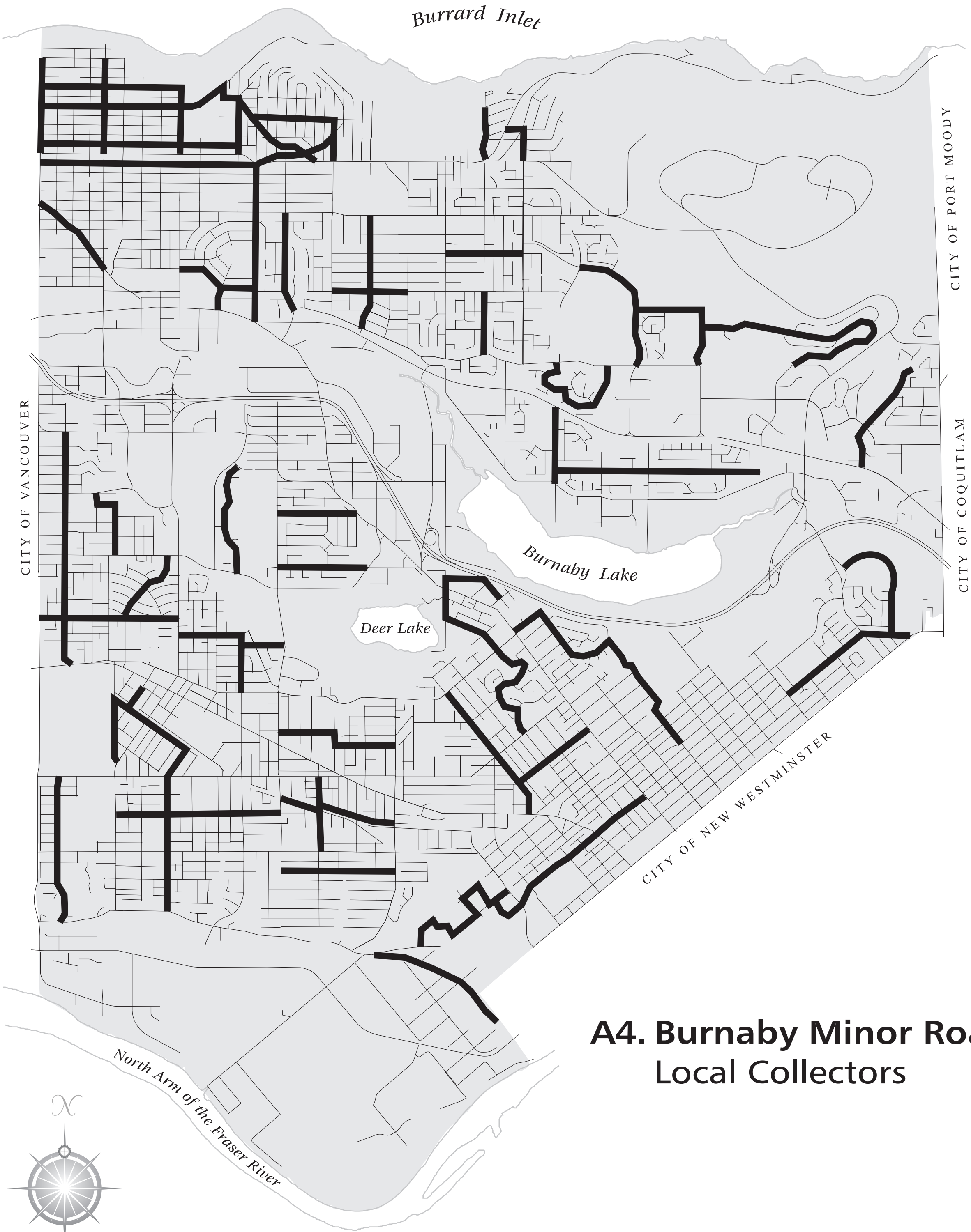
2. Portland Cement (P.C.) Concrete

Item	Structure
Sidewalk, Walkway and Driveway	100 mm P.C. Concrete 100 mm base course Approved subbase
Sidewalk Crossing	140 mm (residential) / 190 mm (multi-family, lane, commercial, industrial) P.C. Concrete 100 mm base course Approved subbase

6.17 Bridges

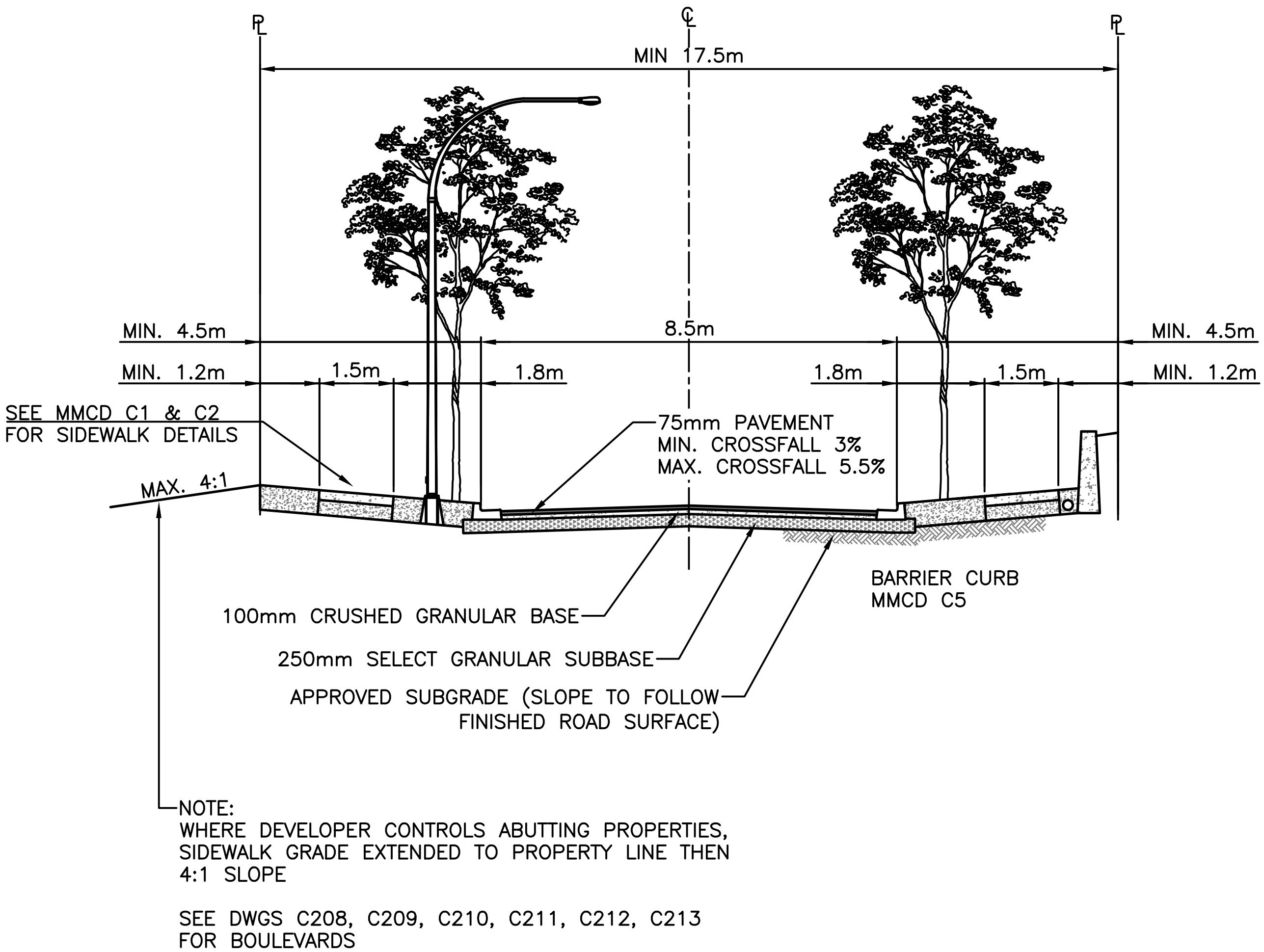
Design bridges in accordance with the Canadian Highway Bridge Design Code CAN-CSA-S6-06 plus all applicable supplements.

Roadway bridges should be designed to a minimum loading of BCL 625.



A4. Burnaby Minor Roads
Local Collectors

FIGURE 6.2



NOTE:
1. WHERE DEVELOPMENT ABUTS EXISTING PROPERTIES, SIDEWALK GRADE EXTENDED TO 0.6m BACK OF WALK THEN 4:1 SLOPE AND/OR RETAINING WALL TO MEET EXISTING GRADE AT PROPERTY LINE.
2. WHEN PAVING UNDERTAKEN IN TWO LIFTS:
   LOWER COURSE MIN. 50mm
   UPPER COURSE MIN. 35mm
3. SEE C207 FOR DRAIN TILE APPLICATIONS.
4. PLANTING AND SOD IN FRONT AND REAR BOULEVARDS TO MMCD STANDARDS AND BURNABY SUPPLEMENTALS.

