CORPORATE REPORT

NO: R001 COUNCIL DATE: January 16, 2017

REGULAR COUNCIL

TO: **Mayor & Council** DATE: **January 11, 2017**

FROM: **General Manager, Engineering** FILE: **6520-20(SCC)**

SUBJECT: **Engineering Servicing Strategy and Related Financial Strategy for the City Centre Plan Update – Stage 2**

RECOMMENDATIONS

The Engineering Department recommends that Council:

1. Approve the engineering servicing strategy and the related financial strategy as documented in this report and as contained in the City Centre Plan as a means of managing the provision of engineering services for development in City Centre;

2. Approve the City Centre Road Classification Map as illustrated in Appendix "I" and reflect these changes by amending Schedule D "Surrey Road Classification Map (R91)" to the Surrey Subdivision & Development By-law, 1986, No. 8830;

3. Approve the City Centre Major Road Allowance Map as illustrated in Appendix "II" and reflect these changes by amending Schedule K "Surrey Major Road Allowance Map" to the Surrey Subdivision & Development By-law, 1986, No. 8830; and

4. Authorize the City Clerk to introduce the necessary amending bylaw for the required readings.

INTENT

The purpose of this report is to provide an overview to Council and obtain approval for the engineering servicing strategy and the related financial strategy for the City Centre Plan in support of the City Centre Plan Update – Stage 2 Report, which has been submitted to Council as a separate, concurrent report.

BACKGROUND

Council approved the City Centre Stage 1 Land Use Plan which included the Land Use and Density Concept, the Basic Road Network, the Road Width Concept, the Parks and Open Space Concept and the Interim Implementation Strategy) for the City Centre area at its Regular meeting of February 9, 2009 (Corporate Report No. C001;2009), and updated at Regular meetings on July 25, 2011 and July 17, 2013 (Corporate Reports No. R151;2011 and R155;2013). The Stage 2 report for the City Centre Plan has been completed based on the Council-approved Land Use Concept Plan.

DISCUSSION

Engineering servicing analysis and financial plans for the City Centre Plan have been completed. Each report has been appended as noted in this report.

Works that routinely form part of the City's Development Cost Charges program, such as major trunk sewer and water grid mains, collector and arterial roads, and major stormwater management infrastructure are included in the NCP servicing strategy. One new area specific DCC funding element is included to support delivery of the finer grained road network within the City Centre, described within the Finer Grained Network Section.

A proposed amendment to the Amenity Contribution categories is included to fund the cost of electrical utility undergrounding, sharing this additional requirement amongst all property owners, described in the Area Specific Development Cost Charge for Strategic Property Acquisition Section. Approval will be sought through the accompanying Planning Corporate Report, "Surrey City Centre Stage 2 Final Plan". Other local engineering servicing will be addressed on a site-by-site basis during the development application review process, which is the usual practice of the City for development in NCP areas.

The following provides a description of each of the principal elements of the Engineering Servicing Strategy for City Centre.

Transportation

The transportation plan for City Centre is based on the guiding principles contained in the City's Transportation Strategic Plan. It is also integral to realizing several of the guiding principles that make up the vision for City Centre, including #3 Break Up the Block Size and #4 Design Roads for Multiple Modes.

Finer Grain Network

The creation of a finer grain road network is a cornerstone of vibrant and successful downtown cores throughout North America. Small blocks encourage high-quality, mixed-use development where numerous commercial, cultural, civic, and social activities are within convenient walking distance. The Plan establishes block sizes in the range of 80 – 100m, which are considered a maximum for walking in a downtown environment. The finer grain road network will consist of roads of all classifications – arterial, collector, local, and green lanes.

Numerous new road connections will be completed through both the development and capital processes. This requirement does not impact developers as in City Centre density is calculated on gross site area. All of the new connections to complete the finer grain network are critical to the success of the City Centre. This is considered a modest and appropriate requirement, when compared to the concentration of roads in other successful downtown cores.

Major Road Classification and Road Allowance

Review of the major roads through the finer grain road network review process, ongoing development applications, and other city initiatives/projects, revealed the need for new connections and minor adjustments to the alignment of some of the roads as well as the road allowance required. Appendix "I" shows the updated Schedule D "Surrey Road Classification Map (R91) and Appendix "II" shows the updated Schedule K "Surrey Major Road Allowance Map". In accordance with City practices, the *Surrey Subdivision & Development By-law, 1986, No.8830* will require an amendment to reflect the changes to Schedule D and K.

Both Schedules D and K identify existing and future sections of the major road network which are important components of the finer grain road network and help to distribute traffic and increase resiliency. Key highlights of the road network include;

- Extension of existing collector roads such as 107 Avenue and 103 Avenue – to be named Central Avenue;
- Reclassification of 105A Avenue to Arterial within City Centre – which is an important multi-modal corridor connection to Guildford and is also anticipated to be renamed;
- Maintaining future missing arterial connections of Whalley Boulevard and University Boulevard.; and
- Creation of a new road allowance width for arterial roads with greenway corridors of 32m that eliminates the need for additional statutory right-of-way requirements and reduces the overall impact to development.

Street Typology

New high quality City Centre Standard Drawings have been developed that reflect the role that streets will play in supporting transportation choices, economic vitality and urban design. "Complete Streets" cross sections were developed in recognition that streets in City Centre will be supporting higher volumes of pedestrians and cyclists as well as transit. The Standard Drawing updates will be brought forward for Council consideration in a forthcoming Corporate Report.

On-street parking will be permitted on both sides of most of the local and collector roads within City Centre. The Green Lanes accommodate pedestrians and include a sidewalk as well as trees. The Green Lanes support broader transportation objectives as well as their core servicing role and are not meant as a replacement for local roads.

The new design standards support the City's Shade Tree Management Plan with large, plentiful street trees to provide an urban forest and enhance the pedestrian experience. They also provide for more active spaces through setbacks in commercial areas that will include merchant zones, enhancing the public realm in City Centre.

Walking and Cycling

Smaller blocks, the additional density of protected intersections, engaging street fronts with wide sidewalks on both sides of the street, and high-quality urban amenities will make City Centre a comfortable and interesting place to walk, and support the following Guiding Principles:

- Design Roads for Multiple Modes,
- Create Vibrant Urban Spaces, and
- Green the Downtown.

All Ages and Abilities separated bike lanes 'cycle tracks', are planned on all arterials and collectors to support what is expected to be the fastest growing modal share in City Centre. They reallocate the space currently used for non-motorized transportation and bring cyclists to a safer place above the curb, rather than in a space shared by motor vehicles with only a painted line for separation. Abundant, secure bike parking will be provided at future transit stations and bicycle parking and other end-of-trip facilities within City Centre developments and on-street will make it convenient to cycle throughout City Centre.

Transit and Ride Sharing

Transit improvements are fundamental to support the changes envisioned for City Centre and are a cornerstone of growth management for the City. The City Centre Plan supports the TransLink Mayors' Council Vision for City Centre as the nexus of LRT and SkyTrain South of Fraser, with new LRT connections to Guildford and Newton on the Surrey-Newton-Guildford Line and Fleetwood, Clayton and Langley on the Surrey-Langley Line.

The Plan also supports a high standard of urban design. City Parkway is envisioned as the hub of the LRT system and will incorporate a pedestrian and transit only zone between 102A Avenue and 103 Avenue including the LRT station, pedestrian connections to a renovated Surrey Central SkyTrain station and adjacent mixed use development. Surrey Central Exchange will be reconfigured as an on-street couplet, integrating the Exchange into the urban fabric. An off-street layover facility will minimize the impact of bus operations on the Civic Core, and facilitate the redevelopment of the North Surrey Centre site and adjacent parking lot.

Arterial and collector roads have been designed as "complete streets" to accommodate frequent transit service and improved pedestrian connections. Wayfinding, urban design and transit shelters will ensure that the transit trip is a natural extension of the walk trip.

The City will facilitate ridesharing options (including taxis) with the provision of regulated parking, and reduced parking requirements in new developments.

Parking Supply and Management

The following actions serve as the building blocks to efficiently maximize the management and use of on-street parking in City Centre:

- Ensure a mix and variety of on-street supply to support City Centre short stay, loading, unloading, daytime, nighttime, and weekend uses;
- Regulate on-street parking spaces to favor higher-priority uses and encourage turn over;
- Price parking and adjust rates as needed to maintain optimal utilization;
- Explore opportunities to utilize technology such as the MySurreyApp and vehicle guidance systems; and
- Develop an Electric Vehicle charging Policy that supports expanded workplace commercial fleet and public facility EV charging.

Area Specific Development Cost Charge for Strategic Property Acquisition

As noted, creation of a finer grid is fundamental to the success of City Centre. A new Area Specific DCC to fund strategic property acquisition is proposed that uses a levy on development in City Centre only. This removes the need for multiple consolidation and benefitting areas to be created. There are a number of key properties where full takes are needed to deliver local roads in the finer grained road network in City Centre, but they are unlikely to be dedicated through a normal rezoning process. This modest levy will be an Area Specific DCC as noted in the table in the Area Specific Development Cost Charge Section which equalizes the costs for providing the finer grained road network as it will benefit all development.

Hydro Infrastructure Undergrounding

The City Centre Plan promotes creating a beautiful City Centre with a high quality street environment. To achieve this higher level of urban design in City Centre, all utilities are located underground. To equitably fund this work, the City will introduce an amenity charge which is discussed further under the Infrastructure Summary and Financial Analysis section.

10-Year Servicing Plan

Key roads and traffic signals critical to growth within the next 10 years are identified in the 2016-2025 10-Year Servicing Plan. A list of the Transportation projects currently included in the 10-year servicing plan is attached as Appendix “III”. Key improvements are located on the following corridors:

- 105A Avenue from Whalley Boulevard to 140 Street;
- Whalley Boulevard south to 96 Avenue and north to King George Boulevard;
- 140 Street from 100 Avenue to 105 Avenue; and
- 100 Avenue from King George Boulevard to 140 Street.

Future iterations of the 10-Year Servicing Plan are anticipated to include improvements to other corridors such as the connection of University Boulevard south of Old Yale Road and completion of the outer ring road which includes 132 Street, 140 Street and 112 Avenue.

Road Frontage Responsibilities

Within City Centre, arterial road frontage construction not identified in the 10-Year Servicing Plan is the responsibility of the abutting development. This is to ensure that streets are finished in conjunction with development, as higher densities will generate immediate walking and cycling trips.

Water

A phased water infrastructure upgrade and replacement strategy is recommended based on the anticipated development timeline and projected population growth. Upgrades will ultimately be driven by the pace of development in the NCP area.

The proposed servicing plan utilizes water from the Whalley Pump Station to meet the increasing water demands in City Centre. The approach will employ a feeder main that directly connects the Whalley Pump Station to the 135 m Kennedy pressure zone, along with upgrades to the Whalley Pump Station and Whalley Booster Station. Additional bulk water supply for the area will be provided by construction of Metro Vancouver's Fleetwood Reservoir by 2023. A boundary shift between the Kennedy and Whalley pressure zones is also recommended to address low water pressure issues that could occur during peak water demand periods.

Watermains throughout the City Centre will ultimately be upgraded to a minimum 250mm diameter size when the water mains reach the end of their useable life or as development proceeds. In addition, the City will require that all watermains be looped within City Centre.

All of the water system improvements required to support the full development of the City Centre NCP area are illustrated in the map attached as Appendix "IV".

Sanitary Sewer

Future residents, businesses and institutions in City Centre will be serviced by a complete and robust sanitary sewer network that effectively captures and conveys wastewater. A phased sanitary infrastructure upgrade and replacement strategy is recommended based on the anticipated development timeline and projected population growth. Upgrades will ultimately be driven by the pace of development in the NCP area.

Several diversions are also proposed to optimize the capacity of the existing sanitary sewer system, delay some sewer replacements and minimize the total cost of upgrades required to support future development. Sewer diversions are proposed at the following locations:

- 132 Street and 104 Avenue;
- Hilton Road and 136 Street; and
- 100 Avenue and 138A Street.

The capacity of the Quibble Creek sanitary pump station will be increased in the short term with the addition of a fourth pump; twinning of the existing forcemain from the pump station to the north catchment will be required in the longer-term.

All of the sanitary sewer system improvements required to support the full development of the City Centre NCP area are illustrated in the map attached as Appendix "V".

Stormwater

City Centre will be a model for sustainable stormwater management in Surrey. Developments utilize a variety of onsite stormwater best management practices (BMP) that strive to mimic the natural hydrologic cycle, allowing peak flows and volumes to be controlled while supplying groundwater recharge and adequate base flows to receiving watercourses. Water quality treatment is provided so runoff can have a beneficial impact on the surrounding environment.

The City has constructed most of the stormwater infrastructure works necessary to address the 100-year return period event in City Centre. To mimic the natural rainfall-runoff response of the area prior to development, as well as protect downstream properties, infrastructure, and natural resources, the following BMP strategy is recommended:

- Onsite BMPs to address runoff volume and flow control;
- Water treatment facilities to remove pollutants from stormwater runoff before discharging into Quibble and Bolivar Creeks; and
- No further encroachment by development on riparian areas.

Developers will be required to include BMPs in their site development plans to ensure early incorporation of the works into the site design.

Flow and volume control BMPs should use infiltration techniques wherever possible; where infiltration is not possible, evapotranspiration techniques can be used. Sites will be required to implement detention facilities if infiltration and evapotranspiration techniques are not feasible.

All of the stormwater system improvements required to support the full development of the City Centre NCP area are illustrated in the map attached as Appendix "VI".

District Energy

District Energy (DE) systems produce hot water at centralized facilities and then distribute the hot water, by way of a dedicated pipe system, to heat buildings and heat domestic hot water in a defined neighbourhood, or "district". Surrey City Energy (SCE) is a City-owned DE utility that supplies all high-density residential, commercial and institutional buildings in City Centre with heat and hot water.

SCE follows a cost of service rate setting methodology that ensures that all costs associated with owning and operating the utility are recovered through customer rates. By leveraging synergies with other City services as well as the City's low cost of capital, SCE is able to deliver community-scale emissions reductions, long-term energy resilience and price stability to all customers at competitive rates without placing an economic burden on the community.

Unlike buildings heated by conventional building-scale heating systems, customers of SCE pay a rate for end-use heat that encompasses the costs of long-term operations, maintenance and infrastructure replacement. Accordingly, decisions on heating infrastructure investments are made by SCE based on efficiency, environmental performance and lifecycle cost.

Infrastructure Summary and Financial Analysis

The development of the City Centre has been underway for a number of years and the full development of the City Centre is expected to take many more years.

Sewer, water and stormwater infrastructure improvements needed to support the development of the City Centre for the next 10-years are included the current version of the 10-Year (2016-2025) Servicing Plan and the expected development cost charge (DCC) revenue from development in the City Centre area is sufficient to fund these improvements.

All of the transportation improvements to support the development of the City Centre for the next 10-years, excluding property acquisition to achieve the finer grained road network, are included the in the 10-Year (2016-2025) Servicing Plan. The expected DCC revenue from development in the City Centre area is sufficient to fund these improvements, excluding property acquisition to achieve the finer grained road network.

Strategic Property Acquisition and External Utility Undergrounding Amenity Charge

In order to achieve the finer grained road network, a number of key properties need to be acquired. It is unlikely that these key properties will be dedicated to the City through a normal rezoning process. The estimated cost to acquire these properties is $60 million. The cost of these acquisitions is not included in the in the 10-Year (2016-2025) Servicing Plan.

As part of the higher level of urban design in City Centre, all utilities will be located underground. These utilities include electrical, telephone, cable and internet. However, under the existing *Surrey Subdivision and Development By-law, 1986, No. 8830,* some properties will be burdened with the undergrounding of private utility on two frontages while some have no underground requirements at all. The estimated cost to underground all private utility infrastructure in the City Centre is $86.2 million, with the majority of these costs being related to the underground of BC Hydro utility infrastructure.

In an effort to acquire all of the key properties to achieve the finer grained road network and to distribute the cost of undergrounding BC Hydro infrastructure across all new developments in the City Centre, it is recommended that:

- A new area specific DCC charge be established for the City Centre NCP area to fund the acquisition of key properties to achieve the finer grained road network; and
- A new amenity charge be established for the City Centre NCP area to fund the undergrounding BC Hydro infrastructure and that this charge be collected on all properties at an equal rate per square foot of building area. The estimated cost of this amenity charge is $1.66 per square foot of building area.

Community Amenity Contribution

Amenity Contributions are being brought forward in the accompanying Planning Report. In accordance with City policy to address the amenity needs of the proposed new residents in Plan Areas, all development proposals at the time of rezoning or building permit issuance will be required to make a monetary contribution toward the provision of police, fire protection and library services and toward the development of the parks, open spaces and pathways.

Area Specific Development Cost Charge

The use of an area specific DCC is not new in the City. They have been used in other NCP areas (Anniedale-Tynehead, Highway 99 Corridor, Campbell Heights and West Clayton) to assist in funding the costs of new infrastructure where the DCC revenues on their own are not sufficient to fund the necessary infrastructure.

The following table provides an estimate of the area specific DCC rate that would be required to fully fund the acquisition of the finer grid network in the City Centre NCP area. These rates were developed in accordance with guidelines contained in the DCC Best Practices Guide as published by the Ministry of Community, Sport and Cultural Development.

Land Use	**Proposed City Centre Area Specific DCC Rate for Strategic Property Acquisition (per sq. ft.)**
Townhouse RM-10, RM-15, RM=23, RM-30, RC (Type III)	$2.83
Low Rise Apartment RM-45, RM-70	$2.62
High Rise Apartment RM-135, RMC-135, RMC-150	$2.09
Commercial - Ground floor	$2.79
Commercial - All other floors	$1.76

The following table provides an estimate of the total DCC rate that would applicable to developments in the City Centre.

Land Use	**Existing City Wide DCC Rate (per sq.ft.)**	**Existing City Centre DCC Rate (per sq.ft.)**	**Proposed Additional DCC Rate for Strategic Property Acquisition in the City Centre (per sq. ft.)**	**Proposed City Centre DCC Rate (per sq. ft.)**
Townhouse RM-10, RM-15, RM=23, RM-30, RC (Type III)	$17.06	$17.06	$2.83	$19.89
Low Rise Apartment RM-45, RM-70	$19.02	$14.20	$2.62	$16.82
High Rise Apartment RM-135, RMC-135, RMC-150	$18.74	$12.38	$2.09	$14.47
Commercial - Ground floor	$9.92	$9.92	$2.79	$12.71
Commercial - All other floors	$5.62	$5.62	$1.76	$7.38

In 2016, the City introduced new DCC rates. As part of this process, rate increases were also projected for 2017 and 2018. In addition to the additional DCC rate for development in the City Centre, staff are working to bring forward the proposed 2017 rate adjustments to Council for their consideration in February 2017 following completion of the public consultation process in January 2017.

Consultation

Staff held two joint meetings with 33 representatives from the Development Advisory Committee and Urban Development Institute. At the first meeting on June 28th, 2016, staff presented the recommended servicing strategy and the need to establish a Strategic Property Acquisition and Hydro Undergrounding Amenity Charge. On September 19th, 2016, staff subsequently presented the proposed Strategic Property Acquisition and Hydro Undergrounding Amenity Charge.

The development community has indicated their support for the proposed Strategic Property Acquisition and Hydro Undergrounding Amenity Charge.

SUSTAINABILITY CONSIDERATIONS

The City Centre Plan outlines a vision for City Centre that aligns with Surrey's Sustainability Charter 2.0 vision for a thriving, green, inclusive city, as well as numerous Desired Outcomes and Strategic Directions across all themes:

- Inclusion;
- Built Environment and Neighborhoods;
- Public Safety;
- Economic Prosperity and Livelihoods;
- Ecosystems;
- Education and Culture;
- Health and Wellness; and
- Infrastructure.

Specifically, for the Infrastructure theme the plan supports the following Desired Outcomes listed in the Charter:

- DO8: Neighbourhood-scale district energy systems provide low-carbon energy in dense urban neighborhoods;
- DO11: An integrated and multi-modal transportation network offers affordable, convenient, accessible and safe transportation choices within the community and to regional destinations; and
- DO12: Surrey residents of all ages and ability have access to active transportation options, enabling them to participate fully in society without the use of a private automobile.

CONCLUSION

The strategies articulated in this report will support the land uses and related development as proposed in the City Centre Plan. The financial strategy as proposed is consistent with the "development-pay" principle, which requires that each NCP area be financially self-sufficient.

Based on the above discussion, the Engineering Department recommends that Council:

- Approve the engineering servicing strategy and the related financial strategy as documented in this report and as contained in the City Centre Plan as a means of managing the provision of engineering services for development in City Centre;

- Approve the City Centre Road Classification Map as illustrated in Appendix “I” and reflect these changes by amending Schedule D “Surrey Road Classification Map (R91)” to the Surrey Subdivision & Development By-law, 1986, No. 8830;

- Approve the City Centre Major Road Allowance Map as illustrated in Appendix “II” and reflect these changes by amending Schedule K “Surrey Major Road Allowance Map” to the Surrey Subdivision & Development By-law, 1986, No. 8830; and

- Authorize the City Clerk to introduce the necessary amending bylaw for the required readings.

Fraser Smith, P.Eng., MBA
General Manager, Engineering

FS/JA/JB/DM/DB/SW/ras/cc

Appendix “I” - City Centre Road Classification Map
Appendix “II” - City Centre Major Road Allowance Map
Appendix “III” - 10-Year Plan of Transportation Projects within City Centre
Appendix “IV” - Water Servicing Strategy
Appendix “V” - Sanitary Servicing Strategy
Appendix “VI” - Stormwater Servicing Strategy

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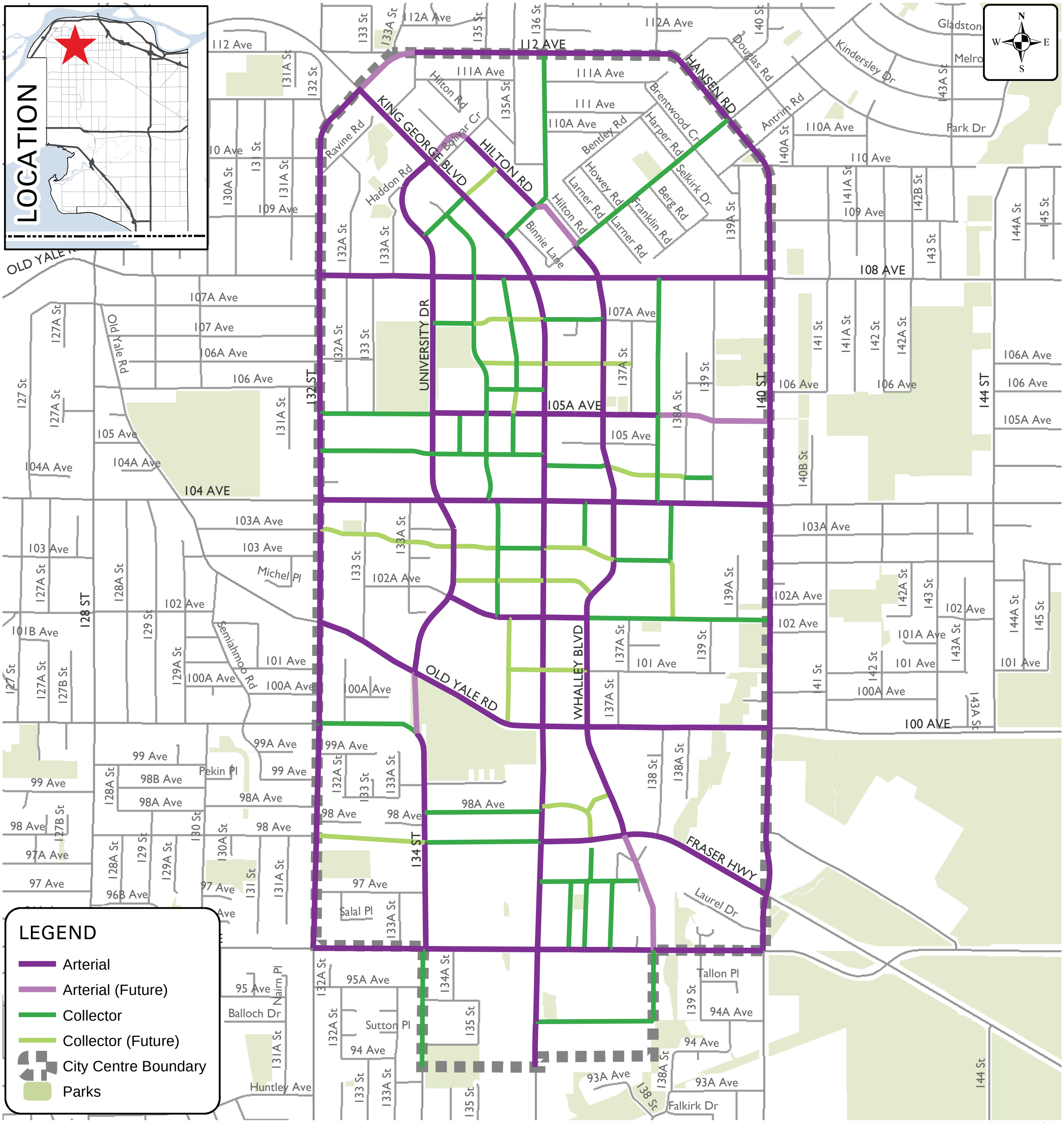
APPENDIX "I"



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City Centre Road Classification Map

ENGINEERING DEPARTMENT

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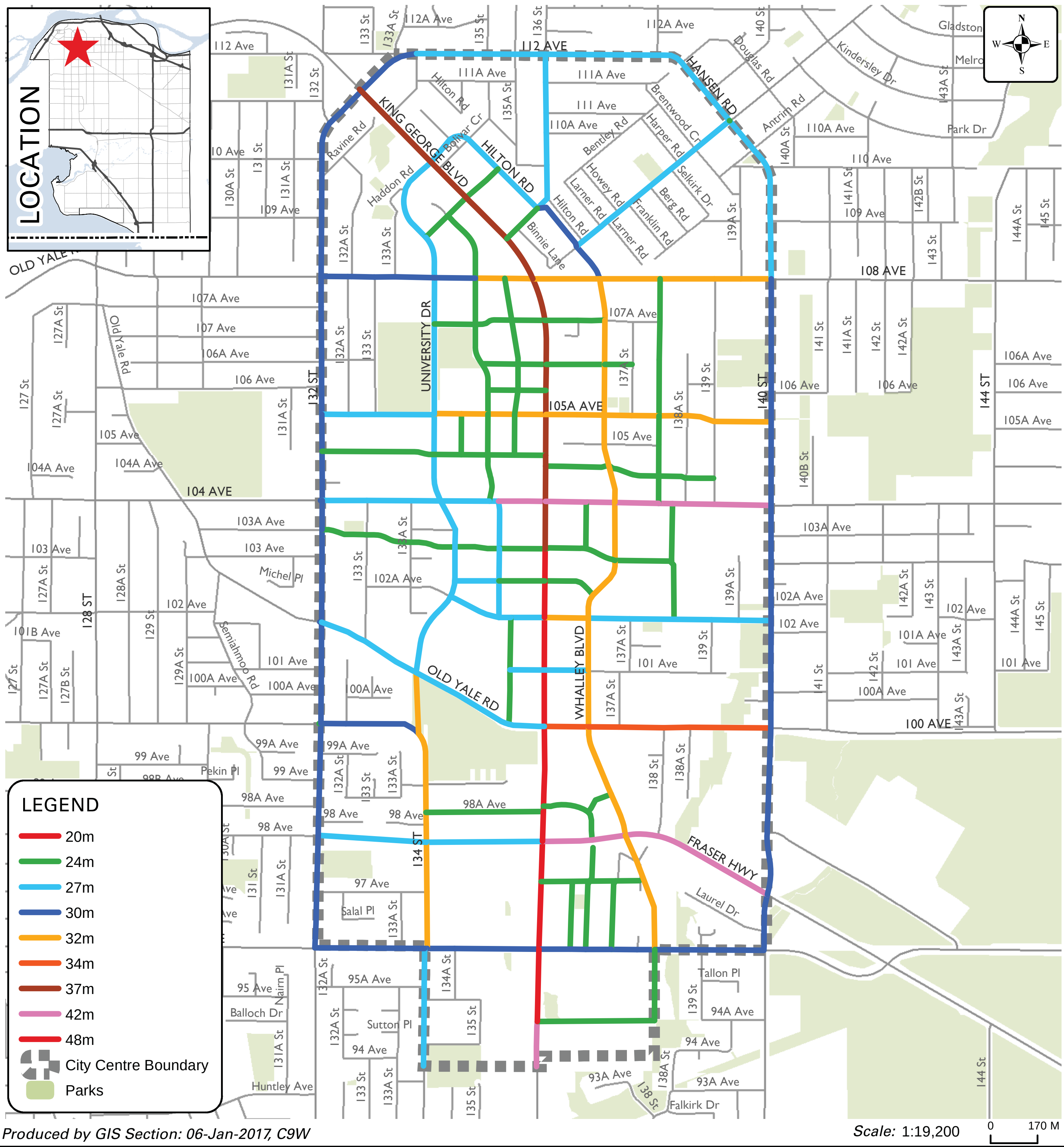
APPENDIX "II"



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City Centre Major Road Allowance Map

ENGINEERING DEPARTMENT

Source:
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APPENDIX “III”

10-Year Plan of Transportation Projects Within City Centre		
Project	**Location**	**Timing**
Arterial Strategic Missing Links		
Whalley Boulevard	96 Avenue to Fraser Highway	Short Term
105A Avenue	137 Street (Whalley Blvd) to 140 Street	Medium Term
Arterial Widening		
Fraser Highway	138 Street – 96 Avenue	Short Term
100 Avenue	King George Boulevard to 140 Street	Short Term
140 Street	100 Avenue to 104 Avenue	Medium Term
Collector Road Completion		
103 Avenue (widening)	City Parkway – King George Boulevard	Long Term
City Parkway (widening)	104 Avenue to 105A Avenue	Medium Term
103 Avenue (new)	132 Street – 133 Street	Short Term
New Traffic Signals		
108 Avenue / City Parkway		Short Term
100 Avenue / 138 Street		Short Term
105A Avenue / 140 Street		Medium Term
103 Avenue / City Parkway		Long Term

APPENDIX "IV"

PART 8 WATER INFRASTRUCTURE

8 Water Infrastructure

The City of Surrey has updated their City Centre Plan, which predicts a dramatic increase in population that will place additional demands on the existing water transmission and distribution infrastructure, and will ultimately exceed the capacity of some existing pipelines. This study estimates water demands for five scenarios and identifies water infrastructure upgrades that will be required to support development. These scenario horizons are:

- Existing (based on Year 2013);
- Year 2023;
- Year 2033;
- Year 2043; and
- Build Out (Year 2083).

The City Centre study area includes approximately 550 hectares (Ha) of land and is generally bound by 132nd Street to the west, 140th Street to the east, 112th Avenue to the north and 96th Avenue to the south. The current City Centre Plan that reflects full build out conditions is shown in ***Figure 8.1.***

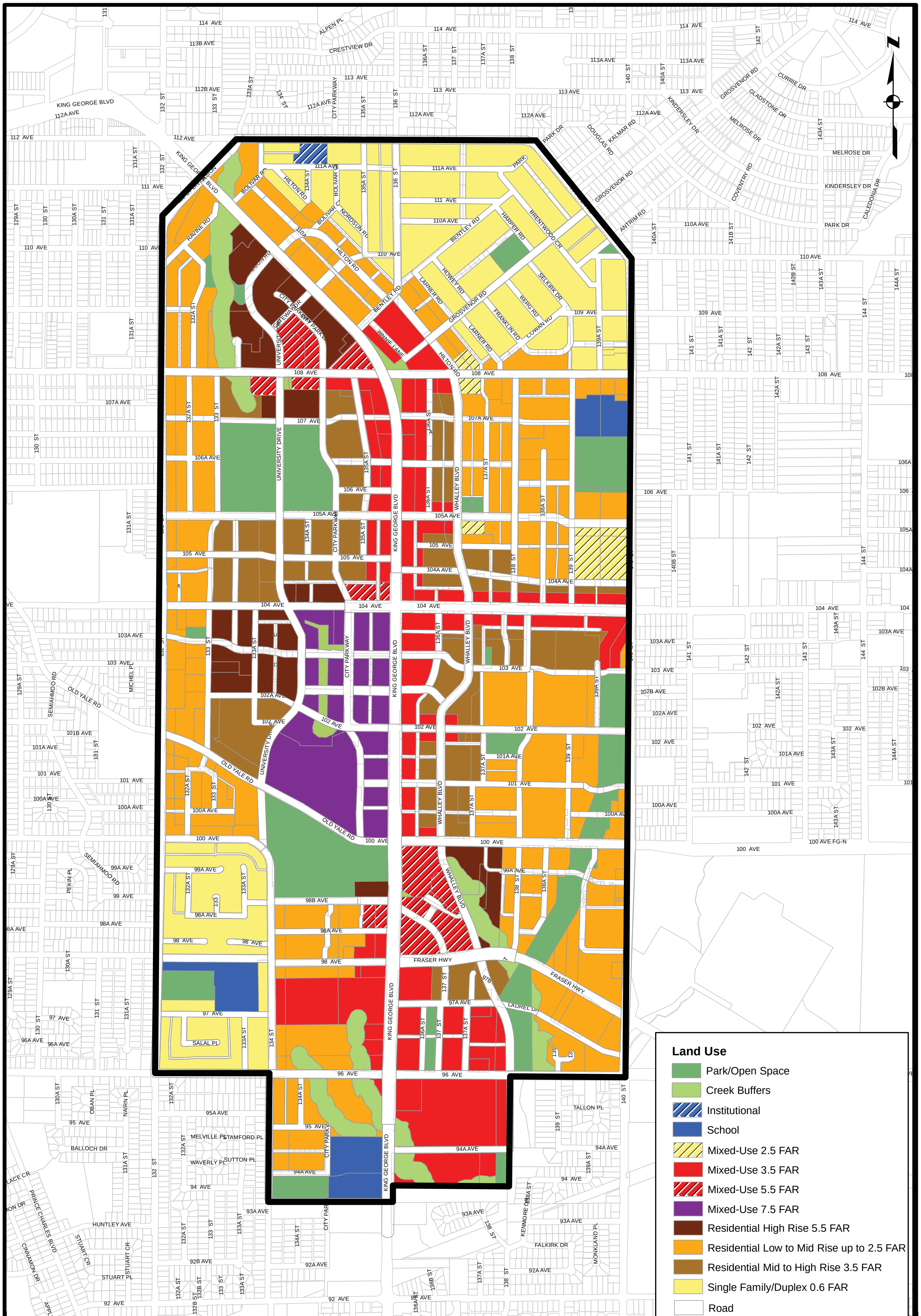
The City Centre area straddles the pressure zone boundary that separates the 135 m HGL Kennedy pressure zone from the 155 m HGL Whalley pressure zone. The 135 m HGL Kennedy pressure zone is generally served by the Kennedy pump station while the 155 m Whalley pressure zone is generally served by the Whalley pump station and the Whalley booster station.

The North Surrey hydraulic water model was utilized to identify existing and future hydraulic deficiencies and identify solutions to those deficiencies. We have assumed that the North Surrey hydraulic water model is calibrated appropriately for use in the current project. We assume that future water demands external to City Centre are based on the best planning information available and is a suitable representation of water demands outside of City Centre. Information for all future scenarios outside the City Centre was obtained from the *Model Development Summary* by Kerr Wood Leidal.

Key Objectives

This report was developed to address the following key objectives:

- Identify water demands for the Existing, 2023, 2033, 2043, and Build-Out planning horizons; and
- Develop phased servicing strategies that meet the water demand requirements for each of the five planning horizons.



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City Centre Plan 2013 Update
Utility Servicing Strategy

Project No.	Date
60278179	August 2013

Legend

City Centre Boundary

AECOM

200 100 0 200 Meters

City Centre Plan
(Build-Out)

FIGURE 8.1

Terms and Definitions

Table 8.1 provides a summary of key terms (with abbreviations) and definitions used throughout this report.

Table 8.1 Key Terms and Definitions

Key Term (and Abbreviation)	Definition
Average Daily Demand (ADD)	Annual water demand from all sources averaged to a single day.
Base Demand (BDD)	That part of water demand that is relatively unaffected by season or weather. Base Demand is largely indoor residential and ICI water use.
Diurnal Pattern	Pattern describing the variance in water-use over an entire day.
Fire Underwriters Survey (FUS)	Standard criteria developed by the Insurance Industry to evaluate fire services, including minimum fire flow and fire storage requirements.
Headloss	The head, pressure or energy (they are the same) lost by water flowing through a pipe, bend/deflection, valve, etc. as a result of friction.
Hydraulic Grade Line (HGL)	The surface or profile of water flowing. The level water would rise to in a small vertical tube connected to the pipe. (HGL = elevation + pressure).
IC	Institutional and Commercial, generally concerning water use sector and demand
WaterCAD	Computer software used to develop a model of the water distribution system and analyze flow and pressure hydraulics
North Surrey Hydraulic Model	North Surrey water model developed by Kerr Wood Leidal Associates (2004) and updated in 2008 by AECOM
Leakage ("water loss")	Water lost from the system through cracks in watermains, unseated valves, misaligned joints, reservoir cracks, overflows. (occurs on City watermains and on private services)
Million Litres (ML)	1 ML/day refers to 1 million litres of water per day
Maximum Day Demand (MDD)	Highest daily water usage over the entire year.
Peak Hour Demand (PHD)	Highest water usage for any given 1-hour period, over an entire year.
Pressure Reducing Valve (PRV)	A control valve that automatically reduces the inlet pressure in a watermain to a set downstream pressure.
Pressure Zone (PZ)	A water service area in which all the users have the same static HGL. Water cannot flow from one PZ to another without passing through a PRV or another control valve. PZ's are often isolated through the use of closed zone valves.
Seasonal Demand	That element of water demand that is impacted by season or weather. The largest part of seasonal demand is residential irrigation in the summer months.
Unit Conversions	
Pressure Psi to "m" or "kPa"	1.0psi = 0.70m = 7.0kpa (so 100psi = 70m = 700 kPa)
Volume Litres to gallons	3.79 Litres = 1.0 US gallon and 4.54 Litres = 1.0 Imp. gallon
HGL Geodetic to GVRD	0.0m Geodetic = GVRD Datum of 91.37 ft
Flow Rate L/s to gpm	1.0 L/s = 15.9 USgpm = 13.2 Imp. gpm

8.0 Existing & Future Servicing Catchments & Details

Existing studies and information utilized in the development of this report included:

- City Centre Plan;
- City of Surrey geodatabase;
- GIS shape files of City water distribution system, pressure zone boundaries, and pump stations;
- City of Surrey, 2004 Model Development Summary, Kerr Wood Leidal;
- City of Surrey, 2007 North Surrey Pump Station Study, Kerr Wood Leidal;
- City of Surrey, "Various Water System Modelling Assignments within the ALR and North and South Surrey" project in 2008 by AECOM (formerly Earth Tech);
- City of Surrey, "Surrey City Centre Water Servicing Strategy" project in 2014 by AECOM
- North Surrey WaterCAD Version 8.0 hydraulic model;
- Legal parcels and water supply network (GIS shapefile format);
- City of Surrey Design Criteria Manual 2004;
- GIS data for the water distribution system (i.e. pressure zones, PRVs, pipe networks, etc.); and
- Topographic information.

8.0.1 Equivalent Population Generation

Based on population projections provided by the City for the land use shown in ***Figure 8.1***, City Centre is expected to grow dramatically in the near future. This section identifies future populations as well as equivalent populations generated to determine water demands. ***Table 8.2*** below is a population summary for the various design horizons included in the Plan. These populations were developed specifically for predicting future water demands in City Centre and are not intended for other uses. It is important to note that there is no predicted industrial component in City Centre and therefore only institutional and commercial (IC) equivalent populations are generated.

For the existing Simon Fraser University (SFU), there are no residents living in this facility and only students and teachers are present. As such, the SFU equivalent population has already been accounted for in the 7.5 FAR where future residential units and apartments may be built.

Table 8.2 Summary of Water Populations Per Horizon Year

Horizon Year	Residential Population	Commercial Equivalent Population	Institutional Equivalent Population	Total Equivalent Population
Existing	33,812	23,585	2,754	**60,151**
2023	52,442	33,064	3,322	**88,828**
2033	71,858	42,543	3,904	**118,305**
2043	92,106	52,022	3,998	**148,126**
Build Out	160,599	89,937	4,601	**255,137**

Further details as to how these populations were generated are provided in ***Appendix B***.

8.0.2 Water Demand Unit Rates

Water demands generated in the North Surrey Hydraulic Water Model are divided into two basic categories:

1. **Base Demand Unit Rate:** Base demand (also called non-seasonal demand) is predominantly indoor water use that occurs on a daily basis regardless of season. This demand is sensitive to population and is represented on a per capita basis.

   The per capita demand utilized in this study for the calculation of base demand is **320 litres/capita/day (L/c/d)** resulting from an analysis of metered residential demands during the winter months, unmetered residential base demands, and an allowance for leakage (estimated at approximately 10%). This unit rate was developed as part of the 2005 KWL *Grandview Pump Station Pre-Design Report* and was utilized in the 2007 KWL *North Surrey Pump Station Study*. To calculate base demand for institutional land uses, the following unit rates were applied:

   - Schools = 45 (elementary) or 90 (secondary) L/c/d (Surrey Design Criteria);
   - Hospitals = 900 L/bed/d (Sewer Model, 2010 & MOH Standards, Health Act);
   - Retirement Homes = 650 L/bed/d (Sewer Model, 2010).

2. **Seasonal Demand Unit Rate:** The seasonal demand primarily represents outdoor irrigation that occurs during the summer months and is sensitive to irrigable area. In this study, Seasonal Demand is calculated on a unit area basis with future scenarios utilizing **0.39 litres/second/hectare (L/s/ha)** as the unit seasonal demand. This unit demand was developed as part of the 2004 water model development effort and is presented in the *2004 Water Model: Model Development* report by KWL.

It is important to separate the base demand representing indoor water use from the seasonal demands for irrigation. As City Centre develops, single family residential areas will be redeveloped into high density mid and high rise developments. High rise apartment dwellers have a lower per capita irrigation demand than single family home owners, due to the smaller amount of irrigable land per capita for the high rise dwellers. Therefore, estimating the irrigation demand based on population increase would over estimate MDD and PHD demands for high density development. This study bases seasonal demand on land area, which is related to irrigable area, and will provide a more accurate seasonal demand estimate for future scenarios.

It could be argued that mid and high rise developments often have built in water sprinkler systems and contract gardeners that maintain green space attached to these developments, therefore, irrigation for these developments is performed more regularly than a single family dwelling. We have assumed that differences in the ratio of irrigable area versus lot size between low density and high density development will be masked by the increase in more regular watering.

8.0.3 City Centre Base Day Demand (BDD)

All BDD scenarios were developed through multiplying the per capita BDD unit rate (320 L/c/d) by the residential, institutional, and commercial equivalent populations developed for each horizon.

8.0.4 City Centre Maximum Day Demand (MDD)

The MDD is the sum of the winter average BDD and the seasonal demand for all scenarios.

8.0.5 City Centre Peak Hour Demand (PHD)

PHD was calculated by combining the peak summer BDD and peak seasonal water demand. Peaking factors provided with the North Surrey Hydraulic Model were utilized for the existing scenario (1.33 for residential and 1.2 for commercial). All future scenarios utilize peaking factors developed from 2007 meter data from the Clayton area of Surrey. Peaking factors were developed for both the base and seasonal demands to better represent the difference between indoor water use and irrigation peaks. As City Centre population density increases, single family residential areas will be replaced with mid and high rise residential. Irrigation demands will be relatively independent of population for high density neighbourhoods and maintaining separate residential (base) and irrigation (seasonal) demands will provide a more accurate estimate of future PHD.

Base demand PHD peaking factors were further divided into residential and commercial water use sectors due to the significant differences in water use between these sectors. The Residential base demand peaking factor was estimated to be 1.7 using November 2007 bulk meter data from Clayton as a basis. For commercial and institutional land uses, the base demand peaking factor was estimated to be 1.2 based on previous studies completed for the Township of Langley and City of New Westminster.

A separate peaking factor of 2.1 was estimated for the seasonal demand based on August 2007 bulk meter data from Clayton. The seasonal demand peaks were assumed to be similar in both residential and IC land uses.

8.0.6 City Centre Fire Flow Demand (FF)

Fire flow demands are based on land use zoning. The City of Surrey Design Criteria Manual (2004) includes 52 separate zonings with five different fire flow values. For modelling purposes, the fire flow demands in the City of Surrey Engineering Department Design Criteria Manual (2004) is simplified to include three basic land uses in City Centre with three different fire flow values:

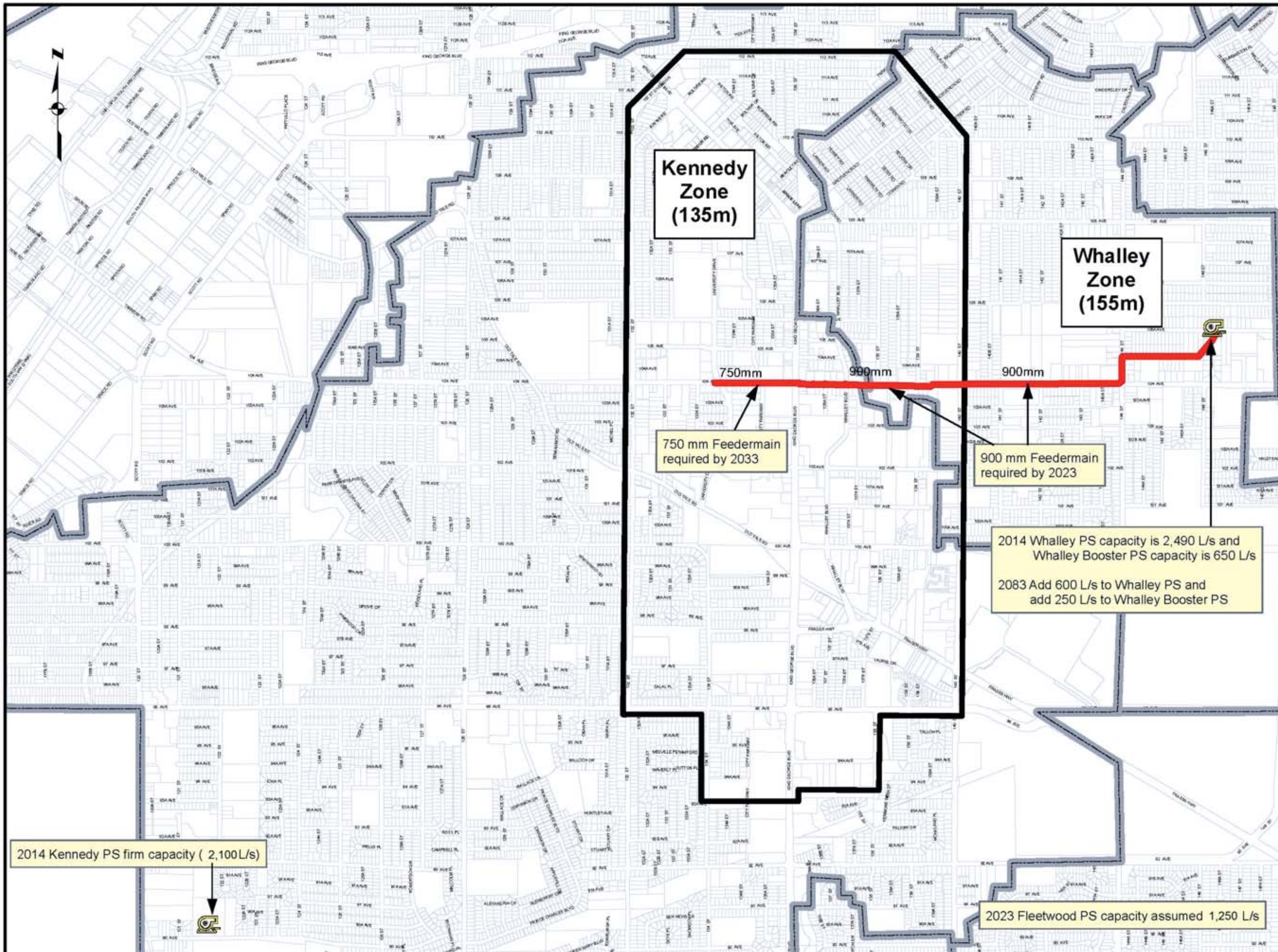
- Single Family Residential = 60 L/s;
- Multi-Family Residential = 200 L/s; and,
- Commercial and Institutional = 200 L/s.

This simplification will overestimate fire flow requirements for duplex residential, neighbourhood commercial and self-service gas station properties. However, there are few existing properties impacted by this simplification and future City Centre is largely dense commercial and residential development with higher fire flow requirements. Therefore, the impact of this simplification is marginal and does not impact the medium and long term infrastructure requirements in City Centre.

8.0.7 Water Demand Outside of City Centre

The North Surrey Hydraulic Model includes a large area that extends beyond the boundaries of City Centre. North Surrey includes 6 pressure zones (7 pressure sub-zones and 4 different HGLs) that cover 13,000 ha of land. City Centre represents 4% of the North Surrey land mass and has 7% of the North Surrey population. City Centre straddles the zone boundary between the Kennedy and Whalley pressure zones (as shown on ***Figure 8.2***) and includes 550 ha of land. As the City's well developed water network serves most of North Surrey, the ability of the water system to serve City Centre is heavily influenced by water demands of areas located outside City Centre.

The 2033 demand scenario in the North Surrey hydraulic model is considered the build out condition for areas external to City Centre. For the purposes of this study, we assumed that the existing and 2033 demands provided with the North Surrey Hydraulic Model are generally adequate for the areas outside of City Centre. A 2023 scenario was developed for the area external to City Centre through linear interpolation of the existing and 2033 demands. 2043 and 2083 horizons reflect the 2033 build out condition.



City Centre Plan 2013 Update
Utility Servicing Strategy

Legend

- Proposed Feedermains
- City Centre Boundary
- Pressure Zone Boundaries

AECOM

0 250 500 Meters

Project No.	Date
60278179	August 2014

Recommended Bulk Supply and Transmission Servicing Improvements for Build Out Condition

FIGURE 8.2

There are two facilities that were added to the North Surrey Hydraulic Model which were not in the original version:

- **RCMP E-Division:** The RCMP E-Division is expected to have approximately 3,200 employees at build out. For E-Division, we have utilized a conservative water demand of 320 L/employee/d.
- **Jim Pattison Outpatient Care & Surgery Centre:** The Jim Pattison Outpatient Care & Surgery Centre is expected to have a maximum of 2,300 patients on any given day up until 2043; this is expected to increase to 3,200 patients under build out conditions. The water demand for this facility was based on 650 L/patient/d.

Both of these facilities and their water demands have been applied to all scenarios.

8.0.8 Water Model Scenarios

Table 8.3 provides a summary of the model scenarios developed for this study.

Table 8.3 Model Scenarios

No.	Scenario	Child Scenario
1	Existing BDD	2013 MDD + Fire Flow 2013 PHD
2	2023 BDD	2023 MDD + Fire Flow 2023 PHD
3	2033 BDD	2033 MDD + Fire Flow 2033 PHD
4	2043 BDD	2043 MDD + Fire Flow 2043 PHD
5	Build Out BDD	2083 MDD + Fire Flow 2083 PHD

8.0.9 Methodology for Water Demand Generation

Based on the unit rates established, information provided by the City, as well as background models previously developed for the City Centre area, water demands were generated for the City Centre Plan. ***Table 8.4*** summarizes the methodology for water demand generation.

Table 8.4 Methodology for Water Demand Generation

Year Horizon	Base Day Demand	Seasonal Demand	Max Day Demand	Peaking Factor	Peak Hour Demand	Fire Flow
	BDD	Seasonal	MDD	PF	PHD	FF
Existing	Calculated by multiplying PE* with Base Demand**	Based on seasonal demand unit rate*** and area for each land use type.	Taken from "North Surrey Hydraulic Model" (KWL, 2004; Updated AECOM 2008)	Obtained from "North Surrey Pump Station Study" (KWL, 2007)	PF x BDD + Peak Seasonal Water Demand	Fire Flows based on zoning taken from the "City of Surrey Criteria Manual" (2004), simplified to use Single-Family Residential **[60 L/s]**, Multi-Family Residential **[200 L/s]**, and Commercial and Institutional **[200 L/s]**
2023	Calculated by multiplying PE* with Base Demand**	Based on seasonal demand unit rate*** and area for each land use type.	Linear interpolation between existing MDD & 2033 MDD	Obtained from 2007 meter data from the Clayton area. IC PF from TOL & City of New Westminster	PF x BDD + Peak Seasonal Water Demand	Fire Flows based on zoning taken from the "City of Surrey Criteria Manual" (2004), simplified to use Single-Family Residential **[60 L/s]**, Multi-Family Residential **[200 L/s]**, and Commercial and Institutional **[200 L/s]**
2033	Calculated by multiplying PE* with Base Demand**	Based on seasonal demand unit rate*** and area for each land use type. At year 2033, City Centre seasonal demand usage does not change after this horizon.	Predicted 2033 BDD combined with Seasonal Water Demand from "2004 Water model: Model Development Study" (KWL)	Obtained from 2007 meter data from the Clayton area. IC PF from TOL & City of New Westminster	PF x BDD + Peak Seasonal Water Demand	Fire Flows based on zoning taken from the "City of Surrey Criteria Manual" (2004), simplified to use Single-Family Residential **[60 L/s]**, Multi-Family Residential **[200 L/s]**, and Commercial and Institutional **[200 L/s]**
2043	Calculated by multiplying PE* with Base Demand**	Based on seasonal demand unit rate*** and area for each land use type. At year 2033, City Centre seasonal demand usage does not change after this horizon.	Predicted 2043 BDD combined with Seasonal Water Demand from "2004 Water model: Model Development Study" (KWL)	Obtained from 2007 meter data from the Clayton area. IC PF from TOL & City of New Westminster	PF x BDD + Peak Seasonal Water Demand	Fire Flows based on zoning taken from the "City of Surrey Criteria Manual" (2004), simplified to use Single-Family Residential **[60 L/s]**, Multi-Family Residential **[200 L/s]**, and Commercial and Institutional **[200 L/s]**
Build Out	Calculated by multiplying PE* with Base Demand**	Based on seasonal demand unit rate*** and area for each land use type. At year 2033, City Centre seasonal demand usage does not change after this horizon.	Predicted 2083 BDD combined with Seasonal Water Demand from "2004 Water model: Model Development Study" (KWL)	Obtained from 2007 meter data from the Clayton area. IC PF from TOL & City of New Westminster.	PF x BDD + Peak Seasonal Water Demand	Fire Flows based on zoning taken from the "City of Surrey Criteria Manual" (2004), simplified to use Single-Family Residential **[60 L/s]**, Multi-Family Residential **[200 L/s]**, and Commercial and Institutional **[200 L/s]**

* *PE = Population Equivalent*

** *Base demand unit rate = 320 L/c/d, North Surrey Pump Station Study (KWL, 2007)*

*** *Seasonal demand unit rate = 0.39 L/s/ha, 2004 Water Model: model Development Study (KWL, 2004)*

^ *Allowance for leakage = 10% of Base Demand*

8.1 Design Criteria and Analysis

8.1.1 Evaluation and Design Criteria

Evaluation and design criteria are based on the City of Surrey's Design Criteria Manual (May 2004). The following minimum pressure criteria were used for the assessment of the water system:

- Maximum Day Demand plus Fire Flow (MDD+FF) Condition – A minimum residual pressure of 14 m (20 psi) is required at all nodes in the system.
- Peak Hour Demand (PHD) Condition – A minimum pressure of 28 m (40 psi) is required at all nodes in the system.

For the watermain upgrades, the recommended long term infrastructure improvement scenario assumes that existing distribution system infrastructure within City Centre will be upgraded to a minimum 250mm diameter size when the watermains reach the end of their useable life or as development proceeds. In addition, the City also requires that all watermains be looped within City Centre.

The developer must provide adequate service as per the City's Design Criteria and all development is required to upgrade the frontage main to the minimum 250mm diameter size and connect to the feedermain. Developers may also be required to replace all associated watermains from the feedermain to the development site.

8.1.2 Existing Water Model

The North Surrey hydraulic model represents the pipe network serviced by the Kennedy, Whalley and Newton pump stations. This network supplies water to over 300,000 residents in North Surrey. The North Surrey water model was originally developed in 2004 by Kerr Wood Leidal Associates. The model was updated as part of the *Various Water System Modelling Assignments within the ALR and North and South Surrey* project in 2008 by AECOM (formerly Earth Tech).

Specific details about the existing pipe network and system demands can be found in the *North Surrey Pump Station Study* completed by Kerr Wood Leidal Associates Limited in June 2007. We have assumed that the hydraulic model provided by the City is calibrated and has adequate population distributions and demand allocations for associated scenarios for areas outside of City Centre.

8.1.3 Existing Water System Assessment

It is important to note that there are some areas within City Centre that do not currently meet the PHD pressure criteria of a minimum 40 psi. If City Centre grows as predicted, existing pressure issues may increase if no improvements are made to the system.

8.1.4 Demand Allocation

The future City Centre water demands were developed at the parcel level. Demands were assigned from the GIS parcels to the nearest pipe and model node utilizing GIS special allocation tools. Segregation of demands by land use at the node level was maintained to facilitate manipulation of demands with peaking factors and diurnal patterns specific to land use.

Fire flow demands were assigned based on land use and fire flow demands previously identified. For nodes that are adjacent to several different land use zonings (i.e. multi-family residential and commercial), the higher required fire flow governed and was assigned to the node.

8.1.5 Future Water Model Demands

Table 8.5 summarizes water demands utilized in the North Surrey Hydraulic Model for each horizon.

Table 8.5 North Surrey Model Demand Summary

Horizon Year	Demand	City Centre (L/s)	Outside City Centre (L/s)
Existing	BDD	222	1,040
	MDD	335	2,633
	PHD	624	4,353
2023	BDD	328	1,673
	MDD	468	3,985
	PHD	797	6,512
2033	BDD	436	2,208
	MDD	615	5,026
	PHD	1,019	8,170
2043	BDD	549	2,208
	MDD	727	5,026
	PHD	1,189	8,170
Build Out	BDD	945	2,214
	MDD	1,115	5,034
	PHD	1,762	8,182

8.1.6 Future Base Upgrades

The existing pipe network and pump station arrangement does not have capacity to support the projected future demand scenarios. Model runs identified large numbers of failed nodes in all of the Future PHD and Maximum Day plus Fire Flow (MDD+FF) scenarios. Without water system improvements the City will experience difficulty in meeting their peak hour and fire flow requirements.

All water model scenarios include the following zone boundary improvements.

Base Zone Boundary Improvements

The recommended adjustment to the boundary between the Kennedy (135m) and Whalley (155m) pressure zones, as reported in the *Whalley 155m Zone Extension* report, was included in all scenarios. The boundary shift into the Kennedy zone results in an increase in demand in the Whalley zone to address low water pressure concerns near the zone boundary during periods of peak water demands.

8.1.7 Future Fleetwood Reservoir

The future Fleetwood Reservoir being constructed by Metro Vancouver will provide a source of water supply to part of the 135m zone, thereby freeing up capacity at the Whalley Station for City Centre. The reservoir is planned to be in operation before the year 2023. For this analysis it is assumed that the future Fleetwood Reservoir and the existing Fleetwood Pump Station with the installed capacity of 1,250L/s at 135m HGL will be capable of meeting the demand in 2023. Further upgrades of Fleetwood Pump Station and the network in Fleetwood would be required after 2023, and the costs will be covered by City wide DCCs which are not assessed in this report.

8.2 Recommended Improvements and Costs

8.2.1 Bulk Supply and Feedermain Improvements

A summary of the demands for the Whalley (155m) and Kennedy (135m) zones in City Centre is provided below in ***Table 8.6***.

Table 8.6 Peak Hour Demand Summary by Zone

Horizon	Whalley (155m) Zone in City Centre (L/s)	Whalley (155m) Zone Total (L/s)	Kennedy (135m) Zone in City Centre (L/s)	Kennedy (135m) Zone Total (L/s)
Existing	217	374	406	1,080
2023	294	482	524	1,322
2033	337	574	688	1,694
2043	386	623	806	1,814
Build Out	527	763	1,247	2,259

*Note: City Centre zone demand include periphery nodes such that sum does not equal values in **Table 8.5***

To service the increase in water use leading up to the build out condition, the water servicing plan outlined in this Section, includes upgrades to infrastructure located both inside and outside the City Centre Plan boundaries. Recommendations for servicing are based on a 2023 in service date for the future MV Fleetwood Reservoir and changes to the Kennedy/Whalley pressure zone boundaries.

Table 8.7 Recommended Upgrades – Bulk Supply and Feedermains

Horizon Year	Major Infrastructure Upgrades	Estimated Cost
2023	Replace existing 600mm and 750mm diameter watermain with 2,312m of 900mm diameter ductile iron feedermain from the Whalley Pump Station, along 104 Avenue to King George Boulevard.	$6,936,000
2033	Install 365m of 750mm dia. ductile iron feedermain, extending from the 900 mm feedermain at King George Boulevard and 104 Avenue, along 104 Avenue to University Drive.	$876,000
2043	None	$0
Build Out	Upgrade Whalley PS to its firm capacity of 3,020 L/s with one additional 600 L/s pump	$750,000
	Upgrade Whalley Booster PS to its firm capacity of 900 L/s with one additional 250 L/s pump	$500,000
	TOTAL	$9,062,000

The proposed system utilizes water from the Whalley Pump Station to meet the increasing water demands in City Centre. This system employs a feedermain that directly connects the Whalley Pump Station to the Kennedy 135 m HGL pressure zone, and requires Whalley Main and Whalley Booster pump stations to be upgraded. The recommended upgrades are graphically presented in ***Figure 8.2***.

8.2.2 Distribution and Major Grid Main Capacity Improvements

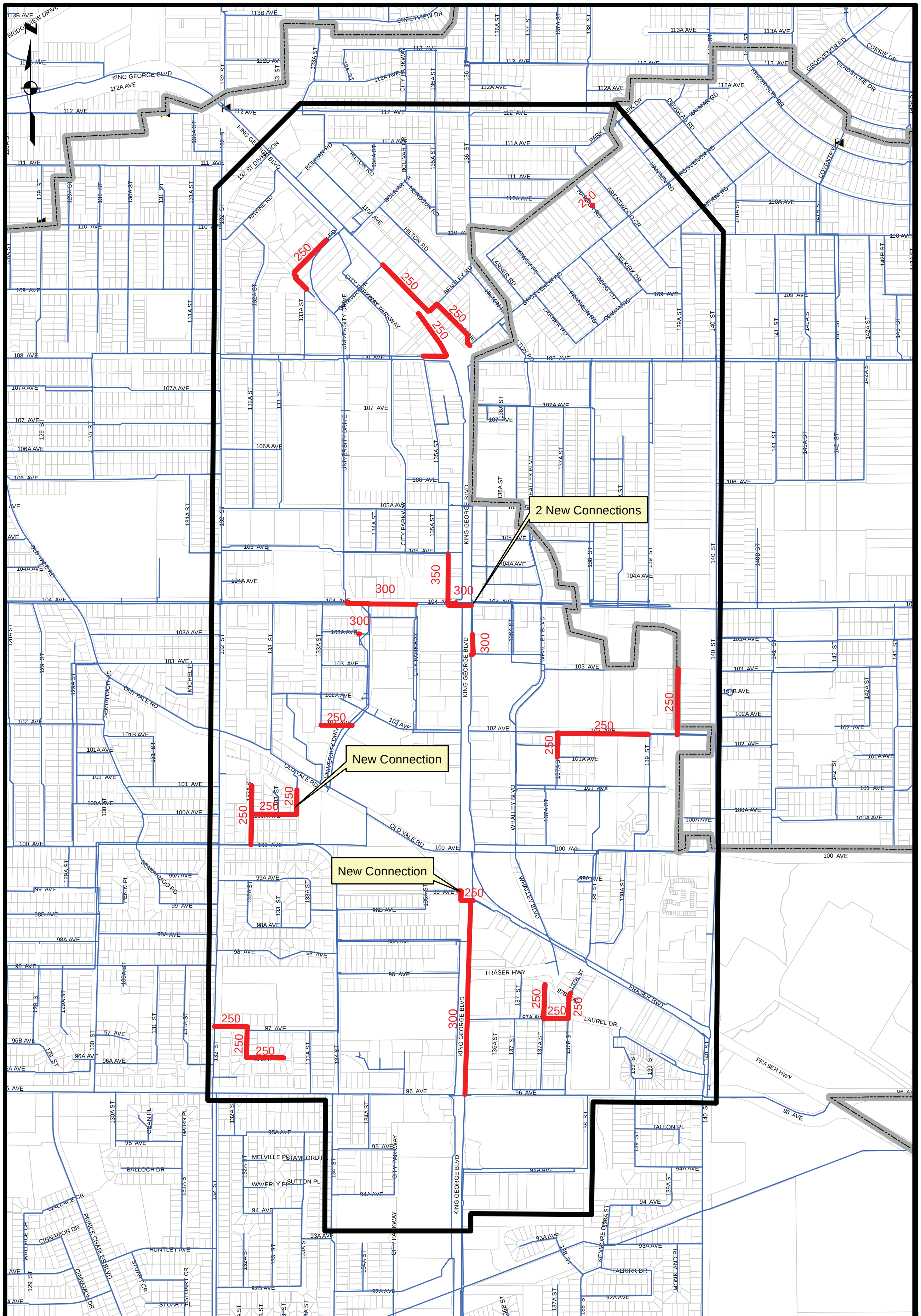
Pipe capacity driven network improvements are required for servicing the City Centre. The capacity based improvement plan assumes that existing distribution mains that reach the end of their useful life are replaced by 250 mm diameter watermains as part of the City's ageing infrastructure replacement program. *Only distribution mains that require capacity improvements prior to their ageing infrastructure replacement date are included in the capacity improvement program*. Current City policy is to contribute to increases in pipe size after the Developer has paid for the size of main they need for the development. All upsizing costs are paid with DCCs. ***Table 8.8*** summarizes the cost for upgrades to the water network.

Table 8.8 Summary of Distribution and Major Grid Main Capacity Upgrades

Upgrade Year	# of Pipes	Total Length (m)	Total Cost	DCC Eligible
Existing	26	2,960	$3,140,300	$71,150
2023	-	-	-	-
2033	-	-	-	-
2043	-	-	-	-
Build Out	15	768	$856,500	$185,550
Totals	**49**	**3,728**	**$3,996,800**	**$256,700**

The minimum pipe diameter for a City Centre pipeline is 250 mm as per the City's Standard. A summary of all the distribution network capacity upgrades is provided in ***Appendix B*** along with a summary of the major system and DCC-eligible upgrades.

As shown in ***Table 8.8***, the water model predicts that upgrades to distribution and major grid mains are required for both the existing and build out condition as properties within the service area become more densely developed. ***Figure 8.3*** shows approximately 3.6 km of capacity related upgrades that are capacity driven based on fire flow requirements. There are four new connections added to increase the water distribution network redundancy and looping. ***Figure 8.4*** shows 768m of replacement watermain required due to PHD and MDD+FF capacity concerns predicted for the build out condition.



City Centre Plan 2013 Update
Utility Servicing Strategy

Project No.	Date
60278179	August 2013

Legend

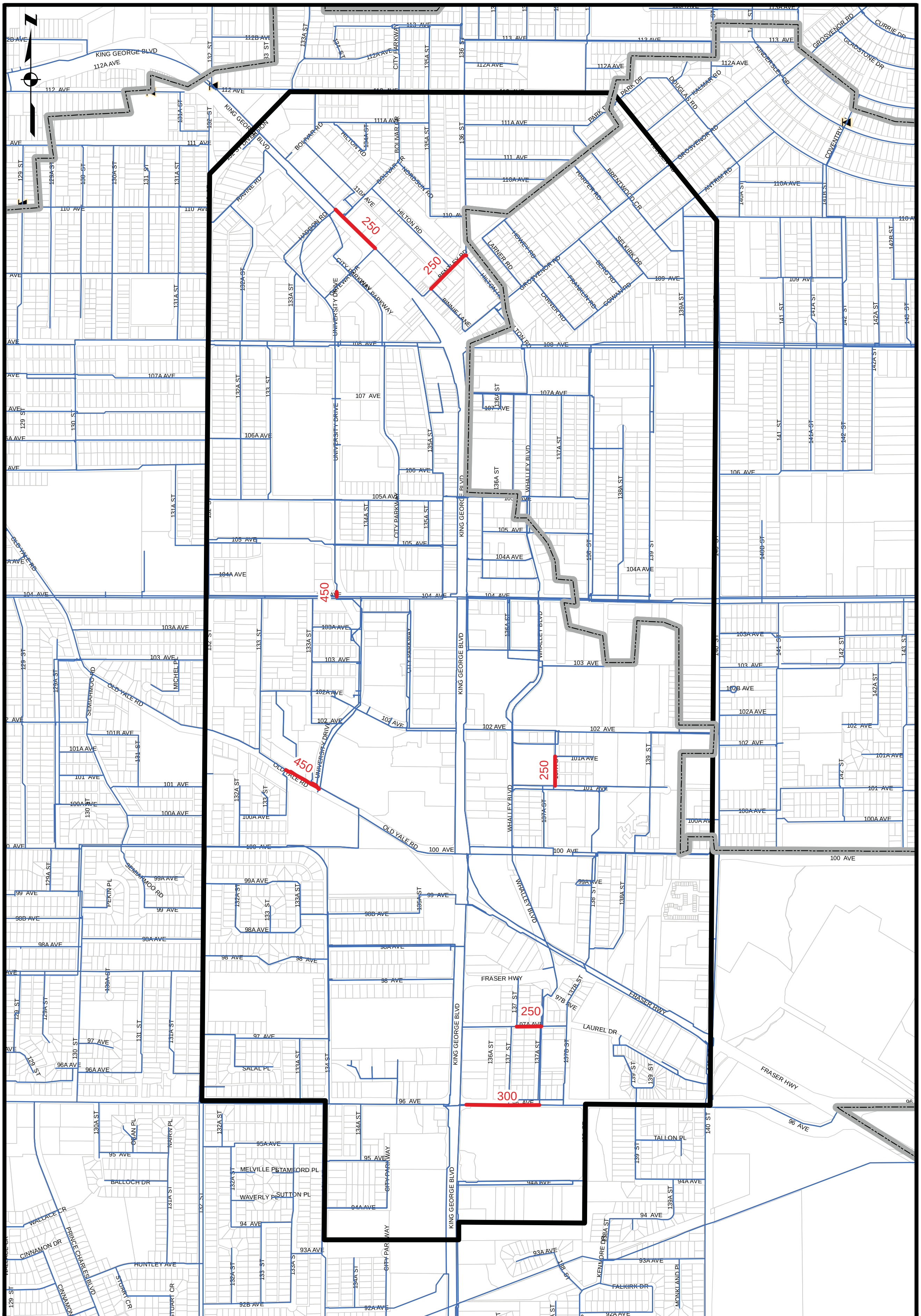
- Capacity Based Upgrades for Existing Land-Use
- City Centre Boundary
- Pressure Zone Boundaries
- Existing Pipes

AECOM

200 100 0 200 Meters

2013 Recommended
Capacity Upgrades

FIGURE 8.3



City Centre Plan 2013 Update
Utility Servicing Strategy

Project No. 60278179

Date August 2013

Legend

- City Centre Required Capacity Based Upgrades
- Pressure Zone Boundaries
- City Centre Boundary
- Existing Pipes

AECOM

200 100 0 200 Meters

2083 (Build Out) Recommended Capacity Upgrades

FIGURE 8.4

8.2.3 PHD and MDD+FF Results

Peak hour demand (PHD) pressures and velocities as well as maximum day demand plus fire flow (MDD+FF) pressures are shown for each horizon in ***Figures 8.5 to 8.14***, and are further explained below.

Existing Horizon
Results for the PHD and MDD+FF model runs are shown in ***Figures 8.5 and 8.6*** respectively. The residential area near 132 Street and 100 Avenue marginally meets the peak hour pressure requirement of 40psi. This is due to the local high elevation relative to the rest of the Kennedy 135 m HGL pressure zone. Fire flow requirements were not met at 12 locations within City Centre. The fire flow requirements at these locations could be met by upgrading all mains to the minimum City Centre size of 250mm diameter.

2023 Horizon
Results for the PHD and MDD+FF model runs are shown in ***Figures 8.7 and 8.8*** respectively. The residential area near 132 St and 100 Avenue marginally meets the peak hour pressure requirement of 40 psi. This is due to the local high elevation relative to the rest of the Kennedy 135 m HGL pressure zone. This observation applies to each horizon. Fire flow requirements were not met at 7 locations within City Centre where the multi-family flow requirement is 200 L/s. The fire flow requirements at these locations could be met by upgrading all mains to the minimum City Centre size of 250 mm.

2033 Horizon
Results for the PHD and MDD+FF model runs are shown in ***Figures 8.9 and 8.10***. Fire flow requirements were not met at 10 locations within City Centre where the multi-family flow requirement is 200 L/s. The fire flow requirements at these locations could be met by upgrading all mains to the minimum City Centre size of 250 mm.

2043 Horizon
Results for the PHD and MDD+FF model runs are shown in ***Figures 8.11 and 8.12***. Fire flow requirements were not met at 11 locations within City Centre where the multi-family flow requirement is 200 L/s. The fire flow requirements at these locations could be met by upgrading all mains to the minimum City Centre size of 250 mm.

Build Out Horizon
Results for the PHD and MDD+FF model runs are shown in ***Figures 8.13 and 8.14***. There are a number of nodes such as those located at 133 St north of 100Avenue, which is an elevated area and does not meet the peak hour pressure requirement of 40psi. Due to the elevation of these locations, the low pressures cannot be resolved without very large infrastructure upgrades. The minimum peak hour pressure within City Centre is 36 psi. Fire flow requirements were not met at 4 locations within City Centre where the multi-family flow requirement is 200 L/s. The fire flow requirements at these locations could be met by upgrading all mains to the minimum City Centre size of 250 mm.

The recommended water servicing strategy for City Centre from present day to build out is a marriage of the recommended bulk supply and feedermain improvements and the recommended distribution and major grid main improvements detailed in ***Sections 8.2.1*** and ***8.2.2***. It should be noted that in order to meet the fire flow requirement of 200L/s for multi-family developments at all locations, the recommended system improvements, as well as upgrading of all local distribution mains to the City Centre minimum size of 250mm diameter is required. A detailed schedule of recommended water system improvements is tabulated in ***Appendix B*** including existing infrastructure description (if applicable), replacement or new infrastructure description and estimated implementation date and cost. A summary of estimated long term implementation cost is presented in ***Table 8.9***. All of the infrastructure improvements are directly related to increases in City Centre water demand and 100% attributable to City Centre re-development.

Table 8.9 Recommended Improvement Program Cost Summary

Recommended Improvements	Total Cost Attributable to City Centre
Bulk Supply and Feedermain Improvements	$9,062,000
Distribution & Major Grid Main Capacity Upgrades	$3,996,800
Capacity Improvement Total	**$13,058,800**

A snapshot of the overall system capacity versus demand with the water servicing strategy and the Build Out distribution network upgrades implemented is provided in ***Table 8.10*** below.

Table 8.10 Demand vs Capacity

Horizon Year	North Surrey Demand (L/s)	City Centre Demand (L/s)	Pumped Supply* (L/s)	Kennedy PS (L/s)	Newton PS (L/s)	Fleetwood PS (L/s)	Whalley PS (L/s)	Whalley Booster PS (L/s)
PHD Flows								
Existing	4,977	624	4,669	1,315	1,381	-	1,973	434
2023	7,309	797	6,541	1,392	1,882	1,223	2,044	479
2033	9,189	1,019	8,279	1,623	2,345	1,969	2,342	582
2043	9,359	1,189	8,446	1,657	2,350	1,991	2,448	655
Build Out	9,944	1,762	9,043	1,756	2,366	1,978	2,943	846
Firm Pump Station Capacities								
Existing	-	-	6,790	2,100	2,200	-	2,490	650
2023	-	-	8,890	2,100	2,200	1,250	2,490	650
2033	-	-	8,890	2,100	2,200	2,100	2,490	650
2043	-	-	8,890	2,100	2,200	2,100	2,490	650
Build Out	-	-	9,420	2,100	2,200	2,100	3,020	900

**Does not include Whalley Booster PS*

8.3 10-Year Servicing Plan

DCC eligible projects for build out of the City Centre Plan total $9,318,700 with some of the upgrades already included in the current 10-Year Servicing Plan (2014 – 2023). It is recommended that all of the DCC eligible projects be included in future 10-Year Servicing Plans. There may be projects shown in Figure 8.3 and 8.4 that have already been constructed, thus are not included in the following list.

List of DCC Eligible Projects

10 Year Servicing Plan ID	Pump Stations	# of New Pumps		Upgrade Year	Unit Cost ($/m)	Cost
-	Add 1 – 600 L/s pump to Whalley Main Pump Station*	1		2083	$750,000	$750,000
-	Add 1 – 250 L/s pump to Whalley Booster Pump Station*	1		2083	$500,000	$500,000
	Feedermains	**Length (m)**	**Dia. (mm)**	**Upgrade Year**	**Unit Cost ($/m)**	**Cost**
13901	104A Avenue: Whalley Pump Station- 144 Street	525	900	2023	$3,000	$1,575,000
13901	144 Street 104A Avenue - 104 Avenue	135	900	2023	$3,000	$405,000
11510	104 Avenue: 144 Street - King George Boulevard	1,652	900	2023	$3,000	$4,956,000
	104 Avenue: King George Boulevard - University Drive	365	750	2033	$2,400	$876,000
	Bulk Supply and Feedermain Total Cost					**$9,062,000**

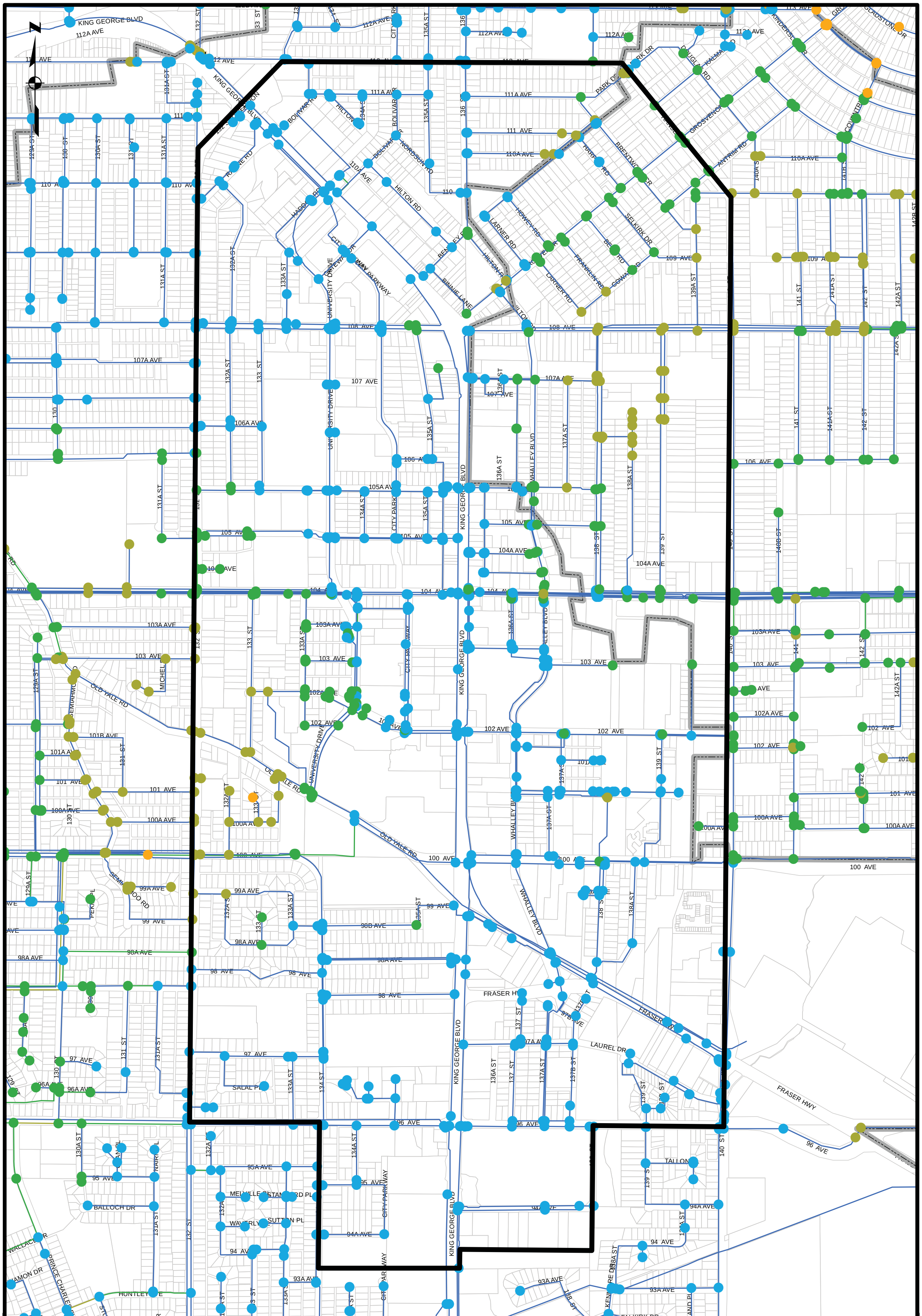
No land acquisition costs required. A spare pump bay is available at each pump station.

Cost estimates calculated from City of Surrey construction unit rates for NCPs and include project contingency.

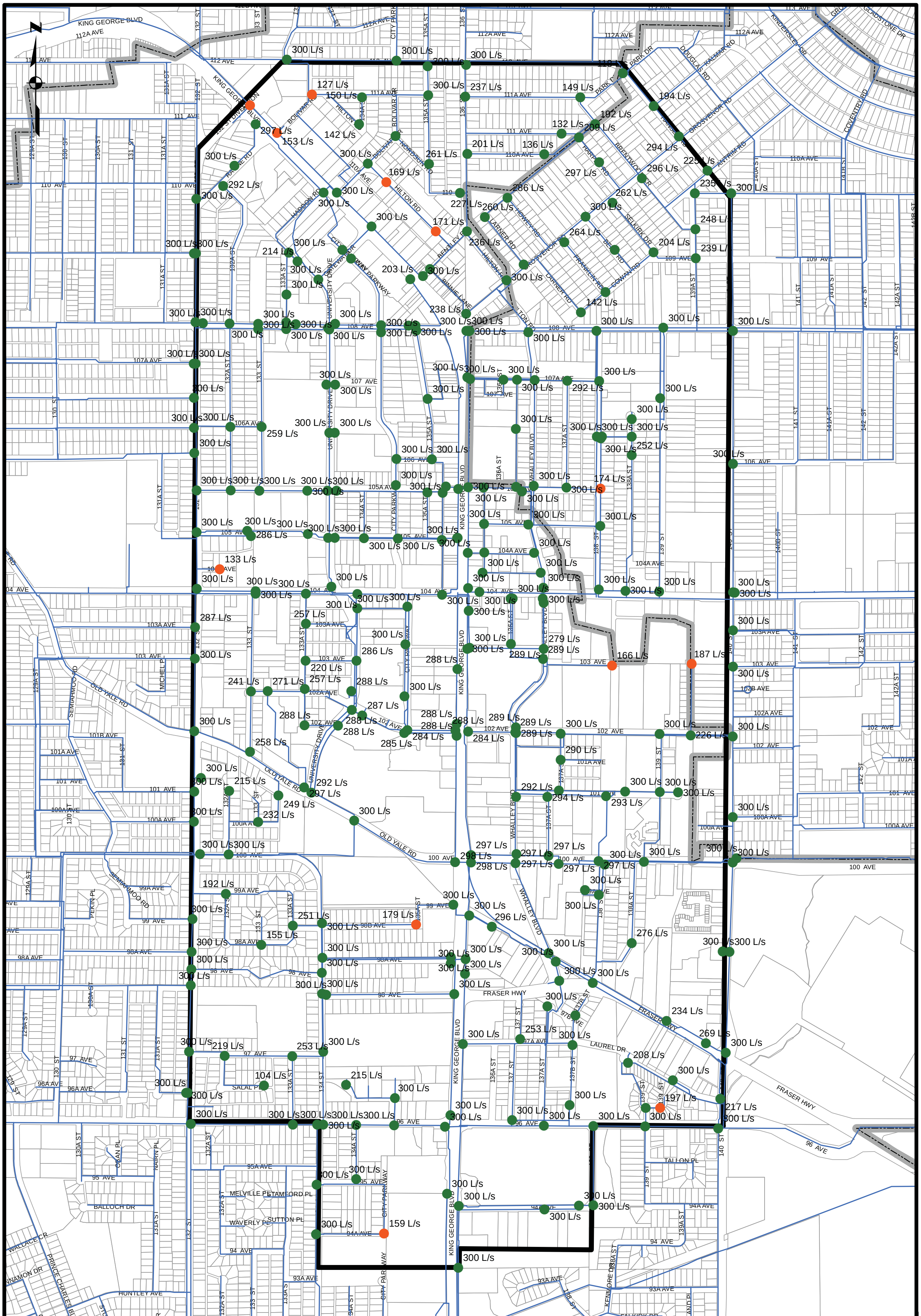
List of DCC Eligible Projects continued

10 Year Plan ID	Distribution and Major Grid Main Capacity Upgrades	Priority	Length (m)	Prop. Dia. (mm)	Unit Cost ($/linear m)	Cost
-	104 Avenue: lane - east side KG Blvd. - New Connection	N	37	350	$1,200	$44,400
13799	King George Blvd. (east side) south of 104 Avenue	U/N	8	300	$50	$400
			64	300	$50	$3,200
7792	King George Blvd: 96 Avenue - 99 Avenue	U/N	249	300	$50	$12,450
			214	300	$50	$10,700
-	Old Yale Rd west of University Drive	N	81	450	$1,400	$113,400
		N	13	450	$1,400	$18,200
11510	University Drive at 104 Avenue	N	9	450	$1,400	$12,600
		N	6	450	$1,400	$8,400
-	University Drive at Old Yale Rd - New Connection	N	20	450	$1,400	$28,000
-	96 Avenue: 137A St - 137B St	U/N	99	300	$50	$4,950
	TOTAL					**$256,700**

Cost estimates calculated from City of Surrey construction unit rates for NCPs and include project contingency.
U = upsizing contribution
N = NCP dependent



City of Surrey City Centre Plan 2013 Update Utility Servicing Strategy	Legend	AECOM	2013 (Existing) Horizon PHD Pressure & Velocity with Improvements
Project No. 60278179 Date August 2014	**Pressure (psi)**: < 40; 40 - 50; 50 - 60; 60 - 70; > 70 **Velocity (m/s)**: < 0.5; 0.5 - 1.0; 1.0 - 1.5; 1.5 - 2.0; > 2.0 City Centre Boundary Pressure Zone Boundaries Existing PRVs	200 100 0 200 Meters	**FIGURE 8.5**



City Centre Plan 2013 Update
Utility Servicing Strategy

Project No. 60278179

Date August 2014

Legend

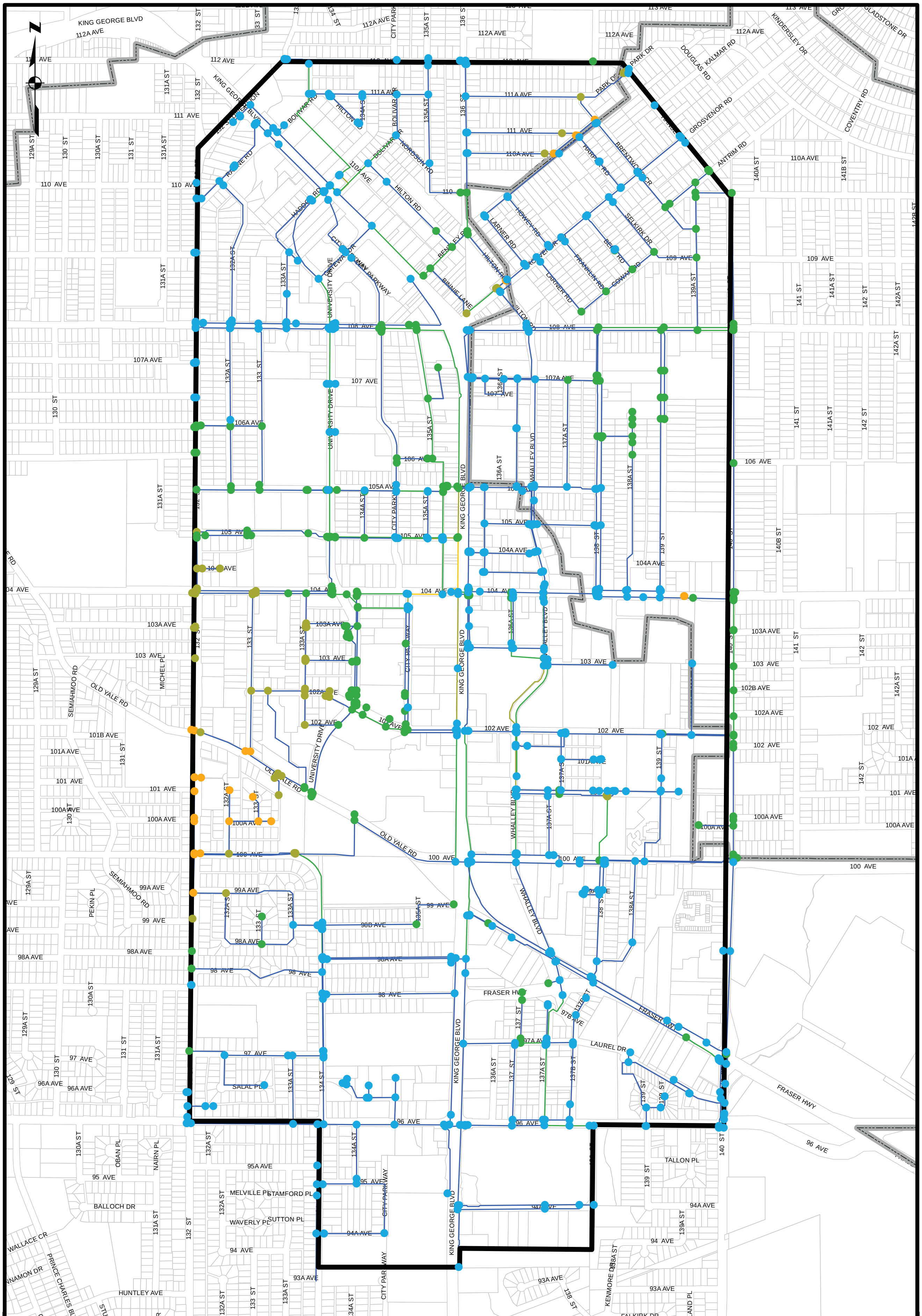
- Insufficient Fire Flow
- Insufficient Fire Flow - Requirements can be achieved if mains are upgraded to the minimum City Centre sizing of 250 mm
- Sufficient Fire Flow
- Watermains
- **City Centre Boundary**
- **Pressure Zone Boundaries**

AECOM

200 100 0 200 Meters

2013 Horizon
MDD+FF
with Improvements

FIGURE 8.6



City Centre Plan 2013 Update
Utility Servicing Strategy

Project No.	Date
60278179	June 2014

Legend

Pressure (psi)	Velocity (m/s)
< 40	< 0.5
40 - 50	0.5 - 1.0
50 - 60	1.0 - 1.5
60 -70	1.5 - 2.0
> 70	> 2.0

City Centre Boundary

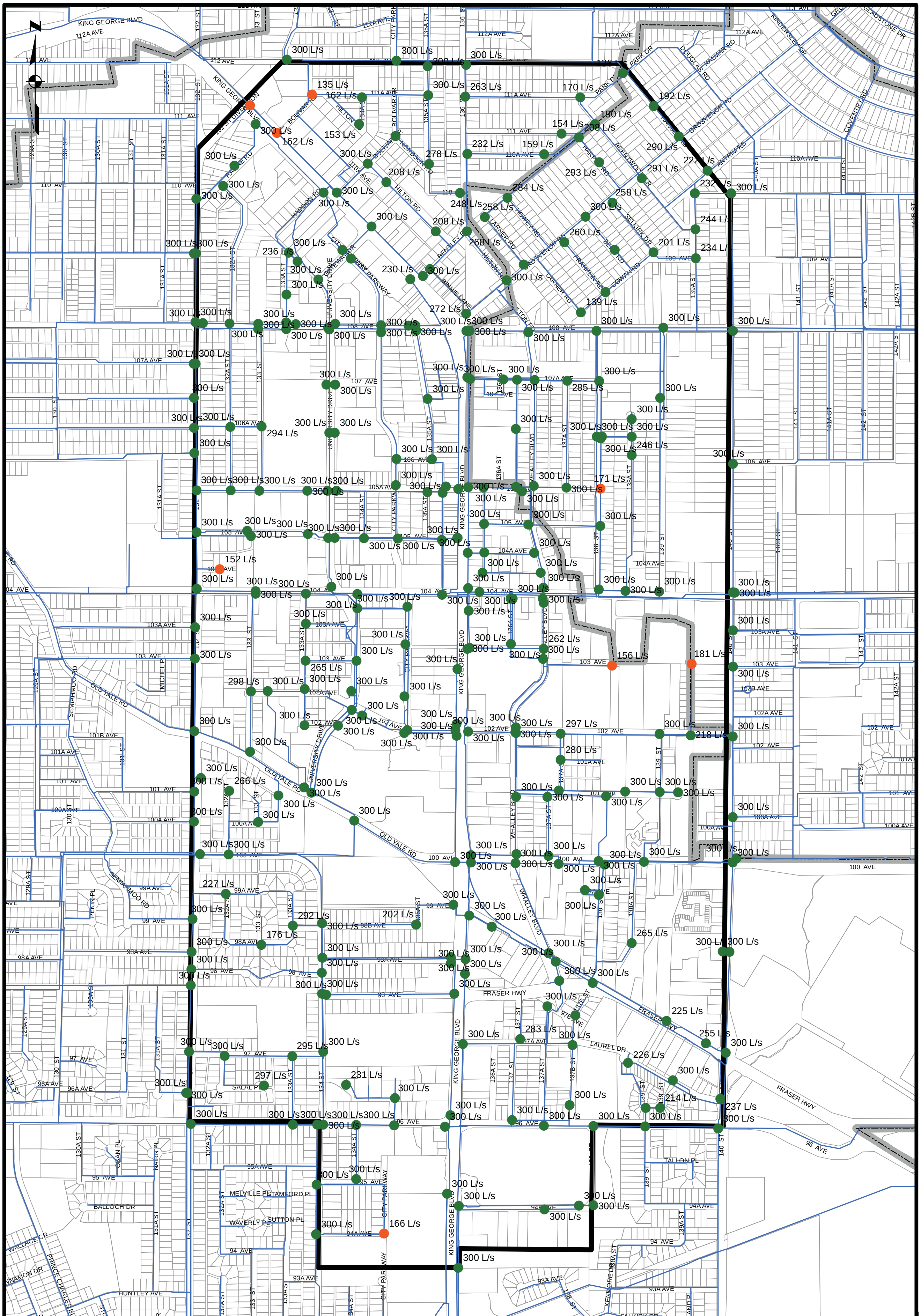
Pressure Zone Boundaries

AECOM

200 100 0 200 Meters

2023 Horizon PHD Pressure & Velocity with Improvements

FIGURE 8.7



City Centre Plan 2013 Update
Utility Servicing Strategy

Project No.	Date
60278179	August 2014

Legend

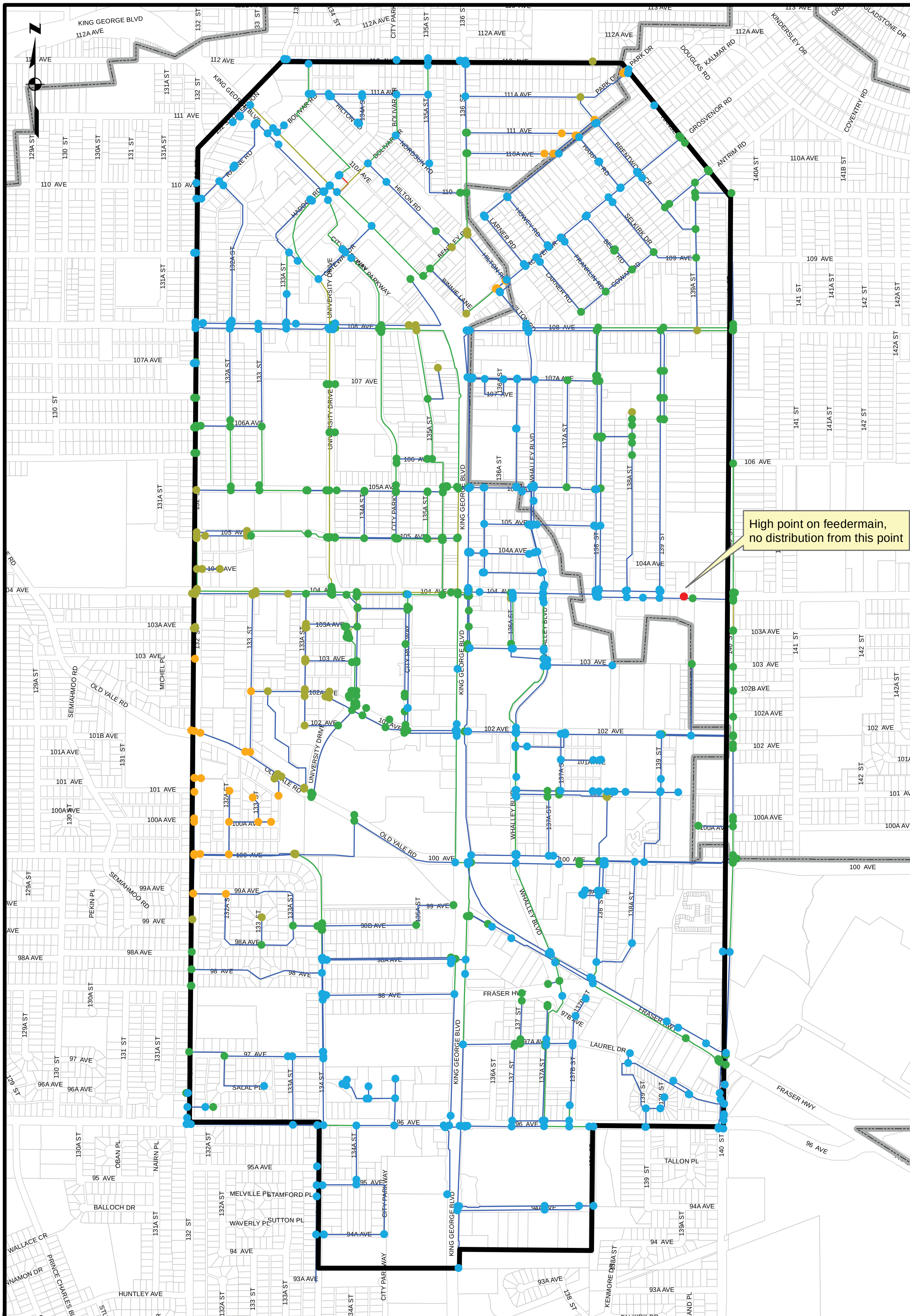
- Insufficient Fire Flow
- Insufficient Fire Flow - Requirements can be achieved if mains are upgraded to the minimum City Centre sizing of 250 mm
- Sufficient Fire Flow
- Watermains
- **City Centre Boundary**
- **Pressure Zone Boundaries**

AECOM

200 100 0 200 Meters

2023 Horizon
MDD+FF
with Improvements

FIGURE 8.8



SURREY
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City Centre Plan 2013 Update
Utility Servicing Strategy

Project No.	Date
60278179	June 2014

Legend

Pressure (psi)	Velocity (m/s)
< 40	< 0.5
40 - 50	0.5 - 1.0
50 - 60	1.0 - 1.5
60 - 70	1.5 - 2.0
> 70	> 2.0

City Centre Boundary

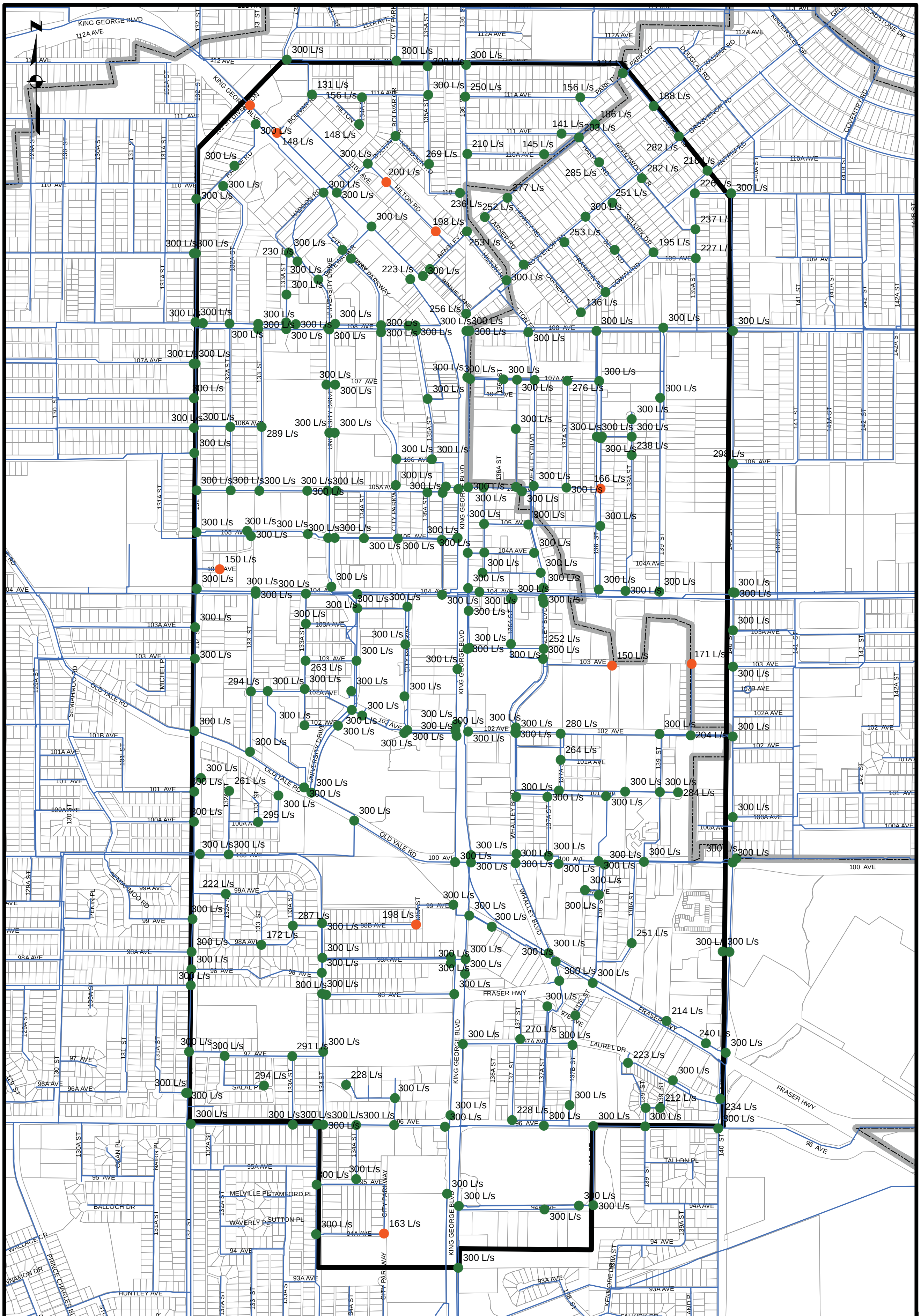
Pressure Zone Boundaries

AECOM

200 100 0 200 Meters

2033 Horizon
PHD Pressure & Velocity
with Improvements

FIGURE 8.9



Legend

- Insufficient Fire Flow
- Insufficient Fire Flow - Requirements can be achieved if mains are upgraded to the minimum City Centre sizing of 250 mm
- Sufficient Fire Flow
- Watermains
- City Centre Boundary
- Pressure Zone Boundaries

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City Centre Plan 2013 Update
Utility Servicing Strategy

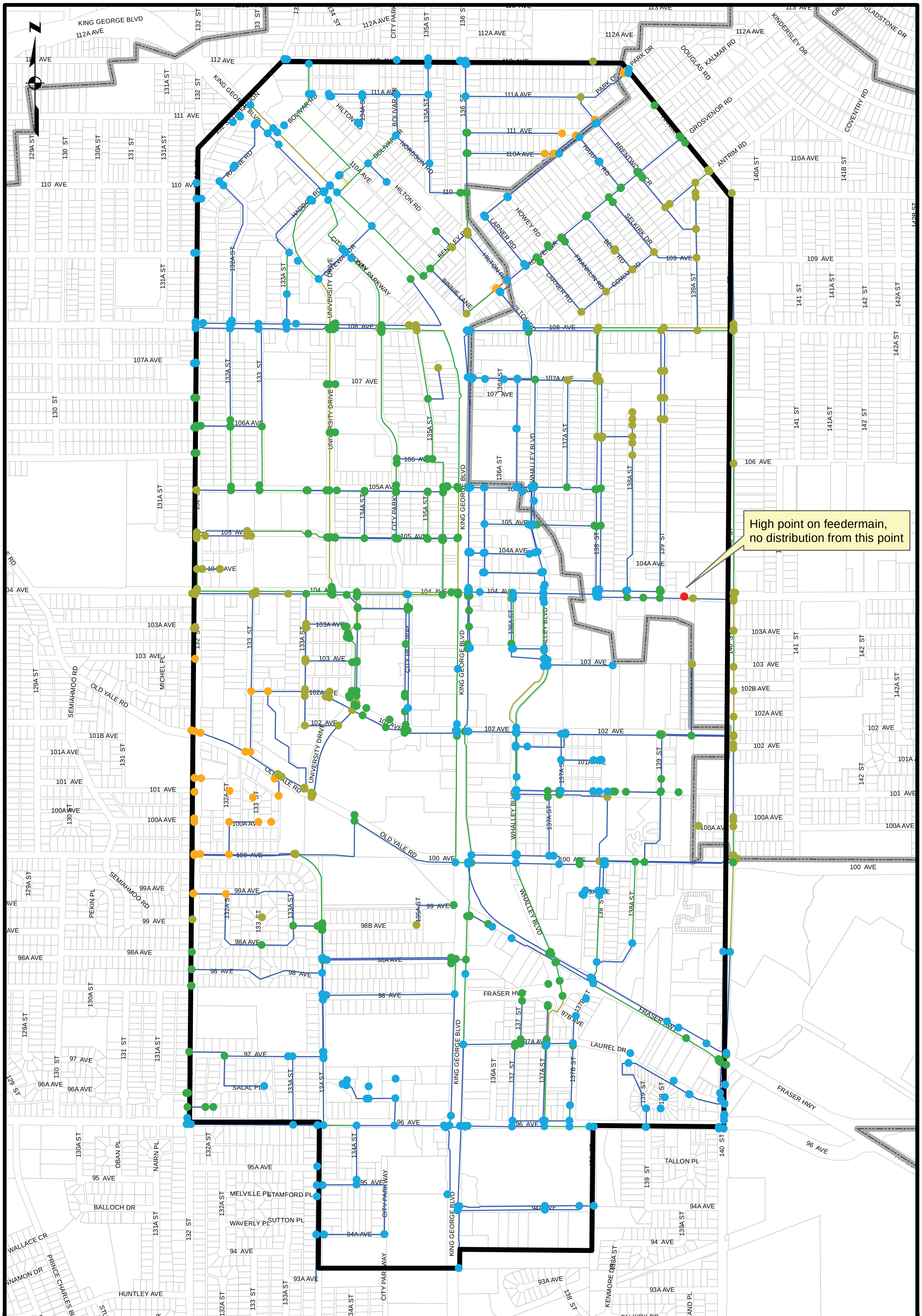
Project No.	Date
60278179	August 2014

AECOM

200 100 0 200 Meters

2033 Horizon
MDD+FF
with Improvements

FIGURE 8.10



City Centre Plan 2013 Update
Utility Servicing Strategy

Project No. 60278179

Date June 2014

Legend

Pressure (psi)	Velocity (m/s)
< 40	< 0.5
40 - 50	0.5 - 1.0
50 - 60	1.0 - 1.5
60 - 70	1.5 - 2.0
> 70	> 2.0

City Centre Boundary

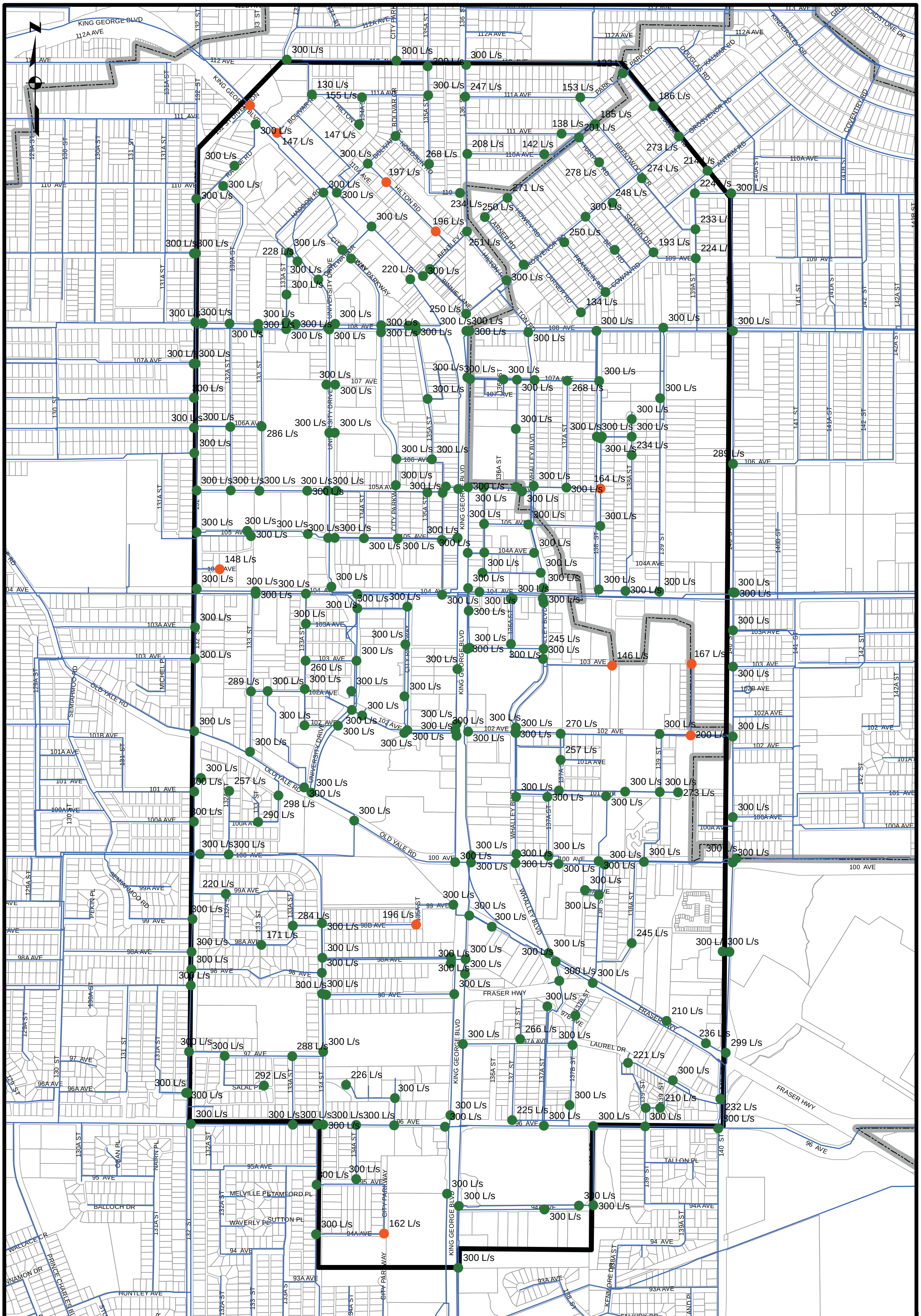
Pressure Zone Boundaries

AECOM

200 100 0 200 Meters

2043 Horizon PHD Pressure & Velocity with Improvements

FIGURE 8.11



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City Centre Plan 2013 Update
Utility Servicing Strategy