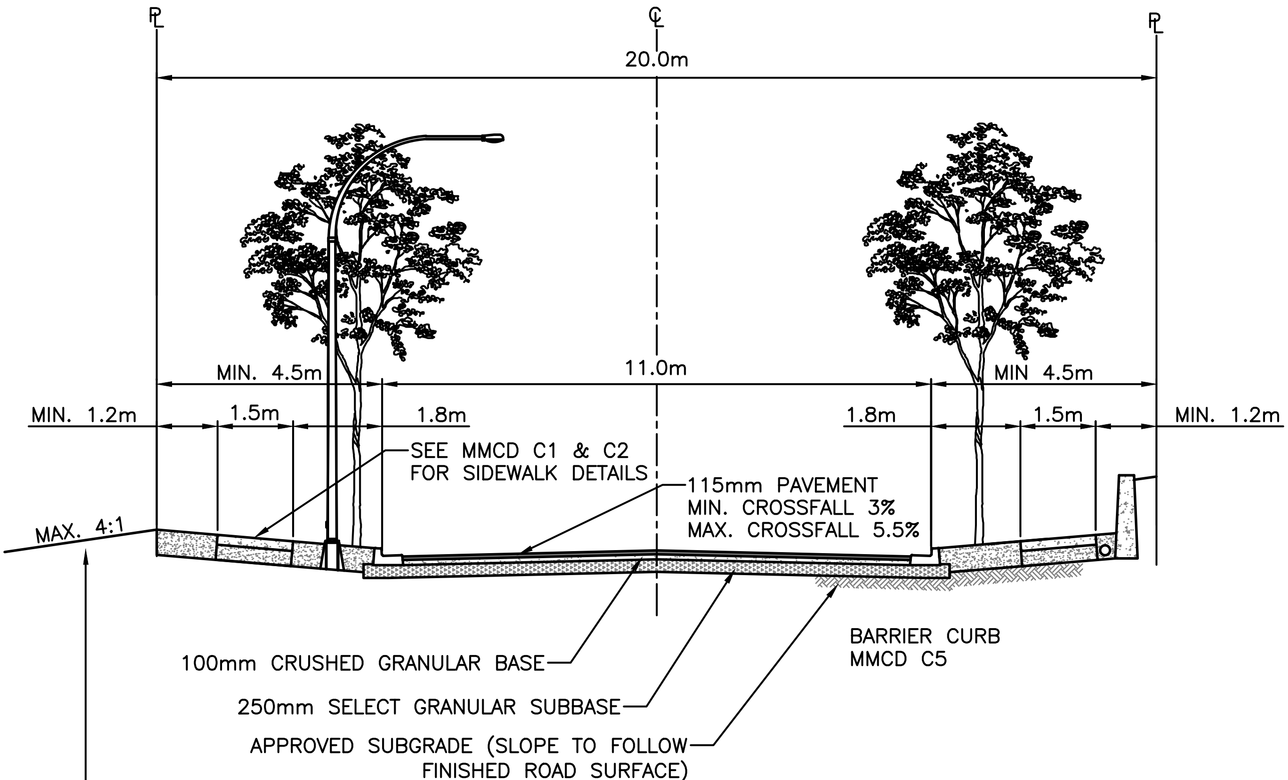
NO.	DATE	REVISION	APP'D	BY

City of Burnaby
ENGINEERING DEPARTMENT

LOCAL RESIDENTIAL
BURNABY MINOR ROADS

DRAWN BY: KADTEC	SCALE: N.T.S.	**BBY-**
APPRV'D BY:	DATE: 2014-05-27	

FIGURE 6.3



NOTE:
WHERE DEVELOPER CONTROLS ABUTTING PROPERTIES, SIDEWALK GRADE EXTENDED TO PROPERTY LINE THEN 4:1 SLOPE

SEE DWGS C208, C209, C210, C211, C212, C213 FOR BOULEVARDS

NOTE:

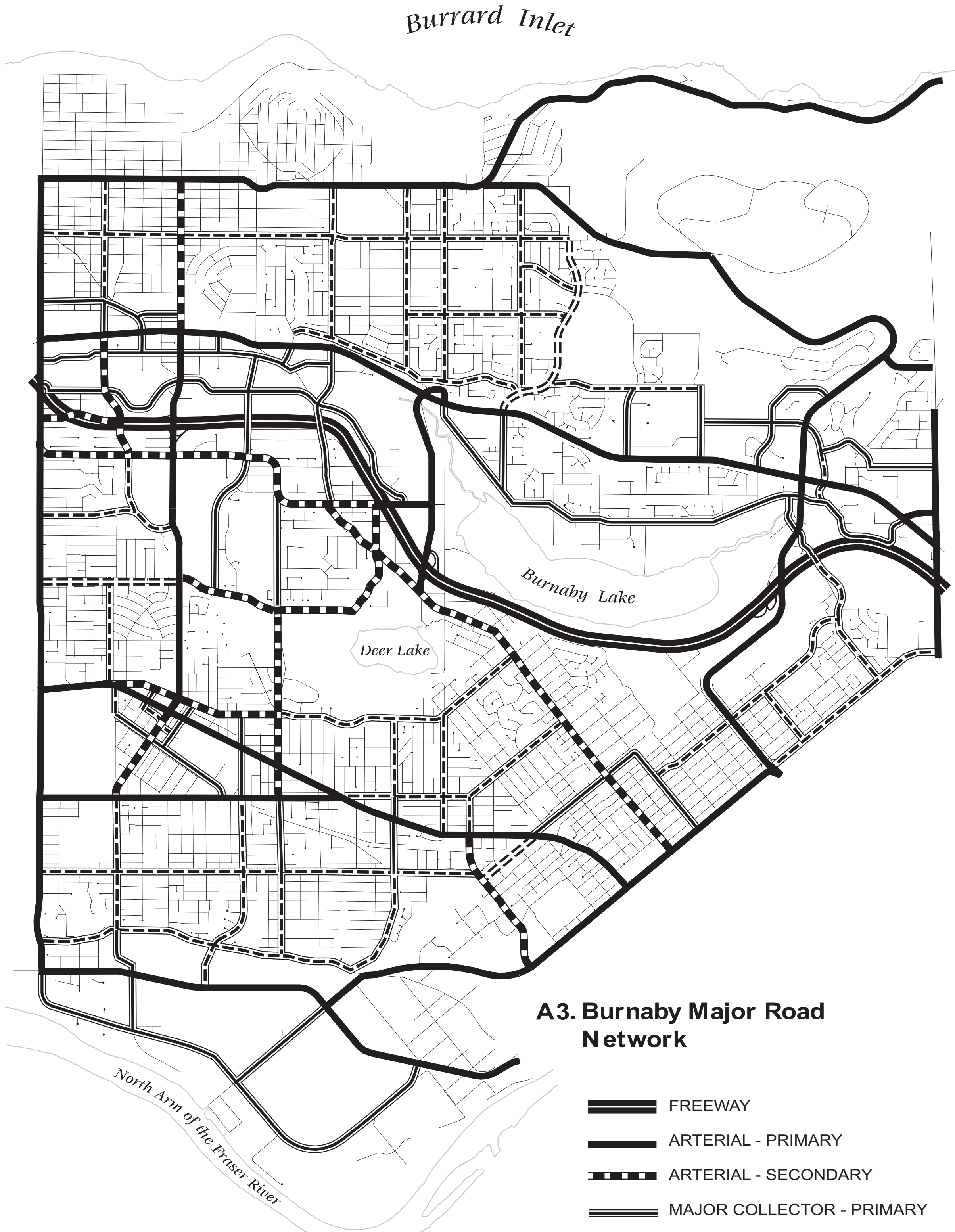
1. WHERE DEVELOPMENT ABUTS EXISTING PROPERTIES, SIDEWALK GRADE EXTENDED TO 0.6m BACK OF WALK THEN 4:1 SLOPE AND/OR RETAINING WALL TO MEET EXISTING GRADE AT PROPERTY LINE.
2. WHEN PAVING UNDERTAKEN IN TWO LIFTS:
   LOWER COURSE MIN. 75mm
   UPPER COURSE MIN. 50mm
3. SEE C207 FOR DRAIN TILE APPLICATIONS.
4. PLANTING AND SOD IN FRONT AND REAR BOULEVARDS TO MMCD STANDARDS AND BURNABY SUPPLEMENTALS.

NO.	DATE	REVISION	APP'D	BY

City of Burnaby
ENGINEERING DEPARTMENT

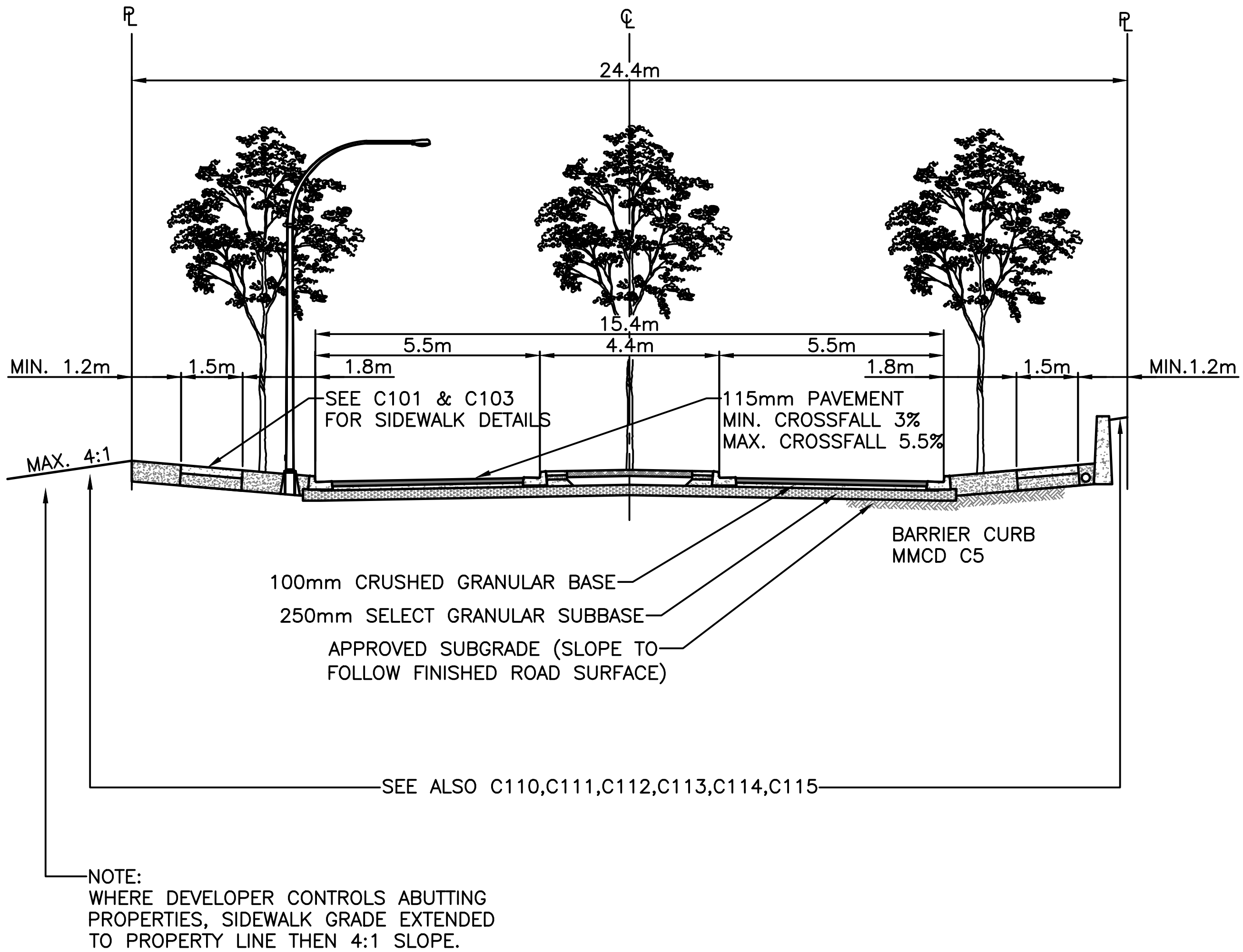
LOCAL COLLECTOR / MULTI–FAMILY LOCAL
BURNABY MINOR ROADS

DRAWN BY: KADTEC	SCALE: N.T.S.	BBY-
APPRV'D BY:	DATE: 2014–05–27	



A3. Burnaby Major Road Network

FIGURE 6.5



NOTE:
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2. SEE C108 FOR DRAIN TILE APPLICATIONS.
3. PLANTING AND SOD IN FRONT AND REAR BOULEVARDS TO MMCD STANDARDS AND BURNABY SUPPLEMENTALS.
4. MEDIAN HARDSCOPE TO BE "ASHLAR SLATE" PATTERN WITH FINE TEXTURE COMPARABLE TO ITALIAN SLATE AND "LAFARGE–ARTERIA LAFARGE SLATE, PREMIUM" COLOUR.