Project No.	Date
60278179	August 2014

Legend

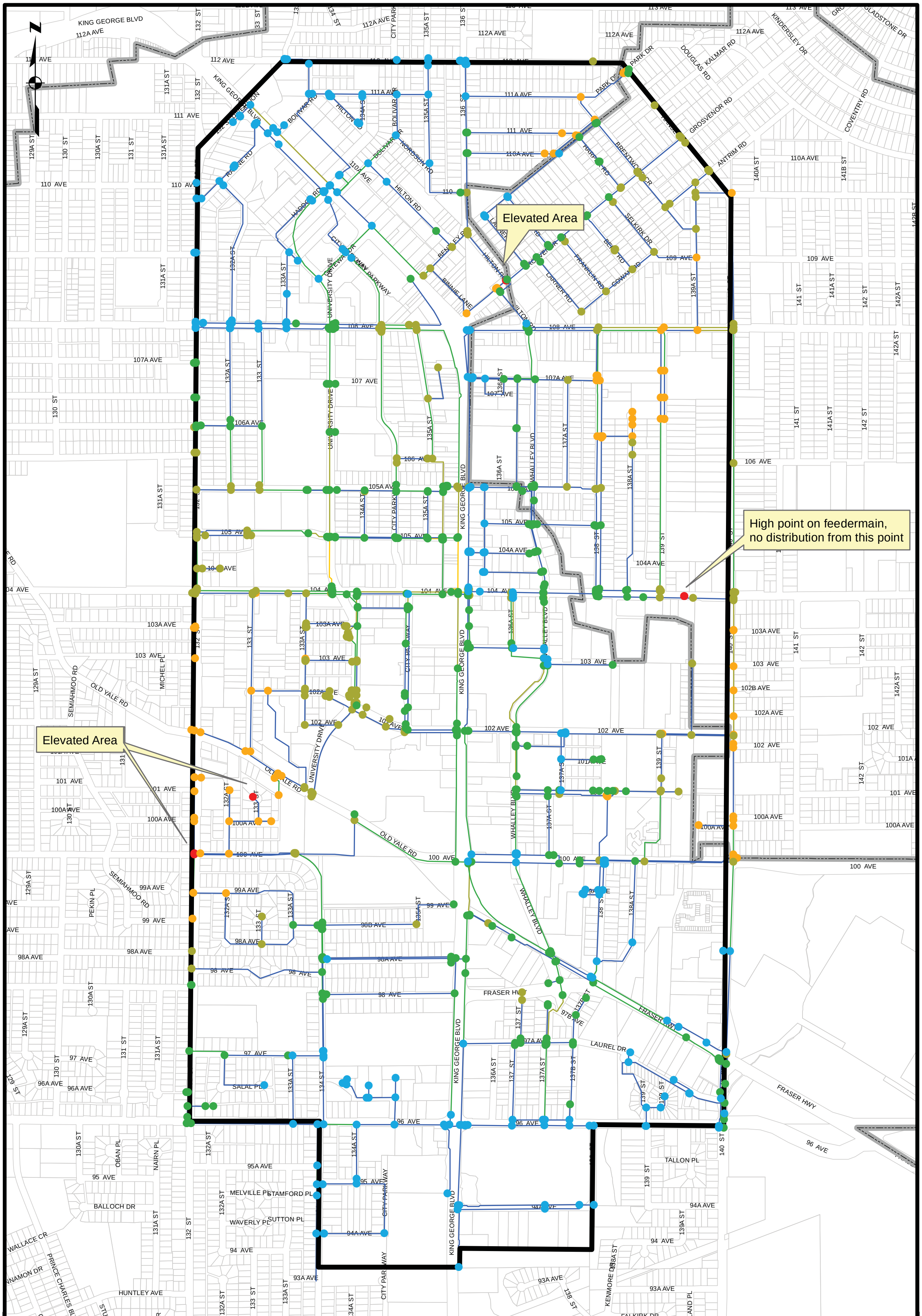
- Insufficient Fire Flow
- Insufficient Fire Flow - Requirements can be achieved if mains are upgraded to the minimum City Centre sizing of 250 mm
- Sufficient Fire Flow
- Watermains
- **City Centre Boundary**
- **Pressure Zone Boundaries**

AECOM

200 100 0 200 Meters

2043 Horizon
MDD+FF
with Improvements

FIGURE 8.12



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City Centre Plan 2013 Update
Utility Servicing Strategy

Project No.	Date
60278179	June 2014

Legend

Pressure (psi)	Velocity (m/s)
< 40	< 0.5
40 - 50	0.5 - 1.0
50 - 60	1.0 - 1.5
60 -70	1.5 - 2.0
> 70	> 2.0

City Centre Boundary

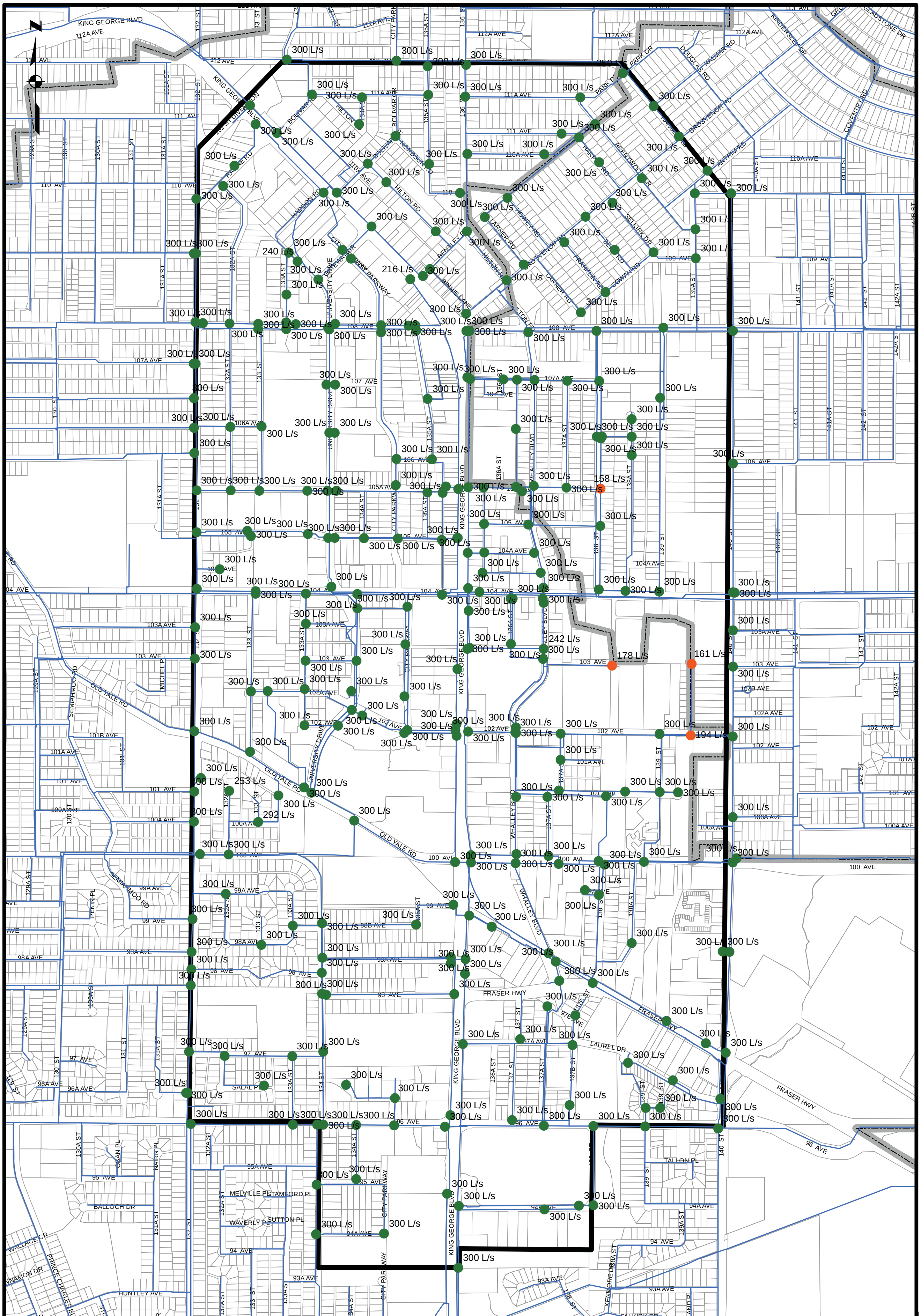
Pressure Zone Boundaries

AECOM

200 100 0 200 Meters

2083 Horizon
PHD Pressure & Velocity
with Improvements

FIGURE 8.13



CITY OF SURREY
the future lives here.

City Centre Plan 2013 Update
Utility Servicing Strategy

Project No.	Date
60278179	August 2014

Legend

- Insufficient Fire Flow
- Insufficient Fire Flow - Requirements can be achieved if mains are upgraded to the minimum City Centre sizing of 250 mm
- Sufficient Fire Flow
- Watermains
- **City Centre Boundary**
- **Pressure Zone Boundaries**

AECOM

200 100 0 200 Meters

2083 Horizon
MDD+FF
with Improvements

FIGURE 8.14

APPENDIX B: WATER DETAILS

- ☐ Existing Water Equivalent Population
- ☐ 2023 Water Equivalent Population
- ☐ 2033 Water Equivalent Population
- ☐ 2043 Water Equivalent Population
- ☐ Build Out Water Equivalent Population
- ☐ Base Day Demand (BDD)
- ☐ Seasonal Demand and Max Day Demand (MDD)
- ☐ Peaking Factors (PF) and Peak Hour Demand (PHD)
- ☐ Fire Flow Demand (FF)
- ☐ Water Model and GIS Discrepancies
- ☐ Capacity Upgrades: Bulk Supply and Feedermains
- ☐ Existing Capacity Upgrades: Distribution and Major Grid Mains
- ☐ Build Out Capacity Upgrades: Distribution and Major Grid Mains
- ☐ DCC Eligible Upgrades

B1. Existing Water Equivalent Population

Residential
The existing residential population was provided by the City Planning Department and adjusted to include the addition of secondary suites (1.93 additional people per single family residence) to 38% of all existing single family homes, for a total population of 33,812.

Commercial
The existing commercial employment population was provided by the City Planning Department as 23,585.

Institutional
Equivalent institutional populations were generated by units and populations provided by the City, City School Board, and Fraser Health Authority. The per capita demand utilized in this study for the calculation of Base Demand is 320 litres/capita/day (L/c/d) and includes an allowance for leakage (estimated at approximately 10%). This unit rate was developed as part of the 2005 KWL *Grandview Pump Station Pre-Design Report* and was utilized in the 2007 KWL *North Surrey Pump Station Study*.

A unit base demand rate of 320 L/cap/day was used to convert the institutional units to equivalent populations, which is shown in ***Table 1***.

Table 1 Existing Water Institutional Population Equivalent

Facility	Units	Flow Per Unit	Institutional Equivalent Population
Surrey Memorial Hospital	500 beds	900 L/bed/d	1,406
Laurel Place Retirement Home	191 beds	650 L/bed/d	388
Forsyth Road Elementary School	271 students	45 L/student/d	38
AHP Mathew Elementary School	426 students	45 L/student/d	60
Queen Elizabeth Secondary School	1435 students	90 L/student/d	404
Cherington Place Retirement Home	75 beds	650 L/bed/d	152
Parks (irrigation)	27.8 ha	3,520 l/ha/d	306
		Total =	**2,754**

B2. 2023 Water Equivalent Population

Residential

The 2023 residential population was provided by the City and adjusted to include the addition of secondary suites (1.93 additional people per single family residence) to 100% of all single family homes, for a total population of 52,442.

Commercial

Commercial employment population was provided by the City Planning Department to be 27,670 for 2023. The commercial employment populations developed by the City Planning Department were compared with a generated equivalent commercial population based on commercial floor space as recommended by City Water Division. The greater population was then taken to be the higher water demand projection.

The commercial floor space in GIS was converted to an equivalent population based on 200 person population equivalent per 10,000 m^2 (1pp/50 m^2) of floor space which includes an allowance for visitors as directed by City staff. An equivalent commercial population of 33,064 was calculated for 2023. This value was utilized to develop water demand projections.

Institutional

Equivalent institutional populations were generated by units and populations provided by the City, City School Board, and Fraser Health Authority. Similar to the method used for existing, a unit base demand rate of 320 L/cap/day was used to convert the institutional units to equivalent populations, which is shown in ***Table 2***.

Table 2 2023 Water Institutional Population Equivalent

Facility	Units	Flow Per Unit	Institutional Equivalent Population
Surrey Memorial Hospital	650 beds	900 L/bed/d	1,828
Laurel Place Retirement Home	191 beds	650 L/bed/d	388
Forsyth Road Elementary School	350 students	45 L/student/d	49
AHP Mathew Elementary School	550 students	45 L/student/d	77
Queen Elizabeth Secondary School	1854 students	90 L/student/d	521
Cherington Place Retirement Home	75 beds	650 L/bed/d	152
Parks (irrigation)	27.8 ha	3,520 l/ha/d	306
		Total =	**3,322**

B3. 2033 Water Equivalent Population

Residential
The 2033 residential population was provided by the City and adjusted to include the addition of secondary suites (1.93 additional people per single family residence) to 100% of all single family homes, for a total population of 71,858.

Commercial
The methodology described in the 2023 horizon was used to generate equivalent commercial populations for 2033. A Commercial employment population was provided by the City Planning Department as 32,332 for 2033.

The commercial floor space in GIS was converted to an equivalent population based on 200 person population equivalent per 10,000 m^2 (1pp/50 m^2) of floor space which includes an allowance for visitors as directed by City staff. An equivalent commercial population of 42,543 was calculated for 2033. This value was utilized to develop water demand projections.

Institutional
Equivalent institutional populations were generated by units and populations provided by the City, City School Board, and Fraser Health Authority. Similar to the method used for existing and 2023, a unit base demand rate of 320 L/cap/day was used to convert the institutional units to equivalent populations, which is shown in ***Table 3***.

Table 3 2033 Water Institutional Population Equivalent

Facility	Units	Flow Per Unit	Institutional Equivalent Population
Surrey Memorial Hospital	800 beds	900 L/bed/d	2,250
Laurel Place Retirement Home	191 beds	650 L/bed/d	388
Forsyth Road Elementary School	437 students	45 L/student/d	61
AHP Mathew Elementary School	686 students	45 L/student/d	96
Queen Elizabeth Secondary School	2,312 students	90 L/student/d	650
Cherington Place Retirement Home	75 beds	650 L/bed/d	152
Parks (irrigation)	27.8 ha	3,520 l/ha/d	306
		Total =	**3,904**

B4. 2043 Water Equivalent Population

Residential
The 2043 residential population of was provided by the City and adjusted to include the addition of secondary suites (1.93 additional people per single family residence) to 100% of all single family homes, for a total population of 92,106.

Commercial
The methodology described in the 2023 horizon was used to generate equivalent commercial populations for 2043. A Commercial employment population was provided by the City Planning Department as 37,742 for 2043.

The commercial floor space in GIS was converted to an equivalent population based on 200 person population equivalent per 10,000 m^2 (1pp/50 m^2) of floor space which includes an allowance for visitors as directed by City staff. An equivalent commercial population of 52,022 was calculated for 2043. This value was utilized to develop water demand projections.

Institutional
Equivalent institutional populations were generated by units and populations provided by the City, City School Board, and Fraser Health Authority. Similar to the method used for existing, 2023, and 2033 a unit base demand rate of 320 L/cap/day was used to convert the institutional units to equivalent populations, which is shown in ***Table 4***.

Table 4 2043 Water Institutional Population Equivalent

Facility	Units	Flow Per Unit	Institutional Equivalent Population
Surrey Memorial Hospital	800 beds	900 L/bed/d	2,250
Laurel Place Retirement Home	191 beds	650 L/bed/d	388
Forsyth Road Elementary School	488 students	45 L/student/d	69
AHP Mathew Elementary School	766 students	45 L/student/d	108
Queen Elizabeth Secondary School	2,581 students	90 L/student/d	726
Cherington Place Retirement Home	75 beds	650 L/bed/d	152
Parks (irrigation)	27.8 ha	3,520 l/ha/d	306
		Total =	**3,998**

B5. Build Out Water Equivalent Population

Residential

The Build Out residential population was provided by the City and adjusted to include the addition of secondary suites (1.93 additional people per single family residence) to 100% of all single family homes, for a total population of 160,599.

Commercial

The methodology described in the 2023 horizon was used to generate equivalent commercial populations for 2083. A Commercial employment population was provided by the City Planning Department as 56,572 for 2083.

The commercial floor space in GIS was converted to an equivalent population based on 200 person population equivalent per 10,000 m^2 (1pp/50 m^2) of floor space which includes an allowance for visitors as directed by City staff. This generated a commercial population of 89,937 at full build out. This value was utilized to develop water demand projections.

Institutional

Equivalent institutional populations were generated by units and populations provided by the City, City School Board, and Fraser Health Authority. Similar to the method used for existing, 2023, 2033, and 2043 a unit base demand rate of 320 L/cap/day was used to convert the institutional units to equivalent populations, which is shown in ***Table 5***.

Table 5 2083 (Build Out) Water Institutional Population Equivalent

Facility	Units	Flow Per Unit	Institutional Equivalent Population
Surrey Memorial Hospital	800 beds	900 L/bed/d	2,250
Laurel Place Retirement Home	191 beds	650 L/bed/d	388
Forsyth Road Elementary School	813 students	45 L/student/d	114
AHP Mathew Elementary School	1,278 students	45 L/student/d	180
Queen Elizabeth Secondary School	4,305 students	90 L/student/d	1,211
Cherington Place Retirement Home	75 beds	650 L/bed/d	152
Parks (irrigation)	27.8 ha	3,520 l/ha/d	306
		Total =	**4,601**

B6. Base Day Demand (BDD)

The BDD for all horizons are developed through multiplying the per capita BDD unit rate (320 l/c/d) by the residential, commercial, and institutional equivalent populations.

B7. Seasonal Demand and Max Day Demand (MDD)

The seasonal demand is based on the unit rate of 0.39 l/s/ha applied to the area for each corresponding land use as developed in the *2004 Water Model: Model Development Study* report.

The existing MDD that was developed for the *North Surrey Pump Station Study* was utilized as the existing scenario in this study. 2023 MDD was generated by interpolating between existing and 2033 MDD. 2033, 2043, and build out MDD was developed by combining the BDD with seasonal water demand. The total seasonal water demand is considered to not change from beyond the 2033 horizon.

However, the distribution of seasonal demand between residential and institutional/commercial (IC) sectors does change as City Centre shifts toward high density mixed use at build out. In residential/commercial mixed use areas, we have assigned the seasonal water demand to the residential component.

At Build Out, the Commercial water use sector has no seasonal water demand as all commercial development has a residential component that includes seasonal water demand in this scenario.

B8. Peaking Factors (PF) and Peak Hour Demand (PHD)

PHD was developed by combining the estimated peak BDD and peak seasonal water demand. Peaking factors provided with the North Surrey Hydraulic Model were utilized only for the 2013 existing horizon. All future horizons utilize peaking factors developed from 2007 meter data from the Clayton area of Surrey.

Peaking factors were developed for both the BDD and seasonal demands to better represent the difference between indoor water use and irrigation peaks. As City Centre population density increases, single family residential areas will be replaced with mid and high rise residential. Irrigation demands will be relatively independent of population for high density neighbourhoods and maintaining separate residential (Base) and irrigation (seasonal) demands will provide a more accurate estimate of future PHD.

Base demand PHD peaking factors were further divided into residential and commercial water use sectors due to the significant differences in water use between these sectors. The residential base demand peaking factor was estimated to be 1.7 using November 2007 bulk meter data from Clayton as a basis. For commercial and institutional land uses, the BDD peaking factor was estimated to be 1.2 based on previous studies for the Township of Langley and City of New Westminster.

A separate peaking factor of 2.1 was estimated for the seasonal demand based on August 2007 bulk meter data from Clayton. The seasonal demand peaks were assumed to be similar in residential, commercial, and institutional land uses.

B9. Fire Flow Demand (FF)

Fire flow demands are based on land use zoning. The City of Surrey Design Criteria Manual (2004) includes 52 separate zonings with five different fire flow values. For modelling purposes, the fire flow demands in the City of Surrey Engineering Department Design Criteria Manual (2004) were simplified to include three basic land uses in City Centre with three different fire flow values:

- Single Family Residential = 60 L/s;
- Multi-Family Residential = 200 L/s; and
- Commercial and Institutional = 200 L/s.

This simplification will overestimate fire flow required for duplex residential, neighbourhood commercial and self-service gas station properties. However, there are few existing properties impacted by this simplification and future City Centre is largely dense commercial and residential development with higher fire flow requirements. Therefore, the impact of this simplification is marginal and does not impact the medium and long term infrastructure requirements in City Centre.

B10. Water Model and GIS Discrepancies

Water Model Discrepancies with COSMOS			
	Description	Old Pipe IDs	New Pipe IDs
1	Connected 450/300mm main on Haddon Rd to 150mm main on King George Blvd.	106942	P-19040
	- additional affected pipes	107020	P-19038
			P-19039
2	Replaced 150mm main on King George Blvd. north of Haddon Rd with 300mm main	107116	P-19051
	- additional affected pipes	107006	P-19036
3	Added 300mm connection across Haddon Rd at 10977 University Drive		P-19037
	- additional affected pipes	106960	P-19033
			P-19034
4	Connected 300mm main on King George Blvd. with 150mm main on 100 Avenue	105728	P-19027
	- additional affected pipes		P-19028
5	Added 300mm connection on 137B St across Fraser Hwy to 96 Ave		P-19021
			P-19022

B11. Existing Scenario - Distribution & Major Grid Main Capacity Upgrades

Location	Pipe ID	Ex Dia (mm)	Ex Mat erial	Year Install ed	Length (m)	Prop. Dia (mm)	Unit Cost	Cost	NPV (3%)
104 Ave b/w lane and east side KG Blvd. - New Connection	P-19086	-	-	-	37	350	$1,200	$44,400	$44,400
King George Blvd (east side) south of 104 Ave	105465	200	DI	2002	8	300	$1,100	$8,800	$8,800
	P-18982	150	DI	1964	64	300	$1,100	$70,400	$70,400
102 Ave bw 139 St and 137A St	105611	150	AC	1970	289	250	$1,050	$303,450	$303,450
	105612	150	AC	1970	12	250	$1,050	$12,600	$12,600
King George Blvd. at 99 Ave - New Connection	FUT-19054	-	-	-	80	250	$1,050	$84,000	$84,000
100A Ave b/w 132A St and 133 St	105893	150	AC	1959	39	250	$1,050	$40,950	$40,950
	105894	150	AC	1959	89	250	$1,050	$93,450	$93,450
100A Ave to Old Yale Rd - New Connection	FUT-19052	-	-	-	102	250	$1,050	$107,100	$107,100
132A St north of 100 Ave	105895	150	AC	1959	100	250	$1,050	$105,000	$105,000
	105896	150	AC	1959	94	250	$1,050	$98,700	$98,700
Binnie Lane b/w Bentley Rd and Grosvenor Rd	107027	150	DI	1975	182	250	$1,050	$191,100	$191,100
Bentley Rd b/w King George Blvd. and Binnie Rd	107215	150	CI	1964	31	250	$1,050	$32,550	$32,550
North side KG Blvd. b/w Bentley Rd and Gateway Dr	P-19017	150	DI	1990	221	250	$1,050	$232,050	$232,050
King George Blvd. b/w 96 Ave and 99 Ave	106035	200	DI	1963	249	300	$1,100	$273,900	$273,900
	105764	200	DI	1963	214	300	$1,100	$235,400	$235,400
Harper Rd b/w Bentley Rd and Grosvenor Rd	106780	50	PV	1992	2	250	$1,050	$2,100	$2,100
King George Blvd. north of 108 Ave	106951	150	CI	1964	245	250	$1,050	$257,250	$257,250
102 Ave west of University Drive	105681	150	DI	1973	102	250	$1,050	$107,100	$107,100
137B St b/w 97A Ave and 97B Ave	105524	150	DI	1980	86	250	$1,050	$90,300	$90,300
137A St b/w 101A Ave and 102 Ave	105590	150	AC	1962	79	250	$1,050	$82,950	$82,950
139A St north of 102 Ave	105605	150	DI	1979	218	250	$1,050	$228,900	$228,900
137A St b/w 97A Ave and 97B Ave	105638	150	DI	1971	14	250	$1,050	$14,700	$14,700
	105639	150	DI	1971	99	250	$1,050	$103,950	$103,950
97A Ave b/w 137A St and 137B St	105630	150	DI	1971	81	250	$1,050	$85,050	$85,050
Haddon Rd b/w KG Hwy and 133A St	P-19036	150	AC	1963	223	250	$1,050	$234,150	$234,150
Sub-Total								**$3,140,300**	

Build Out Scenario - Distribution & Major Grid Main Capacity Upgrades

Location	Pipe ID	Ex Dia (mm)	Ex Material	Year Installed	Length (m)	Prop. Dia (mm)	Unit Cost	Cost	NPV (3%)
Old Yale Rd west of University Drive	105768	150	DI	1972	81	450	$1,400	$113,400	$14,322
	105912	150	DI	1976	13	450	$1,400	$18,200	$2,299
	105682	150	DI	2001	7	250	$1,050	$7,350	$928
	105683	150	DI	1972	24	250	$1,050	$25,200	$3,183
137A St b/w 101 Ave and 101A Ave	105589	150	AC	1962	95	250	$1,050	$99,750	$12,598
Bentley Rd b/w Binnie Lane and Hilton Rd.	107018	150	CI	1964	64	250	$1,050	$67,200	$8,487
	107216	150	CI	1964	93	250	$1,050	$97,650	$12,333
97A Ave b/w 137 St and 137A St	105632	150	DI	1971	76	250	$1,050	$79,800	$10,079
	105631	150	DI	1971	3	250	$1,050	$3,150	$398
University Drive at 104 Ave	107104	350	DI	1991	9	450	$1,400	$12,600	$1,591
	107105	350	DI	1991	6	450	$1,400	$8,400	$1,061
University Drive at Old Yale Rd - New Connection	P-19070	-	-	-	20	450	$1,400	$28,000	$3,536
King George Hwy b/w Haddon Rd and Gateway Dr.	P-19016	150	DI	1987	148	250	$1,050	$155,400	$19,627
	P-19039	150	CI	2002	30	250	$1,050	$31,500	$3,978
96 Ave b/w 137A St and 137B St.						*			
	P-19019	150	DI	1964	99	300	$1,100	$108,900	$13,754
Sub-total								**$856,500**	

Cost estimates calculated from City of Surrey construction unit rates for NCPs and include project contingency.

Note for Table B11 and B12 - Only distribution mains that require capacity improvements prior to their aging infrastructure replacement date are included in the capacity improvement program. Existing distribution mains that reach the end of their useful life are replaced by 250mm diameter watermains as part of the City's ageing infrastructure replacement program.

B12. DCC Eligible - Major Grid Mains Capacity Upgrades

Ten Year Servicing Plan (2014 – 2023) Project ID	Location	Priority	Pipe ID	Ex Dia. (mm)	Ex Material	Year Installed	Length (m)	Prop. Dia. (mm)	Unit Cost	Cost	NPV (3%)
Existing Scenario Upgrades											
-	104 Ave b/w lane and east side KG Blvd. - New Connection	N	P-19086	-	-	-	37	350	$1,200	$44,400	$44,400
13799	King George Blvd. (east side) south of 104 Ave	U/N	105465	200	DI	2002	8	300	$50	$400	$400
			P-18982	150	DI	1964	64	300	$50	$3,200	$3,200
7792	King George Blvd. b/w 96 Ave and 99 Ave	U/N	106035	200	DI	1963	249	300	$50	$12,450	$12,450
			105764	200	DI	1963	214	300	$50	$10,700	$10,700
Existing Scenario Sub-Total							572			$71,150	$71,150
Build Out Scenario Upgrades											
-	Old Yale Rd west of University Drive	N	105768	150	DI	1972	81	450	$1,400	$113,400	$14,322
		N	105912	150	DI	1976	13	450	$1,400	$18,200	$2,299
11510	University Drive at 104 Ave	N	107104	350	DI	1991	9	450	$1,400	$12,600	$1,591
		N	107105	350	DI	1991	6	450	$1,400	$8,400	$1,061
-	University Drive at Old Yale Rd - New Connection	N	P-19070	-	-	-	20	450	$1,400	$28,000	$3,536
-	96 Ave b/w 137A St and 137B St										
		U/N	P-19019	150	DI	1964	99	300	$50	$4,950	$625
Build Out Scenario Sub-Total							228			$185,550	$23,435
Existing & Build Out Total							**800**			**$256,700**	**$94,585**

Cost estimates calculated from City of Surrey construction unit rates for NCPs and include project contingency.

U = upsizing contribution
N = NCP dependent

B13. DCC Eligible - Bulk Supply and Feedermain Capacity Upgrades

Pump Stations	# of New Pumps		Upgrade Year	Unit Cost ($)	Cost	NPV (3%)	Ten Year Servicing Plan (2014-2023) Project ID
Add 1 – 600 L/s pump to Whalley Main Pump Station*	1		2083	750,000	$ 750,000	$ 97,565	-
Add 1 – 250 L/s pump to Whalley Booster Pump Station*	1		2083	500,000	$ 500,000	$ 65,043	-
				Pump Stations Subtotal	**$ 1,250,000**	**$ 162,608**	
Feedermains	**Length (m)**	**Dia. (mm)**	**Upgrade Year**	**Unit Cost ($/m)**	**Cost**	**NPV (3%)**	
104A Ave. b/w Whalley PS and 144 St.	525	900	2023	3,000	$ 1,575,000	$ 1,207,106	13901
144 St. b/w 104A Ave. and 104 Ave.	135	900	2023	3,000	$ 405,000	$ 310,399	13901
104 Ave. b/w 144 St. and King George Blvd.	1,652	900	2023	3,000	$ 4,956,000	$ 3,798,361	11510
104 Ave. b/w King George Blvd. and University Drive	365	750	2033	2,400	$ 876,000	$ 499,571	-
	2,677			**Feedermain Subtotal**	**$ 7,812,000**	**$ 5,815,437**	
				Bulk Supply and Feedermain Total	**$ 9,062,000**	**$ 5,978,045**	

No land acquisition costs required. A spare pump bay is available at each pump station.
Cost estimates calculated from City of Surrey construction unit rates for NCPs and include project contingency.

B15. City Centre Projected Growth Areas for Development Staging Scenarios

City Centre Projected Areas

		2013			2023			2033			2043			2083		
	# of SF Parcels (2007)	% Redeveloped	% SS	SS Pop	% Redeveloped	% SS	SS Pop	% Redeveloped	% SS	SS Pop	% Redeveloped	% SS	SS Pop	% Redeveloped	% SS	SS Pop
Polygon A	72	0%	38%	53	65%	100%	49	21%	100%	110	9%	100%	126	5%	100%	132
Polygon B	280	0%	38%	205	14%	100%	465	22%	100%	422	23%	100%	416	41%	100%	319
Polygon C	452	0%	38%	331	5%	100%	829	13%	100%	759	15%	100%	742	67%	100%	288
Polygon D	286	0%	38%	210	2%	100%	541	2%	100%	541	6%	100%	519	90%	100%	55
Existing	901	0%	38%	661	0%	100%	1,739	0%	100%	1,739	0%	100%	1,739	0%	100%	1,739
Total	1,991			1,460			3,622			3,570			3,542			2,533

	2013	**2023**	**2033**	**2043**	**2083**
General Population	32,352	48,820	68,288	88,564	158,066
Secondary Suite Population	1,460	3,622	3,570	3,542	2,533
Total Population	33,812	52,442	71,858	92,106	160,599

APPENDIX "V"

PART 6 SANITARY SEWER INFRASTRUCTURE

6 Sanitary Infrastructure

The Surrey City Centre area includes approximately 550 ha of land and is generally bound by 132 Street to the west, 140 Street to the east, 112 Avenue to the north and 96 Avenue to the south. The City of Surrey has updated their City Centre Plan, which predicts a dramatic increase in population that will place additional demands on the existing sanitary sewer infrastructure, and will ultimately exceed the capacity of many existing pipelines and the existing capacity at the Quibble Creek pump station.

The purpose of this study is to assess the impacts of the anticipated growth within City Centre and the associated increase in sanitary demands on the existing network and provide recommendations for network improvements taking into account network hydraulics and anticipated costs.

The City provided the City Centre Land Use Plan as the basis for the analysis, as shown in ***Figure 6.1***. The study area is divided into two basic sanitary catchment areas by the local topography, as shown in ***Figure 6.2***. The northern City Centre catchment is collected by gravity and flows into the Greater Vancouver Sewerage and Drainage District (GVS&DD) North Surrey Interceptor. The southern City Centre catchment is collected by gravity at the Quibble Creek Pump Station and pumped to a trunk main in the northern catchment, which in turn flows into the GVS&DD North Surrey Interceptor. Both catchments discharge to the regional system at 132 Street and 114 Avenue.

This study estimates sanitary flows for development conditions under five scenarios and identifies what sanitary infrastructure upgrades will be necessary to support development in this area. These scenario horizons are:

- Existing (2013);
- Year 2023;
- Year 2033;
- Year 2043; and,
- Build Out Year 2083 (Sewer Equivalent Build Out).

The Surrey Planning and Development Department split City Centre into four projected growth areas (see Appendix A), and predicted what percentage of each area would develop under each of the five scenarios. The corresponding number of units and jobs was then used to develop the sewer model.

The Sewer Equivalent Build Out, represents the full development saturation scenario for City Centre sewer demands and is recommended for sanitary sewer sizing due to the long service life, and high installation costs of installing sewer infrastructure.

Existing studies and information utilized in the development of this report included:

- City Centre Land Use Plan;
- City of Surrey geodatabase;
- GIS shape files of City sanitary sewer network and pump stations;
- GIS shape files of the City's legal parcels;
- City of Surrey Design Criteria Manual 2004;
- City of Surrey November 28, 2012 Engineering Bulletin: Design of Sanitary Sewer System Components;
- City of Surrey Topographic information; and
- ASCE Manual and Report on Engineering Practice No.60.

Terms and Definitions

Table 6.1 provides a summary of key terms (with abbreviations) and definitions used throughout this report.

Table 6.1 Key Terms and Definitions

Key Term (and Abbreviation)	Definition
Average Dry Weather Flow (ADWF)	The lowest 24-hour average sanitary flow value during a 7-day period of dry weather. The sanitary flow is comprised of base sanitary flow plus groundwater infiltration (ADWF = BSF + GWI).
ASCE Manuals and Reports on Engineering Practice 60	American Society of Civil Engineers Manual of Practice No. 60 for Gravity Sanitary Sewer Design and Construction.
Base Sanitary Flow (BSF)	All wastewater flow from residential, commercial, industrial and institutional sources that the sanitary sewer system is intended to carry. (BSF = ADWF – GWI).
Diurnal Pattern	Pattern describing the variance in sewage flows over a day,
Groundwater Infiltration (GWI)	Groundwater infiltration that enters the sanitary sewer system during dry weather periods; through breaks, cracks, misaligned joints, tree root punctures and manhole joints and covers. In general, GWI = 70% - 85% of minimum night-time flow.
Metro Vancouver(MV)/ GVS&DD	Regional District whose trunk system collects all sewage from the City, and neighbouring municipalities, and conveys it to a treatment facility.
Hydraulic Grade Line (HGL)	The maximum level of water in the pipe system, calculated as the height that liquid will rise in a piezometer using the Bernoulli's Equation.
Inflow	Stormwater that enters the sewer through direct connections (i.e. CB leads or roof drains connected to the sanitary sewer).
Inflow and Infiltration (I&I)	The total inflow and infiltration that enters the sanitary sewer system from all sources, equal to GWI + RDII.
Peak Dry Weather Flow (PDWF)	Peak instantaneous sanitary flow value during dry weather conditions (peak of the diurnally varying BSF plus GWI).
Peak Wet Weather Flow (PWWF)	Maximum instantaneous sanitary flow value. It represents all flow contributions carried by the sanitary sewer system (equals PDWF + RDII).

Rain Dependent Inflow and Infiltration (RDII)	All stormwater inflow (see above) into the sanitary sewer system plus increase in GWI that occurs directly due to the influence of rainfall.

Unit Conversions

Volume	Litres to gallons	3.79 Litres = 1.0 US gallon and 4.54 Litres = 1.0 Imp. gallon
HGL	Geodetic to MV Datum	0.0m Geodetic = MV Datum of 91.37 ft
Flow Rate	L/s to gpm	1.0 L/s = 15.9 USgpm = 13.2 Imp. gpm

6.0 Existing & Future - Servicing Catchments & Details

6.0.1 Sanitary Population Summary

City Centre is expected to grow dramatically in residential, institutional, and commercial populations. This section identifies future populations as well as equivalent populations generated to determine sewage loadings. The origins of this information are provided in ***Appendix A***. These populations were developed specifically for predicting future sewage loadings in City Centre and are not intended for other uses.

The study area is divided into two basic sanitary catchment areas by the local topography, as shown in ***Figure 6.2***. The northern City Centre catchment is collected by gravity and flows into the Greater Vancouver Sewerage and Drainage District (GVS&DD) North Surrey Interceptor. The southern City Centre catchment is collected by gravity at the Quibble Creek Pump Station and pumped to a trunk main in the northern catchment, which in turn flows into the GVS&DD North Surrey Interceptor. Both catchments discharge to the regional system at 132 Street and 114 Avenue.

It is important to recognize that sewer catchments contributing to the sanitary network within the study area extend beyond the City Centre boundaries and are incorporated as part of this analysis. For the purposes of this report, populations within City Centre are identified as “Internal”, and contributing catchments with residential and institutional land uses located adjacent to the City Centre boundary are identified as “External”.

Some residential areas within the south west region of City Centre drain to sanitary sewers that are located outside of the City Centre boundary. To analyze these sewers it was necessary to consider additional catchments contributing flow to these pipes that are outside of City Centre. These catchments have been labelled as “External 2”. External 2 existing and future populations were estimated with the same unit population densities as External 1. ***Figure 6.2*** graphically identifies the external and internal catchment areas.

The City provided internal residential population, residential units, and employment populations for each scenario horizon. Currently, there is no existing or foreseen future industrial land uses to occur within the study area and as such the population counts have been generated for residential, institutional and commercial (IC) land uses. Therefore, the following internal and external populations have been generated as follows:

Internal Populations:

- Residential populations were provided by the City based on staged growth predictions of development of the Land Use Plan **(Appendix A**). A population density of 3.75 people per single-family unit with a secondary suite at 1.93 additional people per single family residence was added to 38% of all single family homes in 2013, and 100% of all single family homes by 2023 and beyond.

- Commercial equivalent populations were generated using the City’s unit rate of 18.6 m^2/employee (200ft^2/employee) applied to commercial floor space to determine the number of employees. Employees were converted to equivalent population by a factor of 0.27 as per the ASCE Manual and Report on Engineering Practice No.60. This factor is more refined than what is prescribed in the City’s Design Criteria by including equivalent populations for offices.

- Institutional equivalent populations were generated based on the type of facility and projected occupancy. The rates for sanitary flows per unit type were extracted from the 2010 Sewer Model. Details for these facilities are provided in ***Appendix A***. Institutional bed and student estimates were provided by the Fraser Health Authority and Surrey School District respectively. As per the City’s 2004 Design Criteria Manual, an average dry weather flow (ADWF) of 350 l/c/d was used.

External Populations:

- The population external to the City Centre Plan area that contributes to flows into the sanitary pipe network is identified as External 1. As noted earlier, this area drains to sanitary sewers that are located outside of the City Centre boundary. Information for External 1 was provided by the City in the form of a total population evenly distributed over an identified service area (***Appendix A***). Population was then allocated to each lot by applying the unit population density to the area of contributing lots.
- An average population density determined from the external catchment information provided by the City, was applied to the lots in External 2 to estimate the residential population.
- External 1 was reported as having only institutional and residential land uses, and External 2 is exclusively residential.

Table 6.2 summarizes the total equivalent populations used in the sanitary sewer network analysis. Further details as to how equivalent populations for institutional have been generated are provided in **Appendix A** for each horizon year.

Table 6.2 Summary of Sanitary Populations by Horizon Year

Horizon	Catchment	Equivalent Population			Total Equivalent Population	Total Equivalent Population
		Residential*	Commercial**	Institutional***		
Existing (2013)	Internal	33,812	6,368	2,239	42,419	50,951
	External 1	5,645	0	1,907	7,553	
	External 2	980	0	0	980	
2023	Internal	52,442	7,471	2,758	62,671	75,561
	External 1	9,203	0	2,159	11,362	
	External 2	1,528	0	0	1,528	
2033	Internal	71,858	8,730	3,290	83,878	99,393
	External 1	11,217	0	2,436	13,653	
	External 2	1,862	0	0	1,862	
2043	Internal	92,106	10,190	3,376	105,672	121,371
	External 1	11,217	0	2,620	13,837	
	External 2	1,862	0	0	1,862	
Build Out	Internal	160,599	15,274	3,927	179,800	196,466
	External 1	11,217	0	3,587	14,804	
	External 2	1,862	0	0	1,862	

** Residential equivalent populations based on residential populations provided by the City.*
*** Commercial equivalent populations based on employment populations provided by the City and applying a factor of 0.27 as per the ASCE Manual and Report on Engineering Practice No.60.*
**** Institutional equivalent populations based on populations provided by the City, Surrey School District, and Fraser Health Authority.*

6.0.2 Sanitary Flow

Sanitary flows for City Centre were determined as follows:

ADWF

Average dry weather flow (ADWF) was calculated as per the City of Surrey Engineering Department Design Criteria Manual (May 2004) based on a per capita sewage flow rate of 350 L/c/d and the populations determined in **Section 6.0.1**.

PDWF

A Harmon Peaking factor, calculated as per section 4.0 of the City of Surrey Engineering Department Design Criteria Manual (May 2004), was applied to the ADWF on a catchment by catchment basis to calculate peak dry weather flow (PDWF).

Inflow and Infiltration

Inflow and infiltration (I&I) rates for City Centre were provided by the City in the form of shape file titled City_Centre_Lots.shp that identifies I&I unit rates at the lot level. The shape file is based on monitoring results observed by the GVS&DD and the City. A map of I&I levels and their distribution is included as ***Figure 6.3***.

I&I unit rates were applied to lot area to calculate I&I for individual lots. An additional 20% surcharge was added to the calculated I&I to account for road ways.

PWWF

Peak dry weather flow (PDWF) was combined with I&I on a catchment by catchment basis to calculate peak wet weather flow (PWWF).

6.1 Hydraulic Model Development

The City Centre sanitary hydraulic model was developed in Microsoft Excel utilizing attribute tables from the City's GIS database, performance criteria from the City of Surrey Engineering Department Design Criteria Manual (May 2004), and the flow rates identified in ***Section 6.0.2***.

Sanitary Pipe Network

The sanitary pipe network attributes for City Centre were imported from the City's GIS database. Attributes imported included:

- Upstream invert;
- Downstream invert;
- Length; and
- Diameter.

As per the City of Surrey Engineering Department Design Criteria Manual (May 2004) the full pipe capacity for each pipe was calculated using the Manning equation. A Manning's coefficient of roughness n= 0.013 was applied to all pipes.

Sanitary Catchments

Sanitary sub-catchments were developed around block length manhole to manhole pipe segments. Lots connected to each pipe segment were identified as a sub-catchment and their flow was assigned to the pipe segment's upstream manhole. The total number of sub-catchments in the sanitary model is 283. A catchment map is provided as ***Figure 6.4***.

The catchment assigned to each pipe segment included all sub-catchments upstream of the pipe segment plus any catchments attached to the pipe segment. Sanitary flows for each catchment were determined based on the populations and the sanitary flow information previously identified.

Lot attributes, including lot area and sanitary sewer connection location, were obtained from the City's GIS database.

6.2 Design Criteria & Analysis

6.2.1 Evaluation of Existing Sanitary Mains

Existing sanitary mains were evaluated for capacity based on the following criteria from the City of Surrey Engineering Design Criteria Manual (May 2004):

- Local sewers must not have a flow that exceeds 70% of full pipe capacity ($Q_d/Q_f \leq 0.70$) or a depth exceeding 62% of the internal diameter of the sewer; and,
- Interceptor and trunk sanitary mains shall not have a flow that exceeds 83.6% of full pipe capacity ($Q_d/Q_f \leq 0.836$) or a depth exceeding 70% of the internal diameter of the sewer.

6.2.2 Design Criteria for New Sewers

Design criteria for replacement or new sewers as per the City of Surrey Engineering Design Criteria Manual (May 2004, with updates) were as follows:

- Local sewers are designed as open channels with depth of flow, under maximum design flow conditions, not exceeding 50% of full pipe capacity ($Q_d/Q_f \leq 0.50$) or a depth exceeding 50% of the internal diameter of the sewer;
- Interceptor and trunk sewers are designed such that flow under maximum design flow conditions does not exceed 83.6% of full pipe capacity ($Q_d/Q_f \leq 0.836$) or have a depth that does not exceed 70% of the internal diameter of the sewer;
- Minimum sewer sizes are:
  - 200 mm diameter – for single family residential lands, and all other zoned lands with less than 90 ppha,
  - 250 mm diameter – for non-residential zones, residential zones, and all other zoned lands equal to or more than 90 ppha,
  - Minimum sewer sizes above also applies to the frontal sewer for the development that has existing sewer,
  - For new extensions, no reduction in pipe size shall be made for pipes downstream, irrespective of grade provided on the pipe, unless specifically approved, in writing, by the Engineer;
- Nominal depth of sewers are to be between 2.0 meters and 3.5 meters;
- The terminal section of sanitary sewer, servicing 6 or less house service connections, shall have a minimum grade of 1.0%;
- A sanitary sewer, servicing the 7th to 12th house service connections, shall have a grade of 0.6% or greater;
- A sanitary sewer, servicing the 13th house service connection (or more), shall have a grade of 0.5% or greater; and
- Pipe grades less than 0.5% may only be used once peak wet weather flow produces a flow velocity in excess of 0.6 m/s, accounting for dynamics of partial pipe flow

6.3 Servicing Options & Proposed System

6.3.1 City Centre Sanitary Sewer Capacity Deficiencies

The design flow (Q_d) was calculated for each pipe in the City Centre sanitary pipe network for existing (2013), 2023, 2033 and 2083 Sewer Equivalent Build Out scenarios. The Q_d was compared to the full pipe capacity (Q_f) and evaluated against the design criteria. A summary of pipelines with identified hydraulic deficiencies is tabulated below in ***Table 6.3*** and is presented graphically in ***Figure 6.5****.*

Table 6.3 Sanitary Sewer Base Scenario Capacity Deficiencies

Existing Sanitary Pipe Diameter (mm)	2013 (m)	2023 (m)		2033 (m)		2043 (m)		BO (m)	
		Phasing	Cumulative	Phasing	Cumulative	Phasing	Cumulative	Phasing	Cumulative
100	46	0	46	0	46	0	46	0	46
150	515	112	627	899	1,526	390	1,915	2,078	3,993
200	2,932	3,757	6,689	2,321	9,010	2,314	11,324	5,008	16,332
250	293	12	305	314	619	94	713	6	719
300	468	0	468	340	808	0	808	212	1,020
350	0	0	0	0	0	39	39	457	496
450	9	198	207	120	327	192	520	41	561
525	0	0	0	0	0	114	114	402	517
600	0	0	0	113	113	4	117	42	159
675	0	0	0	15	15	0	15	5	20
750	0	0	0	0	0	0	0	0	0
900	0	0	0	0	0	0	0	0	0
TOTAL	**4,264**	**4,079**	**8,343**	**4,122**	**12,465**	**3,147**	**15,612**	**8,253**	**23,864**
Pump Stations and Forcemains	-	1 additional pump required at Quibble Creek PS		Twin 1,598 m of existing 500 mm forcemain with 675 mm		-		Twin 718 m of existing 600 mm forcemain with 600 mm	

6.3.2 City Centre Sanitary Sewer Improvement Scenarios

A number of sanitary sewer diversion scenarios were developed and compared to the base option of simply upsizing pipes that become undersized in the future as per ***Table 6.3***. The following includes a description of benefits accrued through the recommended diversions.

6.3.2.1 132 Street Diversion

This scenario diverts the sanitary gravity main on 132 Street into the sanitary gravity main on 104 Avenue. It avoids future capacity problems and associated improvements for 745 m of the sanitary gravity main on 132 Street north of 104 Avenue.

To accommodate the connection of the 132 Street gravity main the 104 Avenue gravity main must be lowered from 133A Street for 160 m west to 133 Street. These pipes are identified as requiring capacity upgrades in the future with or without the connection of the 132 Street gravity main, therefore the diversion project can financially "piggy back" on the capacity upgrade.

6.3.2.2 Hilton Road Diversion

The Hilton Road Diversion connects the sewers on Bentley Road between Hilton Road and 136 Street. This diversion allows the sewers on Hilton Road and Bentley Road to flow to the interceptor on King George Blvd via Bentley Road rather than the longer existing 136 Street route. The Hilton Road diversion reduces flows in the 136th Street gravity main, reducing the long term capacity improvements required for the 136th Street gravity main and those mains downstream of the 136th Street gravity main.

6.3.2.3 100 Avenue Diversion

The existing sanitary system includes a split flow manhole (# 6961) on 100 Avenue west of 138A Street. This split currently directs 75% of the flow to sanitary catchment N14 and 25% of the flow north to catchment N04. The split flow directed to sanitary catchment N14 is ultimately pumped by the Quibble Creek Pump Station into a gravity interceptor at 102 Avenue and City Parkway. The split flow directed to sanitary catchment N04 flows by gravity to the interceptor at 105A Avenue and University Dr.

The current flow split allows the City to avoid some pumping energy costs through utilization of the gravity network north of the split flow manhole. As flows increase due to growth, neither network will be able to accommodate the flow increase without significant improvements.

To address this, three sub-options for 100 Avenue were analyzed:

- 100% of flow to Quibble Creek Pump Station (Quibble Diversion);
- 100% of flow north by gravity to the sanitary interceptor (Northern Diversion); and
- 100% of flow to Quibble Creek Pump Station until 2029, then 100% of flow to the north (Northern Variant).

Due to higher capital costs (approximately $0.5M), the Northern Diversion and Northern Variant were deemed less desirable than the Quibble Diversion option.

The existing Quibble Pump Station is currently equipped with 3 (2 duty and 1 standby) pumps and has room for one additional pump which will increase the capacity of the pump station. Pump and system curves are provided in ***Appendix A***. An NPV analysis of the Base and Quibble Diversion options for the flow in the 100 Avenue main was also completed and it was found that the Quibble Diversion option offered both capital cost and NPV benefits.

6.3.3 Proposed System

It is recommended that the 132 Street Diversion, Hilton Road Diversion, and 100 Avenue Diversion (Quibble Diversion) scenarios outlined in ***Section 6.3.2*** are implemented. ***Table 6.4*** shows that the Recommended Option reduces the total length of sewer upgrades required by 2,619m and reduces the capital cost of required upgrades by approximately $4.0M when compared to the Base Option.

Table 6.4 Scenario Comparison

Scenario	Total Length of Sewer Upgrades Required (m)	Capital Cost
Base Option	23,864	$34,770,033
Recommended Option	21,245	$30,723,541

**Does not include pump station costs*
^Cost estimates calculated from City of Surrey construction unit rates for NCPs and include project contingency

Figures 6.6 – 6.11 show the recommended system upgrades for each of the phases of development and ***Table 6.5*** lists the corresponding gravity infrastructure costs by phase. All sewer capacity upgrade costs where predicted design flows are equal to or greater than 40L/s, and the incremental sewer main upsizing costs from the required base size, are DCC eligible costs.

Table 6.5 Gravity Infrastructure Costs by Phase

Phase	Total Length of Sewer Upgrades Required (m)	Capital Cost	DCC Eligible Cost
Existing	2,562	$3,915,884	$3,333,094
2023	3,281	$5,060,106	$3,522,612
2033	4,004	$5,897,663	$3,433,101
2043	2,996	$4,366,724	$3,126,228
Build Out	8,402	$11,483,164	$4,976,800
Total	**21,245**	**$30,723,541**	**$18,391,835**

^Cost estimates calculated from City of Surrey construction unit rates for NCPs and include project contingency

Table 6.6 lists the pump station and forcemain costs by phase. All pump station and forcemain costs are DCC eligible.

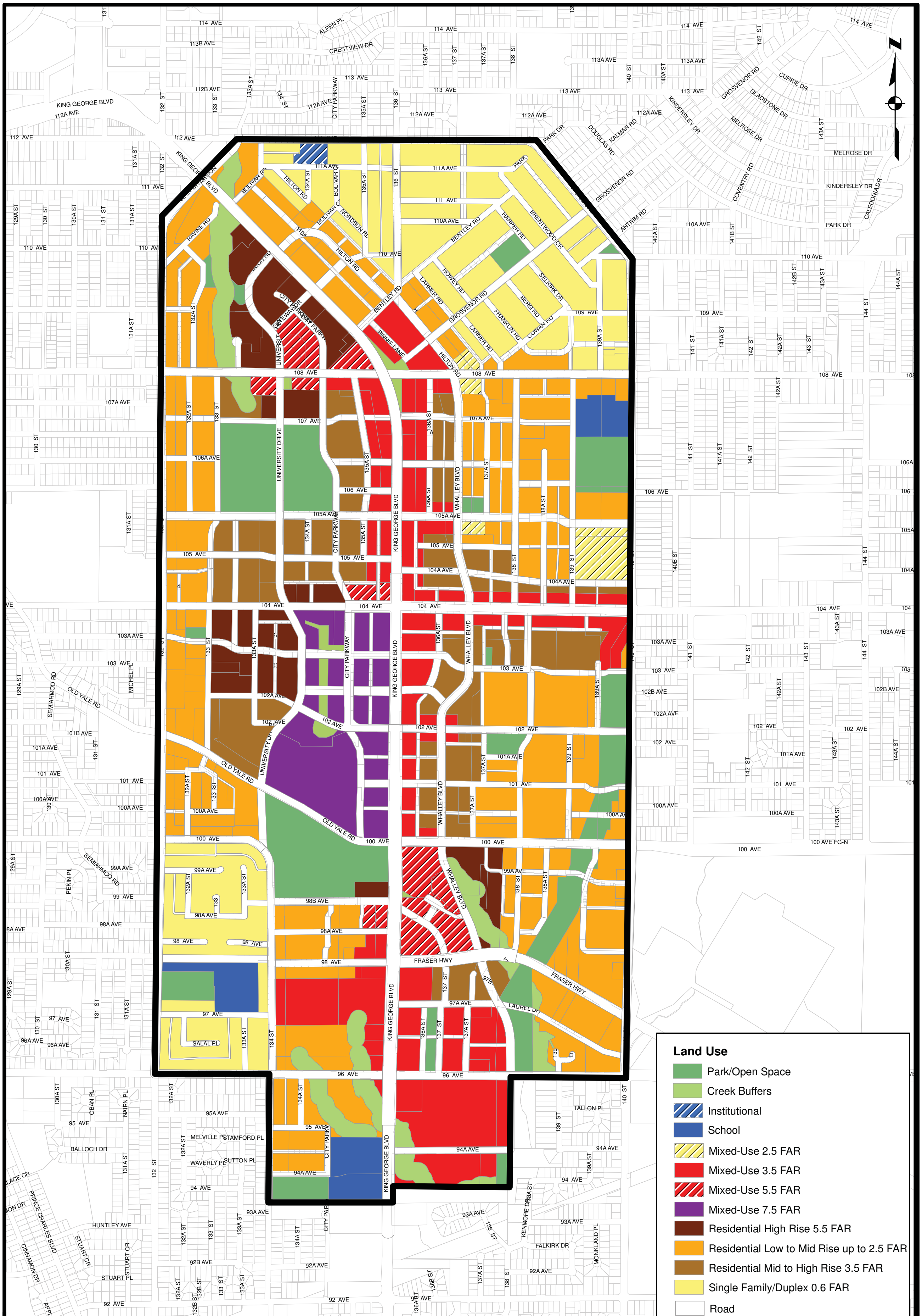
Table 6.6 Pump Station and Forcemain Costs by Phase

Recommended Improvements	Upgrade Year	Unit Cost	Capital Cost	DCC Cost
Add 1 – 225 L/s pump to Quibble Creek Pump Station (4th Pump) for a firm capacity of 347L/s	2019	$110,000	$110,000	$110,000
Twin 1,598 m of 500 mm diameter forcemain with 675mm diameter from the pump station along 94A Ave – 138 St ending at 100 Ave/Whalley Blvd.	2030	$2,125	$3,395,750	$3,395,750
Twin 718 m of 600mm diameter forcemain with 600mm diameter at 100 Ave/Whalley Blvd -102 Ave – 102 Ave/City Pkwy.	2073	$1,950	$1,400,100	$1,400,100
		Total	$4,905,850	$4,905,850

6.4 10 - Year Servicing Plan

DCC eligible projects total $23,297,685. The pump installation in the Quibble Creek Pump Station is the only project included in the 2014 – 2023 10 Year Servicing Plan. It is recommended that all of the DCC eligible projects be included in future 10 Year Servicing Plans.