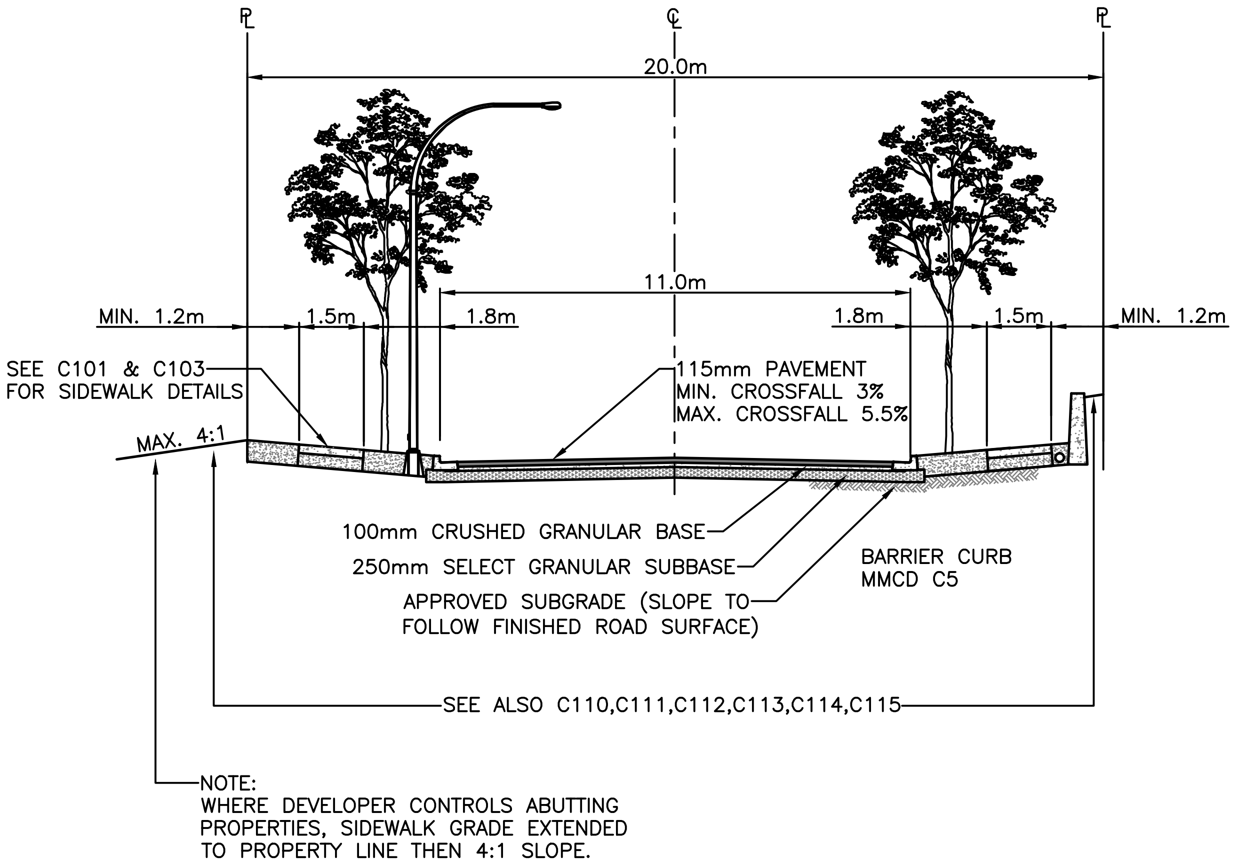
NO.	DATE	REVISION	APP'D	BY

City of Burnaby
ENGINEERING DEPARTMENT

MAJOR COLLECTOR GREENWAY
BURNABY MAJOR ROADS

DRAWN BY: KADTEC	SCALE: N.T.S.	**BBY-**
APPRV'D BY:	DATE: 2014–05–27	

FIGURE 6.6



NOTE:
1. WHERE DEVELOPMENT ABUTS EXISTING PROPERTIES, SIDEWALK GRADE EXTENDED TO 0.6m BACK OF WALK THEN 4:1 SLOPE AND/OR RETAINING WALL TO MEET EXISTING GRADE AT PROPERTY LINE.
2. SEE C108 FOR DRAIN TILE APPLICATIONS.
3. PLANTING AND SOD IN FRONT AND REAR BOULEVARDS TO MMCD STANDARDS AND BURNABY SUPPLEMENTALS.

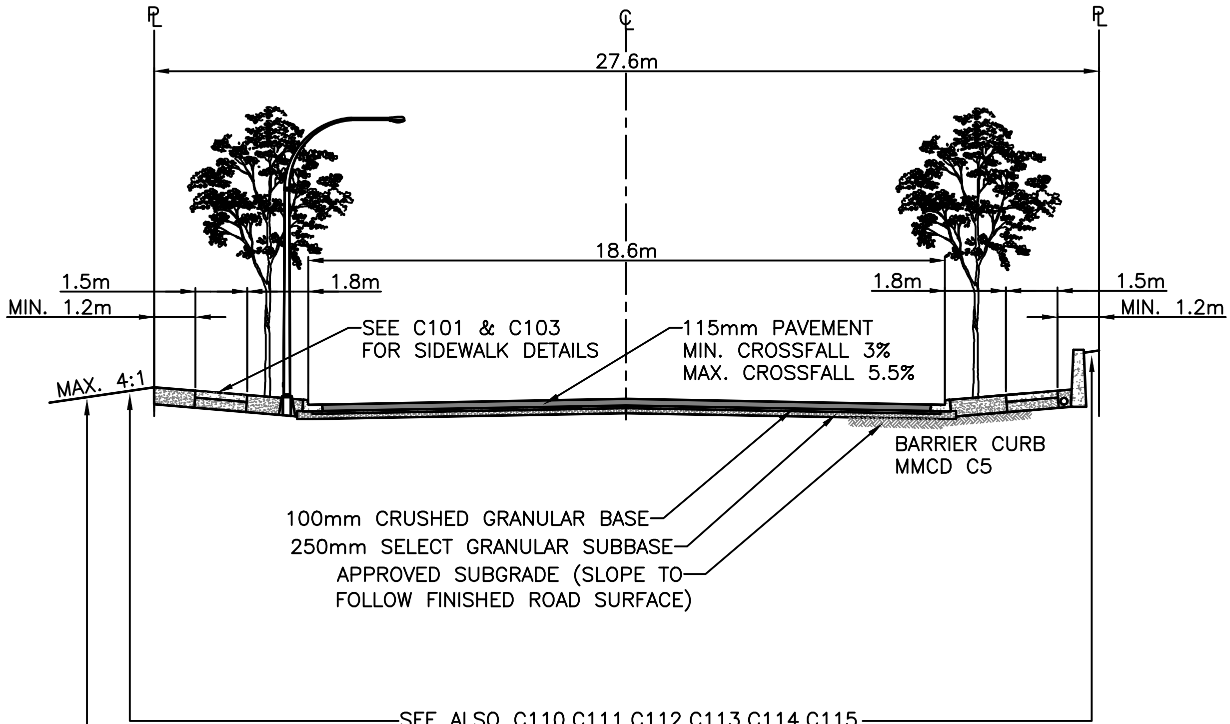
NO.	DATE	REVISION	APP'D	BY

City of Burnaby
ENGINEERING DEPARTMENT

MAJOR COLLECTOR SECONDARY
BURNABY MAJOR ROADS

DRAWN BY: KADTEC	SCALE: N.T.S.	**BBY-**
APPRV'D BY:	DATE: 2014-05-27	

FIGURE 6.7



NOTE:
WHERE DEVELOPER CONTROLS ABUTTING PROPERTIES, SIDEWALK GRADE EXTENDED TO PROPERTY LINE THEN 4:1 SLOPE.

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2. SEE C108 FOR DRAIN TILE APPLICATIONS.
3. PLANTING AND SOD IN FRONT AND REAR BOULEVARDS TO MMCD STANDARDS AND BURNABY SUPPLEMENTALS.

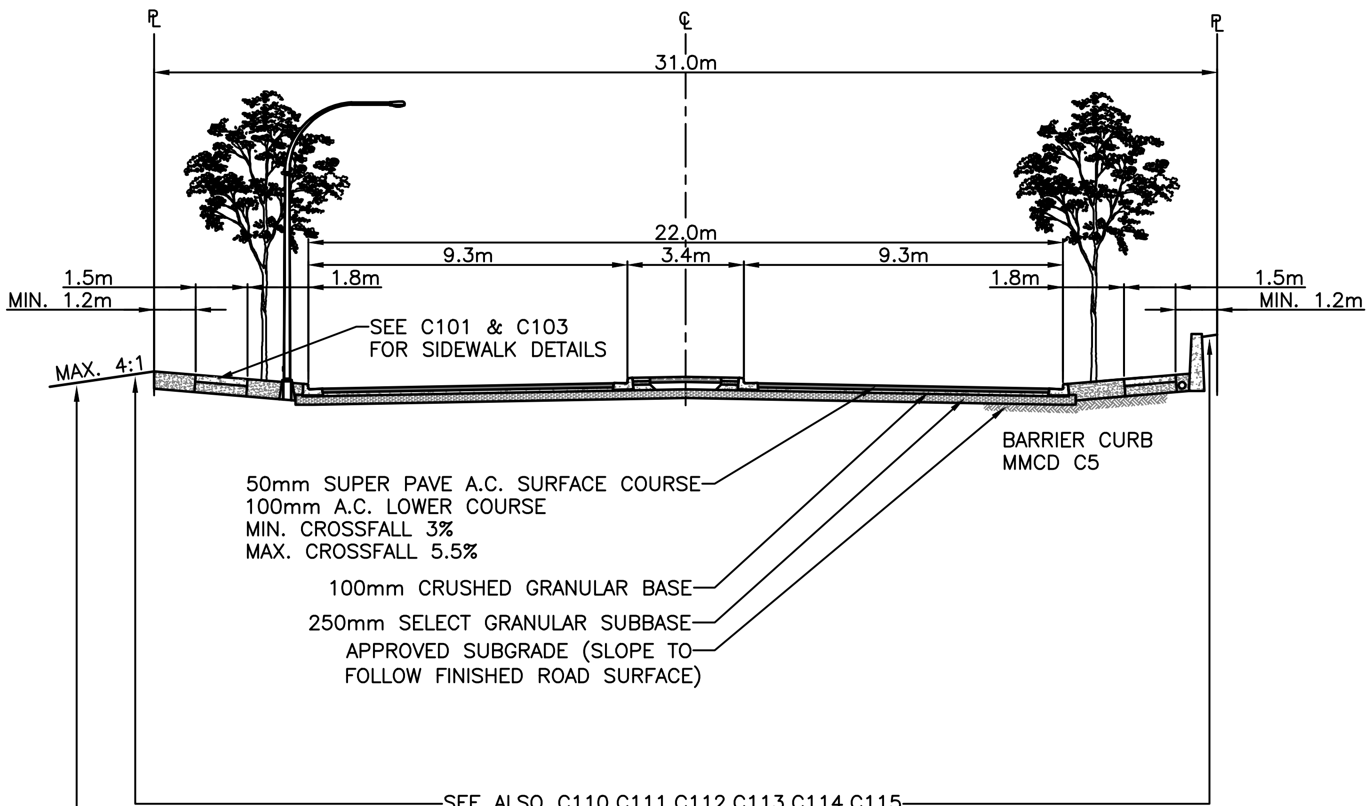
NO.	DATE	REVISION	APP'D	BY

City of Burnaby
ENGINEERING DEPARTMENT

MAJOR COLLECTOR PRIMARY
BURNABY MAJOR ROADS

DRAWN BY: KADTEC	SCALE: N.T.S.	BBY-
APPRV'D BY:	DATE: 2014–05–27	

FIGURE 6.8



NOTE:
WHERE DEVELOPER CONTROLS ABUTTING PROPERTIES, SIDEWALK GRADE EXTENDED TO PROPERTY LINE THEN 4:1 SLOPE.