A detailed schedule of recommended sewer system improvements is tabulated in ***Appendix A*** including existing infrastructure description, new infrastructure description, estimated implementation date, cost, and 10 Year Servicing Plan Project ID number.



CITY OF SURREY
the future lives here.

City Centre Plan 2013 Update
Utility Servicing Strategy

Project No.	Date
60278179	August 2013

Legend

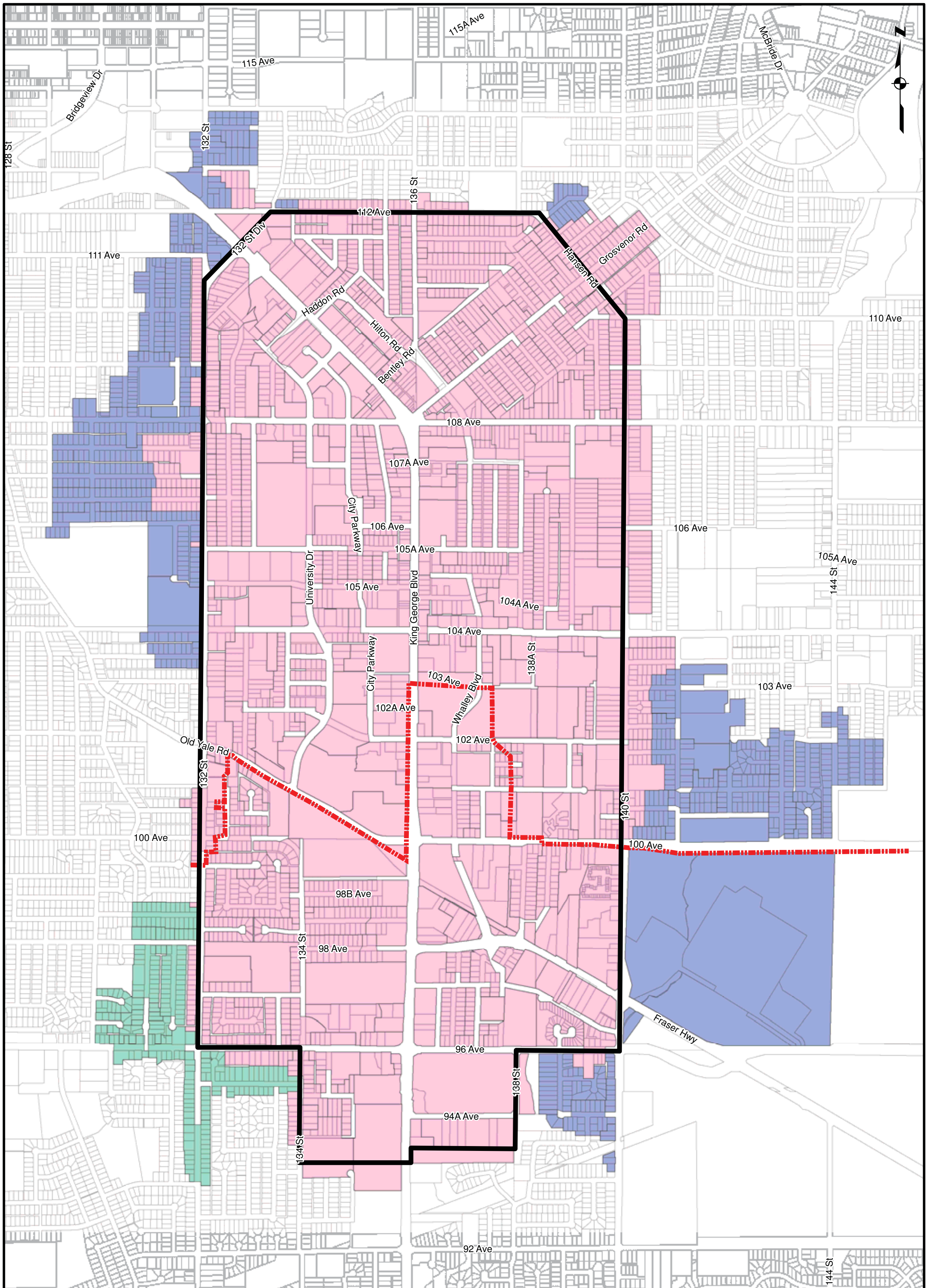
City Centre Boundary

AECOM

200 100 0 200 Meters

City Centre Plan
(Build-Out)

FIGURE 6.1



Surrey City Centre Plan Update
Utility Servicing Strategy

Project No: 60278179

Date: July 2014

Legend

- City Centre Boundary
- North - South Sanitary Catchment Boundary

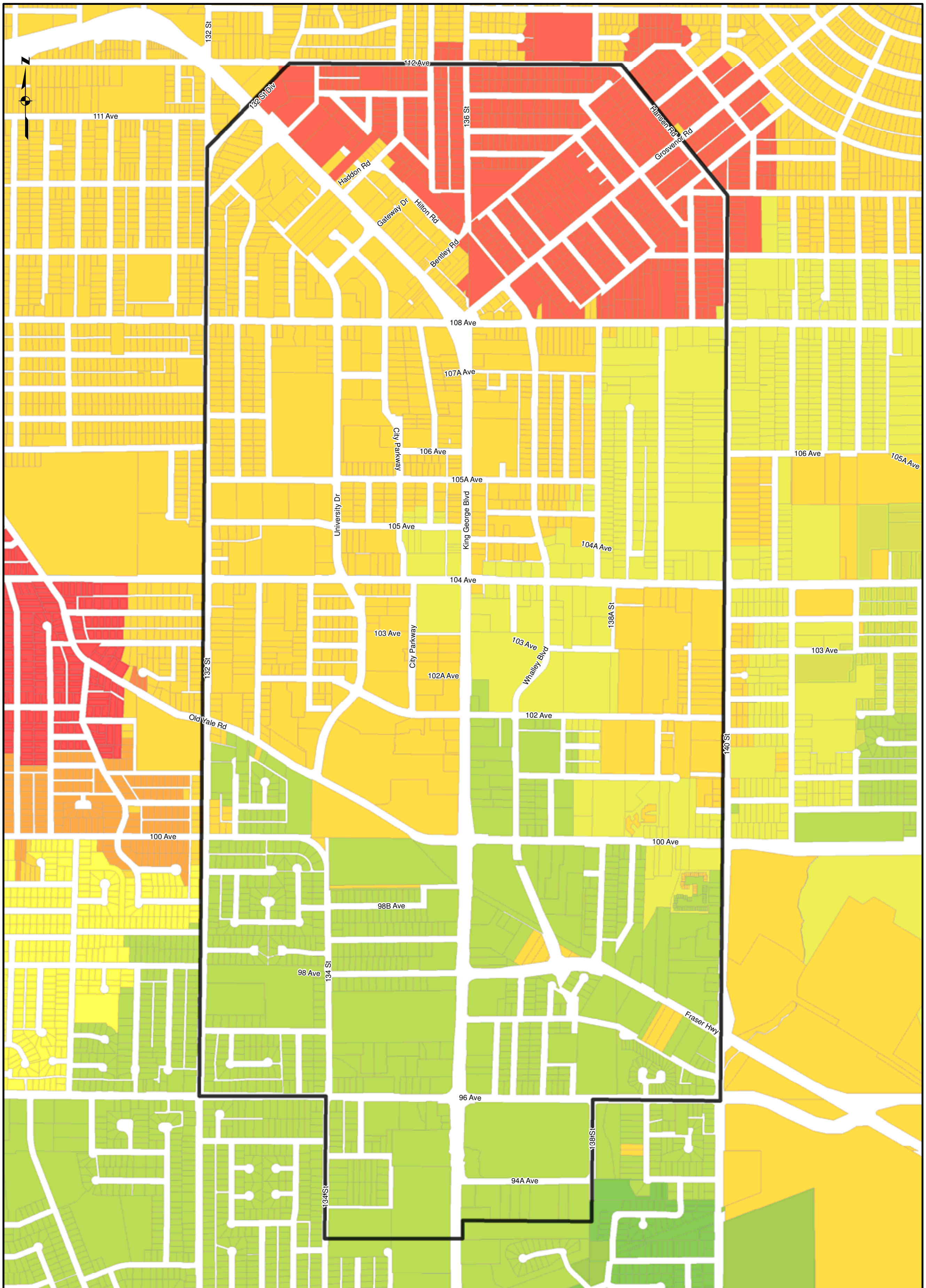
Catchment Area

- Internal
- External 1
- External 2

0 100 200 400 Meters

Sanitary Catchments

FIGURE 6.2



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Utility Servicing Strategy

Project No: 60278179

Date: July 2014

Legend

City Centre Boundary

Infiltration Rates

L/Ha/Day

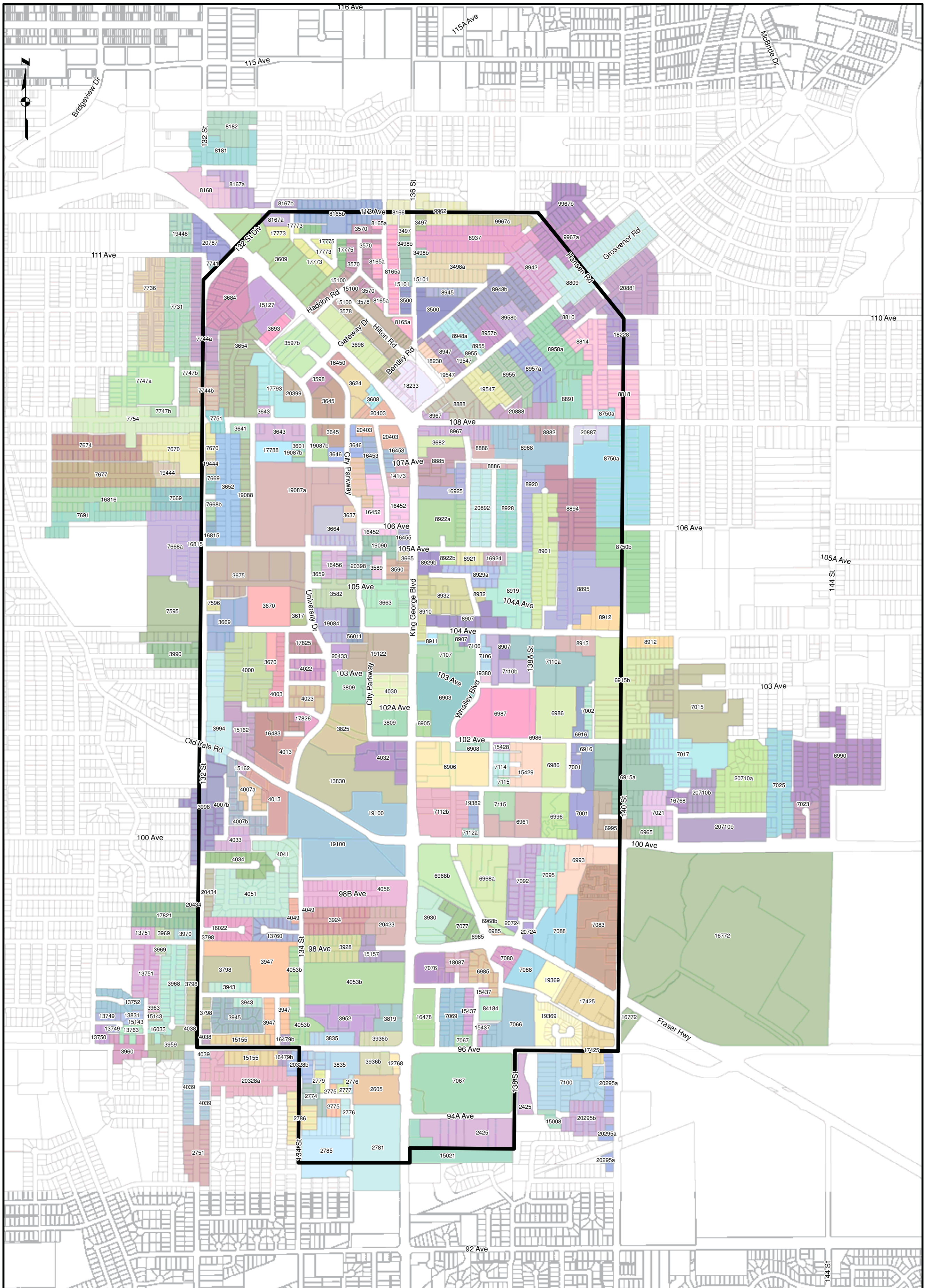
- 9,947
- 11,975
- 15,600
- 17,574
- 17,808
- 24,031
- 28,940
- 30,000
- 39,594
- 40,062
- 61,536
- 122,077

AECOM

0 50 100 200 300 400 500 Meters

Inflow and Infiltration Rates

FIGURE 6.3



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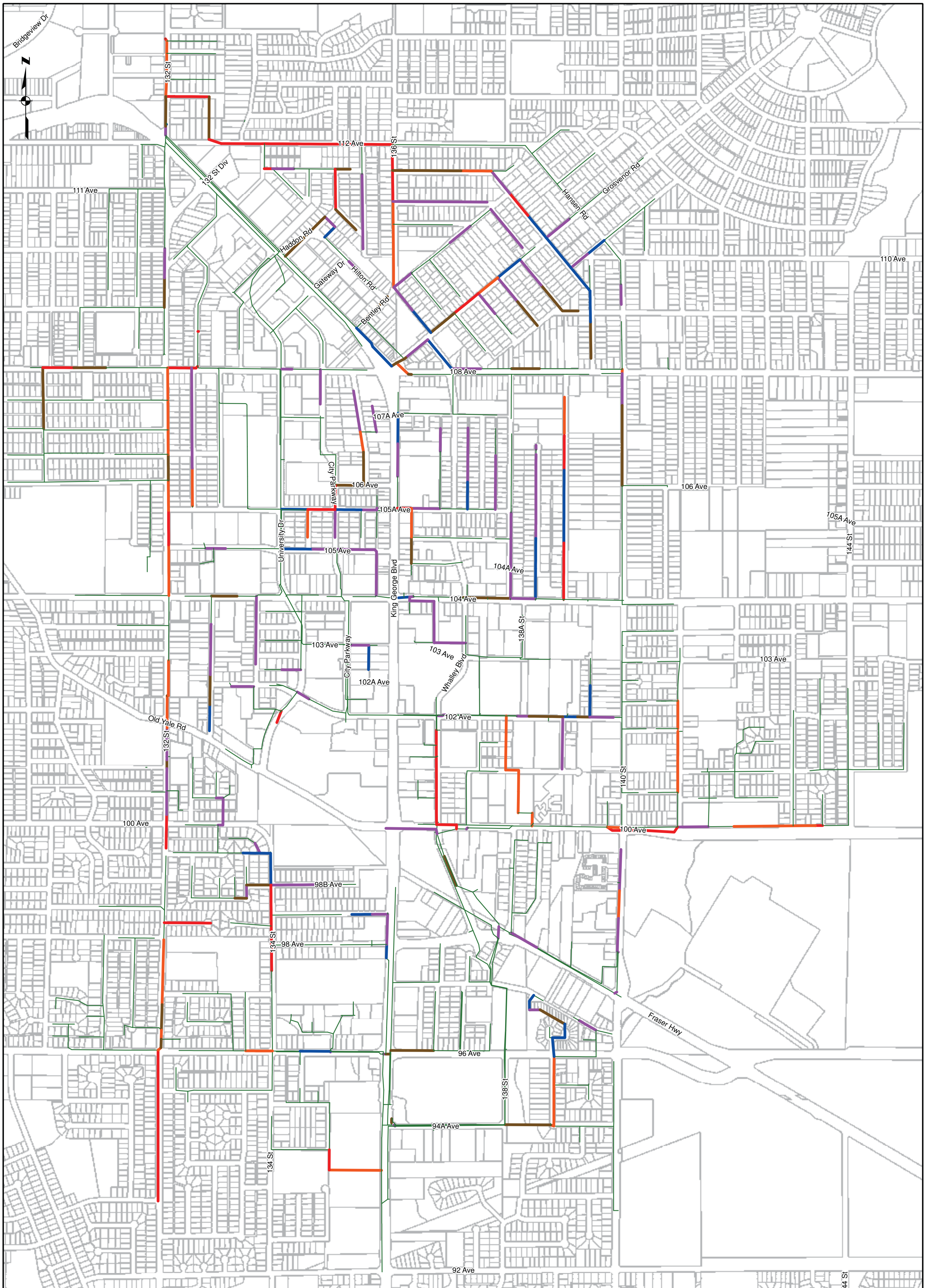
Sanitary Sub-Catchments

FIGURE 6.4



Surrey City Centre Plan Update
Utility Servicing Strategy

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Legend

Upgrade Year

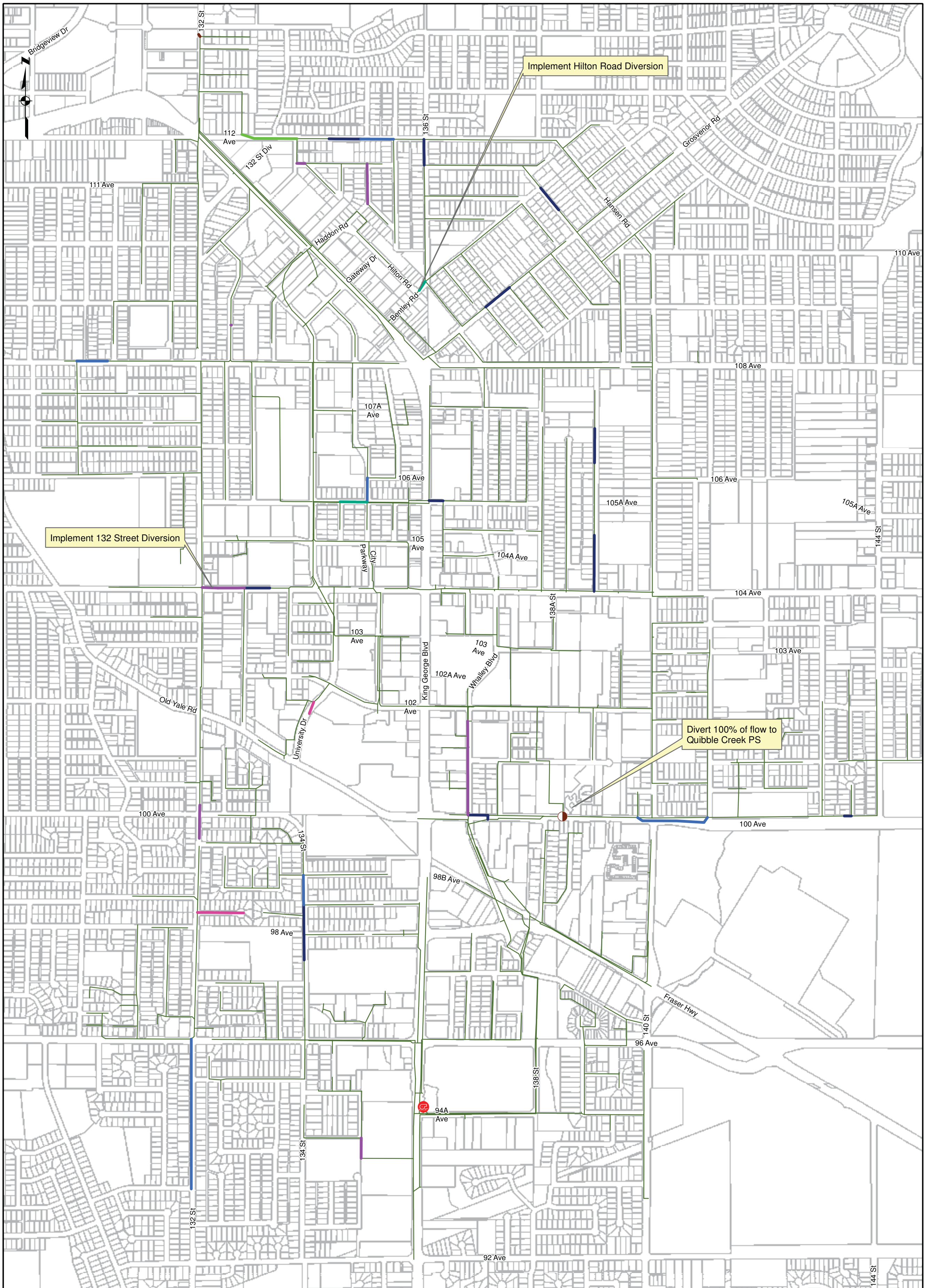
- 2013
- 2023
- 2033
- 2043
- 2083
- No Upgrade Required

AECOM

0 50 100 200 300 400 500 Meters

Base Scenario
without Diversions
Sanitary Pipelines with
Hydraulic Deficiencies
2013 - 2083 MBO

FIGURE 6.5



Legend

Pipe Upgrades

- 200
- 250
- 300
- 375
- 450
- 525
- 600
- 675
- 750
- 900

- Sanitary Network
- Quibble Creek Pump Station
- Split Flow Manhole

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Utility Servicing Strategy

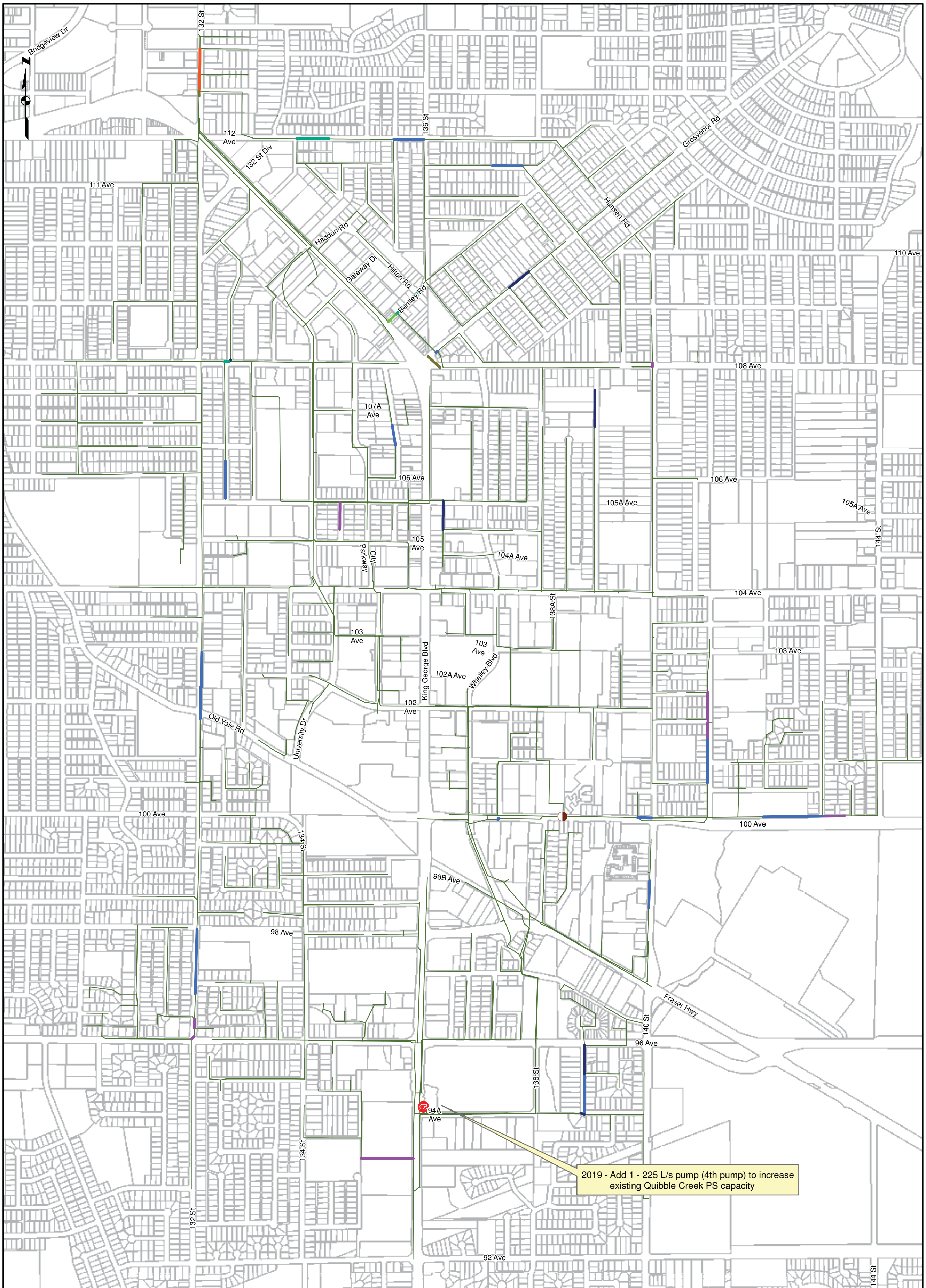
AECOM

0 50 100 200 300 400 500 Meters

Project No:	Date:
60278179	July 2014

2013
Recommended Sanitary Capacity Upgrades

FIGURE 6.6



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Surrey City Centre Plan Update
Utility Servicing Strategy

Project No: 60278179

Date: July 2014

Legend

Upgrade Year

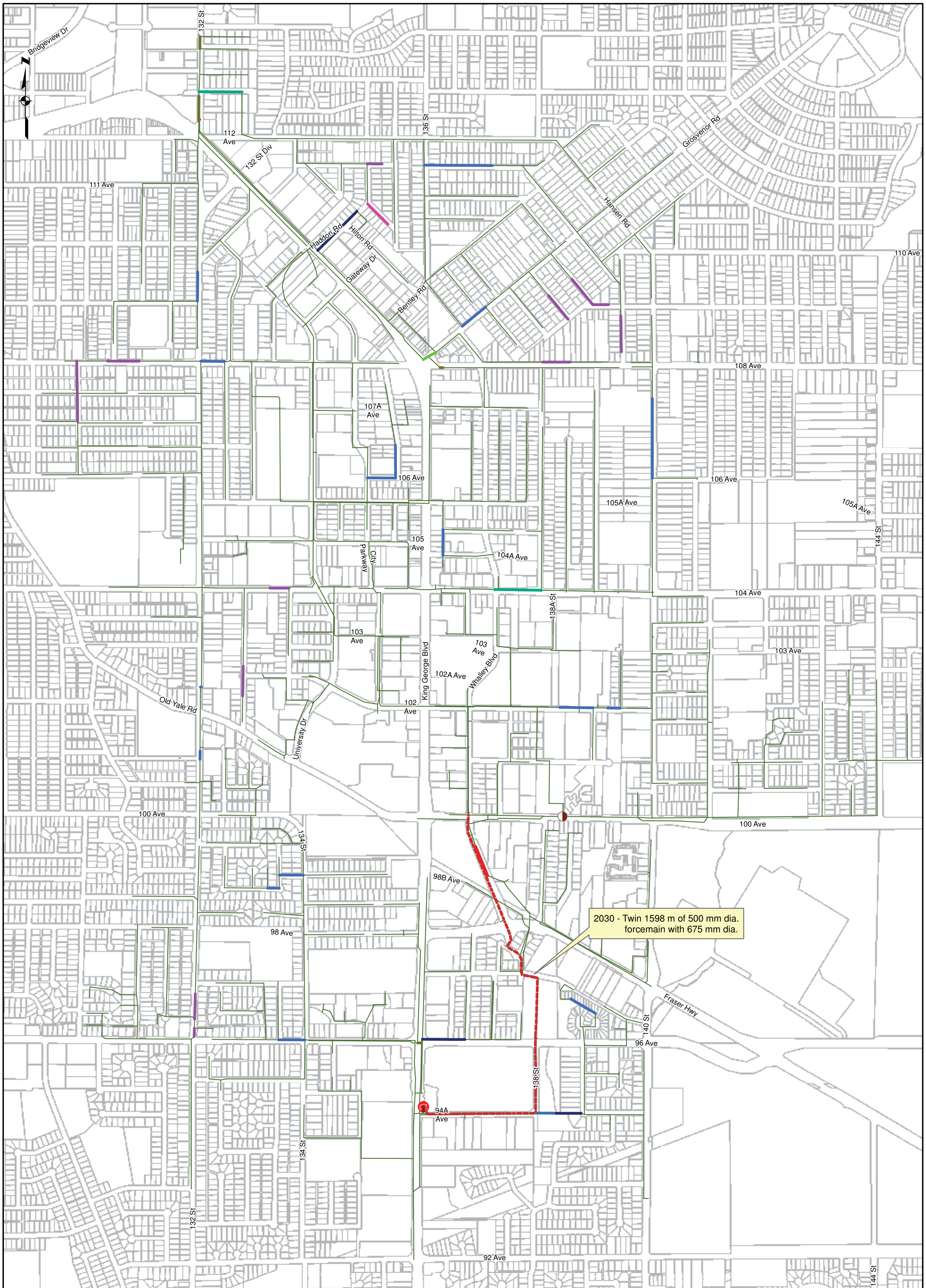
- 200
- 250
- 300
- 375
- 450
- 525
- 600
- 675
- 750
- 900
- Sanitary Network
- Quibble Creek Pump Station
- Split Flow Manhole

AECOM

0 50 100 200 300 400 500 Meters

2014 - 2023
Recommended Sanitary
Capacity Upgrades

FIGURE 6.7



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Surrey City Centre Plan Update
Utility Servicing Strategy

Project No: 60278179

Date: July 2014

Legend

Pipe Upgrades

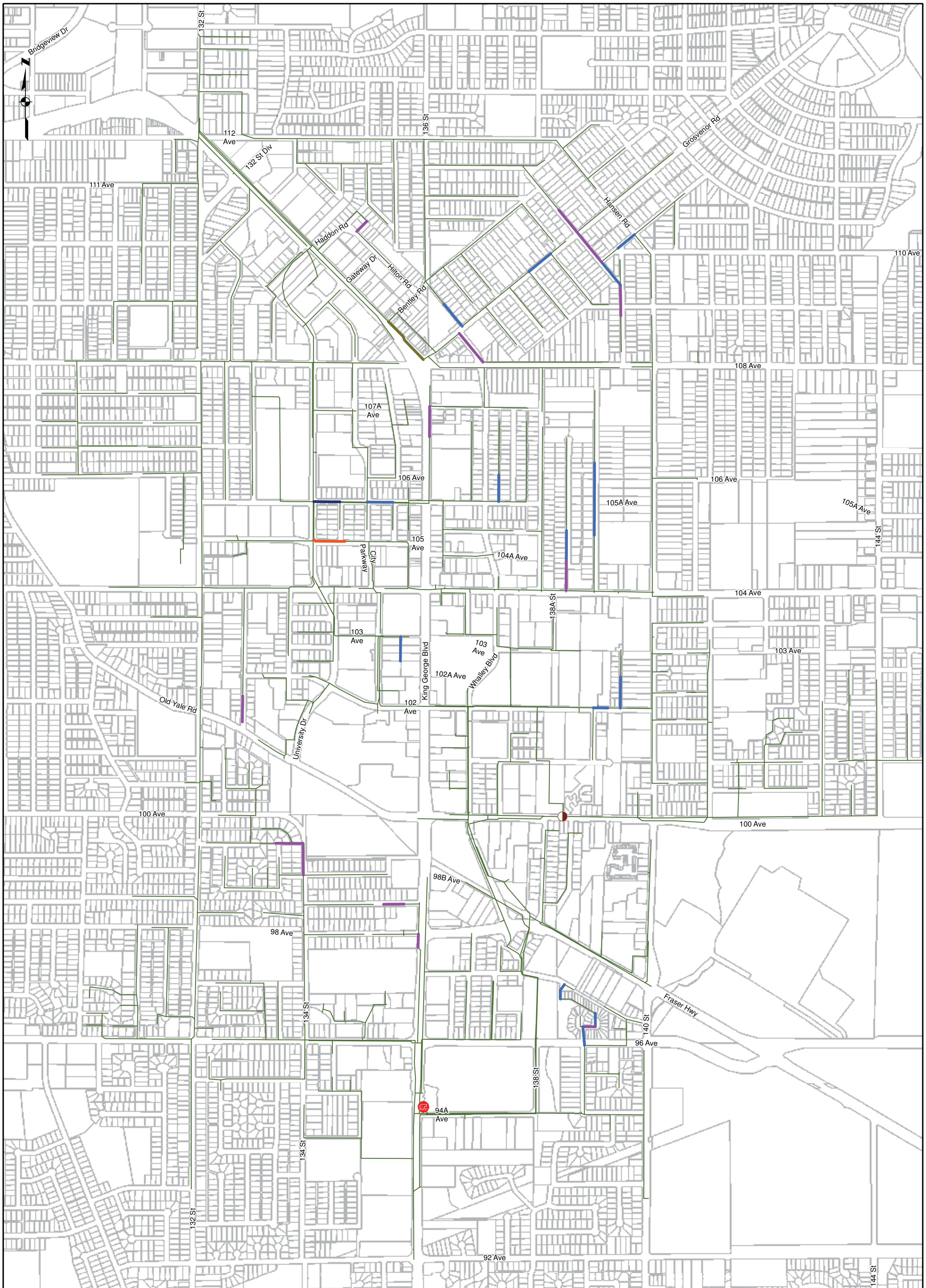
200	525	Forcemain Upgrade
250	600	Sanitary Network
300	675	Quibble Creek Pump Station
375	750	Split Flow Manhole
450	900	

AECOM

0 50 100 200 300 400 500 Meters

2024 - 2033
Recommended Sanitary Capacity Upgrades

FIGURE 6.8



Legend

Pipe Upgrades

- 200
- 250
- 300
- 375
- 450
- 525
- 600
- 675
- 750
- 900

Sanitary Network

Quibble Creek Pump Station

Split Flow Manhole

0 50 100 200 300 400 500 Meters

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Utility Servicing Strategy

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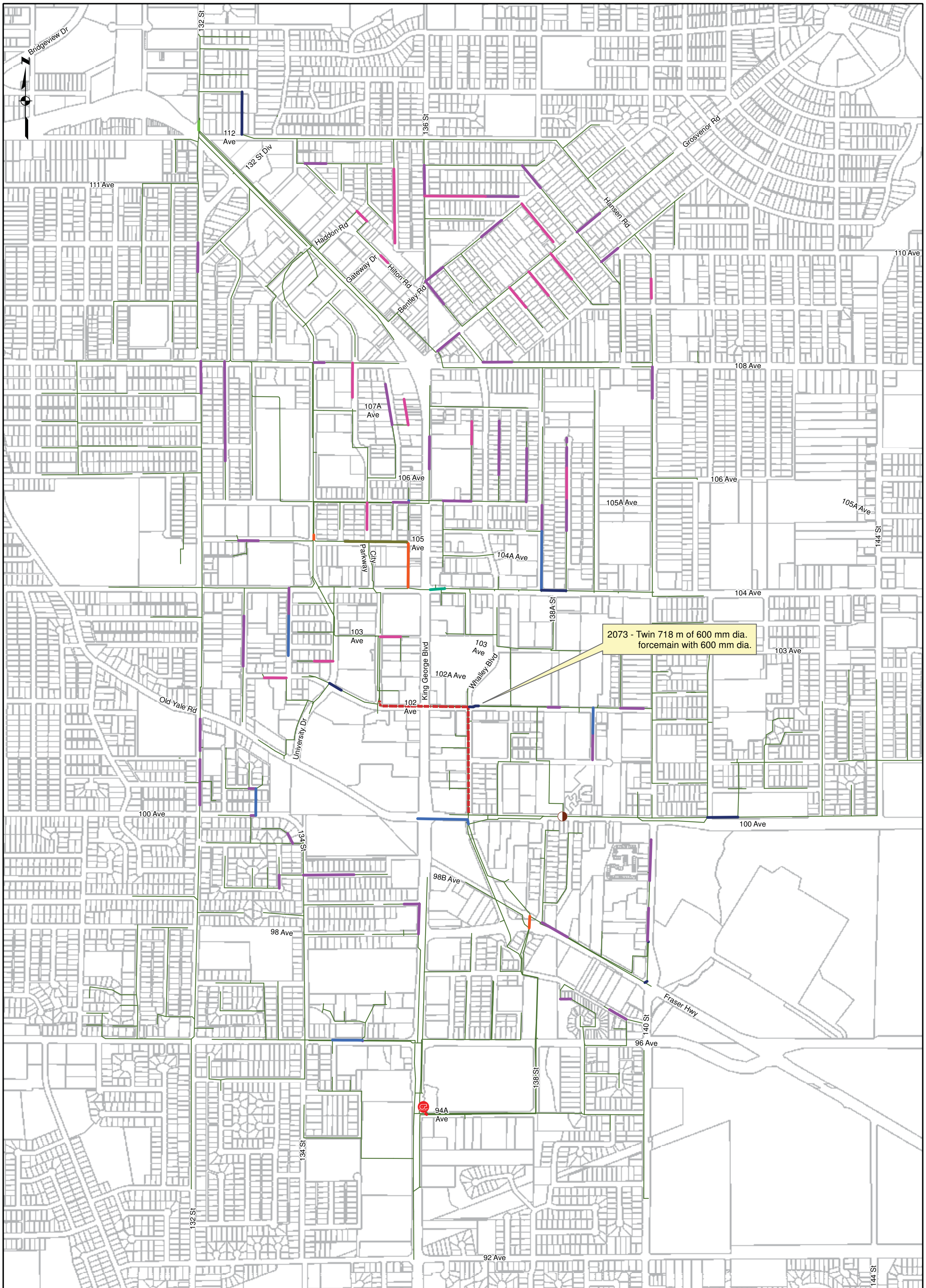
2034 - 2043 Recommended Sanitary Capacity Upgrades

FIGURE 6.9



Legend

Pipe Upgrades

- 200
- 250
- 300
- 375
- 450
- 525
- 600
- 675
- 750
- 900
- Forcemain Upgrade
- Sanitary Network
- Quibble Creek Pump Station
- Split Flow Manhole

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Utility Servicing Strategy

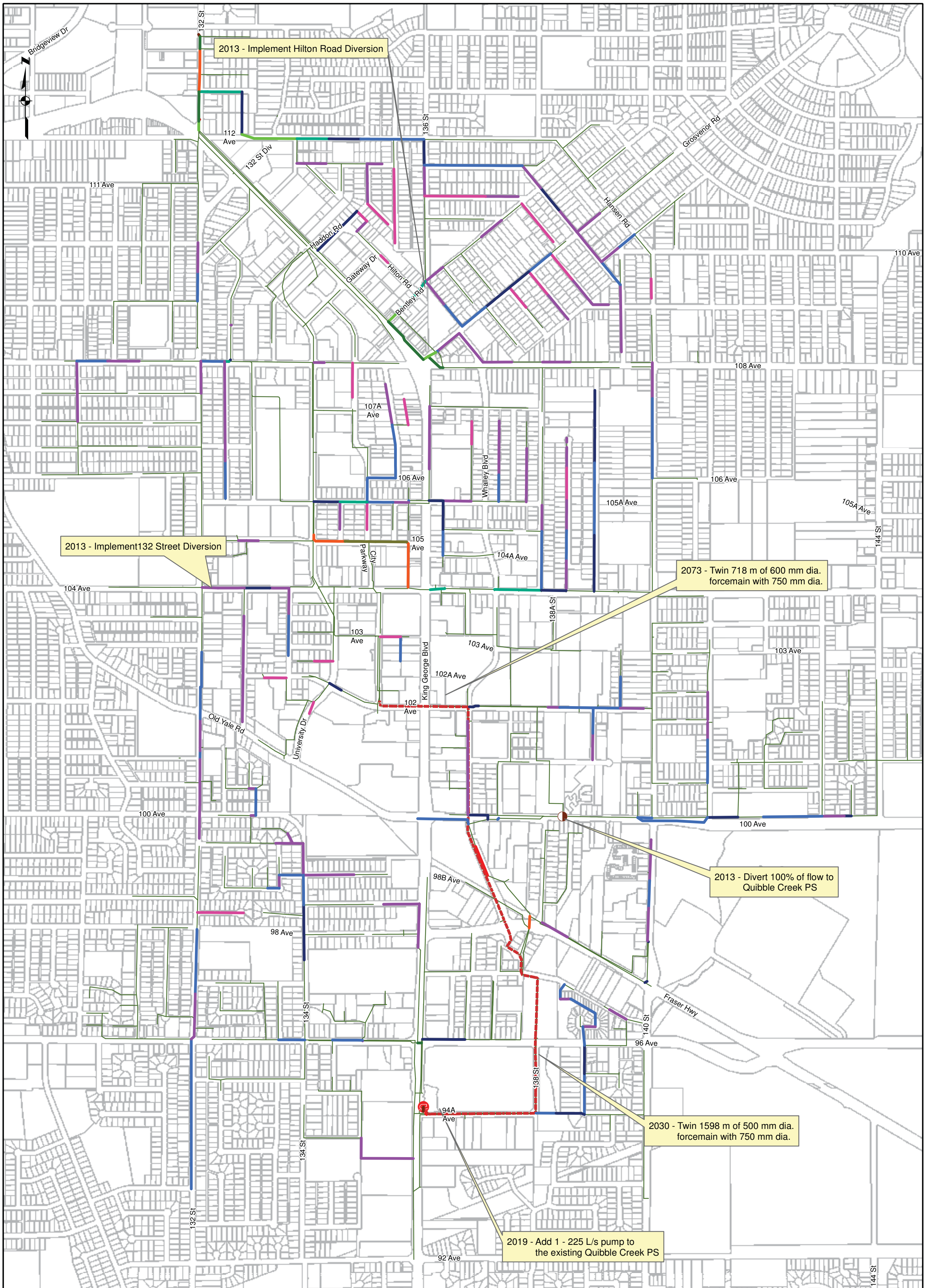
Project No:	Date:
60278179	July 2014

AECOM

Meters
0 50 100 200 300 400 500

2044 - MBO
Recommended Sanitary
Capacity Upgrades

FIGURE 6.10



Legend

Pipe Upgrades

- 200
- 250
- 300
- 375
- 450
- 525
- 600
- 675
- 750
- 900
- Forcemain Upgrade
- Sanitary Network
- Quibble Creek Pump Station
- Split Flow Manhole

Meters
0 60 120 240 360 480 600

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Utility Servicing Strategy

Project No: 60278179

Date: July 2014

AECOM

2013 - MBO Recommended Sanitary Capacity Upgrades

FIGURE 6.11

APPENDIX A: SANITARY DETAILS

- ☐ 2013 Population Horizon
- ☐ 2023 Population Horizon
- ☐ 2033 Population Horizon
- ☐ 2043 Population Horizon
- ☐ Build Out Year 2083 - Sewer Equivalent Build Out Population Horizon
- ☐ 2013 Gravity Sewer Capacity Upgrades
- ☐ 2014 - 2023 Gravity Sewer Capacity Upgrades
- ☐ 2024 - 2033 Gravity Sewer Capacity Upgrades
- ☐ 2034 - 2043 Gravity Sewer Capacity Upgrades
- ☐ 2044 - BO Gravity Sewer Capacity Upgrades
- ☐ DCC Eligible Gravity Main Projects
- ☐ DCC Eligible Gravity Main Upsizing Projects
- ☐ DCC Eligible Pump Station and Forcemain Projects
- ☐ Quibble Creek Pump Station System Curve
- ☐ Sanitary Sub-Catchments Load Assignment
- ☐ City Centre Projected Growth Areas for Development Staging Scenarios

A1. 2013 Population Horizon

Internal residential and commercial populations are generated as previously described in Part 6. Institutional facilities along with their population equivalence are listed in ***Table 1***.

Table 1 2013 Internal Institutional Sanitary Population Equivalent

Facility	Units	Flow Per Unit	Institutional Equivalent Population
Surrey Memorial Hospital	500 beds	900 L/bed/d	1,286
Laurel Place Retirement Home	191 beds	650 L/bed/d	355
Forsyth Road Elementary School	271 students	45 L/student/d	35
AHP Mathew Elementary School	426 students	45 L/student/d	55
Queen Elizabeth Secondary School	1435 students	90 L/student/d	369
Cherington Place Retirement Home	75 beds	650 L/bed/d	139
		Total =	**2,239**

External residential populations are generated as previously described in Part 6, and there is no commercial component. External institutional facilities are listed in ***Table 2*** with their population equivalents. For the existing Simon Fraser University (SFU), there are no residents living in this facility and only students and teachers are present. As such, the SFU population has already been accounted for in the 7.5 FAR where future residential and apartments may be built.

Table 2 2013 External Institutional Sanitary Population Equivalent

Facility	Units	Flow Per Unit	Institutional Equivalent Population
Jim Pattison Outpatient Care & Surgery Centre	1,600 patients	125 L/patient/d	571
RCMP E-Division	3,000 employees	94.5 L/employee/d	810
Discovery Elementary School	104 students	45 L/student/d	13
KB Woodward Elementary School	475 students	45 L/student/d	61
Kwantlen Park Secondary School	1,495 students	90 L/student/d	384
Lena Shaw Elementary School	530 students	45 L/student/d	68
		Total =	**1,907**

Table 3 summarizes the 2013 existing sanitary populations for internal and external catchments.

Table 3 2013 Total Sanitary Equivalent Population

Category	Internal	External 1	External 2	**Total**
2013 Residential	33,812	5,645	980	**40,437**
2013 Commercial	6,368	0	0	**6,368**
2013 Institutional	2,239	1,907	0	**4,146**
2013 Total =	**42,419**	**7,552**	**980**	**50,951**

A2. 2023 Population Horizon

Internal residential and commercial populations are generated as previously described in Part 6. Internal institutional facilities along with their population equivalence are listed in ***Table 4.***

Table 4 2023 Internal Institutional Sanitary Population Equivalent

Facility	Units	Flow Per Unit	Institutional Equivalent Population
Surrey Memorial Hospital	650 beds	900 L/bed/d	1,671
Laurel Place Retirement Home	191 beds	650 L/bed/d	355
Forsyth Road Elementary School	350 students	45 L/student/d	45
AHP Mathew Elementary School	550 students	45 L/student/d	71
Queen Elizabeth Secondary School	1854 students	90 L/student/d	477
Cherington Place Retirement Home	75 beds	650 L/bed/d	139
		Total =	**2,758**

External residential populations are generated as previously described in Part 6, and there is no commercial component. Institutional facilities are listed in ***Table 5*** with their population equivalents. For the existing Simon Fraser University (SFU), there are no residents living in this facility and only students and teachers are present. As such, the SFU population has already been accounted for in the 7.5 FAR where future residential and apartments may be built.

Table 5 2023 External Institutional Sanitary Population Equivalent

Facility	Units	Flow Per Unit	Institutional Equivalent Population
Jim Pattison Outpatient Care & Surgery Centre	1,830 patients	125 L/patient/d	654
RCMP E-Division	3,050 employees	94.5 L/employee/d	824
Discovery Elementary School	134 students	45 L/student/d	17
KB Woodward Elementary School	614 students	45 L/student/d	79
Kwantlen Park Secondary School	1,932 students	90 L/student/d	497
Lena Shaw Elementary School	685 students	45 L/student/d	88
		Total 2023 External Institutional Pop. =	**2,159**

Table 6 summarizes the 2023 sanitary populations for internal and external catchments.

Table 6 2023 Total Sanitary Population

Category	Internal	External 1	External 2	**Total**
2023 Residential	52,442	9,203	1,528	**63,173**
2023 Commercial	7,471	0	0	**7,471**
2023 Institutional	2,758	2,159	0	**4,917**
2023 Total =	**62,671**	**11,362**	**1,528**	**75,561**

A3. 2033 Population Horizon

Internal residential and commercial populations are generated as previously described in Part 6. Internal institutional facilities along with their population equivalence are listed in ***Table 7***.

Table 7 2033 Internal Institutional Sanitary Population Equivalent

Facility	Units	Flow Per Unit	Institutional Equivalent Population
Surrey Memorial Hospital	800 beds	900 L/bed/d	2,057
Laurel Place Retirement Home	191 beds	650 L/bed/d	355
Forsyth Road Elementary School	437 students	45 L/student/d	56
AHP Mathew Elementary School	686 students	45 L/student/d	88
Queen Elizabeth Secondary School	2,312 students	90 L/student/d	595
Cherington Place Retirement Home	75 beds	650 L/bed/d	139
		Total =	**3,290**

External residential populations are generated as previously described in Part 6, and there is no commercial component. External Institutional facilities are listed in ***Table 8*** with their population equivalents. For the existing Simon Fraser University (SFU), there are no residents living in this facility and only students and teachers are present. As such, the SFU population has already been accounted for in the 7.5 FAR where future residential and apartments may be built.

Table 8 2033 External Institutional Sanitary Population Equivalent

Facility	Units	Flow Per Unit	Institutional Equivalent Population
Jim Pattison Outpatient Care & Surgery Centre	2,100 patients	125 L/patient/d	750
RCMP E-Division	3,100 employees	94.5 L/employee/d	837
Discovery Elementary School	168 students	45 L/student/d	22
KB Woodward Elementary School	765 students	45 L/student/d	98
Kwantlen Park Secondary School	2,408 students	90 L/student/d	619
Lena Shaw Elementary School	854 students	45 L/student/d	110
		Total 2033 External Institutional Pop. =	**2,436**

Table 9 summarizes the 2033 sanitary populations for internal and external catchments.

Table 9 2033 Total Sanitary Population

Category	Internal	External 1	External 2	**Total**
2033 Residential	71,858	11,217	1,862	**84,937**
2033 Commercial	8,730	0	0	**8,730**
2033 Institutional	3,290	2,436	0	**5,726**
2033 Total =	**83,878**	**13,653**	**1,862**	**99,393**

A4. 2043 Population Horizon

Internal residential and commercial populations are generated as previously described in Part 6. Internal institutional facilities along with their population equivalence are listed in ***Table 10***.

Table 10 2043 Internal Institutional Sanitary Population Equivalent

Facility	Units	Flow Per Unit	Institutional Equivalent Population
Surrey Memorial Hospital	800 beds	900 L/bed/d	2,057
Laurel Place Retirement Home	191 beds	650 L/bed/d	355
Forsyth Road Elementary School	488 students	45 L/student/d	63
AHP Mathew Elementary School	766 students	45 L/student/d	98
Queen Elizabeth Secondary School	2,581 students	90 L/student/d	664
Cherington Place Retirement Home	75 beds	650 L/bed/d	139
		Total =	**3,376**

No future residential population information is available for the external catchments beyond 2033. Therefore the 2033 external 1 and external 2 area residential populations were maintained as the Sewer Equivalent Build Out external residential populations. ***Table 11*** summarizes the external institutional populations. For the existing Simon Fraser University (SFU), there are no residents living in this facility and only students and teachers are present. As such, the SFU population has already been accounted for in the 7.5 FAR where future residential and apartments may be built.

Table 11 2043 External Institutional Sanitary Population Equivalent

Facility	Units	Flow Per Unit	Institutional Equivalent Population
Jim Pattison Outpatient Care & Surgery Centre	2,300 patients	125 L/patient/d	821
RCMP E-Division	3,150 employees	94.5 L/employee/d	851
Discovery Elementary School	187 students	45 L/student/d	24
KB Woodward Elementary School	854 students	45 L/student/d	110
Kwantlen Park Secondary School	2,689 students	90 L/student/d	691
Lena Shaw Elementary School	953 students	45 L/student/d	123
		Total =	**2,620**

Table 12 summarizes the 2043 sanitary populations for internal and external catchments.

Table 12 2043 Total Sanitary Population

Category	Internal	External 1	External 2	**Total**
2043 Residential	92,106	11,217	1,862	**105,185**
2043 Commercial	10,190	0	0	**10,190**
2043 Institutional	3,376	2,620	0	**5,996**
2043 Total =	**105,672**	**13,837**	**1,862**	**121,371**

A5. Build Out Year 2083 - Sewer Equivalent Build Out Population

Build Out Internal Population

For residential population, the Build Out internal population is based on FAR and areas from the City Centre Plan. The plan identifies floor area ratios (FAR's) for residential and commercial usage in City Centre. Residential floor space was converted to population based on the figures in ***Table 13*** below.

Table 13 Residential Occupancy Based on FAR

FAR		People Per Unit
Low	High	
0.6	0.6	3.75 (main dwelling) + 1.93 (secondary suite) = **5.68**
2.5	2.5	**2.8**
>2.5	7.5	**1.8**

For some parcels, the residential or commercial populations were higher in the interim scenarios than in the Build Out scenario. In these cases, the highest residential population was added to the highest commercial equivalent population from any scenario to form the Build Out Scenario. The build out year is recommended for sanitary sewer sizing because of the long service life and high installation costs of sanitary infrastructure.

Institutional facilities along with their population equivalence are listed in ***Table 14.*** Institutional bed and student estimates were provided by the City and School District respectively. As per the City's 2004 Design Criteria Manual, average dry weather flow (ADWF) of 350 l/c/d was applied.

Table 14 Build Out Internal Institutional Sanitary Population Equivalent

Facility	Units	Flow Per Unit	Institutional Equivalent Population
Surrey Memorial Hospital	800 beds	900 L/bed/d	2,057
Laurel Place Retirement Home	191 beds	650 L/bed/d	355
Forsyth Road Elementary School	813 students	45 L/student/d	105
AHP Mathew Elementary School	1,278 students	45 L/student/d	164
Queen Elizabeth Secondary School	4,305 students	90 L/student/d	1,107
Cherington Place Retirement Home	75 beds	650 L/bed/d	139
		Total =	**3,927**

For the existing Simon Fraser University (SFU), there are no residents living in this facility and only students and teachers are present. As such, the SFU population has already been accounted for in the 7.5 FAR where future residential and apartments may be built.

Build Out External Population

No future residential population information is available for the external catchments beyond 2033. Therefore the 2033 external 1 and external 2 area residential populations were maintained as the build out external residential populations. ***Table 15*** summarizes the external institutional populations.