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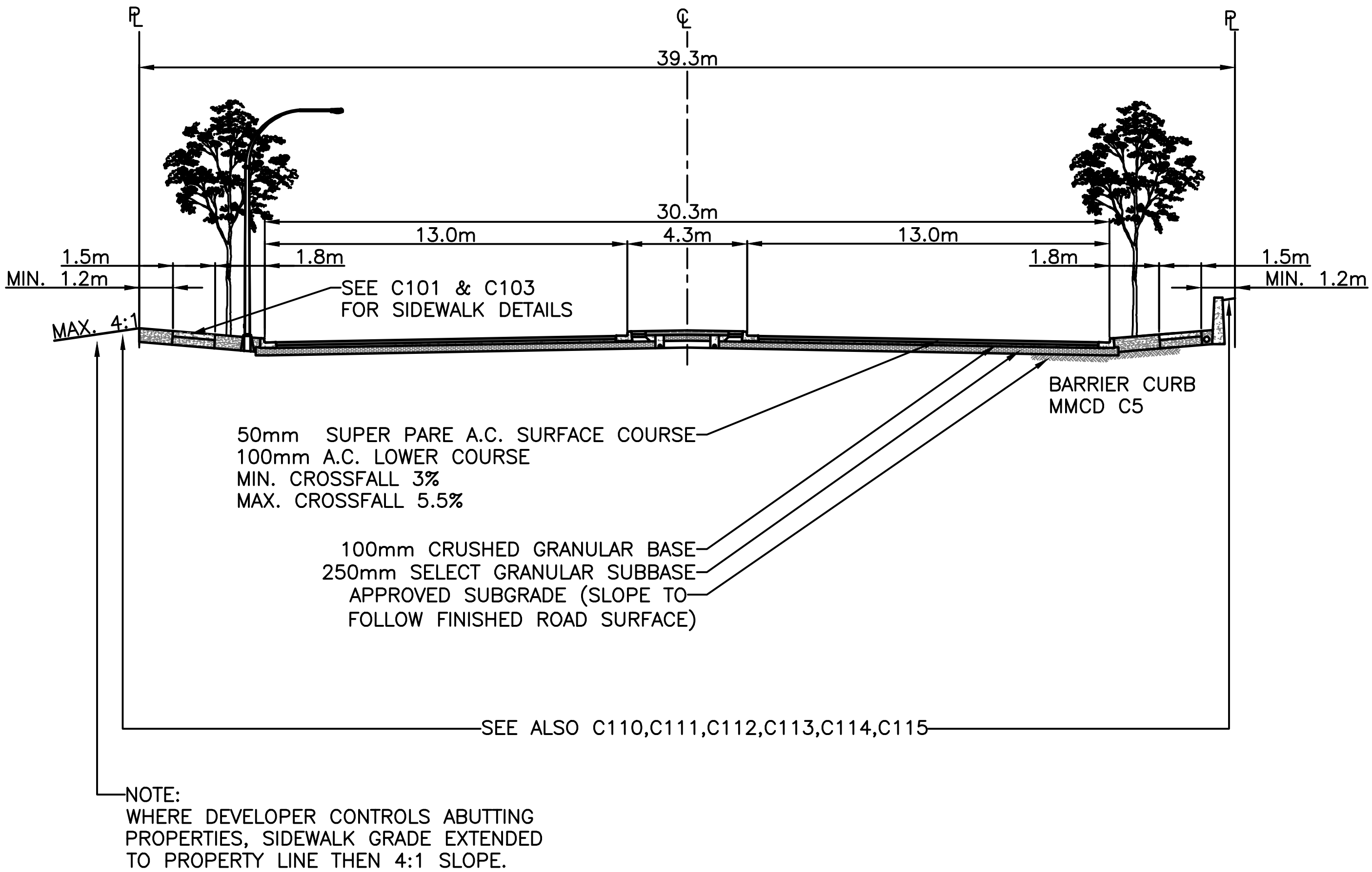
NO.	DATE	REVISION	APP'D	BY

City of Burnaby
ENGINEERING DEPARTMENT

ARTERIAL SECONDARY
BURNABY MAJOR ROADS

DRAWN BY: KADTEC	SCALE: N.T.S.	**BBY-**
APPRV'D BY:	DATE: 2014–05–27	

FIGURE 6.9



NOTE:
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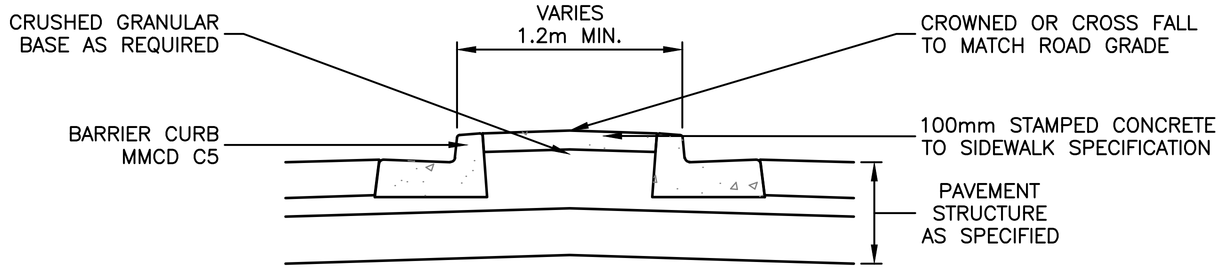
NO.	DATE	REVISION	APP'D	BY

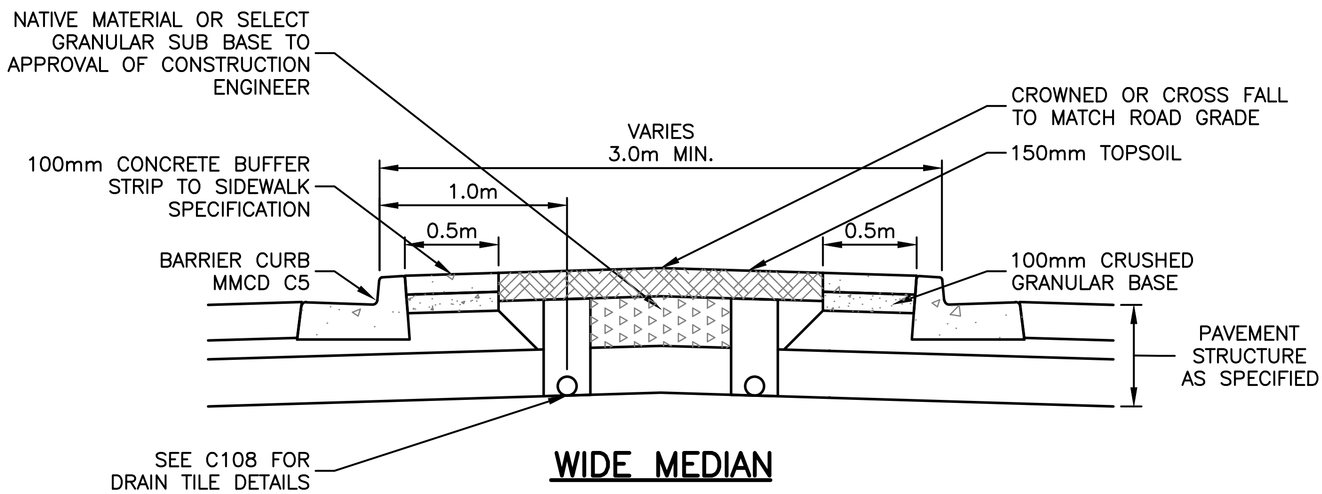
City of Burnaby
ENGINEERING DEPARTMENT

ARTERIAL PRIMARY
BURNABY MAJOR ROADS

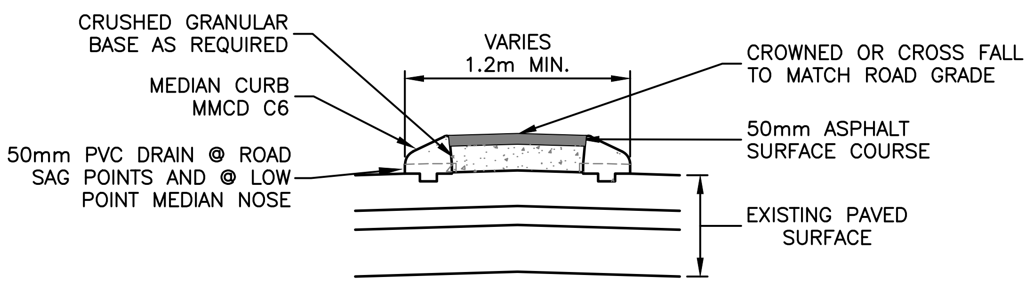
DRAWN BY: KADTEC	SCALE: N.T.S.	**BBY-**
APPRV'D BY:	DATE: 2014–05–27	



NARROW MEDIAN/ISLAND



WIDE MEDIAN



TEMPORARY MEDIAN/ISLAND

NOTES:

1. CURB & GUTTER (MMCD C5) REQUIRED FOR ALL MEDIAN/ISLAND ON NEW ROAD CONSTRUCTION & EXISTING ROADS WHERE PAVEMENT REMOVAL AND BASE REGRADING IS REQUIRED
2. MEDIAN CURB (MMCD C6) ONLY USED WHERE ADDING A MEDIAN/ISLAND ON TOP OF AN EXISTING PAVED ROADWAY
3. FULL CONCRETE INFILL BETWEEN THE CURBS EXTENDED TO THE POINT WHERE MEDIAN WIDTH BECOMES 3.0m
4. CONCRETE BUFFER STRIPS REQUIRED ADJACENT TO CURB ON BOTH SIDES FOR ALL MEDIANS EXCEEDING 3.0m IN WIDTH
5. ASPHALT INFILL ONLY ALLOWED FOR TEMPORARY MEDIAN/ISLAND AS APPROVED BY THE CITY ENGINEER
6. WHEELCHAIR RAMPS REQUIRED AT MEDIANS/ISLANDS FOR DESIGNATED CROSSWALKS. WHEELCHAIR RAMP & CONNECTION WALKS BETWEEN RAMPS TO BE CONCRETE SIDEWALK, WITH INFILL AREAS TO BE STAMPED CONCRETE
7. ONLY SINGLE MEDIAN DRAIN TILE REQUIRED FOR CROSS FALL ROADWAYS & WHERE SUBGRADE GRADING CREATES A SINGLE LOW POINT AS APPROVED BY CONSTRUCTION ENGINEER
8. TOPSOIL REQUIREMENTS TO PARKS SPECIFICATIONS FOR DESIGNATED TREE PLANTING AREAS
9. STAMPED CONCRETE TO BE USED BRICK, BASKET WEAVE PATTERN, BOCA PINK(D106) IN COLOUR WITH A SANDSTONE RELEASE AGENT AND SEALER. HIGH GLOSS SEALERS NOT ACCEPTABLE FOR PEDESTRIAN AREAS
10. FULL CURB HEIGHT CONCRETE INFILL REQUIRED FOR MEDIAN NOSE.

NO.	DATE	REVISION	APP'D	BY
1	2000/01	DRAIN & NOTE ADDED		JK

City of Burnaby
ENGINEERING DEPARTMENT

MEDIAN/ISLAND INSTALLATION

DRAWN BY: HLOUIE	SCALE: N.T.S.	**BBY-** R209
APPRV'D BY:	DATE: 99-02-22	

7.0 ROADWAY LIGHTING

7.1 General

Roadway lighting refers to lighting of roads, walkways, lanes and bikeways. Lighting is generally required in all urban areas and suburban areas. In agricultural areas, lighting requirements are in accordance with warrants as indicated in the TAC Guide for the Design of Roadway Lighting.

7.2 Codes, Rules, Standards and Permits

Roadway lighting systems are to be designed in general conformance with the following:

7.2.1 Codes

- Canadian Electrical Code, latest edition, and bulletins issued by Electrical Safety Branch of the Province of British Columbia

7.2.2 Rules

- Workers Compensation Board
- Canadian Standards Association
- Utility Companies
- Regulations issued by municipal, provincial and federal authorities

7.2.3 Standards

- ANSI/IES Standard RP-8, American National Standard for Roadway Lighting
- IES-DG-5 Recommended Lighting for Walkways and Class 1 Bikeways
- TAC - Guide for the Design of Roadway Lighting – 1983
  - Illumination of Rural Intersections
- AASHTO – Standard Specification for Structural Supports for Highway Signs, Luminaires and Traffic Signals
- CAN/CSA 22.3 No. 7 Underground Systems
- CAN 3 – CSA 22.3 No. 1 Overhead Systems
- MMCD Specifications and Standard Detailed Drawings plus City of Burnaby Supplementary Specifications and Drawings

7.2.4 Permits

- Electrical Permits are required by province and City Building Department Electrical Inspections.

7.3 Roadway Classifications

Roadway classifications for lighting purposes are in accordance with ANSI/IES RP-8. The following three basic classifications are covered by these guidelines. Highway classifications such as freeway and expressways are excluded.

- Major: Serves a continuous route primarily for inter-community through traffic. Includes Arterial Primary and Arterial Secondary roads in defined in section 6.2.
- Collector: Performs the dual function for traffic of land access and movement between local roads. Includes Major Collector Primary, Major Collector Secondary and Major Collector Greenway roads defined in section 6.2.
- Local: Provides direct land access and is not intended to carry through traffic.
- Walkways and Bikeways: Adjacent to or independent from roadways.

The basic classifications are further divided according to the levels of vehicle/pedestrian interaction as follows:

- High (H): Commercial areas such as those adjacent to shopping centres, hotels, and central business districts and village town centres. For Walkways and Bikeways this classification is further divided as follows:
  - P: Pedestrians and bicycles only
  - S: Sidewalk adjacent to roadway
- Medium (M): High density multi-family residential and local commercial, industrial and public areas.
- Low (L): Medium density multi-family, single family and rural residential areas. For Walkways and Bikeways this classification is further divided as follows:
  - MDR: Medium density residential
  - LDR: Low density residential
  - SR: Semi-rural or rural

7.4 Design Methods

Acceptable design methods and criteria are indicated below. The details are shown in Figure 7.1.

7.4.1 Illuminance

Illuminance refers to the average maintained horizontal illumination level measured in lux. Recommended levels are related to pavement types as described in RP-8.

Additional design criteria include uniformity ratio and veiling luminance (disability glare).

The Illuminance method of design is suitable for all roadway classifications, particularly collector and local roads and bikeways and lanes.

7.4.2 Luminance

Luminance refers to the average light intensity reflected off the roadway measures in candelas per square meter (CD/m^2). Uniformity ratios and veiling luminance are also included in the design criteria.

The luminance design method is suitable for most roadway classifications, particularly major roads, freeways and parkways. Recommended luminance levels have not been established for walkways and bikeways.

7.4.3 Small Target Visibility (STV)

The STV design method in RP-8 determines the visibility of an array of targets on the roadway considering the following factors:

- Luminance of the targets
- Luminance of the immediate background
- Adaptation level of the adjacent surroundings
- Disability glare

The average of the visibility level (VL) of the targets results in the STV.

The uniformity ratio is also considered. Suitability of the STV design method is similar to that of the luminance method.

7.5 Verification

While the above design methods are all acceptable as indicated, the Illuminance method is currently the only one for which the actual lighting level can be readily verified in the field using economical measurement equipment and procedures. Prior to proceeding with detailed design, the designer should obtain, approval of the design method from the Engineer.

7.6 Light Sources

The lighting source for street lighting shall be Light Emitting Diode (LED) or High Pressure Sodium (HPS), as approved by the Engineer.

Prior to proceeding with detailed design, the designer should obtain approval from the Engineer of the lighting source.

Specialty lighting in designated areas may use Metal Halide lamps or other sources as approved by the Engineer on a case by case basis.

7.7 Pavement Surface Classifications

The IES has identified four pavement classifications which define the surface reflectance characteristics of common pavements.

Typically R3 is representative of the most common pavement (asphaltic concrete) type used in Canada. Pavement reflectance is required when calculating Roadway Illuminance. Refer to standards (RP-8-00) for definitions of roadway surface classifications.

7.8 Intersection Lighting

Increased lighting levels are required at intersections. Refer to Table 7.1 for details.

Table 7.1 Intersection Lighting Design Criteria

Illuminance Criteria – Class R3 Road Surface				
Functional Classification	**Average Maintained Illumination at Pavement by Pedestrian Area Classification (Lux)**			**Uniformity E_{avg}/E_{min}**
	High	**Medium**	**Low**	
Major/Major	34	26	18	3:1
Major/Collector	29	22	15	3:1
Major/Local	26	20	13	3:1
Collector/Collector	24	18	12	4:1
Collector/Local	21	16	10	4:1
Local/Local	18	14	8	6:1

7.9 Calculations

7.9.1 Lighting System

Lighting system design generally requires a computer model which uses RP-8 calculation methods. Example of a suitable computer programs is LUMEN MICRO and AG132.

Manual calculations may be approved by the local authority for small, simple or rural systems.

7.9.2 Electrical Details

Design requirements include:

- Maximum voltage drop in branch feeders: 3%
- Allow for possibility of future extension circuits
- Conductor sizes: maximum #6 RW90; minimum #10RW90
- Circuit load not to exceed 80% of feeder breaker rating
- Use single pole breakers
- Use VA load of the luminaire ballast
- Include loads for pole receptacles (300 W/receptacle), tree lights and traffic signal controllers

7.9.3 Submission of Detailed Design

Calculation and design details are to be submitted to the Engineer for approval as follows:

- Complete design summary sheet similar to Figure 7.2
- Design drawings to include summary table and circuit loading schedule showing the following information:
  - Roadway Classification
  - Lighting Level (lux or cd/m^2)
  - Uniformity ration (Ave/Mini)
  - Luminaire and lamp details
  - Phases
  - Lighting load in VA
  - Receptacle loads
  - Main and branch breaker sizes
  - Number of Luminaires on each circuit

7.10 Poles

7.10.1 Type and Details

Poles are to be davit type unless otherwise directed or approved by the Engineer. Davit pole heights are to be 7.5 m, 9.0 m, 11.0 m, or 13.5 m.

Post-top poles, where approved by the Engineer, are to be 6.0 m or 7.5 m high. Post-top poles may be suitable for roadways not exceeding 11 m in width.

Pole details are to be in accordance with MMCD Standard Detail Drawings and as follows:

- Octagonal, tapered, unpainted, galvanized steel
- Where poles are to be painted, the powder coating is to be used
- Davits to be 2.5 m with 60 mm diam. X 180 mm tenon.
- Pole shafts and davits are to be separate with bolted flange connections
- Poles to have 100 mm x 175 handhole with cover plate, and backing bar

For rural roads, if approved by the Engineer and the power company, lights may be installed on power poles.

7.10.2 Locations

Poles are to be located at the outer edges, or in special circumstances, in the median of the roadway. Acceptable location patterns include staggered, opposite and one side arrangements, depending on the roadway classification and system design details. Suitable pole arrangements are typically as followings:

- One Side: - Local roads
  - Bike and Walkways
  - Urban Trails
- Staggered: - Collector Roads
  - Major Roads
- Opposite: - Major Roads with Medians

Maintain clearances from features and utilities as follows:

- 1.5 m: Pole to curb return or driveway let-down
- 3.0 m: Overhead electrical lines. Dimension varies with the voltage; refer to power company for details.

7.10.3 Offsets

Standard pole offsets for roadways with barrier curbs or other forms of protection of poles from vehicle traffic are as follows:

Road Configuration	Pole Centreline to Curb Face Offset
Width 14 m or more and sidewalk adjoining curb	0.5 m
Width 11 m or less and sidewalk adjoining curb	2.0 m
Sidewalk separated from curb	1.5 m

For roads without curbs or other barriers, use offsets indicated on Figure 7.3. If the offsets indicated cannot be obtained, and if approved by the Engineer, use frangible pole bases.

7.11 Luminaires

7.11.1 LED

The manufacturer, type and model of LED Luminaire shall be as approved by the Engineer.