Table 15 Build Out External Institutional Sanitary Population Equivalent

Facility	Units	Flow Per Unit	Institutional Equivalent Population
Jim Pattison Outpatient Care & Surgery Centre	3,200 patients	125 L/patient/d	1,143
RCMP E-Division	3,200 employees	94.5 L/employee/d	864
Discovery Elementary School	312 students	45 L/student/d	40
KB Woodward Elementary School	1,425 students	45 L/student/d	183
Kwantlen Park Secondary School	4,485 students	90 L/student/d	1,153
Lena Shaw Elementary School	1,590 students	45 L/student/d	204
Total BO External Institutional Population			**3,587**

Build Out Total Sanitary Population

Table 16 summarizes the Sewer Equivalent Build Out sanitary populations for internal and external catchments.

Table 16 Sewer Equivalent Build Out Total Sanitary Population

Category	Internal	External 1	External 2	**Total**
Build Out Residential	160,599	11,217	1,862	**173,678**
Build Out Commercial	15,274	0	0	**15,274**
Build Out Institutional	3,927	3,587	0	**7,514**
Sewer Equivalent BO Total	**179,800**	**14,804**	**1,862**	**196,466**

A6. Existing Gravity Sewer Capacity Upgrades

10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	Estimated Capital Cost	Net Present Value (3%)
-	132 St. Diversion, 104 Ave. at 132 St.	-	-	-	-	2013	57	250	$1,313	$74,813	$74,813
-	Hilton Rd. Diversion, Bentley Rd. at Hilton Rd.	-	-	-	-	2013	39	450	$1,763	$68,738	$68,738
-	100 Ave. (Quibble) Diversion	-	-	-	-	2013	-	-	$3,000	$3,000	$3,000
-	100 Ave. at 140 St.	1000088338	200	PVC	1989	2013	22	300	$1,413	$30,911	$30,911
-	100 Ave. at 140 St.	1000088339	200	PVC	1989	2013	102	300	$ 1,413	$144,312	$144,312
-	100 Ave. at 140 St.	1000088340	200	PVC	1989	2013	119	300	$ 1,413	$167,382	$167,382
-	100 Ave. at 140 St.	1000088341	200	PVC	1989	2013	21	300	$1,413	$ 29,265	$29,265
-	100 Ave. at Whalley Blvd.	1000088319	250	AC	1966	2013	14	375	$1,591	$ 22,803	$22,803
-	104 Ave. at 133 St.	1000089972	200	AC	1963	2013	91	375	$1,591	$145,240	$145,240
-	104 Ave. at 133 St.	1000089973	150	AC	1963	2013	150	250	$1,313	$197,446	$197,446
-	105A Ave. east of King George Blvd	1000092921	200	AC	1963	2013	51	375	$1,591	$ 80,878	$80,878
-	105A Ave. west of City Parkway	1000089961	250	AC	1963	2013	98	450	$1,763	$171,868	$171,868
-	111A Ave. at Bolivar Rd.	1000089773	200	VCP	1963	2013	29	250	$1,313	$ 38,378	$38,378
-	112 Ave. at 132 St. Diversion	1000090487	300	AC	1963	2013	154	525	$1,938	$297,744	$297,744
-	112 Ave. at 132 St. Diversion	1000090506	300	AC	1963	2013	46	525	$1,938	$89,128	$89,128
-	112 Ave. at 135 St.	1000090508	200	VCP	1963	2013	115	375	$1,591	$ 182,208	$182,208
-	112 Ave. at 135 St.	1000090509	200	VCP	1963	2013	118	300	$1,413	$166,028	$166,028
-	132 St. at 114 Ave.	1000091431	450	CP	1973	2013	9	900	$2,850	$ 26,355	$26,355
-	132 St. south of 96 Ave.	1000080224	200	AC	1973	2013	53	300	$1,413	$ 74,453	$74,453
-	132 St. south of 96 Ave.	1000080225	200	AC	1973	2013	118	300	$1,413	$167,325	$167,325
-	132 St. south of 96 Ave.	1000080226	200	AC	1973	2013	124	300	$1,413	$174,458	$174,458
-	132 St. south of 96 Ave.	1000080227	200	AC	1973	2013	119	300	$1,413	$168,483	$168,483
-	132 St. south of 96 Ave.	1000080228	200	AC	1973	2013	124	300	$1,413	$174,868	$174,868
-	136 St. at 112 Ave.	1000089766	200	VCP	1963	2013	92	375	$1,591	$147,033	$147,033
-	139 St. at 104 Ave.	1000092797	200	VCP	1963	2013	73	375	$1,591	$116,358	$116,358
-	139 St. at 104 Ave.	1000092798	200	VCP	1963	2013	128	375	$1,591	$ 203,642	$203,642
-	139 St. north of 104 Ave.	1000092794	200	VCP	1963	2013	123	375	$1,591	$195,447	$195,447
-	Brentwood Crescent at Bentley Road	1000092938	200	VCP	1963	2013	102	375	$1,591	$162,778	$162,778
-	City Parkway north of 105 Ave.	1000089727	150	AC	1963	2013	87	300	$1,413	$122,520	$122,520

10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	Estimated Capital Cost	Net Present Value (3%)
-	Grosvenor Road at Franklin Road	1000092957	200	VCP	1963	2013	111	375	$1,591	$176,455	$176,455
-	Queen Elizabeth SS	1000080419	200	AC	1973	2013	73	250	$1,313	$95,567	$95,567
		Total					2,562			$ 3,915,884	$ 3,915,884

^Cost estimates calculated from City of Surrey construction unit rates for NCPs and include project contingency.

A7. 2014 - 2023 Gravity Sewer Capacity Upgrades

10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	Estimated Capital Cost	Net Present Value (3%)
-	108 Ave. at 132A St.	1000090181	250	AC	1963	2017	16	450	$ 1,763	$ 27,426	$ 26,628
-	132 St. north of 96 Ave.	1000082350	200	AC	1973	2017	108	300	$ 1,413	$ 152,065	$ 147,636
-	132 St. north of 96 Ave.	1000082351	200	AC	1973	2017	123	300	$ 1,413	$ 174,036	$ 168,967
-	139 St. at 108 Ave.	1000092793	200	VCP	1963	2017	130	375	$ 1,591	$ 206,538	$ 200,522
-	139 St. south of 96 Ave.	1000079824	200	AC	1974	2017	101	375	$ 1,591	$ 161,235	$ 156,539
-	Bentley Rd. at King George Blvd.	1000089791	150	VCP	1963	2017	153	450	$ 1,763	$ 270,368	$ 262,493
-	Queen Elizabeth SS	1000080207	200	AC	1973	2017	115	250	$ 1,313	$ 151,399	$ 146,990
-	100 Ave. at 143 St.	1000088420	200	AC	1972	2018	95	300	$ 1,413	$ 133,841	$ 126,158
-	100 Ave. at 143 St.	1000088421	200	AC	1972	2018	116	300	$ 1,413	$ 164,155	$ 154,732
-	108 Ave. at 132A St.	1000089597	250	AC	1963	2018	9	375	$ 1,591	$ 13,573	$ 12,794
-	Bentley Rd. at King George Blvd.	1000089789	300	PVC	2008	2018	43	525	$ 1,938	$ 83,700	$ 78,895
-	Grosvenor Road at Franklin Road	1000092452	200	VCP	1963	2018	89	375	$ 1,591	$ 141,929	$ 133,781
-	100 Ave. at 140 St.	1000088377	200	VCP	1972	2019	51	300	$ 1,413	$ 72,714	$ 66,544
-	112 Ave. at 132 St. Diversion	1000090507	300	VCP	1963	2019	114	450	$ 1,763	$ 201,792	$ 184,669
-	112 Ave. at 135 St.	1000091574	200	VCP	1963	2019	109	300	$ 1,413	$ 153,612	$ 140,577
-	132 St. north of King George Blvd.	1000091669	450	CP	1963	2019	92	675	$ 2,338	$ 215,078	$ 196,827
-	139 St. south of 96 Ave.	1000079819	200	AC	1973	2019	85	300	$ 1,413	$ 120,472	$ 110,249
-	Lane east of King George Blvd., south of 105A Ave.	1000092936	200	VCP	1963	2019	103	375	$ 1,591	$ 163,318	$ 149,459
-	132 St. north of King George Blvd.	1000091668	450	CP	1963	2019	62	675	$ 2,338	$ 143,957	$ 127,904
-	134A St. at 105A Ave.	1000089953	150	AC	1963	2019	97	250	$ 1,313	$ 126,791	$ 112,652
-	94A Ave. at 139 St.	1000079805	200	AC	1972	2019	61	300	$ 1,413	$ 86,078	$ 76,480
-	94A Ave. at 139 St.	1000079814	250	AC	1970	2019	12	375	$ 1,591	$ 19,491	$ 17,318
-	132 St. at Old Yale Road	1000082409	200	VCP	1963	2020	114	300	$ 1,413	$ 161,423	$ 139,245
-	141 St. at 101 Ave.	1000088410	200	VCP	1972	2020	86	300	$ 1,413	$ 121,066	$ 104,432
-	141 St. at 101 Ave.	1000088411	200	AC	1972	2020	69	300	$ 1,413	$ 97,110	$ 83,768
-	132 St. at Old Yale Road	1000082411	200	VCP	1963	2020	125	300	$ 1,413	$ 176,750	$ 148,025
-	100 Ave. at Whalley Blvd.	1000088321	250	PVC	1987	2020	6	300	$ 1,413	$ 8,302	$ 6,750
-	132 St. north of 96 Ave.	1000082353	200	AC	1973	2021	14	250	$ 1,313	$ 18,001	$ 14,210
-	132 St. north of King George Blvd.	1000859861	450	CP	1963	2021	16	600	$ 2,113	$ 34,206	$ 27,003
-	132A St. at 105A Ave.	1000089939	200	AC	1963	2021	134	300	$ 1,413	$ 189,787	$ 149,820
-	140 St. at 108 Ave.	1000092691	150	VCP	1963	2021	15	250	$ 1,313	$ 19,793	$ 15,624

10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	Estimated Capital Cost	Net Present Value (3%)
-	111A Ave. and Brentwood Crescent	1000092942	200	VCP	1963	2022	108	300	$ 1,413	$ 152,256	$ 116,692
-	140 St. south of 100 Ave.	1000088464	200	AC	1974	2022	98	300	$ 1,413	$ 138,995	$ 106,528
-	141 St. at 102 Ave.	1000088408	200	VCP	1972	2022	99	250	$ 1,313	$ 129,911	$ 99,566
-	King George Blvd. at 108 Ave.	2	375	PVC	2013	2022	52	600	$ 2,113	$ 109,956	$ 84,272
-	Queen Elizabeth SS	1000080208	200	AC	1973	2022	71	250	$ 1,313	$ 93,635	$ 71,764
-	100 Ave. east of 143 St.	1000088419	200	AC	1972	2023	79	250	$ 1,313	$ 104,270	$ 77,587
-	132 St. north of 96 Ave.	1000082397	200	AC	1973	2023	32	250	$ 1,313	$ 42,579	$ 31,683
-	132 St. north of King George Blvd.	1000091667	450	CP	1963	2023	90	600	$ 2,113	$ 189,918	$ 141,317
-	132 St. north of King George Blvd.	1000091670	450	CP	1963	2023	44	600	$ 2,113	$ 93,142	$ 69,307
-	135A St. at 107A Ave.	1000089923	200	AC	1963	2023	73	300	$ 1,413	$ 103,145	$ 76,749
-	141 St. south of 102 Ave.	1000088409	200	VCP	1972	2023	63	250	$ 1,313	$ 82,215	$ 61,176
-	Grosvenor Rd. at 108 Ave.	1000092961	150	AC	1963	2023	7	300	$ 1,413	$ 10,075	$ 7,497
		Total					3,281			$ 5,060,106	$ 4,431,827

^Cost estimates calculated from City of Surrey construction unit rates for NCPs and include project contingency.

A8. 2024 – 2033 Gravity Sewer Capacity Upgrades

10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	Estimated Capital Cost	Net Present Value (3%)
-	102 Ave. at 139 St.	1000088544	200	AC	1972	2024	69	300	$ 1,413	$ 97,980	$ 70,783
-	112B Ave. at 132 St.	1000090503	300	AC	1963	2024	30	450	$ 1,763	$ 53,528	$ 38,670
-	112B Ave. at 132 St.	1000090504	300	AC	1963	2024	124	450	$ 1,763	$ 218,379	$ 157,761
-	130 St. south of 108 Ave.	1000089879	200	VCP	1963	2024	116	250	$ 1,313	$ 151,712	$ 109,600
-	132 St. north of 96 Ave.	1000082352	200	AC	1973	2024	91	250	$ 1,313	$ 119,294	$ 86,181
-	135A St. at 107A Ave.	1000089924	200	AC	1963	2024	118	300	$ 1,413	$ 167,342	$ 120,891
-	94A Ave. at 139 St.	1000079815	250	AC	1970	2024	90	375	$ 1,591	$ 143,967	$ 104,005
-	King George Blvd. north of 108 Ave.	4	375	PVC	2013	2024	27	525	$ 1,938	$ 51,634	$ 37,302
-	130 St. south of 108 Ave.	1000089908	200	VCP	1963	2025	101	250	$ 1,313	$ 133,045	$ 93,315
-	132 St. south of Old Yale Road	1000082141	200	AC	1963	2025	31	300	$ 1,413	$ 43,364	$ 30,415
-	Bolivar Crescent at King George Blvd.	1000089787	200	VCP	1963	2025	94	375	$ 1,591	$ 149,936	$ 105,162
-	Grosvenor Road at Hilton Road	1000092958	200	VCP	1963	2025	109	300	$ 1,413	$ 153,500	$ 107,662
-	102 Ave. at 139 St.	1000088543	200	AC	1972	2026	51	300	$ 1,413	$ 71,747	$ 48,856
-	104 Ave. at Whalley Blvd.	1000093062	300	AC	1963	2026	13	450	$ 1,763	$ 23,110	$ 15,737
-	111A Ave. at 135A St.	1000089778	150	VCP	1963	2026	54	250	$ 1,313	$ 70,391	$ 47,933
-	140 St. north of 106 Ave.	1000092740	200	VCP	1963	2026	95	300	$ 1,413	$ 134,795	$ 91,789
-	140 St. north of 106 Ave.	1000092741	200	VCP	1963	2026	95	300	$ 1,413	$ 134,371	$ 91,500
-	140 St. north of 106 Ave.	1000092742	200	VCP	1963	2026	95	300	$ 1,413	$ 134,357	$ 91,491
-	96 Ave. east of King George Blvd.	1000088188	250	AC	1966	2026	152	375	$ 1,591	$ 242,360	$ 165,035
-	98B Ave, west of 134 St.	1000082363	200	PVC	1977	2026	87	300	$ 1,413	$ 122,633	$ 83,507
-	King George Blvd. at 94A Ave.	1000079680	675	PVC	1999	2026	15	900	$ 2,850	$ 42,543	$ 28,970
-	104 Ave. at 133 St.	1000089971	200	AC	1963	2027	69	250	$ 1,313	$ 90,248	$ 59,665
-	104 Ave. at Whalley Blvd.	1000093063	300	AC	1963	2027	74	450	$ 1,763	$ 130,393	$ 86,205
-	98A Ave. west of 133A St.	1000082369	200	PVC	1977	2027	42	300	$ 1,413	$ 59,468	$ 39,315
-	Bolivar Crescent at King George Blvd.	1000089788	200	VCP	1963	2027	105	375	$ 1,591	$ 167,366	$ 110,649
-	King George Blvd. at 96 Ave.	1000080856	450	PVC	1999	2027	14	600	$ 2,113	$ 29,998	$ 19,832
-	King George Blvd. north of 108 Ave.	3	300	PVC	2013	2027	19	525	$ 1,938	$ 37,394	$ 24,722
-	Lane east of King George Blvd., south of 105A Ave.	1000092935	200	VCP	1963	2027	94	300	$ 1,413	$ 132,367	$ 87,510
-	Whalley Blvd. south of 100 Ave.	1000088346	600	PVC	1992	2027	113	750	$ 2,513	$ 284,383	$ 188,011
-	109 Ave. at 139A St.	1000092447	150	VCP	1963	2028	56	250	$ 1,313	$ 73,579	$ 47,227

10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	Estimated Capital Cost	Net Present Value (3%)
-	111A Ave. at 136 St.	1000092943	200	VCP	1963	2028	116	300	$ 1,413	$ 163,443	$ 104,908
-	132 St. north of Old Yale Road	1000082410	200	AC	1963	2028	4	300	$ 1,413	$ 5,594	$ 3,590
-	104 Ave. at Whalley Blvd.	1000093064	300	AC	1963	2029	81	450	$ 1,763	$ 142,768	$ 88,968
-	106 Ave. at 135A St.	1000089726	200	AC	1963	2029	101	300	$ 1,413	$ 142,811	$ 88,995
-	108 Ave. at 130 St.	1000090176	200	VCP	1963	2029	114	250	$ 1,313	$ 149,087	$ 92,906
-	King George Blvd. at 108 Ave.	1	375	PVC	2013	2029	11	600	$ 2,113	$ 22,329	$ 13,915
-	102 Ave east of 139 St.	1000088343	200	VCP	1972	2030	45	300	$ 1,413	$ 62,890	$ 38,049
-	132 St. at King George Blvd.	1000091568	600	PVC	1999	2030	4	750	$ 2,513	$ 9,140	$ 5,530
-	133 St. at 102A Ave.	1000082558	150	AC	1967	2030	107	250	$ 1,313	$ 139,966	$ 84,682
-	139A St. at 109 Ave.	1000093033	150	VCP	1963	2030	130	250	$ 1,313	$ 170,352	$ 103,066
-	96 Ave. west of 134 St.	1000082383	200	AC	1973	2030	95	300	$ 1,413	$ 134,161	$ 81,170
-	108 Ave. at 132A St.	1000090180	250	VCP	1963	2031	85	300	$ 1,413	$ 120,395	$ 70,719
-	111A Ave. at 136 St.	1000092944	200	VCP	1963	2031	128	300	$ 1,413	$ 180,648	$ 106,112
-	94A Ave. at 139 St.	1000079670	250	AC	1970	2031	72	300	$ 1,413	$ 101,223	$ 59,458
-	Nordsun Rd. at 135A St.	1000089781	150	VCP	1963	2031	103	200	$ 1,200	$ 123,936	$ 72,799
-	132 St. north of 96 Ave.	1000082398	200	AC	1973	2032	30	250	$ 1,313	$ 39,073	$ 22,283
-	Berg Rd. at Cowan Rd.	1000092956	150	VCP	1963	2032	111	250	$ 1,313	$ 145,225	$ 82,820
-	108 Ave. east of 138 St.	1000092789	150	VCP	1963	2033	99	250	$ 1,313	$ 129,964	$ 71,958
-	132 St. north of 109 Ave.	1000090149	200	AC	1963	2033	106	300	$ 1,413	$ 149,334	$ 82,682
-	139 St. north of 96 Ave.	1000088494	200	PVC	1980	2033	102	300	$ 1,413	$ 143,489	$ 79,446
-	Selkirk Dr. at Cowan Rd.	1000092448	150	VCP	1963	2033	119	250	$ 1,313	$ 156,652	$ 86,734
		Total					4,004			$ 5,897,663	$ 3,830,490

^Cost estimates calculated from City of Surrey construction unit rates for NCPs and include project contingency.

A9. 2034 – 2043 Gravity Sewer Capacity Upgrades

10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	Estimated Capital Cost	Net Present Value (3%)
-	139 St. north of 96 Ave.	1000088495	200	PVC	1980	2034	49	300	$ 1,413	$ 68,862	$ 37,017
-	Brentwood Crescent north of Grosvenor Rd.	1000092937	200	VCP	1963	2034	103	250	$ 1,313	$ 135,044	$ 72,593
-	Lane north of 98B Ave at 134 St.	1000082359	200	AC	1977	2034	61	250	$ 1,313	$ 79,961	$ 42,983
-	102 Ave east of 139 St.	1000088280	200	AC	1972	2035	38	300	$ 1,413	$ 54,104	$ 28,236
-	102 Ave east of 139 St.	1000088281	200	AC	1972	2035	14	300	$ 1,413	$ 19,650	$ 10,255
-	105A Ave. east of University Dr.	1000089728	250	AC	1963	2035	94	375	$ 1,591	$ 149,095	$ 77,812
-	133 St. north of Old Yale Road	1000082557	150	AC	1967	2035	93	250	$ 1,313	$ 121,957	$ 63,648
-	139 St. north of 96 Ave.	1000088358	200	PVC	1991	2035	26	300	$ 1,413	$ 36,214	$ 18,900
-	Lane W of KG Blvd S of 104 Ave	1000079424	200	AC	1973	2035	87	300	$ 1,413	$ 122,824	$ 64,101
-	134 St. north of 98B Ave.	1000082370	200	AC	1974	2036	114	250	$ 1,313	$ 149,159	$ 75,577
-	139 St. north of 96 Ave.	1000088359	200	PVC	1991	2036	32	300	$ 1,413	$ 44,623	$ 22,610
-	139 St. north of 96 Ave.	1000088499	200	PVC	1980	2036	67	300	$ 1,413	$ 95,211	$ 48,242
-	Hilton Rd. at Grosvenor Rd.	1000092967	200	VCP	1963	2036	103	300	$ 1,413	$ 145,673	$ 73,811
-	King George Blvd. north of 108 Ave.	5	450	PVC	2013	2036	104	600	$ 2,113	$ 219,066	$ 110,999
-	139 St. north of 104 Ave.	1000092795	200	VCP	1963	2037	130	300	$ 1,413	$ 183,329	$ 90,186
-	139 St. north of 104 Ave.	1000092796	200	VCP	1963	2037	130	300	$ 1,413	$ 183,330	$ 90,186
-	139A St, at Brentwood Crescent	1000093034	150	VCP	1963	2037	111	250	$ 1,313	$ 145,165	$ 71,411
-	139A St. north of 102 Ave.	1000088385	200	VCP	1972	2037	112	300	$ 1,413	$ 158,804	$ 78,121
-	Grosvenor Road at Selkirk Dr.	1000092451	200	VCP	1963	2037	102	300	$ 1,413	$ 144,113	$ 70,894
-	King George Blvd. north of 108 Ave.	6	450	PVC	2013	2037	13	600	$ 2,113	$ 27,251	$ 13,406
-	Lane east of Whalley Blvd., north of 105A Ave.	1000092927	200	VCP	1963	2037	96	300	$ 1,413	$ 136,000	$ 66,903
-	Whalley Blvd. at Grosvenor Rd.	1000092959	150	VCP	1963	2037	134	250	$ 1,313	$ 175,823	$ 86,493
-	105A Ave. east of City Parkway	1000089960	200	AC	1963	2038	93	300	$ 1,413	$ 131,198	$ 62,661
-	138A St. north of 104 Ave.	1000092804	200	VCP	1963	2038	108	300	$ 1,413	$ 152,355	$ 72,766
-	Brentwood Crescent at Grosvenor Rd.	1000093042	200	VCP	1963	2039	138	250	$ 1,313	$ 181,178	$ 84,011
-	Lane north of 98B Ave at 134 St.	1000082360	200	AC	1977	2039	37	250	$ 1,313	$ 49,024	$ 22,732
-	105 Ave. east of University Dr.	1000089731	525	CP	1963	2040	114	675	$ 2,338	$ 267,448	$ 120,402
-	98A Ave., west of King George Blvd.	1000082376	200	AC	1973	2040	73	250	$ 1,313	$ 95,973	$ 43,206
-	King George Blvd. north of 108 Ave.	7	450	PVC	2013	2040	76	600	$ 2,113	$ 159,916	$ 71,993
-	King George Blvd. south of 107A Ave.	1000089986	200	AC	1963	2040	109	250	$ 1,313	$ 142,752	$ 64,265

10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	Estimated Capital Cost	Net Present Value (3%)
-	King George Blvd., south of 98 Ave.	1000080848	200	AC	1973	2040	48	250	$ 1,313	$ 63,175	$ 28,441
-	Brentwood Crescent at 139A St.	1000093036	200	VCP	1963	2041	107	300	$ 1,413	$ 151,467	$ 66,203
-	Hilton Road and Bolivar Crescent	1000089785	150	VCP	1963	2041	52	250	$ 1,313	$ 68,455	$ 29,920
-	138A St., north of 104 Ave.	1000093056	200	VCP	1963	2042	108	250	$ 1,313	$ 141,556	$ 60,069
-	139 St. north of 96 Ave.	1000088496	200	PVC	1980	2042	45	250	$ 1,313	$ 58,552	$ 24,846
-	Antrim Road east of Brentwood Crescent	1000093040	200	VCP	1963	2042	77	300	$ 1,413	$ 108,418	$ 46,007
		Total					2,996			$ 4,366,724	$2,111,907

^Cost estimates calculated from City of Surrey construction unit rates for NCPs and include project contingency.

A10. 2044 – Build Out Gravity Sewer Capacity Upgrades

10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	Estimated Capital Cost	Net Present Value (3%)
-	104 Ave. east of 138 St.	1000093065	300	AC	1963	2044	89	375	$ 1,591	$ 141,426	$ 56,568
-	96 Ave. between 134 St. and King George Blvd.	1000081853	200	AC	1973	2044	108	300	$ 1,413	$ 152,114	$ 60,844
-	City Parkway south of 108 Ave.	1000089930	150	AC	1963	2044	123	200	$ 1,200	$ 148,080	$ 59,230
-	Hilton Rd. at Grosvenor Rd.	1000093023	200	VCP	1963	2044	105	250	$ 1,313	$ 137,756	$ 55,100
-	105A Ave. east of City Parkway	1000089958	200	AC	1963	2045	7	300	$ 1,413	$ 9,309	$ 3,615
-	140 St. south of 100 Ave.	1000088180	300	PVC	2006	2045	9	375	$ 1,591	$ 14,291	$ 5,550
-	102 Ave. at 138A St.	1000088372	200	AC	1972	2046	42	250	$ 1,313	$ 55,694	$ 20,998
-	102 Ave. east of 139 St.	1000088542	200	AC	1972	2046	84	250	$ 1,313	$ 109,787	$ 41,393
-	111 Ave. east of 136 St.	1000092945	150	VCP	1963	2046	117	250	$ 1,313	$ 153,553	$ 57,893
-	104 Ave. at King George Blvd	1000092433	350	AC	1963	2047	20	450	$ 1,763	$ 36,099	$ 13,214
-	104 Ave. at King George Blvd	1000092434	350	AC	1963	2047	19	450	$ 1,763	$ 33,501	$ 12,263
-	133A St. south of 104 Ave.	1000082554	200	AC	1962	2047	76	300	$ 1,413	$ 107,173	$ 39,230
-	133A St. south of 104 Ave.	1000082555	200	AC	1962	2047	75	300	$ 1,413	$ 105,436	$ 38,594
-	138A St., north of 104 Ave.	1000092803	200	VCP	1963	2047	108	250	$ 1,313	$ 141,556	$ 51,816
-	Grosvenor Rd. at 108 Ave.	1000092960	150	VCP	1963	2047	101	250	$ 1,313	$ 132,286	$ 48,423
-	100 Ave. and Whalley Blvd	1000088371	200	PVC	1992	2048	17	300	$ 1,413	$ 23,732	$ 8,434
-	East of 135A St., south of 108 Ave.	1000089921	150	AC	1963	2049	94	200	$ 1,200	$ 112,437	$ 38,794
-	Grosvenor Rd east of Brentwood Crescent	1000093024	200	VCP	1963	2049	107	250	$ 1,313	$ 139,964	$ 48,292
-	103 Ave. at City Parkway	1000079426	150	AC	1963	2050	73	200	$ 1,200	$ 87,937	$ 29,457
-	108 Ave. east of Whalley Blvd	1000092791	150	VCP	1963	2050	104	250	$ 1,313	$ 135,962	$ 45,545
-	136 St. north of 111 Ave.	1000089765	200	VCP	1963	2050	111	250	$ 1,313	$ 145,135	$ 48,618
-	138 St. north of 104 Ave.	1000092915	200	VCP	1963	2050	106	300	$ 1,413	$ 149,757	$ 50,166
-	140 St. south of 100 Ave.	1000088465	200	AC	1974	2050	117	250	$ 1,313	$ 153,554	$ 51,438
-	Lane west of King George Blvd., north of 104 Ave.	1000089730	525	CP	1963	2050	165	675	$ 2,338	$ 386,101	$ 129,337
-	100A Ave. east of 132 St.	1000082421	200	AC	1974	2051	96	300	$ 1,413	$ 135,944	$ 44,213
-	139 St., north of 96 Ave.	1000088493	200	PVC	1980	2052	34	250	$ 1,313	$ 44,784	$ 14,141
-	96 Ave. between 134 St. and King George Blvd.	1000080912	200	PVC	2005	2052	3	250	$ 1,313	$ 3,504	$ 1,106
-	132A St. south of 108 Ave.	1000089941	200	AC	1963	2053	119	250	$ 1,313	$ 155,954	$ 47,809
-	Laurel Dr. west of 140 St.	1000088486	200	AC	1974	2053	37	250	$ 1,313	$ 48,483	$ 14,863
-	138 St. north of 104 Ave.	1000092914	200	VCP	1963	2054	106	300	$ 1,413	$ 149,333	$ 44,446

10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	Estimated Capital Cost	Net Present Value (3%)
-	Antrim Road east of Brentwood Crescent	1000093041	200	VCP	1963	2055	77	250	$ 1,313	$ 101,138	$ 29,225
-	Berg Rd. at Grosvenor Rd.	1000092442	150	VCP	1963	2055	111	200	$ 1,200	$ 133,133	$ 38,470
-	King George Blvd. south of 107A Ave.	1000089987	200	AC	1963	2055	116	250	$ 1,313	$ 152,753	$ 44,139
-	University Dr. at 105 Ave.	1000089692	525	CP	1993	2055	16	675	$ 2,338	$ 37,260	$ 10,767
-	100 Ave. at King George Blvd	1000088370	200	PVC	1992	2056	96	300	$ 1,413	$ 134,982	$ 37,868
-	Brentwood Crescent at Bentley Road	1000092939	200	VCP	1963	2056	103	250	$ 1,313	$ 135,051	$ 37,888
-	100A Ave. east of 132 St.	1000082420	200	AC	1974	2057	25	250	$ 1,313	$ 33,167	$ 9,034
-	139 St. north of 96 Ave.	1000088360	200	PVC	1991	2057	4	250	$ 1,313	$ 4,594	$ 1,251
-	94A Ave at King George Blvd	1000079656	675	PVC	1999	2057	5	750	$ 2,513	$ 13,250	$ 3,609
-	Harper Rd. between Bentley Rd. and Grosvenor Rd.	1000092965	150	VCP	1963	2057	86	200	$ 1,200	$ 103,100	$ 28,082
-	104 Ave. at King George Blvd	1000093059	350	AC	1963	2058	13	450	$ 1,763	$ 22,752	$ 6,016
-	105 Ave. west of University Dr.	1000089977	200	AC	1963	2058	43	250	$ 1,313	$ 55,808	$ 14,758
-	138 St. north of 105 Ave.	1000092912	200	VCP	1963	2058	94	250	$ 1,313	$ 122,761	$ 32,463
-	East of 132 St., north of 112 Ave.	1000090505	300	AC	1963	2058	152	375	$ 1,591	$ 242,056	$ 64,009
-	100 Ave. at King George Blvd	1000082167	200	PVC	1992	2059	84	300	$ 1,413	$ 118,003	$ 30,296
-	102A Ave. at 133A St.	1000082425	150	CP	1968	2059	79	200	$ 1,200	$ 95,064	$ 24,406
-	105 Ave. east of City Parkway	1000089963	525	CP	1963	2059	111	600	$ 2,113	$ 235,322	$ 60,416
-	111 Ave. east of 136 St.	1000092946	150	VCP	1963	2059	109	200	$ 1,200	$ 130,899	$ 33,606
-	133 St. south of 104 Ave.	1000082559	200	AC	1962	2059	67	250	$ 1,313	$ 88,591	$ 22,745
-	Lane north of 102 Ave. at University Dr.	1000082437	150	AC	1963	2059	67	200	$ 1,200	$ 80,797	$ 20,743
-	111 Ave. east of 136 St.	1000092947	150	VCP	1963	2060	109	200	$ 1,200	$ 130,887	$ 32,625
-	132 St. south of Old Yale Road	1000082405	200	AC	1963	2060	80	250	$ 1,313	$ 105,565	$ 26,313
-	139 St. south of 102 Ave.	1000088383	200	AC	1972	2060	91	300	$ 1,413	$ 129,116	$ 32,183
-	Selkirk Dr. at Grosvenor Rd	1000092449	150	VCP	1963	2060	119	200	$ 1,200	$ 142,491	$ 35,517
-	100 Ave. east of 141 St.	1000088278	300	PVC	2005	2062	109	375	$ 1,591	$ 173,510	$ 40,766
-	King George Blvd at 98 Ave.	1000081852	200	AC	1973	2062	108	250	$ 1,313	$ 141,557	$ 33,259
-	Lane east of 137A St., north of 105A Ave.	1000092430	200	VCP	1963	2062	96	250	$ 1,313	$ 125,964	$ 29,595
-	Lane east of 137A St., north of 105A Ave.	1000092928	200	VCP	1963	2062	96	250	$ 1,313	$ 125,964	$ 29,595
-	132A St. south of 108 Ave.	1000089940	200	AC	1963	2063	119	250	$ 1,313	$ 155,954	$ 35,574
-	100A Ave. east of 132 St.	1000079431	200	AC	1974	2064	18	250	$ 1,313	$ 23,038	$ 5,102
-	132 St. south of Old Yale Road	1000082408	200	AC	1963	2064	102	250	$ 1,313	$ 134,349	$ 29,753

10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	Estimated Capital Cost	Net Present Value (3%)
-	133A St. at 98B Ave.	1000082362	200	PVC	1977	2064	47	250	$ 1,313	$ 61,887	$ 13,706
-	Fraser Hwy west of Whalley Blvd	1000088288	600	PVC	1992	2064	42	675	$ 2,338	$ 98,655	$ 21,849
-	Haddon Rd and Hilton Rd	1000089786	150	VCP	1963	2064	51	200	$ 1,200	$ 60,687	$ 13,440
-	Lane east of Whalley Blvd, south of 107A Ave.	1000092926	200	VCP	1963	2064	96	250	$ 1,313	$ 126,358	$ 27,984
-	105 Ave. west of City Parkway	1000089964	525	CP	1963	2065	86	600	$ 2,113	$ 181,683	$ 39,064
-	105A Ave. east of King George Blvd	1000092920	200	VCP	1963	2066	100	250	$ 1,313	$ 131,748	$ 27,502
-	City Parkway south of 105A Ave.	1000089954	150	AC	1963	2066	97	200	$ 1,200	$ 115,804	$ 24,174
-	132 St. south of Old Yale Road	1000082142	200	AC	1997	2067	12	250	$ 1,313	$ 15,658	$ 3,173
-	135A St. south of 108 Ave.	1000089920	200	AC	1963	2067	148	250	$ 1,313	$ 194,022	$ 39,322
-	135A St. south of 112 Ave.	1000089770	150	VCP	1963	2067	141	200	$ 1,200	$ 169,646	$ 34,382
-	Harper Rd. between Bentley Rd. and Grosvenor Rd.	1000092966	150	VCP	1963	2067	91	200	$ 1,200	$ 109,690	$ 22,231
-	Laurel Dr. west of 140 St.	1000088362	200	AC	1974	2067	33	250	$ 1,313	$ 43,485	$ 8,813
-	140 St. south of 108 Ave.	1000092739	200	VCP	1963	2071	113	250	$ 1,313	$ 148,785	$ 26,792
-	Fraser Hwy east of 138 St.	1000088476	200	AC	1968	2071	105	250	$ 1,313	$ 137,674	$ 24,791
-	133 St. south of 104 Ave.	1000082560	200	AC	1962	2072	112	250	$ 1,313	$ 147,634	$ 25,810
-	138A St. north of 104 Ave.	1000092423	200	PVC	1994	2072	15	250	$ 1,313	$ 19,150	$ 3,348
-	139 St. south of 102 Ave.	1000088382	200	AC	1972	2072	95	250	$ 1,313	$ 124,766	$ 21,812
-	140 St. south of 100 Ave.	1000088461	200	PVC	1980	2072	42	250	$ 1,313	$ 55,107	$ 9,634
-	105 Ave. east of City Parkway	1000089885	525	CP	1963	2073	24	600	$ 2,113	$ 50,428	$ 8,559
-	140 St. south of 100 Ave.	1000088463	200	AC	1974	2073	29	250	$ 1,313	$ 37,482	$ 6,362
-	Hilton Rd. east of Haddon Rd.	1000849877	150	VCP	1963	2073	36	200	$ 1,200	$ 43,597	$ 7,400
-	105A Ave. east of City Parkway	1000089959	200	AC	1963	2074	56	250	$ 1,313	$ 73,581	$ 12,125
-	133A St. south of 104 Ave.	1000082556	200	AC	1962	2074	91	250	$ 1,313	$ 119,970	$ 19,770
-	138A St. north of 104 Ave.	1000092800	200	PVC	1982	2074	72	250	$ 1,313	$ 94,593	$ 15,588
-	98A Ave., west of King George Blvd.	1000082377	200	AC	1973	2074	55	250	$ 1,313	$ 72,387	$ 11,929
-	West of Whalley Blvd north of 105A Ave.	1000092922	150	VCP	1963	2074	81	200	$ 1,200	$ 97,611	$ 16,085
-	102 Ave. at University Dr.	1000080870	350	PVC	2001	2075	49	375	$ 1,591	$ 78,060	$ 12,489
-	140 St. north of 109 Ave.	1000093043	150	VCP	1963	2075	70	200	$ 1,200	$ 84,464	$ 13,513
-	Franklin Rd. at Grosvenor Rd.	1000092444	150	VCP	1963	2075	94	200	$ 1,200	$ 112,242	$ 17,958
-	Lane south of 100 Ave. at 134 St.	1000082358	200	PVC	1977	2075	40	250	$ 1,313	$ 52,341	$ 8,374
-	105 Ave. west of University Dr.	1000089978	200	AC	1963	2076	29	250	$ 1,313	$ 38,181	$ 5,931
-	132 St. south of Old Yale Road	1000082407	200	AC	1963	2076	79	250	$ 1,313	$ 103,781	$ 16,120

10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	Estimated Capital Cost	Net Present Value (3%)
-	140 St. south of 100 Ave.	1000088462	200	AC	1974	2076	67	250	$ 1,313	$ 88,085	$ 13,682
-	111A Ave at Hilton Rd.	1000089774	200	VCP	1963	2077	76	250	$ 1,313	$ 99,870	$ 15,061
-	132 St. south of 108 Ave.	1000087078	200	VCP	1963	2077	115	250	$ 1,313	$ 151,452	$ 22,840
-	132A St. south of 108 Ave.	1000089942	200	AC	1963	2077	119	250	$ 1,313	$ 155,967	$ 23,521
-	135A St. south of 112 Ave.	1000089769	150	VCP	1963	2077	125	200	$ 1,200	$ 149,532	$ 22,550
-	Bentley Rd. at Hilton Rd.	1000092431	200	VCP	1963	2077	81	250	$ 1,313	$ 105,921	$ 15,974
-	108 Ave. at University Drive	1000089932	200	AC	1963	2078	37	250	$ 1,313	$ 48,855	$ 7,153
-	98B Ave. at 134 St.	1000082374	200	AC	1973	2078	73	250	$ 1,313	$ 95,974	$ 14,052
-	Lane east of Whalley Blvd, south of 107A Ave.	1000092925	200	VCP	1963	2078	96	250	$ 1,313	$ 126,371	$ 18,502
-	132 St. south of 110 Ave.	1000090150	200	AC	1963	2079	105	250	$ 1,313	$ 137,960	$ 19,611
-	140 St. south of 100 Ave.	1000088369	200	PVC	1997	2079	10	250	$ 1,313	$ 12,490	$ 1,775
-	Bentley Rd south of 110A Ave.	1000092954	200	VCP	1963	2080	94	250	$ 1,313	$ 123,548	$ 17,051
-	132 St. at King George Blvd.	1000091666	450	CP	1963	2081	32	525	$ 1,938	$ 61,982	$ 8,305
-	98B Ave. at 134 St.	1000082373	200	AC	1973	2081	108	250	$ 1,313	$ 141,965	$ 19,022
-	138A St. north of 104 Ave.	1000092802	200	VCP	1963	2082	117	200	$ 1,200	$ 140,028	$ 18,216
-	140 St. south of 100 Ave.	1000088178	300	PVC	2006	2082	5	375	$ 1,591	$ 8,343	$ 1,085
-	102 Ave. east of Whalley Blvd	1000088132	350	DIP	1996	2083	34	375	$ 1,591	$ 54,141	$ 6,838
		Total					8,402			$11,483,164	$ 2,866,733

^Cost estimates calculated from City of Surrey construction unit rates for NCPs and include project contingency.

A11. DCC Eligible Gravity Main Projects

Gravity Sewer Upgrades											
10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	Percentage of Flow Growth from Inside City Centre	DCC Eligible Capital Cost Attributable to City Centre
-	100 Ave. at 140 St.	1000088338	200	PVC	1989	2013	22	300	$ 1,413	100%	$ 30,911
-	100 Ave. at 140 St.	1000088339	200	PVC	1989	2013	102	300	$ 1,413	100%	$ 144,312
-	100 Ave. at 140 St.	1000088340	200	PVC	1989	2013	119	300	$ 1,413	100%	$ 167,382
-	100 Ave. at 140 St.	1000088341	200	PVC	1989	2013	21	300	$ 1,413	100%	$ 29,265
-	100 Ave. at Whalley Blvd.	1000088319	250	AC	1966	2013	14	375	$ 1,591	100%	$ 22,803
-	104 Ave. at 133 St.	1000089972	200	AC	1963	2013	91	375	$ 1,591	100%	$ 145,240
-	104 Ave. at 133 St.	1000089973	150	AC	1963	2013	150	250	$ 1,313	100%	$ 197,446
-	105A Ave. east of King George Blvd	1000092921	200	AC	1963	2013	51	375	$ 1,591	100%	$ 80,878
-	105A Ave. west of City Parkway	1000089961	250	AC	1963	2013	98	450	$ 1,763	100%	$ 171,868
-	111A Ave. at Bolivar Rd.	1000089773	200	VCP	1963	2013	29	250	$ 1,313	100%	$ 38,378
-	112 Ave. at 132 St. Diversion	1000090487	300	AC	1963	2013	154	525	$ 1,938	100%	$ 297,744
-	112 Ave. at 132 St. Diversion	1000090506	300	AC	1963	2013	46	525	$ 1,938	100%	$ 89,128
-	112 Ave. at 135 St.	1000090508	200	VCP	1963	2013	115	375	$ 1,591	100%	$ 182,208
-	112 Ave. at 135 St.	1000090509	200	VCP	1963	2013	118	300	$ 1,413	100%	$ 166,028
-	132 St. at 114 Ave.	1000091431	450	CP	1973	2013	9	900	$ 2,850	100%	$ 26,355
-	132 St. south of 96 Ave.	1000080224	200	AC	1973	2013	53	300	$ 1,413	38%	$ 28,341
-	132 St. south of 96 Ave.	1000080225	200	AC	1973	2013	118	300	$ 1,413	38%	$ 63,693
-	132 St. south of 96 Ave.	1000080226	200	AC	1973	2013	124	300	$ 1,413	38%	$ 66,408
-	132 St. south of 96 Ave.	1000080227	200	AC	1973	2013	119	300	$ 1,413	38%	$ 63,697
-	132 St. south of 96 Ave.	1000080228	200	AC	1973	2013	124	300	$ 1,413	38%	$ 66,111
-	136 St. at 112 Ave.	1000089766	200	VCP	1963	2013	92	375	$ 1,591	100%	$ 147,033
-	139 St. at 104 Ave.	1000092797	200	VCP	1963	2013	73	375	$ 1,591	100%	$ 116,358
-	139 St. at 104 Ave.	1000092798	200	VCP	1963	2013	128	375	$ 1,591	100%	$ 203,642
-	139 St. north of 104 Ave.	1000092794	200	VCP	1963	2013	123	375	$ 1,591	100%	$ 195,447
-	Brentwood Crescent at Bentley Road	1000092938	200	VCP	1963	2013	102	375	$ 1,591	100%	$ 162,778
-	City Parkway north of 105 Ave.	1000089727	150	AC	1963	2013	87	300	$ 1,413	100%	$ 122,520
-	Grosvenor Road at Franklin Road	1000092957	200	VCP	1963	2013	111	375	$ 1,591	100%	$ 176,455
-	Queen Elizabeth SS	1000080419	200	AC	1973	2013	73	250	$ 1,313	100%	$ 95,567
2013 Gravity Sewer Sub-Total							2,464				$ 3,315,544
-	108 Ave. at 132A St.	1000090181	250	AC	1963	2017	16	450	$ 1,763	100%	$ 27,426

Gravity Sewer Upgrades

10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	Percentage of Flow Growth from Inside City Centre	DCC Eligible Capital Cost Attributable to City Centre
-	139 St. at 108 Ave.	1000092793	200	VCP	1963	2017	130	375	$ 1,591	100%	$ 206,538
-	139 St. south of 96 Ave.	1000079824	200	AC	1974	2017	101	375	$ 1,591	100%	$ 161,235
-	Bentley Rd. at King George Blvd.	1000089791	150	VCP	1963	2017	153	450	$ 1,763	100%	$ 270,368
-	Queen Elizabeth SS	1000080207	200	AC	1973	2017	115	250	$ 1,313	100%	$ 151,399
-	108 Ave. at 132A St.	1000089597	250	AC	1963	2018	9	375	$ 1,591	100%	$ 13,573
-	Bentley Rd. at King George Blvd.	1000089789	300	PVC	2008	2018	43	525	$ 1,938	100%	$ 83,700
-	Grosvenor Road at Franklin Road	1000092452	200	VCP	1963	2018	89	375	$ 1,591	100%	$ 141,929
-	112 Ave. at 132 St. Diversion	1000090507	300	VCP	1963	2019	114	450	$ 1,763	100%	$ 201,792
-	112 Ave. at 135 St.	1000091574	200	VCP	1963	2019	109	300	$ 1,413	100%	$ 153,612
-	132 St. north of King George Blvd.	1000091669	450	CP	1963	2019	92	675	$ 2,338	100%	$ 215,078
-	139 St. south of 96 Ave.	1000079819	200	AC	1973	2019	85	300	$ 1,413	100%	$ 120,472
-	132 St. north of King George Blvd.	1000091668	450	CP	1963	2020	62	675	$ 2,338	100%	$ 143,957
-	94A Ave. at 139 St.	1000079805	200	AC	1972	2020	61	300	$ 1,413	100%	$ 86,078
-	94A Ave. at 139 St.	1000079814	250	AC	1970	2020	12	375	$ 1,591	100%	$ 19,491
-	100 Ave. at Whalley Blvd.	1000088321	250	PVC	1987	2020	6	300	$ 1,413	100%	$ 8,302
-	132 St. north of 96 Ave.	1000082353	200	AC	1973	2021	14	250	$ 1,313	40%	$ 7,186
-	132 St. north of King George Blvd.	1000859861	450	CP	1963	2021	16	600	$ 2,113	100%	$ 34,206
-	132A St. at 105A Ave.	1000089939	200	AC	1963	2021	134	300	$ 1,413	100%	$ 189,787
-	111A Ave. and Brentwood Crescent	1000092942	200	VCP	1963	2022	108	300	$ 1,413	100%	$ 152,256
-	140 St. south of 100 Ave.	1000088464	200	AC	1974	2022	98	300	$ 1,413	100%	$ 138,995
-	Queen Elizabeth SS	1000080208	200	AC	1973	2022	71	250	$ 1,313	100%	$ 93,635
-	132 St. north of 96 Ave.	1000082397	200	AC	1973	2023	32	250	$ 1,313	40%	$ 16,998
-	132 St. north of King George Blvd.	1000091667	450	CP	1963	2023	90	600	$ 2,113	100%	$ 189,918
-	132 St. north of King George Blvd.	1000091670	450	CP	1963	2023	44	600	$ 2,113	100%	$ 93,142
-	135A St. at 107A Ave.	1000089923	200	AC	1963	2023	73	300	$ 1,413	100%	$ 103,145
2014 - 2023 Gravity Sewer Sub-Total							1,879				$ 3,273,416
-	102 Ave. at 139 St.	1000088544	200	AC	1972	2024	69	300	$ 1,413	100%	$ 97,980
-	112B Ave. at 132 St.	1000090503	300	AC	1963	2024	30	450	$ 1,763	100%	$ 53,528
-	112B Ave. at 132 St.	1000090504	300	AC	1963	2024	124	450	$ 1,763	100%	$ 218,379
-	135A St. at 107A Ave.	1000089924	200	AC	1963	2024	118	300	$ 1,413	100%	$ 167,342
-	94A Ave. at 139 St.	1000079815	250	AC	1970	2024	90	375	$ 1,591	100%	$ 143,967
-	King George Blvd. north of 108 Ave.	4	375	PVC	2013	2024	27	525	$ 1,938	100%	$ 51,634
-	Grosvenor Road at Hilton Road	1000092958	200	VCP	1963	2025	109	300	$ 1,413	100%	$ 153,500

Gravity Sewer Upgrades

10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	Percentage of Flow Growth from Inside City Centre	DCC Eligible Capital Cost Attributable to City Centre
-	102 Ave. at 139 St.	1000088543	200	AC	1972	2026	51	300	$ 1,413	100%	$ 71,747
-	104 Ave. at Whalley Blvd.	1000093062	300	AC	1963	2026	13	450	$ 1,763	100%	$ 23,110
-	96 Ave. east of King George Blvd.	1000088188	250	AC	1966	2026	152	375	$ 1,591	100%	$ 242,360
-	King George Blvd. at 94A Ave.	1000079680	675	PVC	1999	2026	15	900	$ 2,850	100%	$ 42,543
-	104 Ave. at 133 St.	1000089971	200	AC	1963	2027	69	250	$ 1,313	100%	$ 90,248
-	104 Ave. at Whalley Blvd.	1000093063	300	AC	1963	2027	74	450	$ 1,763	100%	$ 130,393
-	King George Blvd. at 96 Ave.	1000080856	450	PVC	1999	2027	14	600	$ 2,113	100%	$ 29,998
-	Whalley Blvd. south of 100 Ave.	1000088346	600	PVC	1992	2027	113	750	$ 2,513	100%	$ 284,383
-	111A Ave. at 136 St.	1000092943	200	VCP	1963	2028	116	300	$ 1,413	100%	$ 163,443
-	104 Ave. at Whalley Blvd.	1000093064	300	AC	1963	2029	81	450	$ 1,763	100%	$ 142,768
-	106 Ave. at 135A St.	1000089726	200	AC	1963	2029	101	300	$ 1,413	100%	$ 142,811
-	102 Ave east of 139 St.	1000088343	200	VCP	1972	2030	45	300	$ 1,413	100%	$ 62,890
-	132 St. at King George Blvd.	1000091568	600	PVC	1999	2030	4	750	$ 2,513	100%	$ 9,140
-	108 Ave. at 132A St.	1000090180	250	VCP	1963	2031	85	300	$ 1,413	100%	$ 120,395
-	111A Ave. at 136 St.	1000092944	200	VCP	1963	2031	128	300	$ 1,413	100%	$ 180,648
-	94A Ave. at 139 St.	1000079670	250	AC	1970	2031	72	300	$ 1,413	100%	$ 101,223
-	132 St. north of 96 Ave.	1000082398	200	AC	1973	2032	30	250	$ 1,313	40%	$ 15,598
-	139 St. north of 96 Ave.	1000088494	200	PVC	1980	2033	102	300	$ 1,413	100%	$ 143,489
2024 - 2033 Gravity Sewer Sub-Total							1,831				$ 3,158,309
-	139 St. north of 96 Ave.	1000088495	200	PVC	1980	2034	49	300	$ 1,413	100%	$ 68,862
-	Brentwood Crescent north of Grosvenor Rd.	1000092937	200	VCP	1963	2034	103	250	$ 1,313	100%	$ 135,044
-	Lane north of 98B Ave at 134 St.	1000082359	200	AC	1977	2034	61	250	$ 1,313	100%	$ 79,961
-	102 Ave east of 139 St.	1000088280	200	AC	1972	2035	38	300	$ 1,413	100%	$ 54,104
-	102 Ave east of 139 St.	1000088281	200	AC	1972	2035	14	300	$ 1,413	100%	$ 19,650
-	105A Ave. east of University Dr.	1000089728	250	AC	1963	2035	94	375	$ 1,591	100%	$ 149,095
-	139 St. north of 96 Ave.	1000088358	200	PVC	1991	2035	26	300	$ 1,413	100%	$ 36,214
-	134 St. north of 98B Ave.	1000082370	200	AC	1974	2036	114	250	$ 1,313	100%	$ 149,159
-	139 St. north of 96 Ave.	1000088359	200	PVC	1991	2036	32	300	$ 1,413	100%	$ 44,623
-	139 St. north of 96 Ave.	1000088499	200	PVC	1980	2036	67	300	$ 1,413	100%	$ 95,211
-	Hilton Rd. at Grosvenor Rd.	1000092967	200	VCP	1963	2036	103	300	$ 1,413	100%	$ 145,673
-	King George Blvd. north of 108 Ave.	5	450	PVC	2013	2036	104	600	$ 2,113	100%	$ 219,066
-	139 St. north of 104 Ave.	1000092795	200	VCP	1963	2037	130	300	$ 1,413	100%	$ 183,329
-	139 St. north of 104 Ave.	1000092796	200	VCP	1963	2037	130	300	$ 1,413	100%	$ 183,330

Gravity Sewer Upgrades

10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	Percentage of Flow Growth from Inside City Centre	DCC Eligible Capital Cost Attributable to City Centre
-	King George Blvd. north of 108 Ave.	6	450	PVC	2013	2037	13	600	$ 2,113	100%	$ 27,251
-	138A St. north of 104 Ave.	1000092804	200	VCP	1963	2038	108	300	$ 1,413	100%	$ 152,355
-	Brentwood Crescent at Grosvenor Rd.	1000093042	200	VCP	1963	2039	138	250	$ 1,313	100%	$ 181,178
-	Lane north of 98B Ave at 134 St.	1000082360	200	AC	1977	2039	37	250	$ 1,313	100%	$ 49,024
-	105 Ave. east of University Dr.	1000089731	525	CP	1963	2040	114	675	$ 2,338	100%	$ 267,448
-	98A Ave., west of King George Blvd.	1000082376	200	AC	1973	2040	73	250	$ 1,313	100%	$ 95,973
-	King George Blvd. north of 108 Ave.	7	450	PVC	2013	2040	76	600	$ 2,113	100%	$ 159,916
-	King George Blvd. south of 107A Ave.	1000089986	200	AC	1963	2040	109	250	$ 1,313	100%	$ 142,752
-	King George Blvd., south of 98 Ave.	1000080848	200	AC	1973	2040	48	250	$ 1,313	100%	$ 63,175
-	138A St., north of 104 Ave.	1000093056	200	VCP	1963	2042	108	250	$ 1,313	100%	$ 141,556
-	139 St. north of 96 Ave.	1000088496	200	PVC	1980	2042	45	250	$ 1,313	100%	$ 58,552
2034 - 2043 Gravity Sewer Sub-Total							1,932				$3,014,364
-	104 Ave. east of 138 St.	1000093065	300	AC	1963	2044	89	375	$ 1,591	100%	$ 141,426
-	Hilton Rd. at Grosvenor Rd.	1000093023	200	VCP	1963	2044	105	250	$ 1,313	100%	$ 137,756
-	140 St. south of 100 Ave.	1000088180	300	PVC	2006	2045	9	375	$ 1,591	100%	$ 14,291
-	102 Ave. at 138A St.	1000088372	200	AC	1972	2046	42	250	$ 1,313	100%	$ 55,694
-	102 Ave. east of 139 St.	1000088542	200	AC	1972	2046	84	250	$ 1,313	100%	$ 109,787
-	104 Ave. at King George Blvd	1000092433	350	AC	1963	2047	20	450	$ 1,763	100%	$ 36,099
-	104 Ave. at King George Blvd	1000092434	350	AC	1963	2047	19	450	$ 1,763	100%	$ 33,501
-	138A St., north of 104 Ave.	1000092803	200	VCP	1963	2047	108	250	$ 1,313	100%	$ 141,556
-	136 St. north of 111 Ave.	1000089765	200	VCP	1963	2050	111	250	$ 1,313	100%	$ 145,135
-	138 St. north of 104 Ave.	1000092915	200	VCP	1963	2050	106	300	$ 1,413	100%	$ 149,757
-	140 St. south of 100 Ave.	1000088465	200	AC	1974	2050	117	250	$ 1,313	100%	$ 153,554
-	Lane west of King George Blvd., north of 104 Ave.	1000089730	525	CP	1963	2050	165	675	$ 2,338	100%	$ 386,101
-	139 St., north of 96 Ave.	1000088493	200	PVC	1980	2052	34	250	$ 1,313	100%	$ 44,784
-	96 Ave. between 134 St. and King George Blvd.	1000080912	200	PVC	2005	2052	3	250	$ 1,313	100%	$ 3,504
-	132A St. south of 108 Ave.	1000089941	200	AC	1963	2053	119	250	$ 1,313	100%	$ 155,954
-	138 St. north of 104 Ave.	1000092914	200	VCP	1963	2054	106	300	$ 1,413	100%	$ 149,333
-	King George Blvd. south of 107A Ave.	1000089987	200	AC	1963	2055	116	250	$ 1,313	100%	$ 152,753
-	University Dr. at 105 Ave.	1000089692	525	CP	1993	2055	16	675	$ 2,338	100%	$ 37,260