The LED lamp requirements are as follows;

Item	Requirement
Minimum Luminaire Efficiency	70 lumen/watt per IES LM-79
Correlated Colour Temperature (CCT)	Nominal CCT = 3500° k to 4500° k
Colour Rendering Index	Minimum CRI of 70
Light Distribution	Roadway luminaires shall be in accordance with IESNA Type 1, 2, 3, or 4 distribution.
Luminaire Cut Off	Shall be compliant with Dark Skies, or BUG rating provided in IES LM-79 report zero Uplight (90° above Nadir)
LLF (Light Loss Factor)	Shall be determined by the following formula: LLF = LLD x LDD • Lamp Lumen Depreciation (LLD) shall be determined by the manufacturer and be based on the percentage of initial output at 70,000 operation hours calculated in accordance with IESNA LM-80 and TM-21. • Luminaire Dirt Depreciation (LDD) = 0.9, as per IES DG-4 for an enclosed and gasketed roadway luminaire installed in an environment with less than 150 ug/m^3 airborne particulate matter and cleaned every 10 years.
Warranty	Minimum warranty of 10 years for full replacement of luminaire due to failure or inability to operate within specifications.

The LED housing and thermal management system shall incorporate:

- Single unit primarily constructed of die-cast or extruded aluminum rated for wet locations and 1G vibration rated for roads and 3G for bridges.

- Shall consist of heat sink fins integrated within the body with no fans, pumps, or any moving parts and/or liquids, and shall be resistant to debris buildup.
- The heat sink system shall be designed to maintain a junction temperature for the LED's such that the light engine will achieve a minimum lifespan of 700,000 hours (IESNA LM-80) at 10°C
- Driver must be mounted internally
- Ingress Protection rating shall be a minimum of IP66 for both the light engine and power supply chamber.

The LED power supply/driver shall incorporate:

Item	Requirements
Adaptive Lighting	Dimming capability
Operating Voltage	Roadway and intersection luminaires shall operate from 120V-277V
Power Factor	Power Supply should have a minimum Power Factor of 0.90
Operating Current	The driver current shall be 350mA 525mA 700mA unless it can be proven that drivers with higher currents can meet the Mean Time Between Failure (MYBF) requirements.
Transient (surge) Protection	Stand-alone surge protection device compliant with ANSI/IEEE C62.41-2-2002, Rating Category C – High Operation to meet 10KV/10KA Surge level incident.
Rated Life	Rated Life of 70,000 hours
Operating Temperature	Power supply shall operate between -40°C and 40°C.
Frequency	Output operating frequency must be ≥ 120 Hz (to avoid flicker) and input frequency of 60 Hz.
Noise and Ingress Protection	Power supply shall have a Class A sound rating per ANSI Standard C62.41. Assembly or compartments shall be rated IP66, minimum.

7.11.2 HPS

Luminaires are to be energized at 120 Volt or 347 Volt.

Luminaires are to have a minimum Ingress Protection Rating of 65.

Cobra head luminaires are to be either cut-off or semi cut-off, with glass refractors or lenses, and distribution as follows:

<u>Roadway</u>	<u>IES Distribution</u>
Width less than 14 m	Type II
Width 14 m or greater	Type III
Cul-de-sacs	Type IV
Urban trails or walkways in treed areas	Type V

Refer to Table 7.2 for Recommended Light Loss Factors. Ambient environmental conditions range from 1 – Very Clean to 2 – Clean, 4 – Moderate, 8- Dirty, and 16 – Very Dirty. Unless otherwise approved by the Engineer, use Ambient Category 2 and a Cleaning Interval of 5 years.

Table 7.2 Light Loss Factors

Lamp Type	**Ambient Category**	**Cleaning Interval in Years**		
		1.25	**2.5**	**5**
Clear HPS (150 – 1000 W)	1	0.71	0.70	0.69
	2	0.69	0.68	0.66
	4	0.66	0.64	0.61
	8	0.60	0.56	0.50
	16	0.48	0.43	0.32

Ballasts are to be as follows:

- Constant Wattage Isolated Winding (CWI) or Magnetic Regulator (Mag Reg) type with grounded socket shell
- High Power Factor type

7.12 Power Supply and Distribution

Roadway lighting systems are typically services from a 120/240 Volt single phase 3 wire system. Alternately, 120/208 volt 3 phase 4 wire or 347/600 Volt systems may be used if necessary and if approved by the Engineer.

Power is generally supplied by the power company through an unmetered service when servicing only streetlights and traffic signals. Where tree lights and pole receptacles are included, the power company may require a metered service.

Where new lighting systems are replacing existing lights on power poles, submit a list of the poles from which lights are to be removed,

Unmetered services are to have a maximum 60 Amp 2 or 3 Pole main breaker in a service base in accordance with MMCD standard detail drawings and specifications. A 100 Amp service is required where a traffic signal is also being serviced.

Services are to be underground dip type.

Power distribution requirements include:

- Wiring to be installed in Rigid PVC conduit; minimum 32 MTD (metric trade designator)
- Wiring to be stranded copper with RW90 insulation or aluminum, as approved by the Engineer
- Wiring to be colour coded per Canadian Electrical Code (CEC)
- Conduit burial depth to be per the CEC and MMCD standard drawings
- A 78 MTD conduit may be required for future communication needs; confirm with the Engineer.

Figure 6.1
Design Criteria – Roadway Lighting

Roadway	Pedestrian Conflict Area	Maintained Luminance Criteria				Maintained Illuminance Criteria (R3 Pavement)				Small Target Visibility (Luminance)			
		Average	Uniformity Ratio (U/R)		Veiling Luminance (Lv)	Avg	Uniformity Ratio (U/R)		Veiling Luminance (Lv)	Weighted Average	Median <7.3m	Median ≥7.3m	Uniformity Ratio (U/R)
		cd/m²	Ave/Min (Max)	Max/ Min (Max)	Lv max/ Lv avg	Lux	Ave/Min (Max)	Max/Min (Max)	Lv max/ Lv avg	Lv max/ Lv avg	Lav (cd/m²)	Lav (cd/m²)	Max/Min (Max)
Major	*H	1.2	3:1	5:1	0.3	17	3:1	4:1	0.3	4.9	1.0	0.8	6.0
	*M	0.9	3:1	5:1	0.3	13	3:1	6:1	0.3	4.0	0.8	0.7	6.0
	*L	0.6	3.5:1	6:1	0.3	9	3:1	6:1	0.3	3.2	0.6	0.6	6.0
Collector	*H	0.8	3:1	5:1	0.4	12	4:1	6:1	0.4	3.8	0.5	0.5	6.0
	*M	0.6	3.5:1	6:1	0.4	9	4:1	6:1	0.4	3.2	0.4	0.4	6.0
	*L	0.4	4:1	8:1	0.4	6	4:1	6:1	0.4	2.7	0.4	0.4	6.0
Locals	*H	0.6	6:1	10:1	0.4	9	6:1	6:1	0.4	2.7	0.4	0.4	10.0
	*M	0.5	6:1	10:1	0.4	7	6:1	12:1	0.4	2.2	0.3	0.3	10.0
	*L	0.3	6:1	10:1	0.4	4	6:1	12:1	0.4	1.6	0.3	0.3	10.0
Walkways Bikeways	*H**					20 10	4:1 4:1						
	*M					5	4:1						
	*L***					2 3 4	10:1 6:1 4:1						

* H,M and L designations refer to High, Medium and Low levels of potential vehicle/pedestrian conflict, See Roadway Classifications section

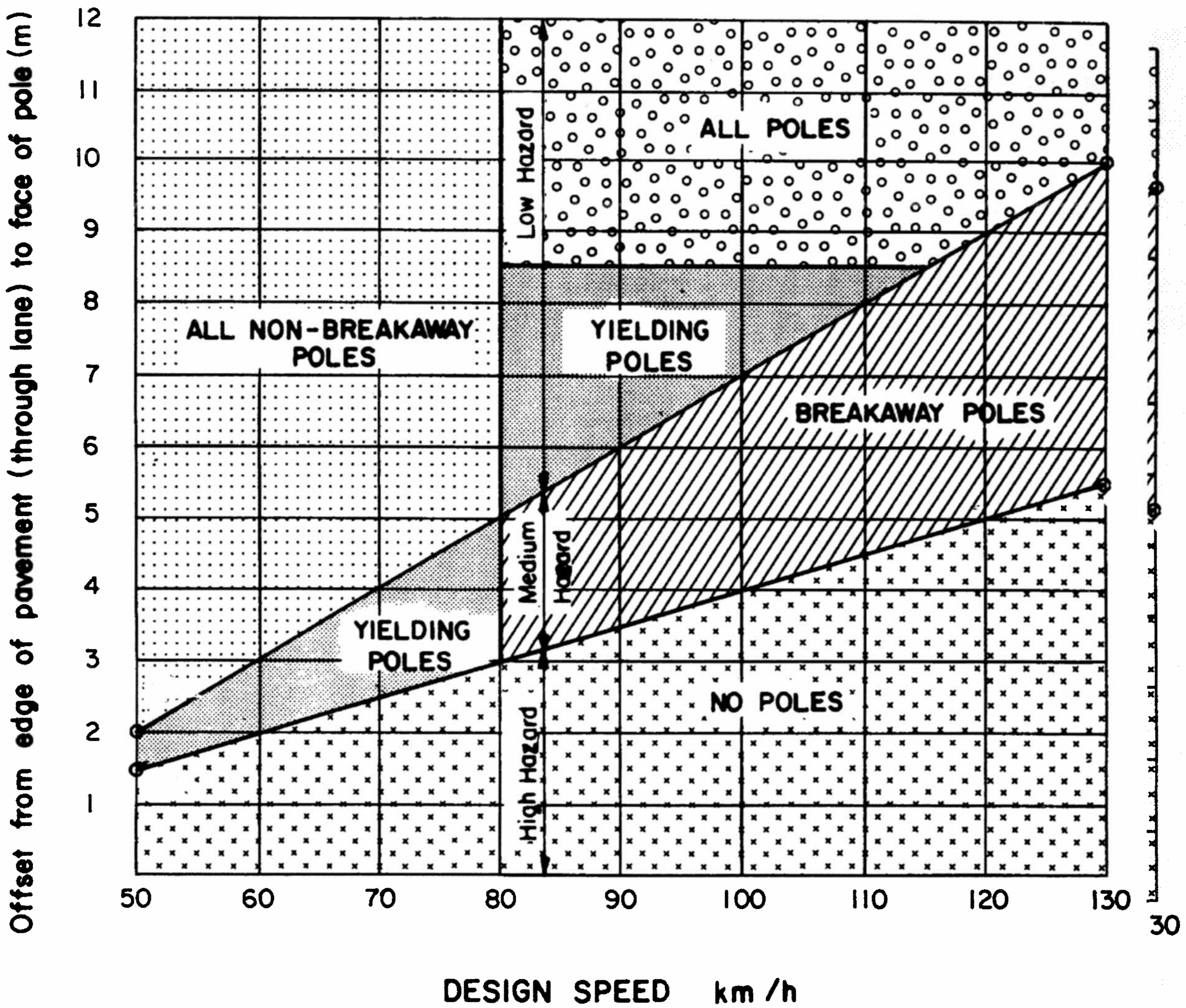
** Upper number denotes Mixed Vehicle and Pedestrian (sidewalk adjacent to roadway).
Lower number denotes Pedestrian Only.

*** Upper number denotes Rural or Semi-Rural area.
Middle number denotes Low Density Residential.
Lower number denotes Medium Density Residential.

Figure 6.2
Lighting Design Summary Sheet

Project Name			Page___ of ___	
Contract No.	Lighting Reference Drawing(s)			
Consultant	Project Number		Date	
SPECIFIC ROAD DESCRIPTION	From (Station or Block)		To (Station or Block)	
LIGHTING REQUIREMENTS				
Roadway Classification				
Pedestrian Conflict Area				
Roadway Design Speed				
LIGHTING DESIGN CRITERIA	Level	Uniformity		Veiling Luminance
	L_{avg} (Lux or cd/m$^{2)}$	$E_{avg/min}$	$E_{min/max}$	Lv_{max}/L_{avg}
GENERAL CONFIGURATION				
Roadway Width (m)				
Median Width (m)				
Pole Offset of Classification (A,B,C)				
Pole Height (m)				
Pole Davit Length (m)				
Calculated Luminaire Mounting Height (m)				
Pole Arrangement				
Pole Cycle Distance				
LIGHTING CONFIGURATION				
Full Luminaire Description (with options)				
Complete Catalogue or Identification Number				
Photometric File Number				
Light Loss Factor				
Luminaire Tilt or spin (if applicable)				
Lamp Wattage			Type	
PREDICTED LIGHTING PERFORMANCE	Level (Lux or cd/m$^{2)}$	Uniformity		Veiling Luminance
	L_{avg}	$E_{avg/min}$	$E_{min/max}$	Lv_{max}/L_{avg}
ACTUAL LIGHTING PERFORMANCE (as measured in field at completion)	Level (Lux or cd/m$^{2)}$	Uniformity		Veiling Luminance
	L_{avg}	$E_{avg/min}$	$E_{min/max}$	$Lv_{max/Lavg}$
NOTES AND COMMENTS				

Figure 6.3
Pole Types and Offsets



NOTES:

1. Does not apply to high mast poles (RTAC Guide Section 6.3.3.1)
2. May not apply to special pole location RTAC (Guide Section 2.2.1.4)

SOURCE: "Guide for the Design of Roadway Lighting" (RTAC – 1983)

8.0 TRAFFIC SIGNALS

8.1 General

Traffic signals may be required to increase intersection capacity or enhance the safety of vehicular traffic or pedestrians. The need for a traffic signal will be determined by the Engineer or based on warrants in accordance with the Manual of Uniform Traffic Control Devices for Canada (MUTCD).

8.2 Standardization

Traffic signal details are to be standardized in Burnaby to be consistent with traffic signal details used throughout British Columbia, including:

- Vertical mounted signal heads
- Left side secondary leads
- Order of signal indication

8.3 Codes, Rules, Standards and Permits

Traffic signals are to be designed in general conformance with the following:

8.3.1 Codes

- Canadian Electrical Code, latest edition, and bulletins issued by Electrical Safety Branch of the Province of British Columbia

8.3.2 Rules

- Workers Compensation Board
- Canadian Standards Association
- Utility companies
- Regulations issued by municipal, provincial or federal authorities
- BC Motor Vehicle Act and Regulations

8.3.3 Standards

- BC Ministry of Transportation Electrical and Traffic Engineering Manual
- Institute of Transportation Engineers (ITE)
- AASHTO – Standard Specification for Structural Supports for Highway Signs, Luminaires and Traffic Signals
- CAN/CSA-S6-00 Canadian Highway Bridge Design Code
- CAN3-CSA22.3 No. 7 Underground Systems
- CAN3-CSA22.3 No. 1 Overhead Systems

- National Electrical Manufactures Association (NEMA) – Traffic Controller Assemblies – TS1 or TS2
- Canadian Manual of Uniform Traffic Control devices (MUTCD)
- MMCD Specifications and Standard Detailed Drawings plus City of Burnaby Supplementary Specifications and Drawings
- British Columbia Pedestrian Crossing Control Manual

8.3.4 Permits

- Electrical Permits are required by province and City Building Department Electrical Inspections
- Interconnection permits from Railroads, Ministry of Transportation, or other authorities
- Right-of-way and utility crossings of electrical transmission lines, railways, highways and regional, provincial and federally regulated pipelines.

8.4 Signal Head Types

Types of general locations of signal heads are as follows:

- Primary: Mounted over the roadway which a vehicle is to enter
- Secondary: Mounted to the left of the roadway which a vehicle is to enter
- Auxiliary: Mounted to the right of the primary head, or other location to enhance visibility
- Pedestrian: Mounted on the far side of the intersection in line with the painted crosswalk

8.5 Visibility

Signal visibility distance is defined as the distance in advance of the stop line from which a signal must be continuously visible for approach speeds varying between 40 and 80 km/h. For speeds exceeding 80 km/h, the minimum visibility distance must equal or exceed the minimum stopping sight distance. Visibility distance guidelines are shown on Table 8.1.

8.5.1 Signal Visibility Distance

Table 8.1 Signal Visibility Distance

85th Percentile Speed (km/h)	Minimum Visibility (m)	Desirable Visibility (m)	Add For % Downgrade (m)		Subtract For % Upgrade (m)	
			5%	10%	5%	10%
40	65	100	3	6	3	5
50	85	125	5	9	3	6
60	110	160	7	16	5	9
70	135	195	11	23	8	9
80	165	235	15	37	11	20

8.5.2 Cone of Vision

Visibility of a signal head is influenced by three factors:

- Vertical, horizontal and longitudinal position of the signal head
- Height of driver's eye
- Windshield area

Lateral vision is considered to be excellent within 5° of either side of the centreline of the eye position (10°) and adequate within 20° (40° cone). Horizontal signal position should therefore be as follows:

- Primary heads within the 10° cone
- Secondary heads within the 40° cone

Vertical vision is limited by the top of the windshield. Signal heads should be placed within a 15° vertical sight line. Overhead signals should be located a minimum of 15 m beyond the stop line.

Refer to MUTCD for additional details.

8.5.3 High Vehicles

Drivers of vehicles following high vehicles must be able to see at least one signal head upon reaching the dilemma point.

The dilemma point is defined as the location where a driver seeing the signal indication change from green to yellow must decide either to bring the vehicle to a safe stop or proceed through and clear the intersection prior to the start of the conflicting green. Factors to consider in assessing signal head visibility are road geometry, design speed, spacing between vehicles, and horizontal and vertical signal head locations.

8.5.4 Environmental

Signal heads need to stand out from the surroundings in order to prevent confusion due to distractions. Primary signal heads should have backboards. Backboards are optional for secondary and auxiliary heads. Backboards should be yellow with a reflective surface. A yellow reflective tape border on the backboard can increase signal visibility.

8.5.5 Flash Rates

The effectiveness of flashing signals is influenced by flash rates. Recommended rates are:

- Red and amber rates: 50 to 60 flashes/minute
- Arrows: 100 to 120 flashes/minute

The ON and OFF periods should be equal.

8.5.6 Size

Signal head sizes are to be as indicated in Table 8.2

Table 8.2 Signal Head Sizes

Signal Head Type	Area Classification	Lens Size and Shape
Primary	All Areas	300 mm round
Secondary	Rural and Small Urban areas	200 mm round green and yellow with 300 mm round red or arrow
	Large Urban Areas	300 mm round
Auxiliary	Rural and Small Urban areas	200 mm round green and yellow with 300 mm round red or arrow
	Large Urban Areas	300 mm round
Pedestrian	All Areas	Combination walk/don't walk indication 450 mm square or Combination walk/don't walk indication 300 mm square with countdown timer

8.5.7 Visors

Visors are required on all signal heads. Cowl-type visors are standard, except in the following cases, where tunnel visors are required:

- Fully protected left turn signal heads
- At skewed intersections, where the signal heads may be viewed from other approaches

8.6 Light Sources

All new and upgraded signal heads including pedestrian signals shall use LED lamps.

All lamps should conform to ITE standards.

8.7 Signal Head Placement

Signals should be mounted on poles, davits, mast arms or gantries.

Mounting heights are as indicted in MMCD standard detailed drawings and as follows:

- Signals mounted above roadways should provide a minimum 5.5 m clearance
- Auxiliary signals should be mounted at any height that meets visibility requirements and is between 2.5 m and 5.5 m above the road.

Each approach to an intersection requires a minimum of one primary and one secondary signal head. Requirements for additional signal heads are to be determined on the basis of visibility issues.

8.7.1 Primary Signal Head Placement

Table 8.3 Primary Signal Head Placement

Straight Through Lanes		
Number of Lanes	**Number of Primary Heads**	**Placement of Primary Heads**
1	1	Centered over through lane
2 to 3	2 (minimum)	Centered over each through lane
3 to 4	3 (minimum)	Centered over each through lane
Left Turn Lanes		
Left Turn Type	**Primary Head Type**	**Placement of Primary Heads**
Protected/Permissive	Flashing Green Arrow, Steady Yellow Arrow and Steady Green Ball	Centered over left-most through lane
Protected – Single Left Turn Lane	Steady Green Arrow	Centered on the left turn lane, either post mounted in median or overhead arm mounted
Protected – Dual Left Turn Lane	Steady Green Arrow	Centered on the left turn lane, either post mounted in median or overhead arm mounted

8.8 Pole Placement

Signal poles should be placed between 1.2 m and 3 m from the face of curb or edge of pavement, preferably behind the sidewalk. Pole arms should be oriented at 90° to the centreline of the road, except where the intersection is skewed. When laying out a skewed intersection, ensure the arms do not block the view of the signal heads.

Other considerations for pole placement are:

- Ease of access for pedestrians
- Arm reach to ensure head is over lane centres or lane markings as appropriate
- Minimizing the number the number of poles is required
- Limiting number of heads on a poles shaft to four

8.9 Left Turn Phasing

Left Turns at signalized intersections are phased in 3 different manners as follows:

- Permissive
- Protected
- Protected/Permissive

A Permissive left turn has no signal indication other than a green ball, which permits a left turn when opposing traffic is clear.

A Protected left turn presents a continuous green arrow indication while all opposing traffic is held by a red ball. A Protected Left Turn is always terminated with a yellow ball.

A Protected/Permissive left turn presents a flashing green arrow followed by a green ball. During the flashing phase (advanced movement), opposing through traffic is held by a red ball. After the advance has timed out, left turn traffic is presented with a green ball permitting the movement when conflicting traffic is clear. The protected phase of this movement is always terminated with a non-flashing yellow indication.

Protected left turns are typically used in the following circumstances:

- Permissive left turns are deemed hazardous due to gap judgement difficulty caused by high speed, geometrics or visibility
- More than 1 left turn on the approach
- Lack of sight distance to oncoming vehicle
- High pedestrian volumes
- High accident experience
- Left turn phase is in a lead-lag operation

Protected/Permissive left turns are appropriate in cases where:

- Peak hour left turn traffic volumes justify the movement
- Left turn delays are a concern
- Accident experience dictates

Care should be taken when considering a left turn phase, as it could cause delays at the intersection by increasing the total cycle length.