Gravity Sewer Upgrades

10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	Percentage of Flow Growth from Inside City Centre	DCC Eligible Capital Cost Attributable to City Centre
-	Brentwood Crescent at Bentley Road	1000092939	200	VCP	1963	2056	103	250	$ 1,313	100%	$ 135,051
-	139 St. north of 96 Ave.	1000088360	200	PVC	1991	2057	4	250	$ 1,313	100%	$ 4,594
-	94A Ave at King George Blvd	1000079656	675	PVC	1999	2057	5	750	$ 2,513	100%	$ 13,250
-	104 Ave. at King George Blvd	1000093059	350	AC	1963	2058	13	450	$ 1,763	100%	$ 22,752
-	138 St. north of 105 Ave.	1000092912	200	VCP	1963	2058	94	250	$ 1,313	100%	$ 122,761
-	East of 132 St., north of 112 Ave.	1000090505	300	AC	1963	2058	152	375	$ 1,591	100%	$ 242,056
-	105 Ave. east of City Parkway	1000089963	525	CP	1963	2059	111	600	$ 2,113	100%	$ 235,322
-	King George Blvd at 98 Ave.	1000081852	200	AC	1973	2062	108	250	$ 1,313	100%	$ 141,557
-	132A St. south of 108 Ave.	1000089940	200	AC	1963	2063	119	250	$ 1,313	100%	$ 155,954
-	Fraser Hwy west of Whalley Blvd	1000088288	600	PVC	1992	2064	42	675	$ 2,338	100%	$ 98,655
-	105 Ave. west of City Parkway	1000089964	525	CP	1963	2065	86	600	$ 2,113	100%	$ 181,683
-	105A Ave. east of King George Blvd	1000092920	200	VCP	1963	2066	100	250	$ 1,313	100%	$ 131,748
-	138A St. north of 104 Ave.	1000092423	200	PVC	1994	2072	15	250	$ 1,313	100%	$ 19,150
-	140 St. south of 100 Ave.	1000088461	200	PVC	1980	2072	42	250	$ 1,313	100%	$ 55,107
-	105 Ave. east of City Parkway	1000089885	525	CP	1963	2073	24	600	$ 2,113	100%	$ 50,428
-	140 St. south of 100 Ave.	1000088463	200	AC	1974	2073	29	250	$ 1,313	100%	$ 37,482
-	138A St. north of 104 Ave.	1000092800	200	PVC	1982	2074	72	250	$ 1,313	100%	$ 94,593
-	98A Ave., west of King George Blvd.	1000082377	200	AC	1973	2074	55	250	$ 1,313	100%	$ 72,387
-	102 Ave. at University Dr.	1000080870	350	PVC	2001	2075	49	375	$ 1,591	100%	$ 78,060
-	Lane south of 100 Ave. at 134 St.	1000082358	200	PVC	1977	2075	40	250	$ 1,313	100%	$ 52,341
-	140 St. south of 100 Ave.	1000088462	200	AC	1974	2076	67	250	$ 1,313	100%	$ 88,085
-	111A Ave at Hilton Rd.	1000089774	200	VCP	1963	2077	76	250	$ 1,313	100%	$ 99,870
-	132A St. south of 108 Ave.	1000089942	200	AC	1963	2077	119	250	$ 1,313	100%	$ 155,967
-	Bentley Rd. at Hilton Rd.	1000092431	200	VCP	1963	2077	81	250	$ 1,313	100%	$ 105,921
-	140 St. south of 100 Ave.	1000088369	200	PVC	1997	2079	10	250	$ 1,313	100%	$ 12,490
-	132 St. at King George Blvd.	1000091666	450	CP	1963	2081	32	525	$ 1,938	100%	$ 61,982
-	138A St. north of 104 Ave.	1000092802	200	VCP	1963	2082	117	200	$ 1,200	100%	$ 140,028
-	140 St. south of 100 Ave.	1000088178	300	PVC	2006	2082	5	375	$ 1,591	100%	$ 8,343
-	102 Ave. east of Whalley Blvd	1000088132	350	DIP	1996	2083	34	375	$ 1,591	100%	$ 54,141
2044 - 2083 BO Gravity Sewer Sub-Total							3,171				$4,820,004
2013 - 2083 BO Gravity Sewer Sub-Total							11,277				$17,581,637

A12. DCC Eligible Gravity Main Upsizing Projects

10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	DCC Eligible Capital Cost
-	Hilton Rd Diversion, Bentley Rd at Hilton Rd	-				2013	39	450	450	17,550
-	**2013**	**TOTAL**					**39**			**$17,550**
-	132 St north of 96 Ave	1000082350	200	AC	1973	2017	108	300	212	22,896
-	132 St north of 96 Ave	1000082351	200	AC	1973	2017	123	300	212	26,076
-	100 Ave at 143 St	1000088420	200	AC	1975	2018	95	300	212	20,140
-	100 Ave at 143 St	1000088421	200	AC	1975	2018	116	300	212	24,592
-	100 Ave at 140 St	1000088377	200	VCP	1972	2019	51	300	100	5,100
-	Lane east of King George Blvd, south of 105A Ave	1000092936	200	VCP	1963	2019	103	375	220	22,660
-	132 St at Old Yale Rd	1000082409	200	VCP	1963	2020	114	300	100	11,400
-	141 St at 101 Ave	1000088410	200	VCP	1972	2020	86	300	212	18,232
-	141 St at 101 Ave	1000088411	200	AC	1972	2020	69	300	212	14,628
-	132 St at Old Yale Rd	1000082411	200	VCP	1963	2021	125	300	100	12,500
-	140 St at 108 Ave	1000092691	150	VCP	1963	2021	15	250	112	1,680
-	141 St at 102 Ave	1000088408	200	VCP	1972	2022	99	250	112	11,088
-	King George Blvd at 108 Ave	2	375	PVC	2013	2022	52	600	800	41,600
-	100 Ave east of 143 St	1000088419	200	AC	1972	2023	79	250	112	8,848
-	141 St south of 102 Ave	1000088409	200	VCP	1972	2023	63	250	112	7,056
-	Grosvenor Rd at 108 Ave	1000092961	150	AC	1963	2023	7	300	100	700
-	**2014 - 2023**	**TOTAL**					**1,305**			**$249,196**
-	130 St south of 108 Ave	1000089879	200	VCP	1963	2024	116	250	112	12,992
-	132 St north of 96 Ave	1000082352	200	AC	1973	2024	91	250	112	10,192
-	130 St south of 108 Ave	1000089908	200	VCP	1963	2025	101	250	112	11,312
-	132 St south of Old Yale Rd	1000082141	200	AC	1963	2025	31	300	100	3,100
-	Bolivar Cres at King George Blvd	1000089787	200	VCP	1963	2025	94	375	275	25,850
-	111A Ave at 135A St	1000089778	150	VCP	1963	2026	54	250	112	6,048
-	140 St north of 106 Ave	1000092740	200	VCP	1963	2026	95	300	100	9,500
-	140 St north of 106 Ave	1000092741	200	VCP	1963	2026	95	300	100	9,500
-	140 St north of 106 Ave	1000092742	200	VCP	1963	2026	95	300	100	9,500
-	98B Ave, west of 134 St	1000082363	200	PVC	1977	2026	87	300	212	18,444
-	98A Ave west of 133A St	1000082369	200	PVC	1977	2027	42	300	212	8,904

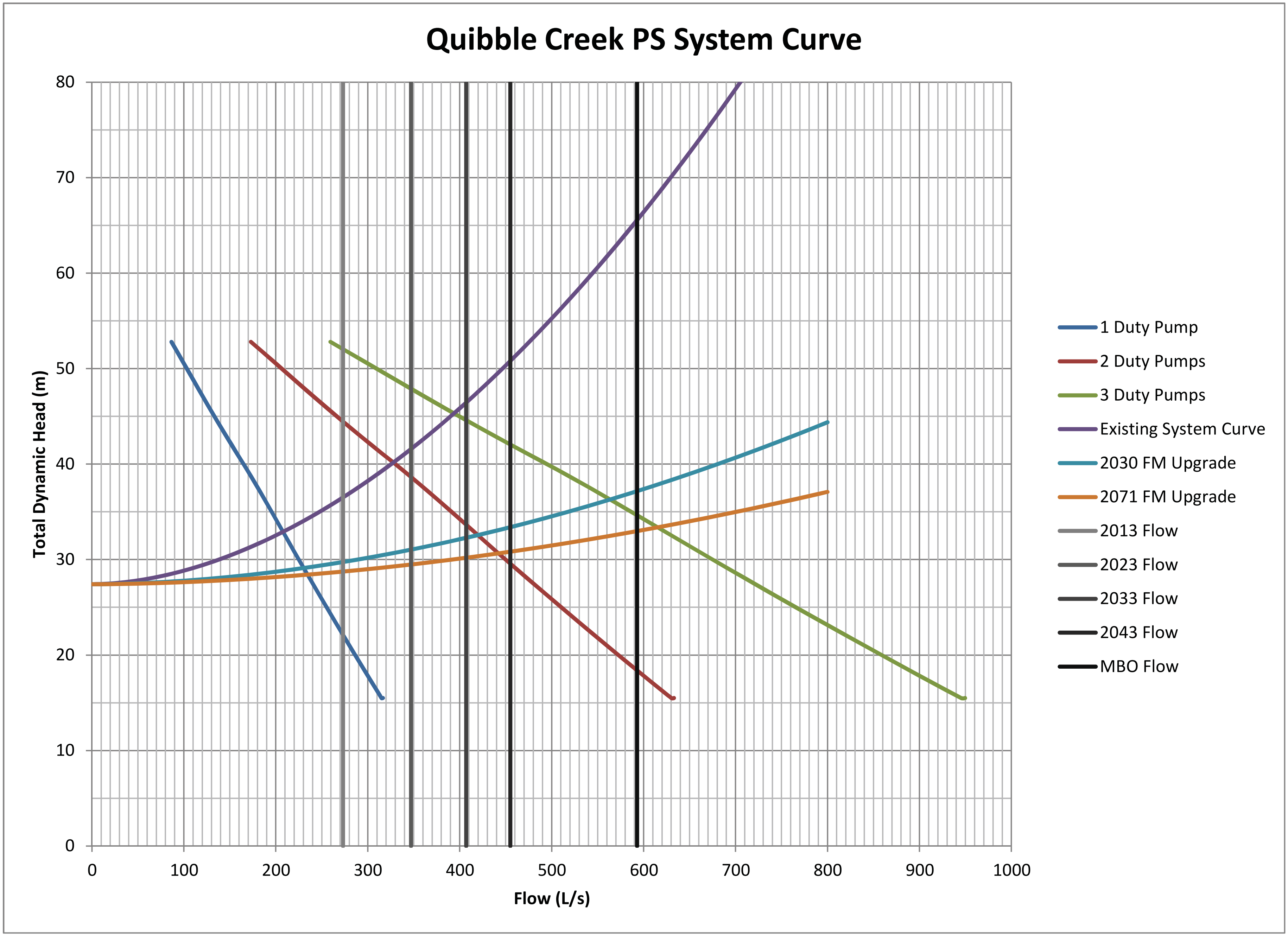
10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	DCC Eligible Capital Cost
-	Bolivar Cres at King George Blvd	1000089788	200	VCP	1963	2027	105	375	275	28,875
-	King George Blvd north of 108 Ave	3	300	PVC	2013	2027	19	525	625	11,875
-	Lane E of KG Blvd, S of 105A Ave	1000092935	200	VCP	1963	2027	94	300	100	9,400
-	109 Ave at 139A St	1000092447	150	VCP	1963	2028	56	250	112	6,272
-	132 St north of Old Yale Rd	1000082410	200	AC	1963	2028	4	300	100	400
-	108 Ave at 130 St	1000090176	200	VCP	1963	2029	114	250	112	12,768
-	King George Blvd at 108 Ave	1	375	PVC	2013	2029	11	600	800	8,800
-	139A St at 109 Ave	1000093033	150	VCP	1963	2030	130	250	112	14,560
-	96 Ave west of 134 St	1000082383	200	AC	1973	2030	95	300	212	20,140
-	Berg Rd at Cowan Rd	1000092956	150	VCP	1963	2032	111	250	112	12,432
-	132 St north of 109 Ave	1000090149	200	AC	1963	2033	106	300	100	10,600
-	Selkirk Dr at Cowan Rd	1000092448	150	VCP	1963	2033	119	250	112	13,328
-	**2024 - 2033**	**TOTAL**					**1,865**			**$274,792**
-	Lane W of KG Blvd S of 104 Ave	1000079424	200	AC	1973	2035	87	300	100	8,700
-	139A St at Brentwood Cres	1000093034	150	VCP	1963	2037	111	250	112	12,432
-	139A St north of 102 Ave	1000088385	200	VCP	1972	2037	112	300	100	11,200
-	Grosvenor Rd at Selkirk Dr	1000092451	200	VCP	1963	2037	102	300	212	21,624
-	Lane E of Whalley Blvd North of 105A Ave	1000092927	200	VCP	1963	2037	96	300	100	9,600
-	105A Ave east of City Parkway	1000089960	200	AC	1963	2038	93	300	100	9,300
-	Brentwood Cres at 139A St	1000093036	200	VCP	1963	2041	107	300	212	22,684
-	Antrim Rd east of Brentwood Cres	1000093040	200	VCP	1963	2042	77	300	212	16,324
-	**2034 - 2043**	**TOTAL**					**785**			**111,864**
-	96 Ave between 134 St and KG Blvd	1000081853	200	AC	1973	2044	108	300	100	10,800
-	105A Ave east of City Parkway	1000089958	200	AC	1963	2045	7	300	100	700
-	111 Ave east of 136 St	1000092945	150	VCP	1963	2046	117	250	112	13,104
-	133A St south of 104 Ave	1000082554	200	AC	1962	2047	76	300	100	7,600
-	133A St south of 104 Ave	1000082555	200	AC	1962	2047	75	300	100	7,500
-	100 Ave and Whalley Blvd	1000088371	200	PVC	1992	2048	17	300	100	1,700
-	Grosvenor Rd east of Brentwood Cres	1000093024	200	VCP	1963	2049	107	250	112	11,984
-	100A Ave east of 132 St	1000082421	200	AC	1974	2051	96	300	100	9,600
-	Antrim Rd east of Brentwood Cres	1000093041	200	VCP	1963	2055	77	250	112	8,624
-	100 Ave at KG Blvd	1000088370	200	PVC	1992	2056	96	300	100	9,600
-	100 Ave at KG Blvd	1000082167	200	PVC	1992	2059	84	300	100	8,400

10 Year Servicing Plan ID	Location	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost ($/m)	DCC Eligible Capital Cost
-	139 St south of 102 Ave	1000088383	200	AC	1972	2060	91	300	100	9,100
-	100 Ave east of 141 St	1000088278	300	PVC	2005	2062	109	375	388	42,292
-	133A St at 98B Ave	1000082362	200	PVC	1977	2064	47	250	112	5,264
-	Bentley Rd south of 110A Ave	1000092954	200	VCP	1963	2080	94	250	112	10,528
-	**2044 - BO**	**TOTAL**					**1,201**			**$156,796**
-	**2013 -- 2044 - BO**	**TOTAL**					**5,195**			**$810,198**

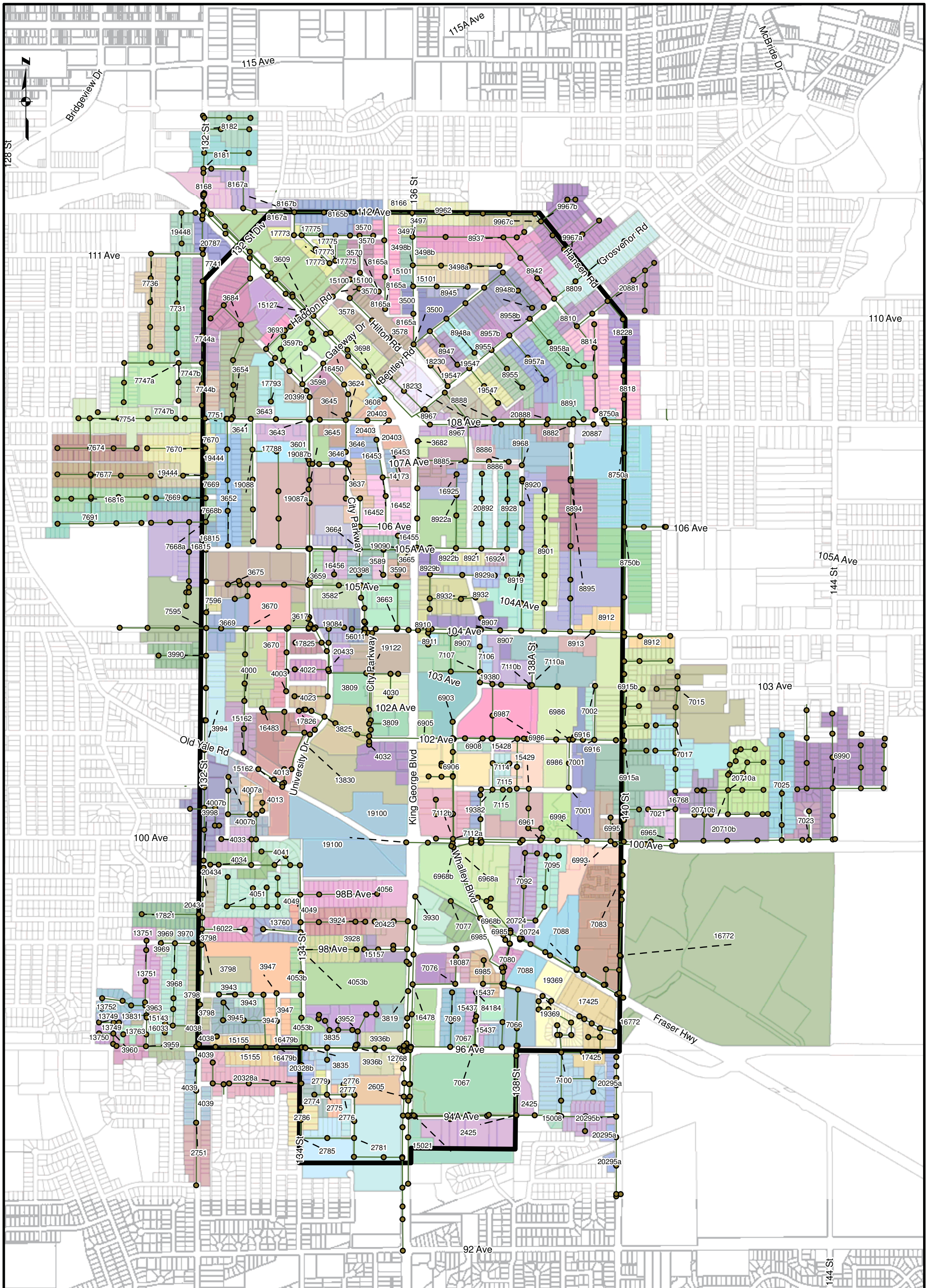
A13. DCC Eligible Pump Station & Forcemain Projects

Pump Station and Forcemain Upgrades											
10 Year Servicing Plan ID	Description	Pipe ID	Ex. Dia. (mm)	Ex. Material	Year Installed	Upgrade Year	Length (m)	Proposed Dia. (mm)	Unit Cost	Percent Attributable to City Centre	DCC Eligible Capital Cost
12721	Add 1 – 225 L/s pump to Quibble Creek Pump Station (4th Pump)	-	-	-	-	2019	-	-	$110,000.00	100%	$110,000
-	Twin 1598 m of 500 mm dia. forcemain w/ 675 mm dia.	-	500	DIP	1999	2030	1598	675	$ 2,125	100%	$ 3,395,750
-	Twin 718 m of 600 mm dia. forcemain w/ 600 mm dia.	-	600	DIP	1999	2073	718	600	$ 1,950	100%	$1,400,100
	Pump Station and Forcemain Sub-Total						2,316				$ 4,905,850
	DCC Eligible Projects Grand Total						**18,788**				**$ 23,297,685**

A14. Quibble Creek Pump Station System Curve


Quibble Creek PS System Curve
Total Dynamic Head (m)
80
70
60
50
40
30
20
10
0
0
100
200
300
400
500
600
700
800
900
1000
Flow (L/s)
1 Duty Pump
2 Duty Pumps
3 Duty Pumps
Existing System Curve
2030 FM Upgrade
2071 FM Upgrade
2013 Flow
2023 Flow
2033 Flow
2043 Flow
MBO Flow

A15. Assignment of Sewage Loadings by Sub-Catchment



City of Surrey — the future lives here.

Surrey City Centre Plan Update
Utility Servicing Strategy

Legend

- Sanitary Manholes
- Sanitary Network
- City Centre Boundary

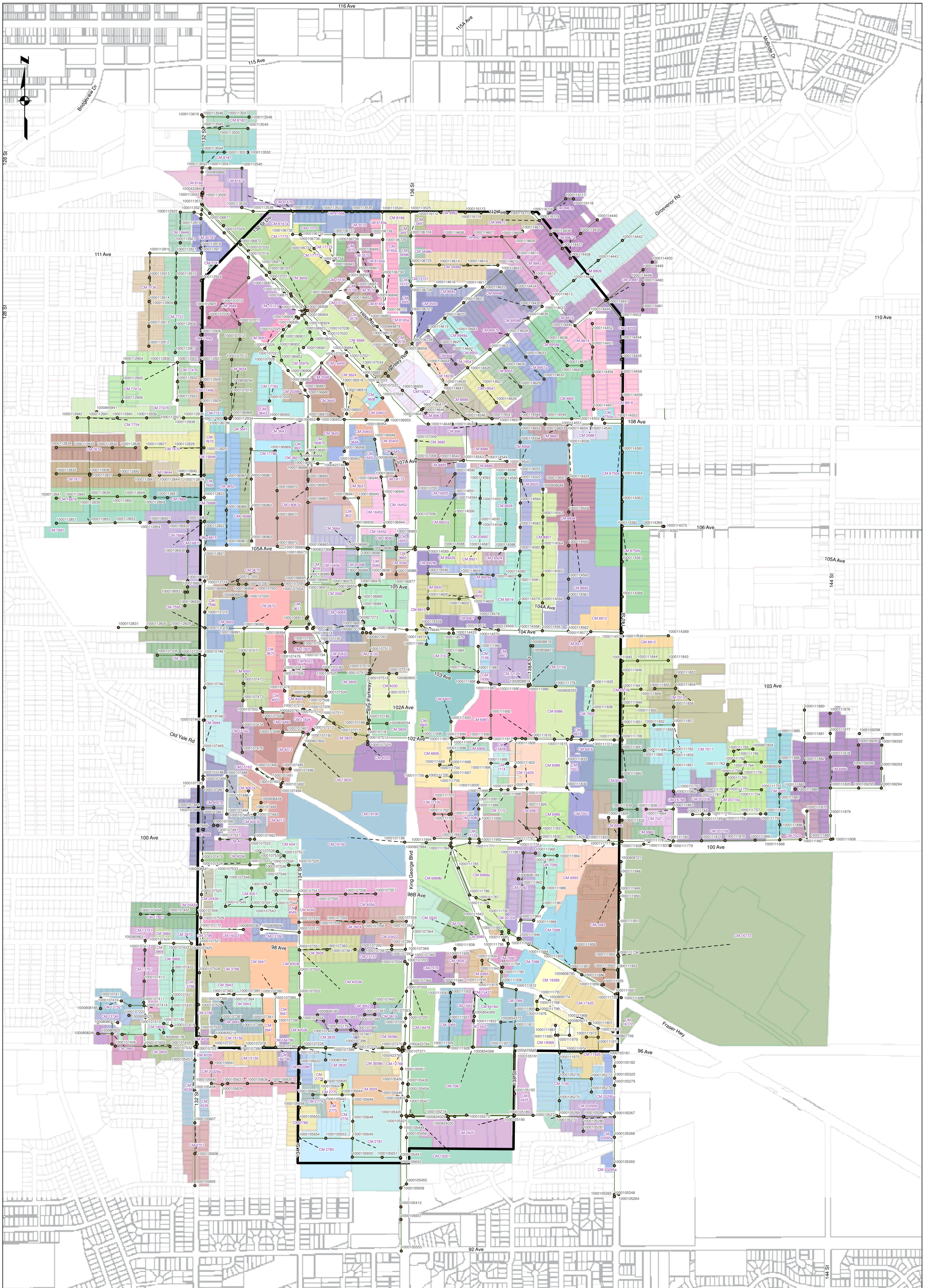
AECOM

Meters
0 50100 200 300 400 500

Sanitary
Sub-Catchments
Load Assignment

Project No:	Date:
60278179	July 2014

FIGURE A13



Surrey City Centre Plan Update
Utility Servicing Strategy

Project No: 60278179

Date: July 2014

Legend

- Sanitary Manholes
- Sanitary Network
- City Centre Boundary

AECOM

0 50 100 200 300 400 500 Meters

Sanitary Sub-Catchments Load Assignment

FIGURE A13

A16. City Centre Projected Growth Areas for Development Staging Scenarios

City Centre Projected Areas

		2013			2023			2033			2043			2083		
	# of SF Parcels (2007)	% Redeveloped	% SS	SS Pop	% Redeveloped	% SS	SS Pop	% Redeveloped	% SS	SS Pop	% Redeveloped	% SS	SS Pop	% Redeveloped	% SS	SS Pop
Polygon A	72	0%	38%	53	65%	100%	49	21%	100%	110	9%	100%	126	5%	100%	132
Polygon B	280	0%	38%	205	14%	100%	465	22%	100%	422	23%	100%	416	41%	100%	319
Polygon C	452	0%	38%	331	5%	100%	829	13%	100%	759	15%	100%	742	67%	100%	288
Polygon D	286	0%	38%	210	2%	100%	541	2%	100%	541	6%	100%	519	90%	100%	55
Existing	901	0%	38%	661	0%	100%	1,739	0%	100%	1,739	0%	100%	1,739	0%	100%	1,739
Total	1,991			1,460			3,622			3,570			3,542			2,533

	2013	**2023**	**2033**	**2043**	**2083**
General Population	32,352	48,820	68,288	88,564	158,066
Secondary Suite Population	1,460	3,622	3,570	3,542	2,533
Total Population	33,812	52,442	71,858	92,106	160,599

PART 7 STORMWATER INFRASTRUCTURE

7 Stormwater Infrastructure

The City Centre vision is to be the Fraser Valley's metropolitan centre supporting vibrant downtown neighbourhoods, a dynamic business sector, as well as civic, university and hospital districts. In addition, Surrey's goal is for the City Centre to be one of North America's most sustainable downtowns.

The following reference to storm drainage system needs within City Centre is taken from the July 2008 City Centre Plan Update for Council:

"Sustainable drainage features are supported for volume reduction and water quality purposes. Opportunities for implementing best management practices, such as "green" practices in all new development projects, would reduce the need for significant stream restoration works and will be investigated as part of this study".

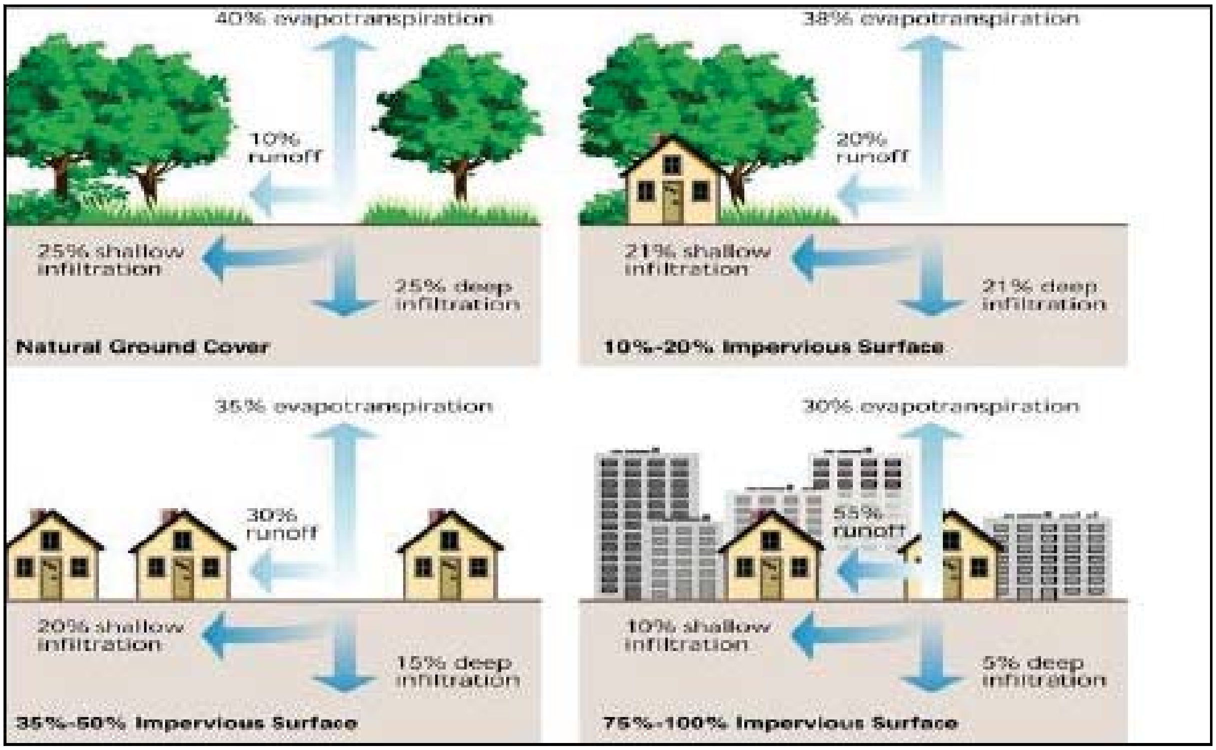
The objective of this study is to identify options for managing the stormwater, including the best management practices referred to above, while supporting the Surrey City Centre vision of a sustainable, liveable and dynamic community.

Urbanization and Stormwater Impacts

Prior to development, most native soils have sufficient permeability to absorb and infiltrate rainwater. This is because of a combination of factors, including the structure of the soil, the connected pores and channels created by plant roots, and the presence of leaf litter and other organic matter. Because most rain storms are not large enough to exceed the soil permeability and completely saturate the native and undisturbed soil, only a small percentage of water collects on the surface. Under these conditions, water that accumulates at the surface typically collects in rivulets that combine to form creeks, streams, and rivers.

Urbanization results in the loss of native soil conditions as a result of soil compaction and the creation of impervious surfaces. These changes disrupt the hydrologic cycle as shown in ***Figure 7.1***. The Impacts include increased stormwater flow rates and volumes as well as decreased groundwater recharge and, consequently, low base flows into streams.

Figure 7.1 Impacts of Urbanization on Stormwater Runoff



Urbanization, that does not include proper protection measures, can have serious negative impacts on the quality of surface water and groundwater. As land is developed, the volume of pollutants from vehicles and other human activities increase. The increase in impervious areas reduces the availability of the natural biological processes of soil to remove impurities from the water. The increased runoff flows wash pollutants from impervious areas, concentrating them in the storm sewers and transporting them downstream to receiving waters. Pollutants of concern include sediment (suspended solids), heavy metals (dissolved and particulate, such as lead, copper, zinc, and cadmium), nutrients (such as nitrogen and phosphorous), bacteria and viruses, organics (such as oil, grease, hydrocarbons, pesticides, and fertilizers), floatable trash and debris.

Managing the quality and quantity of stormwater runoff in the City Centre area will help protect streams so that they remain healthy and productive. Well planned measures can help reduce the need for costly infrastructure and stream restoration as well as provide green public amenities.

7.0 Existing & Future Servicing Issues

7.0.1 Summary of Previous Watershed Studies

Stormwater from the City Centre area flows into Bolivar Creek in the north and Quibble Creek in the south. The City's Watercourse Classification Map, shows Quibble Creek and most of its branches are of 'Class A' category ('inhabited or potentially inhabited by salmonids year-round'); Bolivar Creek is a combination of 'Class B' ('significant food/nutrient value') and 'Class A'.

The City of Surrey completed the "Quibble Creek Functional Feasibility Study" (2003), the "North Bluff Drainage and Slope Stability Assessment", (2000) and the "Quibble Creek Integrated Stormwater Management Plan" (2014), Bridgeview - North Slope (2015). Important conclusions from these studies that pertain to development and storm water management within City Centre are outlined below. These studies are based on earlier density forecasts for the City Centre area.

The City Centre Plan proposes greater levels of imperviousness and population densities than previously anticipated. This makes the recommendations for mitigation and pollution control from the earlier studies more important because the negative impact of development on the receiving waters will be greater than originally expected.

Quibble Creek Issue Functional Feasibility Study

Key points from the Quibble Creek Issue Functional Feasibility Study include:

- The on-going densification of developments in the Quibble Creek watershed is increasing its impervious surface area and contributing to increased stormwater runoff volumes and rates. These higher flow rates and volumes are impacting the receiving watercourses and their flow regimes, leading to streambed and bank modifications. In addition, an increase in imperviousness results in a decreasing the base flows and deterioration of stormwater runoff water quality to the creek. Future development within the City Centre area will increase impervious surface area by an additional 15%. This will increase both potential creek erosion and the volume of sediment entering the watershed. The watercourses are experiencing significant flows during frequent events of up to the 5-year recurrence level. This part of the flow regime has the greatest disturbance impact on aquatic habitat in the watercourses.
- Approximately 35% of the length of Quibble Creek and its tributaries do not have the standard 30m riparian corridor. Almost the full length of the City Parkway and King George Boulevard tributaries do not have a 30m riparian corridor.
- Based on biophysical inventories of Quibble Creek conducted in 1995 and 2000, contaminated sediments continue to be a critical problem in the upper reach from immediately below Fraser Highway north to the 100^{th} Avenue culvert. As a fish-bearing water course, the Quibble Creek report concludes that it is critical to control sediment loading to the watercourse.
- The Quibble Creek Functional Feasibility Study recommends '***on-site storage; riparian (buffer zone) protection; and the addition of sediment collection units'***. In particular the study recommends that '***developers should be required to implement measures that would reduce runoff volume***' and that sediment control/water quality improvement drainage units '***should also be promoted to control the quality of stormwater discharges from new commercial and industrial developments, redevelopments and parking lots, particularly in the City Centre area***'.

North Bluff Drainage and Slope Stability Assessment

Key points from the North Bluff Drainage and Slope Stability Assessment include:

- The proposed ultimate land use for City Centre has a significant impact on volumes of runoff and peak stormwater flows. It identifies a series of storm system improvements to accommodate this additional runoff, including the Bolivar Creek Diversion sewer which will mitigate ongoing and future erosion potential along Bolivar Creek.

Quibble Creek Integrated Stormwater Management Plan

The Quibble Creek Integrated Stormwater Management Plan (ISMP) includes the following key issues:

- Flood management of undersized storm sewers and culverts, erosion management in the stream channels, mitigation of future development impacts from increasing imperviousness in the watershed, environmental protection due to threats to riparian and stream integrity and the need to establish the long term vision for the watershed.

Bridgeview - North Slope Integrated Stormwater Management Plan

The Bridgeview - North Slope (ISMP) includes the following key issues:

- Protect and preserve green space and ecosystem sites, hubs, and corridors that support wildlife habitat
- Include water quality facilities and on-site stormwater detention.
- Stricter enforcement to prevent/reduce polluting of water courses and drainage systems by residents, businesses, and the industrial areas.

The City has implemented a number of the recommended stormwater capacity upgrades for City Centre which are described below on **Table 7.1.** This highlights the investment already expended in the area to prepare for development. The works completed to date are based on a lower level of development than the land use designations of the current City Centre Plan; however it is expected that by incorporating mitigation measures into the current plan, the completed infrastructure will be adequate to service the area.

Table 7.1 City Centre Capacity Upgrades Completed to Date

Year	Watershed	Project	Cost
2000 – 2011	Bolivar	Bolivar Creek Diversion Sewer – Bolivar Creek By-pass north of City Centre Bolivar Phase 3 Storm Trunk – 104 Avenue/City Parkway – 108 Ave/University Drive 1050mm diameter storm sewer	$2,100,000
2007	Quibble	City Centre Detention Pond at Whalley Blvd/100 Avenue	$560,000
2012	Bolivar	Trunk sewer installation servicing the area north of 108 Ave and east of 136 St	$2,200,000
2012	Quibble	Trunk sewer installation along 104 Ave from 140 St to Whalley Blvd, south along Whalley Blvd to 103 Ave and along the alignment of 103 Ave to King George Blvd.	$1,900,000
		Total	**$6,760,000**

7.1 Design Criteria & Analysis

7.1.1 City Strategy and Policy

The City Centre area servicing is aligned with existing key documents and planning processes such as the July 2008 City Centre Plan Update for Council and the ongoing associated planning process, City of Surrey Sustainability Charter, Biodiversity Conservation Strategy and the City's drainage and environmental by-laws and policies.

Objectives from these various documents that are relevant to stormwater management in the City Centre area are outlined below.

City Centre Area Plan Update

The goals listed below were taken from the City Centre Area Plan Update – Phase II, Stage 1 Results. They outline elements of sustainable rainwater management such as implementing best practices, minimizing imperviousness, increasing landscaping and green space, promoting green roofs and the use of green standards for building design and construction.

- Exemplify design excellence by incorporating compact urbanism, density and sustainability to the greatest extent possible, consistent with best practices;
- Minimize surface parking and require extensive landscaping of any surface parking areas;
- Encourage landscaping and screening over most rooftop surfaces;
- Protect and enhance the Quibble Creek Greenway;
- Provide a variety of mini-parks and mini-plazas throughout the City Centre and support the park-like feel of the Binnie Neighbourhood, Hospital District and Fraser Neighbourhood;
- King George Boulevard and University Drive will be developed as attractive planted boulevards with wide sidewalks;
- Create attractive new Greenway routes on 102 and 105A Avenues;
- Accelerate the development of existing Greenway routes to a high standard;
- Create "Green Infrastructure" by introducing accessible natural features into the City Centre;
- Reduce the effective impermeable surface area;
- Promote green roofs, for their social, economic and environmental benefits; and
- Pursue LEED or LEED-like certification for municipal buildings and establish minimum green standards for multi-family and commercial buildings.

City of Surrey Sustainability Charter

The Sustainability Charter is a commitment by the City to place the principles of social, environmental and economic sustainability as the foundation of all decisions. It is the City's over-arching policy document, which guides the actions of the City. In the absence of other specific policies, direction will be taken from the Charter.

The charter identifies actions required to implement the Vision, the Goals and the Action Framework. It reflects the areas of interest within the City's three spheres of influence: corporate operations; municipal jurisdiction; and influencing other levels of government. Under the corporate operations sphere, the sustainability charter has identified a number of actions. Those actions that are relevant to rainwater management and the City Centre area are listed below.

- EN8: Apply Sustainable Engineering Standards and Practices;
- EN9: Institutionalize Sustainable Land Use Planning & Development Practices; and
- EN12: Enhance and Protect Natural Areas, Fish Habitat and Wildlife Habitat.

Surrey Drainage Policy

The City's drainage servicing practice is contained in Storm Drainage Management Policy No. H-45. The objectives that are relevant to a Stormwater BMP Strategy for City Centre are listed below.

- Provide adequate servicing infrastructure to all newly developing areas and minimize downstream adverse impacts;
- Protect the physical integrity of watercourses/creeks;
- Minimize the detrimental impact on aquatic life and wildlife habitats along watercourses; and
- Minimize the potential for water quality impairment resulting from land development in the watersheds.

Metro Vancouver Integrated Liquid Waste Resource Management Plan

In 2010 Metro Vancouver issued the Integrated Liquid Waste Resource Management Plan. This plan outlines requirements for municipalities to minimize stormwater impacts by managing rainwater runoff at the site-level. In particular, all municipalities within Metro Vancouver are required to update their municipal utility design standards and neighbourhood design guidelines to enable on-site rainwater runoff management.

7.1.2 Current Best Practices

Low Impact Development

Local governments are increasingly adopting ordinances that allow and encourage low impact development (LID) practices. In the area of rainwater management, LID works to infiltrate stormwater on-site rather than collecting, conveying and discharging stormwater off-site. The goals of LID are to enhance overall habitat functions, reduce runoff, recharge aquifers, maintain historic in-stream flows, and reduce drainage operations and maintenance costs.

Surrey is among the leaders in environmental responsibility and good engineering design practices. As we become aware of changing practices and as our continuous improvement process identifies appropriate new minimum standards we are bound to adopt these new practices. As an example of changing current best management practices, staffs have become aware of efforts in similar cities to Surrey such as Portland. The City of Portland has been recognized as a leader in innovative and sustainable stormwater management. Located in the Pacific Northwest of the United States, it has a similar climate, density, and urbanization issues as found in the City of Surrey.

Portland developed a citywide stormwater regulatory program in 1999 to meet State and Federal regulatory requirements, which includes water quality and flow control design standards for onsite stormwater management facilities. Their program focuses on low-impact development practices, structural source control devices, and maintenance and operational best management practices (BMPs) designed to improve stormwater quantity and quality.

Stormwater that is generated from private property must be managed on private property, in privately maintained facilities. Total onsite infiltration is required with vegetated infiltration facilities unless a technical analysis proves that it is not feasible due to high groundwater, poor infiltration rates (less than 2 in/hr), steep slopes, contaminated soils or space constraints. Stormwater that is generated from public property must be managed on public property, in publicly maintained facilities. In 2005 the City of Portland had approximately 9,000 public underground infiltration systems to discharge stormwater runoff from publicly owned streets.

Where complete onsite infiltration is not feasible, vegetated onsite retention/detention facilities are required to the maximum extent possible. Flow control for any stormwater discharge leaving the site must be sufficient to maintain peak flow rates at their pre-development levels for the 2-year, 5-year, and 10-year, 24-hour runoff events. For redevelopment projects, pre-development condition is defined as undeveloped land.

The Portland example demonstrates that infiltration in the downtown environment is feasible. While Portland was required by U.S. law to implement the measures, Surrey has the opportunity to implement measures to achieve our sustainability objectives voluntarily, in a professional and environmentally sound way as we move forward.

7.1.3 City Centre Objectives

The objectives of the stormwater servicing of the City Centre Plan is based on the Land Use Plan, City of Surrey Sustainability Charter, environmental and hydraulic assessments of the City Centre watersheds, the Quibble Creek and Bridgeview - North Slope ISMP, and low impact development and best practices. More specifically, the following stormwater objectives are as follows.

1. Adequately service the area to protect life and property;
2. Mitigate the adverse impacts of urban runoff water quality on watercourses;
3. Mitigate the adverse impacts of peak flows and velocities in the watercourses; and
4. Protect the riparian habitat and support the aquatic life along the watercourses.

Table 7.2 outlines strategies and performance targets that would enable the City of Surrey to meet the objectives outlined above.

Table 7.2 Stormwater Strategy and Performance Targets for City Centre Area

Objective	Strategy	Performance Target
Adequately service the area to protect life and property	Ensure the drainage system is designed according to the City of Surrey Engineering Department Design Criteria Manual.	As outlined in the Design Criteria Manual. Design flows for the 5 year to be in pipe and safe conveyance of 100 year.
Mitigate the adverse impacts of urban runoff water quality on watercourses	Control the flow of pollutants from the larger sources (construction sites and motor vehicles),	Total Suspended Solids (TSS) < 25 mg/litre
Mitigate the adverse impacts of flows and velocities in the watercourses	Control volume and rate of flow from frequent rainfall events and ensure sufficient base flows in streams.	Volume: Retain 50% of the 2 year storm Flow Rate: Reduce post-development discharge rate to pre-development discharge rate for the 2, 5 and 10 year 24 hour storm.
Protect the riparian habitat and support the aquatic life along the watercourses	Stream corridors are protected by setting minimum stream setbacks.	30 metre riparian corridor (e.g. 30 metres from top of bank on either side of the stream) is protected along the entire length of all watercourses.

7.2 Servicing Options & Proposed System

7.2.1 Options for Managing Stormwater

The design criteria manual outlines the basic storm drainage infrastructure required to provide Surrey residents with a reasonable level of service and safety. All development in City Centre is required to apply good engineering practices in order to meet or exceed the standards set out in the design criteria. By designing City infrastructure to the Design Criteria standards, we meet the first servicing objective to adequately service the area protecting life and property

To meet the next two objectives the City investigated several servicing options to determine which are the most cost effective and provide the desired results

Three options were evaluated in detail to determine their effectiveness for servicing City Centre:

1) **Diversion:**
   - Diverting stormwater away from sensitive tributaries and directly discharges it into the nearest river.
2) **Community Infiltration Facility:**
   - Collect runoff from a catchment area and gradually infiltrates it into the ground to recharge base flows at a centralized facility.
3) **On-Site BMPs:**
   - Application of BMPs on each site to capture stormwater directly and infiltrate it into the ground.

7.2.1.1 Diversion

The objective of a diversion sewer is to convey stormwater away from sensitive tributaries and directly discharge it into the nearest river. For the northern portion of City Centre that flows into Bolivar Creek the additional stormwater volume will need to be diverted into the Fraser River. This diversion may follow a similar alignment to the diversion sewer detailed in the North Bluff Drainage and Slope Stability Assessment report and would be approximately 2.4 km in length. The estimated cost for the Bolivar Diversion was approximately $2.5 Million.

For the southern portion of City Centre that flows into Quibble Creek the City has indicated that the three tributaries to Quibble Creek cannot accept increased flows and volume. Therefore the nearest outlet for this diversion would be the Serpentine River at 156 Street and 68 Avenue and the diversion sewer would have to be approximately 7.6 km in length and approximately $7.0 Million

These diversions do not allow for groundwater recharge and result in a significant modification to the natural flow regime of the receiving creeks which long term would be noticeable as a possible reduction of dry weather base flows. Although these diversion options would have no on-site requirements for developers, they would not sufficiently preserve Quibble and Bolivar Creeks. This option fails to meet the environmental and financial objectives.

7.2.1.2 Community Infiltration Facility

Community infiltration facilities require a large amount of land in order to store the captured volume from runoff and slowly re-introduce it back into the ground. While this option is more land-intensive, it does eliminate some of the concerns of maintaining many separate on-lot and on-street underground infiltration facilities. However, a community infiltration facility for the City Centre Area would need to be over 50 hectares in size. While the infiltration would provide a good approach to address some of the water quality objectives, due to the lack of available land, a large community infiltration facility is not a viable solution as it costs significantly more compared to the third alternative below.

7.2.1.3 On-Site BMP

The objective of best management practices (BMP) is to provide measures, on each lot, that will mimic the natural rainfall runoff response of the site prior to development. By making the site behave in a manner similar to pre-development, the impact of development is reduced, thereby protecting downstream properties, infrastructure, and natural resources from the increases in stormwater runoff flow rates, volumes and pollution that result from development.

Detention is a BMP that helps control flow rates by storing excess volume and releasing it over time. In the past, flow control efforts often relied solely on detention facilities such as ponds, tanks, or vaults that control peak flow rates. These facilities, however, allow the duration of high flows in creek systems to increase as the stored volume is released, causing the potential for increased erosion downstream. For example, after development with detention, the magnitude of the 2-year peak flow rate may not increase, but the amount of time (duration) that the flow rate occurs will increase.
This highlights the importance of designing BMPs with a system approach rather than as individual components.

Combining systems that can have both storage and infiltration or evapotranspiration such as pervious pavement, eco-roofs, planters, swales, and other surface vegetated facilities, lower the overall runoff volume and reduce the duration and frequency of the peak flow rate.

Stream systems that require erosion protection, such as Quibble and Bolivar Creeks, benefit from the use of the combination of retention systems, infiltration and evaporating stormwater. Vegetated retention systems recharge groundwater that serves as the base flow for streams during the dry season. Where retention systems cannot be used, detention systems that control the duration of the geomorphically significant flow (i.e., flow capable of moving sediment) must be used. Such detention systems lower release rates and must be designed to protect the stream channel.

Time of concentration (the time it takes rainfall to accumulate and run off a site) is an important factor in hydrologic impacts of development. The resistance of soils, natural topography and vegetation slow runoff from undeveloped sites. Flow rates may be controlled using detention, but when they are combined quickly in fast-flowing conveyance pipes, the downstream effect will still be increased in-stream flow rates and volumes. Breaking flow patterns up into surface retention systems helps increase a site’s time of concentration and lessens downstream impacts.

In addition to controlling flow, vegetation may be one of the most cost effective and ecologically efficient means available to improve water quality. Vegetated facilities filter stormwater, removing pollutants as the water flows through the vegetation and soil. Vegetation within riparian areas also shades water courses, which lowers water temperature; captures and absorbs water, which reduces peak flows; stabilizes soils and banks; provides wildlife habitat; and improves the aesthetic quality of the area.

A BMP Strategy for the City Centre Area should ensure that development protects the riparian area of stream channels and that post-development rainwater runoff:

- Controls the flows to the receiving conveyance facilities and water bodies to their natural capacity;
- protects stream banks and stream channels from erosion;
- protect the quality of downstream water bodies; and
- prevents upstream or downstream flooding.

In addition to achieving all of the objectives outlined above, a BMP strategy for the City Centre area can support a functional and attractive public realm.

Managing stormwater involves a variety of measures from on-site BMPs to area-wide storm sewer infrastructure.

7.2.2 Addressing Water Quality through BMPs

Changes in land use, loss of natural bio-filtration capacity, increases in impervious area, and pollutant laden runoff associated with urban development all contribute to water quality which impacts fish and human and fish habitat. The area studies have concluded that protecting Quibble Creek from contaminated sediments is a significant issue. Land development guidelines recommend the treatment of all stormwater runoff. It is recommended that Surrey treat the runoff from City Centre area before discharging to Quibble and Bolivar Creeks. Water quality is now a requirement that must be incorporated into all design practices.

Water Quality BMPs are physical, structural or management practices that reduce or prevent water quality degradation. Many of these are the same as, or similar to BMPs used for runoff volume reduction and rate control, but have ancillary benefits for water quality. For example, infiltrating stormwater on-site will also benefit water quality.

Contaminants within stormwater come from a variety of sources:

- Natural sources;
- Roadways and parking areas; and
- Private property.

A variety of measures are needed to adequately protect water quality, due to the range of sources and contaminants. The measures that are recommended for City Centre are listed below:

- Erosion and Sediment Control By-Law (already in effect) with enforcement;
- Require runoff from underground parking to drain to the sanitary sewer (already in effect)
- Optimised O&M practices such as street sweeping, catch basin cleaning, public education and spill reporting and response.
- Water quality treatment for all street runoff and surface parking areas (proposed new measure).

There are a variety of water quality treatment options which can be generally grouped in the following categories:

- Vegetated swales and strips;
- Dry basins;
- Wet basins;
- Constructed wetlands;
- Vortex separators;
- Oil/water separators;
- Inert media filters;
- Sorptive media filters;
- Drain inlet devices; and
- Infiltration systems.

The BC Water Quality Criteria for Aquatic Life recommends a maximum total suspended solid (TSS) of 25 mg/L. Runoff from vehicle areas (roadways, parking lots) and construction sites will be treated to meet the BC Water Quality Criteria for Aquatic Life (TSS < 25 mg/litre).

Based on land constraints within the City Centre area, we investigated the feasibility of treating road runoff by having an engineered treatment system (such as a vortex separator) upstream of each location where stormwater runoff is discharged to a creek. Within City Centre we identified seven locations where the majority of the stormwater is discharged to Bolivar or Quibble Creek (as shown in ***Figure 7.2***).

By placing an engineered treatment system near each of these discharge points the stormwater runoff within the City Centre area will meet the given performance target. The added benefit is that all the stormwater runoff, and not just road runoff, will be treated.

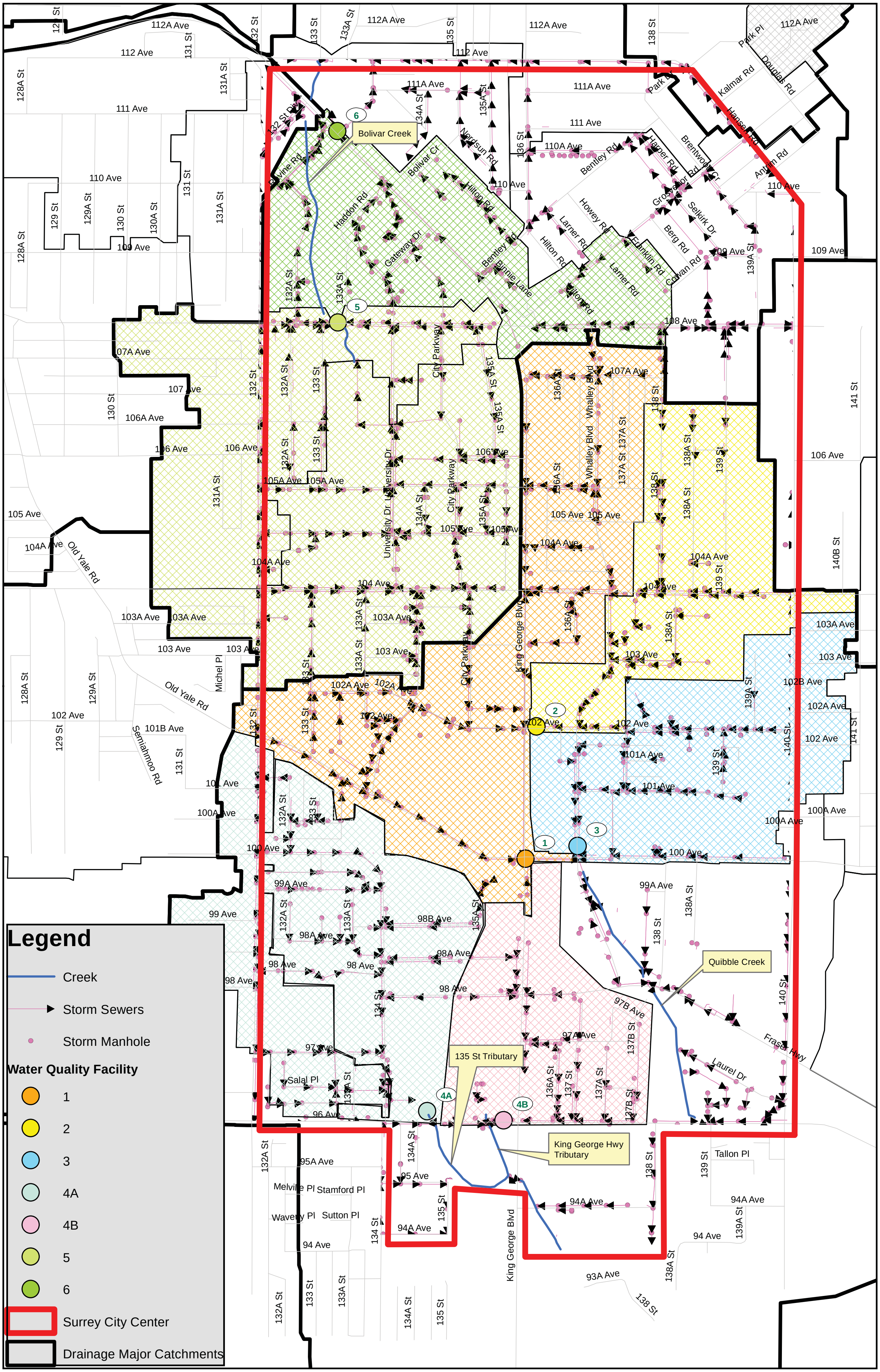


Figure 7.2 Potential Locations for Water Quality Treatment Facilities

7.2.3 Addressing Volume and Flow Control through BMPs

As outlined in ***Table 7.2***, it is recommended that Surrey retains 50% of the 2 year storm and control post development flows to pre-development levels. The most effective way to control runoff is through on-site BMPs such as rain gardens, green roofs and pervious pavement. The 24-hour 2-year rainfall amount for North Surrey is 64.6 mm. Since the objective is to retain 50% of the 2 year storm, 32.3 mm of rainfall must be retained on-site.

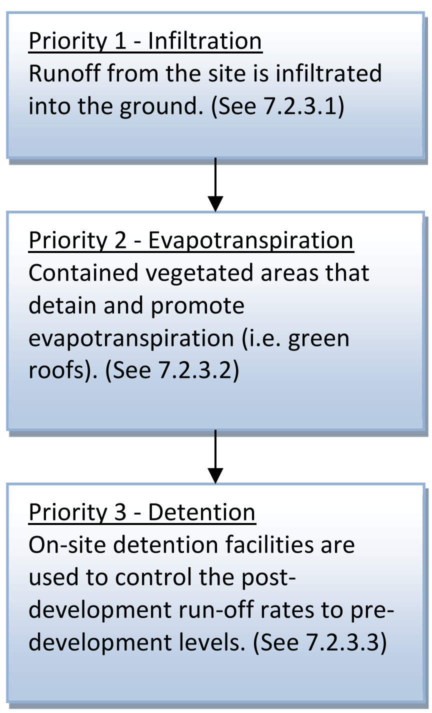
Community detention ponds are complimentary treatment processes for an effective BMP strategy. They provide additional water quality and detention benefits. However, in high density areas like City Centre it is challenging to implement because of high construction costs and the lack of available land. A small community pond has been constructed at the headwaters of Quibble Creek. Additional water quality and flow control is needed to protect this salmon bearing stream.

Controlling stormwater runoff on-site will reduce the degradation of Bolivar Quibble and the downstream Bear, creeks. In order to be effective the BMPs must retain 50% of the 2 year storm and detain post development flows to pre-development levels.

A successful BMP strategy must be simple to implement. The following BMP strategy for on-site stormwater management for the City Centre Area will provide the desired mitigation and is designed to be built into the on-site landscaping that normally is required of new development as part of planning for an aesthetically pleasing and healthy urban environment.

The following flow chart **Figure 7.3** outlines a staged approach based on various landscaping options that can be followed by developers to cost effectively meet the BMP requirements:

Figure 7.3 BMP Implementation



The objective is for sites to use infiltration techniques wherever possible, but where that is not feasible, sites may use evapotranspiration techniques. If both infiltration and evapotranspiration techniques are not sufficient, a site will be required to implement detention facilities. ***Appendix C*** outlines a number of BMPs and whether they are suitable for infiltration, evapotranspiration or detention.

A spreadsheet style worksheet has been prepared for Developers to confirm that they are meeting the landscape values or on-site detention requirements – see **Appendix C**. Each Developer is required to submit this information with their development application.

Additionally, a Stormwater Management Typologies and Strategies for developments in Surrey City Centre and other emerging urban neighbourhoods has been prepared for the City by van der Zalm + associates Inc. and is also included in **Appendix C** as reference material.

7.2.3.1 Priority 1 – Infiltration

Runoff can be infiltrated through absorbent landscaped areas, infiltration rain gardens, infiltration basins/ trenches, soakaway manholes or pervious pavements. Provide 0.5 cubic metres of free draining topsoil for every square metres of impervious area. Place on native soil to provide infiltration. Direct runoff to the landscaped area in an acceptable manner to allow flows to infiltrate. Where there are insufficient native soil areas for the placement of a reasonable depth of topsoil to meet the above requirement, treat the remainder of the site with detention.

Required Volume of Infiltration Material (m^3) = (site area in m^2) x 0.5 metres

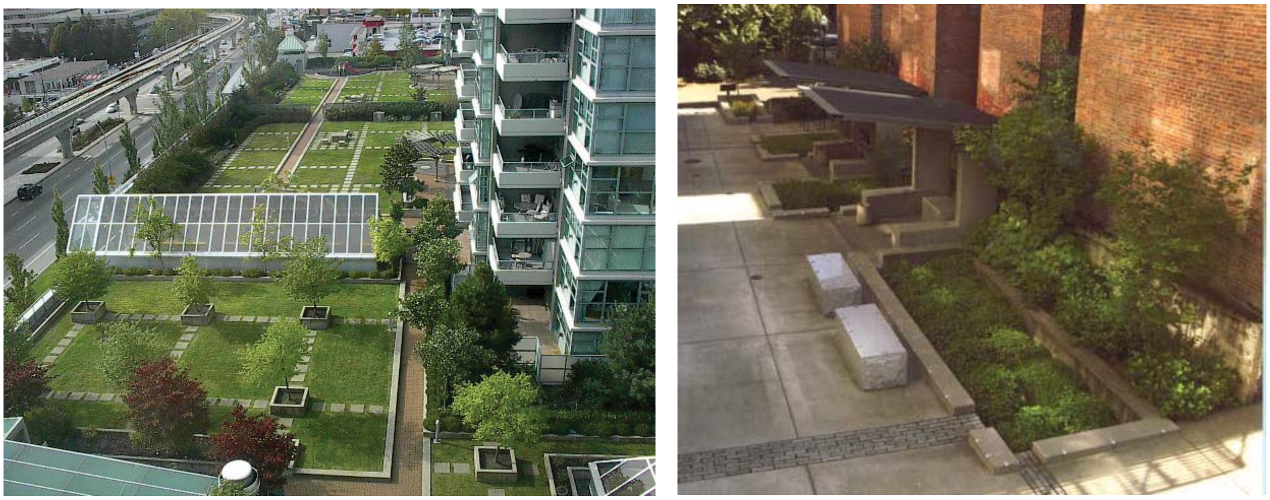
7.2.3.2 Priority 2 – Evapotranspiration

Runoff from areas that cannot be infiltrated into the ground due to site constraints such as underground parking requirements can be controlled through vegetated areas that use detention and evapotranspiration. These vegetated areas must have at least 75 mm of growing medium and be designed to reduce the volume of the 2 year storm by at least 50%. For each square metre of landscaped surface on top of an impervious surface such as a parkade or rooftop, the site must have 0.02 m^3 of stormwater storage. Examples of vegetated areas include green roofs and planters.

Required storage (m^3) = (landscaped area with no infiltration in m^2) x 0.02 metres

Rainwater that is stored on-site should be discharged at a rate that mimics the natural infiltration function of providing low flows to streams. If we assume that under natural conditions the soil had an infiltration rate of 1mm/hr, then the discharge rate should be 3 L/sec/ha. The design of the system is intended to be allowed to drain over 48 hours. Examples of using on-site landscaping to manage stormwater are illustrated in ***Figure 7.4***.

Figure 7.4 Examples of Using On-Site Landscaping to Manage Stormwater



7.2.3.3 Priority 3 – Detention

Runoff from areas that cannot be infiltrated or treated through evapotranspiration will need to be detained such that the post development flow equals the pre development flow. Pre-development conditions should be assumed to be vegetated landscape with a runoff coefficient (C) of 0.20.

For each square metre of bare plain impervious surface, from which the runoff is not infiltrated, the site must have 0.05 m^3 of stormwater storage.

Required storage (m^3) = (impervious surface area in m^2) x 0.05 metres

Detention facility design details are outlined in ***Section 7.2.3.2*** and ***Figure 7.2.***

7.2.3.4 On-Site BMP Scenarios

To understand the implications of implementing the on-site BMP requirements we have developed various scenarios for different development types. ***Figure 7.5*** shows a schematic of the proposed scenarios.

Scenario 1: Townhouse

A portion of City Centre may consist of medium density housing such as townhouses. To assess using BMPs within this setting we have assumed a 9 m x 21 m lot with 80% imperviousness. The pervious areas should be required to contain sufficient soil/landscaping to detain the 32 mm that falls upon it. The driveway and outdoor patio could be constructed of pervious or impervious pavement. They would have an infiltration facility (gravel trench or plastic retention chambers) below them. The roof runoff is directed to the driveway and patio and allowed to infiltrate below. There would be an overflow to the standard drainage system.

It is important to note that although roof runoff is not contaminant free it is relatively clean in comparison to street runoff. Given that there are no highly sensitive groundwater sources in proximity to City Centre, it should be acceptable to infiltrate roof runoff without significant treatment. Some form of basic treatment such as a screen will prevent blockages within the infiltration facility, improve its performance and prolong its service life.

<u>Scenario 2: High-Rise Residential/Commercial</u>

A significant portion of City Centre will consist of high-rise residential and commercial buildings. To assess using BMPs within this setting we have assumed a 30 m x 30 m lot with 80% imperviousness. The pervious areas contain sufficient soil/landscaping to detain the 32 mm that falls upon it. The runoff from the impervious areas (roof) could be dealt with in the following ways.

- Option A: A green roof covers the entire roof top which is designed to retain a minimum of 32 mm;
- Option B: The runoff from the roof is directed to the pervious pavers at grade with an infiltration basin. The infiltration basin must contain approximately 500 mm of soil to provide sufficient storage; or
- Option C: Provide 36 m^3 of detention on-site ((30 m x 30 m x 0.8) x 0.05m)).

A summary of the proposed on-site BMP requirements and how they would look in a high-rise development setting is provided in ***Appendix C***.

7.2.4 Riparian Habitat Protection

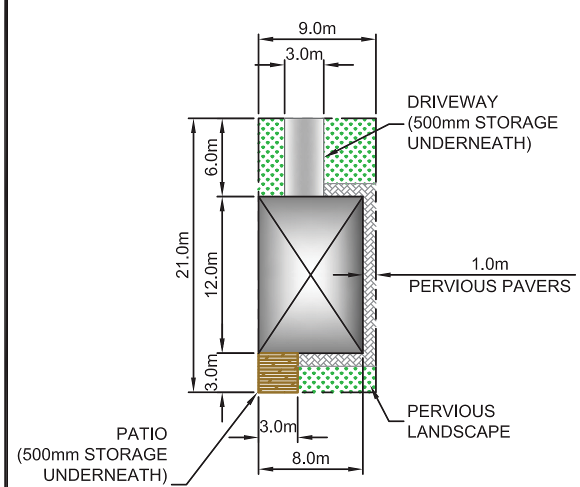
The fourth City Centre servicing objective is the protection of riparian habitat and support of aquatic life along the watercourses. By addressing the second and third objectives there is a reduced impact on the water courses. Maintaining or improving water quality will ensure that fish are able to survive. Control of flows so that that erosion occurs at a natural rate and can potentially be managed for the protection of property and of the riparian areas.

The riparian area adjacent to creeks requires protection from loss due to development and due to human activity. The City is developing measures and policies to address this concern. The .Riparian Area By-law is being prepared by the City to clarify how to best protect these areas.

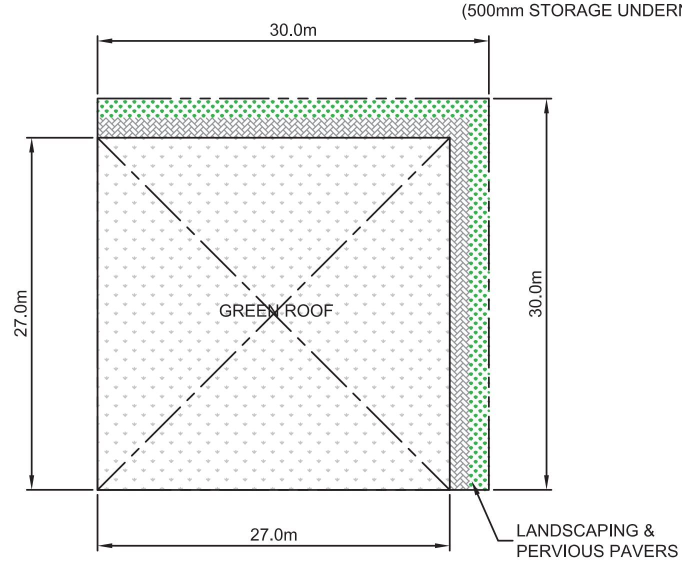
7.2.5 Recommended Servicing System

The City has constructed infrastructure works to address the safe conveyance for the 100 year event throughout the City Centre area, therefore, the following servicing system is recommended:

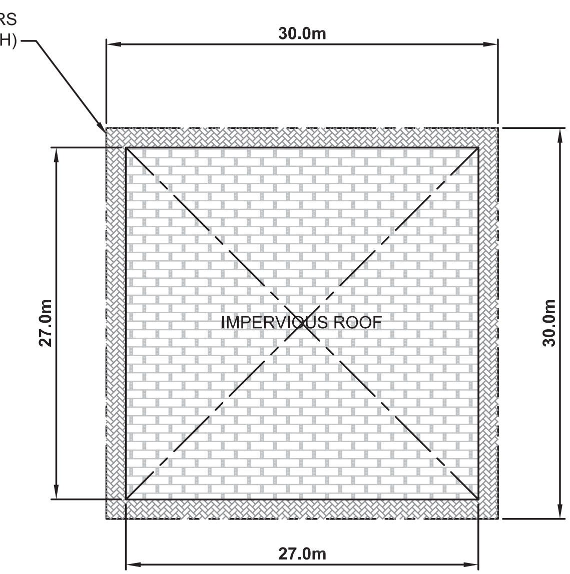
- All sites to meet the basic servicing requirements of the Design Criteria Manual
- On-site to include BMPs to control runoff volume and flow (2 year event);
- Developer's Architect to design the on-site BMPs as part of the site development process to ensure early incorporation of the works into the site design.
- The City to design and have constructed water quality facilities to remove solids and improve water quality from the stormwater runoff before discharging into Quibble and Bolivar Creeks; and
- Development to follow or exceed the Riparian Area By-law requirements.



SCENARIO #1 - TOWNHOUSE



SCENARIO #2A- HIGHRISE



SCENARIO #2B - HIGHRISE

DO NOT SCALE THIS DOCUMENT.
ALL MEASUREMENTS MUST BE OBTAINED FROM STATED DIMENSIONS.

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AECOM

ON-SITE STORMWATER DETENTION CITY CENTRE AREA

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
106544	Figure 7.5	A

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7.3 Infrastructure Costs and 10-Year Servicing Plan

The components of the servicing strategy for City Centre are:

- Treat road runoff before discharging it into Quibble Creek and Bolivar Creek and tributaries;
- Require on-site BMPs, as outlined in Section 7.2.3, which control the volume and rate of runoff from individual sites;
- Establish a 30 metre setback from top of bank for all development adjacent to Quibble Creek and Bolivar Creek and tributaries; and
- Implement the green street designs as provided in the Transportation Part of this Plan.

7.3.1 Capital Costs

Outlined below are the capital costs for implementing the Off-site and On-site BMP measures. These costs do not include maintenance costs.

Proposed New Measure #1 - Water quality treatment for all on-street runoff

The recommended approach to treating road runoff within the City Centre area is to place large vortex separators at the downstream end of each sub-catchment, before the water is discharged to Bolivar Creek or Quibble Creek. We identified seven sub-catchments which capture over 95% of the runoff from the City Centre Area. The estimated cost of purchasing and installing seven vortex separators, which are sized to meet the BC Water Quality Criteria for Aquatic Life, is $1.7 million. It is recommended that the devices be installed within the next ten years and that the City budget for annual inspection and cleaning at each of the installation sites.

The vortex separators are development cost charge (DCC) eligible infrastructure because they service catchment areas greater than 20 hectares in size.

Proposed New Measure #2 – On-site BMPs

As shown in ***Figure 7.5*** we have presented three scenarios for implementing on-site BMPs. The capital cost for developments with the desired BMPs for each of the scenarios is presented below. The cost estimates listed below include the base paving, roofing and landscaping costs. The life cycle costs are not shown and no adjustment are included for benefits unrelated to drainage and water quality.

- *Option 1: Townhouse* $13,000
- *Option 2A: High-rise with green roof* $120,000
- *Option 2B: High-rise with impermeable roof* $50,000

The cost estimate for Option 1 includes the cost of pervious pavement, an Infiltration basin with associated catch basin and observation well, and additional soil for landscaping. If the resident chose to install a chamber rather than pervious pavement with an infiltration basin then the cost would also be approximately $13,000.

The cost estimate for Option 2A includes the cost of a green roof, pervious pavers and additional soil for landscaping. It is important to note that the cost of a green roof doesn't consider other the benefits of a green roof; namely its use as an amenity space, a reduction in heating and air conditioning needs, an extension in the life of the roof, and its aesthetic value. In some cases, an intensive green roof may be required for amenity space, resulting in little or no additional cost to provide the necessary stormwater benefits.

The cost estimate for Option 2B includes the cost of pervious pavement and infiltration basins with associated catch basins and observation wells.

7.3.2 10 Year Servicing Plan

The City has already invested almost $7,000,000 over the past 12 years in upgrading the existing drainage system servicing the City Centre area (**Table 7.1**).

The following four local system upgrades projects (Table 7.3) have yet to be constructed to support the ultimate development, and are included in the 2014 – 2023 10 Year Servicing Plan for future localized system upgrades. These projects are in the 10 year plan because larger capacity is required for servicing or because the pipes require replacement. These are not eligible for DCC rebates as they do not service a catchment of 20Ha or greater. .

Table 7.3 Local system upgrades

10 Year Plan ID	Location	Length (m)	Prop. Dia. (mm)	Total Cost	DCC Amount
6412	140St: 105-105A Ave	172	450 & 600	$119,200	$11,920
11638	140 St: 104 – 106 Ave			$250,000	-
11662	Grosvenor Rd-111A Ave: 136 St-Brentwood Cr			$355,753	-
11640	132 St: 104 – 108 Ave			$592,843	-

To complete the list of projects for the stormwater servicing strategy, it is recommended that the City include the design and installation of the six water quality systems in the current 10 Year Servicing Plan (See Table 7.4).

Table 7.4 Water Quality Treatment Locations

Site	Location	Watershed	Total Cost	DCC Amount
1	Old Yale Rd at King George Blvd	Quibble	$245,000	$245,000
2	102 Ave at King George Blvd	Quibble	$245,000	$245,000
3	100 Ave at Whalley Blvd	Quibble	$245,000	$245,000
4A	96 Ave at 135 St	Quibble	$245,000	$245,000
4B	96 Ave at King George Blvd	Quibble	$245,000	$245,000
5	108 Ave at 133A St	Bolivar	$245,000	$245,000
6	King George Blvd at Ravine Rd	Bolivar	$245,000	$245,000

The City has advanced the area servicing works, and is currently completing the review and design of the water quality facilities, the works were completed using city wide development cost charge (DCC) funding. Developers will only be responsible to complete local servicing that is required to service their development if it precedes routine replacement or the natural progression of building that would have upgraded the existing pipes to the current design criteria.

The trunk drainage servicing for the area is fully funded through general DCC and once the water quality systems are completed, the area trunk servicing will be substantially complete.

APPENDIX C: STORMWATER DETAILS

- On-Site BMP Details
- Surrey City Centre On-Site Stormwater Management Requirements
- Worksheet for Landscaping and On-Site Detention Requirements
- Stormwater Management Typologies and Strategies

C1. On-Site BMP Details

BMP	Priority 1 Infiltration	Priority 2 Evapo-transpiration	Priority 3 Detention	Reference
Absorbent Landscape	X	X		1,2
Infiltration Swale System	X			1,2
Infiltration Rain Garden	X	X		1,2
Pervious Paving	X			1,2
Green Roof		X	X	1,2
Infiltration (or Soakage) Trench	X			1,2
Soakaway Manhole/Catch Basins	X			1,2
Detention Vault			X	2
Planters – open-bottomed with infiltration	X	X		1
Planters – closed (no infiltration)		X	X	1
Rainwater Harvesting	X			2
Rooftop Detention			X	2

1. GVS&DD Stormwater Source Control Design Guidelines 2005
2. MMCDA Green Design Guideline Manual 2005

SURREY CITY CENTRE

On-site Stormwater Management Requirements

Step 1

Infiltrate the stormwater run-off to the maximum extent possible.

For each square metre of impervious* surface area, there must be 0.5 m3 of infiltration material (i.e. top soil, gravel trench etc.).

*Please note that for an area to be considered pervious it must be in its natural state or have sucient top-soil and vegetated cover to mimic pre-development inltration rates.

If you are not able to infiltrate the entire site please proceed to Step 2.

Step 2

Use landscaped areas (including green roofs) to store and reduce run-off through evapotranspiration.

Proceed to Step 3 to determine storage requirements.

Step 3

Provide storage for run-off that is not addressed through infiltration or evapotranspiration.

For each square metre of landscaped surface, from which the run-off is not infiltrated, the site must have 0.02 m3 of stormwater storage.

For each square metre of impervious surface, from which the run-off is not infiltrated, the site must have 0.05 m3 of stormwater storage.

Scenario #1

Office based complex – 1 ha (i.e. 125 m x 80 m)

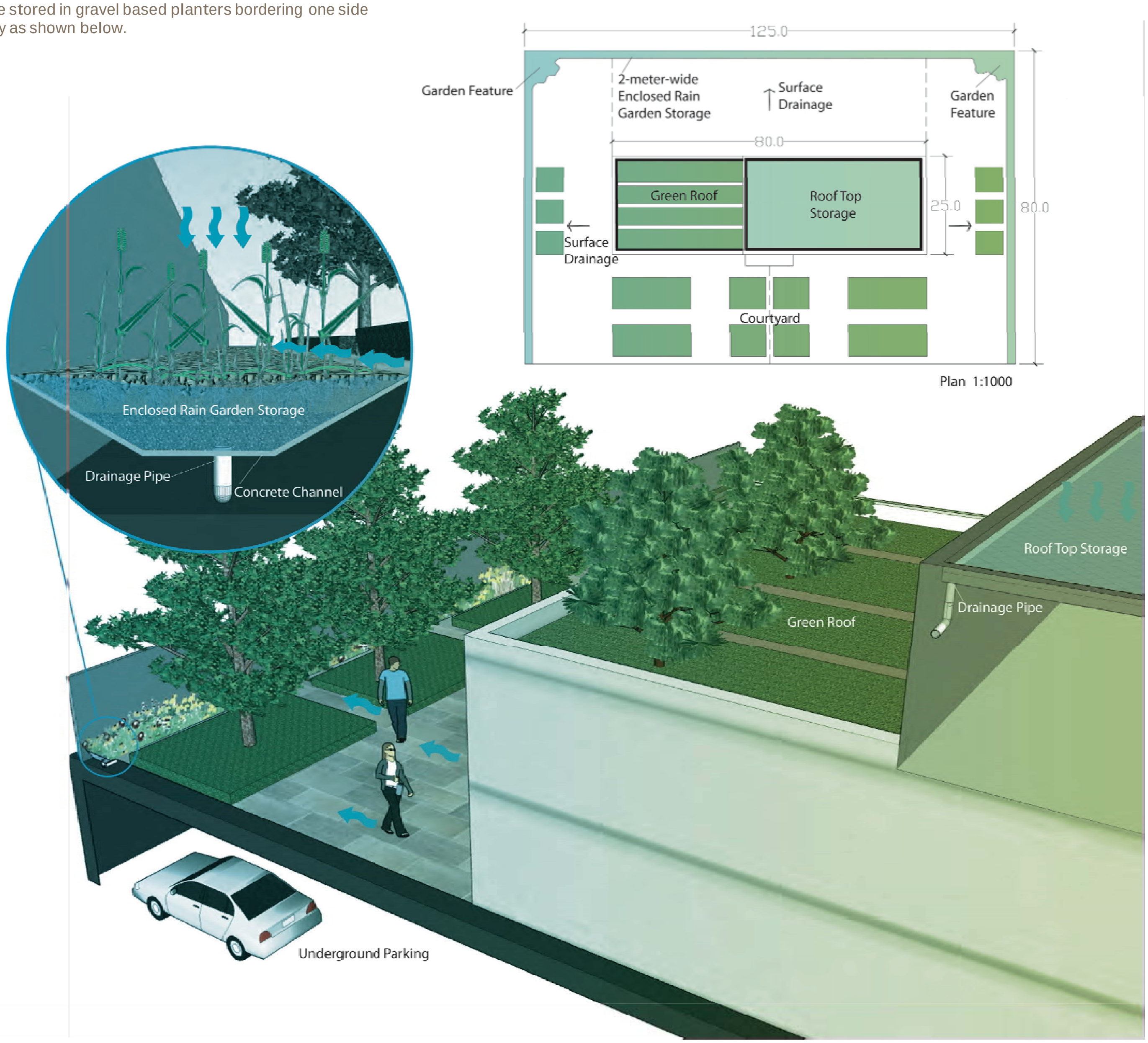
- No infiltration possible due to underground parking
- 25% of site is covered with planters/green roof
- 75% of site is impervious

Volume (V) of stormwater storage required:

V=10,000 m2 *25% *0.02 m3 +10,000 m2*75%*0.05 m3

V=50m3 +375m3=425 m3

Water could be stored in gravel based planters bordering one side of the property as shown below.



Surrey City Centre Development Mitigation

Not to be used for areas outside the City Centre GLUP

Instructions: Provide the values for the cells highlighted in Green

		Input		
A	Total Site Area	6132	m^2	
U	Protected Undisturbed Area	0	m^2	0%
D	Total Disturbed Area Calculated	6132	m^2	100%
P_l	Pervious Landscaping (over native soil)	1200	m^2	20%
S_d	*Topsoil Depth In Pervious Landscaping (over native soil)*	550	mm	Max 450mm unless designed.
P_p	Pervious Surfaces (over native soil)	134	m^2	2%
I_l	Landscaping (min 75 mm growing media over impervious)	584	m^2	10%
I_c	Impervious (no landscaping)	4214	m^2	69%

Summary of Topsoil and Detention Requirements

Stage 1	**Infiltration Provided**		
T_p	Topsoil Provided (S_d x P_l)	660	m^3
I_t	Area of impervious surface treated with topsoil (T_p/0.5)	1320	m^2
I_r	Area of impervious surface not mitigated with topsoil (I_c-I_t)	2894	m^2
Stage 2	**Detention Required**		
D_l	Detention for Landscape over Impervious (0.02 x I_l)	12	m^3
D_c	Detention for Untreated Impervious areas (0.05 x I_r)	**145**	m^3
Dt	Total Detention required (D_l + D_c)	156	m^3
	Allowable Discharge rate is 3 l/s/ha	1.8	l/s

Stage 3	**Detention Accomplished**		
Dt	Total Detention required (D_l + D_c)	156	m^3
Sde	Average soil depth in landscape over impervious*	0.3	m
Sd	Soil detention over impervious (avg. depth * 0.1 * area)**	**18**	**m^3**
D%	Percentage of Impervious (non landscape) availible for mitigation measures***	66	%
Di	Area of opportunuties for detention over impervious***	2781	m2
Md	Average depth of materials ****	0.05	m
Dit	Engineered detention over impervious	**139**	**m^3**
Stage 4	**Deficit Calculations**		
Dtot	Total Detention provided over impervious	157	m^3
Ddef	**Detention deficit*******	**0**	**m^3**

* while 75mm is minimum, average depth by BCLNA standards will be greater, and can likely average 300mm.
** assumes 1mm detention per 10mm of soil.
*** areas where slab drains could be held high (ie/ 25mm or 50mm), use of drainage mat, additional crushed gravels for detention.
Number does not necessarily equal total non-landscaped impervious, due to potential strucutural cost implications, but could, in theory.
**** depth of detention over impervious
***** goal is that this number reaches ZERO, otherwise alternatives to be undertaken, including on site tanking.

Note: this spreadsheet is for evaluation only, it requires the addition of a site figure showing the proposed layout, sections and landscape details before it can be used as an engineering design tool. The spreadsheet is only to be used for City Centre as an aid for design. It is not meant as a design standard or a submission item. It is assumed that anyone using this spreadsheet understands its benefits and limitations of the spreadsheet and is not relying on the above numbers as proof for a servicing strategy. As of this date the values in this spreadsheet have not been confirmed or approved for use and are only provided for information. This spreadsheet is a a work in progress

Storm Water Management Typologies and Strategies

For Developments in Surrey City Centre and Emerging Urban Neighbourhoods

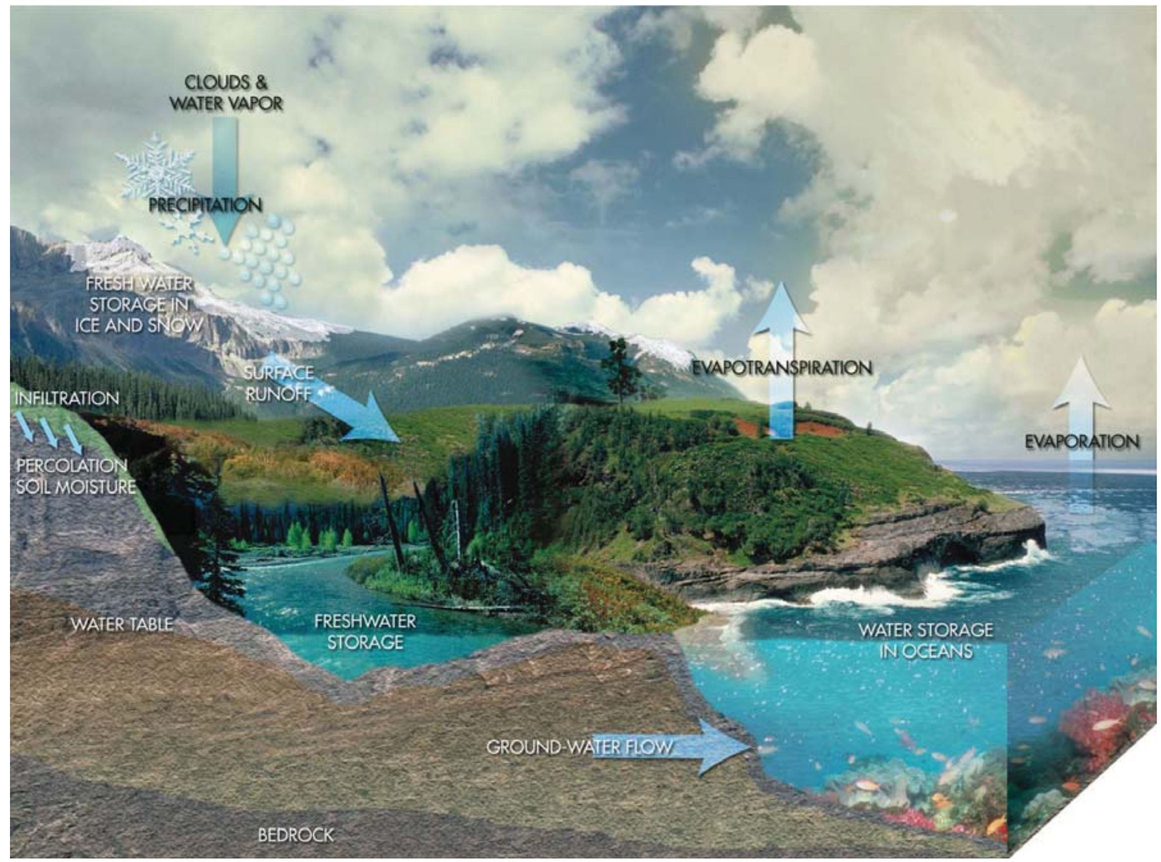
contents

www.vdz.ca/resources.php

presentation prepared by van der Zalm + associates Inc.

part one: understanding urban runoff

Understanding of the water cycle has developed over the past few decades. Water quality in measured in runoff volumes, pollutant levels, and discharge rates had allowed municipalities and governments to better understand the effects that storm water has on our environments.



part one: understanding urban runoff

Past to Present

Traditional design and planning in urban environments relied heavily on infrastructure with little or no on-site storm infiltration.

This created stresses on storm water systems and degraded downstream natural environments from increased pollutant runoff and volumes of water.

The high amounts of darkly paved surfaces in urban areas also dramatically increased the heat in their environments due to the low reflective properties, causing **"the heat island effect"**.

The increased heat and pollutant concentration in urban areas also resulted in an increased potential for smog and poor air quality through evapotranspiration.

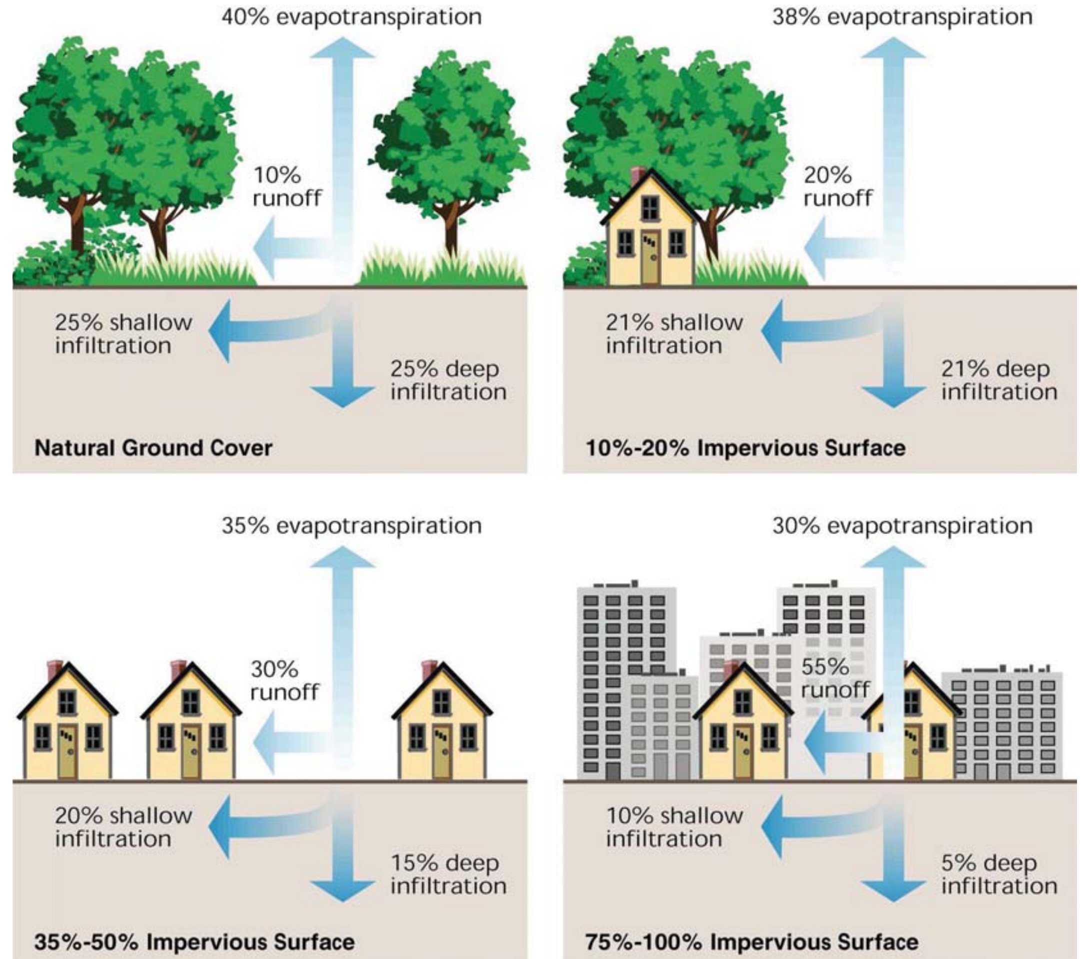


Fig. 3.21 -- Relationship between impervious cover and surface runoff. Impervious cover in a watershed results in increased surface runoff. As little as 10 percent impervious cover in a watershed can result in stream degradation.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).
By the Federal Interagency Stream Restoration Working Group (FISRWG) (15 Federal agencies of the U.S.)

part one: understanding urban runoff

Present and Future

Traditional design of urban storm water management is based on medium to maximum rain events anticipated for areas ranging anywhere from 2 to 200 year storm events. Designers have recognized the benefits of increasing site permeability and infiltration to manage day-to-day rainfall to decrease stresses on storm systems and extended environments. The present and future focus of stormwater design involves management of the majority (or all) storm water within a site.

Benefits of increased site permeability and infiltration design can include:

- Improved site aesthetic with additional soft landscaping and textured surfaces
- Decreased runoff rates of storm that lead to -
- Increased removal of site pollutants and suspended solids through the natural processes of soils and -
- Increased concentration time of site storm water for groundwater recharge or plant absorption

Several methods of rating initiatives to remediate storm water management include:

- LEED Sustainable Sites credits and Water Efficiency credits
- LID (Low Impact Development) measures • Green Globes • Built Green

Developers can work with these systems in coordination with City of Surrey bylaws to develop storm designs that better suit community goals and sustainable living.

TRADITIONAL is defined as:		INTEGRATED is defined as:
✓ Drainage Systems	⇨	✓ Ecosystems
✓ Reactive (Solve Problems)	⇨	✓ Proactive (Prevent Problems)
✓ Engineer-driven	⇨	✓ Interdisciplinary Team-driven
✓ Protect Property	⇨	✓ Protect Property and Resources
✓ Pipe and Convey	⇨	✓ Mimic Natural Processes
✓ Bureaucratic Decisions	⇨	✓ Consensus-based Decisions
✓ Local Government Ownership	⇨	✓ Partnerships with Others
✓ Narrow Scope of Work (drainage focus only)	⇨	✓ Holistic Scope of Work (stormwater integrated with land use)

Stormwater Planning: A Guidebook for British Columbia
Ministry of Water, Land and Air Protection, 2002

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part one: understanding urban runoff

What is Surrey Doing for Stormwater?

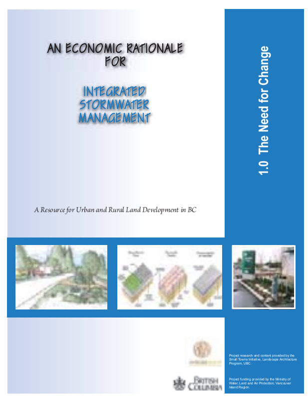
Surrey encourages design professionals and developers to use ISMP's (Integrated Stormwater Management Plans), Best Management Practices (BMP's) and LID (Low Impact Development) practices wherever possible.

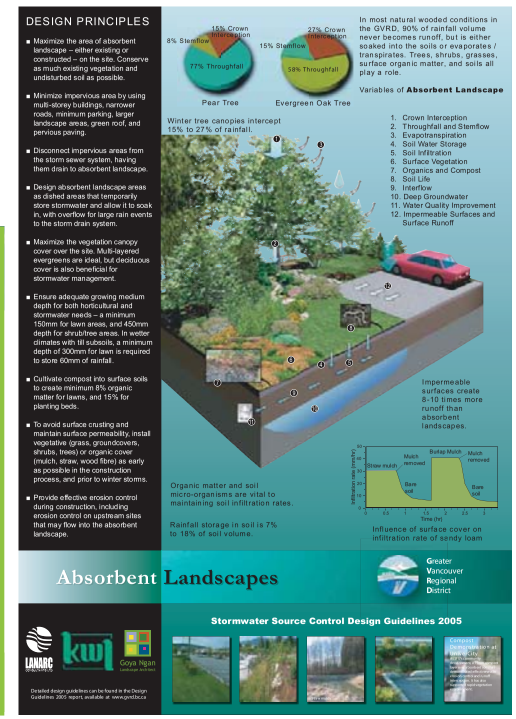
With Surrey being the fastest growing city in British Columbia, it is important that the City develops at an equal or better standard of storm water management as Canada's other largest municipalities. Much of the development occuring now will set a precedent for decades to come.

What are other big cities doing?

Vancouver is continuously amending it bylaws to incorporate increased green standards for achieving its goal of being the greenest city by 2020. For example, in July 2010 it was declared that there will be new green requirements for all rezoning applications recieved as of January 31, 2011. The requirements include that LEED Gold or Built Green Gold standards are applied to developments.

Toronto established the Green Development Standard in 2006 as a means of influencing the quality of developments for the ultimate goal of an 80% reduction in Green House Gases by 2050. Stormwater strategies play a key role in this effort, as standards are outlined for development at the low-rise non residential, low-rise residential, and mid-high rise forms of development.

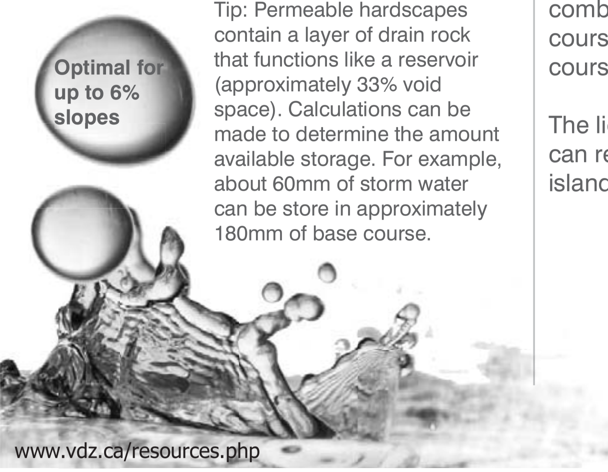




part two: storm water typologies

hardscape surfaces

Hardscape Surface Applications
- **Commercial schemes**
- **New housing developments**
- **Retail parks**
- **Car parks**
- **Government and Community Buildings and Facilities**



Tip: Permeable hardscapes contain a layer of drain rock that functions like a reservoir (approximately 33% void space). Calculations can be made to determine the amount available storage. For example, about 60mm of storm water can be store in approximately 180mm of base course.

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permeable concrete

100-150mm thick slab

11% of finished slab mixture is open air for easy infiltration. Stone aggregates typically range from 10mm to 14mm in size.

Base material for infiltration is key and should be determined by a civil engineer for runoff and infiltration capacity (usually 150mm to 350mm)

Base material is usually a combination of a clear crush top course and road mulch lower course.

The lighter colour of the concrete can reduce impacts of the heat island effect.

permeable asphalt

60mm - 100mm thick slab

A percentage of the finished slab mixture is open air for easy infiltration. Stone aggregates typically range from 10mm to 14mm in size.

Binders and lower courses usually contain a higher stone aggregate size of 14mm to 20mm.

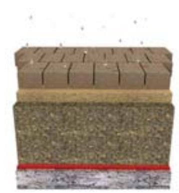
Base material for infiltration is key and should be determined by a civil engineer for runoff and infiltration capacity (usually 150mm to 350mm) depending on existing site soils i.e.) clay soils require more base material under slabs, silty gravel soils require less.
The use of asphalt increases the heat island effect.

permeable pavers

Pavers range in size - usually 80mm+ thick for surfaces that are driven on and 50mm - 60mm thick for surfaces that are only walked on.

Base material for infiltration is key and should be determined by a civil engineer for runoff and infiltration capacity (usually 150mm to 350mm) depending on existing site soils i.e.) clay soils require more base material under slabs, silty gravel soils require less.

Pavers come in a variety of colour options - some may aide in reducing the heat island effect



open pavers

Materials range from open grid hard unit pavers to plastic grass grid pavers.

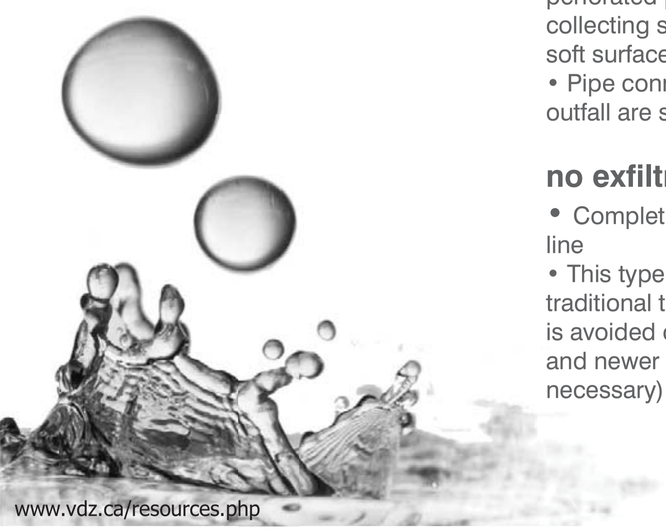
Base material for infiltration is key and should be determined by a civil engineer for runoff and infiltration capacity (usually 150mm to 350mm) depending on existing site soils i.e.) clay soils require more base material under slabs, silty gravel soils require less.

Consult with the project civil engineer and landscape architect for selection of the most appropriate type of paver application and base preparation.

part two: storm water typologies

hard surface drainage

Hardscape Surface Applications
- **Commercial schemes**
- **New housing developments**
- **Retail parks**
- **Car parks**
- **Government and Community Buildings and Facilities**



exfiltration types

full exfiltration
- 100% on site infiltration
- Can occur with the use of softscape surface drainage systems

partial exfiltration
- Infiltration on site with overflow to storm line
- Often achieved through a "systems" approach using perforated pipes or open collecting systems embedded in soft surface drainage
- Pipe connections to storm outfall are solid

no exfiltration
- Complete discharge to storm line
- This type of exfiltration is more traditional to storm designs and is avoided on LEED projects and newer infrastructure (unless necessary)

assisting components

oil interceptors
- Used to remove hydrocarbons left by vehicles or sources of pollution
- Can help filter water before discharge
- Are often implemented as a "back-up" to soft surface storm remediation designs
- Are usually included in storage tanks and central manholes

soakaway pits
- Are composed of a buried catch basin or storage tank for deep infiltration of storm water
- Are often used as central storm infiltration focal point for areas where there is no discharge to storm
- In areas where discharge to storm is used, soakaway pits may be used as final infiltration tactic prior to water reaching an overflow within the catch basin with discharge

cisterns & storage tanks

Works with full and partial exfiltration civil designs.

Cisterns and storage tanks are used for a combination of reasons:
1) storage of storm water during intensive rainfall events where the partial or full systems may not perform at the desired rate
2) storage of storm water from hard surfaces for long-term groundwater recharge
3) storage of storm water from hard surfaces for drip or low emitter irrigation of plantings

irrigation

low emitter
- Includes the use of low-flow nozzles for a reduction in water consumption or the use of drip-emitters from collected storm water
- Additional supporting fabrics or bas-materials may be used in planters in coordination with a low use irrigation system to maintain water levels for plants

xeriscape
- Is an emerging trend to significantly reduce reliance on non-natural water cycles for plant consumption
- Xeriscaping planting puts focus on working with plants that are capable of handling a climates natural water cycles that can thrive without aide from irrigation
- Native plants are often used in these scenarios for their existing adaptability to a climate

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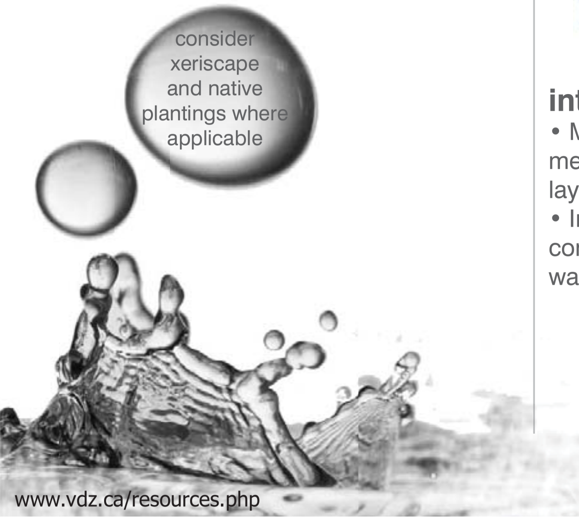
part two: storm water typologies

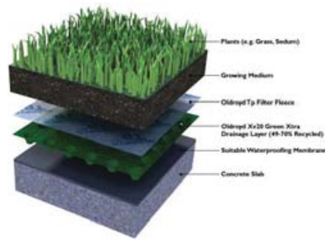
soft surface drainage

Softscape Surface Applications
- **Commercial schemes**
- **New housing developments**
- **Retail parks**
- **Car parks**
- **Government and Community Buildings and Facilities**
- **Streetscapes and promenades**

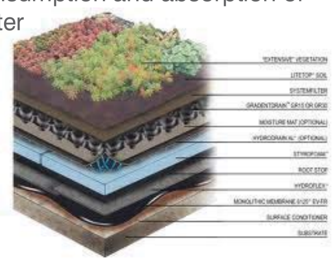


green roofs

extensive
• Usually 150mm or shallower for growing medium depth
• Roof carries lighter load
• Water is absorbed for shorter periods of time



intensive
• More than 150mm of growing medium and requires additional layers of protection
• Intended for longer range consumption and absorption of water



swaling elements

bio-swales
• Usually 2m wide and more than 6m long
• Swaled to have a minimum 12" depth (this is often the maximum allowable depth in municipalities) for infiltration of storm water
• Swales can be grassed or vegetated
• Swales can contain either partial or full exfiltration depending on their area - perforated pipes may be used
• Sand bedding layers, compacted stones, and alternative material are used to create permeability and structure

infiltration strips / trenches
• Pieces of landscape narrower than 2m that contain growing medium and prepared sub-bases for infiltration
• Their sub-structures resemble bio-swales but they can appear less obvious at the surface level

rain gardens

• Pieces of landscape wider than 2m with the capacity to infiltrate large volumes of water and support semi-wet ecosystems
• Rain gardens are intended for deeper infiltration of storm water and remediation of pollutants
• Plantings used should meet anticipated water levels for summer and winter months - great consideration of species should be considered
• Rain gardens contain a slightly elevated point of outfall; often concealed through rip-rap or bouldering used to stabilize side walls

ponds

dentention ponds
• Ponds that are created for short term storage of storm water for infiltration
• Infiltration channels are often used in the in centre of the pond for collect of sediments into dry beds for easier maintenance

retention ponds
• Ponds that a created for longer term storage of storm water for deep infiltration and remediation
• These ponds usually have alteast 1m of water depth and can support small wetland environments
• Aerators and other devices may be used to provide good circulation an prevent algae blooms

part two: storm water typologies

bringing it all together: integrated systems

The most important thing a municipality or developer can do to ensure good storm management is make sure all consultants are coordinated.

To have understanding of the finer details and cross-over between respective scopes of work will play a key role in allowing consultants to select the most appropriate materials for sites and design systems to be **synchronized**.

For example, review of the images on right shows collection of roof rainwater into a splash block retainer that flows through an open system and a curb cut in the sidewalk, into a rain garden. The crossover between the building and the raingarden would have likely included **coordination** of the architect, landscape architect, mechanical engineer. Design of the rain garden would have likely included coordination between the landscape architect and civil engineer.

Remember: The ultimate goal of a storm design is performance and longevity. It's how water flows through various site elements as a system that will determine the long term benefits and success of the project.

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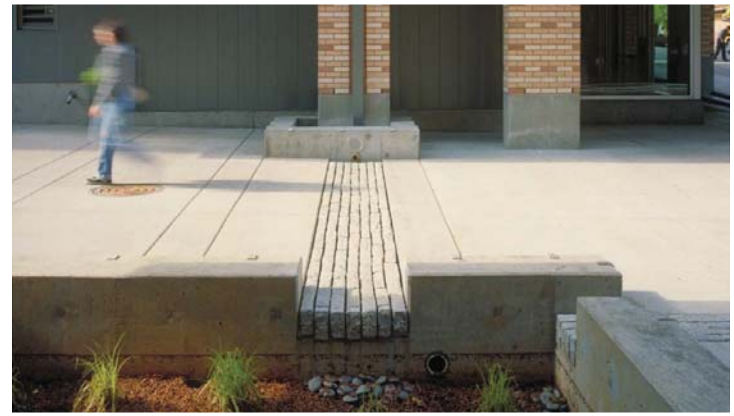
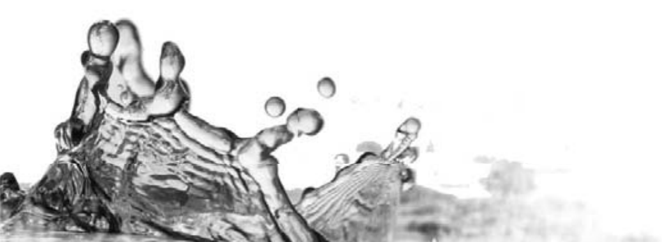


bringing it all together: integrated systems

Examples of integrated systems which show cross-over between consultants. **Good storm water management can be integrated** into urban areas to add art, character, and expression to buildings and streetscapes.



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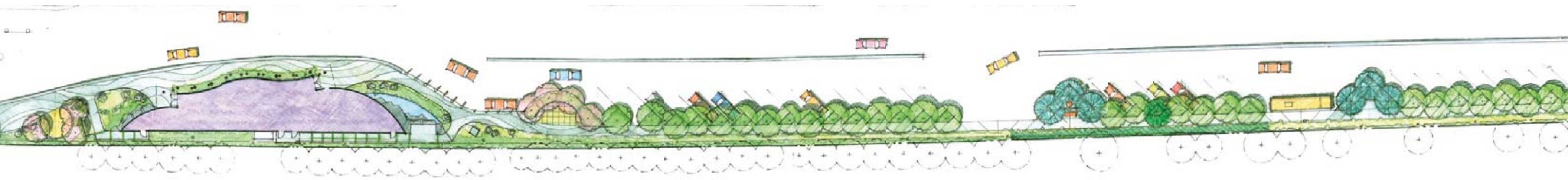
part two: storm water typologies

bringing it all together: integrated systems

Concepts for storm management can include anything from small scale details of curb cuts through large scale expansive green roofs.

LEED Gold: peace arch visitors centre



Fast Facts
- Project site was one of the first muncipal buildings required to meet LEED Gold Standards
- The tourism building visitors centre is located between Highway 99 South and an existing golf course at the border crossing
- The site stretches over 300m long with all storm water collecting into permeable concrete, open bio-basins, and a continuous bio-swale for infiltration
- The project site was the first location in Canada to test an Eco-media product - a compound created by soil scientists with the aim of providing soils with naturally occurring bacteria which break down hydrocarbons and pollutants that run off from vehicles

Rendering provided by
van der Zalm + associates Inc.