8.10 Advance Warning Flashers

Advanced warning flashers should be used where sight distance to an intersection is less than optimal, or where design speed of the road is sufficiently high to justify warning motorists of signal status.

8.11 Signal Pre-Emption

8.11.1 Rail Crossings

Traffic signals in close proximity to rail crossings require interconnection with the rail crossing controls to ensure maximum driver safety. Refer to MUTCD and MoT standards, and the railroad operator pre-emption requirements.

8.11.2 Emergency Vehicle

The City of Burnaby requires emergency vehicle pre-emption to override normal signal operation and provide continuous green signals for emergency vehicles such as fire department and ambulances. The pre-emption systems operate on radio signals. Designers are to obtain pre-emption system wiring, equipment and operations specifications from the Engineer, prior to design. Any exemption from pre-emption requirements require approval of the Engineer.

8.12 Audible Pedestrian Signals

Where required by the Engineer, use audible pedestrian signals to assist visually impaired pedestrians.

The signal is interconnected with the Walk signal, and produces a “cuckoo” or “peep” sound, depending on the direction of crossing. The cuckoo sound is used for north-south crossings and the peep is used for east-west crossings. Where the streets are not oriented north-south and east-west, maintain consistency with adjacent signals.

8.13 Control Types

The principal types of signal control are pre-times (fixed time) and traffic actuated. Traffic actuated controls are categorized as fully actuated, semi-actuated and volume density control. The types to be used will be determined by the Engineer.

Pre-timed controls assign the right-of-way at an intersection according to a pre-determined schedule. The time interval for each signal indication is fixed according to this schedule.

Fully actuated controls require traffic detectors for all phases, with each phase timed according to preset parameters. Fully actuated controls allow for the maximum flexibility of signal control.

Semi actuated controls typically have detectors only on the minor street approaches. Semi actuated controls are effective in coordinated systems, and intersections where the major street has relatively uniform flows and the minor street has low volumes with random peaks.

Volume Density control is a type of actuated control appropriate for major high speed roads with unpredictable fluctuations. This type of control has certain advantages and may be required by the Engineer under certain circumstances.

8.14 Detection Methods

Traffic detection for signal actuation is typically accomplished through one of the following methods:

- Vehicle detector loops (induction)
- Image sensor (video detector system)

The method to be used will be determined by the Engineer. In all cases, bicycle detection should also be considered.

A vehicle detector loop is a coil of wire buried in the road surface. The coil detects the presence of a vehicle by the change in electrical induction. This change is sensed by the detector module in the traffic control cabinet. Detector loop locations and details are indicated in the MMCD Standard Detail Drawings.

The image sensor system is a video detection system using cameras and computer software to send signals to the traffic controller.

8.15 Signal Timing Plans

Calculation methods and clearance times should be in accordance with ITE Standards. Refer to the City of Burnaby Traffic Signal Timing procedures and specifications.

8.16 Signal Coordination

Road capacity and/or driver convenience can be improved on some traffic corridors by implementing a system to coordinate or synchronize traffic signal operation. A detailed traffic study is required to determine the potential effectiveness of a coordination system.

Coordination systems operate by coordinating the timing on some traffic signal controller with the timing plans of the adjacent controllers using the controller clocks. Timing “offsets” between intersections are based on distance and design speed. Signal controller clocks can be synchronized using radio signals, telephone connections or hard-wire interconnections between intersections.

The most effective coordination systems include a master controller which is in synchronization and remote adjustment of system parameters.

The requirement for signal coordination is to be determined by the Engineer.

8.17 Pedestrian (Cyclists) Controlled Signal

There are two types of pedestrian controlled signals, a Full Signal with green-yellow-red indication, and a Special Crosswalk Signal. The requirement for a pedestrian signal and the type of signal to be installed will be established by the Engineer, based on warrant information as indicated in the BC Pedestrian Crossing Control Manual (MoT).

Pedestrian signals serve pedestrian traffic only, and are generally in areas of high pedestrian traffic or in school zones. Pedestrian signals should be located at intersections.

A full pedestrian signal has heads placed on the main road only. Cross street traffic is controlled by signage. When not activated, the signal presents a flashing green indication to drivers. When the signal is activated by a pedestrian, the flashing green indication becomes a steady green ball, followed by a yellow ball and then red. Pedestrian heads provide the Walk/Don’t Walk indications to the pedestrian. Activation by cyclist will also be provided with the installation of push buttons adjacent to the road.

A Special Crosswalk Signal consists of pedestrian controlled signage and lighting designated to draw driver attention to the crosswalk. The special crosswalk has illuminated overhead pedestrian crossing signs, with yellow flashing lights, and crosswalk luminaires. Some form of signal activation indication to the pedestrian may be required. Options include steady or flashing yellow light mounted on the pole in line with the crosswalk, of LED indication on the pushbutton.

8.18 Pole Loading

Traffic signal poles are to be designed to accommodate the weight of the arms and the items mounted on the pole, as well as wind and ice loading, arm length, anchor bolt size and concrete base size.

The BC Ministry of Transportation has made available a load calculator spreadsheet, based on the Ministry’s standard equipment. Designers are encouraged to obtain a copy of the spreadsheet from the Ministry for use in calculations, but should note that the calculations are applicable only to MOT Standard poles, arms and bases.

It is the designer's responsibility to ensure that the pole/base combinations used are appropriate for local conditions.

8.19 Controller Cabinets

Controller cabinets are available in various sizes and styles depending on equipment requirements. MMCD standards include details of cabinet and base sizes and installation methods.

Cabinets should be located entirely within the road right-of-way, including maintenance pad and door swing. Location should be behind the sidewalk, with access door on the side away from the sidewalk and the signals visible from the access.

Cabinets should be heavy gauge, all welded aluminum with powder coat exterior finish, with colour as approved by the Engineer.

8.20 Controllers

Traffic signal controllers should be NEMA TS1 or TS2. The choice of manufacturer is to be approved by the engineer with due consideration for the models already in use, availability of spare parts and experience of maintenance personnel.

8.21 Calculations

As a minimum, the calculations required for each project include:

- Lighting calculations for the intersection (Intersection is defined as the area bounded by the outer crosswalk markings)
- Pole loading
- Service Panel Loading
- Cone of vision calculations

8.22 Submission of Design Details

Calculations and design details should be submitted to the Engineer as follows:

- Completed signal design check list (Figure 8.1)
- Signal Timing Plan (Figure 8.2)
- Design drawings to include summary table and circuit loading schedule showing the following information:
  - Roadway classification
  - Lighting level (lux of cd/m2)
  - Uniformity ratio (Ave/Min)
  - Luminaire and lamp details

- Power supply phases
- Lighting load in VA
- Traffic controller loads
- Additional loads
- Main and branch breaker sizes
- Signal phasing diagram
- Detector or sensor table
- Conductor colour coding/cable connection table

8.23 Electrical Issues

Wiring issues include the following:

- Minimum number of conduits
- 3-53 RPVC conduits on minimum 3 legs
- 1-78 RPVC conduit on 2 legs at right angle to the controller
- Apply 40% conduit fill rule
- Bundle signal phase conductors
- Colour coding of power (red, black, blue, white, green) as per CEC. Taping of power wiring for identification is not acceptable.
- Splicing of signal phase wiring only in pole hand holes
- No splicing of video, radio antenna, detector loop wiring or pre-emption cables
- No cutting or drilling of the enclosure for the traffic controller cabinet

Figure 7.1
Signal Design Checklist

Signal Design Checklist (100% Submission)			
PROJECT TITLE:			
PROJECT No.:			**DRAWING SERIES:**
No.	**ITEM**	☑ **YES**	☑ **NO**
1	Traffic signal phasing/sequence confirmed with local authority.		
2	Electrical service locations confirmed with utility company.		
3	Telephone service locations confirmed with utility company.		
4	Overhead utility lines checked for conflicts with Luminaire, Signal or Sign poles.		
5	Signal and Sign pole capacities checked.		
6	Illumination levels meet MMCDA standards.		
7	Roadworks, Structures, Signing and Landscaping design drawings cross checked with the Electrical Design drawings for general compliance.		
8	Materials List checked and finalized. - Estimate Completed.		
9	Road Design Section comments addressed.		
10	Electrical Section comments addressed.		
11	Signing Section comments addressed.		
12	Electrical Maintenance comments addressed.		
13	Independent Design and Drafting Quality Review carried out.		
REVIEW COMPLETED BY:			
NAME:			
TITLE:			
COMPANY:			
DATE:			

7.23.1 Figure 7.2

Signal Timing Plan

7.23.2		Signal Timing Plan						
Page 1 of 2								
DATE ISSUED:		LOCATION:						
CONTROLLER TYPE		DRAWING:			PROJECT:			
Phase Setting	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
	ON	**ON**	**OFF**	**ON**	**ON**	**ON**	**OFF**	**ON**
STREET								
FUNCTION								
OVERLAP INFO								
MINIMUM GREEN								
PASSAGE								
YELLOW								
RED								
MAXGREEN								
WALK								
PED. CLEAR								
PEDESTRIAN RECALL								
WALK								
RECALL								
MEMORY								
COORDINATION ON PHASE:								
FULL OPERATION PHASE:								
INTERSECTION FLASH:								
ADV. WARNING (CH1/CH2)								
ADV. WARNING:								

DELAY DETECTION TIMING:		COMMENTS:
EMERGENCY PRE-EMPTION		
DELAY TIME =		
PRE-EMPTION TIME =		
CONTROLLER SEQUENCE:		
MIN. FLASH:		
INITIALIZATION:		

Signal Timing Plan

Page 2 of 2

DATE ISSUED:		LOCATION:			
CONTROLLER TYPE					
		DRAWING:		PROJECT:	
Coordination Information					

PHASE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CYCLE 1 SPLIT (1/2/3/4) %								
CYCLE 2 SPLIT (1/2/3/4) %								
CYCLE 3 SPLIT (1/2/3/4) %								
CYCLE 4 SPLIT (1/2/3/4) %								
CYCLE 5 SPLIT (1/2/3/4) %								
CYCLE 6 SPLIT (1/2/3/4) %								
CYCLE 7 SPLIT (1/2/3/4) %								
CYCLE 8 SPLIT (1/2/3/4) %								

CYCLE	**CYCLE 1**	**CYCLE 2**	**CYCLE 3**	**CYCLE 4**	**CYCLE 5**	**CYCLE 6**	**CYCLE 7**	**CYCLE 8**
LENGTH								
OFFSET 1								
OFFSET 2								
OFFSET 3								
OFFSET 4								
OFFSET 5								

TIME CLOCK SETTINGS

TIME OF DAY	**DAY OF WEEK**	**CYCLE (1-8)**	**SPLIT (1-4)**	**OFFSET (1-5)**	**ADDITIONAL TIME CLOCK INFORMATION**			
CHECK								