The revolutionary storm water system for collecting and carrying water earned the project LEED points for:
- Water efficient landscaping - the entire site has no irrigation and is thriving
- Reduction in heat island effect - the introduction of tree cover and permeable concrete met the requirements of using highly reflective materials and producing a 30% canopy cover over 5 years
- Sustainable site credits were earned for reducing the rate and quantity of runoff along with removal of phosphorus and hydrocarbons from site runoff to comply with LEED percentages
- Innovation in design credits were earned for implementing a signage program that teaches visitors about the unique design approach for managing and remediating storm water

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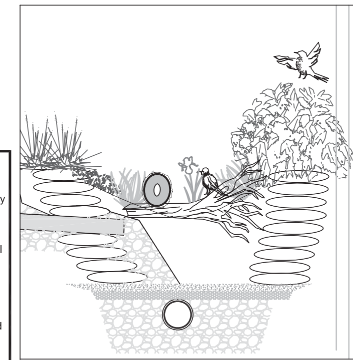
part three: precedents

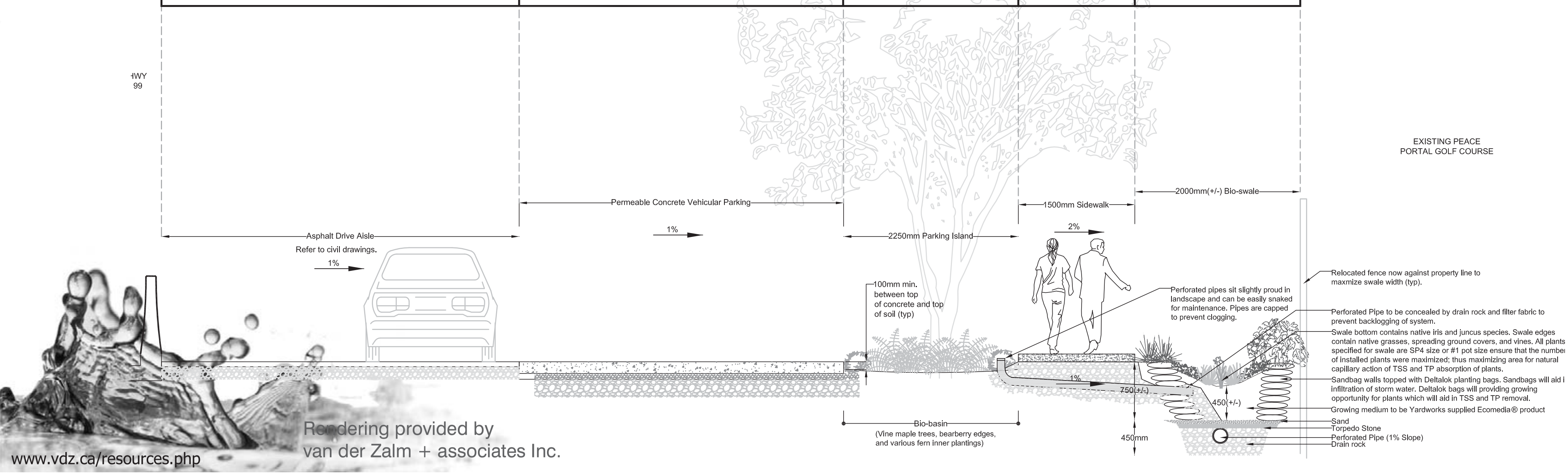
LEED Gold: peace arch visitors centre



VIEW OF TYPICAL HABITAT LOG ENVIRONMENT
REFER TO STEP 5 DESCRIPTION

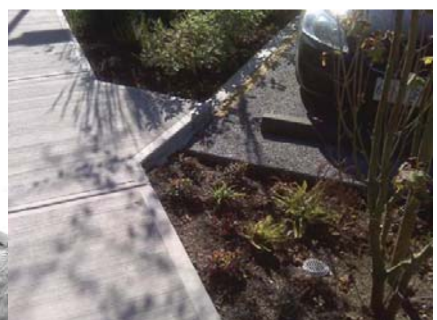
DESIGN APPROACH / NARRATIVE

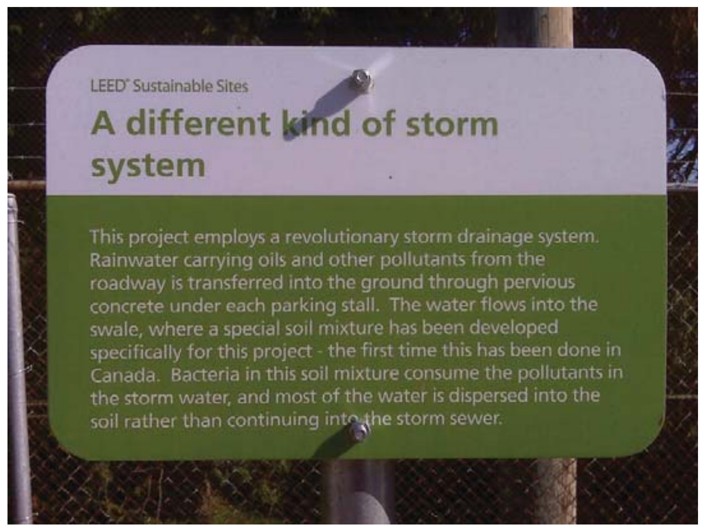
STEP ONE	STEP TWO	STEP THREE	STEP FOUR	STEP FIVE
Water hits the impervious asphalt drive aisle and runs at a 1% slope into the porous concrete slab for infiltration.	The 6" thick porous concrete slab immediately infiltrates the storm water. Water continues to permeate through the slab and 12" sub-base (composed of clear crush and ¾ minus rock). Water captured in this area during a short rain fall will evaporate or eventually drain in the adjacent bio-basins for further infiltration. Some water will permeate into the existing clay soils underneath the slab as part of the natural ground water cycle of the site. If water were to completely fill the porous concrete area during a major storm event, then excess water that collects at the surface of the porous slab traverse across a 1% slope into the adjacent bio-basin. Note: Some TSS and TP removal will also occur in this phase of the storm water management; particularily during average rainfall events where the slab is likely to hold a large quantity of storm water and release it over time via infiltration and evaporation.	The bio-basins located infront of each parking stall sit slightly low in the landscape to intentionally collect excess water that exists at the surface of the hardscape in the parking lot. Native xeriscape plants (ferns, vine maples, and bearberry) can handle wet and dry conditions and will absorb a large amount of storm water. Some TSS and TP remediation will also occur in this phase as plants will absorb these items through capillary action as part of the natural phosphate cycle.	Should an excess amount of water build up in the bio-basins then water can filter into a 4" perforated PVC pipe that flows under the sidewalk at a mild 1% slope. Water exiting the pipes will then filter through a thin cover of drain rock into a densely planted swale containing the Ecomedia® soil product. The water will be remediated via uptake by plants or processes encurred by the Ecomedia® product.	All excess storm water that cannot be infiltrated in the other phases will eventually permeate into the bio-swale for final absorption and remediation. Large amounts of TSS and TP removal will occur through reactions to both the 500mm(+/-) depth of the Ecomedia® soil and the natural absorption of densely planted vegetation. The swale is approximately 200m long and flows at 0.25% surface slope allowing for water to collect and flow slowly; promoting infiltration and absorbtion. Habitat logs are placed strategically at low points in the swale to decrease water velocity and increase infiltration/remediation time.

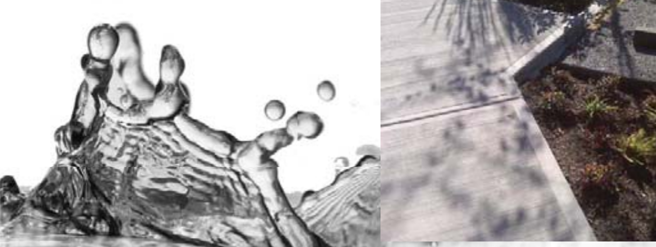


part three: precedents

LEED Gold: peace arch visitors centre







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LEED Platinum: vancouver convention centre

Fast Facts

- The West building features a unique marine habitat, a sophisticated drainage water and recovery system, and a seawater heating and cooling system.
- The West building's six-acre living roof – the largest in Canada and the largest non-industrial living roof in North America – features more than 400,000 indigenous plants and grasses as well as four beehives. Drainage and recovery systems are designed to collect and use rainwater for irrigation during summer months.
- The West building has received LEED (Leadership in Energy and Environmental Design) Platinum certification and is the first convention centre in the world to earn the highest LEED rating.

(facts provided by vancouverconventioncentre.com)

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part three: precedents

LEED Platinum: vancouver convention centre

Water is infiltrated through both the hard and soft surfaces of the site. The 6 acre crossing green roof is the focus of the architectural expression of the building, while surrounding hardscape pedestrian paths and plaza areas all collect storm water runoff for reuse through irrigation.

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part three: precedents

LEED Gold: "Atwater Place"

Portland Oregon

Large urban rain garden and swale networks united the entire property.

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part three: precedents

LEED Gold: "Atwater Place"
Portland Oregon

This mixed use development achieved LEED Gold. Storm water integrated landscaping served as a central promenade to the entire development.

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site stormwater: City of Surrey Standards

The goal for developments in Surrey is to provide:

0.5m3 of topsoil for every m2 of development
and/or
25 - 50mm of detention where landscape areas are provided

There are numerous way to achieve this goal within landscaping and civil design through the approach of creating **integrated systems**. Opportunities for creating integrated systems are numerous and vary in costs. The following slides represent some of the basic strategies for creating integrated systems, with examples seen on a variety of scales.

Permeable walkways in Holland Park, Surrey
Design by van der Zalm + associates

part four: stormwater strategies

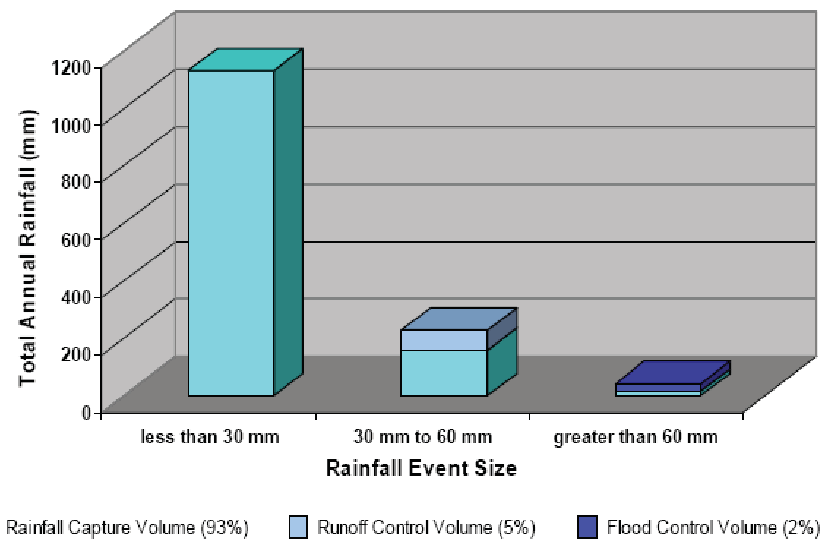
Recommendations to Developers and Committees

There are a number of ways to address site storm water when starting a project. The ultimate goal of a good storm water design is that it functions as a natural system within the site and does not conflict or fight natural process of both design and environmental features. The requirement of 25-50mm of detention or 0.5m3 of growing medium per square meter of development means that 70 - 90% of the MAR (Mean Annual Rainfall) on a local site can be infiltrated without overflow to storm.

The challenge for consultants and developers is to provide intelligent, responsive, an effective storm water solutions on site to deal with the majority of the MAR while still having the ability to overflow during a 5 year major storm event. This can be particularily challenging when dealing with high-density developments in the City Centre where existing sites are flat and surrounding road infrastructure is in place.

site stormwater: Project start-up

Stormwater Planning: A Guidebook for British Columbia
Ministry of Water, Land and Air Protection, 2002



Tip: The minimum soil depth for 60mm of infiltration in a soil with good hydraulic conductivity is 300mm. Soils are able to store approximately 20% of their volume as soil water. Therefore 60mm x 5 = 300mm.

Soil Type	Typical Hydraulic Conductivity Range*
• Sands and gravels	> 50 mm/h
• Sandy loams	10 – 50 mm/h
• Silty loams	5 – 40 mm/h
• Clay loams	2 – 6 mm/h
• Clays	< 2 mm/h

site stormwater: Project start-up

Recommendations for addressing storm design at the start of a project include:

1

1. During the rezoning phase and site servicing phase of a development, examine the existing storm infrastructure and determine what options are available for overflow diversion of storm water. Gather the main consultants impacted by storm design (i.e. civil engineer, landscape architect, and architect) into a meeting. Ask the team questions such as:

a) What elevations are the surrounding site/street storm overflows located at?
b) Based on existing site grades; would surface level drainage (i.e. raingardens, ponds) be able to overflow to these lines in the event of a 5year storm? What would their maximum depth be before they became too deep for positive overflow drainage?
c)Would sub-surface drainage systems (i.e. storage tanks, infiltration trenches) be able to overflow to the site/street mainline during the event of a 5year storm? What would their overflow grade need to be set at?

2

2. The discussion generated by the questions in recommendation #1 should allow the consultants to determine early on what areas of a site should be considered for storm water infiltration. The is critical beacause it plays a role in what areas should be protected from the building location and gives the team a rough idea about where the majority of site storm water infiltration can occur.

3

3. In the Development Permit Process having an idea about where the majority of storm water can be infiltrated on a site can allow designers to make extended recommendations (i.e., that pervious paving be used to accomodate the majority of infiltration, or that it may be beneficial to limit underground parking to a certain area to allow room for storm storage tanks). The continued “systems” approach of enforcing all consultants coordinate with one another during this phase is a developers prime opportunity to also have an understanding of cost options prior to submitting a project for a permit.

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part four: stormwater strategies

Townhomes:
Because units are smaller and already interconnected it is easy to find ways to manage site storm water on a unit to unit basis. This may be done with rain chains, bio-swales, and small amounts of permeable hardscape. Partial exfiltration systems can be used to connect overflow from each unit into a large network for managing site storm water. It is also possible to propose some off-site improvements through offering to develop rain gardens, infiltration strips, or bio-swales along streetscape boulevards for increased community benefit.

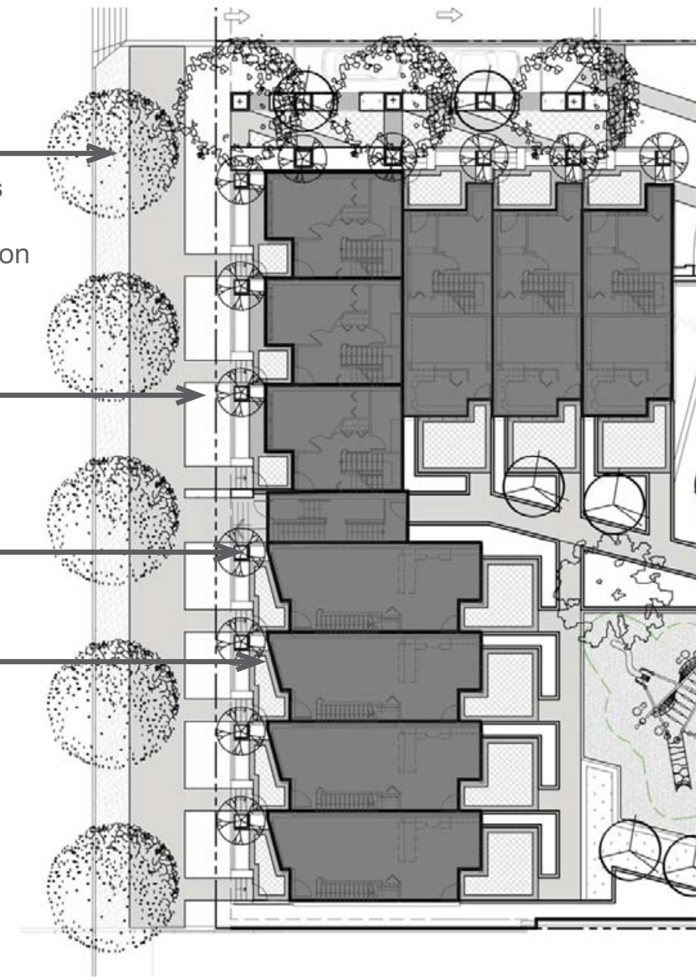
site stormwater: townhomes

Boulevard with curb cuts for street storm water collection. Landscape to have xeriscape plantings and evergreen canopy trees for absorption. Boulevards can have bio-swales for storm infiltration prior to overflow to storm

Landscaped front yard with raingardens or bio-swales along perimeter

Raised planters with low emitter or drip irrigation for xeriscape plants. Downspouts or rain chains can direct a portion of storm water into bio-swales

Permeable paving for infiltration with piping to raingardens for short term detention and reduction in site discharge



part four: stormwater strategies

site stormwater: apartments

Apartments:
Buildings generally range from 2 to 12 floors for apartments. The aesthetic of building (i.e. whether it is tiered with planters and patios or straight vertical) depends on the site so we won't comment on verticality here. What can be said about apartments is that there is a guaranteed larger surface area of continuous hardscape needed to provide site parking. This is the key area for managing site runoff and pollutants generated on site - the use of permeable paving, bio-swales, infiltration strips or rain gardens could all be considered for creating integrated systems for collection and remediation of stormwater.

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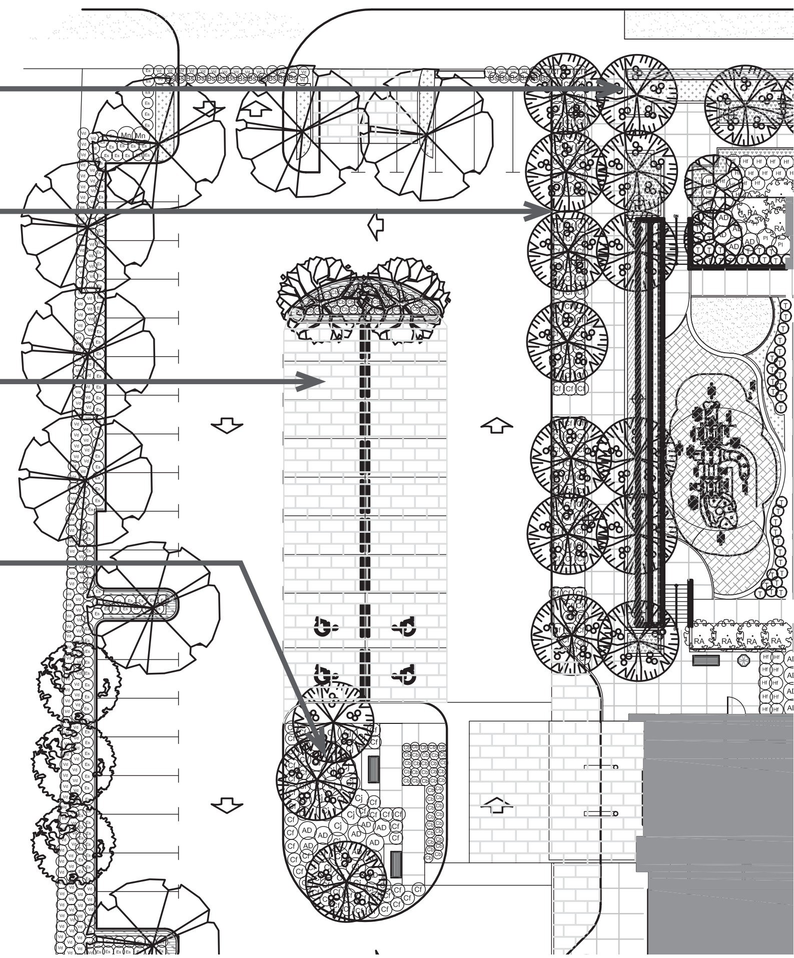
Bio-filtration through a series of planters and swales create streetscape interface and define areas of privacy

Curbless bio-swales for bio-infiltration. Evergreen shade trees for continued absorption of water.

Permeable paving in key areas of parking or mixed use designated zones to separate spaces and provide centralized infiltration

Central rain garden infiltration feature functions as site signage for apartment at drop-off. Permeable paving can drain into rain garden through partial exfiltration



part four: stormwater strategies

High rises:
This form of building often incorporates mixed-use developments as requires large amounts of community open space and semi-public open space. Parking is often offered in various forms such as off-street, temporary, private, and underground to manage volumes of residents and visitors. Larger amounts of permeable paving, stepped slabs, and green roofs are all ways of considering how to manage site storm water in highly urban environments.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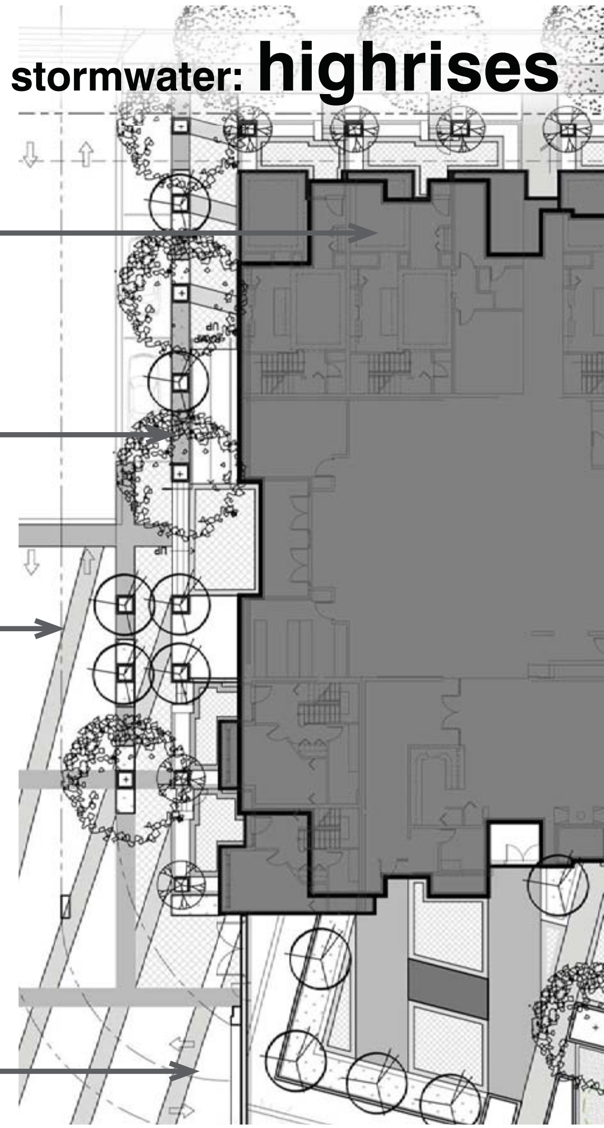
site stormwater: highrises



part four: stormwater strategies

High-rises:
Areas of high impervious coverage in high-rise or high-density developments can become challenging to design when trying to balance project affordability. However the more synchronized a storm water strategy is, the easier it is to achieve the desired outcomes.

The graphic shown right illustrates how on a typical high-density site (85% lot coverage), as little as 7.5% of the remaining lot area could reduce runoff volumes to about 10% of the totall rainfall (where soils have good hydraulic conductivity greater than 13mm/h) or about 60% of the total rainfall (where soils have poor hydraulic conductivity of about 1mm/h).

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Stormwater Planning: A Guidebook for British Columbia
Ministry of Water, Land and Air Protection, 2002

site stormwater: highrises

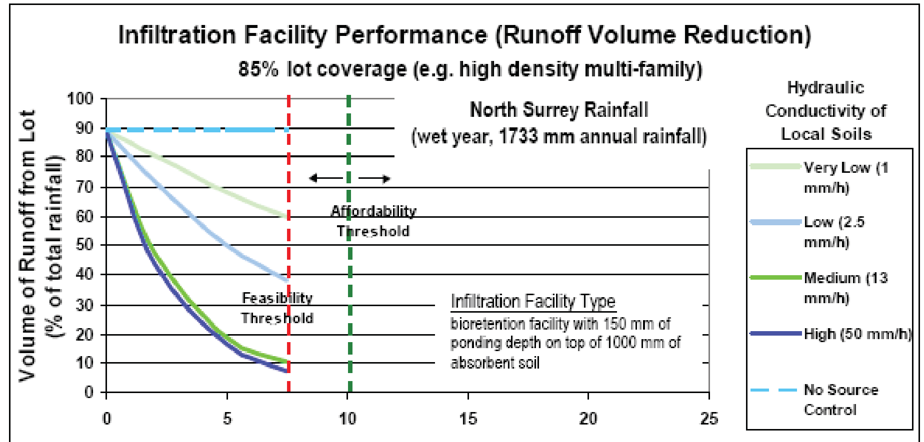

Figure 7-15a

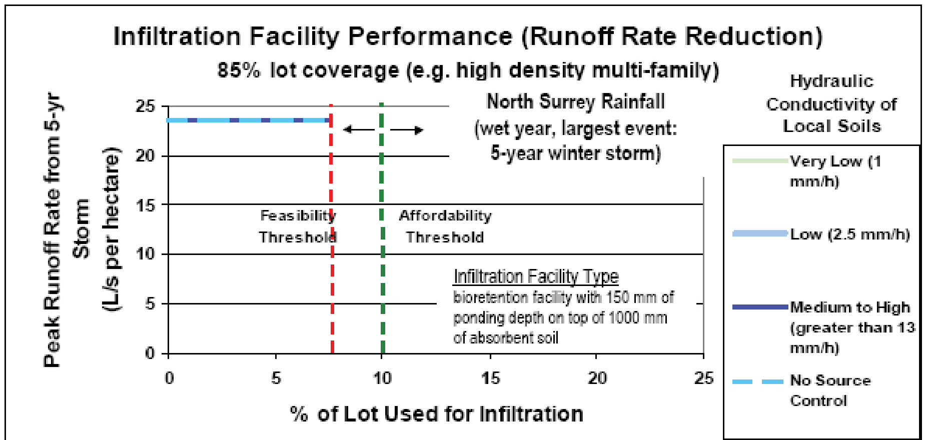

Figure 7-15b

part four: stormwater strategies

The following charts were prepared by the EPA Office of Water during a study on Low Impact Developments for large retail facilities. The recommended best management practices listed could also apply to regular buildings. These charts could be printed as a quick list for generating ideas for how to manage site storm water at the start-up of a project.

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site stormwater: quick list

Types of Best Management Practices

BMP	Circulation and Parking	Building	Loading
Cisterns		x	
Conservation (Vegetation)	x		
Downspout Disconnection		x	
Filter Strips	x		
Infiltration Beds/Trenches or Dry Wells	x		
Pocket Wetlands			
Porous Pavement	x		
Rain Gardens	x		x
Reforestation (Vegetation)	x		
Sand Filters	x		x
Soil Amendments	x		
Vegetated Roof		x	
Water Conservation		x	
Pollution Prevention			x
Tree Box Filters	x		x
Bioretention Slopes	x		x

New Developments vs. Retrofits

BMP	New Development	Retrofit
Cisterns	●	●
Conservation (Vegetation)	●	○
Downspout Disconnection	○	●
Filter Strips	●	●
Infiltration Beds/Trenches or Dry Wells	●	⦿
Pocket Wetlands	●	●
Porous Pavement	●	⦿
Rain Gardens	●	●
Reforestation (Vegetation)	●	●
Sand Filters	●	●
Soil Amendments	●	●
Tree Box Filters	●	●
Vegetated Roofs	●	●
Vegetated Swales	●	●

Key: ● Highly Suitable ⦿ Moderately Suitable ○ Not Suitable

site stormwater: costs and maintenance

Surface and Sub-surface Drainage
The term surface facility refers to features that infiltrate storm water at the surface level (i.e. rain gardens, bio-swales, and storm water ponds). The term sub-surface facility refers to features that infiltrate storm water below the surface level (i.e. trench drains and soakaway pits). Site specific elements such as topogrpahy, scale and soil type affect the scale and design of an infiltration facility. Facilities can range from $30 - $170 per m2. The operation and maintenance of surface level facilities are more frequent but less expensive than sub-surface facilities. The operation and maintenance of surface facilites are unique in that they also serve an aesthetic fucntion (i.e. maintenance of landscape plantings). Annual costs for surface facilities usually cost between 5-10% of capital costs. Cost for sub-surface facilities are less frequent but cost more money (i.e. cleaning of soakaway trenches), resulting between 5-20% of the total annual capital costs.

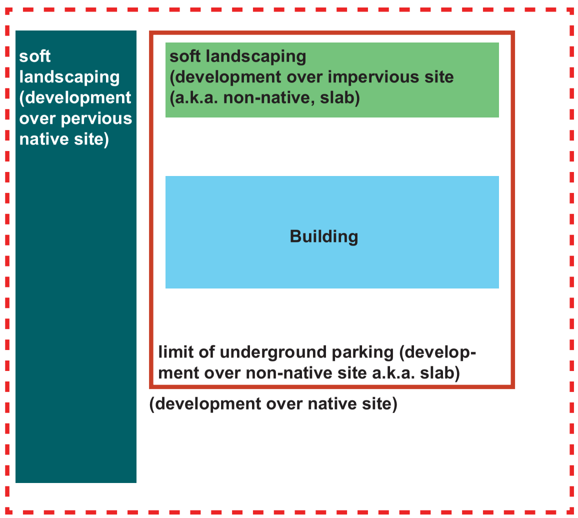
Absorbant Landscaping
Depending on soils depths and plant type, absorbant landscaping can range from $25 to $70 per m2. The lower range of $25 is inclusive of a typical grass setting with approximately 150mm of soil for the grass and tree canopy. The higher end of the range is more typical of shrub bed plantings which include a minimum soil depth of 450mm.

Cost statistics from
Stormwater Planning: A Guidebook for British Columbia
Ministry of Water, Land and Air Protection, 2002

Pervious Paving
The cost of pervious paving ranges from $200-300 per m2 depending on the design and required amount of base material. This can be 2 to 3 times the cost of regular paving which is $50 - $100m2. There are also unique maintenance requirements for this form of paving such as vaccuum sweeping. It is highly recommended that developers are encouraged to locate sources of maintenance equipment and have an understanding of their material costs when determining storm water approaches in the design phase of a project.

site stormwater: real world examples

Working with the Storm Water Mitigation Calculator



Step One: Once a concept plan for a site is developed, complete cells in green on the excel chart to see how initial landscaping (on slab and over the native site) manages site storm water.

In these following scenarios, the total site area is defined by the property line and is graphically shown with the red dashed line (- - - - - - -). The total disturbed area of the site requiring storm water mitigation remains the same as shown in yellow.

Calculate the areas of soft-landscape according to slab vs. non-slab conditions. On the excel chart this is defined as non-native vs. native Once totals have been entered, place in total areas of native vs. non-native landscaping in the excel chart to calculate what percentage of the site's area is being infiltrated and what percentage remains impervious.

Note: This initial step is intended to give developers a quick "snap shot" of how much area is left that needs to be diverted into pervious surfaces (either additional soft landscapes, storage units, or pervious hardsurfaces).

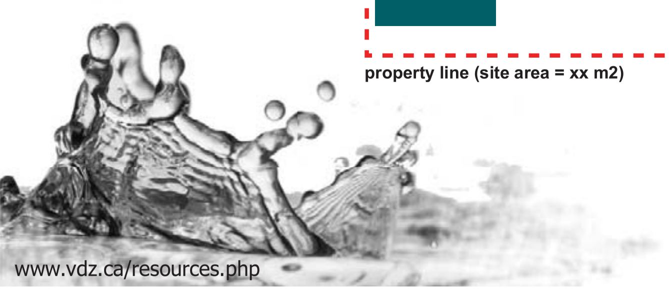
Definition of mitigation for Surrey:
The requirement of 25-50mm of detention or 0.5m3 of growing medium per square meter of development means that 70 - 90% of the MAR (Mean Annual Rainfall) on a local site can be infiltrated without overflow to storm.

Step Two: In step two areas identified in green may be altered with to understand what percentage's of soft landscaping or pervious hardsurfaces are needed to achieve the "detention deficit" of "0".

Step two functions as the developer's cost-benefit analysis - it allows developers to weigh the costs of soft landscape areas against the costs of hard surfaces areas needed for storm water mitigation. Growing medium depths, aesthetics, and material type are all impacted during the design development of a site. Using this tool as a cost-benefit analysis will enable developers and consultants to make conscientious decisions about the site design that respects the requirements of storm water mitigation and economics of the development.

Areas shown in yellow will auto-update in step two everytime areas in green are changed. Consult with the project Landscape Architect and Civil Engineer to understand more about pervious hardsurface options and soil requirements of plants to ensure that green entries are realistic.

Note: Step two functions as a way to work with soil depths, pervious hardscape storage, and other means to determine how much of the remaining impervious area needs to become pervious to completely mitigate storm water. The "detention deficit" must reach "0" in step two in order to prove site mitigation meets Surrey's requirement or the site must recieve storage tanks, etc to comply.

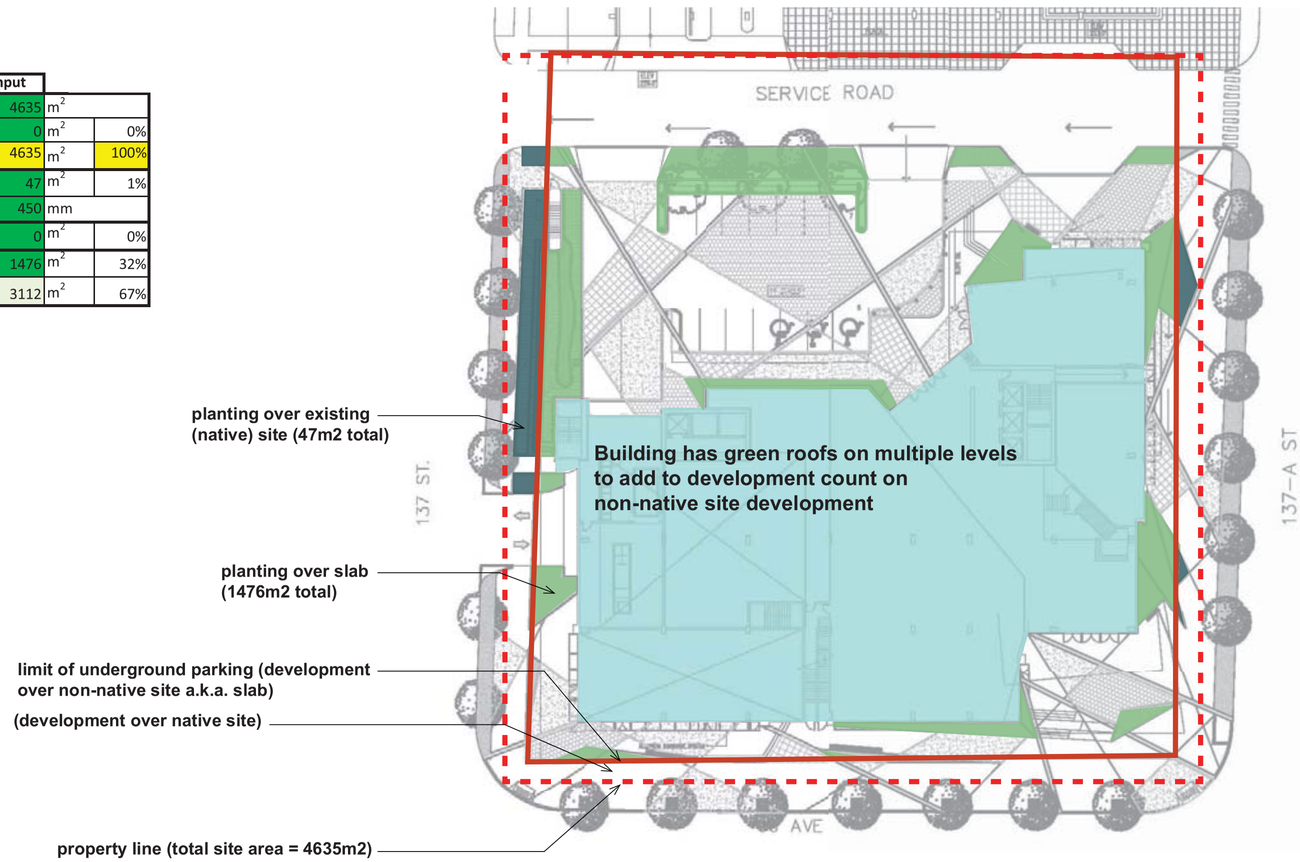


part five: Complying with Surrey standards

site stormwater: real world examples

Surrey City Centre Development Mitigation:
Highrise Mixed-Use Development

		Input		
A	Total Site Area	4635	m^2	
U	Protected Undisturbed Area	0	m^2	0%
D	Total Disturbed Area Calculated	4635	m^2	100%
P_l	Pervious Landscaping (over native soil)	47	m^2	1%
S_d	*Topsoil Depth In Pervious Landscaping (over native soil)*	450	mm	
P_p	Pervious Surfaces (over native soil)	0	m^2	0%
I_l	Landscaping (min 75 mm growing media over impervious)	1476	m^2	32%
I_c	Impervious (no landscaping)	3112	m^2	67%



site stormwater: real world examples

Surrey City Centre Development Mitigation:
Highrise Mixed-Use Development

Instructions: Provide the values for the cells highlighted in Green

Step One

		Input			
A	Total Site Area	4635	m^2		
U	Protected Undisturbed Area	0	m^2	0%	
D	Total Disturbed Area Calculated	4635	m^2	100%	
P_l	Pervious Landscaping (over native soil)	47	m^2	1%	
S_d	*Topsoil Depth In Pervious Landscaping (over native soil)*	450	mm		Max 450mm unless designed.
P_p	Pervious Surfaces (over native soil)	0	m^2	0%	
I_l	Landscaping (min 75 mm growing media over impervious)	1476	m^2	32%	
I_c	Impervious (no landscaping)	3112	m^2	67%	

Step Two

Summary of Topsoil and Detention Requirements			
Stage 1	**Infiltration Provided**		
T_p	Topsoil Provided (S_d x P_l)	21.15	m^3
I_t	Area of impervious surface treated with topsoil (T_p/0.5)	42.3	m^2
I_r	Area of impervious surface not mitigated with topsoil (I_c-I_t)	3070	m^2
Stage 2	**Detention Required**		
D_l	Detention for Landscape over Impervious (0.05 x I_l)	74	m^3
D_c	Detention for Untreated Impervious areas (0.02 x I_r)	**61**	m^3
Dt	Total Detention required (D_l + D_c)	135	m^3
	Allowable Discharge rate is 3 l/s/ha	1.4	l/s
Stage 3	**Detention Accomplished**		
Dt	Total Detention required (D_l + D_c)	135	m^3
Sde	Average soil depth in landscape over impervious*	0.5	m
Sd	Soil detention over impervious (avg. depth * 0.1 * area)**	**74**	**m^3**
D%	Percentage of Impervious (non landscape) availible for mitigation measures***	39.5	%
Di	Area of opportunuties for detention over impervious***	1229	m2
Md	Average depth of materials ****	0.05	m
Dit	Engineered detention over impervious	**61**	**m^3**
Stage 4	**Deficit Calculations**		
Dtot	Total Detention provided over impervious	135	m^3
Ddef	**Detention deficit*******	**0**	**m^3**

* while 75mm is minimum, average depth by BCLNA standards will be greater, and can likely average 300mm
** assumes 1mm detention per 10mm of soil.
*** areas where slab drains could be held high (ie/ 25mm or 50mm), use of drainage mat, additional crushed gravels for detention.
Number does not necessarily equal total non-landscaped impervious, due to potential strucutural cost implications, but could, in theory
**** depth of detention over impervious
***** goal is that this number reaches ZERO, otherwise alternatives to be undertaken, including on site tanking

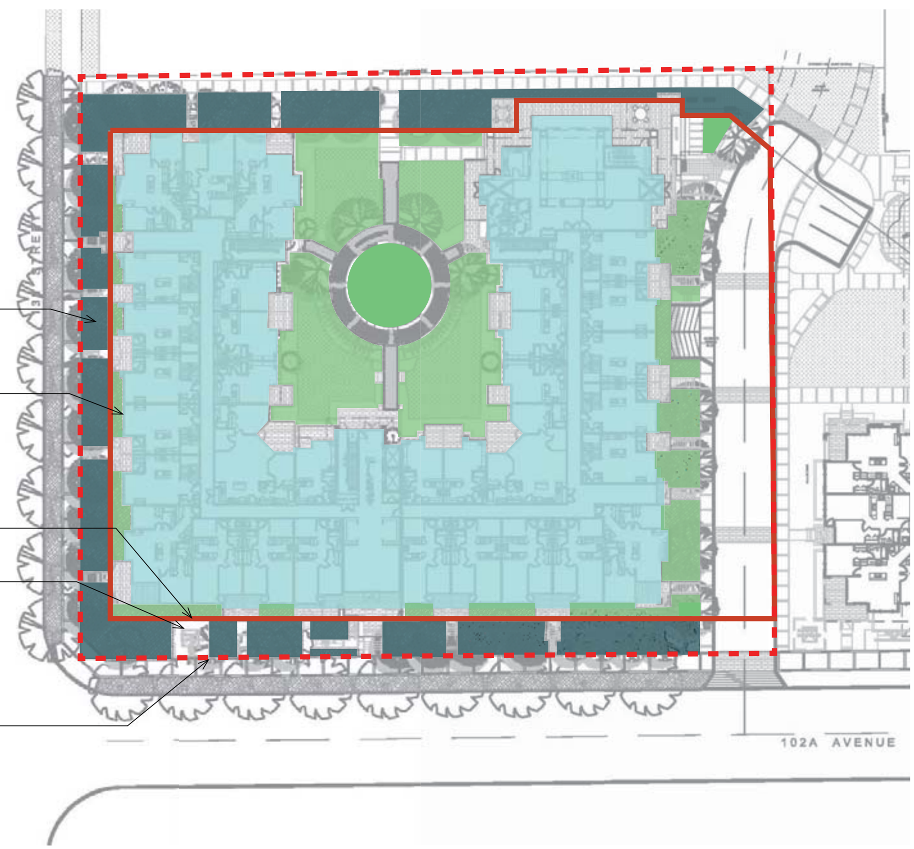
part five: Complying with Surrey standards

site stormwater: real world examples

Surrey City Centre Development Mitigation:

Low-rise Multi-family Development

		Input		
A	Total Site Area	6132	m^2	
U	Protected Undisturbed Area	0	m^2	0%
D	Total Disturbed Area Calculated	6132	m^2	100%
P_l	Pervious Landscaping (over native soil)	1200	m^2	20%
S_d	*Topsoil Depth In Pervious Landscaping (over native soil)*	550	mm	
P_p	Pervious Surfaces (over native soil)	134	m^2	2%
I_l	Landscaping (min 75 mm growing media over impervious)	584	m^2	10%
I_c	Impervious (no landscaping)	4214	m^2	69%



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part five: Complying with Surrey standards

site stormwater: real world examples

Surrey City Centre Development Mitigation:
Low-rise Multi-family Development

Instructions: Provide the values for the cells highlighted in Green

Step One

		Input			
A	Total Site Area	6132	m^2		
U	Protected Undisturbed Area	0	m^2	0%	
D	Total Disturbed Area Calculated	6132	m^2	100%	
P_l	Pervious Landscaping (over native soil)	1200	m^2	20%	
S_d	*Topsoil Depth In Pervious Landscaping (over native soil)*	550	mm		Max 450mm unless designed.
P_p	Pervious Surfaces (over native soil)	134	m^2	2%	
I_l	Landscaping (min 75 mm growing media over impervious)	584	m^2	10%	
I_c	Impervious (no landscaping)	4214	m^2	69%	

Step Two

Summary of Topsoil and Detention Requirements			
Stage 1	**Infiltration Provided**		
T_p	Topsoil Provided (S_d x P_l)	660	m^3
I_t	Area of impervious surface treated with topsoil (T_p/0.5)	1320	m^2
I_r	Area of impervious surface not mitigated with topsoil (I_c-I_t)	2894	m^2
Stage 2	**Detention Required**		
D_l	Detention for Landscape over Impervious (0.02 x I_l)	12	m^3
D_c	Detention for Untreated Impervious areas (0.05 x I_r)	**145**	m^3
Dt	Total Detention required (D_l + D_c)	156	m^3
	Allowable Discharge rate is 3 l/s/ha	1.8	l/s
Stage 3	**Detention Accomplished**		
Dt	Total Detention required (D_l + D_c)	156	m^3
Sde	Average soil depth in landscape over impervious*	0.3	m
Sd	Soil detention over impervious (avg. depth * 0.1 * area)**	**18**	**m^3**
D%	Percentage of Impervious (non landscape) availible for mitigation measures***	66	%
Di	Area of opportunuties for detention over impervious***	2781	m2
Md	Average depth of materials ****	0.05	m
Dit	Engineered detention over impervious	**139**	**m^3**
Stage 4	**Deficit Calculations**		
Dtot	Total Detention provided over impervious	157	m^3
Ddef	**Detention deficit*******	**0**	**m^3**

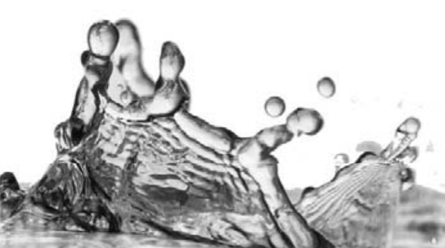
* while 75mm is minimum, average depth by BCLNA standards will be greater, and can likely average 300mm.
** assumes 1mm detention per 10mm of soil.
*** areas where slab drains could be held high (ie/ 25mm or 50mm), use of drainage mat, additional crushed gravels for detention.
Number does not necessarily equal total non-landscaped impervious, due to potential strucutural cost implications, but could, in theory.
**** depth of detention over impervious
***** goal is that this number reaches ZERO, otherwise alternatives to be undertaken, including on site tanking.

part five: Complying with Surrey standards

Surrey City Centre Development Mitigation:

High-rise Multi-family Development

		Input		
A	Total Site Area	10385	m^2	
U	Protected Undisturbed Area	0	m^2	0%
D	Total Disturbed Area Calculated	10385	m^2	100%
P_l	Pervious Landscaping (over native soil)	4516	m^2	43%
S_d	*Topsoil Depth In Pervious Landscaping (over native soil)*	450	mm	
P_p	Pervious Surfaces (over native soil)	538	m^2	5%
I_l	Landscaping (min 75 mm growing media over impervious)	984	m^2	9%
I_c	Impervious (no landscaping)	4347	m^2	42%



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site stormwater: real world examples

Surrey City Centre Development Mitigation:
High-rise Multi-family Development

Instructions: Provide the values for the cells highlighted in Green

Step One

		Input			
A	Total Site Area	10385	m^2		
U	Protected Undisturbed Area	0	m^2	0%	
D	Total Disturbed Area Calculated	10385	m^2	100%	
P_l	Pervious Landscaping (over native soil)	4516	m^2	43%	
S_d	*Topsoil Depth In Pervious Landscaping (over native soil)*	450	mm		Max 450mm unless designed.
P_p	Pervious Surfaces (over native soil)	538	m^2	5%	
I_l	Landscaping (min 75 mm growing media over impervious)	984	m^2	9%	
I_c	Impervious (no landscaping)	4347	m^2	42%	

Step Two

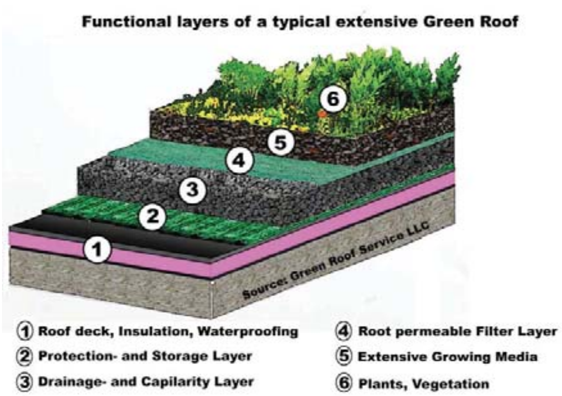
Summary of Topsoil and Detention Requirements			
Stage 1	**Infiltration Provided**		
T_p	Topsoil Provided (S_d x P_l)	2032.2	m^3
I_t	Area of impervious surface treated with topsoil (T_p/0.5)	4064.4	m^2
I_r	Area of impervious surface not mitigated with topsoil (I_c-I_t)	283	m^2
Stage 2	**Detention Required**		
D_l	Detention for Landscape over Impervious (0.02 x I_l)	20	m^3
D_c	Detention for Untreated Impervious areas (0.05 x I_r)	**14**	m^3
Dt	Total Detention required (D_l + D_c)	34	m^3
	Allowable Discharge rate is 3 l/s/ha	3.1	l/s
Stage 3	**Detention Accomplished**		
Dt	Total Detention required (D_l + D_c)	34	m^3
Sde	Average soil depth in landscape over impervious*	0.3	m
Sd	Soil detention over impervious (avg. depth * 0.1 * area)**	**30**	m^3
D%	Percentage of Impervious (non landscape) availible for mitigation measures***	2	%
Di	Area of opportunuties for detention over impervious***	87	m2
Md	Average depth of materials ****	0.05	m
Dit	Engineered detention over impervious	**4**	m^3
Stage 4	**Deficit Calculations**		
Dtot	Total Detention provided over impervious	34	m^3
Ddef	**Detention deficit*******	**0**	m^3

* while 75mm is minimum, average depth by BCLNA standards will be greater, and can likely average 300mm.
** assumes 1mm detention per 10mm of soil.
*** areas where slab drains could be held high (ie/ 25mm or 50mm), use of drainage mat, additional crushed gravels for detention.
Number does not necessarily equal total non-landscaped impervious, due to potential strucutural cost implications, but could, in theory.
**** depth of detention over impervious
***** goal is that this number reaches ZERO, otherwise alternatives to be undertaken, including on site tanking.

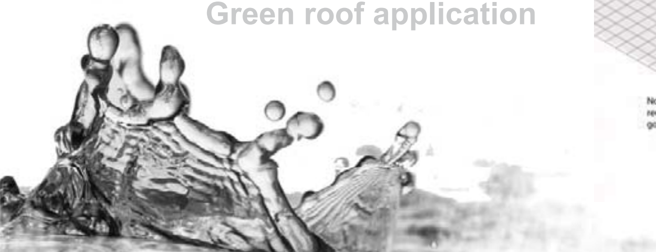
part five: Complying with Surrey standards

site stormwater: real world examples

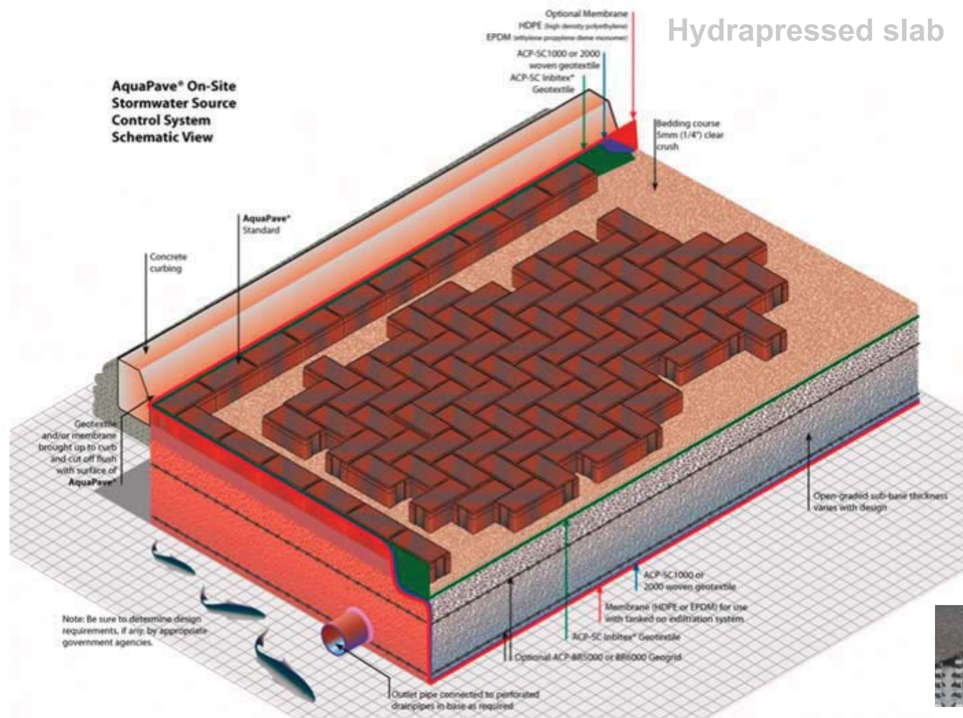
Examples of materials used to create detention on slab



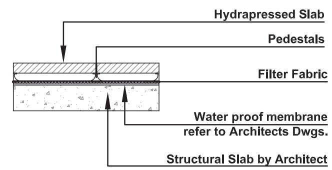
Green roof application



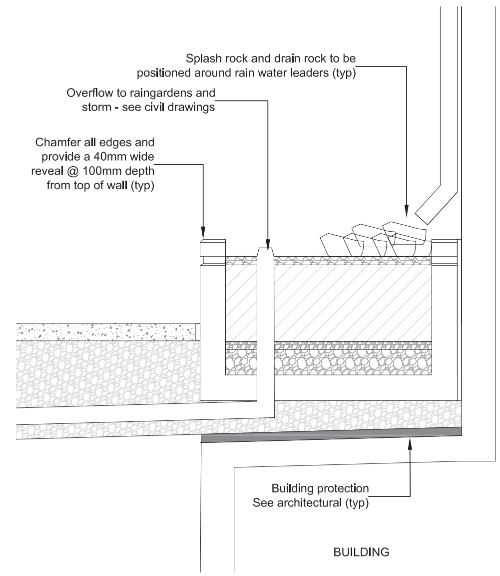
www.vdz.ca/resources.php



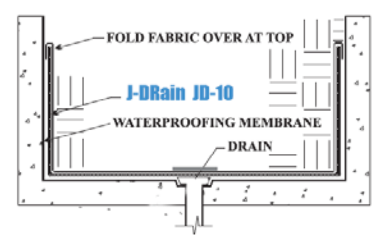
Permable pavers



Hydrapressed slab



Planter with Raised Drain



Drainage dentention fabric for planters

resources & links

National Agencies and Non-profit Links

The Canadian Green Building Council
www.cagbc.ca

The US Environmental Protection Agency
http://www.epa.gov/owow_keep/NPS/index.html

The Green Roofs for Healthy Cities Coalition
www.greenroofs.ca

Provincial and Municipal Links

Stormwater Planning: A guidebook for British Columbia
http://www.env.gov.bc.ca/epd/epdpa/mpp/stormwater/stormwater.html

Rain and Drain Simulator
http://www.sustainabilityinmybackyard.ca/home

Water Bucket
http://www.waterbucket.ca

The Water Balance Model
http://bc.waterbalance.ca

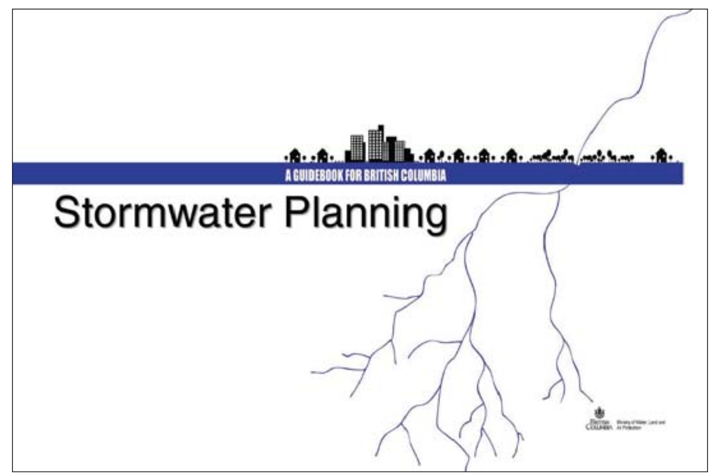
Surrey Storm Water
http://www.surrey.ca/city-government/4706.aspx

Research and Learning

http://www.perviouspavement.org/

http://www.cement.ca/en/Parking-Lots/Pervious-Concrete.html

http://www.concretenetwork.com/pervious/



general suppliers

Permeable Concrete

LaFarge Canada
http://www.lafarge-na.com

Sustainable Concrete Canada
http://www.sccanada.net/

Permeable Pavers

Aquapavers
http://www.aquapave.com/

Unilock Pavers
http://www.unilock.com/Products/Pavers/Permeable

Grass Grid
http://www.landscapesupply.com/products/main.php?cat_id=610

Eco-grid
http://www.terrafirmenterprises.com/

Storm Infrastructure Supplies

Nilex
http://www.nilex.com/

Corix
http://www.corix.com/

Green Roofs & Living Walls

G-Sky Green Walls and Roofs
www.gsky.com

Mubi Green Walls
www.mubi.ca

Roofscapes Inc
www.roofmeadows.com

Tecta America
www.tectaamerica.com

Soils & Plants

Eco-media Soils
www.yardworkssupply.ca

BCLNA
www.bclna.com